Report

of

Sub-Committee

on

More crop and income per drop of water

सत्यमेव जयते

Advisory Council on Artificial Recharge of Ground Water
Ministry of Water Resources
Government of India
October 2006

PREAMBLE

The Ministry of Water Resources had constituted an Advisory Council on Artificial Recharge of Ground Water under the Chairmanship of Prof. Saifuddin Soz, Hon'ble Minister of Water Resources. The first meeting of the Council was held on 22nd July, 06 at Vigyan Bhavan, New Delhi and was inaugurated by Dr. Manmohan Singh, Hon'ble Prime Minister of India. In his inaugural address the Prime Minister mentioned that **" We have to minimize our water use – invest in science and technology to ensure that we can grow crops which use less water. In other words, find ways of valuing the crop per drop"**. To implement the suggestions of Prime Minister, the Council in its first meeting constituted a Sub-Committee under the Chairmanship of Dr. M.S. Swaminathan to prepare a report on **"More Crop and Income per Drop of Water".** The Sub-Committee consists of representatives of Ministry of Agriculture, Ministry of Rural Development, National Fishery Development Board, CGWB, CWC, Confederation of Indian Industry and Agricultural Scientists from IARI, CRIDA, CAZRI, ICRISAT and State/Central Agriculture Universities/Institutes. The Sub-Committee held two meetings on 9th and 29th Sept., 2006 in a brain-storming mode to analyse the available data and offer concrete recommendations.

The report gives details of implementable action plans incorporating technologies along with their economics. The steps that can be taken for Rabi crops have been highlighted so that action can begin from ensuing Rabi season itself.

Irrigation water security is vital both for livelihood and food security. While the country has made large investments in the augmentation of water supply, there have been no commensurate efforts in the management of demand and in the promotion of efficient and economic water use. This report draws attention to the scope available for improving the efficiency of use of irrigation water in a manner that both the productivity and profitability of farming are enhanced. This is the pathway to an ever-green revolution all over the country, designed to enhance agricultural productivity and profitability in perpetuity, without associated ecological harm.

I am indebted to all the members of the sub-committee for their inputs and their dedication to the cause of building a sustainable irrigation water security system for the country. In particular, my thanks go to Shri.S.M Sood, member secretary and Dr K.Palanisami, co-ordinator of the drafting group for their untiring efforts and invaluable contributions.

The report is being presented on 2 October, 2006, the birth anniversary of Mahatma Gandhi to remind ourselves of the eternal truth behind Gandhiji's statement, "Nature provides for everybody's needs, but not for everyone's greed". On this day, we dedicate ourselves to replacing the spread of greed revolution with an ever-green revolution based on the principle of Jal Swaraj.

M.S.Swaminathan
Chairman

CONTENTS

I. Introduction

India is a monsoon dependent country for its water resources. Irrigation sector has been fundamental to India's economic development and poverty alleviation since 25% of India's Gross Domestic Product (GDP) and 65% of employment is based on agriculture. During the post independence period, the country has invested a huge amount of capital in the major and the medium irrigation projects. Among the states, three have already achieved 70% or more of the ultimate irrigation potential with Tamilnadu recording 100% achievement, followed by Punjab and Rajasthan at 84% and 74% respectively.

Six States, i.e., Haryana, Karnataka, Jammu & Kashmir, and West Bengal are in the range of 63% to 71%, whereas in U.P. and Maharashtra, the achievement would be 56% each. The States of Bihar, Gujarat, Orissa, M.P. and Assam have achieved less than 50% of the ultimate potential. The ultimate potential under major & medium irrigation in the eastern States (except West Bengal), i.e. Bihar, U.P., M.P. and Orissa put together works out to about 50% of the total ultimate potential of the country.

Irrigation potential which stood at 22.6 mha in 1950-1951, has now reached about 100 mha, and as a result food production has increased from 50 m tonnes (1951) to about 208 m tonnes (2005). The projections for future population and food requirement of the country indicate that the population of India may stabilise around 1.6 to 1.7 billion by 2050 AD and that would require about 450 m tons of food grain annually at the required level of food consumption. Area wise it is necessary to provide irrigation to at least 130 mha for food crops alone and in an area of 160 mha for all crops to be able to meet the demands of the country in 2050 AD and ensure food security.

Sources of Irrigation

It is estimated that $1.953 \times 10^{11} m^3$ of water is available out of a total precipitation of about $4 \times 10^{11} m^3$. These waters are harnessed both as surface water and ground water. Surface utilization is mainly through dams constructed across rivers served through larger catchments and tanks served by smaller catchments. Groundwater is utilized mainly through wells both open and tube wells. The Central Water Commission (CWC) estimates that the ultimate irrigation potential that can be created through major, medium and minor projects would be about 75.9 m.ha. Irrigation potential making use of ground water has now been assessed as 64 m.ha. Thus the total irrigation potential from surface and ground water sources would be about 139.9 m.ha. The commission also estimates that basin transfer of water from surplus to deficit basins could help to bring additional irrigation potential. This will however have to be done on a win-win mode for all states concerned.

Canal irrigated area has increased from 8.3 million hectares to 18 million hectares during 1950-51 and 1999-00 (Table 1). Like wise, well irrigated area has increased from 6 million hectares to 34 million hectares during the last 50 years. Well irrigation in 1999-00 accounted for nearly 59 percent of the total irrigated area as compared to only 29 percent in 1950-51. Wells and tube wells constitutes the major share (58.7 per cent) followed by canals (31.5 per cent). Growth of well irrigation has been at the expense of irrigation from tanks and other sources. During the period from 1950-1999, the area under tanks had been decreased from 3.6 million hectares to 2.7 million hectares. Tanks are mostly concentrated in areas where other sources of irrigation are less or completely absent.

Table 1. Area and Percentage share of different irrigation sources

Sources of Irrigation	1950-51 Area (m.ha)	percentage	1999-00 Area (m.ha)	percentage
Canals	8.3	40	18	31.5
Wells and tube wells	6	29	33.6	58.7
Tanks	3.6	17	2.7	4.7
Other sources	3	14	2.9	5.1
Total	20.9	100	57.2	100

Source: Central Statistical Organization (CSO), Statistical Abstract,India, 2002

The National Water Policy calls for the conjunctive use of all the available water resources. These are: rainwater, river and surface water sources, groundwater, sea water and recycled waste water. The conjunctive use of ground and surface water can help to improve cropping intensity by using surface and rainwater during <u>kharif</u> and groundwater during rabi and summer seasons. Integrated water resources management is vital for maximizing the benefits of the available irrigation water.

India has a long coast line and the Andaman and Nicobar as well as Lakshwadeep group of islands. There is much scope in coastal areas for promoting agro-aqua farms, involving mangroves, salicornia, artiplex, casuarina and other halophytes as well as cashewnut and the culture of prawns and marine organisms. There is much scope for sea water farming for coastal area prosperity. Sea water is an invaluable social resource, as stressed by Mahatma Gandhi through the Dandi Salt Satyagraha. We have an exclusive economic zone of 2 million sq.km of sea surface and we should also plan to use this resource wisely for creating jobs and income.

Trends in Irrigation Investment in India

India is continuing to invest substantial amount of money for the extension and improvement of irrigation facility. Almost all the investment required for construction of irrigation projects (dams and reservoirs), canals and distribution networks up to the field is financed by the central and state governments under the plans (Vaidyanathan 1994). More than 50 percent of all public expenditures on agriculture have been spent on irrigation alone. During the fifty years since independence, the Government had spent about Rs.2, 31,400 crores (at 1996-97 prices) on major, medium and minor irrigation works. Table 2 shows that though the plan outlay for irrigation sector has increased over the years, the percentage distribution of fund allotted for the irrigation and flood control shows a decreasing trend except during the Sixth plan and annual plan 1979-80. No wonder during the VIth plan period (1980-85), the growth rate in agriculture of 5.7% exceeded the growth rate in GDP of 5.5% for the first time.

Table 2. Outlay for Irrigation Sector in Five Year Plans

Period	Amount (Rs.Crore)	Percentage Distribution
III Plan (1961-66)	664.7	7.8
Annual plans(1966-69)	471	7.1
IV plan(1969-74)	1354.1	8.6
V plan(1974-79)	3876.5	9.8
Annual plans(1979-80)	1287.9	10.6
VI Plan(1980-85)	12160	12.5
VII plan(1985-90)	16589.9	7.6
Annual plan(1990-91)	3974.1	6.8
Annual plan(1991-92)	4231.9	6.5
VIII Plan(1992-97)	32525.3	7.5
IX Plan (1997-02)	55420	6.5
X Plan (2002-07)	103315	6.8

Source: The Economic Survey 2004-05

All the five year plans have given considerable importance to the creation of additional irrigation potential. In 1947, India had about 22 million ha under irrigation. High priority has been given to irrigation with nearly 10 percent of all planned outlays since 1950 being invested in irrigated agriculture. This has resulted in about 0.6 million ha of new irrigated schemes being developed every year. About Rs 7500 crores are invested every year in irrigation programmes in India.

II. Issues

In spite of large investments, the performance of many irrigation and drainage systems is significantly below potential due to variety of shortcomings. These include inadequate design, use of inappropriate technology, system layouts that do not adequately reflect existing conditions, inappropriate governance arrangements, and poor management practices.

The most obvious manifestations of these shortcomings in irrigation are unreliable main system water supply, water wastage and poor maintenance practices. Irrigation can also cause certain environmental problems, in the areas of drainage and salinisation, habitat change, and human health. Over-irrigation and injudicious planning of roads, canals and other rural infrastructure blocking the natural drainage ways also cause many of the drainage problems, especially in irrigated areas.

Irrigation constitutes the main use of water and presently accounts for 84% of the total water withdrawals. The share of per-capita withdrawals by the domestic and industrial sectors is one of the lowest in the developing world (59 m^3 per person in India compared to 132 m^3 per person in China, World Bank, 2005). However, with increasing urbanization and per-capita demand, the water demands of domestic, industrial and other sectors are expected to increase and become highly competitive with the irrigation sector (Table 3). Contribution of public surface irrigation has been on decline, due to inadequate dam storage capacities and poor maintenance of the public irrigation infrastructure.

Ground water Depletion

Out of the total ultimate ground water potential of 64.0 M.ha. available in the country, a potential of 46.01 M.ha i.e 58% has so far been created/developed. The status of ground water development is comparatively high in the states of Delhi, Haryana, Punjab, Rajasthan and union Territories of Daman and Diu and Pondichery, where the stage of development is more than 100% which implies that in these states the average annual ground water consumption is more than average annual ground water recharge. In the states of Gujarat, Karnataka, Tamil Nadu and U.P. the average stage of ground water development is 70% and above. In the rest of the States/UTs the stage of ground water development is below 70%.

Table 3. Water Requirements for various purposes (In billion cubic metres)

Purpose	Demand in 2000	Demand in 2010	Demand in 2025
Domestic use	42	56	73
Irrigation	541	688	910
Energy	8	12	23
Industrial Use	2	5	15
Others	41	52	72
Total	634	813	1093

Source: Report of 10th Five Year Plan (2002-07)

The ground water resource estimation of the entire country has been done as on March 2004. In most of the states, the unit for assessment of groundwater resources has been the administrative units(blocks/taluk/mandal) except for the states of Andhra Pradesh, Karnataka and Maharastra where watershed has been taken as unit. The hilly areas(slope >20%) have been excluded from the computations. The groundwater resource in the poor quality areas have been computed separately. The assessment unit has been divided into commands and non-command areas depending upon the availability of data pertaining to computation of groundwater resources separately for commands and non-command areas.

The annual replenishable Ground Water resources for the entire country is 433 billion cubic metre (bcm). The ground water assessed is the dynamic resource which is replenished each year. The Annual Replinishable Ground Water Resource is contributed by two major sources- rainfall and other sources that include canal seepage, return flow from irrigation, seepage from water bodies and artificial recharge due to water conservation structures. The overall contribution of rainfall to the country's annual Replenishable Ground Water Resource is 67% and the share of other sources taken together is 33%. The contribution from other sources such as canal seepage, return flow from irrigation, seepage from water bodies etc. in Annual Replenishable Ground Water Resources is more than 33% in the States of Andhra Pradesh, Delhi, Haryana, Jammu and Kashmir, Karnataka, Punjab, Tamil Nadu, Uttar Pradesh, Uttaranchal and UT of

Pondicherry. South-west monsoon being the most prevalent contributor of rainfall in the country, about 73% of country's Annual Replenishable Ground Water Recharge takes place during the Kharif period of cultivation. Keeping 34 BCM for natural discharge, the net annual ground water availability for the entire country is 399 BCM. The annual ground water draft is 231 BCM out of which 213 BCM is for irrigation use and 18 bcm for domestic and industrial use. An analysis of ground water draft figure indicates that the States of Chhattisgarh, Delhi, Goa, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Kerala, north eastern states of Manipur, Meghalaya, Mizoram, Nagaland and Tipura, Orissa, Sikkim and UTs of Andaman and Nicobar island, Dadra and Nagar Haveli, Daman and Diu, Lakshadweep and Pondicherry, ground water draft for domestic and industrial purposes are more than 15% which is comparatively higher than the national percentage of 8%. In general, the irrigation sector remains the main consumer of ground water (92% of total annual ground water draft for all uses.)

Out of 5723 number of assessed administrative units (Blocks/Taluks/Mandals/Districts), 839 units are over-exploited, 226 units are critical, 550 units are semi critical, 4078 units are safe and 30 units are saline (Table 4). Number of over-exploited and critical administrative units are significantly higher (more than 15% of the total assessed units) in Andhra Pradesh (where categorization was done upto sub-unit level i.e. within Mandal- command and non-command wise), Delhi, Gujarat, Haryana, Karnataka, Punjab, Rajasthan and Tamil Nadu and also the UTs of Daman & Diu and Pondicherry.

The assessment units have been categorized for groundwater development based on two criteria: a) stage of groundwater development and b) long term trend of pre and post monsoon water levels. The long term ground water level trend has been computed preferably for the period of 10 years. The significant rate of water level decline has been taken between 10-20 cm per year depending upon the local hydrological conditions. Four categories are- safe areas which have groundwater potential for development; semi-critical areas where cautious groundwater development is required; critical areas and over-exploited areas where there should be intensive monitoring and evaluation and future groundwater development be linked with water conservation measures.

Table 4. CATEGORIZATION OF BLOCKS/MANDALS/TALUKAS IN INDIA

Sl. No.	State/Union territories	Total No. of assessed units	States		Semi-critical		Critical		Over-exploited		Remarks
			Nos.	%	Nos.	%	Nos.	%	Nos.	%	
States											
1	Andhra Pradesh	1231	760	62	175	14	77	6	219	18	-
2	Arunachal Pradesh	13	13	100	0	0	0	0	0	0	-
3	Assam	23	23	100	0	0	0	0	0	0	-
4	Bihar	515	515	100	0	0	0	0	0	0	-
5	Chattisgarh	146	138	95	8	5	0	0	0	0	
6	Delhi	9	2	22	0	0	0	0	7	78	-
7	Goa	11	11	100	0	0	0	0	0	0	-
8	Gujarat	223	97	43	69	31	12	5	31	14	Rest 14 talukas Saline
9	Haryana	113	42	37	5	4	11	10	55	49	
10	Himachal Pradesh	5	5	100	0	0	0	0	0	0	-
11	Jammu & Kashmir	8	8	100	0	0	0	0	0	0	-
12	Jharkhand	208	208	100	0	0	0	0	0	0	-
13	Karnataka	175	93	53	14	8	3	2	65	37	-
14	Kerala	151	101	67	30	20	15	10	5	3	
15	Madhya Pradesh	312	264	85	19	6	5	2	24	8	-
16	Maharashtra	318	287	90	23	7	1	0	7	2	-
17	Manipur	7	7	100	0	0	0	0	0	0	-
18	Maghalaya	7	7	100	0	0	0	0	0	0	-
19	Mizoram	22	22	100	0	0	0	0	0	0	-
20	Nagaland	7	7	100	0	0	0	0	0	0	-
21	Orissa	314	308	98	0	0	0	0	0	0	Rest 6 blocks Saline
22	Punjab	137	25	18	4	3	5	4	103	75	
23	Rajasthan	237	32	14	14	6	50	21	140	59	Rest 1 block Saline
24	Sikkim	1	1	100	0	0	0	0	0	0	-
25	Tamil Nadu	385	145	38	57	15	33	9	142	37	Rest 6 blocks Saline
26	Tripura	38	38	100	0	0	0	0	0	0	-
27	Uttar Pradesh	803	685	83	88	11	13	2	37	5	-
28	Uttaranchal	17	12	71	3	18	0	0	2	12	-
29	West Bengal	269	231	86	37	14	1	0	0	0	-
	Total States	**5705**	**4067**	**71**	**546**	**10**	**226**	**4**	**837**	**15**	-
Union Territories											
1	Andaman & Nicobar	1	1	100	0	0	0	0	0	0	-
2	Chandigarh	1	1	100	0	0	0	0	0	0	-
3	Dadra & Nagar Haveli	1	1	100	0	0	0	0	0	0	-
4	Daman & Diu	2	0	0	1	50	0	0	1	50	-
5	Lakshdweep	9	6	67	3	33	0	0	0	0	-
6	Pondicherry	4	2	50	0	0	0	0	1	25	Rest 1 Region Saline
	Total Uts	**18**	**11**	**61**	**4**	**22**	**0**	**0**	**2**	**11**	-
	Grand Total	**5723**	**4078**	**71**	**550**	**10**	**226**	**4**	**839**	**15**	-

Source: MOWR, 2006

Problems of waterlogging and drainage

In India the problem of waterlogging has been assessed from time to time. The State-wise figures of excess salt concentration worked out by the Working Group of Ministry of water resources are given in Table 5.

Table 5 State-wise salt affected areas in India

State	**Excess salt concentration area ('000 ha)**		
	Saline	**Alkali**	**Total**
Andhra Pradesh	5.00	22.80	27.80
Assam	-	-	-
Bihar	224.30	-	224.30
Gujarat	911.00	-	911.00
Haryana	125.20	72.00	197.20
Himachal Pradesh	-	-	-
Jammu & Kashmir	-	-	-
Karnataka	34.23	17.12	51.35
Kerala	-	-	-
Madhya Pradesh	-	35.79	35.79
Maharashtra	5.35	-	5.35
Orissa	-	-	-
Punjab	490.00	-	490.00
Rajasthan	70.00	-	70.00
Tamil Nadu	48.00	92.30	140.30
Uttar Pradesh	1150.80	-	1150.80
Total **(a) in Thousand ha** **(b) in million ha**	 **3063.88** **3.06**	 **240.01** **0.24**	 **3303.89** **3.30**

Effects of Water Logging

Water logging leads to salinity. When the water table rises up or if the plant roots happen to come within the capillary fringe, water is evaporated through capillarity. Thus, with the upward flow of water from the water table to the land surface during evaporation, the dissolved salts present in the water are carried to the surface resulting in deposition of salts in the root zone of crops, which eventually reduces the osmotic activity of the plants leaving the plants to fade away. Thus water logging and salinity may be treated as twin problem, which deserve special treatments based on the local conditions and soil texture, structure and topography.

Remedial measures needed

- Lining of canal system
- Conjunctive use of surface and ground water
- Improvement of drainage system
- Improvement in water management practices
- Development of command area
- Bio-drainage system
- Research and development programme

WUAs and their progress

The Command Area Development Programme started in l974 envisaged the participation of farmer organisations as a necessary step to run the micro system. The Committee on Pricing of Irrigation Water (l992) also recommended farmers participation in the management of irrigation systems.

Inspite of the growing realisation of the urgent need for farmers' participation in the management of irrigation, the progress has been slow so far. It is estimated that today only 8,04,000 hectares are being managed by WUAs (Table 6).

Table 6. Water User Associations

States	No of WUA'S	Area covered ('000 ha)
Andhra Pradesh	10292	4800.0
Assam	509	24.09
Bihar	32	110.50
Chattishgarh	945	1119.0
Gujarat	576	96.68
Karnataka	2318	1528.27
Kerala	4079	149.09
Madhya Pradesh	10282	1502.0
Maharashtra	1329	490.0
Orissa	13434	1054.0
Rajasthan	506	619.65
Punjab	957	116.95
Tamil Nadu	1566	599.40
Uttar Pradesh	279	10.55
West Bengal	10000*	37.0*

* Under MI and RIDF schemes;

Source: MOWR, CAD & WM Wing, 2006

The major reasons for the tardy progress in the implementation of the PIM are: farmers dependent on the Government and farmers are reluctant to adopt participatory approach unless deliveries of water can be made flexible, practical and responsive to the need.

It is believed that only when the operation and maintenance activities are fully handed over to the farmer's organisation, it will create a feeling in the minds of the farmers, that the water resource system is no more a Government property and it is only their own property. This will considerably reduce the problems faced by the operation and maintenance staff of PWD and will result in efficient management of water resource system.

For successful implementation of the PIM, the following aspects need special attention. (a) Legal aspects - Appropriate Legislative backing should be provided as early as possible. (b) Institutional aspects - High Level Committee should be set up to formulate policies for the implementation of PIM and review policy issues from time to time. A Standing Committee for operational and monitoring purposes should be set up. The setting up of training and research institutions like WALMIS where they do not exist has been suggested. Employment of Community Organisers for motivating the farmers and later working with them in setting up WUAs has also been suggested.

Box. 1. Water Users Association: Experiences from Tamil Nadu

Thiru. S. Paramasivam, President, Udukkampalayam Village Water User's Association, Parambikulam Aliyar Project (Inter-state irrigation project)., Udukkampalayam Post Udamalpet (Taluk), Coimbatore, Tamil Nadu says that WUA could play an important / crucial role in increasing the productivity of water along with Irrigation Department Officials to conduct the periodic Water Users Meet along with Agricultural Department Officials at system level before releasing / opening of the canal water for irrigation; in that meeting Irrigation Department Officials should present the details on water availability in the reservoirs and based on the availability, duration of water supply to be announced; other wise simply say that practicable "Water Budgeting" at system level could be drawn with consultation of farmers group. Based on that Agricultural Department Officials can guide / sensitize the farmers' on suitable crops pattern for the given situation and also explain the potential net income derived from per unit area.

Irrigation Department Officials ensure the irrigation water supply on the basis of (based on irrigation duty) water deliver at the each branch and canal distributaries. Unless adequate water is supplied; it is not possible to cultivate the proposed crop under Warrabandi (time schedule given to each farmer based on their ayacut) system of water allocation is followed.

Similarly, recent day's budget allocation for Operation and Maintenance (O & M) of the existing irrigation schemes were inadequate and now water charges collected for irrigation were gone to Government treasury. The WUA suggest that out of the total water charge collected; 50 % of the may be given to the WUAs and this amount may be deposited in the respective Associations account (already joint account between WUAs President and Irrigation Department Official has been in operation to avail one time subsidy given under WRCP – I programme) for repairing and renovation of their territorial distribution canals.

Tamil Nadu state "The Tamil Nadu Farmer's Management of Irrigation Systems Bill, 1999" has implemented and elections were conducted in the Parambikular Aliyar Project (PAP) to select the President and other members to the Association for the all WUAs in 2004; as per the about said bill Distribution Committee (DC) should be formed at the apex level and the Chairman of the DC and along with nine members should be elected through voting by the Presidents of the WUA among themselves; but so far DC Chairman and members was not selected because of the lack of interest among the Government and Irrigation Department Officials. If the above said bill and its mode and opendi were effectively implemented means; definitely it will increase the efficiency of the functioning of the any surface irrigation project.

As on day, I am very much happy and proud to be an one of the President of WUA in the PAP irrigation system, since this system is operating at more than 150 per cent irrigation efficiency level with just 18 TMC of water; giving life line to lakhs of farm families and agricultural labouers by providing irrigation to 1.70 lakh hectares. This could be achieved because of farmers' involvement with group action and conjunctive use of canal and groundwater. Because of compulsion and awareness among majority of the farmers in the command were already installed the drip irrigation system to the perennial crops such as coconut, mango sapota and mulberry and other major crops grown in the system are maize, vegetables, sorghum, cotton, groundnut, gingili and pulses.

Agricultural sector performance

The agricultural growth rate during the past five years has decelerated to about 1.5 percent from about 3 to 3.5 percent during the preceding 20 years, thus dropping below the population growth rate, for the first time during the past 40 years. Capital formation in agriculture at 1.3 percent of the GNP is also one of the lowest in recent decades, adversely affecting irrigation and rural infrastructure development, whereas agriculture accounts for about 20 percent of the national GDP and 60 percent of the employment.

Technology fatigue in agricultural development is being felt widely. The total factor productivity growth rate particularly in the main Green Revolution belts of rice-wheat or rice-rice systems has decelerated.

The problem of technological fatigue is further compounded with huge technology transfer gaps at various levels. Average national yields of most agricultural commodities in India are about 40 to 50 percent of the corresponding World averages. The gaps between potential and realizable and between realizable and average realized yields in the country are generally around 50 to 100 percent, respectively. The existing exploitable yield gaps should be seen as an opportunity for future growth that is consistent with agro-ecological, environmental, socio-economic, political and technological settings in the major production regimes.

Scope to increasing water use efficiency

Our Prime Minister has rightly emphasized the need to double annual foodgrain production from the present about 210 million tonnes to 420 million tonnes within the next 10 years. Since land is a shrinking resource for agriculture, the pathway for achieving these goals has to be higher productivity per units of arable land and water. Factor productivity will have to be doubled, if the cost of production is to be reasonable and the prices of our farm products are to be globally competitive. On an average, rice and wheat yields will need to be enhanced by about 40 percent and pulses, oilseeds, maize, millets, sorghum and horticultural commodities yields by about 50 to 100 percent.

Technological improvements in irrigation systems have also increased production opportunities. Traditional irrigation technologies (furrow, border and flood irrigation) which involve water delivery to plants through gravitation usually resulted in substantial water losses and limited uniformity in water distribution.

Modern irrigation technologies, particularly sprinkler and drip irrigation, increase water use efficiency. They have opened up opportunities to cultivate soils with low water-holding capacity (sandy and rock soils) and to farm low quality lands and steep slopes. This technology has also enabled regions facing limited water supplies to shift from low-value crops with high water requirements (e.g. cereal) to high value crops with lower water requirements such as fruits, vegetables and oil seeds.

Water use efficiency is presently estimated to be only 38 to 40% for canal irrigation and about 60% for ground water irrigation schemes. On the basis of 1991 census, our country's per capita water availability per year was estimated at 2214 cubic metres against the global average of 9231 cubic metres. Irrigation, being the major water user, its share in the total demand is bound to decrease from the present 83% to 74% due to more pressing and competing demands from other sectors by 2025 A.D. and as such, the question of improving the present level of water use efficiency in general and for irrigation in particular assumes a great significance in perspective water resource planning.

It is estimated that with 10% increase in the present level of water use efficiency in irrigation projects, an additional 14 m.ha area can be brought under irrigation from the existing irrigation capacities which would involve a very moderate investment as compared to the investment that would be required for creating equivalent potential through new schemes.

There is considerable scope for preventing and alleviating drainage problems by more integrated planning and water management. This can include integrated use of canal and groundwater for water table control, consideration of upstream and downstream relationships, adapting land use to the natural drainage conditions, exploration of opportunities of biological drainage and serial re-use of low quality drainage effluents.

Box. 2. Groundwater Exploitation in Punjab State

Punjab State is conscious of the food security of the country and intends to continue with maximum share towards central pool of food grains on sustainable basis. Due to favourable production and marketing environment in the State, the area under rice has increased to unsustainable level of 26 lakh hectares. The water table; soil health and environmental status of the State has been badly affected by large scale cultivation of paddy. The agriculture scientists, various committees/panels constituted have suggested that Punjab can sustain 16-18 lakh hectares of paddy cultivation depending upon the average annual recharge of the aquifer. The water table in the central districts of the State producing paddy, having 70% of the tube wells, is receding at an alarming rate of 2 to 2.5 feet annually. At present about 30% of the tube wells have become submersible and it is estimated that during the next 10 years practically all the centrifugal pumps will become non-functional and will need to be converted into submersible pumps requiring much more financial investment and also power to draw the water to irrigate the same area. So area under rice has to be stabilized at 40-45 lakh acres and ensure production on a sustainable basis. For this hard decisions have to be taken (a) sowing of nursery before 10th May has to be restricted by some Law/Legislation, (b) Financial support for R & D efforts to evolve hybrids/varieties with better yield potential and (c) introducing a crop (maize/pulses/oilseeds) which is needed in the country. Hybrid maize has emerged as a promising crop in the State. This season hybrid maize has covered about 2.5 lakh acres and it is feared that in case farmers do not get remunerative price for their produce, they may get disheartened and further expansion of area may get set back.

-The Punjab State Farmers Commission, Sep, 2006

Both technology fatigue and technology gap should have no place in the Indian R&D system. In fact, at this juncture, technology should flow faster through the pipeline and more options should be available to users, and agricultural research, education and extension systems should be revitalised.

With the above backdrop, the researchers and technology developers thus must ask themselves the following questions in deciding their research and technology development priorities:

- Will the technology lead to higher productivity across all farms, water regimes (rainfed drylands), soil types and regions, not just large farmers and well-endowed ones?
- How will the technology affect the seasonal and annual stability of production, especially the highly risk prone rainfed areas suffering from high instability?
- How will the technology affect the energy balance, eco-system and the sustainability of farming?

• Who will be the winners and losers from the technology – and how will it affect the majority small and marginal farmers, the poor and deprived ones?

Hence, performance of new varieties and technologies in terms of net income per hectare, and not just in terms of yield per hectare is important. Therefore, the aim of technological transformation of farming systems should be to enhance income per hectare on an environmentally and socially sustainable basis.

III. Viable technologies for enhancing productivity and income

Saving a drop of water would mean earning a drop of water. All possible rainwater harvesting techniques with striking balance between watershed management and prevention of sea water intrusion along the coastal belts shall be given the onus. Even as the so called micro irrigation systems are gaining popularity and momentum in the context of brilliant water saving (nearly 60%), most of the Indian farmers are still reluctant to adopt these advanced and proven technologies for the sheer reason of enormous initial cost and certain inevitable side effects like salt encrustation along the piping net works. Also the compatibility of appropriate micro irrigation systems layouts with fertigation system components is also on the unveil for aerobic rice production. SRI is another promising rice production technology woven with water saving basics. Hence, the focus should also be contemplated on how best we can improve upon the existing surface irrigation techniques. Hydraulically efficient water conveyance, application and distribution systems coupled with geometrically efficient irrigation layouts will complement to the premise of more crop and income per drop. The needed interventions will be through both supply augmentation and demand management. The demand management offers comparatively more scope in increasing the yield and income both in the short run and long run.

Box. 3. Enhanced Rainwater Use Efficiency could Increase Income and Crop Per Drop

S.P. Wani
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Patancheru 502 324, Andhra Pradesh, India

Rains are the main source of fresh water but generally stored run-off water and groundwater are considered as major sources of water for agriculture. There is an urgent need to bring in the **shift in thinking** of all from the farmers-researchers-development workers-policy makers including politicians that solutions for water scarcity can not be found in supply side only and demand management is the main strategy for overcoming the water scarcity. Water literacy through a campaign mode using the power of ICT is urgently needed.

Water alone can not do the job. Indian soils are hungry and thirsty resulting in low rainwater use efficiency. ICRISAT-led consortium has observed that vast rainfed areas (80-100% farmers' fields) from Rajasthan to Madhya Pradesh to Tamil Nadu are critically deficient in micro- and secondary nutrients such as zinc, boron, and sulphur along with nitrogen and phosphorus. Soil health must be improved. Amendments with deficient micronutrients showed 30 to 70% increased crop yields (maize, soybean, sorghum, green gram, black gram, pigeon pea, wheat, chickpea, mustard, finger millet, pearl millet, castor, etc). Balanced fertilizer application (N,P,K and deficient micronutrients) doubled the crop productivity. **Improved cultivars** can enhance productivity from 10 to 50%, however, main bottleneck is availability of improved seeds of legumes and rainfed cereals in remote areas. This constraint could be overcome through **village seed banks** operated by SHGs with capacity development and supply of foundation seeds in villages.

Infuse knowledge and technologies in rainfed areas **to harness the soil moisture** by matching soil moisture availability with crop maturity. Use of short duration crops and varieties ensure efficient soil moisture use, income stability and crop yield. Short duration chickpea cultivar Shwetha (ICCV 2) has revolutionized chickpea production in Andhra Pradesh. During 1993 to 2004 chickpea production increased by 16 folds through seven folds increase in area and increased productivity from 470 to 1080 kg ha^{-1} benefiting AP Rs. 75 crores annually. In Madhya **Pradesh 2 m ha are kept fallow during rainy season** due to fear of waterlogging and loosing *rabi* crop. ICRISAT-led consortium demonstrated in Vidisha district that that using broad bed and furrow (BBF), short duration soybean cultivars like Samrat along with balanced nutrient management options and minimum tillage for chickpea/wheat crops could double farmers' incomes and minimize land degradation. In Indo Gangetic Plains (IGP) simple **seed priming technique** soaking chickpea seeds in water and micronutrient solution for six hours and drying in shade could establish good chickpea crop in rice fallow areas and increase crop production and incomes by using residual soil moisture. This technology can be applied in 12 m ha rice fallows in India spread in MP, Orissa, Jharkhand, West Bengal and Chattisgarh.

Shift in watershed programs from mere water harvesting to efficient water use need to be brought in. Water management has to be used as an entry point only for improving livelihoods through productivity enhancement, value addition, and income generating activities through market-led diversification. Need of suitable institutions and policy support for these initiatives must be underscored. Millions of hectares of waste lands and low quality lands are unutilized in the country and soil moisture is simply lost through evaporation. Through appropriate soil and water conservation measures and collective action by the community these lands can be used for energy plantations (*Leucaena* (K 636), *Casurina, Jatropha* and *Pongamia)* and grass production enhancing livestock-based income for the vulnerable groups of the society.Suitable water governance policies using participatory water management along with suitable economic policy incentives are needed to ensure ban on cultivation of water guzzling crops such as sugarcane and paddy in rainfed watershed areas. Assured and quality energy supply along with efficient water delivery systems such as drip and sprinkler can enhance incomes through market-led diversification of the farming systems.

I. Supply augmentation

1. Investment in water control measures

In the surface irrigation systems, the water use efficiency is about 40% resulting in poor adoption of the water management technologies due to poor water control and management. Uncertainty of water supply (interms of time and quantity) is the major concern in most of the projects. Hence, in the case of canal and tank systems, future investment should be in strengthening the territory canals so that water control could be ensured. Further, well investment in canal command should be encouraged for better recharge and conjunctive use practices.

Action plans

All government investment as well as investment from lending agencies such as World Bank, should give priority for modernization of the territory canals with control structures. The WUAs should be involved in the decision making so that the maintenance of the structures will be made easy.

Decentralized water control structures such as small weirs, check dams etc., should be constructed in a number of strategic locations below all the major surface irrigation systems.

2.Redefining the watershed programmes and tank management

There are about 12,85,000 tanks with varying sizes in the country with a storage capacity of 50 million cubic meters. The tanks are deteriorating resulting in poor performance. Restoring these traditional water bodies and promoting water harvesting should receive major developmental support. In the case of watershed programs like Desert Development Programme (DDP), National Watershed Development Programme for Rainfed Areas (NWDPRA), Integrated Watershed Development Programmes (IWDP), Drought Prone Areas Programme (DPAP) and the like, water resource development activities have been promoted by GOI, but often in isolation ignoring the rainfall pattern.

Action plans

In the case of regions receiving less than 700 mm rainfall, the watershed development activities should be restricted to *in situ* moisture conservation and livestock only. In the case of regions with more than 1000 mm rainfall, watershed activities should aim at providing more storage structures for supplemental irrigation (like tanks) facilitating crop and aquaculture as the main components. Regions with 700- 1000 mm rainfall should follow a mix of soil conservation and storage structures with a focus on crop and livestock. Also location of the check dams and percolation ponds should be within 300-400 metres distance from the concentration of wells in order to get maximum recharge from the structures. The watershed committee should be exposed to do this. The watershed guide lines should accommodate these norms. Further, about 10 percent of the total investment in watersheds and soil conservation should be allocated for development and fine tuning of technologies for sustainable land management.

In the case of tanks, partial desilting should be attempted and sluice rotation and sluice management strategies should be introduced by revitalizing the traditional waterman community. Catchment treatment including supply channel maintenance are important in getting the rainfall runoff to the tanks. The irrigation department and the local panchayats should be empowered to do this. Proportionate reduction in cultivated area and or change in crop pattern towards non-rice crops should be implemented during poor monsoon years. Rainfall forecasts should be effectively used to predict likely nature of tank filling.

Non-systems tanks should be converted into system tanks by linking the river systems wherever possible.so that surplus water during heavy rains can be diverted to the tanks easily. The tank- chain should be restored to facilitate for the diversion of water from upstream tanks to downstream tanks. In all the future government spending programs on tanks, this should be made compulsory.

II. Demand management

Demand management through improved irrigation practices, including sprinkler and drip irrigation should receive priority attention. A water literacy movement should be launched and regulations should be developed for the sustainable use of water resources. Main streaming and up-scaling the technologies are important. The technologies that could help produce more crop and income per drop of water are discussed below with the needed action plans.

1. System of Rice Intensification

"**System of Rice Intensification** (SRI)" involves the use of certain management practices, which together provides better growing conditions for rice plants, particularly in the root zone, than those plants grown under traditional practices. Four components of SRI include early planting (12 days old single seedlings, wider spacing), limited irrigation (2-3 cm depth after the appearance of hairline cracks), weeding and application of more compost and building soil organic matter content.

The principles of the SRI have been well taken care of and the management practices are appropriately adjusted to suit the farmers' need and local situations. Age of seedling, spacing, fertilizer application, inter cultivation for soil aeration and water management practices are suitably modified for farmer friendly adoption and yield improvement. SRI is being practiced in states like Tamil Nadu, Andhrapradesh, Karnataka in South India and sporadically followed in few Eastern states like Tripura and Assam. Under present situation, our country can not afford to grow rice with intensive use of scarce natural resources like seed, water and labour. Simplification of SRI methodology and up scaling this innovative approach through out the country alone could sustain the irrigated rice cultivation in future.

Box. 4. More Crop and Income Per Drop of Water : Strategies for Jharkhand

S.K.Paul
PAU,Jharkand

The state has total water resources of 28,781 million cubic metres (MCM) including 23,789 MCM (82.66%) of surface and the rest 4,992 MCM (17.34%) ground water. The total utilization of surface and ground water achieved in the state so far is 4776 MCM and 1328 MCM respectively. The unutilized water resources work out to be 19103 MCM surface water (80%) and 3664 MCM ground water (73%). This is not a happy situation so far as the useful utilization of precious water resources is concerned and speaks of "scarcity amidst plenty". Total rainfall of the state (1200 mm) is more than sufficient to raise 2-3 crops satisfactorily, but its distribution is highly skewed, with more than 80% of the rain occurring during four monsoon month (June-Sept.) restricting the farmers with no other choice except to grow only one rainy season crop and rest of the year their land remain fallow in absence of the irrigation water. For efficient utilization of water resources under rolling topography and lateritic soils, appropriate interventions should be made. These include (i) Rain water harvesting and recharge of the aquifer, and (ii) Efficient use of the harvested water.

Rain water harvesting and recharge of the aquifer: (I) There is need to identify different water shed related projects and an attempt should be made to develop a mechanism for their unified monitoring, evaluation and impact; (ii) Evaluation and impact assessment of different soil and water conservation structures already constructed and trials of different tank linings for effective storage of water; (iii) Through mobilization of community, old traditional water bodies like village ponds should be rejuvenated and renovated; (iv) Mobilization and formation of small farmer's group having contiguous fields contributing run off to one common point for enabling single storage structure and development of mechanism for efficient reuse of harvested water. For example, farmers with medium and large land holding should construct water harvesting structure at different elevation so that irrigation can be provided to the adjoining lower field without any power requirement. Whereas, this should be practiced on cooperative basis for small and marginal farmers; (v) Cooperative water harvesting structure may be promoted on common barren lands at the village level and the harvested water should be shared among the villagers; (vi) Farmers should be encouraged to keep some portion of his/her land for wells or pond to harvest and conserve the rainwater falling on his land **"*Khet ka pani khet mei*"**. Marginal farmers who could not afford to have pond in their field should be encouraged to have at least one well in their field, which can support at least a second crop. Whereas, it should be mandatory for the small, medium and large farmers to construct water harvesting structure in their land as per their capacity and (vii) Farmers should also be encouraged for land development including *insitu* soil and moisture conservation measures like land leveling, deep ploughing, field bunding, contouring, contour strip cropping, cultivation across the slope, and use of soil conserving vegetations like "*Khush*" on the bunds for conserving water where it falls.

Efficient use of the harvested water include : (i) It is necessary to facilitate the farmers to form a SHGs for production of high value crops; (ii) Integration of micro irrigation systems with water storage structures so as to efficiently use harvested water; (iii) Introduction of different kinds of micro irrigation systems including Drip, Surface drip, Drip tape, Sub surface drip, Micro sprinklers, foggers and misters etc. in vegetable production (Projected Horticulture), hybrid and high yielding varieties of vegetable and high value crop will be another plus in enhancing the productivity and production from limited water resources; (iv) Ground water should be used rationally only where water can not be stored or conserve or there is no source of surface water availability; (v) Conjunctive use of rain, river and ground water should become the principal method for the effective use of available water resources; (vi) Cropping system of any agro-climatic region should match the water requirements and water availability. Under water scarce area, high value non-cereal crops, which are mostly water intensive crops should be given priority and (vii) Suitable cropping systems need to be developed keeping in mind the water availability for maximum productivity and income per drop of water for different agro-climatic situation.

Benefits of SRI Technology.

SRI is another term for sustainable rice intensification.

- Less seed rate: A seed rate of 5-8 kg depending on 1000 grain weight is sufficient to plant one hectare of land under SRI while in conventional method depending upon the duration group, 60 kg ha^{-1} – short duration, 40 kg ha^{-1} – medium duration and 30 kg ha^{-1} – for long duration varieties and 20 kg ha^{-1} – for hybrids is recommended.
- Less nursery area: A mat nursery area of 2.5 cents (100 sq.m) is sufficient to raise seedlings to cover one hectare of land in SRI while in conventional methods, 20 cents per hectare is required.
- Labour saving: The labour required for nursery period is less (12 labourers) for SRI nursery compared to conventional nursery (30 labourers).
- Water saving: Water requirement under SRI method is only 600 to 700 mm through intermittent irrigation while in conventional method, 1200 – 1500 mm of water is required for continuous flooding.
- Aeration: Conoweeding results in aeration to the root zone besides saving in labour to the tune of 50%.
- Enhanced yield: The additional yield advantage in SRI ranges from 500 to 1500 kg / ha over conventional method of planting. The reason is mainly attributed to more number of lengthy productive tillers with increased number of filled grains per panicle.
- Control of malaria: By avoiding flood irrigation and adopting limited irrigation, the breeding of malarial mosquito in rice fields is checked.

In the recent past no single technology had revealed such a tremendous increase in productivity excepting through release of improved variety/hybrid. The success is mainly due to the ideal crop establishment with effective soil and crop management.

Action plans

A. Improving drainage conditions of rice fields

The major reason for the low adoption rate of this management-oriented technology is the landscape and poor drainage facility existing in the rice growing regions especially in the deltaic situation. Crop establishment with young seedlings, nutrient use efficiency and soil aeration and crop growth are primarily depending on the drainage facility.

1. Mass desilting programme to improve the storage of inland reservoirs
2. Cleaning of the canals for easy drainage
3. Construction of water harvesting structures to store the draining water at appropriate place
4. Restructuring field bunds to have proper inlet and outlet for easy drainage
5. Farmers' participatory research cum demo on improved water management techniques

B. Production of healthy rice seedlings

1. Training to the extension personnel and farmers on production of healthy and robust rice seedlings through modified rice mat nursery or improved conventional nursery method
2. Development of community mat nursery for larger scale distribution and motivating farmers
3. Training to the farm labourers on raising mat nurseries

C. Crop establishment

1. Organizing demonstrations on proper land leveling for successful crop establishment
2. Enhancing the accessibility of farmers to modern leveling equipments on rental basis/at subsidiary rates
3. Training to the farm labourers on square transplanting rice seedlings

4. Intensifying research on evolving simple mechanized transplanter to plant single seedling per hill
5. Developing direct sowing technology so as to establish rice crop with single seedling per hole to by-pass nursery and transplanting stages.

D. Soil and water management

1. Supply of cono rotary weeders at economic price.
2. Demonstrations to illustrate the significance of the cono weeder operation
3. Fabrication of motorized cono weeder for easy operation
4. Training to the farmers on the adoption of intermittent irrigation
5. Large scale demonstrations to illustrate the benefits of intermittent irrigation in comparison with continuous flooding.

The measures suggested are only extension approaches for promoting large-scale adoption of the SRI method of rice cultivation, except the fabrication of motorized cono weeder. Research efforts are already initiated to simplify the inter cultivation tool for easy operation in the field. Breaking the mind-set of the farmers through motivation and ‘seeing is believing’ approach is the pre-requisite for up-scaling this innovative crop, soil and water management approach.

As success in Tamil Nadu, the SRI was demonstrated in large-scale demonstration at the Edamelaiyur village of New Cauvery Delta Zone during 2002-2003. On seeing the initial response and record yields from the Cauvery Delta farmers, the Govt. of Tamil Nadu had sanctioned a scheme during 2003-2004 for popularizing this innovative rice cultivation method in the Cauvery and Tamirabarani river basin area. The adoption of SRI technology during 2005-06 was only 10-15% of the rice area in Tamil Nadu. During current year (2006-07), 2500 numbers of one-acre demonstrations trails in farmer’s field have been organized. It is proposed to cover 25% of the irrigated area in the state with SRI method of cultivation.

All the state Governments should initiate action in popularizing the SRI wherever possible. In particular, Agricultural universities and state agricultural departments should develop special programs on SRI including training and capacity building components. The irrigation departments should ensure proper water control through efficient water allocation methods.

Similarly, The SRI method should be explored for other crops where potential exists. The aerobic and upland rice technologies should also be expanded wherever suitable.

2. Micro Irrigation with fertigation

In India, the area covered under micro irrigation is about 5 lakh hectares. Among the states, Maharastra is the leading state under micro irrigation followed by Karnataka, Andhra Pradesh and Tamil Nadu. Micro irrigation is very popular in 30 different crops especially in wide spaced horticultural crops. Drip irrigation is an effective tool for conserving water resources and studies have revealed significant water saving ranging between 25 and 50% by drip irrigation compared with surface irrigation, with yield increases as high as 100% in some crops under specific locations. The rain gun irrigation system has to be appreciated in light of the current irrigation practices. Rain gun is a powerful mega sprinkler that throws a large amount of water (up to 500 liters per minute) to a good distance (radius of 90 feet and even more) as artificial rain.

Fertilizers applied under traditional method of irrigation are not efficiently utilized by the crops. Once investment on micro irrigation is made, it is very easy to achieve the full benefits through the next ultimate step called as fertigation. Fertigation is a coined term to irrigate and give fertilizers along within. In other words, fertigation is addition of fertilizers to irrigation water and application via micro irrigation systems.

Economics of micro irrigation and fertigation

The cost for installing drip irrigation varies from Rs. 20,000 to 25,000 per ha for wide spaced crops like coconut, mango etc. to Rs. 50,000 to 70,000 per ha for closely spaced crops like sugarcane, cotton, vegetables etc. It is observed that the pay back period is about one year for most of the crops and the benefit cost ratio varies from 2 to 5.

It is worked out that Rs. 30,000 per ha will be the investment with micro sprinkler and rain gun irrigation with improved management technologies and in all the cases the system is viable for more than 10 years under good maintenance. The pay back period is 2-3 years only indicating the viability of the investment.

Box.5 Technologies for improving crop productivity and income in Kashmir region

(Prof Anwar Alam, Vice Chancellor,
Sher-E-Kashmir University Sciences and Technology of Kashmir)

Raised bed farming maintains aerobic conditions and the irrigation in furrows saves irrigation water by about 35%. In temperate region water from the Kool or glacial melt are to cool, holding them in 10-15 cm deep layers before application in the evening increases productivity.

Instead of concentrating on irrigated areas, irrigation should be extended to unirrigated areas where dividends are much more. Saffron a high value crop in Kashmir is raised under rainfed conditions. Studies at SKUAST-K have revealed that micro-irrigation @ $70m^3$/ha in 10 irrigations during reproductive period increases productivity by over 50%. Apple in Kashmir is raised on karewas under rainfed conditions with average productivity of 10t/ha whereas under irrigated condition productivity is easily about 30t/ha. some harvest as high as 50-60 t/ha. Pressurized irrigation system need to be created in Kashmir karewas to realize their potential. Plastic mulching in apples increases productivity by 25%. Temperate regions have great prospects of surface covered cultivation. Strawberry under low cost poly-house natured 45 days earlier than outdoors and productivity increases substantially. Nursery raising and vegetative propagation under poly house conditions is efficient and economically rewarding, enable raising when the outdoor conditions do not permit. For efficient use of water and energy proper stop planning is essential. Areas where water is to be lifted from great depth better to raise crops of low water requirement, drought tolerant crops.

Box.6 Drip Fertigation in Sugarcane : Experiences from Tamil Nadu

S. Mahendran
Tamil Nadu Agricultural University
Coimbatore-641003.

Experiences with the farmers who have already adopted this technology shows that the cane yield can be increased up to 150 to 200 t ha^{-1} compared to the cane yield of 80 – 120 t ha^{-1} registered under conventional method of cane cultivation. Available results on the adoption of MIS to sugarcane crop resulted in a water saving of 25 to 40 %. One of the impact study conducted at Maharastra on the use of drip irrigation to cane crop clearly indicated that by using drip irrigation to cane crop, the yield can be increased by 20 to 24 % compared to non- drip adopted cane crop with a net profit Rs.25,000/- to Rs.30,000/- ha^{-1}, which works to 67 - 83% higher net profit. The water saving was also to the tune of 41 – 47 % under drip irrigation compared to flood irrigation that means an additional area of 0.7 – 0.91 ha can be brought under additional irrigation. The study also reveals that drip irrigation consumes only 12.77 horsepower (HP) hours of water to produce one ton of sugarcane as against 28.28 HP hours of water under flood method of irrigation. Further it is also understood that under drip irrigation the electricity saved was 40% compared to flood irrigation because of the fact that to produce one ton of cane 9.5 kwh power is required as against the non-drip adopters consumption of 21.21 kwh to produce the same one ton of cane. Hence drip system has enormous advantages not only to save irrigation water but also to save electricity and the cost of cultivation besides increasing the cane productivity. In addition to this adoption of drip fertigation technology will result in manifold benefits to all the partners involved in this industry.

Technology from TNAU for Cultivation method under drip fertigation

1. 30 x 30 x 30 / 105 paired row double side planting or
2. Pit method of planting (1.5 m x 1.5 m x 0.3 m dia)
3. 125 to 150 % N & K of the recommended dose as urea and MOP in 14 equal splits in 15 days interval
4. Irrigating the crop once in 2 to 3 days based on ETc
5. System maintenance is most important for efficient drip fertigation

From Farmers perspective

1. Higher cane yield up to 150 to 200t ha^{-1} with a water saving of 25 – 40 % .
2. Night hour irrigation is possible.
3. Drip fertigation to cane crop is not only suitable for drought prone areas and also for high water available areas since this technology is designed for higher cane productivity in unit time and space.
4. Problem soils with poor quality irrigation water can also be brought under cane cultivation with high returns if drip fertigation is introduced for cane cultivation.

The State govt. and Govt. of India will get additional revenue of around Rs.193.73 and Rs. 256.05 per ton of cane rushed at 9.5 % recovery and thus the total revenue to the government works out to Rs. 454.78 / ton of cane crushed. At this rate of income to the government, the total revenue will be around Rs.1248.50 crores and thus leaving a net balance of Rs. 526.64 crores after meeting the expenditure made by the government on subsidy to farmers at 50 % level and after fifth year onwards the government will get an additional income of around Rs.1248.50 crores every year if 2.0 lk ha have been brought under cane cultivation. Introduction of this drip fertigation results in income generation to the tune of around Rs.190 to 253 crores to the agricultural labourers who are depending on this industry and also result in an additional net return of Rs.550 – 575 crores to the cane growers. Introduction of drip fertigation to cane crop will definitely result in water saving to the tune of 25 to 40 per cent and this will in turn leads to electricity saving. Introduction of drip fertigation to cane crop in 2.0 lk will result in a net saving of around Rs.89.60 crores per year through electricity saving which is again a big saving to the government. The entire implementation of the programme can be implemented and monitored by the Directorate of the Micro Irrigation which has to be created for this special purpose that has to be given required powers to operate the entire programme.

Acton plans

The past research work done in different parts of the country has clearly indicated the potentials for large scale adoption of micro irrigation and fertigation techniques in the country for increasing the yield and quality with substantial water and nutrients saving.

Leading micro irrigation companies in the state/ district can be identified and implementation of the system at farm level can be entrusted. After adjusting for the subsidy component, the company can also arrange for easy loans for balance amount to the farmers while installing the system. Monitoring mechanisms by the university department along with the beneficiaries should be done. After successful implementation, Government can release the money to the company. The precision farming approach successfully implemented by the Agricultural University in Tamilnadu state can be experimented in other states.

Agricultural Universities will impart training on micro irrigation and fertigation to various stake holders.

Establishment of model irrigation cafeteria in all research stations to demonstrate various technologies.

Conducting multi disciplinary research on fertilizer scheduling for fertigation, nutrient dynamics, cost reduction in system and impact evaluation.

Low cost greenhouses using fertigation techniques should be popularized. The National and State level bodies, especially the Land Use Boards, should render proactive advice to stakeholders on crop planning in accordance with meteorological and marketing factors.

Marketing facilities or tie-up arrangements can be made with the retail shops or whole sale units so that farmers can benefit due to higher prices.

3. Soil Health

Soil health is 'the capacity of soil to function as a vital living system, within ecosystem and land use boundaries, to sustain plant and animal production, maintain or enhance water and air quality and promote plant and animal health'. Healthy soil functions optimally through balanced interactions amongst its biological, physio-chemical and mineral components. The average productivity of most crops grown in Tamil Nadu is between 25-60 per cent of the potential yield. The gap between potential and actual yields of crops is mainly due to poor soil health, unfavorable / unforeseen climatic conditions and poor agro technology adoption *etc*.

Declining soil health is closely linked through unfavorable alterations in physical, chemical, biological and hydrological activities and mismanagement by human. If the consequences of these activities are not adequately managed, the stability of soil's ecosystem for the next generations will be jeopardized. The decline in soil productivity is primarily due to adverse changes in nutrient status, soil organic matter, structural attributes and toxic chemicals.

On an average, 20 kg N, 4 kg P and 18 – 22 kg K ha^{-1} are removed from the soil to produce one ton of cereal grains per hectare. With the possibility of horizontal expansion or putting more land under cultivation being remote, future augmentation in yield would have to be harnessed vertically through judicious management of all the input resources. The production of food grains for the past one decade has either declined or remained static. The reasons for poor soil health may be attributed to decline in the organic matter content in the soil and use of imbalanced fertilizer.

In the light of above facts, it is necessary to draw action plan to supply sufficient and balanced nutrients to the crops through Integrated Nutrient Management(INM), which will enhance the yield of crops to the desired level besides ensuring sustained soil fertility and soil health.

Action Plan

i). **Establishing STLs at block level –** To ensure balanced fertilization through IPNS, mini STLs at block levels have to be established. Agricultural universities will bring awareness about the need of STLs among the farming communities and impart training on the establishment of STLs, analytical techniques, soil health cards and Decision Support System for Integrated Fertilizer Recommendation (DSSIFER) software. The mini soil testing laboratories will be linked to existing soil testing laboratories for further monitoring.

ii). **Composting of off farm / animal wastes –** An ecofriendly way of effective utilization of on-farm and off-farm wastes in agriculture is composting. Technologies on vermi composting, coirpith composting, sugarcane trash composting and biomanure production developed can be popularized by establishment of composting cafeteria. These outlets can train the extension workers, NGOs, SHGs and small and medium farmers on the effective way of using the farm wastes as manures.

iii). **Composting of solid wastes –**Crude dumping is normally resorted by local bodies without adopting scientific and hygienic approach of sanitary land filling. For example, nearly 10,000 tonnes of garbage is generated per day in Tamil Nadu and this can be converted to viable compost by establishing various compost yards viz., community compost yards, institutional compost yards and industrial compost yards which may yield around 2250 tonnes of compost per day. Annual production of municipal compost would be 8,21,250 tonnes with an area coverage of 65, 700 ha/ year @ 12.5 t/ ha. The NGOs, SHGs and housewives can be trained on the collection of domestic wastes and composting and the municipal workers will be trained on solid wastes composting. The self help groups already engaged in composting may be included for training to improve the quality of composting with a more scientific outlook. Demonstration trials will be conducted in municipal compost yards, supply of bio inputs viz., Effective microorganisms extracts (EME) and bio mineralizer and quality analysis of municipal compost for heavy metals and human pathogens, training on safety precautions to be adopted at composting are the technology interventions. The industrial functionaries can be linked with Agricultural universities to learn the know-how on composting of agro-industrial wastes. The maturity and quality of the compost will be monitored by the scientists. The quality check will help to screen the toxic wastes from entering into food chain, by recommending its application to forest trees and non edible crops. The community compost yards will mitigate the problem on solid wastes disposal and the nutrient potential of the agro-industrial wastes. The successful progress of the compost yards at various levels will provide environmental security.

iv). Green manure production – The application of green manures will promote integrated plant nutrient supply system. However, the lack of quality green manure seeds hinders this approach. For example in Tamil Nadu 22 lakh hectare of paddy fields, 152 lakh tonnes of green manure is required. The requirement of green manure seeds is 1 lakh tonnes but unfortunately we are unable to supply even 25 % of the seeds to cater to the needs of the farming community. Setting up of green manure production units by KVKs, NGOs and farmers will ensure quality green manure seed production. The Extension Officers will create awareness among farmers to take up intercropping of green manures in crops like sugarcane, cotton, coconut *etc*. which results in a yield increase by 20 to 25 per cent.

v). **Biofertilizer production units** - To enhance the use and to meet the demand of biofertilizers, biofertilizer units at research stations can be established using Self Help Groups (SHG) and agricultural graduates. This will motivate the different groups to start their own biofertilizer production units. The proposed biofertilizer units can also supplement the biofertilizer production requirement in the states, which will ensure sustenance of soil health. The quality testing of biofertilizers produced by non-governmental organizations will be carried out at Agricultural University centres.

Box. 7. Strategies for More Crop and Income per drop of water: CRIDA's views

GR Korwar, KV Rao and YS Ramakrishna
Central Research Institute for Dryland Agriculture (ICAR),
Santoshnagar, Hyderabad-500059.

Improving the income and water productivity through water harvesting and supplemental irrigation in high value rainfed crops.

- CRIDA has identified dominant rainfed districts for various crops with opportunity for water harvesting for supplemental irrigation during dry spells or for pre sowing irrigation during the rabi crop. About 11.4 mham. surplus is available for harvesting from those districts.

- **Rainfed rice uplands in Central and Eastern India** generate large amount runoff. Opportunity exists for harvesting of the runoff, which would not only protect rainfed low lands from water logging but also provide supplemental irrigation during dry spells.

- Water productivity can be enhanced by supplemental / pre-sowing irrigation with harvested water **in soybean cropping system,** as potential for water harvesting is high.

- Suitable interventions in these districts through small-scale water harvesting systems can be taken up immediately. The interventions would ensure both assured availability of water, better management practices and increased use of inputs thus increasing the water productivity.

- Promotion of *in-situ* conservation technologies with need based water harvesting in **semi arid areas in Peninsular and Western India.**

- New technologies of irrigation (Drip and sprinkler) to increase the application efficiency in existing perennial plantations (fruit trees) in **semi arid areas in Peninsular and Western India.**

- Water user groups to be created in rainfed areas for ensuring efficient utilization of available resources (both surface and ground water) within a watershed including minor irrigation schemes (on the lines of water user associations in canal command area)

- Organizing awareness among farmers on water use by crops through participatory monitoring (especially in rainfed regions of South and western India)

- Promotion of integrated farming system like fish-duck-rice cropping system can be taken up in **humid areas of Eastern India.**

vi). Promotion of Integrated Farming System – This aims to integrate farming activities, animal, poultry and fisheries production in such a way that the crop and animal residues are recycled to the soil. Inclusion of animal component in the farm system brings additional income to the farmers in addition to nutrient recycling into the lands. Standard IFS models suitable to dry land, garden land and wetland conditions can be popularized. The system also ensures production of atleast 5 tons of organic matter in one acre of land, which can supplement for the soil health sustenance by setting up seven model units at regional stations of agricultural universities. These units can offer training to the farmers of the region, school teachers and children on IFS, benefits of nutrient recycling and ways of additional income generation.

In this context, Land Use Boards both at Central and State level could play a vital role, but have not done much in the past and need to be suitably restructured, strengthened and activated. There is an urgent need for a National Land Use Advisory Service, linked to State and Block Level Land Use Advisory Services.

4. Crop diversification and multiple uses of water

The return per unit of water is varying across the regions and crops. In the high rainfall regions of eastern India, there is scope to increase the income through crop and fish activities. In the hard rock regions of south India, there is scope for increasing the income through farming systems approach. Successful experiences of the rice and fish cultures should be explored.

ICAR has estimated the economics of various categories of Aquaculture as under:
carp polyculture with a return of Rs 75,000 with a low input to as high as Rs 3,00,000 per ha per year with high input use with an employment of 180 man days on labour. In the case of integrated fish farming, the return was about Rs 100,000 per ha per year with a 240 man-days per ha per year labour employment. In the case of other culture fisheries, the return was ranging from Rs 135,000 with carp-prawn farming to Rs 225,000 per ha per year with prawn farming.

The ‘contract farming’ model of agribusiness is gaining momentum. However, usually devoid of formal contract between the farmers and the prospective buyers, the arrangements could be biased in favour of the agribusiness organization. But, there are beneficial effects of such arrangements to the farmers in the matter of access to adequate/timely credit, good quality inputs, new technology, employment generation, introduction to new crops, separation of production and marketing risks and better farm practices etc. Special care needs to be taken regarding clauses dealing with quality standards, withdrawal conditions, pricing standards, paying arrangements and arbitration mechanism.

The state governments should initiate appropriate steps in popularizing the farming systems approach through effective extension systems. Separate funds can be allotted in experimenting the interventions in several locations with proper marketing facilities.

Action plans

State governments should initiate programs to promote crop diversification activities through demonstrations and adaptive research trials in several locations. The concept of village adoption scheme should be promoted by the state Agriculture department. Adequate support for marketing and market information be given to the farmers. Contract farming model should be encouraged.

Coastal regions: About 10 million ha. are water logged in coastal Orissa, Andhra Pradesh, West Bengal and Bihar. Water stagnates on the surface upto 75 cm depth for 3-4 months. Digging out aquaculture ponds raised about 35% of the area under embankment by 1-1.5 metres. Growing fish and prawn in dugout ponds and fruits and vegetables in embankments and rice in part of the farm

5. Weather based crop insurance programs

Climate change leading to adverse changes in temperature, precipitation and sea level is no longer just a theoretical possibility. Most experts agree that we are already beginning to experience the impact of global warming as evident from the melting of glaciers and Antarctic and Arctic ice caps. Coastal storms and cyclones are also increasing in frequency and intensity. Droughts and floods are likely to be more frequent. Although climate change is a product of the unsustainable consumption of non-renewable forms of energy by industrialised countries, the harmful impact of climate change will be felt more by poor nations and the poor in all nations due to their limited coping capacity. Steps will have to be taken to standardise proactive measures that can reduce the vulnerability to climate change. Based on computer simulation models, contingency plans and alternative land and water use strategies will have to be developed for each major agro-climatic zone. Protecting the livelihood security of farm and fisher women and men from adverse climatic changes has to become a priority task. In drought and flood prone areas, experienced farm women and men can be trained as **Climate Managers.**

The national capacity in short-, medium- and long-term weather forecasting is quite considerable. What is now important is to convert generic information into location- specific land use advice, based on cropping patterns and water availability. The Agro-meteorological Advisories issued by Indian Agromet Advisory Service Centre, Pune, can be used by **Panchayat Level Farm Science Managers**, trained to give appropriate land use suggestions. Also, the **National Land Use Advisory Service**, recommended by NCF in its Third Report, would help to make the information relevant to both farm and fisher families. In the case of marine fisheries, data on wave heights and location of fish shoals are now available. These will have to be transmitted to the fishermen before they move into the sea. An integrated internet – FM or HAM radio service would be very helpful to fishermen on the high seas.

Timely and dependable advice on weather conditions will be very helpful to farm families to plan their sowing and the other operations. The National Land Use Advisory Service in collaboration with Panchayat Level Farm Science Managers can help to bring the benefits of the advances in agricultural meteorology to farm and fisher populations.

Weather based crop insurance is a protection for losses that may arise due to abnormal weather conditions. These abnormal weather conditions can be events such as excess of rainfall, shortfall in rainfall or variations in temperature, wind speed and humidity. Varsha Bima 2005, a rainfall based insurance scheme for farmers has been launched by the Agriculture Insurance Company of India Limited in 10 selected states. However, the insurance is based on the total quantity of rainfall of a season rather than the distribution which plays greater role in crop production. Equally accountable damage to crop can be expected by excess rainfall which was not considered in the present scheme.

The Indian monsoon is diverse and varies very widely in spatial and temporal manner owing to the tropical location of India. Hence, dense weather data is required for successful weather based insurance. The presently available district level data will not give sufficient information to operate the weather based insurance due to highly varied spatial variance of weather. Since, the present observation does not require any claims and the variability may likely to create confusion among the parties involved and there are chances that either of them may be a looser for non availability of record. Hence, a dense network of weather station at block level will help both farmers and insurance company in a big way.

For example, Tamilnadu Agricultural University (TNAU) is issuing medium range weather forecast at five locations of Tamil Nadu in collaboration with National Centre for Medium Range Weather Forecast (NCMRWF), New Delhi since 1993. It also issues the location specific seasonal climate forecast for both South West Monsoon and North East Monsoon for more than 40 locations of Tamil Nadu since 2002. Now with the help of Indian Space Research Organization (ISRO), Bangalore, it is establishing Automatic Weather Stations (AWS) with satellite link at 45 locations in Tamil Nadu. These facilities will help the University to develop the location specific seasonal and medium range weather forecast at block level. Besides for issuing crop insurance, the dense weather data will be highly useful for preparing seasonal climate forecast through which a farmer can take strategic decisions and medium range forecast for tactical decisions.

Drought is more frequent (once in three years) and occasional floods are causing heavy damage to the crops and livestock. Such features are highly location specific, and these climate extreme events have to be predicted well in advance for individual locations to develop necessary management options. Understanding of weather and weather based agro advisories is complex and requires a special skill by the farmer. This complexity can be overcome by developing block level Farm Science Managers and village level Climate Managers through specific trainings.

In the Rainfall Distribution Index (RDI) based insurance, the farmers can be provided with the appropriate compensation based on the actual crop losses and hence neither the farmer nor the Insurance Company will put in to trouble.

We should also develop specific proactive action plan in the form of Drought, flood and Good weather codes, which can strengthen the capacity of local communities to cope with the adverse effects of drought and floods, and at the same time increase the ability to maximize the benefits from good monsoons. For example, in desert areas, a good weather code will help to strengthen the ecological infrastructure of the arid zone during the occasional years when there is good rainfall, as during the south-west monsson period of 2006

Box. 8 More Crop and Income per drop of water: Gujarat experience

M.C. Varshneya
Vice Chancellor
Anand Agricultural University, Anand

Gujarat has constructed 1 lakh from ponds and 75,000 check dams with people's participation in last 4 years. Therefore, area under Kharif and Rabi cultivation has increased from 95 to 115 lakh ha. In Saurashtra, the water table has increased substantially because of recharging and rain harvesting. Due to this the pumps which used to run for 2 hours a day now runs for more than 8 hours a day. The heros who controlled the drought by water harvesting technologies are the silent crusaders. Shri Mansukhbhai Sawagia of Jamka village in Junagadh district has constructed 51 check dams with people's participation, now formed a Jalkranti Trust, have guided 4800 villages for constructing farm/village ponds and check dams. There are crusaders like "Premji Bappa". Spreading the message of "Plant a tree and get rain". He is educating villagers to recharge open wells. Shri Chhaganbhai of Bhenkra village in Savarkundala taluka of Amreli district started the watershed development by blocking the water drains by mud and stones, resulted in all the village wells flowing with water in peak summers. Mr.Shyamjibhai Antala, the reviver through "Saurashtra Lok Manch" has taken the task of reviving the dry wells in drought prone Bhavnagar and Amreli district and other parts of Gujarat. Even the states of M.P. and Rajasthan are soughting his expertise in bringing about awareness in the people in their states. Gujarat Krishi Mahotsav was launched by Government of Gujarat in 2005 and 2006, wherein scientists of Agricultural Universities visited village to village and spread the technologies, which helped doubling agriculture income of the farmers. Gujarat has made a noteworthy initiative to promote micro irrigation by establishing Gujarat Green Revolution Company with 1500 crores and to cover 20,000 ha with a target of 1 lac ha.

Potential farmers like : Mr.Gunvantbhai R. Patel of Sarsa village of Anand, having 25 ha. has installed drip in 23 ha. He is growing Banana in 10 ha yielding 60 tons/ha with an average bunch size of 30 kg. The maximum bunch is of 60 kg. Potatos in 10 ha and fodder in 3 ha. He has doubled his income. Narsibhai Patel of Nayaka village of Kheda district has 8 ha drip installation and grows only vegetables like Bitter guard, Brinjal, Tomato, Chilli and Okra. He used to earn 40 to 50 thousand Rs/ha now earns 90 thousand/ha. Similar are many more examples of the potential users of pressurized irrigation systems.

Derol Drilled paddy Research Station has released G-9 variety of drilled paddy in 2005-06 having a productivity of 2.5 tons/ha and having a high water use efficiency. Many farmers have been benefited from it. The production of cotton was 27 lakh bales 6 years before, which has now increased to 89 lakh bales/year due to more area under irrigation, development of high yielding new varieties and improved technology. The area which was 26% four years before is now 32% because of proper water resource management. The state is having an expansion of output for fruits and vegetables. A model for providing support for the produce is developed by NDDB. The same model can be replicated. Gujarat is setting up a perishable air cargo complex at Ahmedabad, International Air port as a special export zone (SE_2) for mangoes, sapota, vegetables and onion.

It is expected that Gujarat will leave no stone unturned to achieve more than 4% growth in Agriculture so that 11% over all growth rate is achieved in 10th Five Year Plan of India.

Action plan

1. In each of the blocks in the country, an Automatic Weather Station (AWS) capable of measuring required weather parameters with satellite link can be installed. The AWS can be linked through satellite with the help of Indian Space Research Organization
2. Besides AWS, ten strategic locations will be selected in each block by identifying a co-operative farmer and rain gauges will be fixed to create a dense network of rainfall observations to narrow down the spatial and temporal variability.
3. Rainfall Distribution Index (RDI) will be worked out at block level considering the quantity and distribution of rainfall, number of rainy days, critical crop periods and cumulative rainfall received over the crop growing season at fortnight interval. Based on the RDI values, crop loss compensation can be fixed and sent to the insurance agencies to enable them to dispatch the compensation to the farmers without being claimed by farmers.
4. The central unit will develop location specific seasonal and medium range weather forecast along with the required distribution, onset and withdrawal of rainfall and will be placed in the university website for use by the Farm Science Managers.
5. Farm Science Graduates is needed to be placed at block level to make this weather information into Agro Advisory Service (AAS) Bulletins and for which they have to be trained suitably. The training on weather and its influence on crop production, forecast interpretation, converting forecast information into AAS, drought and flood and their impact on farming, mitigation of extreme weather events, soil and water conservation measures, drainage etc. will be given with necessary reading materials for their continued reference.
6. Experienced farm women and men will be selected from each of the villages to act as Climate Managers for communicating weather information to the farmers of their locality. Necessary training will be imparted to these Climate Managers by the Farm Science Manager on importance of weather, extreme weather events and their influence on crop production, use of weather forecast, mitigation technique etc.

6. Credit, insurance and market reforms

Since Independence, the flow of institutional credit to agriculture, mainly from co-operatives, has increased by manifold. After bank nationalization, there was a phenomenal growth in commercial banking activity through the expansion of rural branches. The share of commercial banks in total institutional finance to agriculture has increased from 21 per cent during the seventies to about 65 per cent in 2004-05, while the share of co-operatives has come down from 79 per cent to 25 per cent during the same period and the remaining 10 per cent of the credit during 2004-05 was provided by RRBs. The percentage of agricultural credit to agricultural GDP has also increased from 5.4 per cent during seventies to 15 per cent in 2003-04. The wide variations in the development of rural banking were due to the regional differences in resource-endowments especially the irrigation potential, rural infrastructure - other than banking, agro-climatic conditions and so on.

Institutional agricultural credit is a vital input required for capital formation and adoption of new agricultural technologies and in turn for enhancing crop productivity, income and employment. The institutional credit is favoured by weaker sections of the farming community because of its better terms of credit besides the subsidy component of it.

The Self Help Group - Bank linkage approach was introduced by the National Bank for Agricultural and Rural Development in February 1992 as a pilot project realizing the lacunae in credit delivery as well as recovery system of institutional lending agencies. The NABARD's efforts to improve the access of the rural poor to formal banking service through SHGs gathered momentum over the years.

Further, it has been targeted to reduce the poverty ratio by five per cent by 2007 and by 15 per cent by 2012. This heavy task of poverty alleviation could not be achieved unless the rural institutional credit system is strengthened. This becomes inevitable because the institutional credit agencies form a vital channel through which a larger portion of the government welfare funds is flown to the weaker sections of rural community.

Box 9 Precision Farming Project : Experiences from Tamil Nadu

A. OBJECTIVES

- To empower farmers and farmers associations.
- To prepare the farmers for marketed Agriculture.

B. PHYSICAL AND FINANCIAL SIZE

☼ 400 ha

☼ Rs 720 lakhs

☼ Dharmapuri and Krishnagiri District

☼ 2004-05 to 2006-07.

C. TECHNOLOGIES

a. Commercial net house nursery
b. Drip and fertigation
c. Chisel plough
d. Remote sensing
e. Market feedback mechanism
f. Buy-back tie-ups
g. Market sensitization to farmers
h. Buyer sensitization at production site

D. ACHIEVEMENTS

- Yield maximization 40-60%
- Buy-back tie-ups with 9 firms
- Brand promotion
- Water economy 40%
- Empowerment of farmer's organizations/associations
- Produce quality: 25% more weight/unit volume

In order to make the rural credit system development oriented and efficient, an action plan may be designed and operationalized on the following lines:

The lending rate for agricultural loans (crop loan, medium term and long term loans) extended by co-operatives may be subsidized and fixed at 4 per cent upto a loan amount of Rs. 25,000 and at 6 per cent for loans exceeding Rs. 25,000.

'Kisan Credit Cards (KCC)' may be issued by PACBs to all those farmers who regularly repay loan.

Housing Loans for farmers for construction or repairing of houses may be extended at a lending rate of 6 per cent per annum.

Self Help Groups may be provided with adequate credit facilities for taking up production and processing of agricultural commodities. SHGs comprising of farmers may be organized and assisted in adopting new farm technologies and also in establishing agro- based processing units for value-addition. Subsidies may be provided to cover part of the project cost to SHGs for growing horticultural crops, bio-fuel crops, agro-forestry and silvi-pasture in waste lands. SHGs may also be encouraged to take up dairying, poultry and sheep / goat rearing. These SHGs may be encouraged to establish retail outlets in urban, semi urban areas and also in farmers' markets. For taking up all the above said activities, liberal institutional credit may be provided on project basis.

In white areas, the SHG members comprising of farmers can be encouraged to operate and maintain minor irrigation projects and drip irrigation system jointly.

The economic viability of farming depends heavily on assured markets and remunerative prices. Direct sale by farmers and absence of farmers' organizations to reach volumes and protect the interests of the small producers result in reduced income to the farmers. Organized marketing was promoted through a network of regulated markets. A massive programme for creation of the marketing network was taken up. As on 31st March 2004, as many as 7418 markets had been brought under the ambit of regulated markets. Most of these markets are wholesale markets. In addition, out of 27,294 rural periodical markets [village haats, shanties etc], nearly 15% function under the regulated framework. The basic objective of setting up the network of markets was to protect the interests of the farmers and eliminate various malpractices of the traders. Fair play and transparency in transactions was aimed at. Most of the State Governments and the Union Territories enacted legislations (APMC Act) to provide measures for development of agriculture produce markets.

Box.10 Action points for "more crop and income per drop of water" with special reference to Assam conditions

(N.N. Sarmah, Assam Agricultural University, Jorhat)

All Existing farm ponds and community tanks may be renovated and where existing ponds are not available, new ponds may be constructed with financial support form the government. These ponds may be utilized for integrated farming systems involving fisheries and live stock components along with crop production for increased farm income and water productivity.

Waterlogged areas may be developed by excavating ponds to introduce integrated farming systems. Vegetables and other rabi crops may be grown in the surrounding dykes created by excavated earth with application of necessary irrigation from the pond. Installation of shallow tube wells (STWs) and low lift points (LLPs) may be intensified through out the state of Assam.

Cold storages for agricultural products may be established in rural areas. Cool chains may be maintained from producers to retail markets. Unemployed youths may be supported to open small-scale cold storages in rural areas and operate cool vans for carrying perishable commodities.

Box.11 Strategies for Rain Water Management : Experience from Maharashtra

S. A. Nimbalkar, Vice-chancellor,.P.D.K.V., Akola S. M. Taley,
Director, Agroecology & Environmet Centre,
Dr.P.D.K.V., Akola

Vidarbha is mainly rainfed farming region largely subjected to the vagaries of monsoon with instability of yields and incomes. In Maharashtra, even after harvesting of full irrigation potential both from surface and ground water resources about 70 percent of the cropped area in the state will remain subject to the uncertainties of the monsoon. Almost three fourth of the cultivated area in India and even in Maharashtra state is non irrigated and this results the large annual fluctuations in crop production.

The in-situ recharge of rain water which calls for land treatments in such a fashion that the rainfall gets recharged in to the soil profile and it becomes available to the crops and trees during prolonged monotonic break. This required efforts of every farmer to go for in situ soil and water conservation and limited harvesting in view to have sustainable development in productivity and environmental development. The treatments include (i) Inter cropping system, (ii)Sowing across the slope, (iii) Contour seeding & cultivation and (iv) Water conservation ditches in vertisols.

Experiences show that higher insitu soil and water conservation as well as productivity can achieved by adopting intercropping systems, across the slope sowing and cultivation in flat lands and contour sowing and cultivation in medium and shallow soils having multiple direction land slope.

Action plan

A credit – linked agricultural developmental plan for a homogenous area (a panchayat) can be prepared in co-ordination with bankers, farmers, traders, processor, exporters, NGOs, panchayats and government development departments for implementation.

Research on various credit – linked issues such as estimation of demand for credit for different regions / districts, estimation of scale of finance, problems in delivery and recovery of loans (timeliness, transaction cost and utilization) and reasons for overdue, may be taken up on a continuous basis.

Evaluation of rural development programmes financed by banks can be undertaken.

Studies can be undertaken to assess the crop loss due to natural calamities and the extent of benefits reaped by farmers out of the existing crop insurance scheme.

In view of the supply side constraints, the need for orderly functioning of the markets and protecting the interests of the producers and consumers, besides the APMC Acts various other legal enactments were promulgated by the Centre and the State Governments overhauling farmers' markets is required. Amendments to APMA, as suggested by the Union Agriculture Ministry, need to be carried out by State Governments as soon as possible. There is also need for introducing focused Market Intervention Scheme and also market intelligence cells. The model of the DEMIC should be replicated in other regions.

Different crop insurance products (weather based) can be designed and implemented to mitigate the impact of natural calamities on farm income. To have reliable data on rainfall, automatic weather stations may be established in all the block head quarters.

IV. Structures for Implementation

The Prime Minister has emphasised that "we need greater emphasis on research that can increase the efficiency of utilization of inputs; that can improve farm management practices; that can reduce post harvest losses through better post-harvest management technologies in storage, transportation and processing; that can, in the final analysis, increase both yields and value addition at the farmer level leading to better incomes, especially of the small and marginal farmers."

The following three tier set-up is suggested:

Level	Responsibility
Village level	Gram Sabhas will perform the role of *pani panchayats*. Water management groups with technical support from Agricultural Universities. Water users groups and pani-panchayat should have linkages. Gram panchayats launch water literacy movement through Gyan Chaupal Train one woman and man as Water Masters.
State level	Interdisciplinary/inter departmental Task Force on More crop & income per drop of water
National level	Pan-GOI Steering committee on More crop and income per drop will comprise of representatives of MOWR, Agrl,& Animal Husbandry, ICAR, Rural Development, Panchayat Raj, Planning Commisson, National Rainfed Area Authority, National Fishery Development Board, Environment & Forest, Commerce, Finance, National Commission for Women, NABARD, Agricultural Universities & Associations, few tech. Experts, mass media rep. The national level Steering Committee may report to the Agricultural Coordination Committee chaired by the Prime Minister.

Water Supply Management : Long term options

Of the major sources of irrigation, research results indicate that groundwater irrigation efficiency in the country is higher compared to surface sources aided by dams and tanks and distributed through canals. In many areas where groundwater is the only option, its exploitation far exceeds the recharge potentials and only limited scope exists for expanding groundwater irrigated area. Surface sources offer potentials in two major ways. Present irrigation efficiency of the canal system in the country is estimated to be only of the order of around 40 percent implying that the created potentials could serve a larger area/ user industries if its usage efficiency could be improved. Various efforts have been made in this direction with moderate success rates.

Another viable alternative exists in geographical optimization of the rainfall receipts and usage. Considerable imbalance exists in terms of receipts and usage among locations within the country. Inter basin transfer of water resources could therefore be a need of the future to meet the supply demand gap across regions. Efforts have been initiated over many decades to document such transfer potentials and to draw up implementable schemes. Difficulties however, crop up on socio-political grounds. National consensus needs to be evolved to move forward through informed public debate in an apolitical and rational sense, though it may be an inherently slow process. The broad contours of such a move should include acceptance of national character of water resources, in principle inter basin water transfers on technical assessments and on a win-win basis for the States concerned, bringing water under concurrent list of the constitution, creation of a technical national surface water authority with perhaps regional wings, and creation of speedy arbitration mechanism to resolve disputes.

V. Recommendations to the XI Plan

These are indicative of the programmes needing attention and do not represent an exhaustive list.

Supply Augmentation:

Bench marking of all the irrigation projects

Focused investment in territory water control measures

Revised water harvesting norms as per the rainfall ranges

Refocusing ponds and tanks as main water harvesting components

Demand Management:

Programs to expand the area under SRI and Drip fertigation

Programs to improve soil health

Programs on weather based crop insurance and market improvements

Programs on capacity building on water management technologies

Income Enhancement:

Post -harvest technology

Value-addition through agro-processing

Bio-mass utilisation

Further, among the projects to be supported during the XI Plan Period, a Research Network on Biotechnology and Water Security as indicated below is recommended.

Research Network on Biotechnology and Water Security:

Biotechnological approach is becoming increasingly important in addressing the problems of the water security facing agriculture, environment and human health in the coming years. Advances in biotechnology have tremendous potential to save water, principally by reducing water consumption of plants and by treating wastewater. Current research trends suggest that in a few years from now, we will have complete genome structure in many of the higher plants and micro-organisms. It is also likely that functions of many genes will be known in a foreseeable future that will allow engineering of desirable traits for production of transgenics which could be utilized for addressing problems of water stress and treatment of waste water. Contrary to the simple genetic traits, water stress resistance is governed in a polygenic fashion that hinders the practical application of the information available. This requires for concerted effort and bringing together the expertise comprising of breeders, genetic engineers, physiology and biochemical experts in a continuously interactive network. This would ensure that the benefits of biotechnology advances are utilised in addressing several issues pertaining to water security in the coming years.

Role of Biotechnology in Drought and Salinity Stress Research needs:
Understanding genetic and physiological determinants
Perception of Stress
Signal transduction
Gene activation
Protein expression

Likely Impacts:
Crops for marginal land
Increased productivity
Crops with less chemical and fertilizer inputs
Crops which need less water
Crops for saline soil

Policies:
Education for water use
Public participation in promoting research
Long-term commitment and sustained support
Role of Biotechnology in Water Quality & Waste management

Research Needs:
Biochemical pathways for contaminant degradation
Microbial stability in biotreatment systems
Microbial ecology of consortia
Scaling-up of microbial processes including field studies of new detection/ remediation techniques
New detection methods combined with in-situ monitoring packages
Understanding genetic structure of key remediation organisms
Low technology application in general waste water treatment

Likely Impact:
New biotechnology methods for purifying water that was previously not practically treatable
Process integrated technologies where biotech options replace chemical options
Decrease requirement and cost of water purification
Developing tools for reclamation of degraded land
Improvement of water quality

Policies:
Foster application of available technology
Incentives for improvisation of new technologies
Awareness of the value of clean water
Fines for polluters (polluter pays principle)
Incentives for effective water use
Foster public/private partnership

VI. 2007-08 (June 1, 2007 to May 31, 2008) – "Year of More Crop and Income Per Drop of Water"

In order to create wide spread awareness of the uncommon opportunities available now with technologies on the shelf for increasing the productivity and profitability of agriculture, the Agriculture Year of 2007-08 may be declared as the "Year of More Crop and Income Per Drop of Water". During this year starting with a kharif of 2007, 5000 Farmer Participatory Action Research Programmes may be initiated throughout the country with the help of appropriate Agricultural Universities, ICAR Research Institutes, ICRISAT and WALMIS. 50 such Institutions may be entrusted with the responsibility of organizing jointly with farm families 100 Action Research Programmes each for demonstrating that it is now possible to increase yield and income per drop of water through generating synergy among water, variety, agronomic practices, particularly relating to macro and micronutrients in the soil, and implements. Each programme will cover a minimum of one hectare and will be implemented in a participatory mode, with the farm family having a sense of ownership of the programme.

The emphasis will be on rainfed areas where catalytic technological and management interventions will be introduced to make a striking impact. The programme will be so designed that a small Government Project leads to a mass movement in the area of water conservation and use efficiency, as happened in the case of National Demonstrations in Wheat during 1964-65. The economic benefit to the farmer as a result of this programme should be measured. Each Action Research Programme will need about Rs.50,000. Thus the total cost of 5000 Farmer Participatory Action Research Programmes will come to Rs. 25 crores. A well planned Water Literacy Drive together with the revitalization of traditional systems of water conservation will also be undertaken as a part of this programme. Also, Action Research Projects in irrigated areas will aim at phasing out flood irrigation by the end of the 11th Plan.

We urge that such a Farmer Participatory Action Research Programme may be initiated during 2007-08 in arid, semi-arid, hill, coastal and irrigated areas. The necessary financial provision may be made in the Union Budge for 2007-08.

VII. Implementation Structure with agencies

Management options	Thrust areas	Options	Programs	Implementing Agencies
Supply augmentation	Priority for modernization of the territory canals with control structures			Implementing State Government Agencies
	Redefining the watershed programmes and tank management	Restoring these traditional water bodies and promoting water harvesting	*In situ* moisture conservation only in the regions with less than 700 mm rainfall	Watershed Committee
			Providing more storage structure in regions with more than 1000 mm rainfall	Watershed Committee
			Mix of soil conservation and storage structures in regions with 700-1000 mm rainfall	Watershed Committee
	Decentralized water control		Number of small weirs, check dams , tanks below the surface irrigation projects	Irrigation department
	Tanks maintenance	Partial desilting, sluice rotation and sluice management, Catchment treatment and supply channel maintenance		The Irrigation Department And The Local Panchayats

		Non-systems tanks should be converted into system tanks, The tank- chain should be restored. Change in crop pattern depending on the tank storage	Enabling WUA to design strategy	The Irrigation Department & Agricultural department
Demand management	System of rice intensification	Improving drainage conditions of rice fields		The Irrigation Department/CADA/CADP
		Production of healthy rice seedlings		Agriculture Department
		Crop establishment		Agriculture Department
		Soil and water management		Agricultural Engineering Department
	Micro Irrigation with fertigation	Implementation of the system at farm level with private public participation		Agricultural Engineering Department
		Training on micro irrigation and fertigation		SAUs/ Agriculture Department
		Establishment of model irrigation cafeteria in all research station		SAUs
		Research on fertilizer scheduling for fertigation, nutrient dynamics, cost reduction in system and impact evaluation		NARS/SAUs

		Marketing facilities or tie-up arrangements		Agricultural Marketing Department
	Soil Health	Establishing stls at block level		Agriculture Department
		Composting of off farm / animal wastes		Agriculture Department
		Composting of solid wastes		Agriculture Department
		Green manure production		Agriculture Department
		Biofertilizer production units		Agriculture Department
		Promotion of Integrated Farming System		SAUs/ Agriculture Department
	Crop diversification and multiple uses of water	Crop and fish activities	Crop and fish culture demonstrations	Agriculture Department
			The rice and fish cultures	Irrigation /Fisheries Department
			‘contract farming’ model of agribusiness	Agricultural Marketing Department
	Weather based crop insurance programs	Timely and dependable advice on weather conditions, location-specific land use advice	Automatic Weather Station (AWS)	Panchayat Level Farm Science Managers
			Rain gauges in selected farmers fields	Panchayat/Agrl. Dept/Climate Managers
			Rainfall Distribution Index (RDI)	Climate Managers
			Agro Advisory Service (AAS) Bulletins	Climate Managers

	Credit, insurance and market reforms	A credit – linked agricultural developmental plan for a homogenous area		Cooperative /Commercial Banks
		Research on various credit – linked issues		SAUs
		Evaluation of rural development programmes		SAUs

VIII. Options for more crop and income per drop of water across regions based upon the suggestions of the members of the sub-committee

States	Supply management		Demand management		Others
	Modernisation of irrigation projects and tertiary control	Watershed management and tanks	System of Rice Intensification (SRI)	Micro irrigation	
Andhra Pradesh		*		*	SH, PIM, SSDS, CD
Assam		*		*	SI, IFS
Gujarat		*		*	
Jharkhand		*		*	IFS
Karnataka		*	*	*	
Maharashtra		*		*	IFS
Punjab		*		*	
Tamil Nadu	*	*	*	*	SH, PIM, MIB
West Bengal	*	*	*	*	CB
Semi arid areas of Peninsular and Western India		*		*	
Rainfed rice uplands in Central and Eastern India					SI
Humid areas of Eastern India.					IFS
India	*	*	*	*	MIB, PRI, LWRC, IFS,SCM, IR

SI: Supplemental irrigation
IFS : Integrated Farming System
CB : Capacity Building
MIB : Micro Irrigation Board
PRI : Panchayat Raj Institution
SH : Soil Health
PIM : Participatory Irrigation Management
LWRC : Less Water Requiring Crops
SSDS : Sub-surface drainage system
SCM: Supply Chain Management
IR : Interlinking of rivers at national level
CD: Crop Diversification

Composition of the Sub Committee

1.	Prof. MS Swaminathan	Chairman
2	Representative of Ministry of Rural Development, New Delhi	Member
3	Dr. Pratap Narain, Director, Central Arid Zone Research Institute, Jodhpur, Rajasthan –342003	Member
4	Dr. SP Wani, Principal Scientist, ICRISAT, Hyderabad	Member
5	Dr. B.R. Yadav, Professor, Water Technology Center, IARI	Member
6	DR.GR Korwar, Head, Division of Resource, Central Research Institue for Dryland Agriculture, Santosh Nagar, Hyderabad – 500059	Member
7	Shri S. Sen, Coordinator (Development Projects), Consideration of Indian Industries (CII), 249, F, Sector-18, Udyog Vihar, Phase-IV, Gurgaon PIN-122015	Member
8	Dr. S. Ayyappan, Chief executive Officer, National fishery Development Board, New Delhi (Member)	Member
9	S.K. Jain, Scientist 'D', CGWB, Faridabad (Member)	Member
10	Representative of Ministry of Agriculture, Krishi Bhavan, New Delhi	Member
11	Dr. K Palanisami, Director, CARDS, TNAU, Coimbatore	Member
12	Dr. J.C. Katyal, Vice Chancellor, Chaudhary Charan Singh Haryana Agricultural University, Hisar – 125004	Member
13	Shri S. Sen, Coordinator (Development Projects), Consideration of Indian Industries (CII), 249, F, Sector-18, Udyog Vihar, Phase-IV, Gurgaon PIN-122015	Member
14	Shri S.M. Sood, Chief Engineer(IMO), CWC	Member Secretary
15	Dr. S K Pal, Professor-cum-Chief Scientist, Agronomy, Birsa Agricultural University, Kanke, Ranchi – 834006	Co-opted Member
16	Dr. SM Taley, Director, Agro-ecology and Environment Center, Panjabrao Deshmukh, Krishi, Vidyapeeth, Krishinagar, Akola-444104	-Do-
17	Dr B. Bhaskar Reddy, Acharya NG Ranga Agricultural University, Rajendranagar, Hyderabad – 500030	-Do-
17	Dr. MP Kaushal, Prof. & Head Deptt of Soil & Water Engineering, PAU, Ludiana.	-Do-
19	Dr. H.C. Sharma, HOD, Irrigation and Drainage Engineering, GB Pant University of Agri & Tech, Pantnagar – 263145	-Do-

20	Dr. N.N. Sarmah, Chief Scientist, Assam Agricultural University, Jorhat	-Do-
21	Prof Anwar Alam, Vice Chancellor, Sher-E-Kashmir University Sciences and Technology of Kasmir, Shalimar Campus, Srinagar – 191121	-Do-
22	Dr. HE Shashidhar Metahelix Life Sciences Private Limited 3, KIADB 4th Phase, Bommasandra, Ban	-Do-
23	Shri BS Ahuja, Member (WP&P), Central Water Commission, New Delhi	-Do-
24	Dr. J S Samra, Dy Director General (NRM), Indian Council of Agricultural Research, Krishi Bhavan, New Delhi-110001	-Do-
25	Prof. MC Varshney, Vice Chancellor, Anand Agricultural University Anand – 388110	-Do-
26	Dr. S.L. Mehta, Vice-Chancellor, Maharana Pratap University of Agriculture & Technology, Udaipur.	-Do-
27	Prof S. Mallick, HOD, Agricultural Chemistry and Soil Science, Bidhan Chanrda Krishi Viswavidyalay, Mohanpur, Nadia –741252	-Do-
28	Shri CS Ramsesha, Commissioner (GW), MOWR, New Delhi	-Do-
29	Dr. Usha Barwale Zehr, Joint Director (Research)- Maharashtra, Hybrid Seeds Co Ltd, Jalna, Maharashtra	-Do-
30	Dr. KK Narayanan, Managing Director- Metahelix Life Sciences Pvt. Ltd, Banglore	-Do-
31	Dr. CR Hazara, Vice- Chancellor, Indira Gandhi Krishi Viswavidyalaya, Krishak Nagar, Raipur – 492006	-Do-
32	Mr. Tushaar Shah, Project Leader – IWMI	-Do-
33	Dr. N N Singh, Vice Chancellor, Birsa Agricultural University, Kanke, Ranchi – 834006	-Do-