Abstract Volume

World Water Week in Stockholm
August 16–22, 2009

Responding to Global Changes: Accessing Water for the Common Good

with Special Focus on Transboundary Waters

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ABSTRACT VOLUME

World Water Week in Stockholm
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Responding to Global Changes:
Accessing Water for the Common Good

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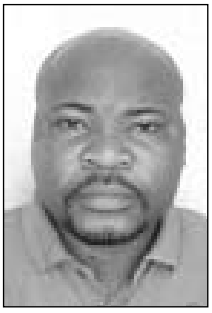

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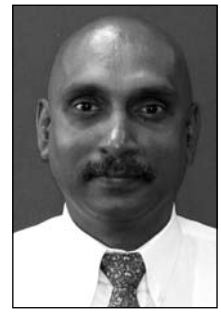

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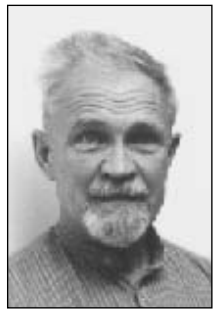

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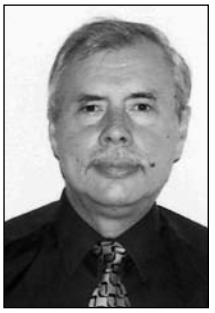

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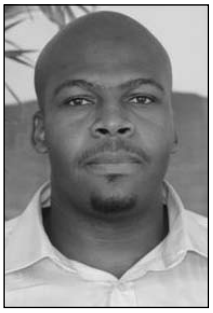

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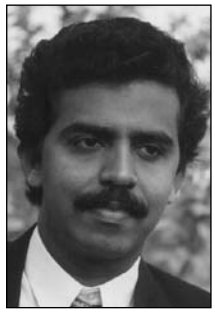

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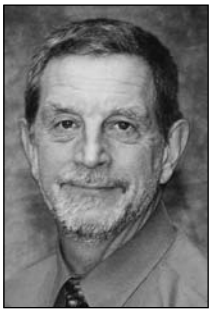

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Workshop 1: Benefit Sharing and Transboundary Waters

FRIEND/Nile Project: A Success Story for Transboundary Cooperation

Author: **Dr. Radwan A. Al-Weshah**
UNESCO Regional Office in Cairo, Egypt

Keywords: FRIEND, Nile, transboundary waters, water cooperation, UNESCO-IHP

Introduction/Problem Identification

The Flow Regimes from International and Experimental Network Data (FRIEND) Programme was first established by UNESCO in 1985 as part of the International Hydrological Programme (IHP).

The FRIEND/Nile project is a member of the global FRIEND family. It was initiated by UNESCO in March 1996. It aims at creating more understandings and quantification of the river Nile system in order to enhance the management of the Nile water resources and to improve the planning of water resources projects in the Nile Basin countries.

Six Nile Basin countries are actively contributing to the implementation of the research activities of the project, namely: Egypt, Ethiopia, Kenya, Tanzania, Uganda and Sudan. However, the project is opened to all interested Nile basin countries. The Water Resources Research Institute is the overall coordination center of the project. Water cooperation within the Nile Basin is a top priority for all partners.

Analysis/Results and Implications for Policy and/or Research

Through the FRIEND/Nile project, a network of water resources experts in the Nile basin and the Flemish community has been established. Four research teams have been defined comprising researchers from the participating Nile Countries and Flemish experts in Phase I of the project, namely:

a Rainfall-Runoff Modeling, coordinated by the University of Dar Es Salaam of Tanzania;
b Sediment Transport and Watershed Management, coordinated by the UNESCO-Chair in Water Resources of Sudan;
c Flood Frequency Analysis, coordinated by the Water Resources Research Institute of Egypt; and
d Drought and Low Flow Analysis, coordinated by the University of Nairobi of Kenya.

In its second phase of the project and after consultation with all stake holders, the following themes were adopted:

- Hydrologic Modelling Component, coordinated by the University of Dar Es Salaam of Tanzania.
- Erosion and Sediment Transport Modeling component, coordinated by the UNESCO-Chair in Water Resources of Sudan.
- Stochastic Modelling component, coordinated by the University of Nairobi of Kenya.
- Ecohydrology Component, Coordinated by Makerere University of Uganda.
- Integrated Water resources Management, coordinated by the Water Resources Research Institute of Egypt.

Over 380 experts including project team members, Flemish counterparts and a large number of researchers in the participating countries have participated in the project activities. Female experts and young scientists were involved in these activities.

The project provided new methodologies, tools, technologies, and software as an effective approach for enhancing the institutional and human resources capacity building in the field of the Nile Basin water resource management.

Nepal-India Co-riparian Conflict: Fresh Case of West Seti River Dam Project

Author: **Mr. Ratan Bhandari**
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Co-Author: **Mr. Gopal Siwakoti Chintan**
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Keywords: trans-boundary, co-riparian, benefits, Nepal-India, West Seti

Introduction/Problem Identification

Nepal has enormous water resources and rivers flowing to the sea via India and Bangladesh. The conflicts over the utilisation of these rivers and the issue of benefit-sharing among all co-riparian states originated in the Himalayas are on the rise. There are no regional or multi-lateral water and benefit-sharing frameworks or arrangements to date.

Nepal and India have many conflicts over the issue of benefit-sharing in relation to several trans-boundary rivers. There have been criticisms and controversies even in those river-sharing arrangements which are bound by official bi-lateral treaties and agreements such as Koshi (1954), Gandak (1959) and Mahakali (1996), including three private sector projects in recent years: the West Seti, the Upper Karnali and the Arun 3. The case of new West Seti river dam project involving a private sector Australian company provides a fresh controversy as it benefits largely India with no investment cost as a lower riparian country.

Analysis/Results and Implications for Policy and/or Research

The most interesting and disturbing common feature of all these official and bi-lateral agreements is that no issue of co-riparian benefits is properly addressed – Nepal as an upper co-riparian state and Bangladesh as lower co-riparian state in the case of Koshi River. The Westi Seti dam project is now at the centre of controversy as to whether and how Nepal should claim and receive co-riparian benefit from India once the project is completed and additional water is diverted to India through the Karnali River. This is the main theme of the poster presentation.

The 750 MW West Seti dam project is located in the western part of Nepal. Although it is a domestic river, a huge amount of stored water will be diverted from the powerhouse directly to India through the Karnali River. It will allow Indian to irrigate 80,000 to 600,000 hectares of land. According to the Environmental Impact Assessment report of the project, the length of the West Seti reservoir would be 25.1 km and the total storage capacity is estimated about 1,566 million cubic meters (m^3) of the 195 m dam. Although, there is no information available on the quantum of flood control benefit, but 90 m^3/s of augmented flow during the dry season (from West Seti) is worth $ 83 million (equivalent to Rs 5.81 billion) annually based on the principle set forth by the agreement between Lesotho and South Africa1 for the purpose. We could also develop a mechanism to share such benefit on the precedent set by the Columbia Treaty.

Although there have been many discussions at the official and unofficial levels in the past few years about making arrangements for co-riparian benefit based on the valuation of total additional consumptive advantage from the dam. There has been no progress and no understanding has been reached to date.

The West Seti has become the first river project in which the issue of riparian benefit for Nepal has become one of the core issues of controversy. Local people and activists groups, under the leadership of Water & Energy Users' Federation-Nepal (WAFED), took the matter to the Supreme Court of Nepal asking it to issue directives to the government to present the project agreement for parliamentary ratification as it involves the fundamental issue of ensuring co-riparian benefit for Nepal from India from the economic benefit it generates. Article 156 of the present Interim Constitution, as in the case of article 126 of the 1990 Constitution, provides for the ratification of any treaties and agreements relating to the sharing and utilisation of any natural resources, water and energy resources in this case. However, the Supreme Court delivered a very disappointing judgement concluding that agreements involving companies, as opposed to those between government(s), are not subject to the above provision of the Constitution requiring parliamentary approval. Now Nepal's water experts, academics and activists are campaigning for the incorporation of clear provisions in the new constitution that the recently elected Constituent Assembly is drafting so as to cover all trans-boundary natural resources and related issues whether they involve governments or private entities.

India's proposed and on-going Inter-Linking of Rivers Project (ILRP) has also raised fundamental controversial issues regarding its own inter-state, e.g. the case of Ganga River diversion from Bihar State of India, and several trans-boundary co-riparian issues involving not only Bangladesh as a lower riparian country and Nepal and Bhutan as upper riparian countries. China also enters the picture separately because is also China reportedly aiming to undertake various large scale diversion and inter-linking of rivers projects of its own. So far the concerns and opposition expressed by Bangladesh officially has not been addressed by India, if the ILRP is implemented without any consultation with and approval of Bangladesh and if the its adverse effects are not negotiated and mitigated in advance, it will take up the issue to international forums such as the United Nations or even the International Court of Justice in The Hague as a declaration of virtual 'water war'! Nepal has not expressed any concerns officially yet despite the fact that the ILRP issue is already at the top of the Nepal-India water conflict debate. It is yet unknown whether Bangladesh has done anything or not in this regard.

In this context, the first and fresh case of West Seti provides ample opportunity for both Nepal and India to address and resolve the issue of sharing co-riparian benefits. It is also hoped that some kind of bi-lateral and multi-lateral framework also emerge gradually aiming for a true regional cooperation with regard to the vast Himalayan waters and their utilisation in the region to the just and reasonable satisfaction of all the co-riparian countries and states.

A Participatory Approach for Assessing Climate Change Adaptation Choices within Sustainable Water Management

Author: **Dr. Stewart Cohen**
Environment Canada

Keywords: climate change adaptation, integrated assessment, group based model, Okanagan region, Columbia basin

Introduction/Problem Identification

How should climate change adaptation be integrated with long-term sustainable water management? A methodology based on participatory integrated assessment is offered as a means by which scenario-based research on climate change impacts, combined with practitioner-based knowledge of regional water systems, is used to assess potential effectiveness of adaptation options. The approach is based on collaboration between researchers, regional practitioners, and decision-makers, within a shared learning environment. Scenario-based studies, dialogue on their implications, and joint construction of a decision model, using a STELLA platform, has been used in a case study of the Okanagan watershed, a semi-arid region in British Columbia, Canada. The Okanagan is a tributary of the Columbia River Basin, a transboundary watershed shared by Canada and the United States.

Analysis/Results and Implications for Policy and/or Research

Results from earlier modelling of Okanagan water supply, and agricultural and residential water demand, combined with interviews and group discussions on water management issues, laid the foundation for creating the decision model. The STELLA platform was used to represent storage and flows of water through the watershed, incorporating current information and scenario-based projections of water supply and demand for future climate change and population growth. Adaptation options included demand management measures, such as metering, as well as measures to increase direct withdrawal from valley-bottom lakes, and to alter upland reservoir releases that would support in-stream flows for fisheries. Model indicators included supply-demand balance for particular water users, deficits below prescribed targets for in-stream flow, and lake levels for Okanagan Lake, the largest of the valley bottom lakes.

Three climate change scenarios were considered in the decision model; HadCM3 with the A2 emission scenario, CGCM2 with the B2 scenario, and CSIROMk2 with the B2 scenario. The A2 and B2 scenarios, part of the SRES series provided by the Intergovernmental Panel on Climate Change (IPCC), represent relatively high and modest scenarios of greenhouse gas emission increases, respectively. The HadCM3 case was the warmest and driest of the three, but all of these scenarios projected reductions in overall annual water supply and increases in regional water demand, exacerbated by projected rates of population growth which could be up to 2.4% per year.

The HadCM3 case indicated a supply reduction of 5% by the 2020s, and 20% by the 2050s. Demand for agricultural and residential use would increase, though this depends on population growth. Projected in-stream use was projected to decrease due to existing policies for reducing such flows during low flow years, which would become more frquent within this climate change scenario. Aggregating these three needs, total average annual demand would be 82-113% of total inflow in the 2050s. This would be unsustainable.

Several adaptation measures were assessed individually and in combination. The most effective was a set of demand reduction measures, including metering with an increasing block pricing structure, landscaping residential areas with native plants, expanded programs for leak detection and public education, combined with supplemental withdrawals from the valley bottom lakes. It was determined that reliance on lake withdrawal alone would lead to declines in lake levels, and deterioration of in-stream conditions for fisheries.

This information was considered by the Okanagan Water Stewardship Council when it released the Okanagan Sustainable Water Strategy [available at http://www.obwb.ca]. The Strategy contains an extensive portfolio of demand and supply measures, and outlines a water governance strategy to implement these measures and maintain a system of continuous monitoring and reporting through the creation of a regional information network. Some of the architects of the Strategy were also among the local practitioners and decision makers that participated in the climate change study. The experience of being part of the study process enabled the region's water interests to incorporate climate change into the Strategy. When combined with other participatory learning activities throughout the Columbia Basin, supported by governments in both countries, the stage is set for incorporating climate change into long-term planning at the transboundary watershed scale.

Benefit-sharing in Transboundary Water Management through Intra-water Sector Issue Linkage?

Author: **Dr. Ines Dombrowsky**
Helmholtz Centre for Environmental Research – UFZ, Germany

Keywords: international waters, IWRM, side-payments, intra-water sector issue linkage, benefit-sharing

Issue linkage has often been mentioned as a strategy to overcome international upstream-downstream problems on the basis of self-interest behavior. Usually it is being assumed that negotiators link different issue areas of international relations. However, given that water is a multi-functional resource that eintails various uses, the question arises whether there are also opportunities for issue linkage within the water sector and thus for benefit-sharing though an Integrated Water Resources Management (IWRM). This paper explores potential opportunities for intra-water sector issue linkage such as (1) the linking uses controlled by downstream riparians with uses controlled by upstream riparians, (2) the balancing of upstream and downstream external effects, (3) the off-setting of negative and positive external effects, and (4) the spatial linkage of different river basins from an conceptual and an empirical point of view.

The paper finds that while some opportunities for issue linkage within the water sector exist they remain limited. Within a river basin, there may be some opportunities for balancing uses controlled by downstream with uses controlled by upstream as well as uses with downstream and upstream external effects. Also the linking of river basins with reversed riparian positions may be conducive towards cooperation. In contrast, there are no opportunities for the off-setting of negative and positive downstream effects. One implication of these findings is that an "integration" of different uses is sometimes – but not always – in the interest of both upstream and downstream riparian countries. However, where they exist they may provide an opportunity for benefit-sharing in international water management.

Transboundary Water Pollution Control Efforts in the U.S.

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Co-Author: **Mr. David Dilks**
LimnoTech, USA

Keywords: transboundary, watershed, TMDL, collaboration, water pollution

Introduction/Problem Identification

The issue of managing transboundary waters for the beneficial uses of all parties is challenged not only by the allocation of flow but also by interjurisdictional impacts on quality and allocation of pollutant loads to achieve a fair sharing of benefits and costs. This paper explores how transboundary waters in the US have been managed for controlling pollution and protecting beneficial uses. Although focused primarily on US waters, there are many transboundary issues between states and with tribal nations which share waters yet each can have very different water quality standards and regulations for control measures. In addition, US shares waters with Canada and Mexico, often struggling to achieve consistent and effective programs. This paper explores the issues and challenges through several examples that illustrate lessons learned from both successes and failures. It highlights the processes used to develop collaboration and decisions on allocation.

Analysis/Results and Implications for Policy and/or Research

In the US pollution today is by legislation controlled through a process that involves establishing a total maximum daily load (TMDL) for waters not meeting beneficial uses and then allocating allowable pollutant load to watershed sources, wastewater and land runoff. In the US, states have the responsibility to list impairments and calculate the allowable TMDLs. However, these efforts are often frustrated when waters share a boundary with another state, or cross state/country boundaries. In these cases benefits are sometimes disconnected from the allocation of needed controls in different parts of the basin. Still, the TMDL program is a very effective vehicle to resolving these problems because it requires a watershed approach not one dictated by political boundaries.

Issues that arise when addressing transboundary pollution include: different procedures and criteria for identifying impairments, different desired uses, different standards, different mixing zones, different strategies for controlling runoff, and different regulatory programs. Cooperation and/or integration of transboundary plans can be inconsistent (even nonexistent) and a large factor in the success or failure of meeting shared benefits. Large scale problems often circumvent the TMDL process thru large multi-jurisdictional compacts, but the need for a TMDL is often an underlying motivation.

This paper explores several transboundary examples, some successful others not. Three very large scale problems demonstrated a range of success: the Great Lakes involving 8 US states and 2 Canadian provinces where success has been dramatic; the Chesapeake Bay Basin involving 7 states where interstate cooperation has been highly successful but water quality progress mixed; and the Mississippi River Basin and Gulf of Mexico involving 31 states where progress has been very poor but a new strategy is now proposed.

In the 1960's there was widespread and growing pollution in the Great Lakes to the extent that one lake, Lake Erie, had been labeled "dead" by the media. However, by the 1970's extensive scientific

research had been underway to determine the necessary reduction of nutrients. Subsequent, US and Canadian agreements supplemented by charters among the states and provinces have established uniform standards, control measures, and management restrictions that have been key to restoring and protecting the lakes. One key to success in this effort was collaboration in building a sound scientific foundation which involved models as a tool for reducing subjective debate. In addition, there was strong public pressure and resultant leadership at all levels of government to find collaborative solutions. Several institutional structures were used to facilitate the consensus plans and requirements.

In the Chesapeake Bay Basin wide spread eutrophication and depleted dissolved oxygen was uncontrolled due to wastewater and up-basin agricultural inputs, far removed from the impaired benefits downstream. In the 1980's several Federal agencies undertook scientific studies and model development in cooperation with impacted parties. As a result there began a series of interstate agreements and a TMDL that established new goals, standards and control strategies, slowing the decline and setting a course for improvements. Results to date include effective state coordination, and substantial progress in tributary rivers but unclear progress in meeting Bay goals. In this case EPA leadership was key to driving the process, but in the end it was not dictated, but achieved thru collaboration.

The third example, in the Mississippi River Basin involves nutrient pollution inputs from 31 states, which has caused not only River pollution but an extensive area of hypoxia in the coastal Gulf of Mexico. There, has been little integrated planning and study, let alone action. Several comprehensive studies have been conducted but progress is stalled because of lack of cooperation. In large part this is because the major sources are far removed from the problems. However, a new National Research Council study has just been completed that identified high priority needs and an adaptive management strategy for beginning reductions. In addition, it outlined a framework for interstate and Federal interagency cooperation needed to implement recommendations.

Several other examples will be provided in this paper that highlight transboundary problems in interstate, US-Canadian and state-tribal nation settings. Lessons learned will be provided. These include as examples: the need to begin intergovernmental cooperation early while building a scientific foundation and shared development of objectives; the need for reliable models that help turn subjective debate into objective discussion; and last the need for third part involvement can be mitigated by leadership housed in a cooperative non-authoritarian framework.

Transboundary Groundwater Resources of the West Bank. The Water Quality Impact

Author: **Dr. Luay Froukh**
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Keywords: transboundary, groundwater, water quality, wastewater, water management

Introduction/Problem Identification

The political boundaries between the Palestinian and Israelis make the water issues critical and sensitive. Groundwater is the primary source for the Palestinian in the West Bank. Groundwater testing results has indicated drop in water quality and increase of salinity, nitrate, signs of pesticides, and herbicides.

Analysis/Results and Implications for Policy and/or Research

The political boundaries between the Palestinian and Israelis make the water issues critical and sensitive. Groundwater is the primary source for the Palestinian in the West Bank. Although, there are many studies on the shared surface resources (Jordan River Basin), there are few studies on the groundwater shared resources between the Palestinians and Israelis.

The shared groundwater basins between Israel and Palestine and lack of coordination between two sides have significantly affected quality of groundwater. There are three primary groundwater basins underlying West bank. Threats to ground water quality include disposal of untreated wastewater, increasing salinity due to agricultural activities and intrusion of native groundwater of poor quality. Widespread use of herbicides and pesticides also represent a threat to drinking water supplies.

The equitable allocation requires shared management. Due to the limited progress in the political issues, most of these concepts did not implement. For example, the Israeli side stills the primary user of groundwater resources within the West Bank. In addition the shared management no more practiced especially after the startup of the seconded Intifada in September 2000 until now.

This Study suggested set of measures to be presented to both parties to protect the groundwater which is important to both sides

The Importance of Innovation and Complexity in Sharing and Managing Transboundary Water: The Experience of the Challenge Program on Water and Food

Author: **Dr. Annette Huber-Lee*** *et al.*
* CPWF, Sri Lanka

Keywords: collective action, partnerships, resilience, basin scale, global drivers

Introduction/Problem Identification

As introduced by the Stockholm World Water Week 2009 'transboundary' water does not only refer to water flowing across nations. Phase 1 research of the CGIAR Challenge Program on Water and Food has studied benefit sharing mechanisms across various biophysical, social and economic boundaries within selected countries. It is argued that such research findings can support the design of benefit sharing mechanisms in transboundary river basins crossing several countries.

CPWF projects have examined numerous aspects of water benefit sharing on water values, benefits distribution, institutional arrangements and implementation mechanisms in Africa, Asia and Latin America. Key for the success of benefit sharing was not limited to increasing the overall benefits of water, it also required a common understanding of the complexity of upstream-downstream problems and opportunities (physical and social), and innovative ways of reaching consensus on mutually beneficial changes in behavior.

Analysis/Results and Implications for Policy and/or Research

The project "Sustaining Inclusive Collective Action that Links across Economic and Ecological Scales in Upper Watersheds" has contributed to strengthening the ability of the poor to participate in collective processes at multiple scales in watersheds. The conceptual framework proposed a new way of looking at social and ecological interactions within watersheds. Resource flows in watersheds were not limited to lateral flows of water but also included "reverse flows" of economic, social and political resources that could go from downstream to upstream in response to actual or potential hydrological externalities.

The project also examined incentives for cooperation in a watershed context and the impacts of potential policy interventions. Economic experiments based on economic game theory were conducted under field conditions with over 600 residents in four watersheds. The results revealed that communication rather than regulation is the most effective way for people to improve levels of cooperation, though. Upstream communities have an important role to play in initiating watershed dialogue. Downstream people, both in the games and in reality, appear to have a deep distrust of upstream residents. Their willingness to initiate cooperation is limited, but they are willing to reciprocate – if upstream people make the first move.

In the Mekong, the Companion Modeling and Water Dynamics project used multi-agent systems (MAS) and the companion modeling method to facilitate water management negotiations across social and economic boundaries between water users, within and among communities. Creating an institution for collective watershed management helped resolve a conflict over the sharing of water resources by establishing a concrete agreement. For example, research in Thailand increased the abil-

ity of poorer farmer groups to communicate effectively with wealthier farmers, leading to significant changes in financial decision-making in communities. Companion modeling is expanding now to look beyond a single community to groups of communities.

In the Andes and Africa, the project "Environmental Services Promoting Rural Development" assessed the impacts of current and potential land uses and proposed Payment for Environmental Services (PES) as a mechanism for promoting rural development in upper watersheds. The project refined a multi-criteria model (ECOSAUT) to maximize net income in different farming systems and environmental change scenarios, predicted livelihood outcomes for different land-use interventions. In Fuquene Colombia, the PES project helped stakeholders determine costs and benefits of modifying environmental externalities. In the Altomayo basin (Peru), the PES project simulated current land uses and compared them with change scenarios of deforestation, reforestation, implementation of live barriers, and agroforestry systems. Results indicate the feasibility of a PES scheme to promote agroforestry systems or to introduce sedimentation reduction measures into traditional farming practices.

CPWF Phase 1 research has designed, tested and implemented a range of social and economic mechanisms for sharing benefits of water and related services (in particular environmental services) across sectors, stakeholders and spatial scales in several country case studies. While it is acknowledged that political issues are of highest importance in sharing water benefits among nations, it can provide valuable tools and lessons for sharing the social-ecological benefits of water across national boundaries.

The Orange-Senqu River Awareness Kit – A Tool for Capacity Building in Transboundary River Basin Organisations

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Keywords: transboundary, capacity building, self-learning, river awareness kit, cd-rom internet

Introduction/Problem Identification

Encompassing four countries (Botswana, Lesotho, Namibia and South Africa) and almost 1-million square kilometres, the Orange-Senqu River Basin is possibly one of the most developed river basins in Africa. The management of water in the river basin supplies water to a population of 19-million people, as well as large industry, power generation, and agriculture; through a network of dams and inter/intra-basin water transfers.

Analysis/Results and Implications for Policy and/or Research

The climate, landscape and cultures of the Orange-Senqu River Basin vary significantly from the source of the Senqu River in the highlands of Lesotho, across semi-arid central and northern South Africa and south-eastern Botswana to desert conditions where the river forms the border between southern Namibia and South Africa before the river meets the Atlantic Ocean. This variation poses many challenges to the management of the water resources of the basin, under growing pressure from increasing populations and the uncertainties of climate change and climate variability. A balance must be struck between meeting the needs of municipal, agricultural and industry water supply, the requirements of the individual basin states and environmental flows.

The Orange-Senqu River Basin Commission (ORASECOM) was initiated in 2000 in an effort to improve the governance of this transboundary water resource. The mandate of ORASECOM is to promote the equitable and sustainable development of the shared resources of the Orange-Senqu River, specifically in the context of the Southern African Development Community's (SADC) Shared Protocol on Watercourses.

As part of their technical support to ORASECOM within the Transboundary Water Management in Africa program, GTZ initiated the development of a River Awareness Kit (RAK) for the Orange-Senqu River Basin. The Orange-Senqu RAK fills a critical gap in supporting the shared management of knowledge about the Orange-Senqu River basin and build capacity within ORASECOM and within the commission members from the national departments of water.

The Orange-Senqu RAK is a web and CD-ROM-based interactive learning tool, developed to improve awareness of key issues in water management in the basin. The thematic content included in the RAK was defined through a participatory process and the information and knowledge sourced to populate the RAK was drawn from existing literature and documentation made available by the contributing countries and associated institutions.

The Orange-Senqu RAK deals with four main themes:

- The River Basin (geography, climate, ecology and biodiversity of the river basin);
- People and the River (the social aspects of water and the relationship between people and their environment);

- Governance (the policy and legislative aspects of transboundary water resource management); and
- Meeting the Water Challenge (dealing with the physical management of water in the basin to meeting the needs of the population and the environment.

The Orange-Senqu RAK is intended to act as a knowledge base for awareness-raising and communications activities in the Orange-Senqu River Basin and the Transboundary Water Management in Africa program. The project provides a source and template for dissemination of environmental information to the various users of water in the basin, institutions with a role in managing or using the resource and stakeholders. It is also designed to support ORASECOM in delivering capacity building and training programs. The innovative approach employed within the project focuses on awareness raising and user-driven knowledge management.

The Orange-Senqu RAK is the fourth River Awareness Kit developed to date, with previous projects completed in the Nile, the Mekong and North America. The overall approach used to develop these kits remains consistent for each river basin, with modifications made to adapt to the local conditions and specific requirements of each River Basin Organization. Therefore, the approach is highly replicable to other river basins in the world dealing with similar knowledge management, awareness raising and capacity building issues.

A River Runs through It. Joint Democracy and the Provision of Transboundary Public Goods

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Keywords: transboundary, event data, bilateral cooperation, democratic structures, benefit sharing

Introduction/Problem Identification

The proposed paper investigates the determinants of cooperation in transboundary freshwater management.

Currently, 263 river basins cross national boundaries, covering some 45.3 % of the Earth's land surface (Wolf et al. 1999, 2003), and about 40% of the world's total population lives in these basin areas. Accordingly, the management of transboundary water resources is of great importance to socio-economic wellbeing. However, successful management of transboundary watersheds can only be achieved by international or bilateral cooperation. That is, countries depend on good relations with their neighbours in terms of water levels and quality in transboundary watersheds.

Based on a global dataset on transboundary water events, I examine why there is great variability in the extent of cooperation over shared rivers between different pairs of countries. Special attention is paid to the impact of democratic structures and countries' general entanglement in the international system.

Analysis/Results and Implications for Policy and/or Research

The theoretical part of the proposed paper departs from the assumption that governments have different incentives to engage in transboundary cooperation and benefit sharing.

In this vein, I analyze whether democratic pairs of countries tend to differ with respect to their ability to engage in benefit sharing, compared to non-democratic or mixed dyads. The gist of my argument is that democratic leaders have an incentive to care about transboundary environmental quality as long as abatement costs are outweighed by electoral support.

Important aspects underlying this argument are both the salience and the severity of transboundary freshwater problems. On the one hand, severity increases abatement costs and thus reduces governments' incentives to react. On the other hand, salience might encourage democratic governments to take action in order to avoid electoral punishment. Both concepts are expected to be highly correlated in democratic regimes, where citizens have easy access to information and thus become aware of environmental problems, such as water pollution. In autocratic regimes, in turn, even very severe problems might not be afflicted with salience, as citizens are simply not informed about the issue. In addition, even if public awareness was high, autocratic leaders would not necessarily need to respond to their citizens' demands as these politicians are relatively independent of their citizens' votes (that is, ignoring the fact that citizens' dissatisfaction might actually lead to political upheaval). Accordingly, autocratic governments are expected to be reluctant to react to severe problems, whereas democratic leaders are expected to take action as long as the salience of the respective problem is high. Further, I expect higher levels of and more successful benefit sharing in transboundary freshwater resources within democratic- than autocratic country pairs. This is because transparency – as it is found in

democratic countries – reduces the risk of unilateral defection and thus facilitates cooperative commitments for mutual advantage.

Further aspects that I argue play an important role regarding the extent and successfulness of benefit sharing are a similar pattern of membership in international organizations (political integration), trade relationships, and ideological affinity. These attributes all hint at collaboration in other issue areas, which may enhance countries' trust in each other and thus facilitate stronger commitments.

I empirically test the above theoretical claims on a time-series-cross-sectional sample of both democratic and autocratic countries, riparian to both cross-border and border-demarcating rivers. In particular, I juxtapose both the severity and the salience of possible environmental problems and water scarcity with cooperative events between riparian countries' governments with respect to joint river management. Existing social sciences research, has been based primarily on individual qualitative case studies or comparisons of results from a few such case studies. There is widespread recognition that large-N quantitative studies are urgently needed to complement the findings from small-N work. Given that existing datasets (such as the Transboundary Freshwater Disputes Dataset (http://www.transboundarywaters.orst.edu/database/) and the ICOW River Claims dataset (http://www.paulhensel.org/water.html#conflict) do not suffice to test the above sketched theoretical assertions, I have build a new dataset on international freshwater management.

The construction of this dataset is an important cornerstone of the project that gave raise to the proposed paper and provides the basis for answering several research questions regarding transboundary water management. It allows for precise spatial and temporal location of action and facilitates analyses relying on spatial covariates such as population density in basin areas.

A first analysis of this dataset using panel data regression techniques provides support for the hypothesis that democratic dyads have a higher potential for benefit sharing than non-democratic pairs of countries in case of water quality and quantity, but reveal a reversed effect with respect to joint management. Further, preliminary results show that -across issue areas- autocracies collaborate less the higher the expected costs of abatement.

The paper thus hints at certain patterns regarding the potential of benefit sharing in different basins across the globe, which may enable policymakers to identify which basins face the greatest challenges in terms of international water management and where to direct respective action.

Through the Preservation of Sturgeon Habitats to Sustainable Transboundary Watershed Management: The Ural River

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Keywords: Caspian Sturgeon, watershed, indicator species, Ural River, environmental flow

Introduction/Problem Identification

Sustainable development of watersheds should consider three main components: economic, social and environmental, which can hardly be reached in real-life management.

As a rule IWRM issues are addressed from a narrow, sectoral perspective. Many watershed management projects based on these principles indicate no success so far.

Apart from these conceptual problems there are a number of obstacles in everyday water management and practical implementation of IWRM principles. In addition the integrated watershed management is often complicated by the transboundary nature of watersheds.

The free-flowing Ural River, the third largest European river, is not an exception in this sense. Shared between Russia and Kazakhstan, the ecosystem shows the trend towards environmental degradation and biodiversity loss. At the same time it is a unique ecosystem with preserved natural conditions, which contains the only available Caspian self-sustaining sturgeon population.

Analysis/Results and Implications for Policy and/or Research

High economic and social values of sturgeon allow the combination of both ecological and socio-economic aspects of sustainable development.

Using sturgeon species as a natural indicator and an incentive for transboundary IWRM cooperation is suggested using the Ural River basin for the case study. The only free-flowing river in the Caspian basin, the Ural River, is a unique ecosystem with a preserved natural hydrological regime and the last sturgeon spawning habitats. It contains the only self-sustaining, viable sturgeon population capable of natural reproduction. The presence and well being of this worldwide flagship species in a river network indicates the "good quality" of a river ecosystem's health. Activities towards successful integrated water management will secure preservation and restoration of sturgeon population and vice versa. Community-based management of sturgeon stocks also resolves social and economic problems by restoration of the traditional life style of local communities, exclusively focused on sustainable utilization of floodplain resources, e.g. fishing. To be successful the initiative should secure the involvement of the local communities, Ural Cossacks, into environmental protection measures and closely cooperate with regional authorities. Special attention is paid to stakeholders involvement, crossdisciplinary integrated assessment and modelling of the Ural River hydrology coupled with sturgeon life cycle.

Legal Approach of Benefit Sharing: Transboundary Watercourses

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Keywords: benefit sharing, trans-boundary watercourses, equitable utilization, sustainable development, just process and outcome

Introduction/Problem Identification

Most common issues and problems of aggregate benefit sharing can be presented as follows: Suppose that State A is a source State of an international river which runs through State B as a successive international river. From State B, the river enters States C and D that are situated on its opposite banks. There has been a considerable decline of the rain fall in the whole drainage basin area of the river in the past decades perhaps because of the global heating – climate change – and easy access to water is becoming difficult in this situation. For State A, this internationally shared river is vital for drinking purposes, for State B, irrigation is important and for State C, the hydroelectricity production is important and for State D, the industrial use is vital.

Analysis/Results and Implications for Policy and/or Research

Several questions arise concerning benefit sharing: For example; what are the rights and obligations of the watercourse States; how to balance the interest of the up/down stream riparian States or those States situated on the opposite bank of a river; whether watercourse use or protection takes precedence over the other, or how the current law balances between them; how the principles of equitable utilization and sustainable development are to be implemented in situations where availability of water is limited and demand is unlimited; whether the first users' right prevails over that of the subsequent users; whether industrial water use prevails over agricultural use if the former appears to be more profitable than the latter; how to prioritize water use, i.e. between drinking and agricultural use, or between development and environment; and is there any contradiction between the principles of uses and protection, and if so how does this relate to the environmental justice?

The aim of my presentation is to explain some models of benefit sharing that have emerged in the recent State practice. This will demonstrate salient features of those models that can be applied in situations where either process is lacking or outcome is unjust, or both. This is a useful method for a broader examination of the context of benefit sharing as a generic legal approach which entails a just process leading to an equitable outcome.

As to the use and protection of trans-boundary watercourses and benefit sharing, the generic legal approach essentially means application of the principle of equitable utilization and sustainable development. Thus, benefit sharing requires an evaluation of the subjective and objective criteria – value all equally, and judge together on a case-by case basis.

Specific models will be examinated and presented including the continents of Europe, Asia, Africa and the Americas, e.g. the Danube and Rhine rivers in Europe; the Mekong, Mahakali and Ganges rivers in Asia; the Zambezi River in Africa, and the Amazon River in South America.

Water Policy Harmonization in the Southern African Development Community: Outcomes and Development Perspectives

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Keywords: SADC, water policy harmonization, SADC water division, GTZ, parliamentarians

Introduction/Problem Identification

Water is perceived by many as one of the main driver for regional integration within the Southern African Development Community (SADC). Hence, since the mid 1990s, SADC member states have been engaged in wide ranging consultations on the development of the water sector. In the process, several policy documents were adopted, the most important being the Revised Protocol on Shared Watercourses (2003), the Regional Water Policy (2005) and the Regional Water Strategy (2006).

Analysis/Results and Implications for Policy and/or Research

With the overall objective of fostering closer cooperation among member states, the Revised Protocol provides the main legal instrument to support coordinated efforts on transboundary basins. The Regional Water Policy provides the context and intent for water resources management at SADC regional level, representing the aspirations and interests of member states. The Regional Water Strategy then represents the framework for the implementation of the Policy and Protocol, indicating actions, responsibilities and timeframes necessary to achieve the desired end state. Since all these three documents were adopted by SADC highest institutions, it is now the member states responsibility to harmonize their water policies with these SADC directives, so that they do not hinder the sharing of international water resources for mutual benefits.

The purpose of this paper is threefold. Firstly, it is to assess for member states the policy requirements associated with the implementation of SADC water policy framework, especially when it comes to water rights, water quality standards and economic and institutional frameworks. Secondly, it aims at highlighting the actual inconsistencies, gaps and incompatibilities between national policies and the proposed SADC framework. Thirdly, the paper examines the initiatives taken by the SADC Water Division, in close collaboration with the international cooperation partners, to support member states with this harmonization process. Special consideration will be given to one of GTZ/SADC's project to support national and regional parliamentarians with policy harmonization and transboundary water management.

Uruguay River Dispute between Argentina and Uruguay: The Possibility of Benefit Sharing For Transboundary Waters

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Keywords: transboundary, management, basin, development, instruments

Introduction/Problem Identification

Argentina and Uruguay have been in conflict and litigating over a case of trasnboundary waters for years. The construction of pulp mills in a riverine Uruguayan town has brought local communities protest which have found echo in provincial, national and international policy in Argentina. The protests escalated and Argentina brought a case against Uruguay to the International Court of Justice alleging that Uruguay is in breach of the Uruguay River Statute. The statute (an agreement signed between the two countries in the mid 1970s) aims at managing the boundary river (including aspects of natural resource exploitation, pollution prevention, etc.).The legal proceeding (still in review) is one of the indicators of the utmost conflict point between the two nations regarding this matter. The work here presented will consider the problems present regarding this case and compel a benefit sharing approach and possible instruments to deal with this matter in a positive sum move forward.

Analysis/Results and Implications for Policy and/or Research

The conflict between Argentina and Uruguay over the construction of pulp mills in a riverine Uruguayan town has brought local communities protest which have found echo in provincial, national and international policy in Argentina. The case against Uruguay has been presented to the International Court of Justice (ICJ) alleging that Uruguay is in breach of the Uruguay River Statute. This allegation is still in review. The pulp mills under question are part of forestry development plan by Uruguay, and each represents a large proportion of the country's GDP and generation of industrial activity in the area.

The river statute (an agreement signed between the two countries in the mid 1970s) aims at managing the boundary river (including aspects of natural resource exploitation, pollution prevention, etc.). The legal proceeding (still in review) is one of the indicators of the utmost conflict point between the two nations regarding this matter. Nevertheless, and notwithstanding what the court rulings might be, a benefit sharing approach and possible instruments to deal with this matter in a positive sum move forward can be impelled, even considering instruments already in place which have worked in other situations.

In the ICJ case, Argentina alleges that Uruguay had unilaterally authorized the construction of a pulp mill without giving prior notification and without complying with the consultation procedures Statute. Also alleging that the pulp mills have the potential of environmentally damaging the river and claiming breach of international obligations, ceasing wrongful conduct, and make reparation for damages. Provisional measures were also requested, including suspension of construction, cooperation in the use of the River, refraining from unilateral and aggravating procedures.

Nonetheless, although the international case is being heard and protests prevail and continue on the Argentinean side, there are instruments that have been in order to co – manage the shared resource (i.e. the international river basin). Although these instruments could be improved as well further

implement the concept of benefit sharing in transboundary waters they have been functioning for three decades. The Uruguay River Treaty, which has been in place since 1975, is one of the instruments that can be highlighted as a positive one to date, yet with a need to improve instruments in order to aggregate benefits.

The Treaty itself is a key instrument to be taken into account. It is one of the first such river basin international tools in the region. Albeit it is a product of its times, its aspects for transboundary river management are still current and an example of international river basin management. Nevertheless, issues such as participatory processes as well as more specific joint monitoring of activities and environmental impacts can be improved in order to provide progress in sharing benefits and absorbing impacts of water use.

The presentation will consider the Treaty and the instruments it has used in the last three decades for transboundary water management. Specially its administration committee, which is the implementing section of the international river management accord.

With the pulp mill conflict in mind, policy recommendations for developing concrete strategies to collaborate in transboundary water management in the region are drawn. Including, but not limited to, improved civil society, technical and policy inclusions in the organizational architecture of treaty – derived instruments. Furthermore, more proactive role of the treaty instruments, or the implementations of new instruments, where joint policy setting is key and joint monitoring is genuine.

In conclusion, looking at a situation where the Uruguay River Treaty has failed to contain a conflict between two countries, but have managed a transboundary river for three decades, policy recommendations are made to improve the instrument to minimize conflict and manage water use issues with a developmental framework and mutually benefitting the countries and societies involved.

Developing a Benefit Sharing Approach: Case from Ukraine

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Keywords: Dnipro River basin, sub-regional meeting, cooperation and collaboration, education, benefit sharing approach

Introduction/Problem Identification

Benefit sharing approach is getting to be an important for using water in a rational manner and assists in implementation sustainability within water sector [1]. In that connection creation a beneficial strategy for strengthening cooperation over water among countries with different political systems is one of the main goals. Such strategy should unite political, economic and environmental aspects, and is assumed to elicit spill-over effects beyond the water sector, producing bigger benefits such as peaceful cooperation, economic growth and integration within the region, i.e. benefits "beyond the river" [2]. The other big goal is developing a dissemination way for a good practice developed in one site of the river basin to the other ones.

Analysis/Results and Implications for Policy and/or Research

Dnipro River is the second biggest river in Europe, it's basin is located within Ukraine, Russia, Belorussia and Moldova. Current river basin management is mainly concentrated on simple water use and involvement of different stakeholders including university and NGO in water spheres and beyond is rather weak within the Sub-region.

Despite Ukraine, Russia, Belorussia and Moldova all belong to the former USSR countries, currently they represented states with different political systems, governmental structure and natural resources management. Ukraine represents a Parliament country which tries to accept a Western life style and systems of treasures, Russia and Belorussia represent Presidential countries with strong centralization, and Moldova is the weakest country in terms of economy. That is why developing cooperation between them including water sector is very important today. Cooperation should be based on equity and with stimulation efforts of involvement of weakest country into policy decision making process. One of the effective ways for this is gathering together main stakeholders in a different workshops and meeting, discussion joint problems and developing a joint solution.

The Sub-Regional meeting of Eastern European countries (Ukraine, Byelorussia and Moldova) was held in fall 2008 in Kremenchug, Ukraine in order to discuss transboundary water management of Dnipro River. Meeting was organized by Sustainable development and Ecological education Center in cooperation with Kremenchug Tech University and was recognized as a preparatory event toward the 5th World Water Forum. Results of the meeting were contributed to the European Regional Process.

Participants of the Sub-regional meeting represented all stakeholders involved in the water sector and outside: governmental officials, public experts, scientists, university faculty, youth, NGOs including gender related and journalists. Two thematic discussions were held at the meeting, one was about appropriative and innovative solutions to address the needs of the society within the transboundary river basin and another one was about developing common strategy for the progress within Sub-Region.

Participants shared experience and case studies regarding proper water management, role of stakeholders and implementation of sustainability approaches in the sub-region.

Participants defined main problems existed within the Sub-Region:
- luck of understanding of human rights for water
- weak involvement of youth in the process of transboundary water management
- low level of water monitoring and weak public access to data base
- luck of effective stimulation of precautionary principles

Participants developed suggestions for problem's solving:
- encouraging youth involvement in the process including the creation of international network between Eastern and Western European Youth communities;
- stimulating a broad information campaign and advisory service regarding benefit sharing approach
- attracting attention to the rights for water by providing training programs and broad media campaign;
- supporting efforts for improving state of water monitoring and linking best practice

Participants sent a message to the international water community: "Youth is the best investment for Future Water" and adopted a Communiqué. Document can be affiliated as a document devoted to implementation of benefit sharing approach within Dnipro River Basin.

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Multi-level Capacity Development – A Strategy for Successful Cooperation in Transboundary Waters

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Keywords: transboundary water management, SADC, capacity development, multi-level approach, GTZ

Introduction/Problem Identification

This poster presents concrete examples of the comprehensive capacity development approach applied to River Basin Organizations (RBOs) in the GTZ Programme on Transboundary Water Management (TWM) in the Southern African Development Community (SADC) to develop an effective and sustainable management of water resources in transboundary river basins by adapting a multi-level approach. Germany is the lead donor in SADC's water sector and has allocated a budget of EUR 12 Million for the water programme (second phase, 2008-2011).

Analysis/Results and Implications for Policy and/or Research

GTZ applies a comprehensive capacity development approach that encompasses strengthening of the performance capabilities of individuals, organizations and societies: increased learning capacity of people and their acquirement of the skills that enable them to assume a role in society. Additionally, political and social framework conditions are important. The GTZ programme on TWMs in SADC orients its work towards the principles of rule of law, good governance and the partner's self-responsibility for the processes of development based on ownership.

Capacity development measures to strengthen human, institutional and organizational capacities are undertaken at three intervention levels: SADC Secretariat/Water Division, River Basin Organisations and national/local water governance level. The following list gives an overview about the completed and ongoing capacity development initiated on all three levels:

SADC Secretariat/Water Divison

- Support to SADC Water Division in coordinating and overseeing the implementation of the Regional Strategic Action Plan 2005-2010, which in turn provides guidance to RBO formation and functioning
- Harmonisation of water policies in SADC member countries through the SADC parliamentary forum, which supports TWM
- Support improved networking among professionals (e.g. Annual SADC Workshop on Strengthening RBOs)
- Documentary on TWM in SADC region
- Website Portal for exchange of information and coordination between International Cooperation Partners (ICPs) and SADC

River Basin Organisations

- Development of organisational structures of RBOs (e.g. Permanent ORASECOM Secretariat in Pretoria, Interim LIMCOM Secretariat in Maputo, regular meetings of Rovuma Joint Water Commission)
- Support to strategic planning of the RBO (development of common work plan of RBOs and ICPs in the Orange-Senqu basin)

- Training seminars for RBOs and relevant national government officials on key transboundary water management issues (i.e. international water law, transboundary EIA, stakeholder involvement, financing mechanisms, river basin agreements)
- Development of River Awareness Kits in three River Basins, namely Orange-Senqu, Limpopo and Kunene, to increase public awareness and involve key stakeholders in the development process
- Exchange visits of high RBO officials to successful RBOs in Europe (study tour to the International Commission for the Protection of the Danube River (ICPDR) in 2008 and a study tour to the International Commission for the Protection of the Rhine River (ICPR) in 2007)

Local/National Water Governance
- Development of transboundary water resource projects (e.g. support to implementation of a water utility in Kunene province in the framework of Caluque Transboundary Water Supply System)
- Training on 'Emporing Local Governments for IWRM' in cooperation with the International Council for Local Environmental Initiatives (ICLEI)

The main challenges GTZ is facing while undertaking the capacity development of Transboundary Water Management (TWM) Units is caused by inadequately functioning or absent organisational, inconsistent or non-existent legal and institutional foundations in member countries and lack of coordination between the national water policies of the riparian countries.

The lessons learned from the GTZ Programme on Transboundary Water Management in SADC shows that a comprehensive capacity development applied that integrate the various intervention levels can more easily overcome problems and circumvent arising deadlock. The successful institutionalisation of the Orange-Senqu River Commission (ORASECOM), the establishment of the Limpopo Watercourse Commission (LIMCOM) and the recently established Joint Water Commission of the Rovuma Basin are examples at hand. The strategy of a multi-level capacity development will be explored further in the second phase of the project.

Argentinean Experiences on Transboundary Water Resources Management

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Keywords: transboundary basin, water resources management, institutional strengthening, transboundary aquifers, pilot experiences

Introduction/Problem Identification

Argentina is located in South America, with a continental area of 2.791.810 km^2. A third part of this territory fall within transboundary basins and correspond to more than the 85% of surface fresh water drainage. Argentina shares water resources with its transboundary countries: Bolivia, Brazil, Paraguay, Uruguay and Chile.

Argentina is a representative and federal republic where the National Constitution establishes that the provinces have the original dominion over the natural resources (including surface and groundwater). International issues are national government responsibilities; therefore, water resources planning and management cooperation between provincial and national government need to be enforced. The National-Federal Water Resources Plan is a framework for the implementation of these coordinated actions.

This paper outlines some experiences gained in Argentina in relation with transboundary basins, in particular at La Plata Basin and Guarani Aquifer.

Analysis/Results and Implications for Policy and/or Research

Argentina is promoting integrated management of water resources at basin level –as other countries in the region-, focusing on the sustainable development through institutional strengthening. At international level, there have been concrete efforts to develop common strategies in several transboundary basins as La Plata Basin and Guarani Aquifer.

La Plata River Basin (Argentina, Bolivia, Brazil, Paraguay and Uruguay) is the fifth largest river system in the world, -extending over 3.1 million km^2- and has enormous economic and social importance for the region. The Basin hydrological system drains approximately one-fifth of South American. La Plata Basin has four main sub-basins: Paraná, Paraguay and Uruguay River systems and La Plata River itself sub-basin.

In 1967, when the Intergovernmental Coordinating Committee for La Plata Basin (CIC, in Spanish) was created, the governments of the five countries agreed to carry out a joint and integrated study of the area. The agreement was consolidated in 1969 with the signature of the Treaty of La Plata Basin. This treaty provides the basis for further bilateral and multilateral agreements concerning jurisdictional matters, navigation, fishing, pollution prevention, scientific research, etc. Currently, CIC has a 'Program of Action' and a 'Framework Program for the Sustainable Management of the Water Resources of the la Plata Basin with respect to the Effects of Climate Variability and Change (FP)'. This FP was defined through a participatory process between the five countries, with the support of the Global Environment Facility (GEF) -through UNEP and OAS-, between 2003 and 2005. The implementation of the FP is expected to start during 2009.

Others bi- or multilateral projects are currently in progress in the basin. Some examples are the integrated management and a master plan of the Pilcomayo River Basin (Argentina, Bolivia, and Paraguay) and the strategic action programme for the Bermejo River Binational Basin (Argentina and Bolivia). Through these projects, basin countries aim to promote better utilization of water and land resources while conserving and rehabilitating ecosystems. These projects also facilitate information exchange in addition to providing a basis for strengthening regional information systems.

There are substantial transboundary groundwater resources in the region. Under La Plata Basin, the Guaraní Aquifer System is the most important groundwater reservoir, due to its extent and volume. It underlies portions of Argentina, Brazil, Paraguay and Uruguay, stretching over an area of approximately 1.2 million km^2, with almost 15 million inhabitants. A joint project -supported by GEF until January 2009- expands and consolidates the current knowledge base through monitoring and evaluating water resources, in order to promote stakeholder participation in decision making and control pollution. The project, helping to shape an institutional framework regarding transboundary groundwater, makes a contribution that could serve as a potential model for other countries and regions.

The integrated management of La Plata Basin and Guarani Aquifer -thus coupling superficial and subsurface watershed- is one of the present challenges for the countries of the region.

This paper draws mainly upon experiences gained in Argentina in relation to transboundary surface basins and aquifers, making a contribution that could serve as learned lessons for other cases. It is important to remark that Argentina promote cooperation among provinces and countries within the region, and between the various main actors and its needs. This allows basing the study on solid science and a shared analysis of the problems and opportunities, their potential solutions and benefits arising from the alternative solutions. This analysis can be used as a basis for setting priorities, promoting civil society participation, and making political decisions within and between the provinces and countries concerning the needed actions to resolve conflicts or pursue opportunities for benefit sharing.

The Connection between the Upper Nile Projects and the Nile Water Agreements

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Keywords: Nile River Basin, The Nile Riparian Countries, The Nile Basin Initiative, The Upper Nile Projects, The Nile Water agreements

Introduction/Problem Identification

The Nile River is one of the world's great assets. Throughout history, the river has nourished livelihoods, an array of ecosystems, and a rich diversity of cultures. Ten countries share the Nile: Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, Sudan, Tanzania, and Uganda.

The two most important agreements for Egypt are the Nile water agreement of 1929 between Egypt, Sudan, and the Equatorial Lakes Plateau Countries, and the Egypt and Sudan Nile agreement in 1959 for apportioning the water shares between the two parties.

The Upper Nile projects can be classified into three groups:

- Projects that have a negative impact on the Nile River inflow, like Karadobi Reservoir project in Ethiopia.
- Projects that have a positive impact on the Nile River inflow, which include the four main projects
- Projects that have a net neutral effect on the Nile River inflow, like the Marowei Dam project.

Analysis/Results and Implications for Policy and/or Research

The objective of this research is to analyze the Upper Nile projects and their negative/positive effects with respect to Egypt and their relationship with Nile water agreements between Nile Basin Riparian Countries. The paper also is performed to emphasize and demonstrate the response of the Nile Basin Riparian Countries to these projects after the installment of the Nile Basin initiative.

The study is concluded by the fact that Egypt is doing its best to put down an inclusive and wide-ranging agreement that includes all the Nile Basin Riparian Countries. It also does not oppose any project proposed by one of the Nile Basin Riparian Countries that increases the Nile inflow on condition that it does not negatively affect its river water share.

A Study of Water and Energy Nexus to Address Development Challenges in the Continent of Africa

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Keywords: water, energy, Africa, renewables, development

Introduction/Problem Identification

This paper is an effort to learn about the energy challenges in Africa within the context of its trans-boundary water system. It does so by studying the water conflicts in the region and its implications on electricity generation and economic development. These water conflicts in the continent, the study believes; might be responsible for massive deforestation, exodus of internal migration in search of fertile land, soil erosion and disruption of growth. It concludes that strategic energy investment by the GEF programs, UNDP and World Bank in the continent will not automatically bring in economic development implying that some additional intervention or efforts are needed in areas such as governance, enabling environment, integrated policies, efficient management, and effective regulatory framework.

Analysis/Results and Implications for Policy and/or Research

The trends in energy use, water availability, and overuse of water will force Africa to take a fresh look at its development, investment and utilization means and ways to sustain the increase in population. Most of the African economies rely heavily on hydropower or traditional biomass as its primary source of energy. That means fluctuations in rainfall and decrease in forest produce will result into a national security issue for some 45 economies.

This report is an attempt to understand energy implications of an effective water policy which extends far beyond the energy embedded in water. It does so by evaluating the relation between water conflicts and energy challenges within African states and accomplishes it after studying the African water system, and confirms that "African hydrology is the present basis of African Union (AU), given the network of international rivers connects almost all African nations together". The report therefore believes that it is necessary to look at different ways to address trans- boundary water conflicts such as hydroelectricity cooperation diplomacy as a tool to address it, for example the Western African Power Pool (WAPP) and Southern African Power Pool (SAPP).

This study makes an attempt to understand the link between naturalization of the nation i.e rife with strife related to water and nationalization of nature i.e. trans-boundary water conflicts in a continent that is responsible for massive deforestation, exodus of internal migration, soil erosion and disruption of growth. This is evident by the fact that an estimated of no more than 20 percent, and in some countries as little as 5 percent, of the population in Africa (excluding South Africa and Egypt) have direct access to electricity, 46% do not have safe drinking water, and about few hundred thousands have migrated during a drought, and still use traditional biomass as a means of energy option.

Most of the countries in Africa face chronic shortage of water due to harsh climatic conditions; relies heavily on seasonal rainfall leading to little or costly generation of electricity; does not have any domestic resource of fossil fuel for domestic use and is paralyzed by power loss due to bad transmission lines and power theft. This has lead to severe environmental problems such as deforestation, soil erosion, and runoff due to overuse of traditional biomass as means of the only cheap domestic energy option.

This report has tried meticulously to understand and quantify the relationship between water and energy, by looking at the clear link between water conflicts and energy challenges within the African states and identifies that if a nation has 1) higher observed water conflicts along w/ higher energy challenge, it is an indicator of a recovering economy unable to be resilient to manage conflicts and be able to achieve development goals milestone. The paper suggests that it is inappropriate for the international community to expect these failed economies to participate in this conversation, given their first priorities would fall under peacekeeping category. It also observed that higher water conflicts states have higher illiteracy rate such as Angola, Chad, Democratic Republic of Congo, Rwanda and Sudan; 2) lower water conflicts and higher energy challenges are mostly countries such as Burkina Faso, Namibia, other landlocked economies; 3) higher water conflicts and lower energy challenges such as Côte d'Ivoire, Botswana; and 4) lower water conflicts and lower energy challenges such as Ghana, Nigeria.

Although the fact remains clear that the delivery of electricity or energy services will not automatically lead to economic development in Africa, this implies that some additional intervention, or efforts are needed in areas such as governance, enabling environment, integrated policies, efficient management, and effective regulatory framework.

The report looks into threats to energy production that might result from scarce water supply bringing to attention the role played by failed energy reforms in Africa due to under capitalization in infrastructure development sector, leading overutilization of wood fuel as the most reliable energy option. It later explores the energy implications on water use and explores importance of water resource management as a policy tool.

An Institutional Framework for Stakeholder Consultation in Transboundary River Basin Management

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Keywords: stakeholder participation, regional economic integration, benefit sharing, watercourse agreements, basin planning

Introduction/Problem Identification

This paper is the result of a research project on the review of the involvement of national water institutions and civil society in international water agreements in Southern Africa. The study was commissioned by the Water Research Commission of South Africa, and covers three river basins that South Africa shares with its neighboring countries namely the Orange-Senqu, Incomaputo, and Limpopo basins. To facilitate implementation of agreements, different intergovernmental structures have been put in place for all three basins. Results from the study indicate that other government departments and spheres of government, water users and civil society stakeholders are not actively involved in the activities of these structures. This paper examines approaches to stakeholder involvement in transboundary river basin management and proposes an institutional framework for South Africa to achieve optimal participatory benefit sharing in the management of transboundary river basins management.

Analysis/Results and Implications for Policy and/or Research

Consideration of international experience reveals little in the way of best practice in the involvement of stakeholders in transboundary river management. It is an area on which the revised SADC Protocol on the Management of Shared Watercourses is silent, as are, to a large extent, the agreements in the three shared river basins. Orasecom is mandated to advise the Parties on the extent of stakeholder participation required, but none of the basin organisations are yet mandated to actually conduct stakeholder participation. Orasecom has developed a road map for stakeholder participation, and, in the Incomaputo, a project is planned to investigate appropriate stakeholder participation mechanisms. It is possible that the responsibility for stakeholder participation could, in due course, be assigned to these organisations by the Parties.

This paper examines two key phases in international agreements with regard to the potential benefits to be derived from stakeholder participation processes: negotiation of the agreement, and implementation.

Negotiation

The negotiation process is generally a state-to-state process, where Ministers and senior officials engage with their counterparts from the other basin states. In the South African context, negotiation processes have not involved other governmental departments, water users or civil society stakeholders, with negotiations being driven solely by the Department of Water Affairs and Forestry. While international experience has shown that stakeholders can play a role in the development and signing of international river basin agreements, this is not necessarily an area in which government representatives feel comfortable with significant stakeholder involvement.

Implementation

There are four key elements in the process of implementing transboundary agreements. These are described as follows:

- generation of knowledge and information through a neutral platform eg through integrated basin studies
- generation of recommendations for Parties – role of Technical Committees vs Council – raises questions of engagement with stakeholders and organs of state by Technical Committee vs Council
- planning – basin level planning, national and sub-national planning in accordance with and in order to meet the international obligations
- implementation of projects e.g. infrastructure development, watershed environmental protection etc

Although a robust legislative framework at both regional and national levels exists in the SADC region, the findings of the paper indicate that there are no existing arrangements for effective stakeholder involvement in transboundary water management. Research has, however, also indicated considerable benefits that can be derived from stakeholder participation, including in understanding and addressing approaches to benefit sharing at the localised or basin level. On the basis of Southern African and international experience, the paper proposes two models for stakeholder participation in transboundary basins, and discusses stakeholder roles that are important to ensure achievement of development goals delineated by the SADC community. Therefore, the authors are of the view that this paper contributes constructively to the debate on the importance of transboundary water management to regional economic integration, and hence benefit sharing.

Benefit Sharing Framework in Transboundary River Basins: The Case of the Nile

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Keywords: valuation of benefits, Eastern Nile hydraulic project, typologies of benefits, scenarios of benefit sharing, Nile Basin benefit sharing

Introduction/Problem Identification

Evidence of global water crisis is widespread. Currently, one-third of the world's 6 billion people have no access to sanitation and one billion are without access to clean water. The UN believes that over the next two decades the average supply of water per person worldwide will drop by a third. Although 60 percent of the African continent is covered by transboundary river basins, about one-third of its population (300 million people) is experiencing increasing water scarcity. It is projected that by 2025 half of African countries will experience water stress and the sharing of transborder water resources will play a significant role in inter-state relations. The objective of this paper will be to develop analytical frameworks, mechanisms and principles of benefit sharing in general terms as well as in the context of the Nile Basin. Attempts will be made to converge macro-economics with micro livelihoods impact to identify potential benefits and costs.

Analysis/Results and Implications for Policy and/or Research

Benefits can mean anything that society recognizes as valuable, such as livelihood improvement, food security, gender equality, amelioration of ecosystems and biodiversity, aesthetics, ethics etc. Benefits in use of transboundary rivers such as the Nile are multiple and interacting. These benefits include political cohesion, economic cooperation, environmental and natural resource protection and development, and social and cultural relations. The findings of the study indicated that benefit sharing in transboundary river basins should dovetail macro economics with micro livelihoods impact to identify potential benefits and costs. For transboundary rivers such as the Nile, attempts should be made to identify the typologies of benefits, aspects of benefit sharing, scenarios of benefit sharing, and the optimization/maximization of benefits. With the better management of ecosystems cooperation can provide'benefits to the river'; with cooperative management of shared rivers benefits can be accrued 'from the river' (e.g. increased food production and power); with easing of tensions between riparian states costs 'because of the river' could be reduced; and with cooperation between riparian states leading to economic integration comes 'benefits beyond the river' (Grey and Sadoff, 2002). In terms of aspects of benefit sharing, issues related to benefit sharing for whom, by whom and because of whom need to be addressed. Similarly, scenarios of benefit sharing should be considered as phases or time perspectives by anchoring short-term works of strengthening the hitherto existing riparian links, medium-term tracking and improvement of in-country and transborder institutional arrangements for resource use and cooperation, and long-term efforts on investment in basin-wide joint development and programs.

There is huge number of benefits in the Nile Basin that are potentially realizable. For instance, the implementation of watershed management in the Ethiopian highlands may lessen siltation and flooding in downstream Sudan and Egypt. By the same token, there could be economic benefits of electricity generation in DRC to the neighboring co-basin states of Rwanda, Burundi and Uganda. There are also benefits that are less tangible, which take a political direction. A good example for

this could be the ease of travel between co-basin countries that can facilitate economic activities and social networking. The on-going Eastern Nile projects, including watershed, power transmission and joint multi-purpose, seem to have focused more on the projects per se than in identifying the likely benefits and the modalities of benefit distribution.

Historical evidences suggest that the centuries of hydropolitical stalemates in the basin spiraled the costs incurred 'because of the river'. There is now a hope that the on-going NBI and its multifarious projects could help in bringing some 'benefits to and from the river' when they will be translated on the ground. Similarly, the diminishing tensions that have come as a result of cooperation through the NBI may enable the basin states to forge regional integration by looking at benefits 'beyond the river'. In sum, the realization of the aforementioned projects could reduce poverty, enhance food security and improve the livelihood of the population inhabiting the basin. The potential benefits that are embedded in the Nile in terms of flood and silt reduction, hydropower generation and poverty reduction need to be smoked out. After these tasks are accomplished, the next steps to be taken include identification of stakeholders who have a stake in benefit sharing, indication of the direction of benefits, building benefit sharing mechanisms, fixing time scales and sorting out scenarios of benefit sharing. Attempts should also be made to come up with benefit sharing model.

After the identification of benefits, attempt should be made to put them in a realistic framework as funded and agreed upon by governments on a multilateral basis. Once this is done, the next important step would be to treatise the agreement so that it becomes part of the treaty. Efforts should hence be made to come up with the Nile Basin Benefit Sharing Treaty rather than restricting ourselves to the Nile Basin Waters Agreement.

Development of Decision Support Tools and IWRM Scenarios for Increasing the Economic Benefits from Sharing the Waters of the Maputo River Basin

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Keywords: shared decision making, sustainable development, socio-economic benefits, IWRM scenarios, decision support models

Introduction/Problem Identification

The Maputo River rises in South Africa and Swaziland as the uSuthu, Ngwavuma and Phongola Rivers. They converge, near the Moçambican border, to form the Maputo River which reaches the sea in Maputo Bay, south of Maputo the capital of Moçambique.

In 2002 Moçambique, South Africa and Swaziland ratified the Interim IncoMaputo Agreement (IIMA), under which they agreed to cooperate in the sustainable management of the Incomati and Maputo river basins for the mutual benefit of the three countries.

The distribution of rainfall, available water resources and volumes of water used for socio-economic development vary significantly across the basin. The basin states needed to fully understand the resource and its use to enable them to develop policies and strategies for managing the shared river basin. These will then lead to joint decisions which will optimise the benefits of water use in the basin. Decision support tools were required to facilitate this cooperative decision making.

Analysis/Results and Implications for Policy and/or Research

The paper will present the results of the Joint Maputo River Basin Water Resources Study which was funded by the EU and implemented by Swaziland's Ministry of Natural Resources and Energy on behalf of the Tripartite Technical Committee (TPTC) of Swaziland, South Africa and Moçambique. The objective of the study was to provide a common vision and knowledge base for the basin, which the three countries could use to develop policies and strategies before agreeing on the best allocation of water for sustainable social and economic development in the basin.

An early study activity was to develop a shared vision and objectives for the river basin among key stakeholders from the three countries. During the study the hydrology, distribution of surface and ground water resources, quantity and quality were modelled. For each part of the catchment, three Environmental Flow (EF) scenarios were provided that will result in different ecological states; maintain Present Ecological State (PES); improve PES and allow PES to decline. The current water uses and the socio economic benefits of that water use were determined together with three scenarios for possible growth in water use.

The EFs required to maintain the PES were adopted as the starting point to model the current water balance and current distribution of socio-economic benefits from water use for each water management sub-catchment in the basin. The analyses showed that meeting the EFs at the ecologically sensitive and largely natural floodplain in Moçambique had the most effect on the water available for consumptive use. If the PES is to be maintained then there is currently no water available for allocation to new users and economic growth will have to be curtailed.

The Maputo River floodplain is of particular social and ecological importance to Moçambique, who only abstracts c. 4% of total volume of water used in the basin. South Africa and Swaziland, who currently derive the most economic benefit from water use in the basin, may need to come to terms with the limitations placed on their economic developments by the requirements of sustainable water resource management in the lower parts of the basin.

To assist the decision makers three possible IWRM scenarios, with different EF requirements, were then developed. The economic benefits of alternative spatial and sectoral allocations of additional water were also modelled. Irrespective of the IWRM scenario chosen, the countries should improve the efficiency of water use, and clear the alien vegetation in the river basin, thereby increasing runoff.

While the countries have yet to debate and agree on how the river basin should be managed in the future the following key decisions will have to be made:

- If the PES is to be maintained and more economic development is to take place in the basin then either:
    - The country planning the development will have to reduce or re-allocate existing water use or construct new dam(s) to provide the water required for economic growth. The environmental advantages and disadvantages of constructing new dams to maintain recommended EFs must be weighed against the costs and economic benefits of increased yield from new dams or the reduction or re-allocation of existing water allocations,

    OR

    - The countries will have to agree that the Ecological state of the floodplain of the Maputo River in Moçambique and possibly other rivers can be allowed to deteriorate to a lower category. Additional economic developments could then be allowed without the developments of new dams. The socio-economic benefits will have to be weighed against the environmental impacts
- If it is agreed that the basin can be managed so that more water can be allocated for development, where should the additional water allocations be made (in which country) and what water uses should receive priority when water is allocated.

The study provided the water resource managers in the basin with common management objectives and a common understanding of the water resources, the water use and benefits of water use in various parts of the basin and in each country. It also provided the tools and initial results required for the water mangers and decision makers assess the implications for each country of alternative management scenarios and decisions. It brought into sharp focus the need for IWRM and the tradeoffs that will have to be made between use of water for economic development and maintaining the environment; improving water-use efficiency; reducing water use; or developing new dams in order to make water available for economic development.

The Protection of the Ecosystems of International Watercourses under International Law

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Keywords: watercourses, ecosystems, environmental protection, sustainable development, international law

Introduction/Problem Identification

The obligation of the riparian states to protect the ecosystems of shared rivers and lakes is well-established under international law. It is a principle that has attained the status of custom and illustrates the evolution of the international legal framework for the preservation of international watercourses. This paper is going to examine both state and judicial practice in order to conclude that the obligation to protect the environment of international rivers and lakes is a cornerstone principle of international law.

Analysis/Results and Implications for Policy and/or Research

The obligation to protect the ecosystems has been incorporated in the United Nations Convention for the Law of the Non-Navigational Uses of International Watercourses, adopted in 1997. Apart from this global instrument, the protection of environmental damage has been also encapsulated in regional agreements, either bilateral or multilateral.

Apart from the treaties and conventions, this has also been reaffirmed twice by the International Court of Justice in the Gabcikovo-Nagymaros dispute between Hungary and Slovakia over the Danube, as well as in its recent decision on provisional measures in the Pulp Mills dispute between Argentina and Uruguay. The Court highlighted that international law has to adjust to the necessity to promote the sustainable development of transboundary waters.

This paper is going to demonstrate that under international law the obligation of the watercourse states to protect the aquatic environment of their shared rivers and lakes is an emerging customary norm, which enables them to achieve environmental security and stability in the region.

The Impact of Domestic Actors on State Behavior in Managing International Rivers: An Examination of Two Hegemons, China and India

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Keywords: domestic politics, hydro-hegemony, non-governmental organizations, Ganges River, Mekong River

Introduction/Problem Identification

As populations have grown and nations industrialized, the demand on a fixed supply of freshwater has grown exponentially throughout the world, leading to warnings of increasing potential for conflict over shared freshwater resources (United Nations, 2007). Yet, our understanding of the forces influencing the rise of conflict and cooperation over shared hydrological systems remains weak and this weakness may be due in part to the tendency within the existing literature to black box the state and focus on the systemic level of analysis (Wolf, 2007).

Analysis/Results and Implications for Policy and/or Research

Combining the second image, two-level games, and hydro-hegemony theories, this paper seeks to unpack the state in order to consider the influence of domestic power struggles on the behavior of the powerful riparian in managing its international river resources in a manner that is mutually beneficial to all riparians. Through a comparison of China's management of the Mekong River and India's behavior along the Ganges-Brahmaputra River, we argue that domestic struggles between powerful interest groups – environmentalist movements, farmers, and NGOs – can under certain circumstances directly influence the hydro-hegemon's behavior in addressing its international water disputes in a mutually beneficial manner for riparians. Interest groups and NGOs can contribute to cooperation and benefit sharing within the basin by pressuring the government to protect an international river's ecosystem and address water quality problems. Thus, the objective of this paper is to examine the interplay between domestic and international power struggles over international rivers and consider the possibility for benefit sharing among basin countries. Data for this paper come from field research in China and India.

Workshop 2: Securing Water in Coastal Zones

Eco-innovation and Corporate Performance: The African Experience

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Keywords: eco-innovation, cleaner technologies, environmental regulation, financial performance, pulp and paper

Introduction/Problem Identification

Addressing a paucity of research about industrial adoption of environmentally benign technologies in Africa and, more generally, in tropical developing countries, we examined the Nigerian pulp and paper industry as a case study.

Analysis/Results and Implications for Policy and/or Research

Qualitative interviews with twenty upper echelon executives representing five Nigerian firms challenge conventional expectations that energy intensive industries in developing markets operate amid highly pollution-intensive conditions, within weak or non-existent formal environmental regulatory frameworks, and with limited institutional capacity. Our findings suggest a strong positive relationship between cleaner technology use and corporate financial performance of African industrial firms. Our study also suggests the adoption of classical 'win-win' integrated preventive environmental strategy, eco-efficiency and green productivity which improves industrial efficiency and profitability. Nigerian pulp and paper firms are shown to have moved beyond end-of-pipe technologies and cleaner technologies and adopted industrial ecology and "zero emission" principles with appropriate reuse of the remaining waste streams turning the production system into a sustainable industrial ecosystem.

Findings from the study also has implication for global greenhouse gas emission and climate change because trees in tropical forests typically hold, on average, about 50 percent more carbon per hectare than trees outside the tropics. This means that an investment in cleaner technologies in the form of reduction, reuse and recycling of waste could potentially reduce tropical deforestation. Land-use change contributes to 20 percent of world global greenhouse gas emission (Stern, 2006). In addition, our study suggests that research and development in alternative raw materials could also contribute to a reduction in global green house gas emission. A demonstration project by the Nigerian Federal Institute of Industrial Research suggests that "Kenaf", a weed like sugar cane available in abundance in savannah area of Nigeria could be a potential raw material for the Nigeria pulp and paper industry.

Cows to Kilowatts: Abattoir Waste Turned into Clean Energy in Nigeria

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Keywords: bioreactor, biogas, pollution control, abattoir waste, environmental regulation

Introduction/Problem Identification

Slaughterhouses are a major source of water pollution and greenhouse gas emissions, especially in the developing world. Specific regulations for abattoirs do often not exist or are poorly enforced. This represents an immediate environmental problem, affecting among others the development of aquatic life. Slaughterhouse waste also often carries zoonotic diseases – animal diseases that can be transferred to humans. Communities depending on polluted water for consumption and agriculture therefore face significant health risks. Moreover, the anaerobic degradation of wastewater generates methane and carbon-dioxide and thus accelerates climate change.

Analysis/Results and Implications for Policy and/or Research

The way out of the dilemma was to find a way of capturing the gas emissions and turning them to productive usages. Relevant cutting-edge, anaerobic fixed film biogas technology for achieving this was created in association with a Thai research institution. The anaerobic fixed film bioreactor treats agro-industrial waste and produce biogas as well as organic fertiliser.

"Cows to Kilowatts" is abating water pollution, improving ecosystem health, mitigating greenhouse gas emission and creating cheap source of domestic energy with environmentally safe organic fertiliser from slaughterhouse waste through the installation of sustainable biogas plant. The innovation is a winner of the prestigious 2005 Supporting Entrepreneurs for Environment and Development (SEED) International Awards (www.seedinit.org). SEED is supported by IUCN-The World Conservation Union, UNDP, UNEP, GPPi Germany, VRom, Global Compact, Swiss-Re, the Government of United Kingdom, Germany, Netherlands, South Africa and the United States of America. The initiative also featured as 2008 Principal Voices www.cnn.com/principalvoices by CNN in association with Shell, Times and Fortune Magazine.

The initiative gained international recognition. Hence, UNDP provides an initial support of US $500,000. The project is designed to be commercially viable. Producing around 270 m^3 of compressed biogas a month, the plant would generate returns on investment after 2 years. With an estimated lifespan of 15 years, the plant creates substantial economic returns. The biogas plant generates several positive environmental, economic and social impacts. The plant is designed to capture 900 m^3 of methane per day and emission reduction of 22,300 tons of CO_2 per year. The captured methane is upgraded and compressed for as household cooking gas which serves 5,400 poor households monthly. The predominantly poor families benefit from the gas because it constitutes a cleaner alternative to other commonly used fuels. At significantly lower cost than currently available sources of natural gas, it reduces indoor air pollution and associated health hazards in poor communities.

Many other cities across Africa are facing similar environmental and health challenges from untreated slaughterhouse waste. Through the use of innovative technology, it presents a solution to the problem of waste treatment which at the same time minimises the carbon footprint of slaughterhouse operations and other organic wastes. Moreover, it is an economically self-sustainable and profitable initiative, generating a classical win-win situation.

Wetland System: A Cheaper and Efficient Treatment Option for the Food Processing Waste in Africa

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Keywords: wetland system, treatment plant, food processing waste, bioreactor, Africa

Introduction/Problem Identification

The study investigates an alternative wastewater treatment system for the food and beverage industry in Africa. A subsurface flow wetland system was designed and compared with a Universal Anaerobic Sludge Blanket (UASB) bioreactor installed for a brewery in Nigeria.

Analysis/Results and Implications for Policy and/or Research

The cost of the installed 3000m^3 bioreactor for the brewery industry is USD 5 million however the cost of the constructed subsurface flow wetland system with a capacity of 5,200m^3 is USD 1.65 million. Hence, the cost of the designed wetland system is 33% of the cost of installed bioreactor. The cost of operation and maintenance of the designed wetland system is much lower than that of the installed bioreactor. The comparative treatment efficiency of the designed wetland system and the installed bioreactor shows that the waste characteristics for the designed subsurface flow constructed wetland after treatment falls within the USEPA threshold for food processing industry. However, for the installed UASB Bioreactor, most of the waste characteristics are above the stipulated threshold. In addition, the treatment efficiency of the designed subsurface flow constructed wetland for the controlling parameters; BOD, TSS and Faecal Coliform are 96.83%, 88.42% and 96.29% respectively. For the installed UASB reactor, the treatment efficiency for the same controlling parameters, BOD, TSS and Faecal Coliform are 62.94%, 15.36% and 63.81% respectively. Hence, the designed subsurface flow constructed wetland is more efficient in the removal of BOD, TSS and Faecal Coliform hence could be an excellent alternative for the food and beverage industry in Africa.

Microbiological Quality of Obohia Stream at Ahiazu Mbaise Nigeria

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Keywords: community sustainability, parameter, sanitation, landfill, disposal

Introduction/Problem Identification

The bacteriological quality of Obohia stream was investigated. Samples were collected from four station and were analyzed for microbiological composition particularly bacteria and fungi. Physiochemical analysis of the samples showed that the water is slightly acidic with pH range of 5.0-6.0. Temperature of the stream varied between 25.7-25.9 ˚C during the sampling period. The bacteria isolated were Klebsiella sp., Escherichia sp., Shigella sp., Salmonella sp., Staphylococcus sp., Pseudomonas sp., and Lactobacillus sp. Fungal organisms include: Culvularia sp., Saccharomyces sp., Penicillium sp., and Aspergillus sp. Heterotrophic count range from 1.16X104 – 2.38X104 (cfu/ml). A population range of 1.6X103-3.3X103(cfu/ml) was obtained for coliform count. The results obtained showed that all sample areas examined are contaminated.

Analysis/Results and Implications for Policy and/or Research

The colour of the water samples was colourless. The temperature of the water samples is shown in table 1. The average temperature range of 25.7 – 25.9 ˚C was obtained from all the study sites. From the results, sampling Station B and C has the highest temperature range of 25.9 ˚C, Station A has moderate temperature of 25.8 ˚C and Station D has the lowest temperature of 25.7 ˚C. The pH of Obohia stream is slightly acidic with average range of 5.2 – 5.5 as shown in table 2. The highest pH range was obtained from sampling Station A with pH of 5.5, followed by Station C with 5.4, while Station B and D has the lowest pH range of 5.2 respectively. Total heterotrophic bacterial and coliform counts result of the water samples are shown in table 3. From the result, sampling Station C has the highest bacterial count of 2.38X104cfu/ml, followed by Station A with 2.24X104cfu/ml, Station D gave count of 1.72X104cfu/ml and Station B has 1.16X104cfu/ml for bacteria. A total of 7 bacterial isolates were obtained from water samples collected from four different sampling stations along Obohia Stream. These bacterial species were Pseudomonas species, Klebsiella sp., Staphylococcus sp., Lactobacillus sp., Bacillus sp., Escherichia coli and Salmonella sp. Although, the bioload of various samples examined showed slight differences. From table 4, coliforms are more in Station D with average count of 3.3X103cfu/ml, these could be attributed to the kind of activities that take place on this location like defecation, laundry and urinating from people bathing in the stream and wash off chemicals from car and fertilizer from farm land. Animals like cattle also drink from this location. Station A show a count of 2.7X103cfu/ml, while Station C has a count of 1.9X103cfu/ml. Station B has the lowest coliform count of 1.6X103cfu/ml. Less human activities take place in Station B which though could be attributed as the reason why there was low coliform count. The culture of the various samples obtained in fungal culture media yielded 4 mold species and one yeast. The spread in occurrence of the fungal species showed a more uniform spread than the bacterial species. These fungal species isolated were: Culvularia species, Aspergillus sp., Trichophylton sp., Penicillium sp., and Sacharomyces sp. There were pink colonies, creamy colonies, green and blue colonies on the membrane after incubation which were isolated and identified. The mean aim of this investigation was to determine the bacteriological quality of the Obohia stream so as to ascertain its suitability for drinking and other domestic purposes and to determine the contaminating organisms and relate it to human activities around the stream.

Climate Change and Adaptive Capacity Enhancement: A Key Necessity for Securing Coastal Zones

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Keywords: securing, water, coastal zone, climate change, disaster prone areas

Introduction/Problem Identification

A common theme that emerges is the need for more impact and vulnerability assessment that is relevant to coastal management needs. This should include the consequences of sea-level rise and climate change on coastal areas from the local to the European scale. This will require continued development of broad-scale assessment methods for coastal management. It is also important to assess coastal adaptation and management as a process rather than just focus on the implementation of technical measures towards securing water in coastal zones. Lastly, the uncertainties of climate change suggest that management should have explicit goals, so that the success or failure of their achievement should be regularly monitored and the management approach adjusted as appropriate.

Analysis/Results and Implications for Policy and/or Research

In Kenya and Lagos in Nigeria. Nigeria's extensive coastline is already being threatened Even though some of the climate change-related risks may not become serious for some decades, there is still a need to act now. Most buildings and infrastructure (roads, piped water systems, drains…) have a long life, so what is built now needs to be able to cope with present risks and likely future risks.

Climate change risk reduction needs to be built into many other aspects of urban development – for instance, avoiding development on flood plains, protecting coasts and, where possible, their natural defences, and ensuring that built-up areas can cope with heavy rainfall.

Towards the end of the 21st century, projected sea-level rise will affect low-lying coastal areas with large populations-including but not limited to Alexandria in Egypt, Cotonou in Benin, Mombasa by sea-level rise and human development, which in combination contribute to degradation and loss of coastal wetlands and mangroves and increasing damage from coastal flooding, with serious consequences for fisheries and tourism.

Coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea-level rise that would result from widespread deglaciation of Greenland and West Antarctic ice sheets. The effects will be worsened by "human-induced" pressures on coastal areas. A large percentage of Africa's population is land-locked and coastal facilities are economically significant. Those densely-populated and low-lying areas and river deltas, where adaptive capacity is low, are especially at risk and are more dependent on climate-sensitive resources such as local water and food supplies.

Relocating populations, economic activity, and infrastructure would be costly and challenging. In Nigeria more than 20million people live along the coastal zone. Billions of dollars would be lost economically and the largest contribution to this loss would come from the oil fields in the area.

The science on dealing with the "impacts, vulnerability and adaptation" to climate change has overseen many developments overtime. The developments are mostly with regard to the various concepts and frameworks that have been introduced and discussed in context. While the focus was initially on impacts assessments, there has been a gradual shift towards vulnerability assessments and assessment of adaptive capacities, placing adaptation in context. Adaptation depends greatly on the adaptive capacity or adaptability of an affected system, region or community to be able to cope effectively with the impacts and risks of climate change (IPCC, 2001).

While the IPCC First Assessment report presented a broader framework, the Second Assessment report mentioned that the vulnerability of a system increases as adaptive capacity decreases, highlighting and inverse relationship with each other. It had defined that factors that help in determing successful adaptation include technological advances, institutional arrangements, availability of financing and information exchange. The Third Assessment report further to this defined vulnerability to climate change as a measure of "the extent to which regions are likely to be influenced by climate, given the inherent and adaptive capacity that exist in those regions in being able to respond effectively to the expected changes". It is thus concluded that vulnerability of a given system(natural or human) largely depends on the adaptive capacities of the system and its potential in coping effectively with the impacts and the risks so associated.

Adaptive capacity is therefore defined as "the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change" (Smit and Piliposova, 2001). In the case of communities it is determined by the socioeconomic characteristics of the communities and their abilities in responding effectively. The capacity to adapt varies across regions, countries, and socioeconomic groups and will vary over time.

The most vulnerable regions and communities are those that are highly exposed to the changes expected in the climate and have limited adaptive capacity. Countries with limited economic resources, poor information and skills, low levels of technology, unstable or weak institutions, and inequitable empowerment and access to resources have little capacity to adapt and are highly vulnerable (IPCC, 2001). Nigeria is one of such countries, therefore enhancement of its adaptive capacity is a necessary condition to reduce vulnerability.

Enhancement of adaptive capacity presents a practical way of coping with changes and uncertainties in climate, including variability and extremes, reducing vulnerability and promoting sustainable development particularly in coastal zones.

Peoples' Initiative to Conserve Safe Water Resources in Southwest Coastal Region of Bangladesh

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Keywords: coastal region, safe water, traditional rights, human intervention, sustainable management

Introduction/Problem Identification

The southwest coastal region has an area of 15,118 square km and a population of over 10 million. It contains a highly productive Sundarban mangrove ecosystem; unique type of biodiversity and world's largest sediment load estimated annually 1.5 to 2.4 billion tons. The sediments are subjected to river flow, tidal and wind actions that lead to accretion and erosion in the coastal belt. The local civilization evolved based on the natural resources of land and water.

Persistent human interventions kept a negative impact on the water regime, causing loss of people's rights on water resources; reduction in fresh water flow from upstream; obstructions in the natural flow of tides; river erosion and silting; salinity increase; climate change and loss of traditional people-invented sustainable management technologies. As a result, environment and ecology degraded, severe safe water crisis emerged and water born diseases increased, People's lives and livelihoods have become vulnerable.

Analysis/Results and Implications for Policy and/or Research

Background

Dacope Upazilla (sub-district) under Khulna district in the Southwest coastal region of Bangladesh, It has a total area of 991.85 square km, out of which 799.01sq. Km, comprises mangrove forest. It lies between 22°24' N and 22°40' N latitude and between 89°24' and 89°35' East longitudes. The total length of the rivers and canals are 180 km. Dacope has 9 Unions comprising 107 villages and a municipality, with a population of 166,032. The livelihoods and culture of the upazilla is dependent on its common Natural resources.

Like other areas in the southwest coastal region, the water crisis in Dacope upazilla is critical. According to government statistics, 43% of the people of Dacope have access to safe water, but peoples' perception is that it is not more than 30%. Presently, most people are dependent on pond and rainwater. During the dry months, people collect water from different sources, 2 to 8 km distant. Due to leasing out of rivers, canals and ponds to influential people or their illegal occupation, people have lost their traditional and constitutional right to water resources; water flows and coastal bio-diversity are being damaged. The lessees introduce saline water for commercial shrimp cultivation, resulting in increase the intensity of salinity, and the sources of fresh water are damaged. Hence social conflict has increased and lives of common people have become vulnerable.

Actions Taken

Grassroots development organization AOSED is implementing two-year (June 2007 to May 2009) Pilot Project 'Grassroots Initiative to solve the safe water crisis' main objective is to Ensure the Right of "Safe water for all" through identification of local resources, their sustainable conservation, maintenance and distribution through participatory processes.

Activities
The activities under the project include; Preparation of a database on water resources; Formation of Peoples' Organizations; Training, meetings, seminars and opinion sharing; Awareness and Media Campaign, Press Conference; Repair and rehabilitation of damaged water sources by joint efforts of the people; Formulation of Peoples' Recommendations; Advocacy and lobbying with the Policy makers.

Stakeholders
About 4,500 vulnerable households, 117 elected representatives of Local government, leaders of political parties, civil society and government officials.

Achievements
A Database on water situation of Dacope upazilla has been prepared. It will help government and NGOs to formulate development plans for this region.

41 Paani Adhikar committee-PAC (Water Rights Committee) were formed. Their knowledge, skills and Capability were enhanced through trainings, meetings and discussions at various levels. A Peoples' Demand-cum-Recommendations has been formulated in a participatory manner. They organized a social movement to realize their right to water and manage the water resources of the Coastal zone.

Through opinion-sharing meetings, seminars, workshops and roundtables with peoples' representatives, political and civil society leaders, government officials and the stakeholders, it was possible to create an atmosphere conducive to resolve the long-standing conflict of interest between the influential people and the commoners. This process resulted in a unanimous agreement that Water is a Human Right and that the crisis can only be permanently solved through Political action.

As a result of awareness campaign about 100,000 people became aware of water conservation and their rights. By means of the media campaign, press conferences, advocacy and lobbying with the Policy makers, the Peoples' demands were widely disseminated and drew the attention of the implementing agencies. They became more sensitive to the issue and began implementing the national policies more effectively. Administrative and social pressure on the influential people made them softer and as a result, the victims of water discrimination and the influentials agreed upon a compromise solution through the mediation of government officials.

Under this project, AOSED is repairing and rehabilitating the existing damaged water sources with the active participation and contribution of the community people. Motivated by public demand the Public Health Engineering Department-DPHE has taken initiative to solve the water crisis in Dacope by repairing and rehabilitating damaged ponds and pond-sand-filters and creating new ones. It is hoped that in this manner, water requirement of 10,000 households will be ensured.

Conclusion
As a result of these concerted actions by the grassroots communities, local elected bodies, civil society, journalists and government departments, it has been possible to ensure the availability of safe water for households, establish the rights of local people over water resources and ensure conservation of aquatic bio-diversity of this coastal zone.

Everybody Helped to Give a Rebirth to the Abandoned Paddy Land in Bundala, Sri Lanka!

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Keywords: community, paddy cultivation, stakeholder participation, traditions, income generation

Introduction/Problem Identification

Hambantota is a fast developing costal district in Sri Lanka. It is producing a considerable portion of the nation's rice requirement of the Island. However around 1,500 acres of paddy land have been out of cultivation due to Natural and humanly induced disasters in addition to the water scarcity, high soil salinity and flooding. Overuse of inorganic fertilizers and pesticides also has aggravated the problem. Paddy fields in Bundala in Hambantota District are no exception to this. It is located few miles away from the border of Bundala National Park and adjoining a major surface water body named Uraniya Wewa, an irrigation tank. The diminution of natural water drainage system to sea through the lagoon has caused increasing the salinity of soil surrounding the lagoon and has propagated up to the paddy land generating much harm for the crop production and community, both environmentally and economically, especially for paddy farmers in the village.

Analysis/Results and Implications for Policy and/or Research

It is reported that 45 acres of paddy field in this village has been abandoned since 1975. The serious issue prevailing at Bundala Village was identified by the District Disaster Management Coordinating Unit (DDMCU) at Hambantota District along with the cordial support of Divisional and District Secretariats. Through a participatory approach facilitated the villagers came up with a workable proposal and the DDMCU was able to extend its assistance through collaboration of Disaster Risk management programme of United Nations Development Programmme (UNDP). Financial support was provided by the Korean Funded 'Sustainable Recovery of Natural Resources of Tsunami Affected Coastal Areas of Sri Lanka with Peoples' Participation' project in consultation with District Advisory Committee which was formed to select, monitor and evaluate the same project under the leadership of District Secretary. The objective of the proposal was to re-cultivate the abandoned paddy field in extent of 45 acres. The cultivation of traditional paddy varieties resistant to salinity and use of organic fertilizer were the two key strategies successfully practiced throughout the project to confront the issues identified. Project further assisted the farmers to upgrade and develop a drainage system by linking with 'Uraniya Wewa', to improve drainage minimizing and decreasing the high salinity in soil in paddy land. "Patchchaperumal", "Dahanala", "Kuruluthuda", "Rathdal", "Madathawalu" were some of the traditional rice varieties promoted among the farmers.

While DDMCU continued working with the community based Farmers Association ("Parakum Farmer's Association") in collaboration with UNDP, it was interesting to note that many of government and non governmental organizations made passive links with the Farmer's Association to accelerate the project. These efforts interpreted a great multi-stakeholder approach to achieve the common goals of the entire community in a holistic manner. Department of Agrarian Services extended its support to construct the main drainage system of "Uraniya" Water Reservoir and also the culverts to control and manage the water flow. The 'Rotary' project was supporting to rehabilitate and expand the water spill of Uranaiya Lake and helping the Farmers Association to increase the water capacity of the tank. The Institute of Traditional Seeds and Resource Board under the 'Practical Action' also extended it's

assistance to farmers by providing traditional seeds sufficient for 15 acres, with technical consultation and assistance. The Department of Agriculture also linked with the program by providing traditional seeds sufficient for 10 acres together with a grant of Rs. 3500.00 for each acre to collect and produce the organic fertilizers. The project progressed well, with the participation of 20 farmers in the society and now hopes to extend to accommodate another 60 beneficiaries. There had been lots of challenges to overcome at the inception of the project. Changing the farmer attitudes to re-cultivate paddy lands which had been abandoned for nearly 30 years, introducing organic farming techniques against the use of conventional chemical fertilizers they got used to, protecting the field from Elephants and other livestock. The training programme which was conducted by UNDP in collaboration with Sri Lanka nature Forum was an ideal event to refresh and change the farmer's attitudes. Farmers also did not forget to extend their gratitude to the project by inviting them for the opening ceremony, organized on 2nd April 2007 at 7.43 am, an auspicious time. Mr. Weerarathana, leader of the Farmers Association expressed his views in a discussion with UNDP and DMC officials during their visits to the field. He stated that using these traditional rice strains organically would attract outsiders and market price could be higher than the high breed paddy cultivation. They hope to link with an Italian Organization to get the certification for rice produced as an organic product so that they can earn a higher income margin. He further stated that they were also happy that the UNDP has made the arrangement to link them with the University of Ruhuna, who would help them in soil testing.

Scientific Understanding and Best Practices in Coastal Aquifers Applied to Face up to Global Change. The Study Case of Mar del Plata, Argentina

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Keywords: scientific understanding, best practices, coastal aquifers, global change, Argentina

Introduction/Problem Identification

Coastal areas are transition spaces between the marine and continental domains where natural or anthropogenic processes of consumption, production and exchange of mass and energy occur at high intensity rates.

The increase of population causes a high demand of water for human consumption and for the development of socio economic activities that produce an intense pressure and pollution on the bodies of superficial and underground water. Consequently, the promotion of the access to safe water, the availability of water resources for agricultural and industrial uses and the environmental sustainability are imperative facing up to the global change.

The capacity building and the effective cooperation between scientific institutions, decision makers and stakeholders are essential to establish policies to achieve the Millennium Development Goals and the sustainable use of groundwater resources.

Analysis/Results and Implications for Policy and/or Research

Mar del Plata, located on the Argentine Atlantic coast, is the main touristic centre in the country and has a population of 600,000 inhabitants increasing up to one million during the summer. Water for urban, agricultural and industrial uses are exclusively supplied by groundwater resources.

The intensive exploitation in order to satisfy the fresh water needs of a demographically increasing city produced sea water intrusion in the urban area and a high number of salinized wells. Recovery of phreatic heads due to the abandoned wells, a high rainfall and the leakage of running water and sewage owing to their obsolescence leads in the flood and damage of the underground urban infrastructures and groundwater pollution by nitrates. Exploitation in rural areas supplies high quality of water volumes.

The present paper refers the results of the scientific researches carried out by the National University of Mar del Plata and the best practices implemented by Obras Sanitarias – the county company in charge of running water and sewage -, to secure the access of water to the permanent and tourist population of Mar del Plata, from 2010 to 2030.

Methodology included the conceptual model formulation, validation of the numerical model of the aquifer from 1913 to 2009 through the inverse simulation, prediction of water demand and prediction of the recharge taking account climate change, and at last, the numerical simulation of groundwater flow for different scenarios of global change during 2010-2030.

The update of the conceptual model allowed identify different hydrogeological environments associated to the lithology and geomorphology of the area, to improve the knowledge of the water entries from the rain, urban recharge and irrigation flows, and the water outputs through the creeks, the flow to the sea and the extractions for human and agricultural consumption.

The numerical model of the aquifer, from the beginning of the exploitation to nowadays, space and temporal well fits the observed piezometric head, for this reason the calibrated parameters and variables were used in the prediction model.

Coastal touristic cities need to secure the availability of water to the maximum population that includes the permanent population of the city plus the tourist population of the warmest month.
In Mar del Plata, the prediction from the logistic equation indicates that population will increase 20% in January (summer in the South Hemisphere) 2030.

In order to achieve the Millennium Development Goals an increase of permanent population with access to drinking water from 80% to 95% were considered. At present, all tourist population has access to running water. The prediction of water demand considered a reduction of daily consumption from 350 liters to 250 liters per capita, taking account a best awareness of stakeholders about the rational use of water resources.

The preliminary analysis of climate change was made from the assessment of the rain in the last 60 years, which present a growing trend of 17% in summer months. Temperatures don't present a significant variation in this period. The prediction of the recharge became from the hydric balance on rural, urban and irrigation areas.

In order to satisfy the gradual demand two scenarios of exploitation were selected, the first according to the Obras Sanitarias project, since considered a homogeneous aquifer, only based on the accessibility of the new areas of extractions to public highways and the second scenario defined new areas of extraction in the best productive hydrogeological environments. The scenarios of climate change comprised the optimism criteria of growing trend of the recharge, and the conservative criteria of constant trend.

The results of the numerical model allowed define a plan of groundwater resources exploitation from 2010 to 2030.

The best practices include the building of infrastructures like drilling of new wells, construction of a hydraulic barrier of exploitation to limit the marine intrusion and the extension of the running water and sewer systems. In districts of low income running water systems are made on the basis of the social participation through a national program called "Water + Work".

Measures of control include a register of the domestic, industrial and irrigation wells, piezometric and hydrochemical monitoring, and punitive actions to avoid the wastefulness and the dumping of toxic waste.

The best practices of groundwater management based on the capacity building and the transfer of the scientific understanding constitute an effective tool to face up to the challenges of global change.

Community Interventions for Water Security in Coastal Areas – Case Studies from Water Starved Gulf of Mannar Biosphere Reserve in Tamilnadu, India

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Keywords: marine ecosystem, Gulf of Mannar, sand minning, traditional water storage, advocacy groups

Introduction/Problem Identification

The Gulf of Mannar is located on the southeastern tip of India is one of the world's few remaining hotspots in terms of exceptional biodiversity of its terrestrial and marine ecosystems. The Gulf of Mannar is already under severe water stress because of the increasing number of industries prevalent on the coast. The effluents from the Kudankulam Nuclear power Plant, Sterlite Industries (Copper Smelting plant), are let in the coast which has caused the destruction of the fragile ecosystem. The planned Sethusamudram Ship channel Project involves digging a mid ocean to develop a channel to link the shallow water of the Palk Strait with the Gulf of Mannar for the movement of cargo ships. Scientists and environmentalists predicted that this project will spell disaster not only for the invaluable biodiversity of the gulf by muddying the pristine, clear waters, but also for the human population who will face the destruction of fisheries and the salination of fresh water wells in the area.

Analysis/Results and Implications for Policy and/or Research

The illegal and legal mining of garnet sand (red sand mixed with uranium) creates further problems in places such as Collachal, Manappadu and also in many parts of Ramanathapuram district. Mining is done to a depth of up to six metres within 10 metres from the high tide line. These operations have the potential to cause severe sea erosion, which will have an adverse impact on the fishing communities on the coast. The encroachment by miners has robbed fisherfolk of the space they have used traditionally to land their catch and keep the fishing equipment. In several places sea water intrusion has resulted in the salinisation of well water and the depletion of groundwater resources. The disappearance of sand dunes owing to indiscriminate mining has made interior land vulnerable to storms and cyclones. The Asian Tsunami of 2004, had a disastrous impact on the collachal area as the sand mining made the wave hit villages at ease. The concerned coastal areas situated along the Gulf of Mannar Biosphere Reserve zone have a history of water crisis as the area has faced severe water shortage from time immemorial. The drainage system in the coastal part of Gulf of Mannar consists of the rivers Vaigai, Kappalar, Kottangui, Gundar, Vembar, Vaippar and Kallar and its tributaries. All rivers in the area are non-perennial and get water only during monsoons.

The water supply for the population in this area is controlled by the local administration and drinking water is supplied only once a week to a population of five hundred thousand. Potable water has become such a scarcity as the salinity level has increased to such high levels. The population consists of largely illiterate people who were not initially aware of the connection and consequences of the industrialization and sand mining to their environment and livelihood. Initially, the people from the community initiated actions to prevent the nature intrusion, like for example in the village of

Oovari, the people started to build a wall around their church to prevent the sea erosion, but it didn't help. Concerned over the deterioration of their natural resources and destruction of the ecosystem, by outsider or settlers, the local community with the aid from few environmental advocacy groups started to act. This article documents the various measures taken by the community to counter the environmental violations with special reference to fresh water resources. The researchers also documented with case studies, various successful and unsuccessful attempts by the community in reviving their traditional water storage systems like "Oorani" (Local name for a dug-out pond that traps rain water run-off and stores), and "Kuttai"(a small small pond) in thwarting sand mining operations, installing the Sethu Samudram canal project, and in making the administration concentrate more in evolving a master plan for water storage in the perennially dry areas of the region. This article also documents the various legal proceedings initiated by the local community against violators and the measures the administration was forced to taken by the public interest petitions filed by different advocacy groups.

The Protection of the Coastal Vegetation from Alternative Technique of Sea Salt Production in Southern Benin

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Keywords: coastal mangrove, salt production, alternative technique, women, Benin

Introduction/Problem Identification

Mangroves are a key natural habitat of the coastal ecosystem. Wetlands in making the transition between the sea and the mainland, they produce plant matter which is the basis for the entire ecological system of mangrove (plant production, spawning ground, nursery). The tangled roots and branches set the banks and serve as a filter against siltation of the lagoon. They are finally at lives of several species of property interests (monkeys, birds, etc.).

Problem overview and Project objectives

The project aims at enforcing salt producers income through the promotion on environmental friendly techniques that ensure their economic sustainability. Specifically, the project seeks to:

- Protecting mangrove and coastal environment
- Strengthening the economical capacity of women sea salt producers
- Increasing fish production in the surround lakes and lagoons

Analysis/Results and Implications for Policy and/or Research

The degradation of mangroves in poor countries is a widespread phenomenon in the world and exacerbated in southern Benin. With the population explosion and lack of economic alternatives, the resources of mangrove wood and fish are overexploited by the poorest people who destroy the economic base of their existence. The fishing techniques can no longer fish reproduction. The cutting of mangrove leaves the shores without protection against erosion and sedimentation and destroyed the spawning grounds of fish and the habitat of several endangered species (monkeys, birds, manatees, sitatunga, otters, and reptiles).

Anthropogenic pressure on the vegetation cover in decades has contributed to its destruction causing a dramatic decline of the two main production areas: fish production and salicola.

To remedy this, AFEL has established two strategies for protection of mangrove and is the dissemination of the technical production of solar salt non-user of mangrove wood on the one hand and other restoration of degraded mangrove areas. Indeed, 3000 tons of salt are produced by heating wood, using each year more than 20,000 cubic meters of mangrove wood. The alternative technique involves the production of salt by evaporating in the sun instead of heating with the mangrove woods.

The technique developed by AFEL, with the help of salt producers Guérande in France, is to put a thin blade to evaporate brine in the sun on a black plastic tarp. The brine salt crystallizes in the day, producing 1 kg of salt per m^2. The economy of wood is about 7 cubic meters per tone of salt produced.

The additional investment is made by the sheet, which costs about 20,000 CFA francs, which can last three years and produce 500 kilograms of salt per year.

This technique also provides health benefits and working hours, especially women and children no longer obliged to supply homes for days in smoky reduced. The estimated cost of solar salt to 55 CFA per kilo against 80 for the salt produced in fire.

In fact, it is an economical solution for the sustainable exploitation of natural resources to protect the mangrove ecosystem and at the same time increase the income of the population.

During 2007, when AFEL received funding from FFEM to employees three moderators and project manager, 250 women were trained in addition to those trained in previous years and 212 of them used the technique to produce 50 tons of salt. It is estimated they have saved and 350 cubic meters of mangrove wood. The project is supported by the French Fund for World Environment, IUCN have to reconcile environmental protection and fight against poverty among women. It is expected that the salt and organic product is positioned on the fair market with certification FLO-Cert and technology through the widespread support of Millennium Challenge Account Project funded by the American cooperation.

Securing Water in Coastal Zones of Odessa City by Creation Effective Strategies for Adapting to Climate Change

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Keywords: water coastal zone Odessa, risk of floods storms erosion, inviting the vulnerable people, solutions in city planning, ecosystem services approaches

Introduction/Problem Identification

The global change escalates, the risk of floods, droughts and severe storms increases, first of all in coastal zones. Odessa developed as the agglomeration along the coastal line. The coastal low located territories from the 18 century were used for industry development and as the living places for the poorest people. The low-lying part of Odessa it is former delta of river Kuyalnik, which started it living cycle after last glacier periods. After some time, when the lend ice disappeared former big river Kuyalnk was divided into two rivers – Big Kuyalnk and Small Kuyalnk. These two rivers created two lagoons Hadgibey lagoon and Kuyalnok lagoon. Later these territories were poor by the send from Black Sea. In such way was created modern low lying coastal part of Odessa city. Today here living 75000 poorest people of Odessa the most vulnerable to the water related extremes events such as floods, drought, salinity ingress, cyclonic storms and their associated surges, erosion.

Analysis/Results and Implications for Policy and/or Research

The OECD in it global screening study "Ranking Port Cities with high exposure and vulnerability to climate extremes" makes a first estimate of the exposure of the 136 world's large port cities to coastal flooding due to storm surge and damage due to high winds. This assessment also investigates how climate change is likely to impact each port city's exposure to coastal flooding by the 2070s, alongside subsidence and population growth and urbanization. The study is focusing on the 136 port cities around the world that have more than one million inhabitants in 2005. The analysis demonstrates that a large number of people are already exposed to coastal flooding in large port cities. Across all cities, about 40 million people (0,6% of the global population or roughly 1 in 10 of the total port city population in the investigated cities) are exposed to a 1 in 100 year coastal flood event.

By the 2070s, total population exposed could grow more then threefold to around 150 millions people due to the combined effects of climate change (sea level raise and increased storminess), subsidence, population growth and urbanization. The asset exposure could grown even more dramatically, reaching US $35,000 billion by the 2070s; more then ten times current levels and rising to roughly 9% of projected global GDP in this period. On a global-scale, for a both types of exposure, population growth, socio-economic growth and urbanization are the most important drivers of the overall increase of exposure. Climate change and subsidence significantly exacerbate this effect although the relative importance of these factors varies by location. Exposure rises most rapidly in developing countries increasingly into areas of high and rising flood risk.

Unfortunately, the policy both on the national and city levels not includes concerns about of adaptation to climate change measures.

The trend of Odessa development to the next 30 years, indicated in city's Strategy paper from 2004 showed that Odessa city has a specific orientation to increase the amount of the multi storey buildings

in coastal areas without accepting ecosystem approaches into his future development.

The Odessa's civil architects and master builders proposed to move the big amount of the new buildings into coastal area by increasing population and infrastructures assets in potentially affected by extreme weather without development the engineering systems of protection territories from the rising sea level, appropriate drainage systems and responsible planning proposal.

The OECD estimated that in 2070s population living in affected area will increase from 75000 till 85000 (our estimation is 105000) and exposed assets in US $ billion will increase from 2,68 till 44,33.

It must be emphasized that exposure does not necessarily translate into impact. The linkage between exposure and residual risk of impact depend upon flood (and wind) protection measures. In general, cities in richer countries have higher protection levels than those in the developing world. Exposed population and assets remain dependent that can fail. Hence, even assuming that protection levels will be high everywhere in the future, the large exposure in terms of population and assets it's likely to translate into regular city-scale disasters across the global scale.

In order to reduce the vulnerability of the Odessa city poor to climate change and climate variability, the Reducing Vulnerability to Climate Change (RVCC) Project was launched in 2007 to identify alternative livelihood options that are sustainable under climate change. The goal of the project was to increase capacity of the communities in Odessa city to adapt to the adverse effects to Climate Change. The RVCC Project of the NGO Black Sea Women's Club was the first initiative in Odessa to address the issue of adaptation to the climate change and variability at local level.

The man methodology, which we used, was on inviting the vulnerable people in exposed communities to define their vulnerability contexts. Some elements of vulnerability were identified, including events that felt vulnerable to (hydro-geographical context of vulnerability) and why people felt vulnerable (socio-economic, cultural and political contexts of vulnerability). A prioritization of vulnerability contexts were completed by assuming values, as directed by participating focus groups.

It was understood that, adaptation not only would deal with reducing vulnerability to climate change, it might call for utilizing the opportunities provided by changes in hydro-geophysical (i.e. natural) system to the climate affected communities. As one of the adaptation Strategy and solutions in city planning was proposed the ideas to use more ecosystem services approaches and create Wetland Park instead to build multi storey buildings in coastal area and green zones instead of industrial areas allocated along the low lying coastal are in Odessa.

Emerging Technologies for Protecting Coastal Waters from Pollutants Delivered through Storm Water Runoff and Flux from Bedded Sediments

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Keywords: water quality, sediment, stormwater pollutants, remediation, management

Introduction/Problem Identification

The high intensity of past and current industrial activities and human habitation in coastal areas stresses water quality. This talk will focus on polluting chemical stressors from legacy and current activities that impact water quality by impacting the natural food web and impairs beneficial use of the water resources including local fisheries. Two primary routes of exposure for the polluting chemicals are ongoing sources from stormwater runoff and diffusive release of legacy chemicals from repositories in impacted sediments. These routes of exposure need to be understood and controlled to preserve the water quality in coastal streams, rivers, and receiving water bodies. New technologies are being developed by us and other researchers to reduce ongoing release of pollutants through stormwater and to manage legacy contaminants in bedded sediments.

Analysis/Results and Implications for Policy and/or Research

In the United States, the Environmental Protection Agency estimates that stormwater runoff is responsible for 21% of impaired lakes and 45% of impaired estuaries, and is likely similar across the world. As stormwater flows over land it can pick up metals, nutrients, bacteria, pesticides and other contaminants and transport them to receiving waters. Research has shown that a great majority of pollutants in urban stormwater are strongly associated with particulate matter. Therefore, the effectiveness of a stormwater best management practice (BMP) is largely dependent on its ability to reduce suspended solids in stormwater. Both street sweeping and bioretention have the potential to decrease stormwater suspended solid loads. Field investigations were performed in this research to evaluate the effectiveness of these two BMPs. A paired-catchment study in an urban watershed of Baltimore, Maryland was performed to physically and chemically characterize street particulate matter (<5 mm) and determine the effectiveness of street sweeping in reducing nutrients and metals in stormwater. Swept streets had 75% lower street particulate matter loadings than an unswept street and material on swept streets also contained 70% less lead (54-58 mg/kg) than material from an unswept street (185 mg/kg). No significant changes in stormwater quality were observed due to changes in street sweeping intensity and frequency in the paired catchments. Legacy repositories of contaminated sediments in stormwater pipes were likely impacting the water from swept streets. Analysis of influent and effluent stormwater from a bioretention cell in College Park, Maryland showed 31 to 99% reduction of polycyclic aromatic hydrocarbon (PAH) event mean concentration. Annual PAH mass load calculations estimated an average reduction of 83% in PAH discharge to receiving waters for bioretention treated stormwater. PAH removal was positively correlated with total suspended solids removal and bioretention media core analysis showed that PAHs travel only a few centimeters vertically in the bioretention cell near the stormwater influent.

In aquatic environments that are impacted by contaminated sediments, risk management strategies focus on interrupting potential exposure pathways by which contaminants might pose an ecological,

human health, and water quality risk. The cleanup process of contaminated sediment sites is complex and creates a unique challenge due to expensive cleanup strategies, large and diverse sediment sites, and presence of ecologically valuable resources or legislatively protected species or habitats. Removal options such as dredging and excavation have certain clear advantages, especially in situations where hot spots exist and there is a desire to reduce sources and risks quickly and to insure a permanent solution. However, dredging and disposal can be expensive and disruptive to existing ecosystems. Moreover, contaminants can be released into the water and air environments during sediment dredging, transportation, and storage. In addition, dredging operations can cause temporary high levels of contaminants in the water column and surficial sediments due to resuspension of buried sediments and release of pore water. Capping with clean sediments may not be practicable in sensitive ecosystems and at sites where there is concern with changing the sediment bathymetry.

In our recent work with contaminated freshwater and marine sediments we have tested the use of activated carbon for in-situ bioavailability control. We have demonstrated that addition of activated carbon to contaminated sediments reduces contaminant bioavailability greatly. Reductions in total polychlorinated biphenyl (PCB) bioaccumulation of 69% by Macoma clams, 72% by Leptocheirus amphipods, and 83% by Neanthes worms were observed in laboratory tests on sediment treated for one month with activated carbon. We also find that sediment treated with activated carbon attains equilibrium PCB concentrations 85 and 92% lower than untreated sediment in one-month and six-month contact experiments, respectively. We have observed similar results with the reduction of biological uptake of mercury by organisms living in sediments after treatment with activated carbon. Our recent pilot-scale studies of the technology in a river and coastal bay has demonstrated the effectiveness of the technology in the field.

Thus, application of sorbents to the biologically active layer of contaminated sediment may be an effective in situ stabilization method to reduce contaminant bioavailability to sediment organisms at the base of the aquatic food web. The cost of this in-situ technology is much less compared to current approaches of dredging and disposal. In situ bioavailability reduction using sorbent amendment may be applicable at sites where bioaccumulation reduction can reduce exposures to organisms and water column and consequent risk to acceptable levels.

Field Investigation on Disaster Announcement in Coastal Towns

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Keywords: disaster announcement, tsunami, high tide, flood hazard, fishing port

Introduction/Problem Identification

Recently, along with the worldwide increasing number of powerful adverse weather events and abnormal high tides, (said to result from global warming) tsunamis resulting from earthquakes have often hit coastal areas. Japan is surrounded by seas and countless people are constantly exposed to threats of flooding. Generally speaking, residents of Japanese coastal areas obtain emergency information on flood hazards by means of public loudspeaker systems. However, although such loudspeaker systems are normally sufficient for providing warning signals and other public information, some residents have experienced difficulty in understanding the announcements. This study reports the results of field investigations conducted on the effectiveness of emergency announcement systems in towns and ports facing the Pacific Ocean. As a result of our study, several key points have been identified and we will propose improvements aimed at improving the operation of emergency announcement systems.

Analysis/Results and Implications for Policy and/or Research

Background of research: The Japanese Islands are located on what has been called an "earthquake belt" and the nation has suffered from numerous disastrous earthquakes and resultant tsunamis in the past. Examples of such earthquakes include the Meiji-Sanriku (1896), Syouwa-sanriku (1933), Tounannkai (1944), Nankai (1946), Chile (1935), Tokatioki (1968), Nihonkai-tyuubu (1983), and Hokkaido-nanseioki (1993). The Chile earthquake is mentioned in this context because 142 Japanese residents were killed by the ocean-traveling tsunami resulting from the earthquake. Furthermore, of the 104 deaths resulting from the Nihonkai-tyuubu earthquake and the 230 deaths from the Hokkaido-nanseioki earthquake, most were the victims of tsunamis. In addition, all of us can clearly remember the aftermath of the tsunamis that struck coastal areas around the Indian Ocean that were caused by the Sumatra earthquake.

Each year a number of typhoons approach Japan and urban areas suffer from flooding. Japan is especially vulnerable to such flooding as most major Japanese cities such as Tokyo, Osaka and Nagoya face the sea. Tokyo itself is especially exposed as 84.9 km^2 of the metropolitan area, known as the 'zero meter area', is below sea level. This low-lying area is the result of land subsidence, which began in the middle of 20th century, was caused by pumping large amounts of groundwater from wells for use as industrial water. The largest amount of subsidence totals about 4.5 meters. This indicates that some coastal areas of Japan are even in danger of flooding caused by high tides. In order to limit the dangers accompanying flooding, it is vital that residents be provided with pertinent instructions in a timely manner. Thus, the role of loudspeaker systems installed in residential areas is important component in overall efforts to limit flood damage.

Result and Conclusion: Coastal towns in Chiba, Kanagawa and Shizuoka prefectures that are considered in especially vulnerable to tsunami and high tides were selected as survey areas. We investigated the

loudspeaker installations around the ports of those selected survey areas by sending a questionnaire to the port manager. Additionally, field surveys were conducted to confirm the loudspeaker installations, and the attitudes of local residents regarding conditions related to loudspeaker emergency announcements were investigated. Individual loudspeaker volume levels were verified using a sound-level meter.

Port managers in the surveyed area responded at a rate of 60% and field surveys were conducted in six towns. During the field survey, the conditions of the installed loudspeakers were confirmed by inspection and questionnaires on the degree of reception were distributed to 150 residents living around each surveyed port. The response rate from the residents surveyed averaged 25%. Furthermore, in order to compare the actual sound level (decibel count) of the loudspeakers with the attitudes of the residents regarding the degree of reception, sound level measurements were taken at each loudspeaker installation surveyed.

Our investigations reached the following conclusions:

1 An adequate number of loudspeakers have been installed by the port management of the surveyed coastal towns. As a general rule, it appears that the loudspeakers have been sited at distances of between 200 m to 300 m from each other.
2 From the replies of residents to the questionnaire, we determined that significant numbers of residents were dissatisfied with the level of loudspeaker reception they received. Although most such residents reported that they were aware of the sound coming from the loudspeaker, the dissatisfied residents stated that they were sometimes unable to clearly understand the information being broadcast because of sound distortion caused by wind and rain. Additionally when winter weather forced residents to keep their windows tightly closed, the loudspeaker broadcasts became even more unclear. Thus, it appears that when conditions are critical, residents might not be able to obtain evacuation information and could fail to escape to areas of safety.
3 Due to the above concerns, it was determined that voice announcements from loudspeakers might not be the most effective method of providing information when conditions are critical, and that vocal loudspeaker announcements should replaced by sirens. Furthermore, it was determined that multiple emergency announcement methods (including sound cars, helicopters, radio, television and e-mail) be introduced. It is also necessary that the people living in coastal towns communicate well with each other.

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Water Resources Management, Development Outcomes and Coping with Environmental Stress – Linking Land, Coast and Sea

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Keywords: IWRM and development, ICZM and marine management, regional economic communities, integrated information, Nile and Baltic Sea basin

Introduction/Problem Identification

The analysis of the Nile Basin and Baltic Sea Basin regions presented highlights key global challenges and opportunities present in water management and development (WMD) in developing and industrialized regions globally. It is concluded that investment in WMD is crucial for supporting responsible economic growth, improve livelihoods and to ensure environmental management objectives. Underinvestment in WMD in developing countries and regions increases vulnerability to water shocks caused by floods and droughts with significant impacts to the society. At the same time in industrialised regions, where water resources have been extensively utilised for economic development, freshwater and marine ecosystems are showing increasing signs of environmental stress through the spreading of dead zones in coastal oceans. This stems primarily from euthrophication caused by excess nutrient runoff from intensive agriculture production, the burning of fossil fuels for transport and energy production.

Analysis/Results and Implications for Policy and/or Research

Continued economic growth in many regions globally is increasing the demand for goods and services. This is placing new and increased pressures on water and natural resources. At the same time, the existing challenge of meeting water supply and sanitation targets for 2 billion people must be faced.

Developing regions with low economic growth and growing populations frequently suffer from severe environmental degradation of the environment resulting from poor land and water management practices. This degradation threatens the functions of life sustaining ecosystems, the water retaining capacity of catchments and thus erodes the base for economic development. It also makes these regions more sensitive to water shocks from floods and droughts as illustrated in the case of the Nile Basin.

Industrialised regions with higher sustained economic growth, improved economic standards and countries in economic transition tend to suffer more from point source and non-point source pollution. This is often demonstrated in the euthrophication of water bodies, algae blooms and subsequent oxygen depletion and threats to marine life. The Baltic Sea Basin case illustrates this situation which is common in many industrialised regions of the world. The coastal zones and the oceans are now showing clear signs of environmental stress, partly because of unsustainable freshwater management use upstream. Runoff of nutrients from agriculture is a major cause for widespread euthrophication of fresh and marine water resources.

Information on freshwater management and environmental impacts of development exists for many regions but the linkages to coastal and marine ecosystems are less well known. As seen in the two case studies on the Nile Basin and on the Baltic Sea Basin, it is clear that integrated and holistic information is not made available and productive to various stakeholders. Scientific actors often do not reach out to the broader civil society actors partly because the messages they deliver on the state of

the ecosystems and economies is conflicting and complex or because they do not have the means to reach out. This prevents innovation in utilizing water resources effectively for economic development and impedes improvements in meeting environmental objectives. Regions facing water challenges must engage all stakeholders (the government, scientific community, and civil society) to be able to address the ecological-economic processes at work.

It is concluded that new strategies to move beyond the current focus on IWRM policy is urgent in order to fully demonstrate the concept's value and ensure responsible growth by sharing the benefits from water resource management and development while minimizing trade-offs from development. The strategies include ensuring IWRM is 1) part of the broader regional economic development planning, 2) better address real development outcomes through investments, and 3) include linkages to integrated coastal and marine management. These three issues are further outlined below with lessons learned from the two cases.

The European Union, a Regional Economic Community (REC), is highlighted as an effective institution to push for environmental legislation compliance within a broader economic planning framework. This is very promising for the Baltic Sea Region because the EU can use legal enforcement mechanisms to pressure most Baltic Sea littoral states to take collaborative management actions and to reinforce existing international management frameworks. Water resources become part of the economic and environmental planning at both the nation and EU sub-regional level. Benefits from transboundary water management and development can be effectively distributed through the EU framework. An overall EU Baltic Sea Strategy that addresses the environment, growth, competitiveness and security is currently being developed.

In developing countries, water related investment for real development outcomes entails focussing on three basic areas to provide a basic foundation for growth: institution building, broad-based capacity building and hydraulic infrastructure. In industrialised regions, water resources managers should consider bringing onboard new stakeholders beyond government representatives to promote innovation and sustainable business more effectively. This can improve performance in meeting environmental objectives and innovation in water resources management and development.

The immediate impacts and long term risk posed by the global spread of euthrophication and Dead Sea zones present a clear need to broaden the IWRM concept to more strongly include linkages to Integrated Coastal Zone Management (ICZM) and marine management. This process is beginning in the Baltic Sea Region, where the EU is putting in place several pieces of water management related legislation on land, at the coast and for the marine environment.

Utilization of Ecosystem Services in the Context of Re-establishing and Regulating Hydrological Functions for Flood Defence in China

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Keywords: ecosystem services, re-establishing, hydrological, functions, flood defence

Introduction/Problem Identification

This paper considers the situation of flood defence in China and provides a brief discussion on re-establishing and regulating hydrological functions in coastal areas in order to secure water for serving human health and economic development in practice and to avoid flooding causing natural disasters on the coasts of China.

The aim of this paper is to identify and explore the principles of a multi-agency approach and understanding which could create a basis for effective, co-ordinated inter-disciplinary flood defence to restore both ecological and hydrological functions.

Analysis/Results and Implications for Policy and/or Research

The possibility of restoration of the hydrological and ecological functions of floodplains and wetlands in coastal areas is increasingly being considered in the context of conventional engineering approaches to flood control. Environmental policy and public efforts are being made towards integrated development of economic benefits in order to reclaim the ecosystem services of floodplains, floodwater and coastal water management, such as integrated application of technology and policies for sustainable development of water resources, reduction of flooding risk and redemption of floodplain values.

The relatively discipline of the ecosystem is related to and applied in coastal floodplains with consideration of conservation and restoration that attempts to integrate ecological, economic, and social objectives in a unified, systems approach. The proposition on which this research will be based is that effective and optimal restoration of ecosystem services and sustainable hydrological systems in floodplains can only be achieved by working in cooperation with agencies representing other interests in flood plain management (e.g. economic, community and engineering).

The paper is intended to identify and explore effective integrated management of water resources to tackle coastal flooding and how to combine this with environmental tools, technology and policy for securing water in coastal zones in practice.

The paper answers the research question regarding what principals the considerations of the stakeholders play in coastal floods defence and how to ensure the security of water in coastal zones.

The development and application of the research will involve the collection and evaluation of relevant and original information, technology and actions related to practice of flood defence system for flooding and water pollution control with different approaches. In China the restoration and development of the hydro-function of floodplain and wetland for the coastal water has been influenced by several factors arising from the over capacity of development between regions to meet the needs of poverty

reduction at the early stage of economic development. That has lead to a lack of integration, and lack of techniques and awareness of sanitary operation in the practice of flood defence in the coastal areas.

This paper suggests that the way of improving water security at coasts should be to re-establish hydrological functions for floods defence which would then have more effective access to, and control of, implementation and be more representative of all stakeholders with different approaches.

Vulnerability and Management of Aquifers in S and SE Asia

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Keywords: coastal, groundwater, recharge, saline intrusion, water use

Introduction/Problem Identification

Coastal areas in S and SE Asia have large sedimentary deposits, especially in the river deltas. The thickness of the deposits varies from less than hundred metres up to 2 km. These deposits host huge quantities of groundwater which however is vulnerable due to natural as well as human factors. Coastal areas are heavily populated and there is a large pressure on the groundwater resources. The Kerala coastal plain has a population density up to 1500 persons/km^2 and the Bengal delta 1300 persons/km^2. Further, coastal areas usually have soils suitable for agriculture and groundwater may offer an easily accessible source of irrigation water.

Analysis/Results and Implications for Policy and/or Research

Depending on the geology the recharge rates vary largely from tenths of thousands of year to tenths of years (Jacks et al., 2007; Shammas & Jacks, 2007). This is a basic fact that has to be taken into account in managing the groundwater use. The larger aquifers have extended memories of the last glacial period with the groundwater being recharged during the period with a sea water level down to 120 m below the present one, thus late Pleistocene and early Holocene (Jacks et al., 2007). In Kerala the recharge period was from 33 000 years BP until 22 000 years BP when it was interrupted by an arid climate manifested in still persisting soil gypsum concretions on the Indian peninsula. Conditions were a good gradient for flow and a sufficiently wet monsoon. The slow replenishment rate must not be exceeded by the groundwater utilisation. In the Mekong delta tidal water enters into the river branches rendering the surface near aquifers brackish while the good quality aquifers are found at depth (Huu-Thoi & Das Gupta, 2001). In the Mekong delta groundwater is allowed only for community water supply, not for irrigation. In the Bengali delta in Bangladesh on the other hand, groundwater stands for 70 % of the irrigation water implying risk for cross-contamination by brackish water and by arsenic (Hasan et al., 2008). Due to reducing conditions created by organic matter sandwiched in the sediments, several flood plains in S and SE Asia have groundwater contaminated by geogenic arsenic. This is the case for the Bengal delta, the Irrawaddy delta and the Mekong and Red River deltas in Vietnam (Bhattacharya et al., 1997; Polya et al., 2008; Norrman et al., 2008).

In the shallower aquifers measures to protect the aquifers from salt water intrusion have more chance for success. Establishing barriers at the sea shore by artificial recharge has successfully been used (Ballukraya & Ravi, 1998). The Salalah Plain aquifer in Oman is subject to stress and the budget is negative, 12 % more is pumped than is recharged (Shammas & Jacks, 2007). Treated sewage water is recharged through injection wells along the sea shore to create a barrier against sea water intrusion (Shammas, 2008). The major water use is grass cultivation for milk cattle, not feasible in the long run. Water harvesting is used in the Kacchh peninsula in Western India to support a confined coastal aquifer (Raju, 1998). Sand is filled into a cubic excavation serving as a filter before the water enters into a borewell extending into the confined aquifer.

Excessive groundwater use causing land subsidence in combination with the expected relative sea water rise is considered to be a serious problem in Asia (Phien-wej et al., 2006; Ericson et al., 2006). An

activity which implies risk for pollution and competition for groundwater is the shrimp cultivation along the Bengal Bay coast of India (Rönnbäck et al., 2003).

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Infrastructure Driven Water for Growth and Development Incorporating Climate Change Adaptive Responses

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Keywords: reconciliation options, climate change, infrastructure management, environemntal sustainability, water demand managment

Introduction/Problem Identification

The Water supply infrastructure supplying the two largest cities in the Western Cape Province namely the City of Cape Town and Drakenstein Municipality has a high level of flexibility to water security and to climate change at the same time accommodating environmental sustainability and best practice with regard to water conservation and demand management.

The Western Cape Water Supply System (WCWSS) displays some best practices with regard to the additional newly built Berg River dam (environmental adaptive constructive mode) as part of the supply side option together with the demand side water conservation option (20% water savings adopted by City of Cape Town prior to approval of the dam). Preventative catchment management was for the first time introduced as a condition of a licence to build the dam resulting in yielding additional water storage, depressed water demand and reduced water loss from the catchment by removal of alien trees, fire management and erosion control.

Analysis/Results and Implications for Policy and/or Research

This Dam is now part of the system of regional Water Supply Schemes delivering the highest standard of potable drinking water to taps to 6 local Municipalities and one large metropolis of the City of Cape Town simultaneously ensuring higher levels of water security (for the next 25years) and appropriate environmental sustainability. It delivers water to domestic and irrigation water users ensuring minimal capacity requirements and universal application of demand management options on a larger scale and over a wider area.

The Strategy also looks at longer-term future water requirements. Of critical importance is when to develop additional and/or alternative water resources and to determine by what date they should be on stream. Various possible water interventions have been identified (including water conservation and demand management) that could be implemented over a period of time.

This spatially integrated water infrastructure system also displays significant climate change adaptation accommodating variations in intensity, spatial and frequency of rainfall. The Western Cape Province has finalised the Provincial response to climate change and is in the advanced stages of finalising the localised implementation plan with budget proposals to be submitted to the Climate change division of UN for approvals.

Recommendations on the order in which interventions should possibly be implemented, are made by means of a scenario planning process, which takes into account factors such as economic and population growth (with the resultant growth in water requirements), the potential effects of climate change on the water resources, the effect of invasive alien vegetation clearing programmes on the availability of water, changes in agricultural practices due to seasonal shifts etc.

The scenarios and action plans dealing specifically with the possible effects of climate change, require that weather patterns, rainfall, land use and runoff should be extensively monitored in order to develop a reliable and early warning system. This means that the impacts of climate change on the water resources will be alleviated with a mix of interventions that that is resilient to climate change can be implemented in time.

The Schemes are managed and operated by the National Government and the City of Cape Town in a system approach (irrespective of ownership of individual schemes) covering most of the Water Management Area in the South – Western most parts of South Africa. This approach enhances the cooperative governance of water infrastructure for mutual benefit to water users, water resource catchment managers and to the growth and development of the country as a whole.

This paper would demonstrate best practice with regard to infrastructure implementation and its sustainability in terms of water supply and environmental integrity while driving growth and development in the face of climate change and limited water resources. Cooperative governance is achieved taking into account the supporting strategies of national, provincial and local government whilst adhering to international standards and guidelines. Knowledge gained and innovations created from this approach can be replicated and are being expanded to other areas in South Africa.

Threats to the Mati Plain Coastal Aquifer; Northern Albania – Inferences for Management

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Keywords: groundwater, coastal, saline intrusion, recharge, isotope

Introduction/Problem Identification

Albania has abundant water sources, quite a few large rivers which however tend to be rather polluted (Cullaj et al., 2005). In the southern part of the country there are large karst springs while northern Albania has coastal plains with loose deposits forming good aquifers. The Mati River has formed a Quaternary sequence of sediments containing at least three aquifers sandwiched by clay layers. The aquifers serve as water source for the scattered habitation in the plain but also for two larger towns outside the plain served with altogether 1.5 m^3/s of groundwater withdrawn in two well-fields in the centre of the plain. This is a case study of the Mati plain aquifers and possible threats to them as a basis for the management of the groundwater. The main issues are the risk for sea water intrusion and the assessment of the recharge of the aquifers from the Mati River.

Analysis/Results and Implications for Policy and/or Research

The aquifers are confined except for an alluvial cone at the entrance of the Mati River into the plain. The alluvial cone has contact with all the three aquifers and is seemingly an important recharge site. While the upper aquifer contains fresh water the lower aquifers are slightly brackish. There are worries about the risk for salt water intrusion. However, these lower aquifers are artesian close to the sea shore, indicating restricted outlets from the aquifers into the sea. The groundwater has a Na-HCO3-Cl character and seven 14C-datings have given ages from 2000 to 7000 years indicating that the groundwater represents a late stage of fresh water flushing. The upper confining clay layer must have been deposited under water but while most of the eastern Adriatic Sea shore has been subject to subsidence the Albanian coast has been subject to uplift (Aliaj et al., 2001). Beach ridges have been observed in Landsat images close to the foothills east of the Mati plain (Mathers et al., 1999). Thus the flushing pattern of the water quality is the result of this uplift during the last 10 000 years BP. The ages of the groundwater may reflect a wetter climate that appeared after 7000 years BP (de Rijk et al., 1999; Rolph et al., 2004). The salinity in the brackish groundwater seems to be derived in part from diffusion from the sandwiched clay layers as per 18O analysis.

A crucial question is the connection between the alluvial cone and the large well-fields. Temperature was measured in a well at a distance from the alluvial cone to detect the seasonal temperature variation in the river. However there was no significant variation recorded in part depending on that the temperature in the river is evened out in a reservoir upstream. Equally there would be little chance of using 18O for tracing the recharge water. Analysis of sulphur isotopes in groundwater in a transect from the alluvial cone to the sea side will give an assessment of the fraction of river water in the groundwater pumped from the well-fields. The sulphur isotope ratio (34S/32S) is close to zero per mille as the sulphate in the river is largely derived from sulphide oxidation from mining activities upstream while it is around 21 per mille in sea water. Before these analyses are available the groundwater chemistry indicates that a major fraction of the well-field groundwater is derived from river recharge. While sea water intrusion does not seem to pose a large threat the ongoing gravel extraction in the alluvial cone is a risky activity. It will decrease the hydraulic head and there is risk of clogging by stirring up

fine sediments. Another threat that should be considered is the rapid changes in coastal morphology under the influence of human interactions (Ciavola et al., 1999; Brew, 2003).

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Blue Gold Conservation – The Road to Sustainability

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Keywords: ground water, over-exploitation, coastal, artificial recharge, sustainability

Introduction/Problem Identification

Chennai a coastal city, one of the major Metropolises of India is experiencing the pinch of urbanization in its suburbs. The rapid growth has generally outstripped the provision of water supply, sanitation and waste disposal. Inadequate supply of municipal water has forced to relentlessly tap groundwater for its needs. This led to seawater ingress in the northern coast (Minjur) necessitating legislation to regulate and control the extraction, use or transportation of groundwater. In the interest of protecting and to realize the full benefits of recharge during precipitation, certain villages in the South Chennai coastal aquifer are notified as aquifer recharge areas restricted for development. Often the restriction is violated. This had led to the problem of over-extraction and lowering of water table. Artificial recharge to harvest flood waters is the best way to sustain groundwater instead of taking up other mega projects.

Analysis/Results and Implications for Policy and/or Research

Groundwater is a distinguished component of the hydrologic cycle supporting economic development, but is still widely under-valued, inefficiently exploited and inadequately protected. As no one owns the resource, users have no incentive to conserve for the future and self interest of individual users leads to overexploitation. Further, due to its nature of occurrence as a hidden resource controlled by hydro-geological features, it does not find its due share in planning process for scientific development and management to understand the dynamics of its flow in space and time. Since most of the surface water resources have already been harnessed, groundwater is the most sought after dependent resource to meet the demand of various sectors. To cope with the demand, rampant drawing of the sub-surface water takes place. Specifically, the coastal zones and their hydrologically linked catchment areas are under heavy environmental pressure in recent decades as they are centers of urbanization, trade, industrial growth and intensive agricultural and aquaculture activities. The strain on development of groundwater in coastal region is thus obvious resulting in seawater intrusion associated with sharp deterioration in quality of water. These effects are quasi-reversible that takes decades to be flushed out even after the flow of freshwater has been re-established. Additional threat of susceptibility to increasing salinity of groundwater is also due to sea level rise as a direct impact of global warming.

Urbanization coupled with industrial development has profound impacts on the hydrological cycle with changes in the frequency, volume and quality of groundwater recharge modifying existing recharge mechanisms. These are the result of widespread reduction in permeability of the land surface and consequent diversion of run-off and drainage by the construction of roof and paved areas. To fulfill water demands in the future, we need to rationalize on various means of capturing and storing water.

This has brought forward the importance of "The greatest river of the Earth that flows underground" as rightly envisioned by Leonardo da Vinci that signifies the magnitude of groundwater availability as well as the importance one has to confer for its sustainable development and conservation. Water is thus no longer being viewed for what it is – just water. As a natural resource it is increasingly being viewed as a commodity that has to be used rationally, priced appropriately, managed, sources

recharged and reused as much as possible and wherever possible. Inspite of the pressing need for rapid development of additional water supplies, adequate attention is rarely given to resource conservation and protection, despite the fact that in the longer term this can be a serious constraint on sustainable development. Before the situation worsens, corrective mechanisms have to be placed in order to set things right. The current problems are the direct result of failure or neglect to follow an integrated approach to natural resources use and management.

As problems of groundwater depletion and its deleterious consequences have surfaced in different parts of the world, a variety of responses have been forged to mitigate or even reverse these. The standard reasoning is that even after several dams are built across the world, the reservoirs can capture and store no more than a fifth of the rainwater, the bulk of the remainder still running off to the seas. In India about 1150 km^3 of its precipitation still runoff to the seas annually in the form of "rejected recharge". If a fraction of this could be stored underground by reducing the velocity of the runoff and providing increased time for recharge, groundwater supplies could be enhanced significantly in addition to quality improvement in brackish and saline areas. Further the conduit function of aquifers can help in natural sub-surface transfer of water to various need centres, thereby reducing the cost-intensive surface water conveyance system.

This is an ongoing study to be completed by May 2009. Preliminary secondary data collection from other sources shows a declining tendency in groundwater level. The paper suggests certain artificial recharge methods using flood waters, for sustaining the groundwater of the area. This sustainability will lead to intergenerational equity and current generation sufficiency.

Strengthening Crosscutting Schemes toward the Integrated Management of Rivers and Coasts: El Fuerte and Los Perros Rivers, Study Cases in Mexico

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Keywords: freshwater, coastal water, pollution, management, biodiversity

Introduction/Problem Identification

Many of the key concerns about global water issues are concentrated in the coastal zone: 80% of the coastal water pollution comes from land sources, watersheds under stress (dams, flood control, channelization, habitat degradation -deforestation, urbanization, agriculture- freshwater withdrawals, pollution, loss of freshwater biodiversity).

Freshwater flow reduction to the sea (saline intrusion into fresh surface water and groundwater and river-borne nutrients flowing from the land to the sea

Analysis/Results and Implications for Policy and/or Research

To understand the hilltops to oceans relationship in an ecological dimension we must keep in mind what it is ignored: lack of knowledge on integrated management and its benefits, poor understanding of its complex interactions and stakeholder competition on common resources and their different visions, this is very important because all natural systems are connected and the impacts of pollution and other associated problems affects the entire system.

Benefits of the study: keep integrity of ecosystems, improve water quality and promote sustainable development in higher and lower watershed areas.

El Fuerte river is located at the northwest part of Sinaloa state, México; the main activities in the area, like agriculture, aquaculture and some industrial production affects the water quality and the productivity of the coastal lagoons. Los Perros river in the state of Oaxaca is strongly polluted by human activities and solid waste along the river, damaging coastal ecosystems and their vital functions as spawning and nursery area coastal fisheries.

Environmental Challenges and Freshwater Security in Coastal Tamil Nadu, India

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Keywords: coastal zones, environmental challenges, freshwater security, coastal disasters, aquifer

Introduction/Problem Identification

Coastal zone comprise a continuum of aquatic systems and the continental shelf is a most taxonomically rich and productive ecosystems (buffer-zone) in the earth. It contains a wide diversity of assets (human, physical and biological). In view of the rich resources, the coast attracts human settlements and various economic activities. Number of mega cities and other urban settlements are located on the coast and it intensifies further. Due to population growth, urbanization, industrial development, trade and capital flow coastal zones are facing many environmental challenges. The freshwater availability is inadequate for meeting various demands. Moreover, it experience degradation due to anthropogenic and natural reasons. This abstract examines environmental problems, its implications on freshwater, various options for mitigating the water demand and the suggestions for sustainable water management strategies in coastal zones based on the experience of Tamil Nadu coast, South India.

Analysis/Results and Implications for Policy and/or Research

Tamil Nadu is a major coastal state in India with a long coastline of 1076 km. Chennai the fourth largest metropolitan city of India, with six million people is located at the Tamil Nadu coast. The zones empowered with rich fragile ecosystems include coral reefs, mangroves and aquatic flora like sea grasses and weeds. The coast has a number of ports, fishing harbors, industries, saltpans, aquaculture farms, rural and urban settlements, tourist centers, historical monuments, heritage sites, and pilgrim centers. Due to all these reasons the water demand as well as its degradation increased substantially in the recent decades.

Coastal zones and their hydrologically linked catchment areas have come under heavy environmental pressure in recent decades. Disposal of domestic, industrial wastes and inflow from agricultural land are the major reasons for pollution. Besides fishing, harbour activities, tourism and salt production also causes degradation. 30 large and medium industries (0.125 million cubic metres -mcm), aquaculture farms (0.253 mcm), and municipalities (0.435 mcm) are generated wastewater in coastal area. Industries and settlements are also generating sludge (9112 tonnes/day) and solid wastes. A study on coastal estuaries around Chennai observed that bioaccumulation of heavy metals such as cadmium, copper, zinc, nickel, lead and iron in gills liver and muscle tissues of certain fish species. Pollution discharge also made significant impact on the freshwater sources. Domestic wastes reduce dissolved oxygen (DO), increase hydrogen sulphide and BOD and incidence of fecal coliform. Industrial waste affects DO, temperature, turbidity, pH and increase BOD, COD, and suspended solids.

In coastal areas aquifers are important source of freshwater but under stress and often get intruded by saltwater as a result of overexploitation. In North Chennai, excessive tapping of groundwater led to seawater intrusion. Unscientific development of aquaculture farming also led to salinization of aquifers. Tamil Nadu coast faces many disasters like wave attacks, cyclone and tsunami (December 2004). All these affect the freshwater sources also. Studies proved severe groundwater quality problems exists in the entire tsunami affected areas of the state.

In most of the coastal cities fresh water sources are highly polluted and not suitable for domestic purpose. Hence augmentation of good quality of water from distance sources is the option for mitigating urban water crises or achieving water security. However, in a water scarce state like Tamil Nadu, the opportunity cost of this to the rural community may be substantial. For Chennai city alone the Water Board supplied 80988 million liters water (2004). Now the Board extending its coverage in the urban agglomerations also and presently bringing 620 mld water from distance sources. Besides, large quantity of groundwater also transferred through tankers. However, the average water availability in the city (90 litres/capita/day - lpcd) is lowest compare to the other Indian cities (270 lpcd in Delhi, 220 lpcd in Pune), which compel the socially vulnerable groups to use the contaminated groundwater. The projected water requirement for the Chennai Metropolitan Area during 2011 will be 1631 mld. Based on the present scenario, meeting such a huge demand is a great challenge. Now government is also planning to go with the costly options like to setup two seawater desalination plants, with 100 mld capacity each at Minjur and Nemmeli.

The above discussion provides a clear picture about the ecological and economic significance of coastal zones, major challenges and its implications on water security in the context of Tamil Nadu. Since freshwater is a precious and scarce resource in coastal zones and is getting degraded due to anthropogenic and natural reasons its preservation is important. Unfortunately, the freshwater available in the coastal areas is not considered as a 'coastal resources' since its availability in all other terrains. Hence the freshwater management issues also to be incorporated in the existing Coastal Zone Management Programmes. Otherwise the overall sustainability of the coastal ecosystem is under jeopardy. Chennai had large number of tanks, which are highly encroached and degraded due to unscientific urbanization. The groundwater was also in good condition. Strict policy initiatives should be enforced on groundwater over extraction, pollution management, preservation of existing water bodies, reclamation of aquifer through rainwater harvesting, wastewater recycling and mangrove plantation (which protect the aquifer from seawater intrusion and coastal disasters). In this regard awareness generation about the criticality of freshwater in coastal zone, its judicious use and management need to be done. Moreover an Integrated Water Resources Management approach with the collaboration of all stakeholders in the coast is required.

Impacts of Coastal Regions Sanitation on Ground Water Quality and Coastal Waters Nutrient Dynamics

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Keywords: groundwater fluxes, mudbanks, coastal sanitation, plankton bloom, climate change

Introduction/Problem Identification

The influences of land-use mosaic among sub-watersheds on coastal processes apply globally to any coastal regions hugged by wetlands and underlain with limestone porous deposits, when the hydraulic level difference between the seawater and wetlands attains a critical value.

Analysis/Results and Implications for Policy and/or Research

Recent investigations across the narrow parallel submerged porous lime shell regions of Vembanadu Lake (RAMSAR site) separating to the Arabian Sea had indications of ground water flows into coastal waters. During low tides, the polluted ground water under the beach can be sucked through the porous lime beds into the surf zone and that creates a kind of hydrologic pump. The human population along the coastal belt with more than 70 % of households without proper sanitation facilities has resulted in concomitant increases in widespread use of septic tanks and nutrient inputs to coastal aquifer. The ground water quality had nitrate (in sediment extract) up to 12 µM, ammonia (in water) 8µM, urea (in water) 14 µM, urea (sediment extract) 15 µM. A fertilization of the coastal waters by injection of nutrients enriched groundwater is expected in the region. Though the present investigation represented a period of no mud banks, the high nitrate-N, ammonia concentrations, enriched particulate organic carbon and Chlorophyll a at certain localized coastal regions indicated external nutrient source. A band of N/P > 15 funneling out was a clear indication of an 'external source' of nitrogenous compounds to the coastal water. These sources of nutrients deserve identification as it was traced in a region far away from any river mouth and the existence of subterraneous channels as the artifacts of porous nature of the lime shell base of the region transporting the nitrogenous compounds cannot be ruled out for the region. Another significance of this finding is that subterranean flows could redefine the very concept of formation of mud banks, which are presently recognized only as an oceanographic process. Unlike the existing theories, it is argued that formation of mud banks are not entirely forced by coastal oceanographic processes; instead a remote forcing from the land involving a subterranean flow through the submerged lime beds appears to be an initiative mechanism.

Contributions of Low-cost Rainwater Tanks and EcoSan Toilets in Securing Potable Water in Southwest Coastal Zone of Bangladesh – An Experience of SPACE

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Keywords: semi and extreme coastal areas, migration to coastal urban, narrowing safe water sources, disaster resilient options, productive sanitation

Introduction/Problem Identification

SPACE has installed 100 household based Rainwater Tanks and 90 EcoSan toilets among 150 families in Kolaroa and Shyamnagar Upazila (sub-district) of Satkhira district locates in the southwest coastal zone of Bangladesh. The Installed Rainwater tanks and EcoSan toilets have successfully demonstrated as the safe, affordable and reliable source of potable water in the coastal zone. Almost all the Rainwater Tanks owners efficiently collect water during the rainy season and safely reserve for the dry season through proper operation and management. EcoSan toilets, on the other hands, prevent water contamination for its non-pit and dry nature, water logging and serge cannot damage and over-flow as the bottom is sealed with concrete. Increasing number of people is becoming interested to these technologies for their needs for potable water. This paper describes how the people efficiently, use, operate and manage these technologies for keeping those always functional.

Analysis/Results and Implications for Policy and/or Research

Salinity associated with excessive presence of arsenic and iron concentration is the major problems of drinking water in the southwest coastal zones of Bangladesh. Geologically, the Southwest coastal zone may broadly be divided into two clusters: i) Semi-coastal and ii) extremely costal areas. Shallow Tube Well (STW) was the major source of drinking water in the semi-coastal zone before detection of arsenic in the groundwater. People stopped using STW water in drinking and cooking purposes after detection of excessive arsenic in the shallow level. Government and NGOs have installed number of Deep Tube Well (DTW), Pond Sand Filters (PSF) and Dug Wells to combat the emerging situations. Rapidly increasing trends of saline intrusion is badly affecting these water sources. In addition to saline intrusion, water logging and floods cause for overflowing and inundating the conventional latrines that severely contaminate the surface and sub-surface level of water.

On the other hands, PSF and Rainwater collection are the major sources of drinking water in the extreme saline areas. But, scope for PSF installation is rapidly narrowing due to many of wetlands have gone under brackish water for shrimp-cultivation that cause for severe potable water crisis in this area. In these circumstances, people are being compelled in fetching water from the safe sources locate at long distances. Generally, women and girl children of poor families are mainly the responsible for fetching water who have to walk to long ways daily for fetching water, which do not only waste their productive times; also cause for various social and health related problems. They, sometimes, cannot go to long distance while they have to consume brackish water that leads them into severe health hazards. Inhabitants of the coastal-urban areas face much more safe water scarcity due to rapidly increasing population caused by migration of rural people the increasingly narrowing sources of sweet water in the ponds.

Realizing these worse situations, SPACE, an NGO exclusively implements safe water focusing to Rainwater utilization and sanitation focusing to Ecological sanitation in rural and urban areas of Bangladesh, has installed 65 household based low-cost Rainwater Tanks and 65 EcoSan toilets among 150 poor families in five villages of Kolaroa and Shyamnagar Upazila (Sub-district) of Satkhira district in 2006. SPACE invented this options of Rainwater Tanks from its experience of working in this area for a long time. Concrete-made rings, which are usually used for latrine construction, have been used for the construction of this rainwater tanks. These tanks are connected with galvanized roof catchments using collection pipes, gutter and down pipe for flashing away dirty water before collecting rainwater in the tank. Water reserving capacity of these tank are 2500 to 4000 liters that can ensure water security for a family consisting of 5-6 members round the year if properly managed. Cost of each tank is Tk. 6000 to 9000 (equivalent to US$ 90 to 125).

SPACE has also introduced double vault EcoSan dry toilets in the same area, which have faced two major floods and water logging during the last two years. It is found that 100% of the installed EcoSan toilets were found disaster resilient and competent for maintaining sanitation demands of people in bothe semi and extreme coastal areas. It was not cause for overflowing and environmental pollution during disaster, water logging and sergal tides since these toilets have been installed up to the ground level and the bottom are sealed. Installation cost of each EcoSan toilets were Tk. 10500 to Tk. 12000 (Equivalent to US$ 150 to 180). Since the EcoSan toilets do not cause for surface or sub-surface level water pollution, it can also ensure contamination free surface water for the people of Arsenic threatened areas. Water quality and sample of feces has been tested and found risks-reduced. 100% of the

The field reports reveals that over 90% of the installed Rainwater tanks and EcoSan toilets are functioning well as the effects of efficient management by the owners. The EcoSan toilets are also used as the productive sanitation, as the owners also safely use the treated urines and feces by EcoSan toilets for homestead organic farming. As the results of implemented activities, physical burden and mental stress of women and girl children have been reduced since they can collect safe wate and safely defecate at their door steps. This information clearely indicates encouraging social acceptance of these options. This experience may be a replicable model for creating access to over thirty million inhabitants of coastal zone of Bangladesh. The policy makers, development partners and other stakeholders should extend their cooperation in replication this model to wider areas in coastal and difficult areas to serve millions of poor people in Bnagladesh and other developing countries as well.

Monitoring Freshwater Discharge in the Coastal Zone of Lebanon Using Remotely Sensed Data

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Keywords: freshwater, coastal zone, groundwater, satellite images, Lebanon

Introduction/Problem Identification

Freshwater flow to the sea is a major aspect of water dynamics in many coastal zones. Rather than direct surface run-off, groundwater is also delivered as plumes, the so-called submarine springs. This study shows the application of thermal Infrared TIR airborne survey and satellite images processing. Therefore, temperature difference between the cold terrestrial water and warmer saltwater is the major parameter of identification; thereby, recognition of thermal anomalies would presume the dimensional measures, configuration and time-change factors of freshwater delivered into the coastal zone. This study aims to investigate the mechanism of water flow from the Lebanese rivers, and to identify the exact location of groundwater discharges along the Lebanese coast.

Analysis/Results and Implications for Policy and/or Research

The analysis in this research was as follows:

1 Airborne survey was carried out using thermal Infrared TIR radiometers to detect the temperature difference between the relatively cold fresh (Terrestrial) water and saltwater, the so-called Thermal anomalies. The temperature difference was up to 0.1 ºC.
2 The identified thermal anomalies from the TIR airborne survey were verified in the field (marine survey) following chemical and bacterial analysis to distinguish the type of the recognized thermal anomalies (freshwater or wastewater, polluted water…etc)
3 The used TIR was applied mainly to detect the exact location of groundwater discharge; therefore satellite images were analyzed to recognize the routes along which this groundwater discharges to the sea.
4 In a regional aspect; however, satellite images were processed using ERDAS Imagine and ENVI-4.3 software. Two types of images were used: high resolution (Landsat & ASTER) and, moderate resolution (MODIS-Terra) to configure the freshwater dimensional and hydrological characteristics from rivers. Thermal bands on satellite images were applied to identify the characteristics of freshwater plums from rivers in each coastal watershed.
5 A comparison was applied between the amounts of precipitated water and the discharged water from rivers in the coastal watershed. Thus the input/output regime was calculated.
6 The mechanism of freshwater discharge into the sea was interpreted considering all hydrological, physical and anthropic influences on coastal water basins and aquifers.

Results

- Fifty three freshwater sources (submarine springs) from groundwater discharge were identified in the coastal zone of Lebanon. Almost all sources of these springs on land were identified. It was found that groundwater is delivered largely along faults and karstic conduits from the coastal aquifers to the sea.
- Accordingly, for the analyzed satellite images, a comparative analysis was obtained each coastal watershed; therefore, the amounts of water entered each catchement was compared with that discharged from it. Consequently, analysis was obtained for each catchment to interpret the mechanism of flow from the rivers of these catchments. Thus, shape, size, time lag, residence time and many other hydrologic properties were concluded.

The Dynamics of Water and Sanitary Problem among Mumbai Slum Dwellers

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Keywords: slum, water, sanitation, wards, administratively

Introduction/Problem Identification

Mumbai is financial capital of India, where around 54 percent populations are living in slums without basic needs like water and sanitation. As such water and sanitation are the vital to urban sustainability, improving the quality of life, enhancing the urban environment, reducing the dependencies, providing the ability to remain competitive in the global arena and creating vibrant economic opportunity.

Analysis/Results and Implications for Policy and/or Research

The Mumbai slum dwellers are facing crucial situation for water and sanitation, they are not accessible to use clean as well as affordable water and proper sanitary facilities for daily life. Along this hazardous life they are dealing with life threatening diseases. Analysis shows that around 90 percent dwellers have problem in fetching water and around 97 percent dwellers are not accessible to drink clean water. Analysis also shows that around 80 percent dwellers are using public toilet, around 58 percent dwellers don't have toilets so they generally go to open and around one percent dwellers have toilets within house.

Securing Coastal Waters in East and Southeast Asia: PEMSEA Experience

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Keywords: integrated coastal management, coastal governance, PEMSEA, World Ocean Week (WOW)

The seas of East and Southeast Asia face a host of management challenges arising from severe ecosystem degradation, deteriorating water quality, overexploitation of natural resources and loss of ecosystem services which are caused and aggravated by heavy population pressures and unsustainable economic developments. Rapid coastal urbanization, change of consumption and use patterns, the negative impacts of climate change and the current financial crisis undoubtedly worsen the already serious environmental, economic and social crisis which stacks one on another in an uncertain time requiring immediate management actions. The cumulative impacts of these risks further challenge the capacity of the region to resolve them given the diverse and yet interconnected socioeconomic, political, cultural and ecological uniqueness of the region.

Economic and environmental managers have increasingly realized the need for integrated management to address the complex and complicated environmental and sustainable development issues of the coastal areas particularly a paradigm shift from the conventional sectoral management or " I " management practice to an integrated management or " T " management practice. There is a need to adopt area-wide or landscape planning and management approach of the coastal land and the adjacent seas, to install appropriate institutional arrangement for interagency and multi-sector coordination as well as to effectively implement policy and functional integration of management measures. The integrated management approach at the local level also facilitates effective implementation of relevance international conventions.

PEMSEA started as a Global Environmental Facility (GEF) / United Nations Development Program (UNDP) initiative 15 years ago to address marine pollution problems in the Seas of East Asia. One component activity was to develop, test and demonstrate the feasibility of Integrated Coastal Management (ICM). The Municipality of Xiamen in the Fujian Province of China and the Batangas Bay within the Province of Bagtangas, Philippines were chosen as the two pilot sites to apply integrated planning and management approach in addressing their environmental and sustainable development challenges. The success of the two demonstration sites led to the replication of similar but more refined Integrated Coastal Management approaches in 6 other countries in the region.

The 8 demonstration sites were able to apply the same governance framework and the appropriate processes which facilitated the implementation of various prioritized management measures ranging from pollution prevention and management of the coastal waters, managing freshwater supply, use and water resources, preventing loss of habitats and ecosystem services, increasing food security and reducing natural and human induced hazards, etc. PEMSEA also developed and implemented a regional marine strategy known as the Sustainable Development Strategy for the Seas of East Asia (SDS-SEA) and promoted political and financial support to achieve sustainable coastal development through the development and implementation of national coastal and marine policy (Japan), strategies (Philippines) and enactment of legislation to implement ICM (RO Korea, Indonesia), marine space utilization (China), sea-use zoning (RO Korea), etc.

Many lessons were learnt and experience consolidated. ICM approach has proven doable under the current complex conditions of the region particularly its ability to effectively utilize the principle of Ecosystem-Based Management (EBM) and Adaptive Management as well as the principle of Precautionary Approaches to seriously consider trades-off arising from political and economic development pressures along the sustainable development path. Based on these experiences and lessons, ICM evolves over time as a system composed of approaches, processes and mechanisms that built upon a decision-making and management framework and an ICM planning and implementing process to plan and implement a series of diversified management measures. An ICM code of practice was also developed to codify management practices in line with international governance and environmental management standards.

With a tested integrated management system, PEMSEA has been able to scale up ICM practices in the regional coastline. Local government practicing ICM has increased to 28 and is expected to increase steadily towards a set target of 20% of the regional coastline. A regional network of local government lead by the mayor of Xiamen and the governor of Bataan Province had been established and operational with annual workshop to promote exchange of experience and approaches.

Sharing knowledge, information and experience through regular interactions between various stakeholders including policy and decision makers, business and scientific communities, the academe, civil society and the local communities become an inseparable part of PEMSEA strategy. A triennial East Asian Sea Congress which was organized as an international intellectual market place began in 2003 at Putrajaya, Malaysia, continued in 2006 at Haikou, China and being scheduled in 2009 at Manila, Philippines and 2012 in Seoul, RO Korea. A remarkable achievement of the Xiamen Municipality is the annual organization of the World Ocean Week since 2005. The development of this international forum is expected to make long term contribution to securing coastal waters, an effort parallel that of the annual Stockholm World Water Week in securing freshwater. This is certainly a reflection not only of the maturity of the ICM demonstration site and the local leadership but also a demonstration of how a tiny local government can make a significant contribution to the global environmental agenda.

Workshop 3: Access to Green and Blue Water in a Water Scarcity Situation

Agricultural Water Availability and Poverty Linkages: São Francisco River Basin, Brazil

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Keywords: water availability, rural poverty, irrigation, agricultural development, rural markets

Introduction/Problem Identification

While water serves a myriad of purposes including sanitation and consumption, in rural areas the majority of precipitation use is for agricultural production. Despite the increase in urban migration, the majority of the world's poor remain in rural areas and are dependent on agriculture for their livelihoods. In many areas, irrigation-led agricultural intensification has led to increased rural economic growth. However, pockets of persistent poverty have remained, and it is unclear if increasing water availability will lift these groups out of poverty. In the São Francisco River Basin (SFRB) of Brazil, for example, poverty has persisted for many decades and policies aimed at increasing water access for agricultural use have been used as a means of addressing this poverty. However, there has not been a quantitative analysis of the linkages between water and rural poverty and the impacts of future policy actions related to water use and delivery on poverty are unknown.

Analysis/Results and Implications for Policy and/or Research

While increased access to water may be an important component for addressing the needs of large pockets of persistent rural poverty, other factors may be necessary to see positive results in these areas. For the SFRB, an index has been calculated that provides a measure of water availability based on precipitation and topography under unforced conditions. An econometric model is developed and used to examine, at município-level, the links between rural poverty, on the one hand, and water availability, agricultural production, socio-economic characteristics, and infrastructure, on the other. The analysis shows that geographic location remains a strong determinant of rural poverty and extreme rural poverty levels; municípios in the northeastern parts of the SFRB are much more likely to be poor or extremely poor. The analysis also shows that increases in irrigated area and in agricultural yields, separately, can reduce rural poverty, but that our measures of water availability were not closely linked to the structure or performance of agriculture. Investments (public and private) that increased economic options across município boundaries for rural populations consistently reduced rural poverty and extreme rural poverty. Finally, once the agricultural and socioeconomic factors related to rural poverty were controlled for, the availability of water (as measured here) had little effect on rural poverty. The robust exception was the spatial distribution of our new measure of water availability; municípios with above-average patterns of spatial variability in water availability had lower rates of rural poverty.

Improving the Efficiency of Rain Water Use on Hillsides in the Sub-Humid Tropics: Agricultural & Environmental Benefits of Quesungual System

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Keywords: agroforestry, smallholder, crop water productivity, food security, sustainability

Introduction/Problem Identification

Slash and burn (SB) is a traditional form of agriculture practiced by small-scale farmers in around 25% of tropical land area. Despite the short-term benefits obtained from using SB (i.e., source of firewood, source of nutrients for crop development, and reduction in incidence of pests and diseases), it is recognized as a non-sustainable, environmentally unfriendly practice that does not guarantee food security. Unfortunately, there are not many alternatives to SB agriculture, especially for small-scale farmers usually forced to produce on marginal soils on sloping lands in the tropics. In southwest Honduras (Central America), in the early 1990s experts from FAO identified native farming practices and worked together with farmers to develop a production system more suitable for that eco-region. The system is known as "Quesungual" or "Quesungual Slash and Mulch Agroforestry System" (QSMAS), and is locally recognized as a suitable alternative to the SB traditional system.

Analysis/Results and Implications for Policy and/or Research

QSMAS is a smallholder production system that makes use of a group of technologies for the sustainable management of water, soil and nutrient resources in drought-prone areas of hillside agroecosystems of the sub-humid tropics. It is based on planting annual crops (maize, common bean, and sorghum) with naturally regenerated trees and shrubs. QSMAS is being practiced by smallholders in Honduras, where the system has been successfully adopted by over 6,000 resource-poor farmers on 7,000 ha. This resulted in biophysical and socioeconomic benefits at multiple scales ranging from farm level (increased crop water productivity, food security) to landscape (better amount and quality of available water).

The main objective of this project was to determine the key principles behind the biophysical resilience of QSMAS and its capacity to sustain crop production and alleviate water deficits on steeper slopes with risk of soil erosion. Research activities were conducted in Honduras, within the Lempa River upper watershed, from 2005 to 2007. Mean annual (bimodal) precipitation is ~1400 mm falling from early May to late October, with a long dry season of up to 6 months. Field plots were established for the comparison of 5 main treatments: QSMAS of three different ages (<2, 5-7 and >10 years old), the traditional SB system, and secondary forest (SF) as reference. The four production system treatments (QSMAS of different ages and SB) were split in order to apply a fertilizer treatment (addition vs. no addition) to maize in the wet season (May-July) and common bean in the dry season (August-October). Studies included monitoring and analysis of soil water dynamics, crop water productivity, nutrient and soil organic matter dynamics, greenhouse gas (GHG) fluxes, global warming potential (GWP) and carbon sequestration.

Soil water dynamics and crop water productivity study showed lower susceptibility to soil erosion, lower soil and nutrient losses, higher water infiltration, lower runoff and better water quality in QSMAS

compared to SB. This suggest that benefits of management practices used in QSMAS under rainfed conditions are associated to rain intensity and soil water balances distinctive of each growing season. In the wet season, when precipitation is high and soil water balance is positive, improved resilience was achieved by dramatically reducing soil erosion. However, in the dry season, when low and erratic rainfall results in soil water deficit conditions, QSMAS improves soil water availability and therefore crop water productivity, contributing to food security. The results from the studies on N and P dynamics suggest that the management principles applied in QSMAS plots not only improve the availability of these two critical nutrients for crop production, but also contribute to the sustainability of the system through maintenance of their pool sizes over time. Main differences between QSMAS and SB are related to biomass deposition and microenvironmental conditions (i.e. humidity and oxygen for the decomposer community) that are inherent to soil depth in undisturbed soils. QSMAS also presents greater environmental benefits than SB, with lower GHG and even being a methane net sink. QSMAS has a much smaller value of GWP (42% lower in a 20 years time horizon) and a greater C accumulation in soil and trees biomass than SB.

The results indicate that the production practices applied in QSMAS have beneficial effects on the soil-plant-atmosphere continuum, soil quality, landscape and the environment. The superior performance of QSMAS through the management of its components is based on a few key principles. These include: (1) No slash & burn, through the management (partial, selective, and progressive slash-and-prune) of natural vegetation; (2) Permanent soil cover, through the continual deposition of biomass from trees, shrubs and weeds, and through crop residues; (3) Minimal disturbance of soil, through no tillage, direct seedling, and reduced soil disturbance during agronomic practices; and (4) Efficient use of fertilizer, through the appropriate application (timing, type, amount, location) of fertilizers.

Potential on the payment for environmental services provided by QSMAS could enhance its attractiveness to local and national authorities in countries with policies to protect ecosystems in the face of climate change and land degradation.

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Business Case for Green Water Credits

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Green water credits create a market for farmers' water management activities that are at present unrecognised and unrewarded. The goals are to safeguard land and water resources and to secure rural livelihoods. The arithmetic of diminishing access to fresh water is inexorable: by 2025, 1.8 billion people will likely be suffering absolute water scarcity and two thirds of the world's population will be under water stress; shortage is increasingly felt in cities. Water scarcity is bound up with land degradation, climatic change and poverty – poor people in developing counties are most afflicted. Land degradation and water scarcity are two sides of the same coin and flooding, always blamed on climate change and rainfall, is actually caused by runoff from farmers' fields – so every land use decision is a water use decision. Over the last quarter century, a quarter of all land has been degrading – mainly in Africa south of the equator, SE Asia and South China; more than three billion people face land degradation and water scarcity and there is urgent need for strategies to enable them to better manage their land.

We can't make any more water but green water resources can be much increased and downstream delivery of blue water better regulated by increasing infiltration at the soil surface – cutting destructive runoff and banking this water in the soil – and by reducing unproductive evaporation: mulching can achieve 65-90% reduction in runoff and 25% reduction in evaporation; conservation tillage 30-90% reduction in runoff; tied ridges, terraces and water harvesting 50-100% reduction in runoff. By arresting runoff, these practices conserve the soil and increase groundwater recharge and steam base flow. Soil and groundwater are free reservoirs that hold orders of magnitude more water than all existing or conceivable man-made reservoirs, so green and blue water management should be the first response to climatic change.

Conventional approaches to watershed management have been tried and tried again – and found wanting. Governments don't have the capacity manage every acre, and the project cycle has no mechanism for extension to the national scale. The alternative is to create a market in water management services that will trigger responses by many individuals. Farmers are well aware of the benefits of good husbandry but the costs are real – and higher for poor farmers because poverty imposes a short time horizon. Green Water Credits address the market failure by bridging the incentive gap with payments for specified water management services – linking upstream water managers with downstream water users who will pay for proper land and water management. This is not a handout. And the cost is no more than the marginal cost of good husbandry as opposed to bad – a fraction of the cost of conventional development projects.

A proof-of-concept in the Tana basin, in Kenya, applied a locally calibrated basin hydrological model (SWAT) and a water allocation and planning tool (WEAP) to assess the feasibility of the financial mechanism. The costs of green water management may be covered entirely by the additional water revenues and extension of the life of reservoirs. In the Upper Tana, estimated annual benefits of full implementation of Green Water Credits are $12–95 million compared with annual costs of $2-20

millions (at constant prices). With a 20% adoption scenario, the annual water benefits are $6-48 millions compared with costs of $0.5–4.3 millions – a ten-fold return on the investment. Half of this benefit comes from hydro-power generation. No account was taken of the savings on sediment damage to hydro-power equipment, flood mitigation, higher crop yields, or environmental benefits. The distribution of benefits depends on contract negotiations between the buyers and sellers – but there are benefits enough to go round.

Planning for pilot operation of Green Water Credits is now under way in the Tana Basin, Kenya, and the Changjiang Basin, for the South-North water transfer project in China; and preliminary studies in the Sebou Basin in Morocco.

Developing a Framework for Managing Water Scarcity Based Around Equity

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Keywords: water scarcity, equity, sustainability, water governance, Australia

Introduction/Problem Identification

Resource scarcity is a natural highlighter for issues of equity and justice in environmental governance. Around the world water scarcity is challenging conventional management approaches which have traditionally focussed on liquid or 'blue' water (Falkenmark & Rockström, 2006). Because it is visible and measurable, blue water is amenable to technical and market based solutions to conflicting demands from different stakeholders and the environment.

However, such water sources only account for a small proportion of the total fresh water available to and used by humans, and increasing scarcity worldwide in recent years has highlighted the limits to traditional water management approaches. This paper argues that a more comprehensive management structure based around equity could help to overcome problems with scarcity. It also considers some of the difficulties in implementing such an approach based on a study conducted in New South Wales, Australia.

Analysis/Results and Implications for Policy and/or Research

Recent research (eg. Falkenmark & Rockström, 2006) has argued for an expansion of the water management paradigm to include both 'blue' and 'green' water. Blue water, being more visible and tangible, is more amenable to management. Green water is more fugitive. However in the context of escalating global scarcity, increasing use of green water will be required to ensure people have adequate water for both basic human needs and agricultural production to feed the world's population.

Ohlsson and Turton (2000) identified three forms of societal adaptation to water scarcity. Firstly, supply-side solutions (which have generally come first), generally driven by engineering solutions including large-scale infrastructure development. Secondly, demand-side adaptations, with the promotion of end-user efficiency and often involving economic incentives for water saving. Finally, further demand-side adaptations in the form of allocative efficiency to maximise the economic efficiency of water use.

The emerging challenge is to establish an institutional framework which is capable of incorporating both blue and green water, so that the environment is not compromised in such a way that it endangers societal adaptation. This paper argues that such a framework must be built around notions of equity, based on a study considering the importance of equity to water management in Australia, particularly between urban and rural areas. It involved thirty interviews with senior water managers in Australia and the analysis of over 280 questionnaires.

The study found that equity provides a framework for addressing competing (and sometimes equally valid) claims in a context which favours compromise and collaboration, can take into account non-market, non-economic and non-quantifiable claims in resource redistribution, and equity is a key cornerstone of sustainability. Importantly, equity provides a framework for redistribution scarce water

while maximising societal engagement and participation. Solutions to the current problems of water scarcity will inevitably cause social pain, but the advantage of a framework based on equity is that it maximises stakeholder ownership of the problems and the solutions, and increases the likelihood that solutions will be socially and politically accepted.

However, there are still some important unresolved issues in developing an equity-based framework for water management that is able to be practically implemented. Although both water managers and citizens in the study considered equity an important goal of water management, it was clear that significant work is required to develop a framework for adequately incorporating equity into water management. Managers found it difficult both to define what equity should mean for water management and how it should be achieved. This contrasted with the ease with which they talked about the development and implementation of supply and demand-side management. The questionnaires reinforced this, showing that conceptions of what 'equity' actually means in practice still requires political and social negotiation.

Nevertheless, it is argued that an equity-based framework for water management offers some important benefits. It reduces our reliance on numerical accuracy in water management, allowing the incorporation of 'green' water into management approaches despite the measurement and accounting difficulties. It also promotes consensus and increases the likelihood of communities accepting outcomes of management (cf. Syme and Nancarrow 2005). Finally, it is a key cornerstone of sustainability, without which water scarcity can only become more severe and damaging on a global scale.

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Addressing Water Scarcity in Australia's Urban Centres: The Tension between Blue and Green Water Provisions

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Keywords: urban water policy, climate change adaptation, water scarcity, Sydney, Australia, South-east Queensland

Introduction/Problem Identification

Australia has a highly variable climate ranging from tropical monsoons in the north to sub-alpine areas in the south. As a result, the population is clustered around major temperate zone coastal urban centres.

Since 2000, Australia has experienced a prolonged drying sequence, sometimes referred to as the 'Millennium Drought'. Seven of Australia's eight capital cities have imposed water restrictions to ration available water in urban areas. This has been a direct response to a shortage of 'blue water' availability.

The drought has also resulted in a shortage of 'green water' with water allocated for ecosystem services also rationed.

This paper will examine the policy and institutional responses adopted in Australia during times of water scarcity focussing on the major urban centres of Sydney and South-East Queensland. In particular, it will explore the tensions between allocations of blue water and green water and the additional challenge of climate change.

Analysis/Results and Implications for Policy and/or Research

The 'Millennium Drought' has provided significant impetus for revisiting blue water and green water provisions in urban centres across Australia. This is true for both Sydney – Australia's largest city and home to 4.5 million people and south-east Queensland – a rapidly growing area, currently home to 2.9 million people with an annual growth rate of 2.4%.

Sydney's response has been articulated in the Metropolitan Water Plan, first published in 2004 and regularly reviewed since. The three pillars of the plan are to reduce demand, increase supply (including through construction of a AU$ 2 Billion desalination plant and the use of recycled water) and protect river health. The mix of measures outlined to achieve a supply / demand balance for Sydney is premised on ensuring that green water needs are not overlooked. However, as dam levels plummeted, the blue water needs of the population were prioritised and measures to ensure additional green water to perform essential ecosystem services became conditional on blue water availability. Despite the rhetoric, some genuine gains have been made in relation to provision of green water, albeit to apply once blue water availability has been secured.

Concurrently, a major research project into the impacts of climate change was commissioned, and it is expected that adaptation will entail a sophisticated response to capitalise on the seasonality of changes expected, especially when considered alongside demand side responses.

In South-East Queensland, the drought has resulted in a major institutional realignment to respond to the challenges arising from blue water service provision during times of water scarcity. A diversification of sources away from reliance on blue water alone has seen major investment (AU$9.2 billion) in manufactured water supply sources – that is purified recycled water, in addition to desalination.

The framework for water resource planning in the region makes explicit provision for protection of the values of green water such as through the inclusion of ecological outcomes that seek to minimise changes to the delivery of freshwater sediment, nutrients and organic matter to estuaries of the Pacific Ocean.

A South-East Queensland Water Strategy is currently being finalised by the Queensland Water Commission. The Strategy addresses the difficulties in forecasting long-term future demands for water – particularly in relation to climate change. Essentially, the Strategy provides direction for the South-East Queensland community in terms of future water supply by describing the relationship between blue water sources and incorporating manufactured water supply sources into the Water Grid.

As each major centre has grappled with drought in its own way, a number of common principles began to emerge. To ensure a degree of consistency, and subsequently to inform national infrastructure investment criteria, a series of National Urban Water Planning Principles have been developed and adopted by First Ministers of all jurisdictions. As a policy response, these principles provide guidance and direction in ensuring that both blue water and green water considerations are taken into account for both long term and short term planning. These principles recognise that the high degree of climate variability already experienced in Australia makes the challenge of adapting to climate change even more pertinent.

The principles cover issues such as:
- agreed levels of service, including consideration of climate change and seasonal variability;
- using an evidence based approach utilising the best information and knowledge available;
- adopting a partnership approach so that stakeholders views are taken into account;
- using a whole-of-water-cycle basis for management of potable water supplies;
- consideration of a full portfolio of options, including the ability to deploy readiness strategies in times of water shortages;
- consideration of sustainable levels of extraction including the ability to reassess changes in scientific knowledge and climate variability;
- using markets and pricing where efficient to signal the full value of water; and
- periodic evaluation through regular reviews.

The principles have tried to adopt an adaptive approach to ensure that changes in scientific knowledge are captured in successive short term and long term water planning exercises. This in effect acknowledges the challenges faced when ensuring that there is access to both blue water and green water. Inevitably, as populations using blue water have a voice and are able to vote, the provision of adequate green water will lag.

The challenge for researchers is to capture a better understanding of the ecosystem services and their values in terms that can be compared on a cost-benefit basis, and the challenge for policymakers is provide a voice for green water during times of water scarcity so that the long term health of the environment is not compromised.

Rooftop Rainwater Harvesting as a Unique Way for Efficient Utilization of Water Resource in Rural Areas: A Case Study in Karnataka State, India

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Keywords: rooftop rainwater harvesting, rural areas, domestic water resource, government, water scarcity

Introduction/Problem Identification

Water is a precious commodity and the basic need for the human survival. Seventy percent of the earth surface is covered with water but only a small part of this water can be used for human consumption. In India rapid population growth, urbanization and industrialization have increased the demand for water. Over exploitation of ground water has resulted in depletion of water table. In this situation government of Karnataka in India has realized that, Rainwater Harvesting is one of the best solutions for water related problems and to meet the ever-growing demand for water in the state.

Analysis/Results and Implications for Policy and/or Research

In the year 2005, the Government of Karnataka implemented more than 3000 Rooftop Rainwater Harvesting systems through the Rural Development and Panchyath Raj Department, in all the 176 Talukas (sub-divisions) of 27 Districts (divisions) in the state, as a part of Drinking Water Resource Development programme. This programme covers one village in each Taluka of the State, with at least 20 household level Rooftop Rainwater Harvesting systems. The principle of collecting and using precipitation from roof area is referred as Rooftop Rainwater Harvesting.

In the present work rural part of the Bangalore district in Karnataka state is selected for the study. The study reveals that Rooftop Rainwater Harvesting systems make a lot of differences to the lives of rural poor, people have realized the need and importance of Rooftop Rainwater Harvesting systems programmes in solving their water problem. Hence, there is a potential demand for Rooftop Rainwater Harvesting systems programmes in rural India. This study emphasizes the importance of developing Rooftop Rainwater Harvesting systems as a domestic water resource in the rural parts of India.

Integrated Green-blue Water Management in the Jordan River Basin, WEAP-Based Scenario Analysis

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Keywords: Jordan River, scenario analysis, green blue water, transboundary water, conjunctive management

Introduction/Problem Identification

Given the complete allocation of all blue water resources in the Jordan River basin, the rapid population growth and the projected dramatic decrease in water availability due to climate change, there is a need for new development pathways that deviate from the current hydraulic mission. Increasing supplies – lately with non-conventional resources – is no longer an option for the future.

Analysis/Results and Implications for Policy and/or Research

In order to explore alternative water futures that integrate green and blue water, we have developed WEAP (Water Evaluation and Planning) based scenarios for the transboundary Jordan River basin, jointly with partners from the riparian countries. The Jordan WEAP addresses green and blue water uses, productivities and potential for improvement. WEAP is a decision support tool that integrates the main water supplies, demands and water system properties. On the blue water side, it integrates surface and groundwater and facilitates conjunctive management through coupling with MODFLOW. More recently we've also begun to integrate within the same framework green water fluxes and their interactions with the blue water part of the basin's water system. The WEAP tool allows comprehensive testing of different scenarios and management options of blue and green water resources, including re-allocations between different users and water demand types.

In an initial application of this WEAP scenario tool for the Jordan River basin, various climate, development and management scenarios have been evaluated and compared with respect to overall water stress and spatio-temporal distribution of water gaps. Furthermore we have compared the effects of the planned Red Sea -Dead Sea Canal (the latest and biggest in the long list of the basin's blue water infrastructure projects) with the cumulative effects of other upstream measures, such as demand management, water harvesting, wastewater reuse and re-allocations of surface and groundwater. Initial findings indicate that the canal will be a less flexible option for covering the future water gap, compared to a combination of upstream and green water measures.

Experiences with Water Supply and Sanitation in Water Scarce Regions in Mexico

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Keywords: biotoilet, controlled soil natural treatm, graywater treatment, rainwater harvesting, sustainable systems

Introduction/Problem Identification

Central Mexico, a semiarid region, is currently facing severe water availability problems and strong pressure on water sources caused by the rapid increase of population, industrialization and intensive agriculture. Overexploitation of aquifers and surface water bodies is becoming restrictive to population water supply. Integration of rainwater harvesting with other strategies such as ecosan technologies and treatment and reuse of graywater arises as a feasible, holistic and sustainable solution for water supply and sanitation at house and house clusters levels. Development of holistic sustainable systems has become a reality through the implementation of two pilot systems in both rural and urban areas of Central Mexico. Such pilot systems involved the design and installation of rainwater systems; installation of biotoilets, fed with conventional electricity or solar power supply, and the design and construction of a controlled soil natural treatment systems.

Analysis/Results and Implications for Policy and/or Research

Two pilot systems were installed and they were integrated by three main subsystems, rainwater harvesting system (RWHS), biotoilet system (BTS) and controlled soil natural treatment system (CSNTS). The procedure adopted to implement and monitor the pilot systems consisted in:

a Selection of project sites
b Establishment of the rain water harvesting system (RWHS)
c Installation of the biotoilet system (BTS)
d Establishment of the controlled soil natural treatment system (CSNTS)
e Monitoring and evaluation of biotoilet performance. Biotoilet was operated continuously in the both pilot systems sites from April 2007 to May 2008. During this period compost stability was evaluated and evolution of temperature, moisture content and nitrogen compounds was monitored regularly.
f Monitoring and evaluation of quality of the CSNTS effluent.

Regarding the current pressure on water resources not only in Mexico, but around the world, and the enormous challenges the water supply and sanitation sector is actually facing, development and implementation of sustainable systems based on holistic integration of technologies for rainwater harvesting, ecological sanitation, treatment and reuse of domestic graywater has become crucial to achieve the Millennium Goals.

Development of holistic sustainable systems has become a reality through the implementation of two pilot systems in both rural and urban areas of Central Mexico. Such pilot systems involved the design and installation of rainwater systems; installation of biotoilets, including a solar power supply system in one of them, and the design and construction of a controlled soil natural treatment systems.

Monitoring of the systems for longer one year has shown that:

a Holistic integration of different technologies for ensuring better water supply and sanitation is feasible on the practice. Procedures and strategies were fully described in this paper.
b Integration of rainwater and graywater treatment and reuse systems ensures enough water with quality to be used in non potables uses inside the household.
c Toilet wastes are completely stabilized on the biotoilet systems operated at ambient temperatures (no heating). It means safe compost at low operation costs.
d Sociocultural evaluation of the biotoilet reveals that its acceptance is similar to the conventional WC and superior to the dry toilet systems.
e Integration of solar power generation plays an important role in providing electricity for operating the biotoilet and hydraulic pumps on isolated rural areas.

Integration of Rain Water Harvesting with Ecosan Technologies and Graywater Treatment and Recycle in Water Scarce Regions in Central Mexico

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Keywords: biotoilet, controlled soil natural treatm, graywater treatment, rain water harvesting, recycle

Introduction/Problem Identification

Rainwater harvesting emerges as an alternative to increase the water availability in water scarce regions around the world. The feasibility of rainwater harvesting in any community depends greatly on rainfall magnitude and intensity. Due to the irregular annual distribution of rainfall, rainwater harvesting is just a supplementary source of water. Thus, in low rainfall regions as 65% of Mexican territory is, rainwater harvesting is not enough to ensure the water supply of population, especially in rural communities where water supply service and facilities are not available. In this study integration of rainwater harvesting with ecosan technologies and graywater treatment and reuse was conducted through the implementation of a pilot system in a rural house of Central Mexico. This integration enhances water conservation, water availability and reduces pressure on aquifers exploitation. At the same time, ensures the water supply, sanitation and the ecological environment of the region.

Analysis/Results and Implications for Policy and/or Research

A cost comparison of different water supply methods respect to the urban water supply tariff, applied on the nearest urban area was conducted. The water supply tariff of the urban area nearest the pilot system installed at the rural house was approximately US$ 0.50/m^3. Comparison results showed that water for rural population results approximately 10 times more expensive than that for urban people. Graywater treatment by means of the Controlled Soil Natural Treatment System (CSNTS) and its reuse for non potable uses and rainwater harvesting represent cheaper options for population of rural regions in Central Mexico, reducing the relative cost to a little more than 3.0 times the urban tariff.

Additionally, it was found that integrating rainwater harvesting with biotoilet and graywater treatment and reuse the water demand of rural regions is plenty satisfied (100% of coverage).

Additional environmental benefits are derived of integrating rainwater harvesting with ecosan technologies (biotoilet) and graywater treatment and reuse:

a Improvement of public health by minimizing the entering of pathogens contained of human excreta into the water cycle.
b Effective stabilization and management of toilet wastes (faeces, urine and toilet paper).
c Reduction of fresh water consumption in 47%: 31.4 L/capita/day are potentially harvested and the biotoilet allows savings of 60.0 L/capita/day.
d Zero wastewater discharge (sewage is not required).
e Onsite graywater reuse in the order of 114.5 L/capita/day.
f Recovery of groundwater levels.
g Stabilization of micropollutants (hormones and pharmaceuticals) contained by the human excreta.
h Safe and hygienic recovery of nutrients contained in human excreta.

i Reduction of consumption of chemical fertilizers and preservation of soil fertility.

The study concludes that:

a Water for rural population results approximately 10 times more expensive than that for urban people. Graywater treatment by means of the CSNTS and its reuse for non potable uses and rainwater harvesting represent cheaper options for population of rural regions in Central Mexico, reducing the relative cost to a little more than 3.0 times the urban tariff.
b Integration of rainwater harvesting with biotoilet and graywater treatment and reuse ensures 100% of coverage of the water supply and sanitation in water scarce regions of Central Mexico.
c The integration of rainwater harvesting with ecosan technologies (biotoilet) and graywater treatment and reuse is an affordable and sustainable solution for water supply and sanitation in rural and peri-urban areas of water scarce regions.

Storing and Sharing Water in Sand Rivers: A Water Balance Modelling Approach

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Keywords: alluvial aquifer, Limpopo basin, sand dam, sharing water, water balance modelling

Introduction/Problem Identification

In order to support planning for optimising water use and storage over evaporation and to provide for more equitable water allocation, the spreadsheet-based balance model WAFLEX was used. It is a simple and user-friendly model, ideal for use by institutions such as the water management authorities in Zimbabwe which are challenged by capacity shortfalls and inadequate data.

Analysis/Results and Implications for Policy and/or Research

Results of the WAFLEX modelling suggest that there is surplus water in the lower Mzingwane system, and thus there should not be any water conflicts. Currently less than 2,500 ha are irrigated, mainly by commercial users. Through more frequent timing of releases from the dam and maintaining the alluvial aquifers permanently saturated, less evaporation losses will occur in the system and the water resources can be better shared to provide more irrigation water for smallholder farmers in the highly resource-poor communal lands along the river. Sand dams are needed to augment the aquifer storage system and improve access to water.

An alternative to the current scenario was modelled in WAFLEX: making fuller use of the alluvial aquifers upstream and downstream of Zhovhe Dam. These alluvial aquifers have an estimated average water storage capacity of 0.37 Mm^3/km of which 0.35 Mm^3/km is below evaporation extinction depth. The 137 km of aquifer could therefore conceivably store some 46 Mm^3 of water, 35 % of the capacity of Zhovhe Dam. This would be sufficient to irrigate 3,000 to 11,000 ha in a belt 100 to 400 m wide along each bank for the full the length of the river. The range depends upon the configuration of reservoirs and their operation and on irrigation efficiency. Such a system would be decentralised, farmer or family owned and operated and the benefits would have the potential to reach a much larger proportion of the population than is currently served. If storage upstream of the alluvial aquifer were available – for example through the construction of a reservoir at the Oakley Block site – then the aquifer could be recharged several times per year and a much increased water supply made available. However, there is very limited information on the hydrogeological properties of aquifers upstream of Zhovhe Dam and the figure could be lower than this. Downstream impacts must also be considered.

Simulation of Smallholder Farming Systems in the Olifants River Basin, South Africa

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Keywords: farmer income, farm simulation, farming systems resilience, gross margin, labour returns

Introduction/Problem Identification

Food security for a healthy life and sustainable landuse have been the focus of a number of domestic (DWAF, 2004) and international policy initiatives (FAO, 1996). However, challenges remain, with more than 800 million people undernourished mostly from Africa and Asia (Weibe, 2002). To many of these resource-constrained people, food security (World Bank, 1986) depends on farm production. Smallholder farming systems are characterized by low yields and high risks of crop failure, thereby threatening family food security. The smallholder farm performance with respect to food production and farm profitability is poorly understood. Through biophysical model, PARCHED-THIRST model and socio-economic farm simulation model, OLYMPE, we evaluated the performance of farms based on maize yield, gross margin and total farm balance in the semi-arid Olifants river basin, South Africa. The work is important to identify farms vulnerable to food security and in need of developmental assistance.

Analysis/Results and Implications for Policy and/or Research

Assumptions on scenarios studied

In maize under different productions scenario, changes in yields are only due to increased productivity of the land as a result of new technology developments in water, land and crop management. There is increase of production without quality changes for the planting basins technology. Farm labour and crop area is limiting. Hence, the size of the farms remains the same during the simulation period. There is no significant deterioration to soil quality such as through erosion during the period of simulation. Under maize price inflation scenario, the change only occurs to maize price others factors (costs of inputs, labour, productivity) are kept at basis level (2008). For fertiliser price inflation scenario, only affects fertiliser price, but not the quantity applied or quality and other input costs are kept at the basis level. The number of family members on farm remains constant in the simulation period (the rate of new farmer is equal to the death rate of farmers).We used the currency ZAR or R to represent South African Rands and according to 2008 figures 1US$ was equivalent to ZAR 9 (SAFEX, 2008). Finally the conditions at farm scale are assumed spatially homogeneous.

Analysis/results and implications

Using OLYMPE model we explored the future farm profitability and farm risks under scenarios of maize and fertilizer price inflation and weather hazards on maize productions for identified farms, subject to constraints of capital, land, water availability, labour, and market price dynamics. Five farming types (A-E) identified from surveys were refined and validated with farmers and extension officers in the field. The results demonstrate the great opportunities that exist for upgrading farming systems in the B72A quaternary catchment in Olifants, especially rainfed agriculture by use of planting basins to ensure food security and profitable farming in rural communities. The farm type vulnerability order to severe droughts and food insecurity, starting with the most vulnerable is farm type B, C, D, A and E. Compared to other shocks tested in the farming systems, severe drought/cyclone resulted in most

gross margin and total farm balance loss, partly due to loss of production for own consumption. The overall resilience of farming systems based on livestock to climatic variability and market shocks is relatively high, followed by crop diversified farming systems when compared to other farming systems. The study suggests that integrating livestock (cattle, goats and sheep) production into the crop farming systems results in a better farming scheme than farm productions solely based on crops to improve farm system resilience. While, new technologies (zai pits/planting basins) may help increase maize productivity, land availability and possibly labour may affect the production response. Suitable marketing strategies are also important. The temporal variation of gross margin was due to rainfall variability that affected maize yield and the price inflation of inputs and outputs.

Returns on labour ranged from 0 under crop based, farm type B and C to ZAR 2 139/capita in farm type E. Farm type D with diversification showed ZAR 471/capita. Planting basins improved farm household own food production and income generation promoting food security at farm level compared to existing crop management practices. OLYMPE model was able to simulate the farming systems productions in the catchment with good performance by revealing that no one best farming solution suits all the farm types. Hence, the OLYMPE model is a suitable tool for farm production risks assessment and better targeting of agricultural policies by planners and policymakers from small scale to a larger scale in future studies, provided adequate model input data is available. Our results obtained with resource-constrained smallholder farmers increase the knowledge of important perturbations that cause food insecurity in the absence of social safety nets. The results revealed that livestock and crop diversification are most adept strategies to ensure stable income and food security for smallholder farmers. Thus, technology innovations and policies should articulate solutions to poor yields and livestock farming based on these two farm types in the Olifants basin. The next step is to discuss among farmers, extension officers and other stakeholders the different management practices that enhance their crop yields, and assess their robustness using OLYMPE model.

Climate Change, Drought and over Exploitation Impacts on Green and Blue Water Management – A Sri Lankan Experience

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Keywords: synergies, water scarcity, ecosystem services, sustainable, application

Introduction/Problem Identification

Global warming and climate change perceived by all over the world also affect our country. In the developing world more and more blue water is needed to support economic development and food production for increasing population, but rivers and ground water are getting increasingly over committed and many water sources are drying and polluted. This has raised interest in making better use of naturally infiltrated rain, where Ruhunu Basin in Southern Sri Lanka were described as a pilot case study in the first World Water Development Report(UN_WWAP, 2003). This Poster illustrate the challenge and how to broaden green water policy development and proper linkages to land use management policies by integrating green and blue water governance in IWRM. It is highlight the pivotal role played by access to safe water and sanitation in fight against poverty, where its crucial role for achieving basic livelihood security through water supply, health, hygiene and food is complex.

Analysis/Results and Implications for Policy and/or Research

Ruhunu Basin (the Kirindi River) is the source of potable water to over half million people with in the basin. Recent studies confirmed the observation that due to rapid urbanization and construction boom taken place under the new development programs, and the Post-Tsunami reconstruction the demand for water in construction, domestic, irrigation, ecological and waste disposal has increased. But in the dry season river basin is drying due to excessive illegal pumping. Pollution of the basin is widespread and identified causes are dumping and discharges of untreated urban domestic and industrial waste, water quality testing showed that surface water polluted by faecal matter, spreading diarrhea. There are about 6700 shallow and 650 tube wells in the river basin, supplying drinking water for 16755 families and commanding 3,300 ha to irrigate intensive cash crops, creating intensive water market in the basin. Over pumping linked to the contamination of drinking water with arsenic, conflicts are also emerging between various water users, leading to over exploitation ground water resources to meet the current high demands.

This alarming growth of water scarcity, decreasing blue water per capita and health impacts, coupled with wide spread environmental degradation has brought in to focus the need for secure access to both green and blue water through planned action to manage water resources in a more effective way. To face these challenge, the government of Sri Lanka, have adopted IWRM planning system, through the National Development Council introduced new Irrigation Policy initiatives, MANIS Project (Management of Irrigation Schemes), granting Rs 4.000 million from the World Bank and IUCN. Address this goal through several approaches; (1) Integrated River Basin Management to secure compatibility between different water uses through green-blue water management, policies and governance. (2) New practices in rain water harvesting and land management to secure the more green water for crops, ground water recharge and stream flow to meet the need of both socio economic development and ecosystem services. (3) Special attention paid to provide equitable provision of fresh water for the environment and for livelihoods. (4) Established Institutional frame work to provide the mutual

relationship required between natural resources and rural communities, with the responsibility of protecting valuable water resources and catchment areas for the benefit of future generations.

Results and Findings

1 MANIS Project and the Water Resources Authority amalgamated for integrated approach, in which basin managed holistically, through the establishment of 36 River Basin Councils (RBCs) with the participation of water user- stakeholders in river management decision making and ensuring catchment based integration of conflicting water requirements.
2 Strengthened institutional mechanism, establishing 53 Sub RBCs for drinking water distribution and management. Stakeholders participated in preparation of upper watershed conservation planes and implemented them with the IUCN funds; given legal status to control the culprits, illegal loggings, clearing in protected areas.
3 Intensive cash crops and the demanding water market persuade to extract, more and more water, depleting the ground water level. As a remedy the project ban 90 % of the illegal wells and registered suitable wells under the RBCs and enacted tariff, ensuring the accountability and transparency in the community management of natural resources as this is the key element for economic development.
4 Awareness programs on river basin, watershed, ground water, soil conservation, rain water harvesting, ecosystem, set up activities for each stakeholders group to educate and raise awareness by the Authority with the IWMI, leads to: (1) They construct hundreds of rainwater catchment surfaces, small dams, land terracing, enabled a potential of approximately 567,456 cubic meter of rainwater per year. (2) Water level of 95 % shallow wells increased,
5 The dwindling water resources need to be optimally managed, without polluting them while minimizing negative impacts on the environment, i.e.; sugar cane and molasses factories in the basin, had to obey to the liability rules of the project and go to cleaner technologies.

Conclusion

Water scarcity is acknowledged to be a key barrier to attainment of proper sanitation, hygiene and economic development. MANIS project was an appropriate tool for sustainable land management, water resource and environmental development. It can be replicate other developing countries as it has been found synergies and complementarities between green and blue water use to meet the needs both socio-economic development and ecosystem services maintenance in the context of extremely scare fresh water of the region.

Keys to Unlocking the Potential for Food, Livelihoods, and Ecosystems

Author: **Dr. David Molden** (Keynote Speaker)
International Water Management Institute (IWMI)

If we continue with our present water management practices, we will need twice as much water as we use today to meet growing demands. Change is desperately needed now to avoid excessive damage to ecosystems, and to improve livelihoods of the poor who will bear the brunt of poor water practices. An important conceptual step in meeting this challenge has been offered by the green – blue water paradigm. These concepts expand the view of water resources past rivers, lakes, reservoirs and groundwater to explicitly include rainfall as the ultimate water source, to carefully consider how water is depleted by evapotranspiration, and to understand how water is reused. Water for agriculture and food production will be a key driver of change, and fortunately there are several possibilities opened by this paradigm that can help us get through the various water challenges confronting us in the near future. But even though these concepts are helpful, and people are innovating, the pace of change is not nearly fast enough. We have good ideas on what to do, but how to do it is more elusive. This presentation focuses on the "how to" by providing strategies for unlocking potential to implement change.

Rainwater Management for Drought Mitigation in Semi-arid Smallholder Cropping Systems

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Keywords: rainwater, drought mitigation, semi-arid, cropping systems, Zimbabwe

Introduction/Problem Identification

Rainfed smallholder cropping in semi-arid Zimbabwe is constrained by frequent droughts and mid-season dry spells despite years of research on soil water management technologies. In southern Zimbabwe, it is actually rare for drought or mid-season dry spells not to occur and this has led to permanent food insecurity for the majority of households in that part of the country. The advent of conservation agriculture techniques such as planting basins and animal drawn ripper, and dead level contours has brought new hope to the smallholder farmers in semi-arid areas. This paper reports on crop yield and soil water results from 3-4 years of study in Gwanda and Insiza districts and Matopos Research station.

Analysis/Results and Implications for Policy and/or Research

The assessment of soil water dynamics in conventional, ripper and planting basin tillage systems with or without mulching revealed similar soil water patterns even in growing seasons with below average rainfall pattern on both clay and sandy soils. The planting basin system had higher profile soil water content at the beginning of the seasn and this facilitated a better maize crop establishment in all seasons. There were no significant maize yield differences observed under the conventional, ripper and planting basin tillage systems regardless of the seasonal rainfall pattern. The study on the assessment of dead level contours and infiltration pits revealed negligible lateral soil water movement from the between field structures into the cropped fields. Lateral soil water movement from dead level contours and infiltration pits could only be detected after rainfall events of more than 40 mm.

The results from our study have demonstrated that the performance of the in-situ techniques and between field structures is heavily dependent on the seasonal rainfall pattern. Research and extension agents still have to modify the current technologies so that they buffer smallholder farmers against variable rainfall in semi-arid southern Zimbabwe.

Rain Water Harvesting: A Community'S Technology to Cope with Water Scarcity

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Keywords: rain, harvesting, cope, water, scarcity

Introduction/Problem Identification

Youth in Development (YID) is a NGO that is involved in the implementation of water and sanitation projects in Mukono district. Mukono district is one of the largest districts in Uganda with a rapidly growing urban population. This is coupled with climate change which has resulted into more frequent extreme weather events like droughts and storms. Thus increasing stress for water needed in agricultural production and domestic purposes. To address the water crisis YID decided to promote low cost rain water harvesting (RWH) technology so as to provide safe water throughout the seasons making a crucial difference for vulnerable people. RWH technology is simple and efficient in adapting to climate change. For instance increased access to water during scarce and unreliable rain showers can be achieved by harvesting rain water in tanks and small dams.

RWH is an avenue for poverty alleviation due to increased access to water for economic activities like agriculture.

Analysis/Results and Implications for Policy and/or Research

A third of nations are suffering from water scarcity. Water scarcity in both its qualitative and quantitative forms is manifesting its self as a major development challenge for many countries. In this particular context this problem is affecting both the rural and urban poor.

The following participatory approaches have been used by Youth in Development to promote low cost rain harvesting jars address water scarcity

Trainings

Several trainings were conducted with the aim of building the capacity of the community members to undertake the rain harvesting technology effectively. The trainings focused the need for rain water harvesting, construction of water tanks, small dams, maintenance of safe water chain and proper operation and maintenance among others.

Establishment of modal homes

Youth In Development established a modal home in each village. This was to enable the women and other community members to acquire skills and knowledge in rain water jar construction. Other hygiene and sanitation structures like, dish rack, hand washing facility and bath shelter were demonstrated. More a small dam was constructed to demonstrate to the community members how to tap runoff rain water.

Exposure visits

The community members have been taken for exposure visits to other communities where the same initiative was successfully implemented. The visits have enabled women to learn from their colleagues through sharing experiences and motivated them to replicate the technology in their communities.

Innovative financing
To make rain water tanks available to poor households, revolving loans were made available to low income households. This project was dominated by women who participated from the start to the end. The men were occupied by agricultural activities. However some men were able to participate. The cost of the materials was set aside by the project, borrowed with no interest and payable in two years. The community members were encouraged to save monthly a portion of their proceeds from agricultural activities so as to service the loan.

Gender consideration
This initiative put more emphasis on empowering women in rain water harvesting due to the fact that they are among the most affected people in circumstances of water scarcity. The women acquired mansonary skills in small dams and rain water tank construction. As a consequence this has become an income generating activity for them. A group of women in from one village were trained in the construction of water tanks and they later trained women groups in other areas.

Development of Information Education Communication materials
I.E.C materials were produced with the active involvement of the community members. The materials were used sensitize community members how to address water scarcity through rain harvesting, construction, proper operation and maintenance of the rain harvesting tanks.

Results
This initiative has resulted into increased access to safe water in the targeted water stressed areas. More so the water has enabled the community members to increase on agricultural production and household incomes. Lastly improved hygiene and sanitation situations have been observed in the communities.

Conclusion
Rainwater harvesting has been identified as the technology with the potential of contributing immensely as a coping mechanism for climate change and variability. This is through increasing the quantity of green water flows through evaporation and transpiration in order to improve food production and ecosystem support.

Tank Based Watershed Development to Harvest the Blue Water and Green Water Enrichment in the Drought Prone Districts of South Tamilnadu, India

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Keywords: tank, watershed, conservation, moisture, drainage line

Introduction/Problem Identification

The southern districts of Tamilnadu particularly, Madurai, Sivagangai, Ramnad and Tuticorin districts are drought prone and vulnerable spots for the water scarcity during major part of the year with rainfall ranging from 750mm to 850mm only. The total numbers of rainy days are limited to 45 to 60 days only. Because of this situation the ancient people in this area have built the traditional earthen water harvesting structures called tanks to store the available rainfall during the monsoon period and use the same for the remaining period of the year for the benefit of the agriculture and drinking water and other uses. But during the ten year cycle these regions are undergoing different situations for the water scarcity situations as 3 years might be of normal condition, another 3 years may be with water scarce situation and the remaining period might be with complete drought.

Analysis/Results and Implications for Policy and/or Research

The DHAN Foundation in collaboration with the state government department implemented the tank based watershed development project at 30 more numbers of the micro watersheds with the areas covered by 30000Ha of geographical land area covered under these micro watersheds. In this innovative pilot on Tank Based watershed Development, we concentrated to rehabilitate all the water bodies say tanks existed in the watershed to augment the storages as to harvest maximum water through the run off as to harness the blue water and this is available to the agriculture and other echo system management such as rearing fisheries and others. The rest of the catchments in the watershed are planned with the insitu soil conservation activities such as contour trenches across the slopes, Filed bunding, tree plantations and providing farm ponds in the private lands etc as to retain the soil moisture to enhance the rainfed agriculture. By this experimentations, we realized the following learnings at the end of the project period as narrated here under:

Before implementing this concept of the tank based watershed, the functional efficiency of the water bodies, particularly the tanks, were only 45 to 50 percent. But after the rehabilitation of these water bodies the functional efficiencies have increased to 75 to 85 percent and through this the tankfed agriculture has been stabilized to 85 to 90percent.

Because of the water stored in the tank for more period the considerable amount of ground water recharge has been happened. People realized the remarkable improvement of ground water table raise.

Because of the soil conservation measures in the tank catchment with in situ soil conservation measures, the tanks have noticed the less amount of silt deposition and soil moisture have been improved in the dry lands in the catchment and people started growing the tree plantation such as amla, mango and other dry land horticulture species. The considerable development related to increase in the livestock population also noticed in the region where ever these watershed development project is implemented.

This concept of Tank based watershed integrated both the water resources development as well as the soil conservation measures as to simultaneously develop and manage the blue and green water when compared to the traditional watershed management which only partially aim to harness the green water say soil moisture.

Working Trade-offs in Complex Water Situations in India

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Keywords: decision support system, groundwater scarcity, water allocation, water demand, hydrology

Introduction/Problem Identification

Increasing water demands by rapidly growing economies is constraining fresh water availability. Virtually all sectors of society intersect in determining the water future, especially recognizing the diverse and competitive needs. This applies to industry and agriculture sectors in India. Both not only play a dominant role in the growth and development of the country, but, also place huge competing, and often conflicting, water demands. The question is how to carefully evaluate trade-offs between water users and how these affect local water concerns in order to optimise investments while fostering sustainable development. A Decision Support System that can integrate natural and human systems has been conceptualized. Validation has been done for a large basin located in north-west of India experiencing competing demands, water scarcity, and high rainfall variability. Various strategies have been discussed. This constitutes a framework for working trade-off under complex water situations.

Analysis/Results and Implications for Policy and/or Research

Industry and agriculture sectors, in India, contribute to around 50 percent of the total Gross Domestic Product of India, employ more than 80 percent of the total workforce, and use more than 90 percent of the total water available. Both the sectors play a dominant role in the growth and development of the country.

In situations of local water scarcity, defined as areas experiencing water depletion, high variability in rainfall and/or frequent drought conditions, both, agriculture and industry, place huge competing and often conflicting demands for fresh water. On one hand, informal riparian rights of farmer communities put a huge pressure on the local government to attract precedence over industrial water use. On the other, industry expects the state government to provide them with a solution that minimizes the risk to their operations arising as a result of conflicts with farmers, even leading to a shutdown of operations under extreme cases. The question is how to carefully evaluate explicit trade-offs between water users and how these affect local water concerns in order to optimise investments while fostering sustainable development, especially under water limiting scenario.

To accomplish this, GIS based Decision Support System (DSS) that has the capability to integrate natural and human dimensions including natural water availability as determined by land phase of the hydrological cycle, groundwater recharge, water used by various users such as agriculture and industry, and water impacts both at aggregate and disaggregate levels (or regional/ basin and local levels), has been conceptualized in this study.

The validation of DSS has been done for a large basin located in north-west of India experiencing competing demands, water scarcity, and high rainfall variability. Results obtained from the application of DSS show a good comparison with the observed water balance in the region, determined by natural availability, recharge and use. Regional impact as a result of groundwater used by various water users, including agriculture and industry, has been compared with observed regional groundwater levels.

Results are found to be in good agreement with the observed water levels. Local impact, at a disaggregate level for a water intensive industry, has been delineated. Water allocations have been estimated for various users. Various strategies have been finally discussed, thereby constituting a framework for working trade-offs under complex water situations.

The study reveals that with increasing fresh water demands from industry and agriculture sector, the trade-offs between allocating scarce water resources to agriculture or industrial sector assume importance. Industry, in general, is able to generate much higher economic rates of return per unit of water than those associated with most forms of agriculture. But at the same time what also emerges is that a water intensive industrial operation in a complex water situation, mainly governed by scarcity, highly variable rainfall, and frequent droughts, would continue to be one of the contributors to a worsening water situation and a source of stress to the local communities around. Hence the opportunities for a successful industry in such conditions are uncertain, and a continued emphasis on the agricultural sector becomes more rationale and viable, at least in the short-term.

Trade-offs within the agricultural sector is indicated in-terms of relative economic return for the farmer per unit of water. Analysis shows that the crop which is most common in the area provides the lowest relative economic return per unit of water. Comparisons are, of course, difficult to make especially since the price of crops such as paddy (rice), for instance, is comparatively fixed (due to assured minimum support prices offered by the government and high yields obtained per unit area of land) and does not fluctuate whereas prices for commercial crops and those of other perishables vary substantially. The key policy gap to highlight in this instance is that as long as water continues to be heavily subsidized or free, comparison of the crop water requirements and the economic return of different agricultural products is of little interest for the farmer.

Another policy implication that emerges from the study places emphasis on developing stricter industrial siting criteria that look at water availability from a long-term and ecosystem point of view, especially keeping in mind risks arising out of present and future competing demands in the area. Study suggests that in assessing water-related risks industry needs to consider local hydrological conditions, socio-economic conditions in production regions that also respect the existing (formal and informal) riparian rights, and business impacts on defined water resources. Industry's assessment of water availability in the vicinity of its operation in an area should be from a perspective that is wider than business continuity.

Social-economic-environmental Indicators of the Efficient Use and Access of Water in Dry-lands River Basin

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Keywords: indicators, IWRM, sustainable use, water scarcity, efficiency

Introduction/Problem Identification

In dry-lands river basins, the application of conventional models to evaluate and allocate efficiently the use and access of water frequently produce inadequate results. Therefore, on one hand, those conventional technical approaches are clearly questionable. On the other hand, interdisciplinary models of water handling including social, economic and environment aspects (such as the ones proposed by the New Water Culture in Spain) are not usually applied to water scarcity situations.

The adoption of interdisciplinary efficiency indicators is strongly recommended in order to evaluate and monitor the progress toward the sustainable water use. These indicators are a powerful policy decision tools. The use of a well-selected set of indicators may help river basin organisms to solve water conflicts, promote the reuse of water along river systems and manage different water uses of both green-blue water.

Analysis/Results and Implications for Policy and/or Research

For the formulation of indicators of the efficient use and access of water, not only technical issues should be considered (related to conventional physical science, such as hydrology, geology, engineering, etc) but also the environmental, social, institutional and economic aspects of water management. The application of those indicators undoubtedly contributes to the better allocation of limited natural, financial and human resources especially in water scarcity regions of the developing countries.

Developing indicators is not an easy task and involves collection, collation and systematization of data. The need for clarity and ease of understanding means that indicators often condense large volumes of data into brief overviews and reduce the complexities of the world into simple and unambiguous messages.

This paper describes the research done at the UNESCO Chair of Sustainability at UPC related to the definition of criteria for the development and selection of sustainable efficiency indicators of the use and access of water adapted to water scarcity regions.

The work methodology is divided in four blocks of activities – identification, development, evaluation and consolidation of the indicators. Initially, though an extended bibliographical research, 250 water resources related indicators have been identified for both green and blue water. The selection process was based on multi-criteria decision tools, such as the construction of decision trees, implementation of specialist panels, and the application evaluation matrixes. As part of the evaluation / selection process, this research adopted, as a framework model, a combination of the cause-effect DPSIR model and a social, economical, environmental and institutional systemic approach.

The main result is a final set of 50 selected indicators that cover the main relevant aspects concerning efficiently evaluation, decisions making and managing water scarcity situations at river basin level. The

final set of indicators present adequate scientific and policy requirements and robustness regarding typical dry-lands river basins characteristics such as the effects of the climate change, the coexistence with drought / extreme events, as well as methods aimed at combating the desertification processes.

The rigorous and transparent indicator selection/development process adopted in this research contributes to increase both the scientific credibility and ensures that they meet management concerns. The selection process aimed to achieve a balance between the ideal indicators – that are consistent with theoretical definitions – and the 'practical' or feasibly measurable variables that provides acceptable approximations at cost-efficient data handling. Therefore, it has been formulated and developed as an easy-to-use, easy-to-understand, and yet robust / reliable set of indicators.

The application of those indicators contribute to the formulation of more efficient public policies related to land and water management, as well as the process of water governance with stakeholders participation.

Finally the study developed in this research contributes to improving the human capacity to become better adapted to water scarcity / drought, through the promotion of regional development, preservation of ecosystems and the improvement of the life quality of the local populations.

Upscaling Stormwater Runoff Management and Reuse in Urban Zones

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Keywords: stormwater management, rainwater harvesting, groundwater recharge, upscaling, runoff utilization

Introduction/Problem Identification

Cities today are major consumers & carriers of both blue and green water systems and flows. With a concurrent increase in urban populations, the symbiotic relationship of man and water resource has changed from "visible water resource- imperative to man's existence- preserve quality" to a "water coming out of a tap – water as sink for pollution and waste – if required purify again" connection. This connection is both socially exploitative and imparts a much larger embodied energy to the ultimately available water to the urban masses, where access from blue water resources needs to be pumped, cleaned & supplied through conventional municipal infrastructure.

But due to the increasing concretization and development of the urban landmass, not much of the green rainwater is being utilized and is wasted as runoff, away from the urban eco-system. This includes a no. of missed opportunities for direct usage together with its potential for natural recharge for underground natural storage.

Analysis/Results and Implications for Policy and/or Research

Rainwater harvesting and groundwater recharge as stormwater utilization concepts have been tried in rural situations, but the large runoff collection potential in urban areas goes unaddressed, both due to lack of knowledge of the techniques and also due to fears of water quality. This situation has escalated problems of urban flooding and soil erosion in downstream waterways, and escalated the requirement of conventional roadside stormwater drainage. Simultaneously, large scale abstraction of groundwater has led to unprecedented lowering of underground groundwater levels. This paper presents the diverse methods being tried out by the author through urban landholding groups, i.e. at individual residential, group residential and institutional levels to create a viable rainwater utilization and groundwater replenishment scenario.

Stepwise, the scenarios which include many case studies executed by the presenting organization could be lined up as follows:

- Individual House Level include rainwater harvesting for direct usage for horticulture, floor washing and for aesthetic purposes and water features like ponds, cascades and for passive cooling purposes for the house. This also includes situations where older groundwater abstraction equipment or ground bores can be reutilized at a fraction of a cost by turning them into recharge pits.
- Group of Houses, where a no. of householders get together and plan for rainwater harvesting based on their common existing stormwater drainage system. The system has problems of individual house owner's apathy, but in the overall analysis, could create visible benefits for the community for purposes of park maintenance, washing of common areas and also creating facilities for wastewater reuse.
- Thirdly, the case studies includes examples of larger institutions, where a larger landmass has a larger runoff collection potential, and examples like schools have a larger learning and replication

potential through its teaching in environmental science subjects. Through committed institutional promoters, the system induces vast improvement of not only groundwater levels, but the levels of local capacity building on these technologies.

- A fourth and more comprehensive level occurs at the level of utilizing large scale municipal infrastructure, including Roads, highways, Parks and sports grounds, whole neighbourhoods, parking areas, flyovers and other large scale civil constructions. These structures & locations have huge potential to serve as large green sinks. Various visible locations at water catchment points have an equally large potential to work as greenwater replenishment zones. But a no. of such areas face lack of policy guidelines besides other hurdles towards this kind of utilization. Large cities like New Delhi, where groundwater levels have recorded a decrease of more than 50' in many locations, need this level of municipal interest the most to significantly alter the ecological water balance in favour of adequate water availability.

Urban development is also a significant generator of stormwater pollutants such as sediments, hydrocarbons, heavy metals, nutrients, pathogens and litter. Stormwater pollutants and peak flows can threaten the health of waterways by degrading aquatic habitats, disturbing local vegetation or modifying their physical form. Urban run-off therefore needs to be managed to minimise the risk of flooding and protect receiving waters and the environment. The receiving waters can be either surface water (creeks, rivers, bays) or groundwater.

Therefore, to upscale rainwater harvesting and groundwater recharge practices, the policy climate is being pursued for a strong orientation towards the following:

- A learning from many traditional cities, where the water is not just a service, but a planning guideline for the city and its spread.
- Preservation of significant Recharge zones from "development" and creating recreational and other usages instead of regular concretization of the land surface.
- Utilization of water sensitive design techniques to manage the quality of stormwater run-off
- In meeting the need of creating sustainable cities, this approach needs to be ingrained into significant policy documents including the master plan and the national policy on climate change, so that it may make a larger mark on adaptation strategies. Therefore analysis of water demand and supply systems to take place not just from a water quantity paradigm, but from a total embodied energy of water paradigm through a life cycle analysis.

Adopt Climate Change Impact through Effective Use of Green and Blue Water in Coastal Region of Bangladesh

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Keywords: green water, blue water, irrigation, coastal region, saline water intrusion

Introduction/Problem Identification

The Intergovernmental Panel on Climate Change (IPCC) predicts that global temperatures will rise between 1.8 °C and 4.0 °C by the last decade of the 21st century. The IPCC also forecasts that global warming will result in sea level rises of between 0.18 and 0.79 meters, which could increase coastal flooding and saline intrusion into aquifers and rivers across a wide belt in the southern part of Bangladesh. Sea level rises leading to submergence of low-lying coastal areas and saline water intrusion up coastal rivers and into groundwater aquifers, reducing freshwater availability and drainage congestion inside coastal polders, which will adversely affect agriculture. This paper is aimed to present the impacts of climate change in blue water use for irrigation in coastal region of Bangladesh and analyze the yield in food production by effective utilization of green water through rain-fed agriculture for adopting the climate change impacts.

Analysis/Results and Implications for Policy and/or Research

Statistics of Bangladesh Agricultural Development Corporation (BADC) showed that Bangladesh's food production remained stagnant around 26 million tons in the recent time against a requirement of around 30 million tons, resulting an annual deficiency of 4 million tons and triggering acute supply crisis and price escalation. Out of 36.7 million acres of total land area of Bangladesh, 20.8 million acres are suitable for irrigation. Apart from that 1.5 million acres area are fallow area and almost one third of which are located at coastal region of Bangladesh. But according to the present estimate of available water resources, only about 16.8 million acres can be irrigated and at present (2005-06) only about 40.77% area have been brought under irrigation. The projected irrigation water demand for the next 20 years is about 14,290 million cubic meters to irrigate 16.8 million acres of land. The coastal region of Bangladesh will face more challenges in using the blue water for irrigation due to saline intrusion, in the present cropping pattern. On the other hand annual total rainfall in the coastal districts of Bangladesh is 2 to 3 thousand mm with significant intensity form May to September. The intensity is likely to increase in the future due to change in climate. Considering the fact that most water vapor returned to the atmosphere by plants is not from blue water sources but primarily from green water source, food productivity can be increased through water and land management that covers both irrigated and rain-fed agriculture. Conventional water-resources assessments highlight the limited possibilities of expansion of direct blue-water withdrawals and hence, the increased pressure on finite blue-freshwater resources would suggest limitations in the opportunities to expand the area under irrigation. Hence, this paper intends to present the impacts of climate change in blue water use for irrigation in coastal region of Bangladesh and analyze the yield in food production by effective utilization of green water through rain-fed agriculture for adopting the climate change impacts. The case study presented in this paper provides an opportunity to replicate the practice of utilizing the green water for crop production in other parts of Bangladesh and countries of similar nature.

Indigenous Wisdom in Green Water Management in the Water Stressed Kandi Region of Jammu Province of India for Food and Health Security

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Keywords: indigenous wisdom, green water, food security, Kandi region, soil moisture

Introduction/Problem Identification

The Kandi region of Jammu is characterized by low rainfall (below 800 mm per annum), low soil fertility, land infested with sand stones and poor water holding capacity of the soil. More than 75% of the population of the region depend on agriculture and allied activities. The whole region is affected by droughts, lasting for 1 to 4 years with a return period of 2 to 3 years, on an average. This has also affected the health of the people, particularly, women and children suffer from malnutrition. Since the women constitute the main working force, their poor health affects the socio-economic milieu of the society as a whole. Diseases like cholera, typhoid, dysentery and malaria are common due to poor hygiene. The consequences are economic losses, environmental degradation, desertification, soil impoverishment and social disorder. Many a times, the women have to bring water for drinking from far-off sources.

Analysis/Results and Implications for Policy and/or Research

Drought is a creeping hydrological phenomenon due to below average rainfall. These are usually hazardous and result in disruption of economic, social and institutional set-up depending on its duration, deficit and impacts on users. It is more conspicuous in under-developed and developing areas where there is more reliance on water without adequate technological backup for the mitigation of hydrological extremes. Because of this reason, people go outside the region for work and sustenance, causing social turbulence. Estimation of drought frequencies in the Kandi region is important for water resources management and drought mitigation. The main problem of facing the harmonious development and management of green water in Kandi, apart from economic constraints, is the paucity of reliable data and lack of human and institutional capacity necessary for confronting the complex interactions of hydrological cycle with the societal needs, consumer behaviour, government policies, water consumption pattern and environment. There is need for optimization of water allocation under physical and socio-economic constraints. It is necessary to promote dynamic, interactive and multi-sectoral approaches to water resources management and, identification and protection of potential sources of fresh water supply, that integrates technological, socio-economic, environmental and human health considerations.

The site of study is the Kandi region of Jammu Province of Jammu and Kashmir state of India. The region is about 200 km in length with width varying from 15 to 50 km and lying between 740 21' and 750 45' E longitude, and 320 22' and 320 55' N latitude. The elevation of the northern portion is about 1050m and the southern part merge with plains with an elevation of about 300m above mean sea level. The farmers of the region have developed innovative techniques of rainwater harvesting and soil moisture enhancement and conservation, due to their ingenuity and skill. After the rainy season

is over by ending August, the soil moisture drops to about 4 to 6% during November, the time for sowing of winter crops. The crop-seed germination is difficult at this low soil moisture. However, soil moisture below 30 cm of soil surface is sufficient. The farmers exploit this deep soil moisture and bring it up to the plough-layer by the manipulation of tillage operations. The farmers do not use mouldboard plough, which inverts the soil, resulting in the loss of even existing soil moisture at the soil surface. They suse indigenous plough which does not inverts the soil but simply loosen it, thus breaking the capillary movement of water and considerably reducing the soil moisture loss to atmosphere due to evaporation. Sufficient soil moisture exists below the base of plough layer; the zone where the crop-seeds are placed at sowing time. Again, heavy dew falls during early morning hours during October-November period of the year. Retention and conservation of this dew moisture in the field is an important aspect of enhancing soil moisture. The field is ploughed early in the morning, 2 to 3 hours before the sun-rise, keeping the furrows open to imbibe dew water. The soil furrows are closed properly before the sun-rise by a heavy leveller or, other-wise, the moisture will be lost through evaporation. The ploughing operation is done 5 to 6 times during October for retaining sufficient moisture and improving physical condition of the soil for easy and optimum germination of crop seeds. The morning ploughings help in two ways viz. retention of already existing moisture in the soil due to reduction in evaporation and addition and conservation of dew moisture in the soil. The study showed that at least 5 ploughings are necessary during October for optimum soil moisture conducive for seed germination. The soil moisture increase varied from 3% to 15% with the number of ploughings from 1 to 5 before sowing the crop seeds. The seed germination was above 90% at soil moisture of 16% and above; whereas the germination per cent was much below at lower ploughing rates. Optimum crop stand ensured two to three times higher crop yields compared to the yields obtained from plots where the ploughings were done only 2 to 3 times. The embankments are also made by the farmers, individually or on community basis, with sandstones and clayey soil at appropriate places to harvest rainwater. The embankments are plastered with clay mixed with chopped wheat straw. The stored water is used for life-saving irrigation at critical stages of crop growth. These embankments not only retain rainwater but also reduce the runoff water velocity during rainy season, thus reducing soil erosion. Only the indigenously available material is used in these innovative methods, which have helped in increasing food production and ensuring food security. The people get nutritive diet in adequate amounts, ensuring improvement in their health and freedom from diseases.

Alternatives Mitigating the Difficulties of Increasing Food Production: SCAMPIS Approach Linking up Micro Irrigation and Liquid Organic Fertilizer

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Keywords: improve crop productivity, mitigation damage agriculture, micro irrigation systems, liquid organic fertilizer, value chain

Introduction/Problem Identification

Water use has been growing at more than twice the rate of population increase in the last century (IWMI). Irrigated agriculture, which represents the bulk of the demand for water, is the first sector affected by water shortage and increased scarcity. Soil fertility problems will increase in the following years as rural farmers in the world have limited access to fertilizers. This context calls for the development of alternatives. In 2008, The COOPERNIC Sustainable Fund launched an initiative to contribute to the mitigation of damages caused by food production worldwide (water and fertilizer use). IFAD has been awarded to implement a project entitled Scaling Up Micro Irrigation Systems (SCAMPIS). SCAMPIS will promote and fund the use of Micro Irrigation Systems (MIS) and Liquid Organic Fertilizer systems (LOF) in selected rural areas of India, Madagascar and Nicaragua for 30 000 households to improve agricultural productivity and saves water for the environment.

Analysis/Results and Implications for Policy and/or Research

In 2008, The COOPERNIC Sustainable Fund (CSF) launched the Scaling up Micro Irrigation Systems project (SCAMPIS), CSF is an European alliance of independent trading companies which are pooling their resources in this co-operation as they are well aware of their responsibilities and want to contribute to sustainable development through their activities and products offer. SCAMPIS aim at addressing two problems at the root cause of food insecurity in rural areas of countries where COOPERNIC members have developed fair trade partnerships. On the one hand, in an ever wider range of environments, irrigation is critical for food security while the availability of agricultural water is under threat, because of growing physical scarcity. The high risk of crop failure associated with water deficits discourages poor farmers from investing in improved inputs and land management. Furthermore, the high cost of obtaining water in the quantities required by conventional irrigation methods reduces the incentives and returns of cash cropping. On the other hand, low soil fertility and nutrient deficits are also serious limitation to cultivated land productivity in many tropical areas. Inorganic Fertilizers are in limited supply and at a cost which is beyond the reach of most smallholder farmers. Intensive production using readily available Liquid Organic Fertilizers (LOF) is however possible on a small-scale with alternatives such as reuse of hygienized human or cow urine. Human and livestock excreta (urine and faeces) are complete fertilizers and contain the same quantity of plant nutrients that are present in the food and drinks consumed. Most of the nitrogen and potassium is excreted with the urine (80%). Using the method proposed by Jönsson et al (2004), it is possible to estimate that an average person excretes around 2.8 kg of N, 0.45 kg P (elemental) and 1.3 kg of K (elemental) per year. This corresponds to 6 kg of urea, 2 kg TSP and 2,6 kg of KCl. The nutrient loop between humans and soil can be closed if urine is successfully recycled as well as crop residues and kitchen waste and transformed into liquid organic fertilizer. The overall goal of the SCAMPIS project is to improve agricultural productivity and saves water for the environment through the use of Micro Irrigation Systems (MIS) combined with Fertigation (Liquid Organic Fertilizers: LOF). MIS allow

small-scale localized irrigation; they operate under low water head and low discharges. They do not demand mechanical pressurization and allow taking advantage of small water yields and/or volumes. Micro irrigation using "minikits" such as those disseminated by IDE India or Chapin Water easily lend itself to the incorporation of diluted organic fertilizer in the water reservoir (a plastic bag, or bucket, or drum), allowing simple "fertigation" that is to say the application of fertilizer through the irrigation water itself. The typical fertilizer application device is a cylindrical container made from light weight metal (which can hold about 60 liters from fertilizer solution). It remains to be assessed what the application safeguards should be so as to minimize a possible risk of accelerated clogging and/or aging of the micro tubes caused by the urine concentration in the water. MIS can apply water to individual plants or trees, by delivering water directly to the root zone and wetting only a fraction of the soil surface, thus significantly increasing the efficiency of the water used. Therefore, a much larger utilization of MIS than is currently the case, complemented with the sound use of LOF is an approach which can boost productivity, alleviate the water scarcity crisis and improve the conditions of a substantial share of poor farmers who will thus be able to embark on growing high value crops and access fair trade opportunities. SCAMPIS will promote and fund the use of those systems for 30 000 households in selected rural areas of India, Madagascar and Nicaragua where the technique is unknown or has not yet been disseminated on a significant scale. SCAMPIS implementing partners (International Development Enterprises (India), Agronomes et Vétérinaires Sans Frontières (Madagascar), Fundación para el Desarrollo Tecnológico Agropecuario y Agroforestal (Nicaragua) will take advantage of the support of three ongoing IFAD Projects in India (OTELP), Madagascar (PROSPERER) and Nicaragua (FAT). The targeted SCAMPIS farmers have little financial capacity to buy materials and to improve their productive capacities and will be supported with innovative financing mechanisms (mobilizing local capital through a Micro Irrigation Venture guarantee). The business opportunities and evolving demand in the project area (providing water and fertilizer for food production, nutrients trade) would be supported together with government commitment to an identified target clientele (poor farmers).

The Green to Blue Water Continuum: An Approach to Improve Agricultural Systems' Resilience to Water Scarcity

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Keywords: rainwater management, irrigation, multiple use systems, resilience, livelihoods

Introduction/Problem Identification

Access to green and blue water for agriculture is not simply addressed by opposing rainfed and irrigated agriculture. Indeed, agricultural systems have never been strictly rainfed or irrigated. History of Mesopotamia teaches us that even if farmers were mastering some irrigation, they were not operating under full irrigation nor were they cultivating only using rainwater. Between irrigated and rainfed agricultural, the farmers reality has been that they simply have never grown any crop without water, which they have stored, mobilized and applied to plants by different ways depending on the nature of the resource available. Irrigated farmers typically also use green water and rainfed farmers sometimes also use blue water, even in the absence of formal irrigation systems. In a nutshell, farmers' reality around the world have always been to deal with a green to blue water continuum, from which they have struggled to extract the best productive value.

Analysis/Results and Implications for Policy and/or Research

The global surface under irrigation has dramatically increased since the 60's: it practically doubled, from 160 to 300 Mha. Most policies have kept rainfed and irrigated agricultures separated, hence trying to negate the existence of this continuum. However a large majority of "new" irrigation farmers – those who were given land to irrigate and crop after the green revolution – were historically rainfed farmers, if not breeders (eg in Morocco). Or their parents and relatives were. In other words, half of today's irrigated surface is cultivated by "traditionally rainfed" farmers.

By keeping these two agriculture types separated during the last decades, policymakers have made them both less and less resilient. Rainfed systems, because green water has become scarcer and irregularly supplied, have often become less resilient for external reasons. And irrigated systems have often become less resilient for internal reasons, which have been well documented: in a few words, the crop varieties grown under irrigation (eg rice) are less resistant to drought, whereas blue water is not provided as regularly as it should because irrigation is often badly managed and operated. Sometimes also, irrigation generates water excess that degrade soils and crop productivity. A significant part of this latter is due the lack of irrigation tradition among farmers but also in decision makers and institutions. Therefore, increasing water productivity and improving farmers' livelihoods should not be addressed by keeping rainfed and irrigated agricultures separated, but rather by addressing the existing green to blue water continuum. Indeed most significant progress could be done by learning from each others' resilience.

Examples from two CPWF projects are used to draw lessons in both ways. What lessons can rainfed agriculture bring to irrigation, eg in terms of resilience to long droughts, extreme events, farmers and markets organizations? What can be learnt from irrigation to improve rainfed agriculture, eg in terms of techniques of water storage and application, institutions, environmental issues, alternative income generation activities?

The IWRM for Improved Rural Livelihoods project works on a range of innovations at multiple scales: soil/water/nutrient management research at the field level; hydrogeological studies at the catchment level; climate analysis at the basin level; and analysis of institutional needs for good water governance at all levels. It seeks to help improve the livelihoods of poor smallholder farmers through an Integrated Water Resource Management (IWRM) framework that enables farmers to better cope with dry spells and droughts through improved use of water flows and better risk management. Lessons learnt for this project that would benefit irrigated agriculture are analysed and discussed.

One innovative way to improve water management in ways that can benefit the poor is the introduction of systems designed to support multiple uses: it is explored by the CPWF Multiple Use Systems project. Multiple uses of water increase the welfare of poor people in different parts or river basins – and also tends to increase water productivity. Unfortunately, most blue water supply systems have been designed with a single use in mind, e.g., irrigation or direct consumption. Not infrequently, they are simply unable to cope with the demands that may be placed on them by the multiple uses of water strategies often preferred by poor households. The answer may lie with water supply systems that are multiple-use by design. Successful examples from the project can help understand how to create more benefits from blue water. Some of them can be successfully applied to farming systems relying mostly on green water, towards the other edge of the green to blue water continuum.

Global Environment Facility (GEF) Hai Basin Integrated Water Resources and Environment Management Project in China

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Keywords: Global Environment Facility, Hai Basin, integrated water resources management, knowledge management, remote – sense ET

Bohai Sea is one great ecological and seriously threatened by pollution water body of the world. It provides important fishery resources to China, Japan, South Korea and North Korea. As well as it is a breeding area for fish and shell of Yellow Sea. From the ecological point of view, Bohai is a large shallow gulf of Yellow Sea and Yellow Sea is continental shallow sea of the Northwest Pacific. It fully shows the global significance of Bohai Sea from the relationship of geography and biology.

Hai River basin is an important basin of Bohai Sea. It includes Beijing, Tianjin, Hebei and other five provinces (municipalities). There are a series of ecological environment problems such as high-level utilization of surface water, excessive extraction of groundwater, water pollution, wetlands shrinking, runoff decreasing and estuaries filling up. "Integrated Water and Environment Management in Hai River Basin" project aims at improving water resources and the basin integrated environmental management, reducing water pollution thus improving the Bohai Sea water quality.

The key aspect of the Hai Basin Project is that it needs to have maximum incorporation of horizontal and vertical integration. Horizontal integration includes cross-sectoral cooperation and coordination of actions mainly between water resources and environmental protection sectors, as well as others including agriculture and construction sectors. Horizontal integration in county level need on the unitive lead of project lead and coordination group and enhance cooperation among different sector, for example water resource, agriculture, environment and municipal construction and so on. It will press the implementation of IWEMPs. Vertical integration includes direct linking and constant interaction of sub-projects activities among the Central, Hai Basin, Zhangweinan sub-basin, Tianjin municipality and counties, Beijing municipality and counties, and Hebei province and counties.

ET is the most important water consumption. Regional water-balance analysis is the basis for water monitoring, evaluation and management. ET also is the important basis for agriculture irrigation management. The target for water saving in agriculture is to increase the agricultural output while reduce ET value. In the overall design of the project, it has introduced the remote sensing monitoring ET technique which is under development and application in the world. In Hai Basin Commission, a remote sensing monitoring ET system center will be established for providing important technical service and support for the basin and regional IWEM. Remote sensing monitoring ET technique is a global advanced technology introduced by the project. To apply the technology into the water resources management of Hai basin is an important content of the project and also a "high light" of the project.

A cooperative mechanism of data sharing by water and environmental departments within the Hai Basin will be established in the project. Hai Basin KM system is being developed and studied in the project. It will provide a scientific and effective tool of unitive management between water quantity and quality, integrated management between water license and waste water drainage permit, monitoring

data sharing between water resource and strengthening environment and integrated water resource and environment management between basin and region. This is another "high light" of the project.

After the implementation of the project, it shall enhance comprehensive management level of water resource and water environment in the Hai River Basin by water conservation and adjustment of industrial structure. Underground water will be discharged properly. Adoption of advanced technology and methods shall reduce inefficiency ET value in the Hai River Basin and ease the contradiction raised by water demand over supply. On the other hand, pollution sources discharging shall be effectively controlled. The discharging of pollutants to the rivers, lakes and other water bodies shall be reduced so that water quality of both surface water and groundwater shall be improved. The reuse of treatment water shall reduce the consumption of new sources and minimize direct discharging of polluted water to the water bodies. It shall be beneficial for the recovery of ecological environment and water quality improvement.

The implementation of GEF Hai Bsin Project will promote to realize regional economic development target. Through reasonable distribution for water resources, it can promote industry structure optimized adjustment. Owing to improve level on water resources management, it is beneficial for alleviating water shortage as well as improve water environment in the region and shall result in a direct economic benefit. Besides, it shall improve investment environment of the project area and be helpful for attracting more investments. It will greatly promote economic developing in Hai Basin.

Workshop 4: The Role of Inter-basin Transfers in Accessing Water

The Ganges-Brahmaputra River Interlinking Plan: Downstream Concerns, Environmental Impacts, and Brewing Water Conflicts

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Keywords: river interlinking, inter-basin transfer, Ganges, Brahmaputra, environmental impacts

Introduction/Problem Identification

This study explains in details the potential downstream impacts of the proposed river interlinking plan in the eastern Indian Subcontinent. The project aims to transport massive amounts of water via an inter-basin transfer mechanism from 'water-rich' areas of the Indian Northeast to 'water-starved' Central and Southern Indian states. However, missing from the project particulars are the downstream concerns, detailed environmental impact investigations, and co-riparian agreements. This research aims to highlight the critical points and pitfalls of this proposed project and underscore the need for a basin-wide approach through detailed analysis of the relevant hydroclimatic and environmental parameters, in light of the changing climate scenarios for this region.

Analysis/Results and Implications for Policy and/or Research

The River Interlinking Plan is an ambitious inter-basin water transfer plan involving many major rivers in India with the aim of providing 'water-deficit' basins with water from 'water-surplus' basins. In the eastern segment of this proposed project, two of the largest rivers in the Eastern Himalayan region, the Ganges and the Brahmaputra, are involved. A significant amount of the total precipitation in India is received in the Himalayan catchments of the Ganges and the Brahmaputra rivers. This precipitation amount falls in greatly varied patterns over the Indian Subcontinent, both spatially and temporally. The northeastern quarter of the country receives substantially larger precipitation amounts due to the monsoon patterns, in comparison with the northwestern, western and southern parts. The proposed program aims to transport monsoon season surplus water to water-starved areas of central and southern parts of India through a massive network of reservoirs, canals, rivers, barrages, and dams. The river interlinking project is claimed as both visionary and controversial as it would attempt to irrigate a massive 34 million hectares of additional agricultural land, perform flood control, and provide urban water supply during droughts. The project, which is perceived as the largest planned construction project in the world, is estimated to cost about US$ 200 billion for the construction works. Adding the social, environmental, and operational costs would possibly translate this as one of the most expensive projects of the world.

In Bangladesh, which is the downstream country of the Ganges-Brahmaputra-Meghna (GBM) system, freshwater availability depends on the share of water diverted by India in the upstream. The majority of the annual precipitation occurs during the four monsoon months of the year. In sharp contrast to the 'water-surplus' image, the region experiences a prolonged dry season and severe water shortages due to increasing upstream usage and diversion. The dry season water scarcity also leads to saline intrusion in coastal aquifers and mangrove ecosystems, lost agricultural and fish productivity, and coastal cholera outbreaks in Bangladesh. India and Bangladesh failed to resolve issues of sharing the dry season flow of the Ganges River, as well as possibly augmenting the flow through cooperation with Nepal. The existing Ganges water sharing treaty has already proved itself inadequate in handling the

situation of extreme dry months and record low flow levels. It is understood that with rising population and agricultural demand, pressure of urbanization, and increasing climate variability, these disasters are expected to be more extreme in coming decades. It is thus a major concern for Bangladesh and eastern part of India that in the future, the absence of adequate dry season flow in the whole GBM basin region may lead to elevated water scarcity, and serious environmental and public health disasters. The main point of concern stems from the fact that the critical sharing of the all-important flows in the pre-monsoon period occurs when the surplus of water is not present and the water needs of these river basins are just as much as the 'water-deficit' basins. Another perspective that is gaining ground in the eastern part of the Indian Subcontinent is that regional river basins may not be 'water-surplus' after all, as each drop of water, from a holistic perspective, perform some ecological service in the basin. Thus, no amount of water in a river basin can be taken out without causing some damage to the ecosystem services provided by the river water.

The ideal way to address the development of water resources in such an international river system would be to recognize the ecological integrity of the basin, take a basin-wide approach and involve all co-riparian countries in the conceptualization process. In the case of the GBM basin, several small bilateral agreements exist between India and the smaller countries, Bangladesh, Bhutan and Nepal. But there is little cooperation regarding integrated planning of water and climate issues among the co-riparian nations of the Ganges-Brahmaputra-Meghna basin. With rising sea levels to its south, increasing flood extremes and climate variability, and burgeoning population levels, hundreds of millions of people in Bangladesh and eastern India are at risk. Thus, together with Indian inter-state conflicts, the interlinking project is sure to generate important inter-country conflicts, reducing the political and long-term economic feasibility of the project. This study will provide an investigative analysis of the relevant hydroclimatic and environmental parameters of the region and highlight the potential downstream impacts of the Ganges-Brahmaputra interlinking plan in light of changing climate patterns.

Role of Inter-Basin Transfers through Dnipro-Bug Channel in Accessing Transboundary Waters between Ukraine and Belarus

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Keywords: inter-basin transfer, transboundary, Baltic-Black Sea basins, water diversion, degradation of river bed

Introduction/Problem Identification

Dnieper-Bug Canal or Dnipro-Bug Canal, or Dneprovsko-Bugsky Canal is a ship canal that connects Dnieper River and Western Bug River. It provides navigational access between the Baltic Sea and Black Seawater systems. Navigation on the Dnieper-Bug Canal has been interrupted by a weir (dam) on the river Bug near Brest, Belarus, the border town. In 2003 the Government of the Republic of Belarus adopted the inland water transport and sea transport development programme to rebuild the Dnieper-Bug Canal shipping locks to meet the standards of a class Va European waterway.

Analysis/Results and Implications for Policy and/or Research

Dnieper-Bug Canal or Dnipro-Bug Canal, or Dneprovsko-Bugsky Canal is a ship canal that connects Dnieper River and Western Bug River. It provides navigational access between the Baltic Sea and Black Seawater systems. The length of the canal is 196 kilometers from the Bug to Dnipro Rivers.

According to Wikipedia, it was built in 1775 during the reign of Stanisław August Poniatowski (1764-1795), the last king of the Polish-Lithuanian Commonwealth. When the canal was first built, it was called Kanał Królewski (Royal Canal), after the Polish king, since he was the initiator of the concept. Additional work was carried out starting in 1837 and completed around 1846-1848.

Navigation on the Dnieper-Bug Canal has been interrupted by a weir (dam) on the river Bug near Brest, Belarus, the border town. This dam is the single most significant obstacle for the navigation of small draught vessels between Western Europe and Ukraine through inland waterways. The waterways from the German-Polish border (Warta, Noteć, Kanał Bydgoski, Wisła, Narew, Bug) used to join the Belarus and Ukrainian inland waterways (Mukhavets River, Dnepro-Bugskiy Canal, Pripyat and Dnipro), thus forming an uninterrupted liaison between north-western Europe and the Black Sea.

Recently the dam in the Bug, making it impossible for ships to pass, has led to a considerable neglect of the most western part of the Mukhavets; some of the locks have been filled in and Brest Harbour can only be reached by vessels approaching from the east. More recently efforts have been undertaken to restore the canal to a class IV inland waterway of international importance. In 2003 the Government of the Republic of Belarus adopted the inland water transport and sea transport development programme to rebuild the Dnieper-Bug Canal shipping locks to meet the standards of a class Va European waterway. According to the Belarusian government, four sluice dams and one shipping lock have been rebuilt which allow for the passage of vessels 110 meters long, 12 meters wide with a draught of 2.2 meters. It is expected that reconstruction will continue over the next few years.

At the same time, as it was discovered during several EU-funded Joint Rivers projects on Pripyat river, there is a number of transboundary Ukrainian-Belorussian problems connected with water diversion from the Pripyat into the Dnieper-Bug Canal (DBC) whose water intake point is the Verkhne-Pripjatsky diversion control unit. In some summer months, it was found, in particular, that about 25% of measured discharge is left in the flow of Pripyat downstream, and about 75% of it comes to Beloozerska water supply system of the Dnipro-Bug channel. There is a marked change and degradation of the river bed below the water intake, deterioration of river water quality, abnormal hydro-ecological regimes of lakes Sviatoe, Voljanskoe and Beloye. The cooperation agreement between the Volyn oblast administration of Ukraine and Brest oblast government of Belarus defines only general lines of bilateral cooperation with regard to protection against floodings and under-flooding, but does not solve ecological problems and issues concerning the operation of the Verkhne-Pripjatsky diversion control unit. It was proposed that special projects with international assistance should be developed in order to help Ukrainian and Belorussian authorities to develop special agreements to address this transboundary "water quantity" issue.

Potential Public Health Impacts of Inter-basin Transfers of Irrigation Water: The case of the 2006 E. coli O157:H7 in Spinach Outbreak in the USA

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Keywords: irrigation water, spinach outbreak, groundwater recharge, interbasin transfer, E coli O157:H7

Introduction/Problem Identification

In September, 2006, numerous cases of E. coli O157:H7 infection were reported to the US Centers for Disease Control and Prevention (CDC). It was quickly established that cases in multiple states contained matching strains of the bacteria and the epidemiologic evidence implicated fresh bagged spinach as the vehicle. Over 200 cases (including 3 deaths) in 26 states were ultimately identified. Environmental investigations on the farms where the spinach originated identified numerous potential sources of contamination, including irrigation water.

Analysis/Results and Implications for Policy and/or Research

This environmental investigation of potential irrigation water issues related to the 2006 E. coli O157:H7 outbreak in the USA associated with fresh bagged spinach focused on four areas: surface runoff from grazing areas onto cultivated fields, construction of irrigation wells, direct use of surface water for irrigation and depths to groundwater and groundwater-surface water interaction. Groundwater used as irrigation water and its potential contamination by surface water recharge were identified as the most likely water-related contributing factors involved in this outbreak based on the available information and analysis of data. One implication of this analysis is that the scope of produce-related outbreak investigations and potential prevention measures need to be conceptually broadened to include factors beyond those actually found on the farms identified as sources of produce involved in outbreaks. One of those factors is the ultimate source of the water used directly for irrigation or for recharging groundwater that is used for irrigation. In California, large scale inter-basin transfers of water for irrigation occur, but the potential implications of such transfers on water quality or public health have largely not been considered. Nonetheless, they may have been a contributing factor to this large outbreak and additional research is needed on the potential impacts on water quality and public health of large-scale inter-basin water transfers and large changes in groundwater regimes.

The Role of Inter-basin Transfers in the Water Resources Management of Sri Lanka

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Keywords: river basin, inter-basin transfers, climate change, conflicts, policies

Introduction/Problem Identification

Sri Lanka's hydrological resources consist of a network of river basins with varying degree of water availability. Although the rainfall distribution defines the boundaries of dry zone and wet zone, the water scarcity and abundance is determined by the flow of water in the rivers. Inter-basin transfers were adopted from the ancient times to address the spatial differences of water availability. With the rise of population and awareness about the importance of sustainable development, the present and future inter-basin transfers are facing new challenges. The investment in such transfers can be justified by an analysis of their benefits. However, current issues, constraints and innovations in this subject area are necessary to formulate policies and strategies for sustainable development and management of water resources.

Analysis/Results and Implications for Policy and/or Research

To achieve this purpose, this paper compares adopted diversion strategies and their impacts in two river basins. The diversion of Mahaweli River is the largest ever inter-basin transfer undertaken in Sri Lanka. The volume of water transfered to dry zone is about 1,800 million m^3. Currently, about 25 % of irrigated lands are positively impacted by the diversions. Other benefits include generation of hydroelectricity and provision of drinking water. In addition, diversions have a positive impact on resolving water related conflicts, which is not much noticed. The two cases cited here, which describe sharing water between urban users and agricultural users, explain that some water sharing issues would have developed into major conflicts without the inter-basin transfers.

The Walawe basin is another large river basin in Sri Lanka, which is an important source of water for the southern dry zone. The water resources development in Walawe basin was ongoing until recent times. Though the volume of water transferred to other basins is small, the hydrological impacts are easily noticed. The strategies adopted in more recent inter-basin transfers are different from those of large scale projects in the Mahaweli basin.

Recent inter-basin transfers were associated with several problems and challenges. They include environmental degradation resulting from over use of water, displacement of people, and high cost. The recent formulation of policies and legislation for conservation of the environment and safeguarding the rights of people to be displaced, have resulted in environmental and social benefits. But they have resulted in increasing the development costs as well. Dwindling investments in large scale water resources developments are complementary to this situation. Similarly, deterioration of water quality is becoming a concern of substantial proportions. Though water diversions enhance the groundwater availability, it has been observed that chemical quality of groundwater poses a health risk in some locations. Intensive agriculture associated with the diversions contributes to aggravate the problem, when the management is poor. Using the ongoing and recently completed water resources development projects as examples, this paper analyzes the current issues affecting inter-basin water transfers.

Despite these problems, the demand for inter-basin transfers is not fully met yet. One of the major reasons for this situation is the change of climatic and weather patterns. The comparison of records pertaining to different time periods indicate that rainfall in the dry zone has decreased over the years. It is also seen that rainfall pattern has gone through a change which adversely affects the agricultural operations. At present, the bulk of the agricultural production, particularly that of paddy comes from the dry zone. The water availability in dry zone heavily depends on the diversions from the wet zone. As such, the changes to rainfall pattern, volume, and rainfall-runoff characteristics are crucial factors affecting the water users. However, recent studies reveal substantial knowledge gap in these subject areas.

Comparison of diversion strategies adopted in two river basins highlight different innovations. Optimum utilization of Sri Lanka's "village tanks" has reduced the construction costs as well as adverse impacts on the environment. Better irrigation water management has resulted in reduced diversion demand. At the national level, hydro-meteorological information systems are planned to be upgraded which is expected to result in better hydrological predictability.

More diversions and storage of water is considered as a solution to the water shortages resulting from changes to hydrological characteristics. As water shortages cause conflicts, economic problems and social unrest, there is a need to overcome the challenges facing water resources development. Therefore, there is a need to incorporate lessons from these isolated interventions into policies and national strategies. A pre-requisite for this activity is filling the knowledge gaps related to the link between climate change and water resources.

Inter-basin Water Transfers – Environmentalists' Curse or Panacea for Some in Need – Central Asia Case Study

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Keywords: inter-basin transfers, Aral Sea, Sibirean rivers, environmental impacts, risk assessment

Introduction/Problem Identification

A paradigm shift is emerging in respect to inter-basin water transfers. Once an anathema, it again attracts support among politicians and decision-makers in many countries. Human population tripled and global freshwater consumption increased more than six-fold during 1900–2000. Humans currently use 50% of all available freshwater, and it will increase to 70% by 2025. Human population growth and increased consumption cause a significant decrease in per capita water availability in water-stressed regions. Such situation will necessitate inter-basin water transfers of a greater scale. Water quantity and quality becomes a national security concern. More than 30 nations receive at least 30% of their water from outside their borders. It is particularly important to find ways of to carry-out inter-basin water transfers in economic, environmentally and socially acceptable way.

Analysis/Results and Implications for Policy and/or Research

Background

Large scale inter-basin water transfers exist in many countries of the world, such as USA, China, former USSR, Australia, and India. For Central Asia large-scale transfer of water from the Ob River in Siberia to the Aral Sea basin in Kazakhstan and Uzbekistan was very attractive and such project was considered by the Soviet authorities back in the 1960-80s. Aim – to save Aral Sea and to secure water for irrigation and population. However, due to large-scale opposition from emerging environmental protection groups, start of economic stagnation and new political developments (perestroika) the project was officially shelved in 1986. Opposition to large scale water diversion projects was not unique only to FSU, but prevailed in some countries (e.g. cancellation of Spain's Ebro Transfer Project).

Current situation

In the recent years, Kazakhstan and Uzbekistan experienced high economic growth (annual GDP increase of 8, 5%). Shortage of water for industry, agriculture and population pose limits for growth. Both countries share the Aral Sea. Its surface area decreased by 50 %, sea depth dropped by 16 meters. In 1990, the Aral Sea split into two parts. Jobs were lost in fishing and agriculture. Agricultural lands are degraded.The Aral Sea problem has two aspects: (1) the need to solve the social, ecological, and economic problems of the Aral region, and (2) the need to preserve the Aral Sea. Climate change forecasts show that by 2050 in the Central Asia, river flow volume will decline by minimum of 5 km^3 per year, but, in the same time, the Ob river flow will increase by 3% (15 km^3 of water per year). To preserve the Aral as a single water basin requires annual inflow of 35-38 km^3 of water.

Project description

Idea of new project for transfer of the Siberian rivers flow to Central Asia resurrected just recently. In 2008,Y.Luzhkov – Mayor of Moscow presented this project. It is proposed to build at the Ob River, not far from town of Khanty-Mansijsk a water abstraction facility which will feed river water into canal with a width of 200 meters and total length of 2,500 km reaching Syr-Darya River in

Uzbekistan. Proposed depth of this canal is 16 meters and its annual throughput capacity about 25 million m^3. The system will need 5 – 8 uplift pump stations. Annual Ob river flow diversion will be in the range of 5% -7%. Implementation of the project will secure water supply to Uzbekistan and Kazakhstan, and, possibly, will facilitate restoration of the Aral Sea ecosystem. Water transfer volume will be sufficient to irrigate 1, 5 million hectares of lands in Russia, and Central Asia. It also may secure economic benefits for Russia through sale of water, if water will become a commodity on par with oil or gas. To make project economically sustainable estimated price for $1m^3$ of water transferred should be about 0.20 US$.

Alternatives

Water crisis may occur in the future that would make bulk water export a necessity, especially for saving of the Aral Sea. If the cost of desalination drops enough, it will be cheaper to generate freshwater from saltwater than to import it. The cost of desalination is less than US$ per $1m^3$. Desalination may become a favoured method of water supply.

Conclusions

Revival of inter-basin transfer of such a scale is an alarming sign indicating that water scarcity issues can be solved by infrastructure development, which is costly, often socially unacceptable, and environmentally dangerous. There is a concern that proposed diversion of water may affect the Arctic ice cover and, possibly, global climate. But, taking into account the fact that inter-basin transfers are needed and, probably, are unavoidable choice for Central Asia, possible measures to reduce their environmental, social and economic impacts should be carried out. Among these measures, reviewed are inter-basin transfer certifications, risk assessment, EIA, SWOC analysis, selection of alternative measures, like use of desalination plans, water saving technologies.

Inter-basin Water Transfers: Sustainable Solutions to Water Shortages?

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WWF International

Keywords: inter-basin water transfer, trans basin management, water footprint, IRBM

The increasing challenge of how to ensure access to adequate water resources for expanding populations and economies, whilst maintaining healthy freshwater ecosystems and the vital services they provide tempts governments to seek solutions by to distributing water more evenly across the landscape by transferring it from areas with perceived surpluses, to those with shortages.

The tempting solution of implementing technical infrastructure solutions to transfer water to deficit stressed water basins may seem even more favourable in the context of the unfolding effects of climate change on freshwater distribution, where wet areas become increasingly wetter and dry areas become even more stressed by water deficit thus adding to the supply imbalance.

The Inter Basin Water Transfer Project from Oubangui River (Congo Basin) to Lake Chad

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Keywords: transboundary, evaporation, restoration, navigation, sustainability

Introduction/Problem Identification

Ongoing water resources management and planning through water conservation and improvement of efficiency was seen in the basin as only a salutary steps to be pursued, which cannot provide a solution to the water crises problem prevailing in the Lake Chad basin. It was viewed that the depletion of water resources in the tributaries of Lake Chad and the Lake itself have long reached the limits of sustainable development. The opinion now is that there cannot be much water saving to be expected from efficient management as the largest amount of water loss is attributed to evaporation. Based on these facts it is deduced that it requires measures beyond management of the available water resources in the basin. It requires a major water transfer to the region to restore the lake, improve base flow and channel storage, arrest groundwater recession and falling water table, and enhance groundwater recharge, so that a state of equilibrium may ultimately be attained.

Analysis/Results and Implications for Policy and/or Research

The Lake Chad Basin Commission (LCBC), a sub-regional organization, was created by the Fort Lamy (now N'Djamena) Convention signed on 22 May, 1964, by the Heads of State of the four countries which share the Lake Chad, namely Cameroon, Niger, Nigeria and Chad. Today Central African Republic (CAR) and Libya have all ratified the convention to become the 5th and 6th member of LCBC. Sudan and Algeria are expected to join in the near future.

Although the hydrographic Lake Chad basin extends over an area of about 2,355,000 km^2, the area of jurisdiction of LCBC, known as the Conventional Basin (CB) covered 443,000 km^2 at inception, extended to about 967,000 km^2 from 1994 to cover the active hydrographic basin. Annual rainfall varies between 1,500 mm in the southern parts of the basin to less than 100 mm in the northern parts. The potential evapo-transpiration exceeds 2m per year at the centre of the basin. The most important rivers influents into the lake are the Chari and its tributary the Logone, the Komadougou-Yobe, the El Beid and the Yedseram.

The lake is very shallow, with mean depth being estimated at 12m in 1969. Since 1964, the lake level has continuously fallen with the surface area reducing from about 25,000 km^2 to less than 2,000 km^2, while its volume has decreased by close to 60%. The Logone and the Chari to a lesser extent spread within their inundation plains during the rainy season, over some 90,000 km^2. Thus, the annual losses through evaporation from the inundation areas (called the Yaéré in Cameroon) are estimated at over 5 million cubic meters per year, or about 30% of the annual runoff from the Logone. By 1991, over 22 million people reside in this conventional basin which has a growth rate of about 2.75%.

About 1500 years ago, the lake Chad completely dried up before refilling itself with water to attain a surface area of 25 000 km^2 at the beginning of the 60s. two scenarios were considered, namely:

- Let the Lake dry u completely and wait for it to refill again, which mean a socio-economic, cultural and environmental disaster.
- Manipulate the hydrology of the Lake for transfer of a portion of the waters of the neighboring Oubangui basin, and this is the advocated scenario.

Two of the broad challenges facing water management in the Lake Chad Basin were identified as increasing freshwater availability and/or reducing water demand and enhancing water allocation mechanisms. Most recently a sequence of inter-related studies focusing on combating the effects of drought has been carried out leading to the proposition of several projects for the basin.

These studies culminated in a Master Plan (LCBC 1992) and Action Program which then led to developing the Strategic Action Plan (SAP) (LCBC 1998). The Master Plan identifies water transfer project to Lake Chad ranking second in terms of priority and the SAP also identified it among the category of priority projects within the 8-year programme. This project is now being pursued as a measure to saving Lake Chad and deterring further environmental degradation and desert encroachment.

The water transfer project is intended to restore Lake Chad to its pre-drought condition and to give access to the four countries, namely Chad, Niger, Cameroon and Nigeria who have portions of the Lake water in their part of the country. Restoring Lake Chad is envisaged to help in reinstating activities such as recession farming, fishing, irrigated agriculture and animal husbandry in which the local population used to be engaged. It is also expected to facilitate communication among countries by allowing year round navigation. The water transfer project is envisaged to deter environmental degradation, enhance environmental and ecosystem equilibrium and reduce migration of people and conflict among settlers and environmental refugees.

A lot of preliminary work has already gone into it to confirm its technical feasibility. Dam sites for water regulation have subsequently been identified. The study has advanced to the point of tentatively locating the alternative open-canal routes for water transfer by gravity which is also envisaged to provide all season navigation that will open up Central Africa Republic and enhance the regional communication in the Northern parts of the Republic of Congo Brazzaville, the North of the Democratic Republic of Congo and South of the Republic of Chad.

This water diversion project has received the support of the riparian countries of the Lake Chad basin. Most of the countries in the regions have equally given their support at the political, diplomatic and financial level. Now the feasibility will start once the go ahead is given by the Council of Ministers of LCBC.

Accessing Water Responsibly as Environmental Stewards

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Keywords: integrated management, drought, sustainability, inter-basin transfer, resource diversification

Introduction/Problem Identification

The concept of moving water throughout the world to where it is needed is one of the great marvels of our society. Today, building upon the progress of early Roman engineering, resource managers deliver water to communities through the use of canals, aqueducts and pipelines, conveying billions of cubic meters of freshwater each day. Especially in arid regions, this water equates to prosperity, vitality and life.

In recent past, large-scale infrastructure projects have been developed with little regard for the environment. Often, negative effects were left to be addressed later at significant effort and cost. To fully embrace sustainability, we must acknowledge that the development of new resources cannot come at the expense of the surrounding ecology, and that an innovative model must be forged to protect critical water and environmental resources.

Analysis/Results and Implications for Policy and/or Research

Protecting Against Drought

A devastating drought afflicting the Colorado River Basin, on which Southern Nevada depends to meet 90 percent of its water needs, has reduced reservoir storage by almost half. As reservoir levels decline, Southern Nevada's ability to access the water has been put in jeopardy. While the Southern Nevada Water Authority (SNWA) continues to build an additional intake in anticipation of still lower lake levels, it recognizes that the community requires greater diversification of available water supplies.

Accessing Nevada's available water plays a significant part in SNWA's strategy to protect the community against the impacts of drought on the Colorado River. In what will be the state's largest inter-basin project, the SNWA plans to convey up to 210 million cubic meters per year of groundwater from six hydrographic basins in eastern Nevada. This essential project will bring additional water to the more than 2 million residents of the Las Vegas Valley and assist in reducing the community's dependence on the Colorado River.

Safeguarding Nevada

Battling the effects of drought does not absolve us from acting as responsible environmental stewards. Extensive federal and state laws and regulations including the Endangered Species Act (ESA), National Environmental Policy Act (NEPA) and Nevada Water Law protect the land and wildlife. Through strict compliance with these requirements, the SNWA proactively works to safeguard Nevada's ecology while moving forward to bring additional water to Southern Nevada.

In the course of meeting federal and state rules, the SNWA has chosen to go beyond the minimum expectations in many areas and set a standard for excellence that will allow for the best possible management of sensitive resources. For example, the SNWA elected to enter into additional agreements

with federal agencies and other interested parties to work collaboratively in monitoring and managing the basins. Together, the SNWA and these stakeholders continue to keep Nevada's ecology vibrant and healthy. The following section provides an overview of key SNWA activities that will provide for more sustainable water development.

Creating an Advance Warning System
The SNWA has several teams of expert scientists working together to create a library of information that covers every aspect of biology and hydrology in the project area. Before the first drop of water reaches Las Vegas, the SNWA will have more than 20 years of data in place to help understand the dynamics of water, environmental and cultural resources in the region.

The SNWA is also working to develop a highly sophisticated ground and surface water monitoring network to help inform management actions. Several locations are equipped with real-time data collection that provide for hourly system monitoring. Monitoring wells enable the SNWA to learn how different areas of the region respond to pumping in advance of any water exports from the basins. In total, the SNWA will have more than 180 groundwater and surface water monitoring locations to alert the agency to any potential unforeseen pumping impacts.

The SNWA's biologic team partnered with nine other outside organizations, including the Smithsonian Institute, to create a baseline biological record of the region. A pedestrian survey, currently being conducted, will cover the 640 kilometer proposed and alternative pipeline alignment. Other regional studies are being conducted to gather detailed information on additional areas of potential impact. These include more than a dozen flora and fauna surveys which target bird, reptile and small mammal populations. These surveys are revealing behavioral and ecological secrets that will contribute to the ongoing efforts of scientists throughout the western United States.

Integrating Resource Management
Southern Nevada is committed to ensuring that the development of in-state resources does not come at the expense of rural Nevada or the environment. Through the course of groundwater development, the SNWA will continue to develop strategies that will manage the land and water resources to the benefit of the region's ecosystem. This level of integrated management defines the new approach to resource development.

As environmental stewards and responsible water managers, our view must also continue to expand. Beyond looking at the needs of a particular population or basin, we must begin to collaboratively work to solve water issues on a much greater scale. As we act to address these problems on a regional, national and international level, we can continue to meet our goal of providing safe, reliable water to all people, while also protecting our other ecological assets.

Accessing Water through Linking Major Rivers of India

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Keywords: quirky weather, surplus floods water, droughts, interlinking of rivers, cultivable land

Introduction/Problem Identification

India's population density at present is 350 persons / km^2 which is already quite high and incidentally it is continuously at rise. Water availability which is already extremely low in some regions is bound to become a national issue in coming decades. Though, the country is well placed in terms of national average annual rainfall of about 1100mm (Assam, the wettest place of the world in NE India receiving 1200mm of precipitation annually to Rajsthan in NW India receiving about 11mm of annual precipitation) and the mean per-capita water availability yearly is of the order of about 1800m^3 / person. However, regional differences of rainfall are enormous, causing floods in one part and the drought in another part. Therefore, there is no uniform availablity of water in the country.

Analysis/Results and Implications for Policy and/or Research

The country has a large network of rivers with an estimated annual flow of 1900 km^3 and many snow fed rivers in the northern part of India are frequently affected by floods and discharge copious amount of water during monsoon months of June to September whereas other parts of India remain thirsty. It is also not possible to control flood through dams where the magnitude of the river water flow is of the order of 5 to 16 m above the danger mark. Of the county's total geographical area of 329 million hectare, 40 million hectare is prone to floods, out of which 32 million hectare can be provided with reasonable degree of protection. Therefore, to deal with the surplus flood water and drought, the interlinking of rivers appears to be a viable solution In order to resolve these problems of flood and drought, the Interlinking of Rivers (ILR) is suggested for arriving at speedy consensus amongst the States for sharing and transfer of surplus water to deficit areas. Till March 2004 an area of 16.46 million hectare has been provided with reasonable degree of protection against flood by construction of embankments rather than dams (except a few which are primarily constructed for the purpose of flood control), drainage channels and by raising villages. Total withdrawal of water is estimated to be 750 km^3 currently, and have been projected to increase to 1050 km^3 by 2050. At present, to mitigate the damages from floods, a nationwide Flood Forecasting and Warning System are establishes by the Indian Government. Forecasts about water level in rivers likely to be attained as result of floods and volume of inflow into reservoirs are formulated and disseminated to various administrative authorities, media and other users in order to reduce the loss of human lives and miseries, and immovable properties. According to the UN report, in the Himalayas, rapidly melting glaciers due to global warming are causing floods followed by a dip in river flow. Such decrease can be witnessed in the Gangetic plains which is turning from fertile to infertile in the northern part of India where the snow fed perennial river Ganga, originating from the Gangotri glacier in Himalayan flows throughout the year. Quirky weather sees eastern Bihar in north India getting twice as much rainfall as normal, resulting in flash floods. Cholera and malaria cases increase because of floods. Food production is expected to drop by 30% by 2050, devastating an agriculture-led rural economy of India. Food insecurity and loss of livelihood along with cultivable land is a nightmarish scenario. The scheme envisages effecting 30 river links. The idea of inter-basin transfer, at first instance, envisages the construction of a Ganga – Cauvery Canal, drawing nearly 60000 cusecs of flood flows of

the Ganga near Patna in the north for about 150 days in a year and link it up with water starved river Cauvery in the south. The cost of the project is estimated at about Rupees 560000 crores (1 US$ = Rupees 40 and 1 crore = Ten million) a year, if it is to be completed in a decade. Government of India has a very ambitious plan for a Sustainable Floodplain Management through linking major flood prone rivers of north with the drought prone rivers of south India. When completed, the ILR is expected to to meet the objectives of transferring surplus water from north to water deficit regions of southern and western part of India; control the twin problems of flooding and drought; irrigate the land thus, producing additional food grains. Water – in terms of temporal as well as spatial distribution – is expected to be highly vulnerable to anticipated climate change. Growing populations and concentration of population in urban areas along with other key factors such as changes in land use pattern and economic development will exert increasing pressure on water availability and water quality. Taking into account projected dynamics of economic development in India, combined with the climate change-imposed effect on hydrological regimes, agriculture and the public water supply would require priority attention to secure sustainable development.

Overlook from Central Asia to the Idea of Transfer Water from Siberian Rivers

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Keywords: transfer from Siberian rivers, water trade-offs, water strategy, water productivity, bridge across the nations

Introduction/Problem Identification

In early 21st century talks on old idea about transfer of water from Siberian rivers to Central Asia were renewed by some leaders of Central Asian countries (Kazakhstan and Uzbekistan). These proposals met an enthusiastic response from one of Russia's most influential politicians, Moscow mayor Yuri Luzhkov. "We are talking about water as a good, of which Russia has plenty" to sell, Luzhkov said. He made an economic case for the diversion project, which Luzhkov estimated would cost at least $34 billion, and pay for itself in five years' worth of water fees. The Ob floods in spring and its floodwaters do not have a clear economic use. The mayor argued that water-related failures in Central Asian republics could cause a huge wave of migration to Russia, and that constructing a canal from Siberia to Central Asia would create an economic bridge across the nations.

Analysis/Results and Implications for Policy and/or Research

First of all let us remind the idea: an engineering hydro system developed by Soviet scientists in the 1960-70s was called Sib-Aral. It was supposed to become a canal to transport water from the Ob River (about 5-7 per cent if the river's flow will go along the canal) from the city of Khanty-Mansiisk to the territories of the Amudarya and Syrdarya rivers. According to the project, the length of the canal was expected to be over 2,200 km, the width – 200 and the depth – 16 meters. The total expected volume of transportation was to make up 25-27 cubic kilometers per year.

If the project is to be taken up today it should be done on a quite different level as it was initially proposed in 1970s or even renewed by Luzhkov. It is important not to try and improve the Aral Sea situation as it was planned in the Soviet era, but first of all to give more water for solution of social-economic problems of the middle region of Russia it-self, combining West Siberia, vast areas of the Russian North and industrial zones of South Ural, and only after that part of water could be delivered to the arid virgin regions of Northern Kazakhstan, for grain crop irrigation, and finally to some regions of Uzbekistan – again for purposes to sustain irrigation. The project could not be implemented on a commercial basis as proposed by Luzhkov – Central Asian countries never will agree to buy water as a "pure good". There should be elaborated new principles of trade-offs around water – Central Asian countries can accept mechanisms of proper cost sharing for construction and O&M of the new hydro system, and maybe, will agree to share benefit, which will be created by delivered water. For the moment, there are enough available water resources within the Central Asian region, and actually countries are concern mostly with the issue how to use these resources more efficiently minimizing huge unproductive losses and coordinating some tensions around flow regime (scheduling) both to satisfy demands of hydropower and irrigation. The real water deficit will appear in the region within coming 15-30 years – for that prospective horizon the idea of water transfer from the Siberia could be at the priority.

Challenges in Low-cost Inter-sub-basin Water Transfers in Serbia

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Keywords: inter-basin water transfer, economic efficiency, conflict resolution, MODSIM simulation, decision making

Introduction/Problem Identification

In Vojvodina, northern Serbian Province, there is a unique Danube-Tizsa-Danube (DTD) hydro-system, a canal network built for irrigation, drainage, flood control, water supply, waste water evacuation, navigation, tourism, fishing, etc. System connects four out of five river sub-basins in Serbia: Sava, Morava, Tisza, Banat-Eastern Serbia, and Pannonian Central Danube. Because water flows in Serbia are seasonally uneven, and expectations are that this problem will increase with climate changes, there is a public awareness that transfer of waters from water rich to water poor basins could be a good alternative to solve the problem, but at high financial costs, usually not payable by developing country.

Recent studies show that water transfers between sub-basins within DTD system are possible at acceptable costs. To come-up to this conclusion, comprehensive modeling and simulation is undertaken for various priority schemes in water distribution and allocation between the sub-basins.

Analysis/Results and Implications for Policy and/or Research

To simulate inter sub-basin water transfer possibilities and consequences, regional hydro system Nadela in Vojvodina Province is selected. System covers the area of 140 thousands of hectares and the length of the main canal is 83 km. Purposes of the system are drainage, collecting used waters, industrial supply, irrigation ond other purposes, such as fishing and some outdoor recreation activities. The system is selected as a case study for the three reasons.

First, this regional hydro system faces the problem of water allocation conflicts, especially between the upper and downstream users. Along the first 30 km of main (Nadela) canal, water is of desired quality ('blue and clean') and mostly used for irrigation. Downstream, during the summer season, it is usually not possible to augment even ecological minimum flow of 0.5 m^3/s. This un-balanced water supply, and especially heavy pollution in most downstream section of the canal, can be improved by inter sub-basin water transfer.

The second reason is heavy pollution problem itself. Industrial waste water, waste water from the farms and settlements cause high values of organic matters (HPK, BPK5) and low values of dissolved oxygen in canal waters. Introducing the fresh surface water into the canal from the Danube river is foreseen as a good solution to improve water quality.

And finally, the Nadela system belongs to the Banat-Eastern Serbia sub-basin, but it also very near to the Tisza sub-basin. These two sub-basins are connected by the Danube-Tisza-Danube hydro system, and there will be no need for significant canal reconstruction works and other related construction investments that usually restricts inter-basin water transfer.

Tizsa is one of the major rivers in Central Europe. It drains the area 158 square kilometers in five

countries. The Lower Tisza basin is in Serbia, riht south of the Hungarian-Serbian border. It is directly fed with waters by the Begej river, and indirectly by other tributaries via the Danube – Tisza – Danube system. The mean discharge at the confluence with the Danube is 766 m^3/s. Due to the precipitation in the upper sections of Tizsa, heavy flash floods are common in spring and summer. This excess water in Tizsa river could be, through Banatska Palanka – Novi Becej canal, transferred and used in Nadela which sometimes has no flow during period January-May.

Three water transfer strategies were defined, differing in amount of transfered waters, water demands and priorities in supply. Simulation of strategies is performed using the software MODSIM, worldwide known river basin network model based on combined simulation and optimization. It is also used in this study as a decision support system and combined with multicriteria decision-making tools to assess and compare different simulated water transfer scenarios.

The Discussion over the Multi-agent Coordination Mechanism of South-to-North Water Diversion Project Management and the Corresponding Function of GWP China

Author: **Mr. Junxian Yin** (Keynote Speaker)
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Keywords: south-to-north water diversion project, multi-agent, coordination mechanism, GWP china, ecological water operation

South-to-north Water Diversion project (S-NWDP) is a major strategic infrastructure facility, will alleviate water scarcity in North China, optimize water resources allocation and ensure the sustainable development of social economy and ecological environment. The project was planned to divert water from the upstream, middle stream and downstream of Yangtze River and across four basins including Yangtze River, Yellow River, Huaihe River and Haihe River, forming a general pattern of "Four Horizontal Lines and Three Longitudinal Lines, south-north allocation, and west-east association" of the country. The East and Middle Routes of S-NWDP have been constructing in 2002 and 2003, respectively.

The water reception area of S-NWDP involve three river basins that is Yellow River, Huaihe River, Haihe River and seven provinces such as Hebei, Shangdong, etc, one of the socio-economic developed regions in North China. However, the pressures on ecological environment keep growing for human activities and natural drought in water reception area of S-NWDP. Especially, the serious ecological environment issues in the water reception area of the Middle Route. In addition, the limited quantities of ecological water diversion aggravate competitive contradiction among the provinces or cities in the water reception area, which make the ecological water compensation work more complicated and difficult. To ensure these works scientifically, efficiently, fairly and justly, this paper proposes to build coordination mechanism and introduce non-profit civil groups (GWP China) to preside overall coordination work.

The Middle Route of South-to-North Water Diversion Project(MRS-NWDP) divert water from Danjiangkou Reservoir located on Hanjiang River, which is a biggest tributary on left bank of Yangtze River, to Tuancheng lake in Beijing city and to Waihuan river in Tianjin city along northern margin of Tangbai River plain and the western margin of North China plain, through three provinces that is Hubei, Henan and Hebei. The length of the Middle Route(from Taochain canal head to Tuancheng lake in Beijing) is 1277km. The multi-year mean water quantities of first stage are about 9.5 billion m^3 and around 1.3 billion m^3 for ecological environment. However, the water reception area relates three River Basins of Yellow, Huaihe,Haihe and covers more than 150 thousand km^2 in MRS-NWDP. The regional features of ecological environment problems and the spatial and temporal variations of water resources among basins make the contradiction discrepancy of ecological environment use water particularly stark under different runoff states between different parts within the water reception area. Therefore, the starting-point and emphasis of coordination need to be adjusted correspondingly in order to adapt operation practice.

The funding of main MRS-NWDP construction comes from central and local governments. The project involves in many stakeolders, such as Hubei, Henan, Hebei, Beijing and Tianjin, etc. The multi-faceted investment structure determines the diversification of policy maker for ecological wa-

ter diversion. Therefore, the distribution mechanism of ecological water diversion should be built to coordinate divergence and contradiction between different stockholders.

The comprehensive benefit maximization as well as justification between different provinces for ecological environment use water distribution should be considered during decision-making process due to the objective complexity and policy maker diversification of ecological water distribution in MRS-NWDP. This paper analyzes two type of distribution mechanisms that are comprehensive benefit maximization as well as based on ecological environment water right comparatively, then distributed group decision making model based on interprovincial coordination is built. So a feasible Multi-agent Coordination Mechanism which provides scientific evidence for ecological water divertion practice of MRS-NWDP is proposed.

Whether the distribution coordination mechanism of ecological water diversion working smoothly or not, we need a tackling system and a corresponding norm. As a cross-departmental, inter-industrial, and non-profit NGO, GWP China and its provincial partnerships have a widespread network and independent standpoint that enable it to gain confidence from different provinces and possess organizational conditions and professional qualification to preside the coordination process for ecological water distribution of MRS-NWDP. Through set up a large connecting information communication and supervision platform, GWP China will promote dialogue between different stakeholders, strengthen regional cooperation, maintain project's sustainable operation, and maximize comprehensive benefits.

Climate Change, Inter-basin Transfers, and Institutional Resilience along the Jordan River System

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Keywords: climate change, Jordan River, inter-basin transfers, institutions, river basin commissions

Introduction/Problem Identification

Various climate change models are predicting an increase in temperature, a decrease in precipitation, and an increase in the evaporation rate for the region covered by the Jordan River system. Combined, these expectations lead experts to argue that there will be an increase in natural hazards, such as floods and droughts, and a decrease in freshwater supplies (Evans, 2009). In this region plagued by severe water shortages, any decrease or variability in freshwater supplies is likely to complicate an already stressed crisis and contribute to significant losses by exacerbating the potential for conflict over water.

Analysis/Results and Implications for Policy and/or Research

To minimize the social, economic, and political losses from the anticipated changes, scholars have searched for means by which states and their societies can adapt. Yet, one issue largely neglected is the role of institutions, whether domestic or regional, in facilitating the adjustment to ever-decreasing and variable water resources and negotiating interbasin transfers of water to compensate for decreasing supplies. Drawing on neoliberal institutionalism, the paper explores the role and resilience of institutions in managing the transition to the anticipated decrease in water availability or increase in its variability and facilitating interbasin transfers of water. As the paper argues, the design and capabilities vested in these institutions are expected to influence their resilience in the face of uncertainties. To demonstrate this argument, the paper characterizes the nature and degree of uncertainty that can likely be expected as the result of climate change in the region. With this information as input, the paper examines the various bilateral river basin commissions established to govern the Jordan River and their role in augmenting exiting supplies through interbasin transfers. The paper also considers domestic institutions for managing national water resources and their function in searching for additional water supplies. Case studies include transporting Disi waters to Amman, the Wahdah dam's ability to meet domestic and regional water needs, and the Red Sea-Dead Sea network of water transportation system.

Workshop 5: Safe Water Services in Post-conflict and Post-disaster Contexts

New Solutions for How to Reduce Flooding Hazards Risk (Application for EL Hamiz Basin, Algeria)

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Keywords: hydrology, rainfall, flow, floods, basin

Introduction/Problem Identification

The study area (Hamiz basin) knows a serious flooding risk in the winter period; unfortunately we have many cities near the Hamiz River. This condition lets us to think or to look for one method to minimize the flooding risks in peri-urbain area.

Analysis/Results and Implications for Policy and/or Research

The aim of this work is to develop a statistical model describing the floods regime of a catchment.

We adopted an approach based on the flow-duration-frequency (qdf) analysis, which takes into account the temporal variability of floods.

We propose, with the example of the Hamiz basin (284 km²) in North East Algeria, a simple method to account for available information related to the event space-time variability of rainfall in a rainfall-runoff modelling, in order to check its influence on the shape, magnitude and timing of resulting hydrographs.

This approach is analogous to the intensity duration frequency (idf) applied to the rainfall.
A local and regional approach is developed. In this last case, the model uses classical concepts of regional hydrology (index flood method) and can be applied to basins where no flow data is available. In the end this model gives us new solution for how to reduce risk associated with disasters at basin scale.

Groundwater, Glacier, Flooding and Global Warming in Himalayas

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Keywords: groundwater, glacier, flooding, global warming, Himalayas

Introduction/Problem Identification

Groundwater is poorly understood subject in mountains specially the high altitude cold mountain deserts of Ladakh, Himalayas. Geological complexity, geographical inaccessibility, climatic extreme variability and unavailability of hydro geological data all combine to make groundwater, a mystery to understand and difficult to develop as a resource for policy makers and politicians. Present paper tries to bridge this gap by compiling the available data from the wells drilled and establishes the relationship between groundwater, glacier, floods and global warming in mountains so that groundwater could be understood and used in totality. On one hand paper laments that global warming is natural cyclic process and glacial melting will lead to increased water in the natural mountain system which supports increased evolution and diversification of life forms on other it advocates steps required to cope with floods induced due to glacial melt which pose great threat to habitants in valleys.

Analysis/Results and Implications for Policy and/or Research

Present paper highlights significance of groundwater exploration for sustainable water development in Himalayas. To explain relationship between groundwater, glacial melt, flooding and global warming, I am presenting Case study of Khardungla-Leh catchment in Ladakh Indian Himalayas. This catchment houses Khardungla (K) glacier at the top and Leh town at its distal end on the banks of Indus River. This K glacier extended upto Spituk in geological past but today it is on the verge of extinction and is confined only to the peeks of Khardungla at 18000 feet above the mean sea level. The K glacier located at top of the Batholithic hill is the main source of water (both surface and groundwater) to the Leh town. Surface water from the glacial melt and Indus River were the only source of drinking water in the Leh till end of 20th century. Experiments carried by author laid the foundation for sustainable development of groundwater resources. Groundwater today has become a household commodity and everyone is enjoying the fruits of resource which was considered to be nonexistent about a decade ago. Important question here is how long are these resources going to last. Global warming has already taken its toll and K glacier has already receded considerably. It is matter of time, groundwater will last till the snow cover remains in the Khardungla. No Glacier means no water in Leh catchment. All streams and spring sources would dry up or become seasonal. This is story of all glacial mountain catchments the world over. All the major glaciers world over had already receded much before the advent of man or industrialisation. Today these mountain glaciers are on verge of extinction. Impact of man and his activities was negligible in those times but still rates of receding of glaciers were very high. Indus glacier itself owe its extinction from Indus basin to global warming which happens to be natural cyclic process and has nothing to do with man or his activity or rather to any geological activity on sustainable basis in past. Author after studying more than 1000 wells drilled in different hydrostratigraphic formation across Himalayas clearly shows that global warming has resulted in melting of glaciers since time immemorial. Immediate impact of this activity is increased groundwater and its storage in mountains. Long term impact would be their activity leading to flash flooding once storage capacity of these hills exceeds the threshold. This activity will first lead to mountain bursting and cause flash floods which have capacity to wash anything which

comes in its way downstream within seconds. If cyclones and hurricanes are talked about and feared events in coastal areas, mountain flash flooding is an event to be watched in future in mountains. Today economic compulsions and geological ignorance is forcing the habitations to flourish along the valleys which were considered to be geologically fragile few decades ago but negligence of the geological data will lead them to pay a heavy prise in near future. A simple flood will lead to heavy loss of life and property in the mountain state.

Based on observation of samples collected while drilling borewells to develop groundwater resources to provide drinking water for army and civil population in high altitude, cold, mountain deserts of Ladakh which are geologically complex and geographically isolated for more than 6 months due to extreme cold climatic conditions. Though author was able to develop groundwater for providing sustainable water solutions on one hand but study also resulted in discovering evidences of Indus Glacier deposits in borewell samples at depth varying from 70 feet to 130 feet below ground and paleoglaciated deposits of K glacier of 290 feet thick at North Polu (base camp for Khardungla) at altitude of 15000 feet above the mean sea Level. Presence of paleo Indus glaciated channels at these depths are source of rich reservoir of groundwater resources for meeting drinking water requirement for Leh town now and in near future on one hand but did this resource (melting of Indus glacier) lead to flooding and extinction of Indus Valley civilization has yet to be investigated? Important question here again is will the thickness of 290 feet deposits at North Polu actually lead to dooms day for Leh town in near future! Though glaciers are main source of groundwater recharge in mountains, other side of glacial melting (FLASH FLOODING) due to global warming is very dangerous event threatening the very existence of the communities residing in hills or mountain valleys. Therefore if proper precautions are not made while selecting habitations entire civilisations along mountain basins will become extinct. Loss of Indus valley civilisation in past has to be examined from this point of view. Though at present this subject and phenomenon is poorly understood but detailed study holds key for our very existence in near future.

Prospects of Using the Solar Energy for Water Supply of Population in the Aral Sea Disaster Zone

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Keywords: water supply, desalination, solar energy, Aral Sea, well waters

Introduction/Problem Identification

The qualitative drinking water supply of population in the Aral Sea region is one of the major problems in Uzbekistan and Central Asian (CA) region and at the present time the solving of this problem on the focus of CA countries. For the decision of the given problem many international organizations and foundations are involved. The large governmental program on improvement of drinking water supply in Aral Sea region is executed. It is a part of a wide package of the projects financed by several international institutes within the framework of assistance of the international community for solving of social and ecological problems in the region.

Analysis/Results and Implications for Policy and/or Research

It is a part of a wide package of the projects financed by several international institutes within the framework of assistance of the international community for solving of social and ecological problems in the region. The financial support was rendered by the National centers of scientific researches of two countries – CNRG, France, and DFG, Germany. Financing of the projects by a total cost of 103,2 million US dollars was carried out from means of the loans of the International Development and Reconstruction Bank and, Kuwait Foundation of the Arabian Economic Development (KFAED) and Deutsche Bank of development KFW with attraction of means of the state budget. Within the framework of these projects in the basic emphasis is made to improvement of existing water supply systems and creation of new water supply systems which requires significant efforts and expenses.

Despite of it in the present time an ecological situation in Aral Sea zone has worsened, that it has left from frameworks of the Central Asia region and has got more global importance. Its pernicious influence today is felt on health of the population and gene pool of the future generations, and as in a climate change and biological balance all over the world. However, still the problem of drinking water supply of population in the Aral Sea disaster zone remains unsolved.

In a today's economically difficult situation in CA including Republic of Uzbekistan the performance of such expensive projects is insolvent. It would be a reasonable decision if the problem would be solved by using environmentally safe and less expensive technologies and equipments. From the economically point of view on our sight more effective creation of the independent solar water desalination, and also to use of energy of the sun for the lifting of underground artesian well waters and on this it is possible to consider them as reliable sources of pure water.

On the other hand use of the solar energy for a solving of this problem is rather perspective even by virtue of that in Uzbekistan where the average 300 sunny days per year. Thus the energy of the sun can be used doubly: both for water desalination and for maintenance of lifting a water of artesian wells by so-called solar water systems.

At the present time in the world there is a set of variants of the solar desalination systems. Water

desalination system which we offered use two kinds of the concentrator of solar radiation: the first concentrator with use of optical lenses of the large diameter received by Zol-Gel method, second concentrator of solar radiation of a mirror type. In both systems with the help of the concentrated solar radiation the intensive evaporation saline water and their subsequent condensation is extracted, that provides of the water desalination.

Using the artesian wells are the most reliable and optimum way of water supply of the population especially in the villages where the big water supply stations are not effective. At the same time it is necessary to take into account that the economic and social developments in the Aral Sea region have had in last 25-30 years extremely negatively on the environmental condition.

Offering water desalination equipment and artesian water lifting system by using a solar energy will help with improving a situation in the region as well.

In the conclusion it would be possible to note, that the created portable equipment for desalination of water by using of solar energy may work independently in villages where the electricity is the big problem. Also it is less expensive in cost and environmentally safe. In Uzbekistan and other CA countries almost 90% customers use the ground waters as a main source of drinking water. Using of solar water systems in the artesian wells is very perspective in the CA region and especially for water supply system of population in the Aral Sea disaster zone.

Strengthening Community Management of Water Schemes in the Post Conflict Context of Eastern DRC

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Keywords: capacity building, piped water scheme, community management, water, gender

Introduction/Problem Identification

In Eastern DRC, advancement in provision of adequate water and sanitation facilities has been hampered by conflict, weak government institutions, and poor infrastructure linking the provinces to the capital city. In this post-conflict context large numbers of Congolese refugees are returning on a daily basis to Eastern DRC from camps in neighbouring countries. They are arriving into an environment with inadequate, war damaged infrastructure, including lack of adequate safe water and sanitation services, which has resulted in frequent cholera outbreaks. In addition there is a climate of uncertainty about lasting peace within the region (highlighted by the recent events in North Kivu) and therefore reluctance from donors to invest heavily in substantial hard infrastructure. It is therefore critical that water services management capacity is re-built to enable infrastructure development and sustainability of safe water services.

Analysis/Results and Implications for Policy and/or Research

Analysis/Results

This paper presents a case study from Swima Village, South Kivu, DRC, illustrating the value of coordination between government, international agencies, local communities and non-governmental organisations for successful re-building and management of essential water services in a post conflict environment where government capacity is limited and where strengthening of traditional community water management structures has proved to be very successful in achieving sustainability.

One such community water management group is Kamati la Maji Safi (Committee of Improved Water) from Swima village. Tearfund has worked in partnership with this group for four years to strengthen their capacity to successfully manage rehabilitation and ongoing operational management of a spring fed, piped water supply system, providing safe water to more than 10,000 people. In addition there has also been a focus on community empowerment for provision of adequate sanitation services and hygiene education. Kamati la Maji Safi are now independently managing the water supply and sanitation services within their community and actively raising capital to extend the coverage of their water supply network due to increasing demand from recent returnees.

Success of the programme may be attributed to several key areas:

1 A focus on strengthening and empowering existing community groups to manage and resolve their own water and sanitation problems. Including empowerment of KMS to plan and manage rehabilitation of their own water supply scheme, resulting in a high level of technical knowledge retention within the community.

2 The inclusion of women, at all stages in the capacity building process, resulting in high representation of women on the board of KMS.
3 Establishing government recognition of KMS was an official 'local water association' with a recognised mandate. KMS has currently begun bidding through proposal writing for up-coming WASH projects in the areas where it covers.
4 Recognition of the importance of development of human capital to enhance the chances of project sustainability for communities' emerging out of war; or in case of re- displacement of communities due to renewed fighting; and effective long-term management of structures by user groups.

Implications/Conclusions

This paper illustrates how communities can enhance their capacity, and expand their outreach and input into the very same societies they function in. The KMS story is one that highlights growth, the challenges and roadblocks, the importance of community participation, and the capacity jewel that is within societies to achieve.

Capacity building of communities in the management of water systems in fragile states is an effective method that ensures sustainability and builds the capacity of the communities to be able to ensure clean and safe drinking water after exit by International Non-governmental Organisations (INGOs) and before government has established adequate institutional capacity.

Investment in local human capacity should be a priority to enable sustainability of safe water services in post-conflict fragile states.

Innovative Ultra-low-cost Rain Water Harvesting Techniques for Emergencies

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Keywords: rainwater harvesting, post-conflict, post-disaster, Sudan, ultra-low-cost

Introduction/Problem Identification

In the context of global climate change, rain water harvesting (RWH) presents itself as a water source with significant environmental, social and economic benefits worth serious consideration in post-conflict and post-disaster contexts.

This paper presents a case study of new innovative ideas for ultra-low-cost RWH techniques appropriate for transient populations, together with analysis of performance, based on a practical field test in Southern Sudan.

The study was carried out in a village in Southern Sudan facing an influx of returnee refugees. The situation is one of reduced capacity, weak civil society, and weak government that lack adequate resources to provide the population with secure access to safe drinking water. Returning refugees have placed incredible strain on the existing 'improved' water sources. Clean drinking water wells are few and widely spaced, so that during the wet season, disease increases as communities resort to unsafe surface water sources near their homes.

Analysis/Results and Implications for Policy and/or Research

Analysis

The provision of adequate water in a post-conflict/post-disaster context is a complex issue and one that often needs multiple approaches to ensure security of supply. An often overlooked, easily accessible and sustainable source of safe drinking water during the wet season is rain, which falls in abundance in most tropical and sub-tropical climates. Self-help RWH water supply has distinct advantages for the users, namely easy access, low-cost, and ease of management.

For this pilot project a number of innovative low cost RWH techniques were adapted for the Southern Sudan context. Firstly, very low cost domestic roof water harvesting methods were successfully piloted using corrugated iron rooftops, various forms of guttering, first flush diverters, with collection and storage in plastic or ferro-cement tanks. Local tradesmen were coached in techniques for fabrication and installation of the systems. However, as in many emergency and post emergency situations, there were very few permanent structures. The structures with corrugated iron rooftops suitable for RWH were limited to one health clinic and a few shops. Most of the population live in simple thatched roof structures, known as Tukuls, which don't lend themselves towards traditional roof rainwater harvesting techniques.

Therefore in order to make self-help RWH accessible to the majority of the population living in simple thatched roof structures. A second innovative simple' ultra low cost' approach to RWH without rooftops was therefore researched and piloted.

As with many transient populations, especially in emergency and post emergency situations, plastic sheeting is a basic commodity that many households obtain from distributions at IDP and refugee camps, or purchase on the local market. These plastic sheets are used for multiple purposes including shelter for homes or shops, and at the same time can be used for RWH.

The innovative 'ultra-low cost' idea is to use plastic sheeting together with other locally available materials to intercept rainwater and channel it into suitable collection containers. Several designs have been successfully piloted to collect rainwater and channel it into jerry cans and drums. All the materials used were locally available, including storage containers which in many cases were locally made clay pots.

After the pilot programme demonstrations most community members were convinced of the benefits of rainwater harvesting and many constructed similar rainwater collection systems at their homes. Initial follow-up monitoring indicated that a high proportion of the community, are collecting rainwater as a primary water source during the wet season. Some members of the community also volunteered to spread knowledge about self-help RWH techniques to neighbouring communities. Further follow-up monitoring and evaluation will be carried out over the next three years to conclusively verify the level of technology uptake within the wider community.

Self help 'ultra low cost' rainwater harvesting does not need to be limited to the use of plastic sheeting for harvesting, other locally available materials can also be successfully used, such as single corrugated iron sheets and cloth. Self-help traditional methods of rainwater harvesting used in Uganda and Sri Lanka also include rainwater collection from trees, using banana leaves or stems as temporary gutters; up to 200 litres may be collected from a large tree in a single storm.

Results

Key environmental benefits of RWH include flood attenuation and reduced demand on groundwater reserves. In addition where care is taken to ensure a clean harvesting surface and collection container, the quality of water is good and can be safely consumed without further treatment; and in tropical and sub-tropical climates the quantity of water collected from a rainfall event is excellent.

Key social benefits of RWH include ease of access, good taste, and ease of management. In addition point-of-use water collection results in reduced risk and burden to women and children during water collection; and due to its self-help nature, plastic sheet RWH can be an interim measure used by communities following a disaster and before aid arrives.

Key economic benefits of RWH include the low cost – especially the 'ultra-low cost' self-help water collection methods, which can be accessible to the majority of the poor and most vulnerable; and the potential for livelihoods development.

Conclusion

RWH in its many forms should always be considered as a potential water source to supplement other supplies. This is especially true in emergency and post emergency situations, where RWH in its simplest form, can become a self-help water source available to all, while in more complex forms, it can contribute as a significant water source to large communities and camps.

Over 30 Years Technical and Field Research Experience in Post Conflict and Post Disaster Contexts; So What Has WEDC Learned?

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Keywords: capacity-development, applied-research, evidence-based, knowledge, technical-support

Introduction/Problem Identification

Established over 30 years ago, WEDC is one of the world's leading education and research institutes developing knowledge and capacity in water and sanitation. Focusing on solutions we help to provide evidence-based answers to important questions about what to do and how to do it. Increasingly we provide effective and efficient technical and research capability in post conflict, post disaster and fragile states. Other agencies have expertise in these areas yet few are able to synthesise sector specific lessons from technical support, applied research, teaching and capacity development. With global expenditure in post conflict reconstruction and development up more than 400% since 2000 (PRDU 2009), we have reviewed our experiences; enabling us to better understand our contribution and distil learning. The outcome we believe will assist our partners and clients; students, governments, development agencies and academics to improve the relevance, efficacy, and efficiency of response.

Analysis/Results and Implications for Policy and/or Research

WEDC's work is premised on the understanding that the water and sanitation sector in stable contexts represents a highly complex institutional and operational environment. In post conflict, post disaster and fragile states this complexity is exacerbated, requiring heightened inter-disciplinary approaches and multi-dimensional problem solving. Our internal review looked at the range and content of commissioned technical support missions by WEDC staff, our applied research findings and the key messages and trends that we have promoted in our related capacity development activities and post graduate teaching since our establishment in 1971.

Our qualitative review involved examination of our understanding of the types of disasters, their trends, causes and consequences; programmatic knowledge of infrastructure provision in post emergency and crisis contexts; appreciation of the range of technologies and infrastructure needed by affected communities; and the policy, institutional and human resource requirements that enable country-based stakeholders to take a central role in working with traumatised populations to deliver essential services.

Our findings emphasise the role of institutions like WEDC in assisting to bridge the knowledge, information and skill gaps that exist between transition from crisis management through reconstruction to longer-term development programmes; and the importance of an independent perspective, institutional memory and reputation, along with the need for strong and practical linkages between ground realities, academia and teaching. Key recommendations include: the need to structure joint reflection on water and sanitation project and programmatic goals, strategies and outcomes as a means of improving response; the need to look beyond the confines of water and sanitation to secure public health objectives; recognition that all sector professionals require a set of core competencies in post-conflict and crisis decision making, regardless of where their country of operation sits on the

emergency to development continuum; and an urgent need to smarten the dissemination of practical information to a wider stakeholder base including households and communities, through the use of information and communication technology.

Post Disaster Management in Water and Sanitation Activities Sri Lanka – Experience from Tsunami

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Keywords: disaster management, water and sanitation Sri lanka, tsunami Sri lanka, impact of tsunami, tsunami disaster

Introduction/Problem Identification

The Tsunami wave generated by an underwater earthquake of 9.3 on the Richter scale, on the western end of the coast of Sumatran-Andaman islands of Indonesia on the morning (6.58 a.m. local time) of 26th December 2004, witnessed the devastating blow to the coastal region of Sri Lanka. The Tsunami claimed over 30,000 human lives from the coastal belt of Sri Lanka and about 2/3 of that from the Northern and Eastern coast. Over 400,000 people lost their homes and livelihood following two, in some places three waves. Thirteen districts in Northern, Eastern, Southern, Western and North-Western Provinces were affected. The table 1, obtained from the Rapid Technical Assessment – Water Supply and Sanitation (2005) carried out by a DANIDA mission indicates the statistic of damages to lives and property. Over one million people were directly affected to varying degrees of destruction to lives, homes and jobs and equipment.

Analysis/Results and Implications for Policy and/or Research

Impact on Water Supply and Sanitation

The Southern and North Eastern Districts were affected by broken distribution lines that ran close to the coastline. The head works at high elevations were not affected. The coastal belt extending from South-East to Eastern and Northern districts rely on well water for drinking. These open dug wells were contaminated with saline water. The process of dewatering have to be repeated several times before the water is potable.

Preliminary Need Assessment

The water and sanitation sector incurring loss of USD 42 million constituting 4.2% of the total losses. Study shows about 12,000 drinking water wells being affected with saline contamination and over 50,000 wells being abandoned. The damages caused to the pipe schemes are mainly to the distribution lines rather than intakes, treatment plants and main transmission lines. The sanitation facilities affected are mainly house-hold latrines, and in worst cases total destruction of the entire system.

Remedying the Loss to Water Supply and Sanitation Sector

The Government sought to resolve water supply and sanitation sector issue caused by the Tsunami with focus on the following for basic water supply and sanitation support;

1 Immediate restoration of services.
2 Medium to long term focus on rehabilitation and expansion.

The following approach is proposed is address above;

a Immediate sector support to the people living in temporary and transit camps.
b Immediate and Medium term support to people who have moved back to the restored original residence.

c Immediate and medium term support to people resettled in new areas.
d Support to meet the longer term needs of the people on a 10 year planning horizon.

Rapid Technical Assessment (RTA)
The RTAs were carried out to outline the basis and approach for possible donor support and, in line with the GOSL's strategy, assess the investment needs and the total prioritization of investments.

The methodology and subsequent analysis of data will produce information on damages and requirements of following:
1 Transit camps and temporary settlements
2 Resettlement Areas
3 Affected areas with defunct water supply
4 Piped water supply schemes

The Technical Requirement
The technical requirement to assist in water supply and sanitation restoration and facilitation of efficient implementation and effective administration is broken down to three distinct phases. The three phases are:
In Phase I –the water and sanitation requirements is in urgent deficit, particularly transit camps will be addressed.
In Phase II – Medium Term; restoring water supply and sanitation services to disrupted areas and to transit camps and resettlement areas constructed.
In Phase III – Improvements to the water supply with further improvements to the schemes supplying to the Tsunami victims.

Experience Gained and Difficulties Encountered
Phase I – addresses supplying water and sanitation to temporary settlements. Transit camps are houses built as blocks or barracks with 2 to 6 units. The overall structures are temporary nature with cement rendered floors. Toilets are common and placed outside the buildings. Where piped water supply is available, common yard taps are installed on compartment basis.

Toilets are placed commonly outside the settlements. This is inconvenient to women and children are pushed towards open air defecation(OAD). The general practice of OAD can lead ground water pollution and consequently to diseases. In rain water harvesting systems there is a risk of breading of Malaria mosquitoes.

Phase II –Concentration on construction and rehabilitation of partly damaged houses. The resettlement process is governed by essentially Land availability, Funding assistance and availability of infrastructure and utilities.

Design criteria for water supply should be based on National Standards, qualifying through socio-economic base-line details. Sanitary pit latrines, one per house hold and several sewerage pits per resettlement scheme.

Phase III – The final stage of the process includes expansion and improvement to the systems that were established at phase II. Reducing the 40% of the non-revenue water mainly due to leakages in the distribution system can make a shift from poor supply to regular.

Conclusion and Recommendations

Future policies and designs for structures along the coastal stretch will cater to withstand tidal and cyclonic attack and to cope with disasters.

Crisis Management Plan (CMP) will be developed a methodology to face disasters. This CMP will allow for flexibility of modification for degree of impact and magnitude. This Plan will be grouped on – Physical and Financial. Financial Category should include a fast track procurement plan which can be executed for emergency situations. Sharing of knowledge on disasters among vulnerable nations can prevent loss of life.

Challenges in Providing Water and Sanitation for Northern Sri Lanka after the Conflicts

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Keywords: rebels, war, development, water, sanitation

Introduction/Problem Identification

Sri Lanka has been undergoing an undeclared war between Tamil rebels and government armies for the last 25 years. Fighting was mainly restricted to Northern and Eastern parts of the country although sporadic incidents were reported from other parts especially from capital Colombo. Since 2005, fighting against rebels has been intensified and by mid of 2007, Government could take entire Eastern province under their control. Thereafter fighting was directed towards Northern parts and by end of January 2008, security forces were able to bring about 95% of the area under their control. The Government expects whole Northern Province to be cleared within next few months.

With the liberation of areas under the control of rebels, the immediate challenge was to provide basic facilities for the displaced people. Water and sanitation was among the immediate basic needs. Provision of water and sanitation facilities was undertaken under three stages.

Analysis/Results and Implications for Policy and/or Research

Immediate water and sanitation requirements for temporary camps, for transitional camps and permanent housing were them. First two phases were handled with the assistance of international and national NGOs, with the Government taking leading role with their budget. Then the third and most difficult phase in the process has to be started. It is the provision of water and sanitation facilities for permanent houses. The experience gained after tsunami disaster in 2004, was very much helpful in this process. This process has already been started in the Eastern Province. This paper will elaborate the challenges to be faced in providing water and sanitation for permanent houses in post conflict situation in Northern Province of Sri Lanka.

Even before 1983, only a very small percentage of population in the Province was covered by Piped water supply. Many people depended on shallow ground water for their water needs. There were no piped sewerage schemes at all. Every household used on site sanitation. However with the recent trends in the world undoubtedly people will demand more improved water supply and sanitation facilities. There are a number of challenges that are expected in the process of providing water and sanitation facilities.

1 The Northern Province of Sri Lanka consists of five administrative districts. The capital of the province was Jaffna. The extent of the province is about 7500 SQ. KM. The population in the province was 650,000 as per the last census carried out in 1981. It had an average growth rate of 1.6% per annum in 1983. Accordingly the present population should be about 1,200,000. However due to the unsettled conditions in the Province, a substantial number of people have migrated into all parts of the world. Another large number of people are still living in near by Southern state of India

(Thamilnadu) and a lot of people have shifted to southern parts of the country. A large number of youths have lost their lives due to the armed conflict. Therefore an estimation of population is quite difficult. A large number of people who may return from Thaminadu and other countries have also to be considered in future planning.

2 Future resettlement areas have to be clearly identified for the planning purposes. As some towns and urban areas have been completely destroyed by the war, a comprehensive planning for land use is also possible. While this may delay the provision of indented facilities, this is advantage as it will allow for properly planned residential, commercial and agricultural areas.
3 Another serious challenge is the lack of sufficient surface water sources. Apart from some irrigation tanks and small rivers, there are no major water sources for the province. The condition of ground water is also undesirable in many parts due to the geological formations. Therefore water conservation has to be seriously considered. Simple technologies such as rain water harvesting have also to be promoted.
4 This process will require huge capital investments. As the country is facing a severe difficult situation due to the global recession and pro longed war, finding of necessary funds will be a major challenge.
5 Although funds are available necessary skilled and unskilled man power, experienced contractors and equipment and machinery may be difficult to be found.
6 Generally water supply and sanitation plans are forwarded for comments of the beneficiaries including local and provincial level political bodies. As those administrative units are still not been formulated, it will be difficult to proceed with the people's consent. Furthermore it may take time to establish a proper administrative mechanism and this may cause delays in implementation.
7 Although water and sanitation facilities are provided, there may not be sufficiently capable work force to run them. Therefore capacity development of people working in the water sector is also required.
8 Provision of water and sanitation has to be in par with other development activities in the area. If there are difficulties in proceeding with development in all sectors, that will be another challenge.

Even with the above challenges, Government has already initiated action for preliminary planning of proposed interventions and intends to continue with them during the coming months of the year. Although this is a challenging process, it should be considered as an opportunity to develop the area to suit to the 21st century.

Post Disaster Water and Sanitation Reconstruction – Potential for Improvement

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Keywords: natural disaster, reconstruction, participation, process oriented, preparedness

Introduction/Problem Identification

The paper presents observations and experiences from the South Asian Earthquake in 2005 in Pakistan and discusses the effects of a lack of participatory methods on mitigating for future natural disasters in the region. The paper aims to be a support to implementing and donor organizations and practitioners in the water and sanitation sector, and also seeks to contribute to an improvement in WATSAN approaches in post disaster reconstruction and development.

Analysis/Results and Implications for Policy and/or Research

A major earthquake hit parts of Northern Pakistan in October 2005, and the following relief and reconstruction efforts indicated how far the international humanitarian society has come in its approaches towards the local. It was observed that local communities to a large extent were left out of important decision making processes regarding the reconstruction of water and sanitation facilities. This paper argues that in order to mitigate for future earthquakes in the region and any earthquake prone zones in developing countries, the development approaches promoted have to be reconsidered based on the actual processes taking place on the ground. Many national and international humanitarian and developmental organizations already have policy papers promoting participatory approaches in water and sanitation, but the South Asian Earthquake (SAEQ) post disaster efforts effectively showed that there is a considerable gap between paper and practice. In many of the NGOs and INGOs working in the area it seemed to be common practice to implement projects with a minimum of local involvement. This practice will possibly save the organization time in a tight implementation schedule, but ultimately compromises the capacity of the local communities to manage the water supply systems in the longer term and to tackle maintenance and repairs when needed. Men and women's understanding of and contribution to the development of appropriate water and sanitation systems is central to ensure local motivation, recovery and development. We argue that a reconstruction process in which representatives from the local communities are not only included, but also given the power to discuss and influence the process outcomes, is crucial for the communities to gain sufficient competence and self confidence. This is possibly the single most important factor to mitigate and prepare for a future disaster. It is also important to support the existing relevant local government institutions, and to strengthen their capacity to cope with the new emergency and reconstruction situation. For example, in the SAEQ local government was hugely understaffed, and was thus often a bottleneck for organizations in obtaining the necessary papers to implement projects within water supply and sanitation.

Post-disaster Water Quality Assessment Scheme in a Small Suburban Watershed in the United States

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Keywords: disaster, flood, nutrient, water quality, watershed

Introduction/Problem Identification

The quality of water in the Midwestern United States is a matter of great concern. Most rivers and lakes in the Midwest are being degraded from diffuse influx of nutrients (nitrogen and phosphorus) from land areas adjacent to these water bodies. In many cases the land contains high concentrations of herbicides, and insecticides that get washed into the lake, along with erodible soil, as runoff during large storm events or high floods. Phosphorus (P) and nitrogen (N) are the primary causes of eutrophication of numerous surface water bodies. Eutrophication is an environmental condition that leads to the depletion of oxygen at depth (<2 milligrams per liter) in the surface water. This condition of eutrophication can also cause bigger problems dealing with drinking water quality in rural as well as suburban communities. It is important that each community has an emergency water quality assessment plan so that post-disaster responses can be coordinated efficiently.

Analysis/Results and Implications for Policy and/or Research

The proposed water quality assessment plan has 3 aspects, (1) research on episodic loss of nutrients from farmlands caused by unusual rain events and high floods; (2) Water quality education of students and community members; (3) Policy research at the state government level. The long term goal of these activities is to gain a better understanding of water quality science and to deal with the variety of complex and interrelated scientific, educational, and policy issues surrounding water use. In order to get baseline data on water pollution caused by natural disasters (such as high floods), a study was conducted in the Dry Run Creek Watershed of Cedar Falls, Iowa, USA. The Dry Run Creek watershed is a drainage system that is moderately farmed as well as urbanized. It covers an area of approximately 15,200 acres with nearly 24.5 miles of stream channel. The watershed was listed on the Iowa's impaired water list in 2002 and 2004 with government support to develop probable mechanisms of remediation. The objective of this study was to find out the contribution of fertilizers from the agricultural land to the dry run creek and find their temporal as well as spatial variations. A long-term goal was to develop an emergency water quality assessment plan in the watershed following natural disaster, such as a flood. In the summer of 2008, the state of Iowa was hit by a 500-year flood. Unfortunately, this was the second 500-year flood encountered in Iowa within a period of 15 years. A considerable amount of damage was done to the agricultural lands in terms of crop and nutrient loss from the soil. The state government put a huge initiative in place to develop emergency water quality assessment plan and management strategy. One way to deal with post-disaster damage assessment is to conduct a systematic field sampling of water and soil to delineate the problem areas, commonly referred to as nutrient or soil erosion "hot-spots". A prior knowledge of "hot-spots" and a well established sampling scheme would allow the city officials or the state agencies to respond according to the immediate needs. The state must prioritize the field response areas to make the post-disaster effort a successful one.

In order to define the problem areas in the Dry Run Creek watershed, a total of 13 different sites were chosen for sampling. The sites were geo-referenced using GIS. A total of 221 samples were collected for nitrate, chloride, sulfate, phosphate, and suspended sediment analysis. The samples were taken

from April through October of 2007. Some water quality parameters like conductivity, dissolved oxygen, pH, turbidity, and temperature were measured on-site using proper hydrologic instruments. Stream discharge was measured at all the sampling sites. The levels of dissolved ions and suspended sediments are generally expected to increase during late summer (June, July) due to increased runoff from agricultural fields compared to early summer (April, May) or Fall (August, September, October). It is hypothesized that similar response can also be expected as a result of flooding. The concentration of suspended sediments was as high as 84.68 mg/l after a small flood event at site 6 in late May. The highest levels of chloride, nitrate and sulfate had been observed as 89.22 ppm, 88.36 ppm and 50.04 ppm respectively. The results were correlated with types of land-use in the watershed to determine the probable impacts of large floods. Finally, an emergency response map was developed by using the observed data.

Water Sector Reform in the Democratic Republic of Congo

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Keywords: sector reform, water law, road map, water supply and sanitation, integrated water resources man

Introduction/Problem Identification

The military conflicts during the last 12 years caused an erosion of the governmental structures of the DR Congo, also within the water-sector. No infrastructural investments were made within the water management sector.

A further result of the political turmoil is the absence of a clear water policy. The legal regulations and strategies are antiquated. Numerous overlapping responsibilities and a lacking communication causes an inefficient management. The administrative capacities of the water management organisations are weak. Along with neglecting important fields of duty, these circumstances inhibit a successful development of water supply, wastewater management and water resources management.

The CNAEA, the National Water Supplier REGIDESO and the Rural Water Service SNHR, which should carry out the reform, are lacking capacities and financial resources to carry out water and wastewater management in an effective and cost-efficient manner.

Analysis/Results and Implications for Policy and/or Research

The joint project of GTZ and KfW Development Bank aims to form the basis for an overdue reform of the water sector in the DR Congo. KfW finances the recovery and extension of water supply in twenty middle sized towns in the Kasai and Bandundu region and advises REGIDESO with her structural reform plans and the improvement of her management capacities at regional level.

GTZ's focus is laid on the development of CNAEA, which can be seen as highest water authority of the DR Congo. The program advises CNAEA on the reformation of the national water policy. The three existing drafts for a water law have been subsumed to a new Water Law, concurrently accompanied with a rearrangement of the institutional structure of the sector. As anchored in the new constitution, a widely planned decentralisation is thereby taken into account. A strategy for the Water Resource Management, including all sub-sectors has been developed. According to their technical standard and relevance, bylaws and regulations of the water sector are going to be revised, Furthermore, CNAEA's role as coordinator of the various donor activities have been strengthened. For the next three years several areas of work has been identified and are being carried out:

- A "Road Map" of the reform is under development, which describes the strategy of the reform, indicators, and activities to be undertaken. A time table and a financing plan complete the document.
- A Water Information System including a measurement and date transfer system has to be developed. Implementation will be financed by international banks and donors.
- For all subsectors of water sector development plans will be elaborated including elaboration of management procedure manuals and training of the staff.
- The institutional landscape will be reformed including creation of a "National Water Council" and a "National Water Agency", which will have provincial equivalents to take into account the decentralized water management as it is foreseen by the new constitution.

Activities of Ukraine in the Development of Floods Management in Carpathians River Basins on Local, National and International Levels

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Keywords: floods, management, problems, needs, activities

Introduction/Problem Identification

The natural conditions of the Carpathians rivers basins (Dnister, Prut and Tisza rivers) are favourable for the floods runoff formation. Floods in these river basins can form in any season as a result of rainstorms or snowmelt. The territories of these river basins have been severely damaged during past years from extreme floods which occurred in November, 1998 and March, 2001 in Tisza river basin and in July 2008 in Dnister and Prut river basins. Taking into account the fact that river floods affect large areas with intense economical development and that Dnister, Prut and Tisza Rivers are transboundary rivers, one of the major requirements of comprehensive integrated water resources management is the development of floods management on local, national and international levels. The present state and new challenges in the development of flood management in Dnister, Prut and Tisza river basins are considered in this paper.

Analysis/Results and Implications for Policy and/or Research

The national activities in the field of water management, including floods management, are coordinated by the Cabinet of Ministers of Ukraine. The number of state governmental bodies are involved in this activities:

- the State Committee on Water Management is responsible maintenance of flood protection constructions, development of new engineering structures of water management;
- the State Hydrometeorological Service is responsible for providing economic sectors, governmental bodies and general population with meteorological and hydrological forecasts and warnings;
- the Ministry of Emergency is responsible for flood control combats, organization of the preventive protection, evacuation of the population, properties and livestock.

The local activities in this area are provided in the administrative regions located in Dnister, Prut and Tisza river basins by the local Governments, local branches of above mentioned governmental bodies.

The international activities of Ukraine in transboundary river basins are regulated by the Convention on the Protection and Use of Transboundary Watercources and International Lakes, the Declaration on Co-operation in the Field of Water-Related Issues, the Program on Hydrology and Water Resources of the WMO, the UNESCO International Hydrological Program, the Tisza River Basin Forum; Bilateral and Multilateral Agreements.

The experience of floods in the region of the last years indicated number problems at the floods management:

- in the river basins there are often not effective communication between state and local authorities during floods;
- the scarcity of the budget funds to provide with sustainable floods management;

- the separated planning and management of social, ecological and economical aspects of floods management;
- the lack of modern technical equipment and technology of hydrometeorological observation and forecasting;
- the low level of public participation in the water-related activity.

The concept of the Integrated Flood Management (IFM) can be a good basis for development of all aspects of flood disaster reduction through prevention of flooding. The IFM practices allow for rational decisions on prevention of negative impacts of floods and reduction without limiting the development potential of floodplains.

The policy of the development of floods management is implemented by means of elaboration and realization of national and local programs and action plans, and improvement of co-operation of all actors involved in the flood management. Several national programs of development of floods management, including the technical improvement of hydrometeorological observation and forecasting system, have been adopted from 1996 up to 2008: the Program of Prevention of Floods in the Tisza River Basin; the Program of Climate Researches;the Program of Prevention of Floods in Dnister and Prut river basins has been elaborated in the end of 2008.

To improve a coordination between different institutions the Interdepartment Council has been created. Representatives of water-related and NGO's have been included in this Council. This Council works together with international partners. These measures should help general co-operation between state governmental bodies, local authorities and general public, increase knowledge about floods management, and provide for a more coherent integrated floods management approach, including, the management planning for disaster reduction. The planning for disaster reduction includes:

1 Pre-disaster activities:
    - preparedness: risk analysis, public awareness, education and training, regulatory measures, spatial planning;
    - minimizing loss of life, property and environment: monitoring and forecasting, prediction and warning, evacuation and sheltering.
2 Past disaster activities:
    - emergency operations: search and rescue, rapid damage assessment;
    - recovery and reconstruction: planning in general, reconstruction, rehabilitation (economic, environmental, social).

Conclusions

Floods are inevitable, but their impacts can be reduced through an adequate planning of mitigation and prevention measures, including the establishment of adequate preparedness systems to increase the effectiveness of the emergency response triggered by early warnings and emergency operation. In spite of economical problems Ukraine is developing its floods management policy on local, national and international levels. Much attention is given to reformation and development of institutional background, i.e. changes for improvement of co-ordination of all central and local state bodies and general public. Implementation and enforcement of international and EU norms are a priority for all actors which are responsible for floods management and protection policy.

Obstacles in Delivering Water Systems in the Central African Republic

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Keywords: poverty, conflict, water system, hygiene, solutions

Introduction/Problem Identification

The Central African Republic (CAR) is a small country with a population of just 4 million. Decades of brutal dictatorships, revolts and coups has seriously hampered development.

There has been minimal or no investment in the public sector for decades and much infrastructure were destroyed due to conflict. The water and sanitation sector is no exception. Only 26% has access to safe drinking water while 27% have access to adequate sanitation facilities. CAR has some of the highest infant morbidity and mortality rates worldwide.

15 organizations including UNICEF provide WASH activities through rehabilitation and development as well as emergency interventions. However, high material costs, inadequate funding and insecurity restrain efforts.

UNICEF proposed solutions include persistent innovative advocacy with government and donors, ongoing support for peace consolidations and constant awareness-raising of the fact that the people of CAR need urgent assistance.

Analysis/Results and Implications for Policy and/or Research

Obstacles in delivering water systems in the Central African Republic
The Central African Republic (CAR) is a country the size of Texas located in the heart of Africa. The small population of about 4 million has suffered decades of brutal dictatorships, revolts and coups. Lawlessness has attracted regional road bandits which in recent years have pillaged through the northern parts of CAR. More than 200,000 people have been internally displaced or fled to neighboring countries. Ongoing insecurity has contributed to the immense poverty of the country.

There has been very little or no investment in the public sector for years and a lot of infrastructure was destroyed due to conflict. The water and sanitation sector is no exception. Only 26% of the population has access to safe drinking water while 27% have access to adequate sanitation facilities. Due to poor hygiene practices, CAR has some of the highest infant morbidity and mortality rates worldwide.

The government estimates that out of approximately 3,000 manually operated water pumps (main source of potable water nationwide), about 25% need total replacement. Furthermore, the 3,000 pumps are primarily located in 9 regions out of the country's 16. And ironically these 9 regions are along the northern corridor, which is burdened by displacement and ongoing insecurity. Humanitarian organizations including UNICEF, implement water, sanitation and hygiene (WASH) activities throughout the north however, this is done as emergency interventions rather than on a development basis.

Nationwide some 15 organizations including UNICEF provide WASH activities through rehabilitation and development as well as emergency interventions. However, activities are hugely hampered by

various factors including: a) High costs of construction materials. CAR is a landlocked country with minimal production activity. Imports are many and prices are high e.g. cement (integral to water and sanitation work) is imported and sold at US$40 per bag. International organizations (NGOs) are not tax-exempt when importing and purchasing. b) Adequate funding for water and sanitation development is scarce. c) Insecurity occasionally hinders implementation and/or effective evaluation of needs.

The combination of safe drinking water, adequate sanitation facilities and hygienic practices is a precondition for health and for success in the fight against poverty, hunger, child deaths and gender inequality. The lack of WASH interventions in CAR has an indisputable impact on the population, especially on children.

UNICEF proposed solutions to further WASH interventions in CAR:

a Advocate for tax-exemption for international humanitarian organizations (NGOs). A dollar less spent on imports is a dollar more toward hygiene promotion.
b Upscale funding activities such as the forthcoming Round Table on WASH sector development in CAR scheduled for April 2009.
c Support peace consolidations in northern CAR in order to initiate countrywide WASH development programs.
d Constant awareness-raising to the fact that the people of CAR need urgent assistance.

Traditional Community Response to Water Related Disasters in South Asia: Significance of a Gender Perspective

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Keywords: post-disasters, gender, safe-water, sanitation, livelihoods

Introduction/Problem Identification

People in several parts of South Asia live in perennial floods and related disaster conditions. Over the years, what is observed is that although early warning systems, risk reduction and response have improved considerably, but the severity and occurrence of disasters has increased primarily due to intensive development related activities, climate change and high population. What is also observed in the last 2 decades or so is that multiple stakeholders/agencies and local communities are now coming together with a wide range of innovative interventions to manage flood related post-disasters. There are several cases to illustrate where in such situations, the indigenous knowledge and traditional wisdom of local communities, especially that of women have helped reduce the impact of such disasters. Despite the importance given to gender considerations at policy levels, there is little evidence however of action at the planning and implementation levels. It still remains a lip service.

Analysis/Results and Implications for Policy and/or Research

The objective of the paper is to understand how local communities, particularly women along with multiple stakeholders – Government, Task Force for Rebuilding the Nation, UN agencies, NGOs, People's Institutions and Civil Society Organizations, International Development and Donor Agencies have been able to deal with and respond to water related disasters in different parts of South Asia. The idea is to understand the process of coming together of various agencies along with the local communities especially women's groups and their long term engagement with preparedness and post-disaster response with a focus on safe drinking water, sanitation and sustainable livelihoods. Gender mainstreaming in post-disasters has become a buzz word at the same time a lip service as evidence shows that very little is visible at the action level. This no doubt has implications in terms of further marginalization, gender stereotyping and gender based gaps in opportunities for skill development in planning and decision making, alternative employment and rehabilitation in general. The gender dimension will be deliberately highlighted as it gets subsumed in the name of communities and community participation.

It is a well established fact, that there is a differential impact of disasters on women and men. Women are more vulnerable in the aftermath of floods, tsunami and cyclones because of their physical vulnerability, less access to resources, overburdened with domestic responsibilities within the framework of gender based division of labour as they are the primary caregivers to children, elderly and disabled, less able to mobilize external resources for rehabilitation. Yet, observations from the field indicate that women are able to come up with several coping mechanisms in the face of disasters occurring regularly and have been able to contribute effectively to survival of their households and communities. Women's groups have also responded well to the external agencies in coming together to manage and reduce risks in disasters. A unique observation is the authenticity of information provided by women relating to disasters in terms of nature and intensity, impact, relief or rehabilitation.

Access to safe drinking water, sanitation, public health and safety become prime concerns for women affected by water related disasters. Women's coping mechanisms under adverse conditions over the

years, during and after disasters will be the focus of the paper. Several cases like Tsunami in South India, Sri Lanka and the Andaman Islands and efforts by the NGO coordination committee, Subarnarekha floods in Orissa and people's response, the Kosi floods in Bihar and other Cyclone/Disaster affected areas in South Asia would be discussed in the paper. In all these cases, there is a presence of strong people's platforms, women's collective action, local campaigns and movements, along with the efforts of the external agencies to combat disasters has provided local communities not only shelter, but also, access to safe drinking water, proper sanitation and safety especially for women and children and rebuild communities in a manner that is sustainable. In many such cases, the role and presence of people's institutions to which women can easily relate to at the grassroots level, are commendable in facilitating efforts of local women to organize themselves. The need of the hour is systematic and appropriate documentation of community response from a gender perspective (keeping in view the nature of gender relations at the household and community levels) of water (floods, tsunami, cyclones) related disasters which will be of use to government and non-government organizations engaged in disaster preparedness and management policies, plans and programmes in South Asia. By doing so, there can be meaningful community based strategies and actions planned around disasters with a gender perspective.

Mitigating Urban Flood Disasters in Syria: A Case Study of the Massive Zeyzoun Dam Collapse

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Keywords: flood management, risk reduction, safe water, post-disaster rehabilitation, emergency management capacity

Introduction/Problem Identification

Analysis/Results and Implications for Policy and/or Research

Floods are the most natural disaster and part of their observed damage can be attributed to socio-economic factors, such as the increase in population and wealth in flood prone areas. Also, other parts can be seen in the changes in the terrestrial system, such as urbanization and deforestation, that have lead to the loss of wetlands and natural floodplain storage. Climate changes can also includes another dimension of flood risk. All these factors are inter-related and this trend of flood and water risk is one of the main challenges in the reduction of poverty. Some cities in Syria have witnessed lose of life and property, disruption to transport and power, and most notable amongst them being Zeyzoun on June 2002. Local communities were devastated by the collapse of the Zeyzoun dam, north of the city of Hama, bursts, dumping nearly all of its 71m cubic metres of water over 60 square km of farmland and swamping several villages. Over and above the already serious impact of the disaster on the population directly affected (loss of houses, property, agricultural products and livestock), it must be considered that the economy of an entire agricultural region would be severely affected by the sudden disappearance of the major source of irrigation water available. It was confirmed that some 20 people have been killed and over 10,000 people were directly affected by this incident to varying degrees, with at least 2,000 rendered completely homeless. Damage to human settlements varies from the total destruction of the village of Zeyzoun, located next to the dam, to partial destruction of settlements located between 2 and 3 km from the dam, to flooding of the ground floor of houses in villages further away. According to the latest estimates, there were about 251 houses completely destroyed, some 121 partially destroyed, and about 200 damaged. Sixty kilometers of roads were reported by the government to be damaged. Also damage on the electric power lines and the telecommunication system was reported. Two schools were reportedly completely destroyed and at least three damaged. One health center was partially damaged but still functioning and one of the storehouses of the agricultural credit bank was reported to be damaged. It is estimated that up to 8,000 hectares of arable land have been submerged for up to a week.

This disaster has served as an eye-opener for the planners and it has indicated the perils of rapid development in this region and other similar areas to the Zeyzoun region. Since the failure of Zeyzoun Dam in June 2002, the awareness of the safe dam management has been rising rapidly. In addition to the National Emergency Committee chaired by the Prime Minister set up by the Syrian Central government, the Provincial Government of Hama established an Emergency Co-ordination Committee, chaired by the Governor of Hama. This committee includes all principal provincial sectors. The emergency committee has formed four sub-groups to address specific areas of interest, namely

an assessment committee to assess damage to agriculture, infrastructure, public property and private property. The local authorities are currently overseeing the distribution of practically all relief supplies, including those provided by the central government and by the numerous bilateral donors. In addition to that, local authorities provide drinking water (tankers and bottle water) and emergency health assistance (mobile clinic). Since cholera and malaria are not endemic in the region, there was a very low risk of such epidemics. Also, the local government is planning for provisional housing for 800 people. The military authorities have been involved in the response to this incident, particularly for the early evacuation of people most at risk. The Syrian Red Crescent Society has channelled the assistance of the Red Cross/Red Crescent Movement (including donations from the United Arab Emirates Red Crescent and the incoming substantial assistance from the International Federation of the Red Cross). The UN Country Team in Syria, immediately established a coordinating mechanism to bring together the UN response and to establish a common interface with government authorities, as well as with bilateral and multilateral donors. UNDP of Syria worked with local authorities on plans in the post-disaster rehabilitation phase and to preserve sustainable livelihoods of the affected population through a pilot micro-finance scheme and capacity building, including repair of the dam and irrigation systems. The project is designed around 5 pillars: a survey of the socio-economic and environmental situation in the aftermath of the disaster; a technical, economic and environmental study of the physical rehabilitation of the region including the dam and the irrigation system; micro finance pilot schemes to support income generating activities; capacity building for local community participation in the rehabilitation process; and building local government capacity in coordination and resource mobilization. Both the Syrian authorities and the UN Office in Syria provided every possible support for the mission, including full access to their information, documents, and facilities.

This disaster, as a man-made incident, demonstrates the necessity to improve the emergency management capacity and contingency planning in the country. The role of prevention and preparedness is clearly recognized as being the most effective form of defence against disaster. This capacity should be strengthened by appropriate international assistance. An effective contingency plan can make the difference between a successful and an unsuccessful response to a disaster. Such a plan should not just be a document, but needs to be a tested mechanism that is sufficiently flexible, robust and practical to meet the unpredictable demands placed upon it by a disaster. Such plans should exist at all levels and for all organisations, tying together into a coherent system.

Enhancing Inter-agency Collaboration in a Post-conflict Situation: A Case of the Liberia WaSH Consortium

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Keywords: post-conflict, aid, consortium, interagency, harmonisation

Introduction/Problem Identification

This paper is about a model of making interventions, and therefore concentrates on practice as well as the rationale for delivering aid in a post conflict state. It covers the work of the Liberia WaSH (Water, Sanitation and Hygiene) Consortium which is comprised of five International Non-governmental Organisations namely Oxfam GB, Tearfund, Concern, Solidarites and Action Contre la Faim. The paper focuses on the benefits of interagency coordination, harmonisation and alignment to government plans in seeking to increase access to safe Water, Sanitation facilities and improve hygiene standards. With the ongoing debate on how aid can be made more effective as espoused by the Paris declaration and subsequent Accra agenda for action, novel ways of making aid more effective serve as examples for practice.

Analysis/Results and Implications for Policy and/or Research

After 14 years of civil war, Liberia's infrastructure fell into severe disrepair, making it difficult for the government to provide for peoples basic rights including water and sanitation. Four in five people still lack access to basic health and education, and similar proportions have no jobs. Only one in four Liberians has access to safe drinking water while less than one in five has access to human waste collection and disposal facilities. Over half (55 percent) of the households do not use any toilet facility Eighty-two percent of households do not treat their water, and only 16 percent treat their water with bleach or chlorine (LDHS, 2007). This compounds poverty, which is high at 64 percent implying that three in five Liberians survive on 1 US dollar everyday (PRSP, 2008).

The Government's aim is to increase access to safe drinking water from 25 to 50 percent of the population, while providing adequate sanitation to 31 percent from 15 percent by 2011 (PRSP, 2008). The consortium contributes to this aim by providing WaSH services (building latrines, boreholes etc) and building capacities of the Ministry of Health (MOH) County Health Teams (CHTs) and the Ministry of Publics Works (Consortium Strategy, 2008).

The Consortium, which was formed as a way of assisting the government to deliver WaSH services to targeted communities is a novel way of delivering aid in a post conflict state transitioning from humanitarian assistance to development. The model unites five institutions through one common strategy, interagency management structures, joint project proposals and reports. This has led to increased collaboration with the government, maximising impact and is proving to be cost effective for both donors and the implementing agencies.

The key lessons being learnt include:

1 Alignment to Government Plans: The Consortium strategic plan is based on governments plans. The Government is also represented in the management structure of the Consortium thereby providing the government full knowledge of the projects being implemented. Government has also been able to easily provide guidelines on implementation of projects.

2 Harmonisation: Consortium members work with government in meeting the targets of the Poverty Reduction Strategy. A Joint consortium strategy ensures that donors have one funding channel and can use one strategy to agree on their support to the five-members of the consortium. This has reduced the burden of having to deal with project proposals, reports and other administrative requirements from all the five implementing agencies.
3 Maximises impact: In addition to providing basic services, the Consortium invests in the much needed capacity building for government personnel. Enhanced government capacity to respond and account for national development is a major principle for national ownership.
4 Accountability: Strict accountability code-of-conduct is followed at the same time involving the beneficiaries and local suppliers and NGOs in the implementation of programmes. Through peer reviews among the five members, a number of best-practice strategies are collected and implemented.
5 Wide geographic coverage: The consortium approach covers a wide geographical area. Collectively, Consortium activities are taking place in 10 of the 15 counties.

Within the targeted communities making up a population of almost one million Liberians, the consortium has been able to:

1 Increase Accessibility to Water and Sanitation: To the end of September 2008, the programme provided 141,350 Liberians with access to safe drinking water. This means the Consortium has helped increase access to water by 15 percent above the baseline in the first 15 months of the Consortium programme. Over 43,000 Liberians also now have access to safe human and solid waste disposal through the provision of a number of new family pit latrines, rehabilitated family pit latrines, communal latrines, etc.
2 Involve Local NGOs and contractors: The Consortium has managed to involve local contractors and NGOs in implementation of consortium work. This has helped to boost their ability to handle development contracts and implement project management cycles.
3 Build government capacity: After an Institutional capacity assessment of the Division of Environmental and Occupational Health Services under the Ministry of Health, government is now implementing reforms to improve the efficiency of the Division.
4 Improve Community Level participation: The Consortium has helped to establish and strengthen community structures and systems for sustainability of WASH activities and facilities through training of community committees, pump mechanics and community health volunteers.

The Consortium model is model that is emerging and has potential for exemplifying the real meaning of aid effectiveness in post-conflict states.

TSUNAMI-2004 Victims in Sri Lanka are Still Thirsty!

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Keywords: drinking water & sanitation, conflict affected areas, integrated approach, disbursement procedures, commitments

Introduction/Problem Identification

Other than few isolated inundations frequently occur due to monsoonal floods or small scale land slides, Sri Lanka was safe in respect of the major natural disasters during the past recent history. In contrast, TSUNAMI 2004 affected over 100,000 families in 10 coastal districts within few hours which is considered as the biggest disaster ever faced by Sri Lankans during the recent history. Around 550,000 people were displaced and moved in to around 1000 IDP camps within few hours. Around 40,000 were dead or missing. Around 40,000 shallow wells and 50,000 pipe borne water service connections were damaged. The country was fortunate enough to get the world attention in getting emergency assistance through materials, manpower, expertise advice etc within very few days. In spite of the massive manpower and money invested up to date, around 20% of the affected population is still without permanent drinking water facilities as at today due to various reasons discussed in the paper.

Analysis/Results and Implications for Policy and/or Research

Many of the big townships situated along the coastal belt affected by TSUNAMI already had a reasonable pipe borne water supply coverage. Although the majority of the water intakes and head-works located few miles interior were not affected by the TSUNAMI waves, distribution and transmission pipe lines laid along the coastal area were considerably affected. Individual shallow wells built on precise fresh water lens too had been destroyed. The government planned to handle the disaster relief programme in three phases namely initial recovery, medium term and long term. Many local and international organizations wanted to participate in all three phases in a very active manner. Donor agencies and NGOs selected various WATSAN projects based on various criteria such as magnitude of the project, sector speciality, location of the project etc. The Government faced a big challenge in giving equal opportunity to everybody while keeping all happy. However, it is now to be seen that some of the Donors/NGOs had not respected to their commitments and as a result the Government is now facing difficulties in finding the funds for reactivating and completing some of the committed projects. Out of ten Districts affected by TSUNAMI, six districts were situated in conflict affected areas. Although there had been a peace agreement in force between the parties involved in the conflict, implementers had to mobilize under various restrictions and were unable to move freely like in other four Districts. Restricted accessibility, restricted working hours, material restrictions, shortage of skilled builders etc made the situation more worst. Limited NGOs were willing to work in these areas whereas very few skilled contractors were prepared to take up construction activities limiting the competition during procurement phase resulting high costs. Deteriorated security situation occurred subsequently caused suspension of such delayed programmes permanently. Due to the higher demand for skilled labour, many semi-skilled labourers joined the construction teams pretending they were skilled. This hampered the quality of construction outputs. Allocation of suitable lands for permanent settlements was an essential task to move ahead with the provision of infrastructure facilities. In many occasions the selected sites for housing units had to be shifted due to various reasons such as changes in buffer zone boundaries, land disputes, objections from land owners, disagreement by the intended

settlers due to social reasons etc. Identification of water sources, hydro-geological investigations etc for water supply projects had to be delayed until the settlement locations were finalized. Only a very few Donors/NGOs took over integrated approach during the implementation of the third phase. In most of the cases, one Donor took over the construction of house, another was assigned with provision of septic tanks, while the third Donor took the responsibility of water supply together with Government Institutions and so on. Each Donor/Institution had a specific individual responsibilities and they moved out of site as soon as their responsibility was over. In contrast, few agencies implemented their programmes on an integrated approach including housing together with other infrastructure facilities/ utilities. Such programmes showed faster and flexible implementation through better coordination. Almost all the sub projects have now moved from planning stage to implementation stage. In many occasions, after the tendering phase it has been revealed that the contract bids are very much excessive than the originally prepared estimate. Remoteness of the area, security risks prevailing in certain districts, less competition, usual tendency to quote higher bid prices by local contractors for foreign funded projects are some of the reasons for the enhanced project costs. This created financing difficulties in some of the programmes and implementers found difficulties in finding additional funds. Funding assistance were provided under three models for the proposed restoration programmes. Under the1st Model, funding was provided by the Donors through the Central Government in a formal way whereas the 2nd Model disbursed funds directly without the involvement of the Central Government but including direct limited assistance to Government Agencies which helped the implementation. The 3rd Model implemented completely independent projects without any involvement of the Central Government or the Government Agencies. Many INGOs operated on 2nd or 3rd model as a policy, whereas some Donor Agencies who already had previous experiences with the Government followed the 1st model. In respect of the procurement packages in minor projects, the 2nd and 3rd models seemed to be faster than the 1st model where as 1st model seemed to be faster in major projects, as the Government already had procedures set up for the procurement activities.

Water for All – Reducing Vulnerability and Restoring Resilience

Author: **Ms. Rajyashri Waghray*** *et al.*
* Church World Service, USA

Keywords: water, tsunami, communities, Indonesia, Kenya

Introduction/Problem Identification

Issues
Human-induced climate change is modifying patterns of extreme weather, including floods, cyclones and droughts and threatens to increase humanitarian need and derail global development. Over the next 20-30 years, the intensity, frequency, duration and extent of weather-related hazards will increase in many parts of the world.

For humanitarian actors, of major concern until 2030 are likely to be areas already subject to extreme weather and with high human vulnerability. The largest and most important regions of high overall human vulnerability identified by a recent study are: (Reference: UNOCHA/CARE Report: Humanitarian Implications of Climate Change)Africa, particularly the Sahel, Horn of Africa and Central Africa; Central and South Asia, particularly Iran, Afghanistan, Pakistan, India and the Caspian region; Southeast Asia, particularly Myanmar, Laos, Cambodia and Indonesia.

Analysis/Results and Implications for Policy and/or Research
Church World Service captured lessons from immediate post-Tsunami interventions in the areas of the worst impacted communities: Banda Aceh, Nias, and Meulaboh, Indonesia offer critical insights into post-Tsunami interventions and community role in recovery management. With very limited account of water and sanitation availability, due to broken facilities and contaminated water sources, the immediate concern was to provide clean water for survivors and emergency sanitation facilities. During the initial period, people were almost totally depended on support of aid agencies. In this period, almost all materials to enable the provisions were 'brought in' from another city, province or even country. As the response transgressed within the three-year assistance period, the activities relied on community and locally available materials to try to develop sustainability. Rebuilding and rehabilitation in the fields of water and sanitation, housing, livelihood, health and nutrition created a huge demand for hardware materials such as pipes and timbers, ballooned, creating a huge challenge.

At the same time it created an opportunity to plan, bring in experts and at the same time, utilize local wisdoms best practice for these projects. We have learned that the community is more than willing to invest their time in capacity building opportunities that can increased their own capacity to respond to disasters as well minimize impacts of disasters.

Role of communities, access, and accountability to resilience and recovery is significant in these responses. With the paralysis of official systematic and structural roles, the strength of community becomes the backbone in responses and recovery. In Kenya, CWS was even more intentional in the use of the community-based model: Water for All. In remote rural areas of Kenya, the program demonstrates some key insights into the role of communities and women in particular in critical issues of access and accountability.

Lesson-learned/Conclusion/Recommendation:
How do these roles and practices render a community less vulnerable, to the extent of being more prepared, and maybe even capacitated to respond to disasters?

These in turn offer some pragmatic opportunities for cross-cutting role of capacity building and practical applications in crisis prevention, post disaster interventions, and recovery.

We have learned that the role of women and their capacity development as central to design and implementation to any risk-reduction preparedness.

Challenges include new environments created post disaster period that have never been experienced before. It changes how people do their daily activities, and how aid is delivered. Continuous learning, flexibility and creativity are important in responding.

Many of CWS programs in for example Indonesia and Pakistan have integrated disaster risk reduction into recovery programs, which includes climate change issues. This has in turn empowered the community to lessen the impacts of disaster and also strengthen their capacity to respond to disasters. Relying on the community has been key to our programs and work.

There has not been much knowledge sharing and documentation on post disaster environmental change and how communities are coping with them. More knowledge sharing is encouraged between humanitarian actors.

Visualization for Rapid Information Integration

Author: **Mr. Michael Wilson**
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Keywords: data, visualization, modeling, decision-support, interoperability

Introduction/Problem Identification

Policy makers, response planners and intervention strategists based in OECD-type countries commonly have means of rapid access to and integration of key data, to computer models for examining inter-relationships between social, environmental and economic factors, and means visualize. Practitioners in developing and transitional countries have to date lacked these key facilities for preparedness, response planning and follow-up assessment in post crisis situations. Recent rapid technical development and the emergence of opens standards now places in their hands capabilities that can help clarify and convey compelling stories in otherwise complex situations, and at significantly reduced cost compared to even a few years ago.

Analysis/Results and Implications for Policy and/or Research

There is a need to build national capacity for disaster adaptation planning by bringing together a number of existing capabilities plus some innovative components to effectively address the bottlenecks cited above. This paper proposes a three pronged approach: 1) make access easier 2) Create knowledgeable users; and 3) Expand the science and data base. The proposal is not for investment in super-computers or broadband internet for DTCs but rather to lower the barriers that prevent planners in DTCs using modeling capabilities already existing in developed countries.

This approach proposes:

- Addressing the computing capacity issue by teaming with partners participating in cutting-edge "grid" computing projects and exposing their massive computational power to planners in DTCs.
- Providing to national adaptation planners a web 'window' designed for non-specialists into the joined-up models. The web service would be designed specifically to work well through the narrow and expensive internet connections found in DTCs.
- Building improved access to data to drive the models. UNEP, for example, has data facilities that can with little investment be reconfigured to support integrated models. The Global Earth Observation System of Systems would be another rich source of data for driving models related to land cover change, deforestation and its reduction, carbon sequestration strategies, climate changes driven by global warming and so on. These in turn would couple well with land degradation models and their impacts on water quantity and availability modeling.
- Building institutional capacity. Hands-on training is an unavoidable requirement for ensuring that national adaptation planners and policy developers appreciate the limitations and capabilities of joined-up modelling so as to be best able to apply them.

Workshop 6: Securing Access to Water-related Goods through Trade

Understanding the Problemshed: The Role of Diversified Economies in Achieving Water Security

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Keywords: water security, problemshed, diversified and strong economies

The purpose of the contribution is to highlight how beyond the watershed processes mitigate even the most extreme water scarcity. Water resource endowments only restrict the options of weak and non-diversified political economies. Water poverty does not determine poverty. Poverty determines water poverty.

When a political economy achieves high levels of socio-economic development it is secure – including being water secure – in a world at peace. Poor political economies do not have the capacity to substitute other factors of production for absent water resources. Highly diversified and strong economies do. In brief – if natural resources are absent a society has to develop its human resources.

Singapore is an extreme example of how an economy can successfully develop its endowments – that is its environmental capital – including its water resources, its manufactured capital, and its financial capital. Key to the successful management of these elements of the political economy has been the development of its human and social capitals. Singapore has only five per cent of the water that its society and economy needs. This is only half of the blue water required for its domestic and industrial water needs. Singapore has neither blue water nor green water to support self-sufficient food production. All food apart from some vegetable commodities is imported.

Diversified and strong economies achieve these qualities by developing their human resources. Skilled and flexible human resources make it possible to achieve very impressive economic returns to water. Those with the skills to keep in place the essential administrative and regulatory functions of government as well as the educational, health and municipal services earn incomes of between US$ 10k and $50k but only use about two cubic metres of water per year costing about two dollars. The same is true of the services provided by the private sector in banking, insurance, and much retailing. The resulting returns to water of US$ 5k-25k per cubic metre are numbers to conjure. Returns to water in industry can also be high. Returns to water in food production are always very much lower at a few cents per cubic metre. The Singapore case shows how non-determining natural resources are with respect to economic outcomes.

It is important for those responsible for regulating and using water resources that they focus on the watershed. But this focus should start with prioritising the environmental services provided by water. It should next recognise the hydrological and economic fundamentals that underpin sustainable and effective water resources utilisation. Any rational knowledge based water allocation and management policy must also take in its stride the role of the problemshed. Water security can be achieved in the problemshed, that is in the global hydrological and political economy systems beyond local watersheds. Virtual water 'trading' systems play a key role in these processes. Almost all very serious water scarcity problems are solved beyond local watersheds. Making their economies diverse and strong is the way that the 200 economies of the world will achieve water and food security.

Cross Sectoral Alignment on Strategic Water Footprinting, Watershed Risk and Watershed Protection Projects

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Keywords: footprint, business, partnership, watershed, risk

Introduction/Problem Identification

The emergence of the water footprint concept has helped to engage numerous business entities into exploring water dependence and risks in their business model. The experience of SABMiller takes this concept through to its operational phase and highlights how this company is beginning to evaluate its role and response to the water crisis.

This session will explore the water footprint journey in South Africa, consider the challenges of understanding the local context of watershed risk and consider how partnerships can best be structured to improve watershed protection.

Analysis/Results and Implications for Policy and/or Research

To be meaningful a water footprint must go beyond the absolute numbers and look at the context of water use in each watershed concerned. This requires a much broader partnership approach than traditionally needed for corporate risk management. WWF and The Nature Conservancy have been pioneering watershed risk analysis across the world. SABMiller has undertaken a leading water footprint exercise for its operations in South Africa with strategic advice from WWF, as part of its broader water value chain strategy.

Once a water footprint and the watershed context is established, the most important step is then prioritising actions to protect and restore watersheds. SABMiller and its subsidiaries and joint ventures have a number of active projects with both WWF and The Nature Conservancy in Colombia, South Africa and the United States, focused on protecting watersheds of strategic importance for both the countries concerned and the company.

This paper will highlight the findings and challenges of this research and provide new considerations for water footprint analysis if it is to be applicable for business use at the watershed level. This research is some of the first of its kind in actually opertationalising water footprint and has important considerations for future studies as well as other tools needed to fully understand and address the types of risks that are present for the business sector.

Identifying Best Options for Food Security through Water Footprints

Author: **Mr. Stephan Pfister*** *et al.*
* ETH Zurich, Switzerland

Keywords: food security, virtual water, water scarcity, global assessment, development aid

Introduction/Problem Identification

Global agriculture is facing substantial pressure from increased food and bio-energy demand affecting water and land availability. Globalized trade also requires global water resource management approaches, as local water management can hardly cope with the global market demand and its adverse effect on the producing regions. There is a need for water management at each scale, locally, in watersheds and by balancing the impacts in the global dimension. The latter requires a more holistic perspective while integrating the high spatial dependency of hydrological processes. Otherwise, well defined conservation activities in one threatened catchment lead to greater water import from other regions of higher water pressure. Appropriate metrics to assess the strong competition for the vital resource water are not available. The key question is how to optimize the water efficiency of crops and, by this, minimize environmental impacts in the global context.

Analysis/Results and Implications for Policy and/or Research

This leads to the next question, how much and what type of water is hidden behind the crops of the global trade? Answers will be fundamental for achieving food security in developing countries.

The virtual water concept and water footprint calculations are intended to tackle these questions. However, the underlying concept has so far been limited to the differentiation of blue (irrigation) and green water (soil moisture). In order to account for the environmental impact caused by water use for crop production, we introduce the concept of red (related environmental deficiency) water. Red water content quantifies the severity of the consumed water with respect to environmental issues, and describes unsustainable water management involved in the production of a good. We developed a comprehensive environmental impact assessment method for water consumption evaluating the damage potential regarding ecosystem and human health for major watershed levels worldwide. This assessment is based on a combination of different vulnerability studies and water scarcity measures with global coverage.

Regional crop water and irrigation requirements on a high level of spatial resolution (10 arc minutes grid), based on remote sensing data for the 50 globally most traded agro-products are computed. Red water footprints of crop production are generated for each grid cell, for each country and, based on international trade data, for the average product on the global market. For instance, one ton of wheat on the global market has a virtual red water content of 0.23 m^3/kg and a virtual blue water content of 0.98 m^3/kg. For the top ten wheat exporting countries, these values vary between 0.03 and 0.83 m^3/kg for red and 0.23 and 3.3 m^3/kg for blue water, respectively.

Based on this approach, those countries can be identified, where local crop production results in red water content below global average. In these countries, fostering local production should be favoured over imports. In the opposite case, development aid might better be used to improve water-extensive sectors. This would advance economic development and imports of food. In case of wheat, countries

like India, Pakistan, Morocco and China should better rely on imports than on self-sufficiency. On the other hand, local wheat production would be a favourable option in most Central African countries. The detailed results of this study can also be used to analyse the best practice within large countries as China or India to find the best water use practice regarding food security.

Water Wastage as a Consequence of Food Wastage: Case Study of Fresh Mango in Australia

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Keywords: food security, food waste, water footprint, virtual water, horticulture

Introduction/Problem Identification

In many parts of the world, freshwater is already a scarce and overexploited natural resource, raising concerns about global food security and damage to freshwater ecosystems. This situation is expected to intensify with the FAO estimating that world food production must double by 2050. Our research concerns the mapping of food waste through the distribution and consumption stages of the product life cycle and quantification of the consequences in terms of wasted water. This case study focuses on the small and geographically well-defined Australian mango industry, having an average annual production of 44,692 t of marketable fresh mango.

Analysis/Results and Implications for Policy and/or Research

The average virtual water content (sum of green, blue and gray water) of 1 kg of Australian grown fresh mango at orchard gate was 2298 L. However, due to wastage, the average virtual water content of 1 kg of Australian-grown fresh mango consumed by an Australian household was 5218 L. This latter figures compares to an Australian-equivalent water footprint of 217 L calculated by the method of Ridoutt and Pfister (2009) using the water stress index of Pfister et al. (2009). Nationally, distribution and consumption waste in the food chain of Australian-grown fresh mango to Australian households was responsible for 26.7 GL of wasted green water resources and 16.6 GL of wasted blue water. These findings highlight the environmental impact of waste in horticultural food chains and suggest that strategies to reduce food waste have an important role in addressing issues of global water and food security.

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Securing India's Water Future 2050: Can Domestic Virtual Water Trade Play a Role?

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Keywords: virtual water trade, food trade, comparative advantage, inter basin water transfers, India

Introduction/Problem Identification

'Virtual Water' refers to the volume of water needed to produce commodities. When a commodity is traded, the buyer essentially imports (virtual) water used in the production of the commodity. Virtual water trade is considered as a tool to address national and regional water scarcity. The concept has also been suggested as an alternative to physical water transfers, which are often costly and potentially environmentally detrimental. It has been argued that instead of physically transporting water, virtual water can help water scarce regions through trade.

India is currently debating a grand plan of inter basin transfer to overcome the recurrent problem of concurrent floods and droughts in different parts of the country. The plan is to transfer the flood waters from water-rich eastern India to water scarce western and peninsular India. This study looks at the potential role that virtual water can play in securing India's water future in the coming decades.

Analysis/Results and Implications for Policy and/or Research

Kampman (2007) estimated that the virtual water flow as a result of interstate crop trade in India is roughly 13 percent of India's total fresh water use. At the state level, the states of Punjab, Uttar Pradesh and Haryana were found to be the largest exporters of virtual water while Bihar, Kerala, Gujarat, Maharashtra, Jharkhand and Orissa being the key importers. Thus, water rich eastern India imports large quantities of virtual water from water scarce regions of India. States which enjoy a natural comparative advantage (in terms of water endowments) actually reveal a comparative disadvantage in trade! Why do water rich states import even more water (in virtual form) from relatively water scarce states?

Our analysis shows that besides water endowments, two other factors critically determine the quantum and direction of virtual water trade flows – per capita availability of land and access to secured markets. Thus while the virtual water argument focuses entirely on water endowments, other factors influence the relative comparative advantage of regions resulting in a trade pattern that may appear counter-intuitive. Hoekstra (2003) referring to Wichelns (2001), observed that "the economic argument behind virtual water trade is that, according to international trade theory, nations should export products in which they possess a relative or comparative advantage in production, while they should import products in which they possess a comparative disadvantage." This statement neatly sums up the economic logic behind the concept of virtual water trade. However, virtual water trade theorists have often implicitly assumed that water abundant countries (or regions) enjoy a comparative advantage in water intensive commodities and vice-versa. As we see in the case of Indian states, this is not always true.

According to international trade theory, five factors explain trade between two entities: (1) differences in technological abilities [Ricardian model of comparative advantage]; (2) differences in resource endowments [Heckscher-Ohlin (H-O) model of trade]; (3) differences in demand [Linder effect]; (4) existence of economies of scale [New Trade Theory]; and (5) existence of government policies which might create artificial comparative advantages (or disadvantages).

Much of the literature on virtual water trade so far has focused almost entirely on differences caused by water endowments, explained by the H-O model of trade. In order to have a comprehensive understanding of the behavior of agents in trade, all other reasons including non-water factor endowments (e.g. land availability) and the impact of government policies need to be taken into consideration. The H-O model does not explain the quantum and direction of interstate virtual water trade in India because:

1 The H-O model requires pre-trade resource prices to be in relation to resource endowment of availability. In the case of water resources, this does not seem to hold, especially at the individual farm level. Farmers in water rich states such as Bihar actually face a steeper price for irrigation vis-à-vis farmers in water scarce states like Punjab. Thus, the price of water to the individual farmer is not in relation with the physical resource availability.
2 The H-O model works to efficiently allocate water resources if (and only if) they constitute the most critical resource in the production process. If, on the other hand, another factor of production such as land becomes the bottleneck, the efficient allocation will shift to that resource.
3 By the virtue of our estimation procedure and assumptions, we ignored what is termed as the Linder Effect. We assumed that all traded agricultural goods are undifferentiated commodities and are only to be traded only between a surplus and a deficit state. However, several products can be exceptions to this assumption – basmati rice, branded dairy products and all other differentiated (or branded) agricultural commodities.

Given the huge deficits in food grains in eastern India and the limited availability of arable land, it seems unlikely that eastern India will be able to produce surplus food grains to export to the rest of the country. However, reducing its dependence on food grain imports from water scarce regions will definitely free-up critically scarce water resources in water stressed regions for alternative uses. Thus while the virtual water trade option might not entirely be able to dismiss the need for inter basin water transfers, it can certainly act as a good complementary policy to inter basin transfers.

Workshop 7: Water Storage Options for Secured Access

Sustainable Water Management Options

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Centre for Ecology and Hydrology, UK

Keywords: water storage, irrigation, water supply, hydropower, ecosystem services

Water is essential for all life both directly (e.g. for growing food, drinking and supporting industry) and indirectly (e.g. maintaining ecosystem services, such as fisheries). The natural spatial and temporal variability in hydrological cycle means that water of sufficient quantity and adequate quality is not always available where and when we want it. Almost 900 million people lack safe and reliable water supplies and we need to improve water availability to meet the Millennium Development Goals. Future anticipated climate change and population increases are likely to exacerbate this problem. The economic performance of countries is linked to their ability to provide water for human use and to cope with floods and droughts. For many centuries, artificial storage has been created by dam construction throughout the world to address this. However, many countries, particularly in Africa, have exploited little of their water storage potential thus restricting the development of hydropower production and irrigated agriculture. The World Commission on Dams concluded that large dams had made an important and significant contribution to human development by providing stable water resources and flood alleviation, but the social and environmental costs had, in too many cases, been unacceptable and often unnecessary. Dams have led to displacement of communities that have not benefited and to the loss of biological diversity. Development of hydropower is seen as a green option, as it does not require burning fossil fuels. Yet, in certain circumstances, reservoirs may release greenhouse gases. Construction of large, expensive dams may also be a high risk option under unstable political regimes and changing climates.

The Dams and Development Project provided guidance on how to implement the Commission's recommendation, including assessment of alternative options and improved stakeholder participation and environmental safeguards where dams are considered the best solution. Other organisations, such as the International Hydropower Association, the World Bank and IUCN also produced guidelines to make dams more sustainable, such as releasing sufficient water to maintain downstream ecosystems and their dependent livelihoods. Where dams provide the only option, networks of small dams may provide greater flexibility than single large dams.

Other water storage options include exploiting and enhancing natural storage, such as enhancing groundwater recharge and managing catchment runoff to maximise water yield. Additional options involve using the concept of virtual water, demand management, desalinsation and waste water reuse. A recent focus has been on assessing how people survive in areas where hydrology is currently very variable, as a model for locations where climate change may increase variability. Strategies include social and economic strategies and low-technology enhancements of the hydrological cycle.

Water Storage Options: Small Dams versus Large Dams, in Central West Asia and North Africa

Author: **Dr. Jean Albergel** (Keynote Speaker)
IRD & UMR LISAH, Kenya

Keywords: large dams, small dams, environmental impacts, artificial flood, wetlands

The presented note is inspired from a study carried in the framework of the International Assessment of Agricultural Knowledge, Science and Technology (AKST) for Development (2005 – 2008) [1].

In Central, West Asia and North Africa (CWANA), the control of water always has been a powerful factor in the development of civilizations. Since ancient times, different hydraulic systems have been built to increase the efficiency of rain and to collect, store, and transport water. From simple cisterns in the ground, vital instruments for the survival of families in arid zones, to large dams that are part of national policies to guarantee water supplies to the greatest number of people, water storage always has been a primary preoccupation of CWANA governments which face recurrent droughts and limited water resources.

Irrigation covers about 48 million hectares in CWANA region. Central Asia represents 59% of this total, although it covers only 21% of the total area of the region. Pakistan alone, covering a little over 4% of the region, accounts for 33% of the irrigated areas. By adding Iran Turkey, Iraq and Egypt, 72% of the areas under irrigation are controlled by five countries in the CWANA region.

Since the 1950s CWANA countries have built a great number of dams, some of which are among largest in the world. They have also, over varying lengths of time, had a policy of constructing small dams that appear as very specific structures designed not only to mobilize the surface water resources but also to control erosion.

Thirteen large dams in CWANA: Morocco, Tunisia, Iran, Pakistan, and Turkey have been studied by the World Commission on Dams which has published an overview on dams and development in 2000 [2]. While there is great variability in the performance of the large dams, the majority of dams in the CWANA Region under-perform with respect to the achievement of intended benefits and delivery of services. In some instances, though, benefits occurred for much longer periods than predicted in the studies and still continue. Adverse impacts on ecosystems occur frequently and a significant number of these adverse impacts were unanticipated in planning and decision-making.

Irrigation components fall well short of targets in terms of the irrigation command area developed downstream of large dams. Actual irrigated area achieved and to a lesser extent, the cropping intensity are below the objectives. In contrast to irrigation, the hydropower performance of large dams is on average closer to target. But as irrigation dams, the variability in performance is significant across the projects.

Development of these large dams in purposes of irrigation, hydropower, navigation and / or protection of cities against floods decreases drastically surfaces usually flooded or filled with fresh water. Such development also upsets the geochemical balances of stagnant, current, sweet, brackish or/and salted waters in littoral. The loss or the degradation of wet zones, today and tomorrow, endangers

fundamental ecological functions as well as economic, cultural, scientific and entertaining value of flooding areas.

Within the framework of programs for protection, management and rational use of wet zones which are very rich but sensitive zones, the concept of "artificial floods" appeared in the 90s. "Artificial floods" can reconcile social and economic activities with the long-lasting preservation of natural equilibrium. The realization of artificial floods consists in water releases from upstream dams allowing minimal floods to protect the essential wet zones and to save environmental and economical services of flooding cultivation, fisheries in lakes and natural resources in mangrove forests.

Yet, data obtained on smaller dams suggested greater consistencies in performing closer to targets than larger ones for irrigation and environmental services. Small dams are structures that have their own characteristics and that can supplement a policy of water resource mobilization. They can be focal points for local agricultural development. Storage reservoirs are good sediment traps. They protect downstream infrastructures and can prolong the life of a larger dam located downstream. Rapid silting of the reservoirs acts as a brake on agricultural development. In the Mediterranean countries, they are perceived as a water resource to be used. Development of soil and water conservatory infrastructures on the slopes increases their life expectancy.

From an environmental point of view, impacts of small dams are positive, provided that water quality is maintained by paying attention to possible effluents. Small dams are usually located in rural environments with a low population density, so they are adequately protected. They are small wetland areas, contributing to biological diversity and the protection of birds and other animals. The major environmental risk is dam failure.

Using examples in different r sub regions of CWANA, this note describes the role of different dams in the development and conservation of agricultural land and try to list the environmental impacts and the ways to mitigate the negative ones.

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Ground Water Dams, A promise Options for Water Resources Sustainability in Arid and Simi-arid Regions

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Keywords: subsurface dams, ground water, water harvesting, sustainable water, underground dams

Introduction/Problem Identification

In order to bridge periods of drought in arid and semi-arid regions which are drought prone, water harvesting is of particular importance. This water harvesting measures if adopted on a large scale may alleviate water scarcity even during severe drought years. One of the water harvesting options in those arid regions to retaining flowing water in these ephemeral rivers by building a dam. In many cases a dam can built behind which surface water is stored. However, surface water storage has some negative side effects such as evaporation and water quality. To overcome such problems the water can be stored subsurface if the local conditions allow subsurface storage. This storage can be reached by building a dam, behind which sand accumulates, enlarging natural aquifer. The ground water in the river bed is obstructed by the dam and retained in the pores in the sand. This water can be harvested using scoopholes or wells.

Analysis/Results and Implications for Policy and/or Research

The aim of the proposed present research work is firstly to document the main principles of the ground water dams (subsurface and sand storage dams) as well as their construction in-addition to the hydrology of those ground water dams. Secondly, the study will aquire insight in the hydrological processes, water flows and water quantities around ground water dams. The design and environmental criteria of the subsurface and sand storage dams will be discussed too. To achieve the above aims of the research work, the following aspects will be studied and presented:

1 Inventory of general literature related to the hydrology of subsurface and sand storage dams.
2 Response of ground water levels in the riverbed and riverbanks on rainfall and runoff.
3 The effect of subsurface and sand storage dams on ground water in a catchment.
4 The storage capacity of subsurface and sand storage dams and amount of available water for people and cattle.
5 General water balance of ground water dam.
6 Knowledge gaps and recommendations for further researches.

This research work may suggest that large scale application of water harvesting using subsurface and sand storage dams in drought areas may be seen as a strategic tool for drought mitigation, if it is realized through the adoption of relevant polices and investments at different levels such as users, watershed, district, state and country.

Water Storage: Scale Effects on Health Risks

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Keywords: water storage, health hazards, diseases, reservoirs, vectors

Water is stored at all scales from a huge reservoir to a small pot or gourd within the home. This presentation explores the changes in health hazards with scale, in the light of historical and epidemiological understanding, within the triple frameworks of geometry, biodiversity and functional classification of risk. The hazards depend upon access of people and diverse other biota to the water, processes occurring during storage, and the patterns of use to which the water is put. Water may be contaminated prior to or during storage, during which pathogens may die off or proliferate (in the water or within fresh water fauna), and arthropod vectors of disease may breed in the water, while carriers and users of the stored water may become infected. Indirect effects on those displaced for storage construction may be substantial, and diseases may be transmitted beyond the water users.

Because storage is a function of volume whereas hazards are more closely related to periphery and shallow water, relations of hazard to size are non-linear. In particular, pollution tends largely to take place close to the shore, and the majority of health-related insect vectors also breed in shallow water. Aquatic snails that transmit schistosomiasis predominantly are found on or near vegetation, again close to the shore, although more widely distributed where there is abundant floating vegetation. There are exceptions. Risk is decreased in larger water bodies due to a dilution effect on pathogen contamination and also because there will be larger parts at greater depth. Steep sides will reduce most biological hazards but may increase hazard of drowning.

While insect vectors show great diversity of breeding habitat between species, many particular species may be relatively selective in choice of breeding place. Most, especially mosquitoes, primarily breed in small water bodies and shallow water. Stable deeper waters provide less cover from predators. Moreover the vector-related risks are highly dependent on context, particularly temperature and the ecology and vectorial capacity of the local vectors, so hazards cannot be generalized in a simple way.

Large storage reservoirs have been much studied; small storage facilities much less so. Even where primary storage is in a large tank or dam, secondary storage at household level may introduce new risks or remedies. Secondary contamination is frequent, but storage in situations exposed to strong light may reduce pathogens. Some disease vectors are adapted to container breeding, especially mosquitoes of the genus Aedes which can transmit yellow fever, dengue and other viruses. Only one species of malaria vector, in India, is commonly found breeding in water tanks and in the water storage cisterns of older houses.

Moreover, in many poorer communities there is seasonal variation in sources of stored water, either because wells dry up or because only surface water is available and few of the sources are perennial. During times of rapid socio-economic change and consequent or concurrent environmental changes there may be large alterations in available stored water (and its concurrent uses) and the associated hazards, especially where different sectors of the economy act independently, and without reflection,

on water sources subject to multiple use. The dynamics of pathogens in newly constructed large water facilities are complex. The paper seeks to systematize these complex processes as an aid to assessing risk and also minimizing health hazards and optimizing health benefits, revisiting an old theme in the light of extensive recent research at many scales.

Water Reservoirs for Hydropower Arrangements and Other Utilizations – Romanian Experience

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Keywords: hydrographic catchments, hydropower developments, land reclamations, water runoff, water storage

Introduction/Problem Identification

Water is the cheapest and cleanest source of renewable energy and Romania has a rich experience in its utilization as electric power source. By water accumulations in hydropower arrangements that include a series of hydraulic works from which the most important ones are dams, reservoirs and hydropower plants, there have been created possibilities for water utilization not only for energetic purposes, but also to diminish floods, water supply, irrigations, fish farming, recreation etc.

The objective of the European Directive 2001/77 to grow the weight of the renewable energy sources from 14 to 22% of the EU brute consumption of electric energy until 2010 has been transposed into Romanian legislation since the period of its adhesion to the European Union. As new member state of the European Community, Romania proposed itself that the consumption of electric energy from renewable resources will reach 33% of gross internal consumption until 2010.

Analysis/Results and Implications for Policy and/or Research

From the oldest times, the water energy has been used on the Romanian territory for the mills acting, minerals breaking, textures washing and processing. The first Romanian stations that used the hydraulic power in order to produce electricity, with an installed capacity of 50 to 1,000 kW, were built between 1888 and 1900. In the period 1901-1950 about 64 hydropower stations, with heads between 3 and 304 m and installed capacity of 25-16,130 kW, which totalized a power of about 56 MW with an energy production of 290 GWh/year, were built.

The technically available potential of the Romania's water courses, estimated on the basis of the developed studies between 1951 and 1962, emphasized a production of about 36,000 GWh/an, with an installed power of 10,800 MW. These studies referred to the significant water courses and their tributaries with a specific potential more than 200 kW/km.

The Romania's total production of hydropower energy in 2005, in conditions of a favorable hydrologic year, was 20,200 GWh (representing 34.4% of the electric energy consumption), the total installed capacity being 6,346 MW (representing 53% of the economically available hydropower potential). In the same year, 380 small hydropower stations were in operation.

Although the energy production of hydropower stations, evaluated to 17,700 GWh/year in an average hydrologic year, would ensure the fulfillment of the EU objectives for renewable sources in the absence of production of other renewable sources, the Romanian legislation imposed production separation for each renewable energy source in the view of development of each of these resources. In

this sense, it was enforced that the energy provided by the hydropower stations be 18,200 GWh in 2010 (from which 1,100 GWh in the stations with the installed power under 10 MW) and 18,700 GWh (from which 1,600 GWh in the stations with the installed power under 10 MW) in 2015. For achieving this objective, new hydropower stations with total installed power of 120 MW have to be built in 2003-2010 and 2011-2015.

At present, Romania has 1606 water storages developed by dams' construction. Among these dams, 246 are registered in the World Register of Great Dams. It is to remark that from the total of storages, approximate 90% (most of all created by small dams) are not used for electric energy generation. It is understood that for utilization of these storages it must be drown up efficiency studies that have to take into account the hydrologic regime.

The performance of the dams and their reservoirs influence directly and indirectly the environment in all its elements (biotope, biocoenosis and ecosystems) and in the different areas of characteristic impact (upstream of the reservoir, in the reservoir area, downstream the flow discharge, in neighboring areas).

Most productive stage in taking some measures for mitigation the ecological impact is during of dam design. A well designed dam has a reduced and ameliorable impact, while in case of a badly designed one no measures taken subsequently to its performance can reduce the impact up to an acceptable one.

Another disadvantage of the hydroelectric developments is the need to relocate the people living where the reservoirs are planned. Only two dams in Romania, Izvorul Muntelui (Bicaz River) and Iron Gates (Danube River) created major problems from this point of view, but these have been favorable solved.

The following actions have been carried out during the designing and construction of the main Romanian hydropower development: sociological, anthropological. etnographical, folklore studies and investigations, as well as investigations concerning the monuments; discussions with the local authorities and obtaining the approval of the inhabitants; extended field studies and utilities (drinkable water, roads, sewerage system, electric power supply, churches, schools, cemeteries) performed in advance for the new site; observance of the previous environmental conditions (climate, landscape) and of the conditions for practicing traditional customs and occupations (pottery, wood or stone carving, hemp retting, grazing); relocation and reconstruction of representative monuments and edifices (village church and commemorative monuments, cemeteries preserving the relative disposition of the tombs, special village markets and fair places).

Achievement of hydraulic arrangements offers a number of additional advantages such as: floods mitigation in reservoirs and protection of neighboring zones, sources of drinkable and industrial water, sources of water for irrigations, tourism development, fish breeding development and also jobs on the construction sites of the hydraulic and additional works.

Rainwater Harvesting in Rural Sri Lanka; Findings of a Recent Study on Community Water Supply and Sanitation Projects (1993 to 2008)

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Keywords: rain, water, quality, acceptance, harvesting

Introduction/Problem Identification

Sri Lanka needs an investment of over 8,000 million Rs annually to meet the Government of Sri Lanka's water supply targets. On top of the difficulty of financing this investment, the situation features the drying up of water sources and the growth of demand for water due to population pressure, leading to conflict among water users.

Since 1993, Rain Water Harvesting (RWH) support had been granted through a range of initiatives. Efforts have increased to facilitate its adoption, including the work of several NGOs involved in improving water security among water scarce communities particularly in the dry zone of Sri Lanka.

Rain Water Harvesting was one of the technological options considered under World Bank funded Community Water Supply and Sanitation Project I (CWSSP) which was considered the first national level intervention in the rural water supply

Analysis/Results and Implications for Policy and/or Research

The benefits of RWH under the CWSSP I, include:
Improved water security to beneficiary communities (20 to 30 percent Improvement) particularly in reducing time spent for collecting water was considered a major benefit. Rain water is also seen as a reliable source of water at home. Increased water availability per capita and improved food preparation and personal hygiene were also considered some of the benefits. Convenience of being able to collect water at any time irrespective of age and sex is another benefit in addition to having more time for economic and personal activities

Although RWH has been accepted as an alternative rural water source, there is less than 10 percent take up by the rural communities that most stand to benefit.

Reasons for lack of acceptance

Initially, most of the buildings on which RWH was tried had thatched roofs and people found the water collected on these had unacceptable taste. Water collected from roof catchments contained leaves, organic materials, and atmospheric dust. Presence of mosquito larvae, other insects, discoloration from rusted iron roofing materials and organic debris etc. played a major role.

Many traditional RWH storage systems presently in use rely on small cement open tanks or storage vessels covered with cadjan leaves, polythene or tin sheets. The systems are not secure and water can generally only sustain a supply for some five to seven days depending on the family size.

Debris, dirt and dust are collected on roofs during non-rainy periods. When the first rains arrive,

this unwanted material may be washed into the storage tank causing contamination of water and rendering it unfit for drinking and cooking purposes.

Filters were introduced towards the latter stages of CWSSP 1 when it was realized that poor management of RWH units was leading to fast deterioration of water quality due to contamination of stored water with leaf litter.

Tank covers were initially not included in the subsidy under CWSSP 1, resulting in most people using temporary covers in the form of Polythene sheets, which do not adequately protect the stored water and allow some contamination. Subsequently the lid became a compulsory requirement of construction, but the weight of the lid has been a practical problem inhibiting access, especially for women in the absence of a hand pump. This has led to a tendency to leave the storage tank open during the day, with increased risk of contamination.

Conclusions

There are many constraints associated with the use of rain water for drinking. Perception regarding the quality of rain water has to be changed. Continuing move from a donor driven response to a demand driven approach has also become necessary. Awareness of the need for improved and innovative technical options, improved designs, improved construction standards, improved systems for collection, first flush control, filtration and storage. Etc. should be carefully re visited. Cost and subsidy including the need to reduce overall costs, and to lend support to the move for greater community contribution in an equal partner status with the GOSL.

The Impact of a Large Reservoir on Malaria and the Possibility of Using Dam Operation for Vector Control in Ethiopia

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Keywords: malaria, mosquito breeding, reservoir water-level, dam operation, Ethiopia

Introduction/Problem Identification

Investment in water storage infrastructures, including large dams, is widely advocated as crucial for sustainable economic growth and poverty reduction in sub-Saharan Africa. However, construction of dams in Africa is often associated with negative public health impacts such as increased malaria in surrounding communities. The degree and nature of this impact is rarely quantified and the feasibility of environmental control measures (e.g., manipulation of reservoir water levels) to mitigate malaria impacts has not previously been investigated in Africa.

Analysis/Results and Implications for Policy and/or Research

The present study assessed the impact of the Koka reservoir in central Ethiopia on malaria transmission and investigated the possibility of using dam operation as a tool to reduce transmission. Time series of clinical malaria case data (i.e. 1995 to 2007) were obtained from malaria control centers for 13 villages located at different distances from the reservoir. Larval and adult mosquito samples were collected for a period of 16-months from two villages located close (i.e. < 1km) to the reservoir and two villages located farther away (i.e. > 7km) from it. Multiple linear regression (step-wise) analyses were conducted to determine the relative importance of distance to the reservoir in conjunction with other factors that might affect malaria, including climatic variables. To date, the dam has not been purposefully operated with the intention of reducing malaria. Nevertheless, analyses were also conducted to determine the impact of changes in monthly reservoir water-level over and above climatic variables on monthly malaria case rates and mosquito vector abundance.

Mean annual malaria case rates were significantly greater in villages situated closer to the reservoir than in those farther away. The analyses confirmed that distance from the reservoir was a significant explanatory variable ($R2 = 0.406$, $P < 0.001$) of the variation in annual malaria case rates. The average annual malaria cases among people living within 1 kilometer of the reservoir was 3.7 times as great for those living 2 to 5 kilometers from the reservoir and 19.9 times as great as those living 5 to 9 kilometers from the reservoir. Larval and adult mosquito collections showed that, throughout the study period, the two primary malaria vectors in Ethiopia (i.e. Anopheles arabiensis and An. pharoensis) were much more abundant in the reservoir villages than in the control villages. Furthermore, puddles along the reservoir shore were found to be the most prolific mosquito breeding habitat. Analyses of the link between rates of change in reservoir water levels and mosquito larvae abundance found that drawdown at a rate of 25mm per day was associated with larval abundances approximately five-times less than a drawdown of 10 mm per day. This indicates that more rapidly falling water levels were associated with lower mosquito larvae abundance in shoreline puddles. However, the link between drawdown and malaria case rates was less clear. High correlation between rainfall and water level changes confounded the analyses making attribution difficult. Nevertheless, in reservoir villages, water level changes were found to be the most significant explanatory variable, moderately correlated with malaria case rates.

The major finding is that by creating numerous mosquito vector breeding sites around the reservoir shoreline, the Koka dam has led to intensified malaria transmission in communities close to the reservoir. Although not definitive and requiring further investigation, evidence from the study suggests that increased rates of drawdown could play a role in reducing larval habitat with a possible consequent impact on malaria transmission. Given the increase in dam construction currently underway in Africa there is need for more research to determine when and where water management can be successfully integrated into malaria control strategies.

Note: This paper presents findings from project no. 36 of the CGIAR Challenge Program on Water and Food entitled "Improved planning of large dam operation: using decision support system to optimize livelihood, safeguard health and protect the environment".

Influence of Natural Organic Matter on the Drinking Water Quality at Water Storage and Transfer

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Keywords: water transfer, organic matter, bioavailability, biostability, water quality

Introduction/Problem Identification

The quality of drinking water can change during transfer and within a distribution system. Quality changes are mainly associated with biological activity during transport process. The deterioration of drinking water quality in the distribution system is generally caused by expense of organic substrate which leads to biofilm formation. Most organic matter in water supplies is natural in origin. Natural organic matter (NOM) may include humic and fulvic acids et al.

Protecting the transfer and distribution system is essential to ensuring a supply of safe water to consumers. Biofilm formation in the distribution network decreases its capacity for transport and creates ideal conditions for many kinds of micro-organisms to remain in the pipes, thus increasing the risk of disease in the recipient communities. Bioavailabity of NOM in natural water is main reason of the secondary microbial contamination of drinking water in distribution and transfer system.

Analysis/Results and Implications for Policy and/or Research

Bioavailability of NOM is determined in units of the total organic carbon (TOC) and it is named biodegradable organic carbon (BDOC). Source water quality and storage management are linked with water treatment practice as well as understanding impact treatment has on the fate and impact of BDOC in the distribution system.

A role of the NOM in both the treatment technology and water transfer and distribution is the problem of an extremely topical importance for the drinking water supply of the Ukraine. A state analyses of the surface waters of Dnieper storages show that the organic matter content as concerns its chemical oxygen demand (COD mgO/l) for the main water storages of the Ukraine varies from 54.0-65.0 (worst-case values) and 40.5-43.2 (mean values) in the Kanev storage to 36.0-40.0 (worst-case values) and 25.0-30.2 (mean values) in the Kachovsk storage. This corresponds to a content variation of the dissolved TOC from 24 to ~10 mg/l surpassing much this index characteristic for a number of the river basins of the West and Central Europe. At the water treatment barriers progressively remove NOM present in the surface storage, producing good quality water and minimizing risk of disease and biofilm formation during transfer.

It is reached by provision of biological stability of the treated water, which is determined by the presence, type and amounts of biodegradable fractions of NOM. A distinction is made between two types of biologically available organic carbon: biodegradable organic carbon (BDOC) that is mineralized by heterotrophic organisms and assimilated organic carbon (AOC) that transforms into cellular biomass. It is known that an AOC concentration below a threshold of 10 µg acetatecarbon equivalents per liter (ac-C•l-1) provides biological stability in transfer and distribution systems in the absence of

chlorine residual. The goal of the paper given consisted the BDOC and AOC contents in a few kinds of water (storage, artesian, tap and model ones) and its variation in water treatment process with different methods to reach water biological stability in Ukraine. The obtained results showed that the content of TOC in mentioned above kinds of water amounted to 12.7; 7.7; 7.7; and 2.1 mg/l, while BDOC content was: 1.4; 1.2; 0.3; 0; 0; mg/l respectively. Thus, the BDOC content in water storage from the Dnieper amounts to 13% with respect to TOC. Coagulation reduces the BDOC content only by 15% indicating the biological instability of water after this stage of treatment. It is observed the reduction of BDOC in the tap water as compared with the water after its coagulation treatment. This is evidence of the continued process of biodestruction in distribution systems. The content of AOC in the tap water is in the limits 200-600 µg/l indicating a possible intensive biological fouling of distribution system during transfer of such water. The water from artesian wells of different depth contains AOC within the limits 4-10 µg/l featuring its high biological stability.

Storing Percolated Spring Water for a Gravity Flow Water Supply System: Gram Vikas' Solution to A Gravity Flow System Problem

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Keywords: gravity-flow, induced spring water, piped water, tribal communities, 100% inclusion

Introduction/Problem Identification

Gram Vikas are a non-governmental organisation working with some of the poorest and most marginalised communities in the state of Orissa, India. Through their flagship integrated development programme, MANTRA- Movement and Action Network for the Transformation of Rural Areas, rural communities are helped to access a 24 hour supply of piped, potable water. The water is transported to, and stored in an overhead village water tank, from where it is transported to every household.

The water is transported to the village water tank via a number of methods, of which the preferred choice is gravity-flow, as this overcomes the problem of many villages being extremely remote, and having no electricity source to pump water.

One problem that Gram Vikas regularly faces is how to use a gravity-flow system when there is no suitable perennial spring?

Analysis/Results and Implications for Policy and/or Research

Gram Vikas have developed a truly innovative solution, of establishing a sanitary well. Down one side of the well, a slit is cut and a pipe attached to the bottom. The slit is then filled back up with mud, and the entire well lined with stones. Water then percolates into the well, and flows down the pipeline to the village overhead water tank.

In addition to the physical construction, this paper will explain the other important aspects of this programme, which serve to ensure the water is safely stored without being contaminated, as well as using the water sustainably, and ensuring the surrounding environment is protected. Measures to protect the stored water include covering the well with a concrete cover, and ensuring the pipes are dug well into the ground. Extensive watershed management activities are also undertaken to promote ground recharge and also protect the surrounding ecology. These activities include tree planting, and erecting stone bunds.

Another measure is the recently undertaken initiative to train some staff to become "Barefoot Hydrologists." The aim being that by having trained staff in basic hydrology issues, specific to their geographic location, the site selection for wells will be more scientific, and the success rate of these wells will increase. In addition they will be trained in testing the water quality and will know the necessary action to be taken if the water becomes contaminated.

Gram Vikas' water project is part of a whole village development package, of which building sanitation facilities is a pre-requisite to starting work on a water system. This is crucial to the protection of the water source, as if open defecation is still occurring, then water sources will continue to be

contaminated. Another key factor to Gram Vikas' success at reducing water-borne diseases by 80% and enabling communities to access safe water, is the insistence on 100% inclusion. Every household without exception must be involved. This is vital to the safe storage of water, as even if one family continues to defecate in the open, the water sources will still become contaminated. In conjunction with building infrastructure, much work in changing habits and attitudes towards hygiene and sanitation is also carried out, since even with proper sanitation facilities in place, if people are not engaged in using them the water sources will continue to be contaminated from raw human waste.

In keeping with Gram Vikas' core values and principles, villagers have to contribute both financially, and in terms of supplying the locally available materials and manual labour. This all adds to the sense of ownership, and therefore long-term success and sustainability of the project.

All of these issues are important to the long term safe storage and protection of the water source, and therefore will also be included in this paper.

Home Based Rain Water Harvesting Jar, an Option for Secured Access to Safe Clean Water in Central Uganda

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Keywords: home, based, water, harvesting, jar

Introduction/Problem Identification

Increasing access to safe clean water for every citizen in any country, Uganda in particular is still a big challenge. Nevertheless, the Government and Civil Society Organizations (CSOs) have come out strongly to support this noble cause.

The Government of Uganda and the CSOs have constructed and protected communal water sources like the shallow wells to benefit all community members. However, little emphasis has been put to water storage options in case of any crisis like the long drought, which has become a big issue of concern due to globalization, and this has an effect on the springs causing them to dry out forcing the community members to resort to using the ponds.

In addition, the protected water sources do not cater for the most vulnerable groups of people like the elderly and physically challenged. The constructed wells are located far from the community members' homesteads and this makes it difficult for the vulnerable people to easily access the safe water

Analysis/Results and Implications for Policy and/or Research

A Home Based Rain Water Harvesting Jar is an option for water storage, where rain water is harvested from the roofs of the buildings. The Home Based Water Harvesting Jar is a simple water storage technology that can mainly be broken in four primary processes and three treatment procedures. These include the catchment surface with the first flash device which flashes away all unsafe water before it goes in the conveyance and this actually filters the water and removes all the dirty that might have reminded after the first flash. The third process is the storage and in here, water can further be treated before it is stored into the delivery part where it can further be filtered before usage.

The Home Based Water Harvesting Jar can be constructed/designed to suit particular household water needs. However, the jar storage can enhance easy access to safe water for different purposes like for home consumption, irrigation and animal rearing. This storage options can better be applied in countries, which receive rains all throughout the year. A case in point is the central part of Uganda.

The jar is designed in a JAR shape as its name. However, one can design the storage system in the most convenient shape preferred. For this particular design, the following issues should be put into consideration during construction:

1 Well as, the water jar can be designed using locally available material, binging wire is recommended to be used as reinforcement in the storage wall and the foundation instead of welded mesh.
2 The storage must have a provision for an overflow and wash out pipes to ensure water treatment and quality to reduce on health threats.

3 For construction, the ground must be concrete to hold the weight of the storage capacity.

If well designed, the water jar can easily be managed and it has no health threats to worry about if the first flash device is installed and the wash out pipe, to do away with unsafe water before stored.

This water storage option has a number of advantages including;

1 After construction, there is no water fees attached
2 The end use of harvested water is located close to the source, eliminating the burden of distance, hence saving valuable time
3 The technology is cost effective, compared to other storage options like the Ferro cement tanks or community spring tanks.
4 This technology does not discriminate among users. The elderly, physically challenged persons, women, children and men can all comfortable use access water.
5 The home based jar, provides a safe water source where ground water is unacceptable or unavailable, hence a better option for secured access water.
6 The zero hardness of rainwater helps prevent scale on appliance, extending their use, rain eliminates the need for water softener and the salts added during the softening process.
7 Rain water jar is sodium free and recommended for persons on low sodium diets
8 The technology is simple to construct

How the Home Based Water Harvesting Jar can advance knowledge of the theme/implications
Water being a common good, all people should aspire for it. This storage system affirms to the theme in that it recommends storing encourage safe water at all times, such that at no time, the users are in lack. Being a common good, the water jar gives the beneficiaries an opportunity to enjoy this good with no struggles but with easy access. A common good is that, which is enjoyed by every one

All beneficiaries including the physically challenged people, children, women and the elderly who are not strong enough to fight for communal water, can easily access this storage technology. Since the water storage is constructed in the household premises, users can access it with easiness without any burden of haunting for safe water, by moving long distances.

Putting the global factor into consideration, availability of this common good in some parts of the continent which are so dry and the surface water is scarce, the rain water provides a water source where ground water is un available. This technology can further address the issue of equity. Due to its low costs for construction, every household can afford to put up in order to enjoy this common more.

The Emergence and Sustenance of Household Based Treatment and Safe Storage of Drinking Water in Urban Zimbabwe

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Keywords: HWTS, urban WASH, diarrhoea, cholera, Zimbabwe

Introduction/Problem Identification

This paper shows how household based water treatment and safe storage (HWTS) of drinking water have emerged as a safety net for the preservation of public health in a protracted humanitarian crisis. The paper focuses on the context set by the breakdown in the municipal water supply and sanitation service delivery in urban Zimbabwe and the subsequent water supply, sanitation and hygiene (WASH) related public health crisis. It outlines how HWTS technologies have emerged as a significant mechanism that has ensured safe drinking water for households in many parts of the urban community in a country in throes of political, economic and social instability.

Analysis/Results and Implications for Policy and/or Research

Over the years, the world over the focus on HWTS as a potential WASH public health intervention has increased. The interventions, comprising a range of technologies have been shown in laboratory studies and field trials to be effective in improving the microbiological quality of stored water as well as reducing diarrhoeal diseases. In 2007, a review of the evidence from field trials in Africa, Asia and Latin America identified ten thematic areas impacting on the acceptance and long term adoption of HWTS namely; compatibility with existing social and cultural norms, convenience, time, taste and visual appeal of the treated water, cost, need for water treatment, self-efficacy/knowledge, motivation, access to the intervention or its availability and perceived efficacy of the intervention. The themes appeared related and were classified into two broad categories; those that had influenced acceptance and those that had impacted on the long term adoption of the practice of HWTS, or change of water handling behaviour. Acceptability of the intervention clearly appeared to be required before adoption. Despite these findings, the interactions between the themes were clearly complex and highly dependent on the setting and the technology being introduced.

As the water supply, sanitation, hygiene and related public health crisis in Zimbabwe unfolded some of the factors determining acceptance were manifest and the urban residents started adopting HWTS of their drinking water. The central water supply systems became increasingly unreliable prompting residents to turn to alternative sources of water. As early as 2007, significant proportions of residents were using unprotected wells, rain and river water as sources of drinking water. Also, the practice of storing water in the home became more prevalent and by the year 2008, over 90% of Harare residents, the capital city, were storing drinking water in the household. At the same time, reports of diarrhoeal disease incidence were on the rise and there was increased public awareness and concern over the negative health impacts of unsafe water and poor environmental sanitation. These developments were parallel to an increase in the practices of boiling drinking water. There was also an increase in the demand for chlorine based water treatment tablets. The cholera outbreak later in the year led to a marked increase in the demand for these.

This paper presents and argues that the situation in urban Zimbabwe has provided greater understanding for practitioners in similar contexts promoting HWTS as a public health intervention, particularly insight into the inter-play between the factors previously identified. Of greater practical significance, the paper shows how household based treatment and safe storage of drinking water present an option to assure access in resource limited unstable contexts. Their low-cost nature somewhat limits their dependence on the external political and economic environment (as opposed to centralised service delivery) and thus provides for secured access to the household.

Water and Poverty in the Andes: Preliminary Results from the CPWF Andes Basin Focal Project and Their Contribution to Supporting Water Policy

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Keywords: policy-support, dams, Andes, poverty, interventions

Introduction/Problem Identification

Global water resources are generally unevenly distributed relative to demand. Careful water management is therefore crucial. The Andes Basin Focal Project, part of the CGIAR Challenge Program on Water and Food (CPWF) is working to understand the role of water in poverty in the Andes system of basins and the technological and institutional innovations for increasing water productivity, facilitating equity and sustainability in water use and removing water barriers to poverty alleviation. This is being achieved through detailed hydrological research at the Andean scale and below, through analysis of the role of biophysical, socioeconomic and institutional factors in water management, through impact analysis of interventions and their role in reducing water-based limits to sustainable growth and through the engagement of stakeholders with new knowledge and tools for knowledge-based policy making.

Analysis/Results and Implications for Policy and/or Research

This paper presents some early results from the project half way through its two-year period of activity. The project completes in 2009. All deliverables are available from www.bfpandes.org (blog) and www.policysupport.org/aguaandes (website). Unlike other Challenge Programme basins the Andes is not a single basin but rather a heterogeneous collection of sub-basins. Population in the Andes was 95 million in 2005 (Colombia, Ecuador, Peru and Bolivia only) and is growing by 2.5% p.a. (1980-2005). Less than 15% of this population occupies rural areas and 46.9 million of these people are consider poor because their income is less than is necessary to satisfy essential needs. Both agricultural area and fertiliser consumption have increased since the 1960s. The topographic setting and latitudinal expanse of the Andes leads to significant variation in rainfall from hyper arid through to hyper-humid. Agricultural productivity can be affected at both extremes as well as by seasonal variability and by the erosional hazards associated with steep slopes. Water management is carried out by national and sub-national entities at various levels as there are few trans-frontier flows. The legislative framework is complex and environmental concerns are more significant than in some other basins.

Crop production is not the only element of water productivity in the Andes, though some 40% of water use in Colombia and up to 80% in the drier Andean countries is consumed by agriculture. Water also supplies massive urban populations, mining operations, industrial processes, transport needs and HEP generation as well as the maintenance of globally important ecosystems. HEP supplies up to 80% of regional energy needs in the Andes. Water productivity in the Andes is thus much more than the 'crop per drop' and has to be broadly defined as the contribution of water to human well being through production of food, energy and other goods and services.

Human interventions whether soft (policy) or hard (engineering) interventions can have complex effects on water, poverty and environment in spatially complex areas like the Andes. Yet these interventions

are important, for example there are around 140 major dams in the Andes (above 500m.a.s.l for the BFP study area) whose upstream areas cover around 10.4% of the Andean surface area (397,676 km^2) and potentially have access to some 20% of the streamflow produced in the region. Around 20% of the Andean population lives upstream of such dams. Understanding the impact of building a dam or implementing policies such as PES (payments for environmental services) to support existing dams requires an understanding of the hydrological and climatic setting and processes combined with the dynamics of water demand, access and productivity, land use, economy and income as well as scenarios for how climate, population and markets may change into the future. These are the basis of the AguaAndes policy support system – a web based, geobrowser-supported tool for understanding the cross-sectoral impacts of specific interventions in specific places.

The tool allows the policy maker or scientist to implement hard or soft interventions within an integrated assessment model (IAM) combining the biophysical and socio-economic systems based on the best available data and knowledge for the region. The impact of these interventions against local, regional or national Millenium development goal (MDG) targets can then be measured and any unexpected or unintended consequences evaluated. The PSS ties together the data and knowledge generated by the project in a way in which it can be better used in the policy domain for locally specific studies. The PSS can be applied at 1km spatial resolution to a 10 degree grid or at 100m spatial resolution for a 1 degree grid anywhere within the Andes, indeed many of the databases used are generated globally so that the system can also be applied in other basins. Though all data required to operate the system are supplied by the project, but if the user has alternative data these may be uploaded and used. The PSS is being developed alongside regional partners who intend to use it as part of their toolbox. Though not the only deliverable from the project the PSS is unusual in that it is a dynamic deliverable which can be applied to multiple uses within the Andes and be further improved through use.

Management of Water Storage for Multiple Uses and Users: The Experience of the Challenge Program on Water and Food

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Keywords: multiple use water systems, water productivity, storage water management, integrated assessment, reservoir fisheries

Introduction/Problem Identification

In developing countries growing competition over water storage resources often affect the poor and ecosystems most thereby decreasing the social-ecological resilience of the water system. More equitable allocation and management of water is urgently needed to satisfy the multiple objectives of food production, ecosystem conservation and poverty alleviation in rural areas whilst meeting the needs of growing cities and industry. Most water infrastructure and management systems are used for multiple purposes whereas they are usually designed for a single or primary use. Other water uses can significantly increase economic and social benefits of water often at a relatively low cost in terms of water consumption. Providing benefits for multiple uses and users of water is also one of the key mechanisms by which irrigation can contribute to poverty reduction. Yet this necessary shift in water management often requires more complex technical and governance arrangements of storage systems.

Analysis/Results and Implications for Policy and/or Research

Part of the CGIAR Challenge Program on Water and Food (CPWF) Research for Development has aimed to improve the management of water storage for secured access to a variety of stakeholders and to a range of productive and non-productive uses, including the contribution to ecosystem conservation and public health. For this purpose several projects have focused on the integrated assessment and management of water quantity and quality in a wide range of agro-ecological, economic and socio-political contexts, essentially at community and watershed scales.

Achieving effective and equitable multiple use of water storage systems requires the assessment of all actual and potential uses and users of the system. Several CPWF projects have identified and made visible the often neglected but important uses and users of different types of water systems across Africa, Asia and Latin America, notably: livestock (e.g. through the assessment of livestock water productivity), fisheries (e.g. through the increased fisheries productivity of reservoirs), health issues (e.g. through the assessment of dam operation impact on malaria prevalence), gender distribution of water users, and the interaction between these different uses and users (e.g. the "Multiple Uses Services (MUS)" and "Small Reservoirs" projects).

Beyond the identification of multiple uses and users, the representation of water needs and interests was supported through the development of multi-stakeholder platforms and negotiation support tools, and through attempts to up-scale local government representation and actions. This helped identify the physical and socio-economic distribution of winners and losers to better balance the allocation of water resources at watershed scale. This sometimes required changes in informal and formal institutional arrangements including water rights and priority allocation for small-scale users, the poor in particular. For example, the MUS project has piloted a methodology that addressed institutional challenges at multiple scales while identifying technological and policy innovations for multiple use systems. Particular emphasis was given to domestic use, small-scale productive uses, health and gender

issues. In terms tangible impact the South African Government has, for example, adopted the multiple use services approach as a result of the MUS project efforts.

Beyond this diagnostic and engagement of identified stakeholders, several projects have contributed to improving the conceptual and empirical understanding of the impacts of livestock, fisheries, aquaculture and other uses on the quality, availability and productivity of water, on public health and on the equitable distribution of water resources in selected river basins. The project "Improved fisheries productivity and management in tropical reservoirs" has contributed to rehabilitating 'single use' irrigation reservoirs for other users, fisheries in particular. Improving the management of fisheries has often been an overlooked alternative in maintaining water quality for domestic purposes. For example, enhanced fisheries management in Indian irrigation reservoirs has, besides increasing the water productivity from fisheries, helped to control eutrophication. It thereby contributed to improving water quality for downstream users. On health issues, the impact assessment of reservoir water operation on the prevalence of malaria in Ethiopia showed the possibility of using dam operation for vector (mosquito larvae) control. Results suggest that increased rates of drawdown could play a role in reducing larval habitat and decreasing malaria transmission.

Despite significant progress in the above areas, the CPWF has identified key research areas that urgently need to be further developed:

- Characterizing multiple use storage systems, and assessing their actual and potential benefits and costs;
- Improving the technical performance and management of multiple use storage systems;
- Evaluating the social-ecological tradeoffs between different needs at different times in terms of both water quantity and quality;
- Creating an enabling governance and policy environment

Developing this research aims to enhance the productivity as well as the social-ecological resilience of storage water systems in developing countries.

Parasitological Contamination of Stored Water in Rural Communities of Southeast Nigeria – Implications for Public Health

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Keywords: community, water, malaria, diarrhoea, contamination

Introduction/Problem Identification

In rural communities of developing countries, water storage systems are prone to contamination by parasitic disease agents. Apart from rainwater harvestation, local streams and ponds are other sources of gathering water for storage, These sources are often fecally polluted and likely to contain cysts of parasitic intestinal protozoa. Thus the use of such contaminated water for food preparation, dental hygiene or for drinking has been a major source of diarrhoeal diseases. Moreover, the poor storage systems have been found to be breeding sites for mosquitoes. As a result, transmission of malaria, filariases and mosquito-borne viral diseases are likely to continue in these areas unabated. In the light of the foregoing, a research was carried out during the dry and wet seasons of 2008 to identify the parasitic disease agents associated with poor water storage systems in rural communities of Southeast Nigeria and highlight their implication for public health.

Analysis/Results and Implications for Policy and/or Research

A total of 30 domestic water sources mainly ponds and streams were surveyed for parasitic agents. 100 water samples were collected at different points from each water source and examined for parasites using the filtration and centrifugation techniques. 76.4% of the total samples were positive for at least one of Entamoeba histolytica cyst, Giardia intestinalis cyst and eggs of Ascaris lumbricoides. Similarly, a survey of major mosquito species was conducted. A total of 4650 samples of stored water from 465 households were examined for mosquito larvae. Larval sampling was carried out using standard mosquito larval dipper with extendable handle. Larvae from the scoops were extracted using a dropper and placed in a vial with screw. Morphological features were used to identify and classify them into genera, and using light-dissecting microscope. The studies revealed seven mosquito species belonging to three genera, Anopheles, Culex and Aedes which are known vectors of malaria, filariases, yellow fever, dengue fever, and encephalitis. This paper observes strongly that provision of safe drinking water to every household should be a primary goal of healthcare delivery at all levels. Interim approaches should be adopted to enhance the health gains associated with safe drinking water for those whose water supplies are unsafe. In some of these rural communities the quantity of water might be adequate but the quality might be very poor. The paper recommends effective health education and enlightenment of the largely illiterate and ignorant local population. This should form the basis for a result-oriented point-of-use intervention. Families should be educated on the need for boiling, chlorination, filtration, solar disinfection as well as anti-mosquito and anti-larval measures. If sustained, this approach will in the short run deliver reasonable health benefits of improved water storage and use.

Application of Rainwater Harvesting Technology in the Pastoral Bangladesh

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Keywords: Bangladesh, drinking water, rainwater, statistical analysis, storage volume

Introduction/Problem Identification

In Bangladesh, the sources of water are surface water and ground water. Surface water sources are categorized as rainfall, transboundary flow, water on standing water bodies (water storage in reservoir, water bodies such as river, lake and pond), water on seasonal wetlands, and in-stream storage. But the main source of ground water is the recharge from surface water. Most of the areas of Bangladesh have been formed from the sedimentary alluvial and deltaic deposits of three major rivers and are characterized by an unconfined aquifer. Groundwater is the main natural water resources but the presence of Arsenic in shallow aquifer has completely changed the situation. The total population exposed to arsenic contaminated water above 50 µg/L and 10 µg/L are estimated as 32.5 million (25.9% of total population) and 56.7million (45.2%) respectively.

Analysis/Results and Implications for Policy and/or Research

Bangladesh is a tropical country and receives heavy rainfall due to north-easterly winds during the rainy season. Up to 85% of the annual rainfall occurs between June and September. Mean annual rainfall ranges from about 1200 mm in the west to almost 6000mm in the northeast. The average annual rainfall in the Himalayas and in the Meghalaya hills to the north of Bangladesh reaches about 10,000mm. The rainfall from November to March is not adequate to meet the demand during the periods. Therefore, rainwater has to be stored during rainy seasons for the rest of the year. Rainwater harvesting for long-term use was not considered as a potential source in past due to unavailability of suitable catchment area and inconvenience of storing water for few months when it is compared with the hand tubewells. This paper is aimed to assess the suitability of adopting rainwater harvesting technology especially to the pastoral areas based on authors experience and statistical calculations.

The houses of Bangladesh have different types of roofing materials. These include cement concrete, tiles, corrugated iron (C.I)./metal sheet, straw with or without polythene covering, bamboo with polythene covering where about 48% households in the pastoral area have tiles, C.I./metal sheet as roofing materials. These roofing materials are suitable for rainwater catchment. About 30% of those houses have the roofing area between 40-60m^2 and about 25% have 20-40m^2. Therefore, considering 6 persons in a family and assuming daily water consumption for drinking and cooking purposes is 5 lpcd, the statistical analysis show that the required storage volume in the Sylhet division is about 19000, where 36% of them have the volume of 20m^2, 29% of them have 40 m^2 volume and rest of them require 60 m^2 storage volume. The same for Rajshahi division is about 35000 where 40% of them have the volume of 20m^2, 30% of them have 40 m^2 volume and rest of them require 60 m^2 storage volume. In the Barisal division, the total number of storage volume require about 25000, where 38% of them have the volume of 20m^2, 33% of them have 40 m^2 volume and rest of them require 60 m^2 storage volume.

A storage tank is the most expensive component of a rainwater harvesting system. The storage tanks can be constructed from different materials depending on local situation. Considering the local condition and the economy, the cement ring tank might be the low-cost suitable option for pastoral Bangladesh. The average cost of a cement ring tank with a capacity of 5.0 m^3 is about 150US$.

The rainwater harvesting in pastoral Bangladesh seems as a viable alternative water source particularly in the arsenic contaminated area of pastoral Bangladesh. The required size for a typical family would vary between 2.9 and 4.4 m^3 volume is required in the western part, and a higher storage volume is required for north-western part. The quality of rainwater is high and the stored water is also safe when proper attention is taken. This water is free from two extreme contaminants i.e., arsenic and fecal coliform (with due care). The major advantage of the rooftop rainwater harvesting system is that the system is independent and suitable for scattered settlements. The operation of the rainwater harvesting is easier than other water supply system. No specialized skill is necessary to operate the system. It does not require any pumping device to abstract the water. The system also requires less maintenance work.

However, the success of rainwater harvesting system program depends on the interest, enthusiasm and active support of the users. Groundwater is the major source of water supply for more than two decades in Bangladesh. People may have negative attitude about the rainwater. The rainwater harvesting program can be implemented only when people have the willingness to use the system. Failure to involve the community in the planning, design and construction of the rainwater harvesting is commonly a cause of failure of the system in many countries.

Ferrocement Water Storage Tanks; Cost effective Solution for Water Storage for Secured Access

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Keywords: ferrocement, safe water storage, increasing demand, hoop wire, stress

Introduction/Problem Identification

In Sri Lanka safe water coverage is about 75% and safe pipe born water coverage is about 35%.The average annual rainfall in Sri Lanka exceeds 1500mm per year and hardly anywhere does it fall below 1000mm. In highlands, it is over 4000 mm. Therefore, it is obvious Sri Lanka is a country rich with water resources. But seasonal water shortage following the ever increasing demand in the rise of rapid economic development therefore, storage of water during rainy season is much advantageous. It is essential to have efficient water storage management in individual houses where water is supplied by pipe borne water supply schemes especially during drought periods as water is supplied intermittently due to water source issues.

Therefore, Sri Lankans have thought of numerous water storage options over centuries. As a result ancient kings to store water built tanks. At present various storage devices are available to store water for secured access.

Analysis/Results and Implications for Policy and/or Research

This paper describes the main features of those tanks. Water quality variation on water storage with time and cost involvement of each tank, unit cost comparison durability of these options will be discussed. The main low cost water storage solution used in projects is Ferrocement tank. There are about 20,000 Ferrocement tanks, which have been constructed since 1985. The unique features, advantages and disadvantages it posses will be discussed under this paper.

A typical ferrocement tank consists of three basic components namely, the base, the vertical wall and the dome, The base of the tank is made of 100 mm thick grade 25 reinforced concrete slab with 10 mm diameter tor steel bars Spaced at 150- 200 mm intervals both ways The vertical walls and the dome are generally 40 mm thick ferrocement with a single layer of No. 4 gauge 20 mesh. The ferrocement shell is connected to the base slab through a line of skeletal steel of 6 mm diameter mild steel at 200 mm spacing. In addition to this there is a spiral like GI hoop wire at 75 mm spacing, throughout the wall. The mortar used is1:3 Cement: Sand with 0.5 water cement ratio. Well-graded clean river sand of less than 4.3 mm should be used in the mortar to achieve the required quality and the finish of the final product.

Ferrocement is a highly versatile construction material. It is a kind of composite material where the filler material usually brittle in nature (called matrix is reinforced with fibers dispersed throughout the composite resulting in better structural performance than that of individual one).

The tensile strength and the flexural strength of ferrocement component can be varied within a considerable range. According to Naaman [Nannan 2000], the ultimate tensile strength up to 35 MPa and a modulus of rupture of 70 MPa can be achieved, by changing the type and number of wire meshes, their locations and the overall thickness of the mortar matrix.

The type of wire mesh commonly available in the Sri Lankan market is, hexagonal mesh (also known as chicken mesh), and woven mesh. The composition of the mortar ranges from 1:1.5 to 1:3 cement: sand and the thickness of ferrocement components vary from 20 to 40 mm. A series of laboratory experiments were conducted Jointly National Water Supply & Drainage Board and Faculty of Engineering University of Peradeniya to investigate the tensile and bending characteristics of the composite, at the Department of Civil Engineering, University of Peradeniya.

Increasing the water height of the water tank, considered above by changing either the water height of the tank or the diameter of the tank or both at the same time. The increase of the water height of the tank, while keeping the diameter unchanged result increasing bending moment at the wall-to-base joint of the tank. This will need a ferrocement section with a higher bending capacity and the wall is also susceptible to buckling due to the large height to thickness ratio. The design of ferrocement structures follows the same design philosophy generally adopted in structural engineering, particularly for reinforced and pre-stressed concrete structures. The design procedures, however, has not been evolved to the level of a "code of practice" as yet but is available in a form of a "guide for the design, construction and repair of ferrocement", by ACI committee 549. The philosophy adopted in the guide [ACI: 549 1993] is essentially a limit state design, where the collapse is considered under factored loads. Nevertheless the guide also gives provisions for the permissible stress or working stress design in which a maximum stress criteria is specified.

Improving Software for Decision Support Systems of the Dnieper River

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Keywords: reservoir system, decision support system, Dnieper River, management, software

Introduction/Problem Identification

The Dnieper River is the third largest river in Europe, with a catchments' area of 50400 km^2. The lower part, from the border between Belarus and Ukraine to the Black Sea, is regulated into a cascading series of six reservoirs. The total head is approximately 100 m. The average flow varies from 1050 m^3/s (33.1 km^3/year) at the upper reservoir (Kiev) to 1650 m^3/s (52.0 km^3/year) at the lower reservoir (Kakhovka). This is a multipurpose river regulation, mainly for irrigation, hydropower, and navigation. This situation has led to extensive reservoir utilization, which has resulted in increased conflicts with other user interests. To achieve this, the whole cascade system would need to be modeled and managed as an integrated unit, which is impossible without proper simulation models.

Analysis/Results and Implications for Policy and/or Research

The construction of the Cascade was forced by an increasing regional deficit of water in the lower part of the Dnieper basin. Was decided that the main industrial centers with water consuming branches of industry and the largest irrigation schemes were to be located in southern and south-eastern parts of Ukraine on areas with insufficient natural water resources. The hydropower system has an annual production of approximately 10 TWh. The Dnieper Cascade has also played an important role as a reserve energy production facility during the last decade.

The Joint Commission has proved to be a useful instrument for compromising between conflicting interests among its members. It is mandatory for the member organizations – the main water users – to participate in the meetings and to reach decisions. The main conflicting interests are the need for the hydropower companies to draw on reservoirs to produce energy, the irrigation interests to extract water from the reservoirs. Specially authorized bodies carrying out the management of the water resources use, protection and restoration are identified in the Water Code:

- the Ministry of Environmental Protection and Nuclear Safety of Ukraine;
- the State Committee for Water Management of Ukraine,
- the State Committee on Geology and Utilization of Mineral Resources of Ukraine, their local bodies and other state bodies according to the legislation.

Decision support system is important decision support tools both for short and long term planning of reservoir and HPS operation. In work the analysis of the software decision support system is represented and the methods of its improving are shown.

In order to prevent negative influence on fish and other aquatic organisms in the Dnieper reservoir and river, measures such as maximum allowable flow variation, velocity of flow reduction are accepted. However, these considerations are difficult to maintain, it is from example impossible to maintain a required minimum discharge of 1000 m^3/h at Kakhovski HPS during low water periods.

There is always room for improving the hydrological forecasts in a system like the Dnieper River, and it would normally be cost efficient to do so. A hydrologic forecasting model for the Dnieper would seem to be an obvious upgrade of the present forecasting system. In the present situation, however, it is even more important to focus on the necessity and importance to maintain and upgrade the real time hydrometeorological monitoring and data collection system of the Dnieper Basin, including Belarus and Russia. The obstacles in such a process are mainly financial and administrative, not technical.

The short term planning is essentially an internal matter for the reservoir and hydropower operators, and is commonly strongly integrated with other decision support software for the operators. Development of such software is best seen in connection with the new SCADA system planned for the Hydropower Stations in the Cascade. Standard program systems developed by specialized software development firms companies like VNIIE or other providers are probably the best choice for this task.

The weakness of the present simulation/optimization model (VNIIE "BWD") is, apart from its limitations in number of time steps and its somewhat outdated user interface, that it requires deterministic input, i.e. that the inflow is known throughout the simulation period. This is not very well suited to the hydrology of the Dnieper, which in spite of its size show rapid variations that is difficult to predict. It is easy to develop in a modularized approach that does not interfere with the other programs and the day-by-day operation of the HPS. As a result of this, an integrated inflow forecasting/hydrograph generation module, FHGM, has been developed and implemented at the Client. This software generates hydrological input to the "BWD" model, which is the standard optimization/simulation model used at UKRENERGO.

A stochastic simulation model can further be combined with economic loss functions (when they are better developed than presently) to describe risk and expected losses and gains for the different users. When this is done, with the consensus of all users about the loss function parameterizations, an optimizing water allocation model is in principle realizable, treating the environmental aspects through constraints.

The information on the economics of other water users than the hydropower sector is still too scarce and unsystematic to parameterize optimization models for water allocation. Further, the organizational set-up of the water management of the cascade, with negotiations between the users through the Joint Commission, calls more for simulation models to clarify consequences of alternative actions than for optimization models. It is recommended that the BWD model in due time is replaced by a stochastic simulation model that describes probabilistically the outcome of different operation alternatives.

Securing Access to Quality Perennial Re-use Water through Wastewater Recycling for Urban Landscaping

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Keywords: waste-water recycling, bio-phyto remediation, decentralized holistic system, alternate source – reuse water, rejuvenation of landscape

Introduction/Problem Identification

New Delhi, a city of 14 million people, needs 3000 million litres of water per day(MLD), but receives only 2/3rd of the same through municipal supplies. This water supply gap, besides pressurizing the population for generic water supply needs, also prevents maintenance of parks and open spaces. In addition, only half the huge quantities of wastewater produced in the city is conveyed through normal sewerage as wastewater piping is ineffective due to multiple reasons. The other half is released into open drains which are actually part of the stormwater drainage sloping towards the city's adjunct river, the Yamuna, thus creating a heavy pollutant load.

Bringing these two issues together, this paper creates a case for waste water treatment at a decentralized scale to serve as a local resource to makeup this demand–supply gap. This practice helps create an example of grassroots action in wastewater recycling, to help bridge the deficiencies in large scale municipal infrastructure.

Analysis/Results and Implications for Policy and/or Research

Under the National Directive – 'Jawaharlal Nehru National Urban Renewal Mission', the State has an aim to encourage reforms and plan development for identified cities. Its focus is on efficiency in urban infrastructure and service delivery mechanisms. One of the specific objectives is to afford integrated development of infrastructure services such as water. Also among the objectives of the Master Plan for Delhi 2021, there is relevant attention for the rejuvenation of the river Yamuna including refurbishment of trunk sewers, treatment of drains, recycling of treated effluents and compliance with 'Zero liquid discharge- ZLD' policy at a city level. Due to scarcity of clean surface water, ground water is being extracted for irrigating parks, lawns etc. This has disturbed the hydrological balance leading to decline in the productivity of wells and increased the energy requirements.

This wastewater recycling approach is utilized by the organization in small communities where the wastewater (domestic sewage) is treated based on a set of treatment principles, which are non mechanized and use minimal power. The selection is determined by their reliability, longevity and tolerance towards inflow fluctuation and also because these treatment principles dispense with the need for sophisticated control devices and maintenance. Its practice is cost effective, low- technology and matches well with grassroots efforts. A few cases implemented in waste water recycling at a range of sites are as given below:

(Name, location, project type, design flow, process, inflow sourced, quality, quantity, outflow, use – area of irrigated land, others)

1 Vasant Vihar nursery: Wastewater Treatment (WWT) of 40 KLD, Anaerobic, aerobic with bio-phyto-remediation, Inflow at 40 KL & 350 BOD, producing 35 KL Re-use water & 30 BOD, 15,000 Sq.m - greens

2 Centre for Science & Environment, Institution at Delhi : WWT 10 KLD, Anaerobic, aerobic with bio-phyto-remediation, Inflow at 10 KL & 300 BOD, producing 8 KL Re-use water at 20 BOD, 1,500 Sq.m – greens and flush water for toilets
3 IIT-Delhi, premier Technology Institute: WWT 10 KLD, aerobic with bio-phyto-remediation, Inflow at 10 KL & 200 BOD, producing 8 KL Re-use water at 20 BOD, 3,000 Sq.m – greens and water for floor cleaning at canteen- mess and research.
4 Scindia School, Gwalior: WWT 10 KLD, anaerobic with bio-phyto-remediation, Inflow at 10 KL & 300 BOD, producing 8 KL Re-use water at 20 BOD, 2,000 Sq.m – greens and water for flush water for toilets and cleaning of paved areas.

Case Study at Wastewater Recycling Plant at Vasant Vihar, New Delhi

The Wastewater Recycling Plant is located on the banks of an urban-drain at an affluent colony at New Delhi. This drain carries domestic sewage from un-sewered nearby areas. The waste water recycling plant daily sources 40 kl and evolves 35 kl reuse water, It operates with adequate BOD reduction and removal of pathogen and irrigates a total area of 45,000 Sqm of greens. It is observed that the average waste water flow in the drain is more than 150 Kl per day. If all this water was taken up for process and re use, it could cater to irrigating more than 200,000 Sqm. This plant is designed on the concept- Dewats (Decentralized Wastewater Treatment Systems) which provides primary treatment in sedimentation ponds, septic tanks or Imhoff tanks, secondary anaerobic treatment in fixed bed filters or baffled septic tanks(baffled filter reactors) & tertiary aerobic treatment in constructed wetlands and ponds.

Implications & Results

Social acceptance in the initial phase was low, as citizens were hesitant to use the remedied sewage water. But with apt water advocacy, it picked up and future projects sought encouragement from the public & organizational stakeholders. Increased green coverage resulted in increase in value of residential property and aesthetics and providing wider acceptance for this decentralized initiative rather than the conventional STP-process which were failing.

Results realized in the form of social, economic & environmental good in the respective habitats. The social good perceived through better greenery in parks provided value leisure time. The economic good showcased increase in property rates of plots along the parks due to better visual characteristics, together with secured access and storage of water within the site itself. Energy and direct water costs were also lowered. Direct environmental gains are in the form of preservation of inherent bio-diversity, augmenting fresh water supply and lesser use of ground aquifer-water. Indirect environmental gains are in the form of restoring ground water by infiltration, restoration of soil texture & moisture gain enhancement during rains

Household Water Treatment among Flood Affected Populations in Teso Region, Uganda

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Keywords: Uganda, post-disaster, household water treatment, Teso Region, IEC

Introduction/Problem Identification

Heavy rains and flooding in the fall of 2007 compromised sanitation, hygiene and water sources in eastern Uganda for communities in the Teso region many of whom already lacked access to basic sanitation and health facilities. In response to this humanitarian emergency, PSI/Uganda, in partnership with UNICEF and local health agencies, distributed Non Food Item kits (including one long-lasting insecticide treated net, water purification products, soap, water storage vessels, and Information-Education-Communication materials) and conducted complementary social mobilization and communication activities. Distribution of NFI kits was implemented using distribution teams at local distribution points in four districts: Amuria, Katakwi, Kumi, and Bukedea, and activities were conducted at distribution points and across the region.

Analysis/Results and Implications for Policy and/or Research

In the three months of intervention, 38,832 households were reached (exceeding the target of 27,000), 2,104 Village Health Teams were trained, 96 films on topics including malaria control, safe water treatment, hygiene and sanitation practices were shown, and two radio talk shows were conducted to promote knowledge of product use.

A cross-sectional household survey conducted at the conclusion of the distribution period found that nearly all households in each of the districts were doing something to improve the quality of their drinking water, with 57.9% of households purifying their water with WaterGuard tabs, ranging from 27.0% (Kumi) to 68.9% (Katakwi). PUR sachets were also distributed in lesser quantities, and 3.8% of households were using PUR sachets to purify their water. The primary reason cited for non-use was lack of awareness, and the major reason for discontinuation of use was that the product had run out.

Among all individuals surveyed, one third of individuals surveyed knew the correct steps to use the WaterGuard tab, and only 16.1% knew the correct steps to use PUR. Knowledge was higher among current users of the product, with 39.5% demonstrating correct use of the WaterGuard tab and 28.3% demonstrating correct use of PUR.

The emergency response demonstrated that households can be effectively reached with needed water purification products utilizing local distribution teams and points.

Additionally, coordination between the numerous agencies providing humanitarian relief was critical in reducing duplication of services and product provision, which allowed PSI/Uganda to reach more households than projected. The high levels of water treatment reported in the survey indicate that the community was receptive to water treatment messages and products.

Future distribution programs should focus on improving distribution through training of distribution teams and coordination of simultaneous registration and distribution. A door-to-door model

of distribution is recommended to increase equity and coverage. Additionally, programs directed at improving water treatment should focus on increasing general awareness of hygiene and sanitation issues, specifically on the correct use of water treatment products.

Traditional Water Karez System

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Keywords: water, karez system, local knowledge, research, development

Introduction/Problem Identification

The amount of water in the world is finite. The number of people is growing fast and their water use is growing even faster. A third of the world's population lives in water stressed countries now. By 2025, this is expected to rise to two-thirds. The UN recommends that people need a minimum of 50 liters of water a day for drinking, washing, cooking and sanitation.

Analysis/Results and Implications for Policy and/or Research

Objective
Determine the efficiency of Balochistan's traditional underground irrigation system Karez during the drought

Design
A cross section study

Duration
3 months

Subject and Methods
Total 20 Karez visited in five districts of the Pakistan's largest province (Area 347000 Sq. Km.) and interviewed 120 old people with more than 60 years of age and living in that particular area. Questionnaires were developed in two local languages by the experts. These information collected includes, the underground mud made system of Karez, its beginning in the area (More than 1000 years back), its efficiency in normal rain fall/water conditions, effect of drought on Karez, Efficiency of Karez as compared to open irrigation channels during drought

Results
Being around 25-35 feet deep in the soil, the water loss through evaporation is very low, it's a traditional method loved by every person in the area, efficient even during drought but due to continuous drought and low water level its highly affected, more over with the provision of electricity during last few years, tube wells installed in nearby areas reduced water availability for Karez and thus its efficiency

Conclusion/ Recommendations
Due to ill planned installation of tube wells, many hundred years old traditional Karez system (Very low cost method) being destroyed drastically. A detailed study in all the province should be conducted and awareness campaign should be designed for the people/government installing tube wells without any planning that is causing very low water table level in the low rain fall areas. These areas do not have any other means of water (Irrigation/drinking) other than rains and underground water.

Deeper Water Crisis, Need to Understand and Augment: Case of Ahmedabad and Chennai Cities, India

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Keywords: tube wells, water consumption, rainwater harvesting, quality drinking water, stakeholders

Introduction/Problem Identification

The case of Ahmedabad city in Gujarath State of India is leading towards drinking water crisis exhibiting the negligence on the part of all those concerned with water. The actual groundwater level in Ahmedabad city measured 120m. The uncontrolled number of deeper tube wells in the city draws huge quantity of groundwater from deeper depths of the sedimentary beds. Comparing this case with that of Chennai city wherein the government in 2004, through a legislation, made installation of Rainwater Harvesting compulsory in all the buildings in the city. There was some effect of groundwater improvement in terms of quality and quantity as observed by the competent authority. The increasing population in general and expansion of urban areas in particular, has exerted tremendous pressure on water resources to meet the growing demand. There are islands of success wherein individuals, Institutions and Government Departments in these cities have demonstrated benefits of Rainwater Harvesting.

Analysis/Results and Implications for Policy and/or Research

Ahmedabad Municipal Corporation has distributed a total of 545 million litres a day to about 3.52 million population @ 155 litres per capita per day (lpcd) during the year 2002-03, out of which 64 percent was tapped from river source and the rest 36 percent from the groundwater source. Groundwater is declining at a rapid rate of 3m per annum as the municipal water supply is not sufficient to meet individual, agricultural and industrial needs. Average water consumption was 450 lpcd for the entire city area. In Municipal area the average water consumption was 385 lpcd and in Urban Development Area, it was 514 lpcd. In Urban development Area, people have been drawing both municipal water supply as well as groundwater from their own tube wells. In individual Bungalows the average water consumption was as high as 604 lpcd, in low-rise buildings it was 369 lpcd, in high-rise buildings 494 lpcd and in tenements the average water consumption was 332 lpcd.

Minimum water consumption was found in an apartment where there was restricted water supply to the flats, two hours in the morning and evening times. Restricted water supply made people to have controlled usage of water. On the other extreme, maximum water consumption was found in a government officer's residential quarter. The reason for such a high consumption of 1879 lpcd was not the number of persons living in the house but, the lawn maintained by using the municipal water.

Second highest consumption was in an apartment in Western Fringe Area where it was on an average 752 lpcd as the building was getting both municipal water and own tube well water round the clock.

The entire Ahmedabad city consumed 1002 million litres a day (MLD) per annum during 2002-03 which worked out to 223 lpcd. Out of this, 406 MLD was drawn from groundwater source, which included municipality owned tube wells as well as private tube wells owned by apartments, bungalows, and government quarters. There are around 100 to 120 tanker water suppliers in Ahmedabad. On an average, a tanker company supplies 75,000 litres per day. The sale goes upto 95-100,000 litres per day in summer months.

Chennai urban area requires about 800 MLD of water to supply to its 5.5 million citizens. Presently it could meet upto 680 MLD from various sources as per Chennai Metropolitan Water Supply And Sewerage Board. People supplement water requirements from private tankers who fetch groundwater from private well owners in the semi-urban areas. The Board has notified about 60 villages in sub-urban areas through a groundwater regulation act for the private tankers to collect water. Further to this act, in the year 2004, the Tamil Nadu government made through government order notification mandatory installation of Rain Water Harvesting systems in every building in the Chennai city, be it residential, commercial, hospital, hotel or industries. The order notified in August 2004 had only two months period and by September 30th all the buildings should have installed the RWH system without fail.

The analyses of groundwater level graphs and its correlation to the variations before and after the mandatory implementation of RWH structures reveal that the depth to ground water which was at 6 to 8 meters on an average have recovered to a depth of 2 to 4 meters, particularly during the 3 months rainy season from October to December when good recharge took place. The graphs plotted for the water level difference between the years (2003-04; 2004-05; 2005-06) have also shown the ground water recovery of 4 to 6 meters.

Rainwater harvesting was undertaken in the city in August – September 2004 and the TDS values for January and February of 2005 showed reduction from 3800 to 1300 ppm in the case of Thondiarpet well and from 1500 to 800 for Pulianthope well. However, there were no significant changes in the TDS values in the other wells.

The investment on external sources of water for feeding the ever-increasing urban population in both the cities is always at a huge cost and runs out of requirements. Further, the inequity in distribution of drinking water to all the households leads to increased cost of maintenance and management. For example, the government quarters getting continuous public water supply which allowed them to use for gardening thereby depriving the poor families of their part of water requirement, as water supply in poor families colony is time bound with a limited supply points. Urban water management needs stakeholders' involvement with the concern for the present day requirements and also for the future demands on a sustainable basis. Water Managers in urban areas should become 'smart managers' by shouldering responsibility to collect data, involve researchers to analyse the data and provide recommendations with precautions for future trends in the resource constraints.

River Flow Regulation and Environmental Problems in Deltas

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Keywords: water storage, flow regulation, deltas, environment, degradation

Introduction/Problem Identification

Intensive water storages construction and river flow regulation in arid, semiarid and sub-humid zones for irrigation, hydro-power engineering and water supply has caused large-scale degradation processes in lower reaches of these rivers, first of all in their deltas. Therefore the environmental situation on the huge areas of deltaic plains has essentially worsened; unique landscapes began to lose their productivity, and hydromorphic soils – to become salt-effected and desertificated. Investigation of these processes is very important for local population in deltas to access fresh water, to restore environmental and goods services of deltaic landscapes, to predict further nature degradation, to prevent strong social problems in deltas, especially – people migration from those regions.

Analysis/Results and Implications for Policy and/or Research

Degradation processes in deltas are caused by radical transformation of hydrological and hydrochemical regimes of the rivers. As the major indicators are considered: reduction of a water inflow into deltas; changes of seasonal flow distribution; accumulation of a sediment load in water reservoirs, channels and on fields, and erosive processes strengthening in channels of deltas; increase in a mineralization (salt content) of river waters, change in ionic composition and deterioration of their quality.

The long-term surface research, added last years with decoding of space images, and also the analysis of the published materials have allowed to establish, that appreciable (in some cases – catastrophic) deterioration of a land cover takes place in deltas in Central Asia (the rivers Ili, Syrdarya, Amudarya, Chu, Zarafshan, Tejen, Murgab, Heihe), Southern and Southeast Asia (Euphrates, Tigris, Indus, Red River, Huanghe, etc.), Africa (Nile, Senegal, Okavango, etc.), Northern and the South America (Colorado, Mississippi, La Plata, Sao Francisco, etc.), Europe (Ebro, Po, Danube, Dnepr, etc.). In all these cases processes of environment degradation in deltas proceed very originally. And different measures for their weakening or overcoming are needed. Nevertheless, long-term researches have allowed revealing the general regularities of land cover changes, used for prognostication.

Depending on a climate the dominating processes are as follows:

- Arid and semiarid zones – desertification, salinization, aeolian destruction of soils
- Sub-humid zone – steppe-like soil formation, slight salinization, sometime-desertification;
- Humid zone – peatbog and fen drying-up and degradation.
- Depending on geomorphologic conditions:
- Continental deltas (Chu, Tarim, Heihe, Okavango) – fast and strong desertification and salinization;
- Continental deltas with inflow transfer (Tejen, Murgab, etc) – waterlogging, salinization, desertification;
- Deltas on the shore of inner water bodies (lakes and seas) – (Ili, Syrdarya, Amudarya, etc.)
- Drying-up, desertification, salinization, aeolian destruction;
- Deltas in sea estuaries (limans) – (Dnepr, Dniester, and South Bug) – drying-up, meadow formation, slight salinization;

- Deltas in the sea bays (Euphrates and Tigris, Colorado, etc) – intrusion of sea water, desertification, salinization, aeolian destruction
- Deltas on the coast of seas and oceans (Nile, Huanghe, Mississippi) – abrasion of the coast, sea water intrusion, drying-up, desertification, salinization.

Peculiarities of land cover changes in deltas of the rivers Syrdarya, Ili (Ily), Chu, Tejen, Heihe in connection with river flow regulation are analyzed in details. Rate of degradation processes is established, ecologo-genetic series of soil changes which are used for forecasting are revealed.

Climate Change Impact to the Water Resources of Transboundary Kura River Basin and Ways of its Mitigation

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Keywords: water, run-off, deficit, discharge, flow

Introduction/Problem Identification

Kura is the main water artery of the Caucasus. The researches shows that total water resources of Eastern Caucasus rivers (The Kura basin rivers and directly falling into Caspian Sea rivers, including the Samur and Astarachay rivers) make up 31.5 km^3.

At present water resources of Kura and Ganikh in Georgia and water resources of Araz in Turkey, Iran and Armenia in result of water intake and partly in connection with negative impact of climate change are decreased by 20% as a result of water intake.

Assessment of water resources during last 30 years also shows their decrease by climate changes. All above issues show that if the current antropogenic impact continues it together with climate change negative impact to water resources will create any problems of water supply and urgent measures needed to be taken to solve this issue

Analysis/Results and Implications for Policy and/or Research

Climate change impact assessment on run-off of Eastern Caucasus Rivers is given in this work. The spatial-temporal assessment of changes of the run-off, temperature and precipitation over the river basin has been undertaken. In accordance with GISS, GFDL-3 and SRES_A2 climate change models and a scenario with regard to an air temperature increased by 2 degrees, an appropriate model was developed to assess the change of annual and seasonal values of water discharges and the ecological flow of rivers under the climate change.

Results of this work show that annual and seasonal water resources and ecological flow of Eastern Caucasus Rivers may in all three of given climate change models decrease by 20% with an air temperature increase.

Identification of adaptation fusibilities of water resources to remove negative consequences of climate change is the final stage of quantitative assessment of vulnerability. Basic task of this stage is to identify feasible adaptation measures, which should be realized with purpose to prevent climate change consequences and to contribute stable development of the country. It is shown that without measures of adaptation will be an arid situation under all climate change scenarios and a more difficult situation by GFDL-I scenario, that is where water resources may be reduced about by 40 %.

In this case the most vulnerable will be energy, agriculture sectors, provision of population with fresh water and ecological conditions of rivers. For different branches of economy climate change impact

assessment carried out and ways of its negative consequences mitigation were been determined. Several adaptation measures are given.

As one of ways to execute necessary adaptation measures to facilitate water resources management in condition of water deficiency it is prepared some project proposals directed to increasing of forest areas in the basins of small and large rivers and creation of water protection zones and water reservoirs(which may also be used for production of hydro energy instead of thermal power plants). The amounts of underground waters have also been indicated for use in different region as sources of safe drinking water. Available for use in this purpose capacity of which makes up approximately 25-30% from surface waters.

Others relates to decreasing the water losses through improvement of water supply and distribution system and use of modern technology, adoption of measures on use of water recycling and treatment practices, increasing of efficiency of water use, transfer to integrated water resources management on the basis of ecosystem approach.

Implementing of mentioned measures may play positive role for decreasing the negative impact of climate change to water resources of the basin.

Fresh-keeping of Harvested Rainwater at Loess Plateau and Accessible Treatment for Farm Families

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Keywords: rainwater harvesting, water quality, water treatment, chlorine dioxide, zeolites

Introduction/Problem Identification

Rainwater harvesting has played a prominent role in farmers' domestic usage and agricultural irrigation in arid and semi-arid loess plateau of northwest China. The rainwater stored in cisterns commonly had the quality issues such as high pathogen numbers, organic and inorganic contaminants and annoying odor etc. Our research that was supported by SIDA, successfully used chlorine dioxide for rainwater fresh-keeping, controlling bacteria growth and decomposing organic contaminates in cisterns when odors were removed too. A simple water treatment apparatus was designed with zeolite adsorption combined with ClO_2 oxidation for drinking water purification. With practical use of above techniques in 5 villages, the stored rainwater can meet the criteria of drinking water quality. Moreover, local people's health has significantly improved if they simply treated drinking water with the apparatus when farmer's digestive system diseases decreased by 94% and cancer possibility reduced by 86%.

Analysis/Results and Implications for Policy and/or Research

A long-term investigation of harvested rainwater quality through the three different catchment systems, i.e. roof, land surface and road surface in loess regions, indicated that harvested rainwater at loess plateau can wash many types of bacteria, molds, algae, protozoa and other contaminants into the cistern. The analytical results proved that the concentrations of inorganic ions in harvested rainwater generally met the standards for irrigation water quality. But color, turbidity, hardness, TDS, COD, Cl- and Fe^{2+} appeared to be higher than the drinking water criteria of WHO. From spilled petrol and dissolved pesticides, 55 different organic compounds with the total concentrations 0.437 mg/L were identified, including aliphatic hydrocarbons, phthalates and small amount of aromatic compounds etc. The concentrations of total N for all the investigated cisterns had a range between 0.535 and 9.117 mg/L, less than the WHO guidelines of 10 mg/L for drinking water while total P were still lower than the maximum admissible limit 2 mg/L set by the EEC standard. The pH values were within the WHO guidelines of 6.5-8.5 for drinking water. Our investigation confirmed that the number of Faecal Coliform in the harvested rainwater from the roof-yard systems and road surfaces was tremendously higher than that the WHO guidelines for drinking water. The enormous F-coli in harvested rainwater might widely be resulted from cattle and poultry's manure.

An advantage of newly designed concrete cistern chambers is able to decrease the corrosiveness of rainwater by allowing the dissolution of calcium carbonate from the walls. It was emphasized that a thin layer of red clay must be tightly laid on the bottom of cisterns instead of concrete in order to minimize seepage losses and create proper conditions for the natural purification of stored rainwater through adsorption and biodegradation. Thus, algae could not grow if cistern bottom packed with red clay. Moreover, the number of degradable microorganisms reached 105-107 cells/cm^3 on the top clay layer. Therefore, the organic compounds in cistern water collected right after raining were more complicated than the long–period stored water because self-purification mechanisms, especially biodegradation, strongly decomposed some components in cisterns. With regard to the formation of trihalomethanes produced by the reaction between chlorine and organic pollutants, it was sug-

gested not to use sodium hypochlorite for disinfecting. Technically, chlorine dioxide was preferred to be used with the suitable dosage 0.1-0.2 mg/L to keep the harvested rainwater in cisterns "fresh". The monitories indicate that chlorine dioxide can significantly restrain production of trihalomethanes (THMs) and control of bacteria growth particularly for F-coli, Cryptosporidium and Giardia oocysts, additionally, odors gradually disappeared too. An economical methodology was studied to generate ClO_2 solution by the reaction between $NaClO_3$ and H_2SO_4 with sugar as the catalysis. The optimal conditions and available approaches for the storage of pure chlorine dioxide solution have been suggested without adding any chemical stabilizing agent. The accessible method is to store the pure chlorine dioxide solution in dark-color containers that are made of ordinary glass or glass fiber reinforced plastics. Meanwhile, the pH value needs to be adjusted around 6 and be placed at dry location under the temperature less than 10°C. The prevention of conversion of chlorine dioxide into the by-products, such as chlorite, from sunlight radiation should be particularly considered. Financially supported by the Hygiene Agency, ClO_2 solution has freely been offered to farm families for substituting sodium hypochlorite.

Zeolites, as the natural minerals, are widely distributed in Northwest China, and are introduced to rainwater treatment due to low costs. With respect to the high turbidity of rainwater runoff caused by loess soil erosion, we designed the installations of the zeolite particle filters for removing suspended solids and adsorb chemicals, particularly for adsorption of organic contaminants. A link of connected columns filled by sieved zeolites with size of 0.6-0.8 mm can remove more than 98% of suspended solids and 30-60% of organic contaminants. The zeolite columns were periodically washed by counterflow when zeolite particles were reacted with NaCl solution of 1mol/L. Then the filtered water continued to be oxidized by using ClO2 with a dosage of 0.5-0.8mg/L for 15min even longer. As a result, the residuals of organic compounds could be removed by 60-80%, for example, benzene homologous compounds were decomposed by 80% at pH<7.0. In meantime, Fe^{2+} concentration reduced by 60-70% through precipitation in oxidation process. F-coli, Cryptosporidium and Giardia oocysts were absolutely killed after the oxidation and disinfection. Finally, the rainwater stored in cisterns might match with the drinking water standards.

Workshop 8: Subsidies and Financial Mechanisms in the Water Sector

Effective Financing of Local Governments to Provide Water Supply Services in Ethiopia: The Case of Tenna

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Keywords: financing, water, Ethiopia, Tenna, Oromiya

Introduction/Problem Identification

This study was conducted with the objective of understanding water supply financing mechanisms under decentralization framework to the local governments. Policy mapping, resources flows, score cards, percentages, per capita and graphs were used. Findings revealed that capital budget decisions are vested in the federal and regional governments, and as a result, local governments receives very low and inconsistence capital budget to provide water supply services. Besides, weak capacity in drawing accurate plans and budgets, and weak sector coordination are among the challenges for local governments in the provision of water supply services. From this study the authors recommend for more works in the areas of capacity and resource flows to the local governments for effective delivery of water supply services.

Analysis/Results and Implications for Policy and/or Research

Financing mechanisms: in Ethiopia water sector is financed through three channels.

Channel 1 is 'on-budget' and 'on-treasury' and is managed by the finance and economic development. A new formula to determine the allocation to regions has been recently approved by the house of federation. Allocations to local governments by regions are made on the basis of sector unit costs and development indicators. Local governments usually receive a large portion of their budget through block grants. In theory, the local governments have the power to decide on allocation of funds from the block grant. In practice, however, most of the grant is absorbed by recurrent costs. Any remaining budget for capital (five percent of the total budget in case of Tenna) is decided on the basis of the written directives from the zonal finance and economic development office, with the result that the local governments have no autonomy on allocation of capital expenditures.

Channel 2 funds are made available to the ministry of water resources, then allocated to the regional bureaus and are then channeled down to local government water offices; these funds are 'on-budget' but not 'on-treasury'. Decisions on which regions and local governments benefit from these funds are usually made at federal level and criteria used are not clear to regions and/or local governments. Donors may apply different criteria to select local governments for investment. Local governments are rarely involved in program design and implementation. Regions have a role in identifying local governments with relatively poor water supply services, and participating in the joint technical reviews of sector programs with donors and NGOs. Some of the challenges faced by regions include the problem of raising matching funds for implementation, lengthy processes and complex procurement procedures, as well as lack of implementation capacity.

Channel 3 funds are generally transferred directly to service providers and are often entirely off-budget as far as finance and economic development is concerned. These funds come from non-governmental organizations (international or national) and other donors.

Local government planning and budgeting:
Local level planning is weak for many years, including limited information on coverage, limited understanding of natural/regional targets, limited information regarding off-budget investments, and lack of technical skills. Developing information systems and building local capacity is of paramount importance. The poorest of the poor are not being reached for various reasons. First, funds available for the local government are very limited and benefit the more accessible villages. Secondly, few government staff has adequate training in social ranking and the identification of the poverty pockets. Thirdly, the UAP aims to reach full coverage of water and sanitation services by 2012. This implies that all the rural and urban population living without safe drinking water and sanitation are, by default, targeted. In other words, there is no clearly defined strategy to target the most vulnerable groups.

In most local governments there is insufficient finance for the operation and maintenance of existing schemes. This leads to a high non-functionality rate. To address this problem and sustain operation and maintenance based on per capita requirement indicated in the financing strategy. Donors and/or regional governments should also invest in the building of capacity for private and community water service providers to take up operation and maintenance. This would require a reformulation of law/proclamation for privatizing operation and maintenance.

Prior to 2004 – when the water desk was under the office of agriculture and rural development – no budget was allocated to provide WASH services. This trend persisted even after the water desk became an independent office responsible to the zonal water resources department. The water office is not represented in the cabinet, unlike other sectors, and is therefore unable to defend its budget during budget hearing, while other sector offices have the chance to defend theirs.

Evidence shows that at the local level capital expenditure on water supply and sanitation is extremely low. Non-governmental organizations' investment in the water sector accounts for 64% of capital expenditure, community contribution accounts for 33% and the remaining three percent comes from the local government. On-budget per capita capital expenditure is very low and inconsistent ($0.03 during 2004/5, 0 during 2005/6 and 0.05 during 2006/7) for water. Compared to other sectors this per capita is relatively lower (education is $0.25; health is $0.12).

Microfinance and Sanitation in Rural Areas: An Innovative Approach to Contribute to the Achievement of the Millennium Development Goals

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Keywords: microfinance, guarantee funds, ecological sanitation, sustainable sanitation, stakeholders

Introduction/Problem Identification

Under the Water for African Cities (WACII) initiative, UN HABITAT set up, in collaboration with CREPA a sanitation project in Senegal. UN HABITAT gave a subsidy that covered partly the cost of the projet. To allow the poor pay their contribution and benefit the sanitation systems, CREPA put in place a microcredit mechanism through an agreement concluded with a Microfinance Institute in order to make easier the access to laon for the recipient.

Analysis/Results and Implications for Policy and/or Research

The base line of the mechanism is the allocation of loan with no interest rate to the populations of the surrounding villages of the Lake de Guiers to make easier their access to onsite sanitation systems proposed by the project.

This initiative has started by identification of a local micro finance institution and sensitization of the target populations to the new concept. The institution identified is the MFI named MECAPP located in the project area – at Keur Momar Sarr. This Microfinance Institute was selected for two raisons: the first is its location in the project area and second is its relevant experience in financing small development project in rural area for the benefit of the women association.

An agreement was then concluded between CREPA and MECAPP. Following the issuance of this agreement, a guarantee funds equivalent to thirty thousand American dollars was deposited on an account open at the MECAPP in the name of CREPA.

These funds would be used to cover the risks of non-recovery of loan and would allow the micro finance institute to finance the counterpart of the recipients up to at least twice the amount of the guarantee in the form of small loan to the recipients refundable over a period of nine months. The agreement fixed the maximum amount of loan at $1000 with no interest rate.

Nevertheless an institutional support of 30% of the guarantee was granted to the MFI to balance out loses. Up to now $36.106 were allocated to 311 recipients who opened an account with MECAPP. This amount corresponds to the contribution of the recipients for the construction of 479 onsite sanitation systems. Cash is not given to the recipients but deposit on CREPA's account.

The recovering of the loan is managed by MECAPP with the support of CREPA. Grouped recovering is often adopted. That means the recovering team goes to the villages to meet recipients in an appointed time.

Up to now, although the deadline for paying back the loan is has not come yet, we noted that some

villages the recovering rate is quite high –about 60%. But for the entire loan this recovering rate remains relatively low.

More than 90% of people subscribe to the microcredit scheme to pay their counterpart of the project. That enables them to benefit from a broad range of sanitation systems considered to be much more convenient.

For the sustainability of the system, the trained local stockholders – masons- will be organized in formal associations in order to continue constructions in partnership with the Microfinance Institution MECAPP after the project.

Decentralization of Urban Water Supply and Sanitation in Yemen and Its Financial Mechanisms to Enhance Services Provision and Sustainability

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Keywords: decentralization, governance, financial instruments, sustainability, services

Introduction/Problem Identification

The decentralization of UWSS aims to improve service delivery and to enhance the local utilities to put their cost recovery policy through putting an applicable local tariff to cover the operation and maintenance of these utilities and also a strong representation of local authorities and communities in the management. The financial instruments are weak in the country for developing the services of water and sanitation either for the big or small utilities. The utilities at the governorate level and local levels should be stronger for following up the other resources from its resources to increase the efficiency and search for opportunities to be financially sustainable.

It became clear that available investment does not lead to increased service provision, as absorption capacities are weak due to limited competence available at the UWSS sector organizations. Poor human capacity and sustainable financial resources are the main constraints and challenges to overcome.

Analysis/Results and Implications for Policy and/or Research

The challenge of the decentralization process exposes that different models emerged for the design of water utilities at a local level. The autonomous utilities have distributional independency in its administrative and financial management from a governorate to another depends on the degree of understanding and political interferences from the central or governorate levels. The specific measures to encourage utilities and local authorities at the governorate and local levels should be placed for participating in infrastructure financing and management. The proposed approach is to convert some of the successful utilities according to technical, financial and managerial criteria to be public water and sanitation companies and also to be under the supervision of proposed regulatory agency and with the various approaches of Public Private Partnership. These companies set up are different for the big local corporation or small autonomous utilities and its shareholding percentage and management set up is also different according to the local circumstances. The proposed public companies are to enhance the commercialization of water and sanitation utilities and ensure the financial sustainability of these utilities.

Managing Mechanisms for Cost Recovery and Subsidies in Urban Water Supply

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Keywords: subsidies, water policy, cost recovery, water sector reform, urban water supply

Introduction/Problem Identification

Osun State is located in the South West geographical zone of Nigeria, with a population of Osun State of 3,423,535. Osun state Water Corporation (OSWC) is statutorily responsible for water supply to both urban and semi-urban settlements in Osun state. In July 2008, the Bread of Life Development Foundation was contracted by the European Union Water Supply and Sanitation Reform Programme (EU-WSSSRP) Osun State to:

a Review the organisational, financial, commercial and technical structure including PSP assessment of OSWC and make recommendations for improvement as considered appropriate with a view to making its operations more efficient and effective leading to sustainability.
b Recommend and develop restructuring plan for Osun State Water Corporation to improve efficiency and effectiveness of its services delivery for sustainability of its operations.
c Support the Osun State Ministry of Water Resources and Rural Development develop a Water Supply and Sanitation Policy

Analysis/Results and Implications for Policy and/or Research

The findings of the study are as follows:
1 Water rates and charges have not been reviewed for the past 11 years, and this has made the current charges uneconomical and unrealistic particularly for Commercial and Industrial consumers. For instance, under the present charges, Banks are being charged a mere N100 (less than a dollar) per cu. m
2 A deficit of about 80% in operational cost is recorded monthly by the Corporation because of its inability to generate enough revenue to fund its operation and maintenance
3 OSWC depends mostly on government for funding of most of its activities especially capital requirements. Thus its responsibility of extending and developing water schemes is lacking. No new water works is been developed and the old ones are not refurbished in order to increase their outputs as a result of lack of funds.

To address these problems, we recommended the following restructuring measures:
1 The present water tariff of the OSWC is presently considered too low and the management of the Osun State Water Company should after necessary public consultation increase its water tariff by 50% for domestic consumers living in Bungalows, community stand pipes and Government owned primary schools, while it should be increased by 100% for other categories of users
2 OSWC should conduct a Water and Poverty Mapping to determine poor households within Urban and small towns that need to be targeted with subsidies and social connections.

The following measures were also adopted by stakeholders in the water sector in the state to address the problems of over subsidy and over dependence of the Corporation on government subventions. The measures are not incorporated into the Osun State Government draft water and sanitation policy

1 The Osun State Government shall adopt a policy of sustainable cost recovery, rather than full cost recovery, for the financing of its publicly owned water and sanitation agencies, implying that the Osun State Water Corporation, the Osun State Environmental Protection Agency, and the Small Towns Water Supply Agency would aim for revenue sufficient to cover their recurrent costs (operating and maintenance) and they should develop sustainable long-term cost recovery policies, anticipating all future cash flow needs. Sustainable cost recovery includes operating and maintenance cost as well as the cost of renewing existing infrastructure.
2 Funding for capital projects of the public water works and sanitation agencies shall be the sole responsibility of the governments (Federal, State, and Local Govt, in the short term) and in the long term, the public owned water works and sanitation agencies shall fund expansion and new construction through internally generally revenues coupled with financing from the Private sector.

Water supply Tariff policy

a All water connections shall be metered starting with Industrial and commercial consumers to communal outlets down to domestic consumers.
b Tariff policy shall ensure that the time for the return on investment provides adequate comfort for the consumer.
c Tariff policy shall protect the consumer from bearing the additional cost of the inefficiency of the water supply undertaking.
d Tariff should be structured according to the population densities to favour the poor.
e Tariffs of the Publicly owned water service providers in the State shall in the minimum, cover the cost of production (including operation and maintenance)
f Water Tariffs shall be determined by the Osun State Water Regulatory Agency.

Subsidies and free basic water

a The Tariff policy under the Osun State Water and Sanitation Policy shall guarantee cross subsidy to accommodate water supply to meet the basic human needs for the poor.
b Water subsidies when considered necessary, should be affordable to Government that is providing them, targeted to the groups intended to benefit, (designed and) transparently administered with the involvement of the intended beneficiaries.
c Free Basic water
d The following bodies shall be considered for a specific cubic meter of improved water as free basic water, as would be determined through metering by Osun State Water Regulatory body. Any other improved water consumed, above the free basic water shall be appropriately paid for
    i. Orphanages
    ii. Social Homes for the Aged/senior citizens
    iii. Emergency Relief Centres
    iv. Care and Support homes of People living with AIDs, and other vulnerable groups.
    v. Offices of Associations of the physically challenged.
    vi. Privately or publicly owned Kindergartens and Nurseries of pupils Aged 1-12

Sanitation Tariff policy

Tariffs charged by the OSEPA shall in the minimum, cover the cost of production (including operation and maintenance), and shall be determined by the Board of the OSEPA.

Ensuring Affordable Water Tariff for a Pro Poor Water Service Delivery: The Tubigan Sa Pangarap Project

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Keywords: affordable, tariff, pro poor, partnership, agreements

Introduction/Problem Identification

The Streams of Knowledge together with the UNDP-PPPUE has implemented a project in the development of a pro poor model for the improved delivery of water service in urban poor communities within the framework of public-private partnership. Thus, the Tubigan sa Pangarap (Water for Pangarap) Project in Caloocan City. It is an urban poor community within the concession area of Maynilad Water Services, Inc, one of the 2 concessionnaires in Metro Manila. The area has no access to piped water for the last 15 years or so mainly because of land ownership problem in the area. As there is a pending case, there is no way that the concessionaire can provide piped water to them. As a result, the poor urban households in Pangarap of about 7,000 households have to buy water from water vendors, usually truckers at a very high price of US$ 3.3 per cubic meter. With such water price, it means that an average household spends at least US4.4 daily for their water needs.

Analysis/Results and Implications for Policy and/or Research

The Tubigan sa Pangarap Project: A pro-poor model of afforable water tariff for urban poor areas
The Tubigan sa Pangarap (TSP) project is a pilot initiative among Streams of Knowledge, a global coalition of resource centres engaged in capacity development in water, sanitation and hygiene; the Maynilad Water Services, Inc (Maynilad), the water concessionaire for the West Zone, which covers the City of Caloocan; and the 2 barangays, 181 and 182. The barangay is the lowest political unit in the Philippines. These 2 barangays are urban poor communities within Maynilad concession not yet provided with piped water connection due to land ownership problem. As such, in the last 15 years or so, these 2 areas has to buy water from vendors, mainly truckers at exorbitant price. The tripartite partnership among Stream, Maynilad and the 2 barangays was made possible through a Memorandum of Agreement (MOA) between Streams and Maynilad for bulk water supply as well as between Streams and 2 barangays for Streams to provide them with affordable safe water. The first MOA between Streams and the concessionnaire clearly spelled out the terms of engagement such as putting up of 2 bulk water meters at strategic location, bulk water price, the volume to be supplied, the quality of water and take over schemes should the need arises. Under the arrangement, the bulk water price is computed as average consumption of all household connected. A two- month deposit equivalent to the number of connected houses has to be paid by Streams to the concessionaire. Subsequent payment will be based on actual consumption of the community.

The second MOA between Streams and the local government authority (barangays) also provided for clear terms such as the water tariff that the community has to pay, the guarantee fund and connection fee, the collection of payments and the quality of water to be delivered. To enable water to reach the households, Streams has to put up the reticulation system from the 2 bulk meters. It must be noted that in setting the water tariff for the community, a general meeting was called in order to clearly explain how the tariff was arrived at. Part of the water tariff was allocated to the Barangay water, sanitation and hygiene (WASH) funds and donation for barangay development projects. In addition, under this pro poor scheme, income is also being generated by way of the barangay water coordinators who share

with Streams the responsibility of delivering water to customers without individual meters.

In terms of regulatory arrangements, the agreement between Streams and Maynilad is being regulated by the MWSS-RO, the body created to oversee the operations of the water concessionaires. On the other hand, the agreement between Streams and the Barangays is subject to the National Water Regulatory Board (NWRB) regulations. These arrangements are being done to ensure that all the parties concerned are given protection, especially in the area of tariff and tariff increases. This is also to ensure that tariff setting in the pro poor model within the framework of public-private partnership is working to the advantage of the urban poor communities and small water service providers such as in the case of Streams.

Learnings from the Model

Implemented since April, 2008, the Tubigan Sa Pangarap pilot initiative has already resulted in the following:

- Significantly lower the cost of access to water (from the US$ 3.3 per cubic meter, it is now only US$ 1.6)
- Provided some source of livelihood to members of the community by being a water coordinator helping bring water to households not yet connected to the system (as of Dec. 2008, there are 66 water coordinators in the project site)
- Provided WASH funds for the barangay (as of end of 2008 Barangay WASH fund was US$ 3,000)
- Provided a working pro poor model within the framework of public private partnership (as of Dec, 2008, another similar initiative is being worked out)
- Provided a basis for recommending a regulatory framework appropriate for such kind of water service delivery model (Light Handed Regulation is being proposed to help those who will engage in similar projects)

A Sustainable Approach to Financing Rural Water Supply (RWS) Sector Development in Sri Lanka

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Keywords: CWSSP, RWSSP, stakeholders, RWS development, community contribution

Introduction/Problem Identification

Eighty percent of Sri Lanka's total population lives in rural areas. In spite of the efforts of successive governments to provide safe drinking water to the rural sector, 37% of the rural population do not have access to safe drinking water. Service coverage is low in villages and small towns, and it is very low in plantation communities, with almost 70% of estate workers having to haul water from rivers, streams and unprotected springs.

Although respective Governments have recognized the importance of providing safe drinking water to the rural people, expenditure in such areas as defense, health, education and decentralized administration has taken priority, resulting in only scanty investment in RWS development. The RWS sector at present faces two major issues viz:

1 addressing the increasing demand for improved water supply by rural people with limited available funds
2 maximizing RWS coverage, including to marginalized rural poor, by utilizing the limited funds wisely.

Analysis/Results and Implications for Policy and/or Research

The major RWS projects implemented in Sri Lanka over the past decade, the ADB-funded Rural Water Supply and Sanitation Project (RWSSP) and the WB-funded Community Water Supply and Sanitation Project (CWSSP), tested a new approach to financing rural water supplies. The key was to seek contributions from various stakeholders, in a manner that was both flexible and adapted to prevailing social and other conditions. The approach relied basically on the following principles: (i) project contribution is limited; the project provides 80% of capital cost of a water supply project or pre-determined household subsidy, whichever is less. The ceiling on the household subsidy is based on the community's preferred WS technology and associated cost. For example, if the people prefer shallow wells as their water source, the household subsidy is Rs.13,000. In the case of a piped supply, the household subsidy is Rs. 20,000; (ii) project communities are expected to contribute a minimum of 20% of capital costs in kind and cash. All unskilled construction labor is provided by communities even if it results in their contribution exceeding 20% of capital cost. This financial approach ensures the community is provided with at least a minimum acceptable RWS system. However, any community that can afford it may construct a higher service level scheme by increasing household contributions above the ceiling set by the project.

Experience gained over the past decade using this financial arrangement has shown areas where it may be further strengthened. The sector authorities looked at the possibly of other major stakeholders such as Provincial Councils (PC), Local Authorities (LA) and Plantation Companies contributing to RWS development in their areas of jurisdiction. Accordingly, in a subsequent and ongoing decentralized CWSSP the PCs and LAs were requested to contribute 5% each towards the capital cost of RWS

development, while in the Plantation sector, the Plantation Companies were obliged to contribute 15% of capital costs.

However, field realities have demanded there be flexibility in these strict funding arrangements. For example, in some instances the cost of RWS system components, such as water treatment and power supply, are fully project subsidized outside the household cost ceiling. This has been done to ensure the community is provided with safe quality water, or to cater for pressing needs for water due to rapid growth, or if raw water sources are particularly difficult and therefore expensive, to develop. If development potential and population growth in related areas are high the project will consider providing additional funds to meet the consequent higher capital costs. Importantly, this additional funds helps relieve poor people from having to make excess contributions if the overall community decides to construct a piped water supply with treatment beyond just a basic system.

Experience has been that in general the community contribution for RWS development has been more than the minimum 20% of capital cost as most communities have preferred a piped water supply (higher service level) even though they have to bear the additional cash contribution. Under the ADB-funded RWSSP the total community contribution in water supply development in 861 village and 42 small towns was around 26%, representing cash and labour contributions of Rs 230 and 514mil respectively. In ongoing CWSSP the community share of capital costs has significantly increased, the community contribution in both cash and labour has been around Rs1,691mil (35% of total project cost) in 818 village schemes. The project has contributed approximately Rs 2,810mil (58%) while PCs and LAs have contributed Rs 302mil (6%). In the Plantation program, the contributions of stakeholders were: Plantation Companies Rs1.82mil (9.7%), Project-14.2mil (75.5%), LAs-0.9mil (4.8%) and Community unskilled labor-Rs.1.8mil (10%). The differences between the normal rural communities and the estate communities reflect a long-standing problem of poverty and general social deprivation in the plantation sector.

With the introduction of these approaches to rural water supply funding, service coverage has increased impressively, with the projects mentioned providing improved water supply to approximately 2.3mil people, far more than the planned coverage.

Rigorous assessment is required in the RWS sector to identify potential and affordable funding by stakeholders in order to increase coverage with limited available funds. The achievements in Sri Lanka have help address a common problem in the developing world where Governments have little excess funding to invest in RWS development. However, such financial approaches should not undermine the community self reliance and sense of ownership, and must be aligned with stakeholder obligations toward rural communities, in the provision of safe drinking water supply facilities and for their long term sustainability

Community Financing In Rural Water Sector: A Case Study from Uttarakhand, India

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Keywords: Swajal project, sector vision 2012, Sector Wide Approach (SWAp), Uttarakhand sector program, affordability & willingness

Introduction/Problem Identification

Uttarakhand has witnessed a paradigm change in the rural water and sanitation sector in the last decade. Prior to 1996, all the rural water supply schemes were fully financed by the state and central governments. During 1996-2003, the successful implementation of the innovative, community oriented and demand based pilot Swajal Project (Uttarakhand Rural Water Supply and Environmental Sanitation Project) demonstrated for the first time the community financing initiative in the rural water sector. The beneficiary village communities contributed towards the partial Capital Cost recovery and full Operation & Maintenance (O & M) cost recovery.This initiative was subsequently taken up in the Government of India's Swajaldhara program.Uttarakhand has now adopted a Sector Wide Approach (SWAp) in its rural water sector policy. Uttarakhand Rural Water Supply and Sanitation Project (2006-2012) is presently under implementation on the community financing model.

Analysis/Results and Implications for Policy and/or Research

Swajal Project (Uttarakhand Rural Water Supply and Environmental Sanitation Project) was implemented in 857 villages of Uttarakhand from 1996 to 2003. The beneficiary community contributed around 10 percent of the capital cost (broadly 1 percent in cash and 9 percent labour) and full O & M Cost. Against the capital cost of the water supply schemes of Rs 58 crores (US $ 15 million), the communities contributed 10.5 percent (US $ 1.6 million) in cash and labour.The annual Operation and Maintenance (O & M) requirements for these schemes translate to around Rs 4 crores (US $ 0.1 million).It can be concluded that due to full O & M cost recovery by the beneficiary communities, savings of US $ 0.6 million till date (January 2009) have accrued to the state exchequer, a substantial amount for the newly carved state of Uttarakhand. The community financing initiatives in the rural sector has thus yielded rich dividends for the state and vindicates its reforms policy initiative.

The success of Swajal Project and the Government of India's rural water sector policy approach triggered the Government of Uttarakhand to introduce large scale reforms in its rural water and sanitation sector, on the principles of community management. The Sector Vision 2012 reflects the commitment of Government of Uttarakhand in replicating reforms and empowering the rural communities as the rural local government in partnership with rural communities, shall plan, design, construct, operate, and maintain their water supply and sanitation schemes; so that they get potable water and attain health and hygiene benefits; GoUA and its sector institutions shall act as supporter, facilitator, and co-financier and as per need shall provide technical assistance, training and cater for bigger construction works and sectoral contingencies."

The Sector Vision realization efforts led the state government to embark on Sector Wide Approach (SWAp) for the rural water sector. SWAp essentially means a state investment program utilizing uniform policy framework, uniform operating procedures and fund flows to achieve the Vision goals. As a result, the Uttarakhand Rural Water Supply and Sanitation Project also called the Uttarakhand

Sector Program (2006-12) has been formulated with the financial support of the funding agencies namely The World Bank, Government of India, State Government besides the contribution from the beneficiary communities. The US $224 million project envisages covering about 8000 habitations and constructing around 3500 schemes.

As a part of the preparation process of the Uttarakhand Sector Program, a study was carried out to assess the affordability and willingness to pay by the rural households for water supply schemes. The survey data was collected from 2500 representative households. The affordability norm was the water related expenditures incurred by the bottom 30 percent of the households while the contingent evaluation method was used in the survey to elicit households' willingness to pay for the improved services. The results of the analysis indicated that the households would be able and willing to contribute about Rs 600 (US $ 12) on current dollar Rupee conversion rates towards capital cost of schemes and about Rs 55 (US $ 1) per month for the operation and maintenance (O&M) of a private connection and Rs 10 (US $ 0.2) for standpost.

Financing Principles in Uttarakhand Sector Program: The beneficiary communities shall bear 10 percent of the cost of all new investments, which should not exceed the affordable ceiling as defined by the affordability analysis mentioned. The balance funds shall be provided by the funding agencies through pooled funding mechanism.O&M cost for new investments have to be fully recovered from user charges within the affordability ceilings mentioned.

For Single Village Schemes, the community contribution toward capital cost shall be 10 percent of the capital cost against the service level of 40 litres per capita per day (lpcd), subject to a maximum of Rs 600 (US $ 12) for private connections and Rs 300 (US $ 6) for standposts. This contribution may be 2 percent cash and remaining in the form of cash or labour, as decided by the user communities.

The user water charges in all the single village schemes shall be a maximum of Rs 10 (US $ 0.2) per household per month for standpost/ handpump and Rs 55 (US $ 1) per household per month for private connections.

For high cost Multi Village Schemes, the O&M requirements in excess of the affordable level by the communities shall be provided by the state government.

Based on the above norms, the capital community contribution comes out to US $ 5 million against the total capital cost of water supply schemes approximating US $ 150 million while the O&M costs will be estimated as per the norms mentioned. About 150 schemes have been completed and 500 schemes are in varying stages of construction. Uttarakhand is all geared up to make this model a success.

Subsidized Subscription to Public Drinking Water: A Tool for Sustainable Access to Safe Drinking Water for Poor Households in Urban Centers

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Keywords: subsidized access to water, poor settlements, payment of invoices, low-income, sustainable access

Introduction/Problem Identification

The cover rate as regards urban water is 87%. However, the rate of subscribers is still low at around 1 per 100 inhabitants, especially in the poor settlements. This situation is mainly due to the financial inaccessibility linked to the low-income of households which is average of 60,000 FCFA per month while the cost of subscriptions amounted to 169,000 FCFA. These people have recourse to dealers whose water quality is deteriorating in the supply, transport and storage. In addition, the cost of the acquired water in this way varies between 750 and 1,000 FCFA per quarter instead of 238 FCFA per cubic meter if they had direct access to public drinking water supply. The project aims to show that the poor can also have sustainable access to public drinking water supply provided that they are using. Hence, the need for subsidy that will remove the financial barrier.

Analysis/Results and Implications for Policy and/or Research

Thus, 2,000 households were subscribed from September 2006 to September 2007. The point of follow-up carried out in 2008 shows a rate of cancelled of 5%. On average, the households pay 3,300 FCFA per quarter instead of 10,500 to 14,000 FCFA.

Sustainable Solution for Safe Drinking Water in Saline Affected Costal Zone through Community Based Integrated Water Resource Management

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Keywords: scarcity (safe drinking water), community led management, integrated pond management, entrepreneurship with PSF, sustainability

Introduction/Problem Identification

Satkhira is one of the southwest coastal districts in Bangladesh. Lack of safe drinking water is an increasing problem in the area, with potable water becoming a scarcity. Previous sources, surface & groundwater are being contaminated by either saline water used for shrimp farming, by bacteria as a result of unhygienic practices or by both. People are being forced to drink which are unpalatable & unsafe or they have to travel several kilometers to collect. As a result diarrheal diseases are common, & a main cause of infant mortality.

The main water facilities are Pond Sand Filter (PSF) or Tube wells (TW), but most of TWs are becoming saline. There are some reverse osmosis system / solar distillation have been explored but due to highly expensive, low flow rates etc have been believed unacceptable for use. As experienced, in many cases, main option PSFs become out of order due to pond water contamination for intensive fish culture and lack of proper operation & maintenance.

Analysis/Results and Implications for Policy and/or Research

In many areas of Satkhira, the presence of saline and arsenic in TWs sourced from the shallow aquifer, means that villagers have chosen to use surface water/pond water as a source for drinking water. Shushilan and WaterAid Bangladesh (WAB) have identified effective pond & PSF management in line with community based integrated water resource management as one possible method in addressing the need for safe drinking water.

At the initial stage, we faced a big challenge as these ponds were commonly used by the villagers for farming fish. The fish-feed used to supplement the food source of the fish and increase growth is nutrient rich and severely risks pond contamination. As the villagers are marginalized in terms of economic and social status, and ponds are a valuable resource, it is not acceptable to preserve any pond for the sole purpose of drinking water.

To overcome the challenge, we discussed the concept of community based integrated water resource management with the community & pond owner several times, and the community became inspired to implement the concept. The community peoples organized and formed pond & PSF management committee. The committee harnessed the responsibilities spontaneously as they understood the need for safe water as well as the reasons behind poor operation & maintenance of PSFs.

The practice of natural fish cultivation in the pond has been started. No additional food supplement was supplied, except naturally growing phytoplankton & Zooplankton available in the ponds. Mostly, fishes are indigenous species which are popular and sold at a higher price on the local markets where the production cost was minimal. To improve the quality of water, some other factors have been ad-

dressed by removing leafy trees & bushes from the pond's edge and planted varieties which are less shady, drop fewer leaves & seasonal vegetables and have a higher economic value. To ensure pond water is microbially safe for drinking and cooking, Pond Sand Filters (PSFs) have been installed and re-excavated the pond with a cost sharing from the community which varies depending on ability to pay of HHs. In order to monitor the effectiveness, periodic water quality testing has been carried out to confirm improvements.

Prior to pond re-excavation & construction of PSF, an agreement was signed between pond owner and PSF management Committee. The agreement sets out the terms for pond owner and management Committee regarding access rights, use of pond & surrounding, and overall management of pond & PSF.

Once the agreement was made and PSF was constructed, an entrepreneur (caretaker) was selected by the management committee. Another agreement between caretaker and management committee was made detailing the roles & responsibilities, employment conditions and salary. The management committee may re-select or extend the agreement based on performance.

To enhance the capacity of entrepreneur, committee members and users community, a number of training have been provided on community based integrated water resource management, leadership development, PSF operation & maintenance (O&M), book keeping and overall management of PSF. An O&M pocket book and tools kit support the entrepreneur in conducting the necessary works.

The water tariff varies from Tk0 to Tk10 per month depending on the income of the users households and their ability to pay, and is agreed in consultation with management committee. This ensures that even the hardcore poor households have access to safe water. The entrepreneur collects water tariffs every month, records them in the register book and gets signature of each household. The collected amount is handed over to management committee every month. Out of the collected tariff, Tk 1000 is used by the entrepreneur for his monthly salary, the remaining amount has saved in a bank account by the management committee for future maintenance requirements.

The PSF is currently providing water for drinking & cooking to 846 people from 186 households. The majority of which live in the near by community. People also travel up to 3 km to come to the PSF, on foot, by bicycle and flat bed rickshaw van. The entrepreneur gets some extra income through charging by the load for external demand and by delivery of water to wealthy households, elderly and disabled persons within the close vicinity.

Finally, we have achieved the following successes by implementing the concept which has already been recognized as a best practice:

- A sustainable mechanism has developed to ensure safe drinking water in the community
- Well maintained pond & PSF with a growing fund for future use
- Increased income from pond & its vicinity
- HHs' medical expenditure has reduced as eliminated water borne diseases
- Students' attendance has increased significantly
- Remarkable changes has made in lives & livelihood of community peoples specially entrepreneur's livelihood

Cross-subsidization of Water Services in Zambia: Policy, Practice and Lessons

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Keywords: cross-subsidy, Zambia, water, water tariff, policy

Introduction/Problem Identification

Provision of water services is an essential component of public services. In many developing countries, there are large sections of the population that have difficulties paying for clean water services. The customers' failure to pay for water creates a double dilemma: on one hand, the customer's failure to pay for water compromises the water utilities' ability to provide and improve the quality of water services, while on the other hand, the water utilities' inability to provide clean water results in people accessing water from unsafe sources. This calls for an innovative way to ensure that the cost recovery, sustainability and improved quality of services objectives, on the one hand, are balanced with the objectives of equitable access (social equity) and environmental sustainability on the other. This paper presents the findings of a study on the subsidy policy in Zambia.

Analysis/Results and Implications for Policy and/or Research

In Zambia, a cross-subsidization policy was formulated to achieve the objectives of financial sustainability of water utility companies and social equity. Essentially, since the government was unable to provide direct subsidy, the cross-subsidization policy was meant to ensure that the cost of water among poor households is partly subsidized from the water consumption of richer households. This was supposed to be achieved through a differential tariff system, specifically, the rising block tariff. The focus of the paper is to present the outcome and lessons learnt from the Zambian cross-subsidy policy case study. It examines the differential tariff schedule used as a subsidy mechanism to ensure that poorer households have affordable access to water.

One of the key lessons of the study presented in this paper is that a well-intended policy to improve access to clean water among poor households has had opposite outcomes where poor households have ended up subsidizing water consumption of richer households. It is the richer households that capture the benefits of a water subsidy while poor households continue to shoulder the unmitigated burden of accessing clean water. The paper highlights some of key reasons why the subsidy policy in Zambia has failed to produce the intended results. Views from members of poor households are also included.

An important contribution that the paper makes is to highlight the fact that the challenges of providing clean water to today require creative ways of ensuring that the inherent conflicting interest are negotiated properly among all stakeholders. It is not just the poor failing to pay for water, nor the state failing to regulate other actors effectively, nor the utility companies' prime interest in profit. Rather the challenge is about how to reconcile these interests in ways that secure access to clean water for everyone. It is argued in this paper that, in order to adequately rise to the challenge, the state through collaboration with other actors has an important role to play in not just formulating policy, but most importantly, in ensuring that various conflicting interests are negotiated effectively. What the Zambian case demonstrates is that even in cases where water services are provided by private service providers, the state has a crucial role to ensure that policies and regulations are implemented and that a conducive environment which promote equitable access to and sustainable use of water is

created. Lessons learnt from this study can be used to explore innovative ways in which the inherent conflicting interests in water can be bargained.

The Debate on Subsidies in Sanitation Programmes

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Keywords: sanitation, subsidy, sanitation finance, sanitation policy, policy objectives

Introduction/Problem Identification

More than 2 billion people still need access to basic sanitation and knowledge of hygienic behaviours. Given that most of those are extremely poor, and given the public-health benefits of universal access to sanitation, public subsidies to increase access seem an obvious policy response. However, many commentators have suggested that public subsidies have failed to significantly increase access and may indeed have stifled service provision. Others suggest that there are insufficient public funds to address the global sanitation crisis so discussion of subsidies is little more than a distraction. The argument is often heated but rarely draws on empirical evidence.

Analysis/Results and Implications for Policy and/or Research

One major problem is that the roles and objectives of subsidies are rarely defined clearly and explicitly. Policy makers need to be clear on why they are injecting public funds and what they hope to achieve. Objectives may include: better health, increased productivity and a cleaner environment, all to be achieved sustainably, through to political and social objectives such as equity between different communities, empowering people to help themselves and plain old vote buying. A second problem is the often blurred lines between public goods and private goods, and between public infrastructure and private facilities.

The debate needs to be informed by an understanding of the different elements of sanitation services and improvement programmes and the scope for different types of funding. Examples of funding types and their use are: household funds for household facilities and running costs, public funds for "software" components, shared or community infrastructure and a range of subsidies, and private sector finance for privatised sanitation services or as loans for public infrastructure. The mix of sources of finance will vary according to settlement type and technologies used or promoted, and the approaches adopted on subsidies and cost recovery for investments and running costs.

An emphasis on the public good aspect of sanitation has led to the widespread use of public funds to build and operate sewerage schemes. In some communities large investments are made with borrowed funds and debt servicing is recovered from the sewerage tariff or a surcharge on water tariffs. In others, especially in developing countries, investments are covered solely from public funds and thus represent a largely inequitable subsidy to the fortunate few connected to the system. This gives rise to pressure to subsidise other forms of sanitation on equity grounds, but a direct hardware subsidy for household facilities can also generate unintended consequences (see below). Other subsidies are indirect eg by supporting the running costs of utility operations in order to reduce or remove the need for cost recovery from users. Unfortunately, in developing countries such subsidy transfers are notoriously unreliable and, unless accompanied by performance targets, they can reward and prolong operational inefficiency.

In addition to clarity on the objectives of a proposed subsidy, before implementing it is important to investigate what kind of unintended consequences might result. Examples of such consequences include:

an emphasis on toilet construction without accompanying hygiene promotion – leading to limited health benefits; heavily subsidised toilet construction – unused toilets, low health benefits and passive attitudes of beneficiaries; once-off prizes for total coverage – unsustained behaviour change and low health benefits; sub-economic sewerage tariffs – poor maintenance and environmental degradation; and many more such as heavy subsidies until the budget ran out, leaving many without similar assistance. These have all been borne out by experience in well-intentioned programmes in many countries. Successful outcomes of a carefully managed subsidy regime may include: confining support to the very poorest while encouraging all others to invest from their own resources; charging city dwellers a more cost-reflective tariff with rebates for the very poor; remedial works to improve the public/ shared components of a sanitation system; confining support to the software aspects eg demand promotion, awareness of hygiene practices, once-off support to improve supply chains etc.

In conclusion: sanitation services and sanitation improvement programmes have significant private benefits and considerable public benefits. The use of subsidies on various components of the funding structure may be justified in some instances but they must be planned carefully, with clarity on which objectives are most important, and with due regard to the likely consequences. Any proposal to use subsidies should be located within a larger funding and subsidy strategy that links budgets to objectives and projected outcomes, while consciously addressing equity issues and ensuring the minimum of unintended consequences. Budgets for subsidies must be sufficient to meet the demand on a sustainable basis so as to meet the entire need. In the case of direct subsidies to households for private facilities it may be best to delay their introduction for several years while assessing whether they are really needed and what form they might take. In summary: if in doubt, do not start with subsidies, but do not rule out the possibility that something might be needed several years later as a result of experience gained.

Micro-credit for Supporting Water Supply Service for the Peri-urban Poor Populations: Experience and Lessons Learnt in Burkina Faso

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Keywords: microcredit, water supply, urban poor, capacity, building

Introduction/Problem Identification

The drinking water coverage in urban areas in Burkina Faso was 66% in 2006 according to the 2008 report of the joint monitoring program of the millennium development goals. The water service is delivered by the National Water and Sanitation Agency (ONEA), and small operators (water vendors). In the peri-urban areas and the informal settlements, the households are served exclusively by water vendors and boreholes equipped with hand pumps. The water tariff is 1-2 euros a cubic meter with the water vendors while it is 0.50 Euro for the national water company. Since 2000, ONEA invested a lot in extending the water pipe to cover some peri-urban areas but the low income households cannot afford the connexion fees (100 US dollars). In this context and in the framework of the national programme for achieving the millennium development goals for water and sanitation, implementing an alternative financial mechanism for the poor is a key factor of success.

Analysis/Results and Implications for Policy and/or Research

In this article we describe and analyze how CREPA (Research Centre for Water and Sanitation at low cost) in collaboration with the municipalities and other partners implemented a micro-credit mechanism in Burkina Faso. The research-development started with a pilot project in Bobo-Dioulasso, an urban commune of 400.000 inhabitants located in the west part of Burkina Faso. The main goal of the micro-credit is to build the financial capacity of the poor households for connecting to water pipe. A local micro-credit committee was set up to manage the credit activities: raising demand, selecting households according to credit access criteria, recovering credit to help fund-revolving, advising households on family water consumption and hygiene. The interest rate was 7% with 5% for financial fees and 2% to motivate the members of the local credit committee. The recovering delay is ten months. After two years of implementation (2006-2007), the evaluation reveals that 32% of the potential households (245) demands for the credit, and 39% of them have been connected to the water pipe trough the credit received. The local committee recovered 40% of the credit from the beneficiaries. No beneficiary has been disconnected from the water pipe because of difficulties to pay the water bill. The main problems faced are: (i) the dispersion of demand in the project area didn't favour the national water company to extend the pipes and connect the interested households, (ii) after 10 months the local committee was not anymore motivated to manage the credit because of time consumption and they are not paid for that, (iii) the repayment of the credit is low due to lack of adequate marketing activities and will impact the revolving system and the sustainability of the fund, (iv) the repayment conditions are not adapted to the target populations which are involved in informal economy and have no monthly revenue.

Based on this experience, CREPA and his partners decided to upscale the project in Bobo-Dioulasso and replicate the system in two cities. In the case of Bobo-Dioulasso, the micro-credit will be extended to the whole city and for sanitation facilities (latrines, solid waste). For that, a local NGO

will be involved for the social marketing and the recovering operations. A database associated with a GIS has been developed to reinforce the monitoring system. For the two other cities, a microfinance institution is involved for funding and recovering the credit. In all cases, the collaboration between municipal authorities, microfinance institutions, local communities and the water supply company is the key success factor. A collaborative agreement has been signed between the municipal authorities, the national water and sanitation agency, the microfinance institution or the local NGO and CREPA. This agreement defines the role and responsibility of each partner.

For up scaling and replicating the micro-credit mechanism for water supply, the strategy should be well designed with all stakeholders in the beginning for more sustainability of the revolving fund. Involving a microfinance institution and a long repayment period are required to sustain such a financial alternative mechanism for water in poor areas.

An Analysis of the Implications of Water Pricing and Subsidy Policies on the Viability of Small Municipalities in South Africa

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Keywords: cost recovery, municipality, South Africa, subsidies, tariff

Introduction/Problem Identification

This paper analyses the implications of water pricing policies on the viability of small Municipalities in South Africa. A significant number of Municipalities in South Africa are failing to pay for bulk water services that are rendered by Water Boards due to poor cost recovery for water and sewerage services. This is evidenced by cases reported to the Department of Water Affairs and Forestry (DWAF), The Department of Provincial and Local Government (DPLG) and The National Treasury whereby Water Boards request regulatory intervention and assistance in the recovery of outstanding debt. As of March 2008 Municipalities owed Water Boards a whooping R866 million. In order to maintain the water and sewerage systems, Municipalities are forced to divert funds intended for other basic services such as health and education or the water system is persistently under-funded and services progressively degrade.

Analysis/Results and Implications for Policy and/or Research

The failure by Municipalities to pay Water Boards is mainly due to weaknesses and gaps in South Africa's water pricing and subsidy policies as well as pressure from political and residents associations. Water is enshrined in the national constitution as a basic human right, not an economic good, making efficient pricing of water and enforcing payment a huge constitutional challenge. Furthermore, the country's trade unions and residents' associations have demonstrated against water price increases making it difficult for Municipalities to set efficient tariffs. The situation for Municipalities is further compounded by the fact that they are compelled to supply 6000 litres per household per month of free portable water to low-income and poor households in line with the national policy of Free Basic Water adopted by the DWAF in 2000. Yet the subsidy provided by the government through the Equity Share Grant (ESG) is not enough to cover costs incurred by Municipalities.

The study also identifies gaps with South Africa's Water Pricing Strategy which applies to raw water and the Water Services Act that deals with treated water distributed to households. Furthermore, there are no clear guidelines to guide Municipalities on how to achieve the seemingly contradictory national policy objectives of Equity and Efficiency when it comes to setting prices for water. Lack of a clear business model at the Municipal level further complicates cost recovery for water supply and sewerage systems.

Balancing national policy objectives of efficiency (cost recovery) and equity (basic needs) has been a major challenge for water managers and policy makers for decades. This study adopts a two pronged approach that applies, on one hand, cost accounting to establish the actual cost of delivering a unit of water to the customer and on the other hand, contingent valuation methods to elicit the willingness of households and other customers to pay for water. The gap between household willingness to pay and actual cost of water is used to enhance government equity share grant and cross subsidy policies. This information, together with access to external finance is then used to develop a business model for small municipalities in South Africa.

WaterCredit: Turning Water Subsidies "Right-side up"

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Keywords: water, subsidies, credit, finance, India

Introduction/Problem Identification

Subsidies in the water sector targeting water consumption have historically been "upside down", disproportionately benefiting the wealthy who can afford a utility's connection fees. Financial mechanisms that allow poor households to secure legal access to water connections can potentially reverse this trend. They can also benefit local utilities by providing an increased customer-base – increasing system efficiency by supporting proper infrastructure maintenance. However, access to micro-credit for water connections for the poor has not been typically available as micro-credit institutions have favored more traditional income-generating activities.

Analysis/Results and Implications for Policy and/or Research

As part of its WaterCredit Initiative, WaterPartners, a U.S.-based non-governmental organization (NGO), has piloted multiple credit for water programs globally to increase access to water connections and sanitation for the poor. This research will focus on a case study of WaterPartners' credit-based work in Southern India. In this initiative, working with its local partner organizations through a network of women's Self Help Groups (SHGs), WaterPartners has provided approximately $179,000 in loans to households for over 1,400 household water connections over the past five years. Repayments rates have averaged 83% over the life of the initiative, with repayment rates above 98% in the most recent years of the program.

Notably, of the $179,000 in loan capital, approximately $80,000 was secured from local commercial financial institutions. While financial institutions have not historically been willing to lend for water connections for the poor, WaterPartners' provision of "smart subsidies" to its partners – in the form of grants to support credit program administration development costs, investment in social capital, and demand creation activities – catalyzed the creation of this viable credit market. This paper will further explore the viability of credit-based work to turn water subsidies "right-side up" and the potential for "smart subsidies" to catalyze a market for such credit-based work in the water sector.

Financial Assistance to Resource Poor Irrigation Farmers: South African Experiences with Community Participation and Stakeholder Engagement Processes

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Keywords: water infrastructure funding, water subsidy, resource poor farmers, rainwater harvesting, food security

Introduction/Problem Identification

The South African Government through its National Department of Water Affairs and Forestry (DWAF) in its efforts to ensure equitable access to water and water related infrastructure, developed and is implementing financial support to resource poor farmers to harmonize Agrarian Reform. This is a pro-poor policy that enables active provision of water and necessary support for productive water uses by the poor to deal with high levels of poverty, unemployment and infrastructure backlogs in a very direct, tangible and immediate way.

The paper outlines relevant South African legislation and policy that forms the foundation for this financial mechanism, and highlights products funded and approach of targeting the poorest of the poor. This approach focuses on implementing projects from household basis to emerging commercial scale and by collaborating with relevant and interested stakeholders, to ensure sustainability of farming practices.

Analysis/Results and Implications for Policy and/or Research

The process followed in terms of beneficiary selection and the eventual outcomes which shows that because of socio-cultural dynamics, not always the poorest of the poor benefited from the projects is sketched. The paper cites constraints experienced at the different implementation levels, highlights lessons learned and gives recommendations for future implementation.

Additionally, the paper gives an overview of training conducted with beneficiaries to ensure that investment made in providing water resources for food security yield positive results. Together with data from field visits conducted on various implementation sites, the paper evaluates the use of some funded infrastructure like rainwater harvesting tanks to date; whether or not rainwater harvesting is used as multiple water use systems including food gardening, and if so, what the factors for success were. It also examines the reasons why some funded infrastructure is not used for their intended purposes and offers recommendations to increase their usage for achieving the South African Government's commitment on Millennium Development Goals.

Nirmal Gram Puraskar (Open Defecation Free Award), Total Sanitation Campaign – Its Impact and Sustainability

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Keywords: subsidy, sustainability, sanitation, slippage, ODF

Introduction/Problem Identification

TSC is a people centered, participatory and demand driven approach, which is being implemented in a campaign mode, taking district as a unit. This new paradigm is a shift from allocation based and supply driven program to a demand driven programme; from a top down to participatory approach; from a high to low subsidy regime and it tries to generate a campaign in the entire district to highlight issues related to sanitation by involving all stakeholders. This paper will discuss strengths and weaknesses in existing subsidies for constructing latrines The emphasis will be on ways (how, where and when) to reduce perverse incentives.

Analysis/Results and Implications for Policy and/or Research

TSC is implemented in a campaign mode, where district is taken as a unit so that 100 percent saturation in terms of households, anganwadi and school toilets can be achieved.Recognizing the role of PRIs(Local body) and to motivate them for promoting rural sanitation on mass scale, an incentive scheme called Nirmal Gram Puraskar (NGP is open defecation free award) had been initiated under TSC on 2nd October 2003. The whole concept of NGP is to reward those districts, blocks, and GPs, which have achieved full sanitation coverage.

Sustainability of NGP villages is a big challenge. A TARU survey in 2008 reveals that out 162 studied NGP villages in India, only 6 NGPs are maintaining the open defecation-free status.

Nevertheless, it is crucial that sanitation systems are evaluated carefully with regard to all dimensions of sustainability. Since there is no one for all sanitation solutions which fulfill the sustainability criteria under different circumstances to the same extent, this system evaluation will depend on the local framework and has to take into consideration existing environmental,technical,socio-cultural and economic conditions.

Process Adopted for TSC Implementation:

1 Conducted Baseline Survey, set the targets
2 Project Approval for Individual Districts by Central Government
3 Formation & capacity building of District level teams – TSC Cells
4 Launching of IEC Campaigns – campaign continuity maintained
5 Identification of key players at all levels – recurring exercise
6 Organization of Capacity Building Programs
7 Construction of toilets
8 Application for National & State level Awards
9 Assessment through rigorous evaluations

10 Awards and Recognition; identified as model villages
11 Scaled up in rest of the villages
12 Quality Assurance – ensure sustainability

Strategy devised:

1 Decentralized implementation plementation at Local Governance level
2 Model Villages under both the schemes are recognized as resource centers.
3 Other villages sensitized through IEC and Exposure Visit to these.
4 Frequent visits to model villages to upgrade the motivational level of other villages & efforts to sustain the change
5 Involvement of all stakeholders involved at the village level

Electricity Subsidies and Reforms and Its Impact on Groundwater Use in States of Gujarat and West Bengal, India

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Keywords: groundwater, electricity, reforms, subsidies, Gujarat, West Bengal

Introduction/Problem Identification

Managing externalities of groundwater use in order to minimize the negative impacts of over-exploitation while preserving the benefits derived from such use has emerged as the key natural resources management (NRM) challenge in South Asia. Direct regulation of groundwater is not a feasible option in the region given the large number of pumps (over 20 million or so) and the huge transactions costs involved. However, the urgency of the problem is such that groundwater can no longer remain un governed. In this context, indirect mechanism, such as regulation of electricity supply and changes in electricity pricing and subsidies can provide an effective handle for governing groundwater. Indeed, prompted by dire financial straits, most state electricity boards (SEBs) have embarked upon electricity reforms. These reforms have profound influence on groundwater use. This paper will document the impact of electricity reforms and pricing on groundwater.

Analysis/Results and Implications for Policy and/or Research

Indian policy discourse on the most suitable mode of agricultural electricity tariff has come full circle. Until the early 1970s, all state electricity boards (SEBs) charged their tubewell owners based on metered consumption and this was later changed to flat tariff. However, over time flat tariff rates became downwardly sticky and the SEBs started making huge losses. Low flat tariffs also led to over-exploitation of groundwater in arid and semi-arid states of India. Therefore, recently, there is a renewed interest in reforming the electricity sector. States of Gujarat and West Bengal have adopted different approaches to electricity reforms. Gujarat has separated electricity supply to agriculture from those of domestic and industrial feeders and started rationing electricity supply to agriculture. West Bengal opted the path of metering of agricultural tubewells. Both these initiatives had profound impact on groundwater. This paper analyses the impact of electricity sector reforms and pricing policies on groundwater use.

As a part of the ongoing power sectors reforms in India, the state of West Bengal is in the process of metering agricultural electricity supply. This state has a thriving informal groundwater market. Results suggest that the majority of the pump owners benefit from the reforms in two ways: first by having to pay a lower electricity bill for same usage and second through increased profit margins by selling water. This is because in response to changed incentive structure, water prices rose sharply by 30-50% immediately after metering. In contrast, water buyers have lost out by having to pay higher water charges and face adverse terms of contract. Impact of metering on operation of groundwater markets and volume of groundwater extracted is less clear; they may expand, contract or remain unchanged, though water use efficiency is likely to go up. At current tariff rates, the electricity utilities are likely to earn less revenue than before. These findings are context specific and holds good for West Bengal where high flat tariff had fostered competitive groundwater markets and hence cannot be generalised for other Indian states.

In September 2003, the Government of Gujarat pioneered a bold scheme—the Jyotirgram Yojana—to separate agricultural feeders from non-agricultural ones. By 2006, Gujarat covered almost all its 18000

villages under the Jyotirgram Yojana. With this, two major changes have occurred: [a] villages get 24 hour three-phase power supply for domestic uses, in schools, hospitals, village industries, all subject to metered tariff; [b] tubewell owners get 8 hours/day of three phase power but of full voltage and on a pre-announced schedule. Jyotirgram has radically improved the quality of village life, spurred non-farm economic enterprises, halved power subsidy to agriculture and reduced groundwater draft. It has also offered a mixed bag to medium and large farmers but hit marginal farmers and the landless. These depend for their access to irrigation on water markets which have shrunk post-Jyotirgram; and water prices charged by tubewell owners have soared 30-50 percent. This paper offers an assessment of the impacts of Jyotirgram and argues that with some refinements, it presents a model that other states can follow with profit.

Subsidies from Public Budgets: A Need and a Risk for Water Services

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There are both advantages and disadvantages in using subsidies from public budgets as part of the revenue of water services. In an idealised and theoretical world subsidies might not exist. However, to face the practical and political challenges of providing water and sanitation, properly constructed subsidies have a key role to play. Using them properly and avoiding the pitfalls is a major challenge.

Subsidies are common

Water-users and public budgets are the two main sources of funds that finance the cost of public water services. The more the users contribute to covering the costs the easier it is to ensure the financial sustainability of water utilities. However, even in developed countries cases of full cost-recovery are rare. It is very common that public budgets contribute. They do it through different ways such as direct subsidies, investment in new infrastructure financed by the State and not by the utility, tax exemptions, soft lending, etc. The OECD report Managing Water for All (March 2009) explains that the ultimate sources of funds (the 3 Ts) are (T1) the water-users (through Tariffs) and (T2) subsidies coming from public budgets (Taxes) or (T3) from external subsidies (external Transfers such as international aid grants).

Sustainable cost-recovery

Combining user payments with public subsidies deserves careful attention if it is to work satisfactorily. In 2003 the "Financing Water for All" report of the "Camdessus Panel" recommended to combine them in a way that secures "Sustainable Cost-Recovery" by ensuring the affordability of user payments and the predictability of budget subsidies. This predictability is essential to allow the utility to anticipate revenue streams and develop a sound investment program. It requires that the amounts to be allocated to the utility are known several years in advance, which is not the case in many locations. This concept of Sustainable Cost-Recovery was further developed by the "Gurria panel" (2006), the Hashimoto Action Plan (UNSGAB 2006) and quite recently (March 2009) in the OECD report on "Managing Water for All (March 2009)"

Ensuring no harm subsidies

If public budgets subsidies are often used to partially fund public water services, this must be done with caution. Indeed, subsidies that are designed to facilitate water services may result in the opposite if not managed carefully. For example, if subsidies are too important in the total revenue, the tariffs may be insufficient to avoid water wastage. If subsidies are grants that are allocated without any financial constraint, they will cause the other types of funds to dry up and potentially result in a decreased investment capacity. This risk may be faced by economic recovery policies when stimulus packages provide grants without any co-financing. If subsidies fund new infrastructure without making sure that the water utility is able to finance its operation and maintenance this infrastructure will fall quickly into disrepair.

If designed appropriately, subsidies can compliment user payments in a way that allows the water utility to finance its operation, maintenance and investment costs in a sustainable way.

The Remission of Water Fees – Is It Good Solution for Financing in Irrigation Sector?

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Keywords: water fees, irrigation, financing, maintenance, operation

Introduction/Problem Identification

The paper concerns the implementation of new water fees policy relating to irrigation financing in Vietnam. In accordance with new policy, the remission of water fees has been applied for farmer households in agriculture, forestry, fishing and salt sectors. It means; since 2008 the farmers using water from hydraulic works don't have to pay water service fees for state-owned Irrigation and Drainage Management Companies (IDMCs), except small fees for on-farm irrigation services. In other words, all expenditures for Operation and Maintenance (O&M) in hydraulic works have been subsidized from Government budgets.

Analysis/Results and Implications for Policy and/or Research

Currently, 110 state owned provincial-level IDMCs together with more than 13,000 local Water User Organizations (WUOs) have managed 91% of existing systems serving 80% of total irrigated area, apart from 1,500 WUOs that managed the remaining 9% independent small-scale systems. In principle, IDMCs have general functions in water provision, collection of water fees and maintenance of irrigation facilities, were expected to be financial autonomous and self-financing enterprises. However, IDMCs are not autonomous and transparent as required in reality because their operation and maintenance activities have still followed central planning on yearly financial allocation; the output of service (water fees) has been determined and controlled by the GoV policies while IDMCs operate under market machanism. In the past, major part of IDMCs' income (average 70%) is derived from water service fees. However these incomes failed to cover all O&M expenses because water fees collected make up about 50% of required expenses, then top up by 10-20% from GoV subsidies. The existing challenges are; IDMCs are operated in low effectiveness, hydraulic works continue to deteriorate due to lack of proper operation and maintenance. The key questions for the assessment in the paper are: How do IDMCs deal with the organizational reform when applying new water fees policy? New situation seems create the mechanism "beg-give" ("xin-cho") between IDMCs and WUOs/farmers, and between IDMCs and financial allocation organizations. It would distort consumer-oriented relationship between service suppliers and consumers, and/or create unhealthy behaviour, untranspenrancy financial allocation. The paper also concerns the perceptions and incentives from IDMCs, WUOs and farmers in irrigation management in this situation.

Financing of Water Projects: Institutional Reforms and Cost Recovery Issues in India

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Keywords: water financing, cost recovery, institutional reforms, public finance of irrigation, water use efficiency

Introduction/Problem Identification

The paper outlines important issues involved in the financing of water control projects in India such as costs of irrigation projects, trends in them, role of the State and private investment, extent of recovery from government projects, their impact on operation and management of projects, institutional reforms required for better financial management of water control project.

Analysis/Results and Implications for Policy and/or Research

There have been huge investments by the State since independence, on major and medium projects in India. These investments have been made as a part of planned development by the State. Not only investments in absolute prices but also in constant prices have increased.A study by the author has shown that the real cost per hectare in most of the Indian states is on the increase to a statistically significant level.The reason was that more number of projects were taken up with out considering financial availability which resulted in time and cost overruns. Not only substantial investments on irrigation made by the public sector but also by private. Investments were made by farmers on ground water irrigation especially after `green revolution' in India. A study by the author shows that the private investments are substantial but a significant part of it became redundant due to failure of wells because of unregulated ground water irrigation. Though huge investments are made by the government, the recovery from the users is very less in almost all states in India. It is seen that the recovery is hardly enough to meet even the operation and maintenance (O & M) costs of projects, leave alone the capital costs. It is estimated that for the country as whole the cost recovered by way of user charges is about 34 percent of O & M cost (working expenses). When we consider the total costs (including depreciation and interest on capital) the recovery rate is 10 percent only. The main reason is that in most of Indian states, the water charges are low for irrigation and almost free. It is about Rs.50 (0ne USD)per hectare of irrigated land. It is to be noted that water charges are levied on the basis of land cultivated but not on actual volume of water supplied. It is seen that O & M cost per hectare is about Rs.200-250 in many Indian states. Hence recovery rate per hectare of irrigated land is in the range of about 20-25 percent of O & M cost. Moreover the financial allocation by the government for meeting the O&M cost itself is inadequate in many states compared to the required level. It is estimated that the allocation is deficient to the extent of about 50 percent of the actual requirements. As the allocation is inadequate, which results in the substandard maintenance affecting the performance of irrigated agriculture which in turn leads to poor recovery rate. Thus Indian irrigation sector is caught in a vicious cycle of low recovery rate, less investment, improper maintenance, low performance, and low recovery rate.

Paradox: However there is another dimension of the problem, not focused by many: Farmers are already contributing a substantial amount through local collective effort which are meant to solve their problems. From many studies it is reported that farmers have contributed to the extent of about Rs.1000/ hectare towards maintenance and repair works undertaken by village communities them-

selves; this is relatively very high compared to the amount paid as water charges for government efforts. What does this phenomenon indicate?In many irrigation projects the benefits are uncertain given the `agency' problems; there are uncertainties as regards timeliness and adequacy of water and hence farmers are not willing to pay. Whereas in local efforts they can foresee the benefits hence farmers are interested to contribute. This also points to the importance of local level institutions to solve the problems arming out of governance by the state. It is the joint management, which pays well for both bureaucracy and people.

Farmers Perspectives: Though the cost recovery from irrigation projects is stated to be low there is a different perspective by farmers organisations on this issue. In many part of India though water charges are low, an additional tax (locally known as cesses) is collected along with water charges. This is collected on the basis of water charges (multiples of water rates), but it is used for financing of local bodies like village panchayats. Farmers' contention is that as these taxes are assessed on the basis of water rates, it should be treated as user charges for irrigation. Inclusive of these cesses the total amount collected per hectare is much higher than water rates per se.Another argument by the farmers' organisation is that the bureaucracy is inefficient in financial management, which results in wasteful expenditure. Hence farmers are hot required to pay for the `inefficiency' of irrigation bureaucracy.Inorder to address the problem,it is suggested that both farmers and bureaucracy are to be involved jointly in the estimation of the costs and assessment and collection of revenue(water charges).The recent experiments in the states of Andhrapradesh, Orima, Maharastra and Tamil Nadu in India in involving farmers' organisation in the system management have given enough encouragement on this.

Groundwater Irrigation: Need for Coupling Subsidies with Resource Conservation

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Keywords: groundwater, electric power, free-power supply, water use efficiency, energy conservation

Introduction/Problem Identification

Energy supply, in the form of electricity, is a vital input in groundwater agriculture in many states in India. In Andhra Pradesh and other south Indian states, about 50% of irrigated area is under groundwater irrigation. Average increase of number of tube wells in Andhra Pradesh is around 50,000 per year with trends of further increase.

The demand for electricity in groundwater agriculture is increasing rapidly with an increase of about 30% over last 5 years. Power supply to agriculture is subsidized (is free in AP) and often not metered. At the micro level, increasing number of wells is over-loading the Distribution Transformers (DTs) and causing economic losses to farmers as a result of motor / DT burnouts. Power supply quality is poor with frequent interruptions and low voltages.

Analysis/Results and Implications for Policy and/or Research

Energy use in agriculture has a bearing on water use efficiency also. Quality and timely power supply will help farmers to schedule irrigation properly and save groundwater. On the other side, lower pump efficiencies and low voltages at pump-sets result in low discharges while consuming the same or more amount of power from the power distribution network.

Free power policy and un-restricted groundwater extraction is resulting in wastage of energy as well as water resources. While subsidized or free power is a necessity to the deserving small and marginal farmers, there is need for a mechanism to couple the objective of energy and water conservation with it, for economic health of energy companies and long-term sustainability of groundwater resources. In order to achieve that, there is need for devising new and innovative mechanisms of coupling such subsidies with incentives for conserving energy and water.

Normally, agricultural pump-sets are given about 8 hours of power supply in a day. Farmers may be offered incentives for those hours of power supply not utilizing by them in a given agricultural season. Such new subsidies and incentive structure will help to achieve the objectives of targeted subsidies to deserving people to protect their livelihoods as well as resource conservation.

Increasing Women's Access to Safe Clean Water through a Revolving Scheme

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Keywords: increasing, safe and clean, water, access, revolving scheme

Introduction/Problem Identification

Financial subsidies, donations, grants and all kinds of financial assistance often have a short lived impact in the communities where it's given. This is due to the fact that there is often no strong financial mechanism to sustain such projects. The government, and other development partners often inject large sums of money into the water sector, but such large sums of money often lacks a lasting impact on the lives of the communities into which its injected. If such money is not misused, then it only provides service to only a few people and no sustainability. When the water source provided gets a problem, often there is no means provided for repair and maintenance. And there is no multiplier effect of such funds. The end of the project often implies end of the service to the community.

Analysis/Results and Implications for Policy and/or Research

A revolving scheme is where the first beneficiary of the water service or facility, is required to pay back in very small instalments, so as to enable other people benefit from the same fund. The instalments may be as small as the beneficiary may afford, but consistent.

Experience especially in developing countries has shown that free services have been taken for granted and communities have not felt part of such water services. They often refer to government water sources as "government well". And such communities will never take responsibility to maintain or even repair such wells or water sources.

If empowered, communities are able to have access to clean and safe water using their own resources. this will not only help such resources benefit much more people, but also enable communities take responsibility for maintaining such water sources.

Katosi Women Development Trust has often engaged and empowered women to have access to safe water through such revolving schemes. Women are given water harvesting tanks on a loan basis; they are allowed to pay in small instalments until full payment is made. The tank is again given to another person and the scheme continues until very many women are reached using the same fund. Though this method, the organisation has reached many more people, and made the projects sustainable.

A revolving scheme therefore can be used to help water facilities reach as many people as possible and also instil a sense of ownership among the community members.

Community Financial Contribution for Rural Water Supply

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Keywords: cost sharing, community participation, sustainability, cost and benefit, community training

Introduction/Problem Identification

The Asian Development Bank assisted the Third Water Supply & Sanitation Sector Project being implemented in the six districts of Sri Lanka, through community participation. Appropriate water supply options were proposed by the community itself with community agreement to a 20% financial contribution. Then the sustainability of the proposal was analyzed, with an appropriate operation & maintenance model. The total project cycle was divided into several phases to assure active participation of community with financial contribution.

Use of a cost sharing model is an important feature of this project. This has been introduced to get the community more realistically involved. When sharing part of the cost they feel ownership of the scheme. Therefore there is a high successful completion of the project and sustainability is also ensured. Detailed analysis of data from the projects has been carried out to show how community contribute for rural water supply.

Analysis/Results and Implications for Policy and/or Research

1 Methodology Selected for Implementation and Fincial Contribution

The total project cycle was divided into several phases as explained below and the project staff (a team of technical & community development experts) were involved in the complete process with the active participation of community.

1 Social Mobilization phase: The following processes were completed in this phase.
   - Establishment of the village coordination committee & the selection of village level animators.
   - Formation of an active group & the establishment of a community based organization.
   - Organization of the village participatory survey, the collection of self assessment information & a situation analysis report.
   - Identification of reliable water sources & preparation of a work plan.

2 Participatory planning & design phase:
   - Selection of reliable water sources & participatory planning of alternative options for each village cluster.
   - Preparation of tentative estimates for each option including probable O&M costs.
   - Selection of the most suitable option considering technical, financial and O&M viability issues with the concurrence of the community for a 20% (cash & kind) contribution.

3 Collection of community contribution & signing of MOU (Memorandum of Understanding) with the CBO to commence construction work once the community contribution is collected.

4 Construction & supervision phase: Construction work was carried out through community participation. All technical support was given by the project staff. While submitting the project proposals decisions were taken by the community with the help of the project staff to identify which part of the work, was to be carried out to cover the community contribution(cash & kind).

4 Operation & Maintenance phase: This phase consists of the following processes:
    - Training of CBO personnel in plumbing, pump operation & small scale water treatment
    - plant maintenance.
    - Setting up of technical support units in each local administrative area to support the CBO's whenever necessary. These units will function continuously with the help of Local Administrative Authority in order to ensure the sustainability of the water schemes.

2 Data and Analysis

Different options such as pipe-borne water, shallow well, deep well & rain water harvesting were selected by different communities depending on the availability of source and their affordability. Project contribution is limited for each option, and a minimum of 20% is borne (see Table 1)by the community itself. Sometimes the project cost exceeds the limited amount in the proposed cost sharing model. On such occasions the balance is also borne by the community in addition to the 20% community contribution. Table 02 clearly shows such occasions. This is due to scarcity of water in the area and the community understands the importance of a safe & reliable water supply. However most of the community's first choice is to have pipe-borne water if reliable sources are available.

While estimating the total cost of the project, unskilled labour component of each & every item was separated and cost of these were calculated depending on the work norms & day work rates. These works were carried out by the community itself, for instance excavation, backfilling of pipe trenches & well pits and helping to masonry, concreting works etc. Then the cash contribution was decided by deducting the kind contribution amount from the total contribution. Some of the poor community had difficulties in contributing the cash at once, in such instances Rural Banks and Community Development Foundations helped the community by providing concessionary payment loan schemes.

The total population of project area selected in first phase was 77, 600. From theses only 7% had existing water supply facilities, a further 81.5 % of the population has been covered by the project. While implementing the project our target was to cover a minimum of 75% of the total population. However, we were able to cover more due to active participation of the community and the excellent contribution of the project staff.

Appropriate low cost water treatment techniques were adopted depending on the water quality. High iron content & fluoride problems were found in some of the ground water sources and treatment techniques were adopted.

Water Subsidy Dynamics: Some Views on Governmental Investment and Non-Investment Incentives/ Subsidies in an Uncertain Global Financial Meta-paradigm

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Keywords: uncertain financial scenario, evaluation of water subsidy, adverse impact, 'the Three Es', policy design

Introduction/Problem Identification

The Global water industry is growing fast. Even in the current turbulent and uncertain financial environment, the universe of water related business (including the market for pumps, pipes, filters, and other equipment) is expected to grow from current $522 billion to $1 trillion by 2020. Given the rising scarcity and the potential geo-political significance of water, many consider investments in water and related businesses to be recession proof, or at least "recession resistant". Investors are thus seeing fresh water as a commodity that is under-appreciated, under-valued, and therefore worth investing in, with the promise of long-term returns. At the same time, governments continue to provide investment incentives/subsidies (in the form of preferential lending, guarantee provisions, and other exemptions) and non-investment subsidies (price control, cross-subsidization, etc) to water projects aimed at poverty reduction and service coverage improvements towards achieving MDGs.

Analysis/Results and Implications for Policy and/or Research

Given the above scenario, we examine the current literature on investment and non-investment subsidies/incentives (relatively little, especially in reference to countries such as India) and argue that often, determining when an 'investment or a non-investment incentive' is a subsidy or not is a difficult question – partly because these often "have a way" of being non-transparent. We also argue that the environmental consequences of such subsidies are rather unclear and certainly under-researched. Moreover it will be discussed that subsidies (or incentives) cost a lot of money, though no one knows exactly how much and that these costs are exacerbated by the increasing mobility of capital and by information asymmetries between governments and investors, with the latter often manipulating this asymmetry through the use of site-location consultants. We substantiate these arguments by focusing on the theoretical constructs of the "the three E's" of (economic) efficiency, (market) equity, and environment sustainability and suggest that subsidies have potential drawbacks in all of these areas and unless structured effectively can cause adverse impacts.

We then examine policy constructs and schema in order to evaluate the relative strengths and drawbacks of investment and non-investment subsidies, building arguments that will contribute to the design of subsidies/incentives which can maximize benefits, minimize risks to host governments and mitigate adverse impacts. These include transparency (clarity of eligibility and participation criteria and effective implementation by responsible entities), incentive responsibility (whether incentives of different stakeholders compatible with public policy goals), flexibility (ease with which the subsidy program can be modified), sustainability (compatibility of subsidy to take of external costs, subsequent expenditures such as O&M and develop technical capacities), auditing, spillovers (extended costs or

benefits), rent-seeking, administrative & political feasibility (ease of implementation and prevention of political backlash) and encouragement of research and development. Case studies exemplifying examples of subsidies (both successes and failures) will be built in to substantiate the theoretical construct. Moreover a view of the impact of the current uncertain financial environment on both the quantum and design of the subsidies will be made.

We then present our conclusions that provide a better understanding of designing, implementing and managing such financial mechanisms to contribute towards effective ways to diminish perverse impacts. The paper concludes by opening further research agendas – the unknowns, and the questions that need to be answered. For example, whether investment incentives/ subsidies are, in general, good policy decisions, or specifically a good policy for developing countries? If not, what could be the other feasible alternatives?

Using ODA to Leverage Repayable Financing: Recent Trends

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Keywords: financing, leveraging, ODA, private finance, water and sanitation

Introduction/Problem Identification

The water and sanitation sector is seriously under-financed in many countries, leading to the deterioration and potential collapse of the infrastructure. ODA can be used more effectively to attract repayable finance so as to increase the overall amount of financial resources available to the sector.

Analysis/Results and Implications for Policy and/or Research

Even though innovative financing tools to mobilize market-based repayable finance do exist, they have been under-utilized in the water sector by comparison with other infrastructure sectors. This may be due to a number of factors. On the one hand, there has been insufficient demand for these products due to a lack of awareness and training (which means that demand, even if it is there, is not expressed) and over-crowding from concessionary finance which tends to chase (and capture) the most promising water projects. On the other hand, supply of market-based repayable finance has also been limited given that the economic characteristics of the sector are often not conducive to adopting such innovation. Too often, the sector is perceived as a high-risk/low return sector by external financiers when, through reforms, it could be transformed into a low risk/ low but steady return sector, which may prove attractive in the current economic climate.

In the context of the financial crisis, Official Development Assistance (ODA), in the form of concessionary repayable finance or in some cases grants will be needed to get credit flowing again. This does not necessarily mean pouring public money into water projects (although this is partly what some governments are doing via stimulus packages) but rather improving the targeting in the use of public funds so as to leverage market-based finance. It will also be more important than ever before to pay attention to the long-term sustainability of such financing: this will entail establishing institutions at the national level that can channel funds (both public and private) into the sector in order to finance relatively small projects rather than focus on a few landmark transactions at the international level.

ODA could be used more efficiently in order to leverage repayable finance in the following ways:

- providing seed financing for micro-finance institutions offering financial products to support water and sanitation investments
- financing output-based subsidies to entrepreneurs and households to leverage their investments;
- providing guarantees and risk insurance where perceptions of risk keep private investment away;
- where applicable, making equity injections so as to improve the ability of utility providers to raise debt financing;
- supporting the establishment of pooled financing facilities;
- contributing to improving the sector's transparency and addressing the lack of knowledge of the sector at the level of financial institutions, by supporting the development of credit rating systems;
- supporting the development of bankable projects in the water sector through the establishment of project preparation facilities.

Can Water Services O&M be Incentivised? Going with the Franchising Flow

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Keywords: water, sanitation, operation, franchising, South Africa

Introduction/Problem Identification

In recent years, some areas of the developing world have seen an increasingly poor and often unacceptable quality of water and sanitation service. The reason for this is invariably inadequate arrangements and incentives for operation and maintenance (O&M) – including not just skills shortfalls, budget shortfalls and sometimes inadequate design and/or construction, but weak institutional arrangements, and unwillingness, or inability, to change.

Improved institutional and financial mechanisms, where corporate, social and ethical responsibilities are given due attention, are needed. An important aspect that needs addressing would be how to increase positive incentives. Part of this must undoubtedly be the measurement of performance, and a system for rewarding on the basis of that performance.

Analysis/Results and Implications for Policy and/or Research

Much of South Africa's public sector water and sanitation services infrastructure is very well operated, and delivers a safe and reliable service – however there is a growing creep of the symptoms of poor services delivery attributable to the challenges mentioned in the introductory paragraph above.

Ongoing work by the Water Research Commission (WRC) of South Africa and the Council for Scientific and Industrial Research (CSIR) finds that franchising partnerships for operation and maintenance could alleviate and address many challenges in the delivery and management of water and sanitation services. Generically, franchising:

- transfers appropriate skills transfer to local personnel,
- brings ongoing performance measurement and support, and mentoring and quality control, and
- provides backup at-a-distance skills together with the incentive, on the part of the local (franchisee) personnel, to call for those at-a-distance skills and, on the part of the franchisor, to make them available, because there is a binding contract between them and a shared reputation.

Costs of operation and maintenance would no longer be internal and hidden, and external costs would become apparent

The partnerships would involve three parties – that is, franchisor, franchisee and the owner of the water services infrastructure. The main incentive of the franchisor and franchisee to perform is, frankly, that their livelihood depends on it. The incentive to many owners of water services infrastructure (most of them municipalities) to reform their current often inadequate provision for quality service delivery is the increasing pressure from the South African national Department of Water Affairs and Forestry (DWAF), which is threatening to prosecute authorities that do not comply with the legislated requirements for safe drinking water and adequate sanitation.

Many opportunities lie in the franchising of suitable parts of the water and sanitation services value chain – of activities inter alia "suitable" for microenterprises in that they can be readily systematised. A selection of these has been modeled by WRC and CSIR, and is being made available to emerging entrepreneurs as the basis of viable businesses.

Funding for pilot implementation during 2009 has been budgeted by Irish Aid and by DWAF.

Help from the franchisor would be of particular value away from the major urban centres. For example – few rural municipalities in South Africa can afford to employ competent qualified staff, and this directly results in periodic unreliability of supply and frequent non-compliance with national standards relating to, for example, wastewater treatment works effluent quality. Significant improvements would soon be seen if the generally under-qualified and under-resourced water and sanitation services staff could have this ongoing support, mentoring and quality control – or if the municipality could partner with microenterprises and/or community-based organisations which would, through franchising, enjoy the necessary ongoing support, mentoring and quality control from the franchisor, and would have quick access to skilled assistance when they needed it.

The cost of the higher skills levels, which are needed only intermittently, is spread across many sites – thus cost per franchisee, or per municipality, is low.

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