Technical Brief 1

Evaluating the use of DHI software MIKE Basin to optimize the water use in Malaprabha catchment area in Karnataka, India.

Technical Briefs are short summaries of models used in the project aimed at a non-technical audience. The aim of the PES India project is to assess feasibility criteria for schemes for payments for environmental services (PES), particularly watershed services(PWS). In order to test such feasibility criteria the project is carrying out a number assessments on different issues regarding water supply services in the Malaprabha river basin. This includes land use scenario analysis using hydrological and water allocation models; evaluation of water conservation measures by upstream land-users, and the legal and institutional feasibility of Payments for Watershed Services schemes.

In this technical brief we report from modelling of Malaprabha river basin. Modelling has been done related to water users as irrigation and drinking water. Modelling results will be used identify optimal water allocation scenarios in the catchment.

Mike Basin has been chosen as water allocation tool for the PES project in Malaprabha river basin (Shrinivas Badiger et al., 2007). The decision criteria were:

1. ability to use remotely sensed land-use and land cover information
2. ability to use spatially distributed hydro-meteorological data
3. ability to represent in a reasonable way surface and sub-surface interaction
4. user-friendliness in set-up and implementation.
5. not too demanding in terms of input data

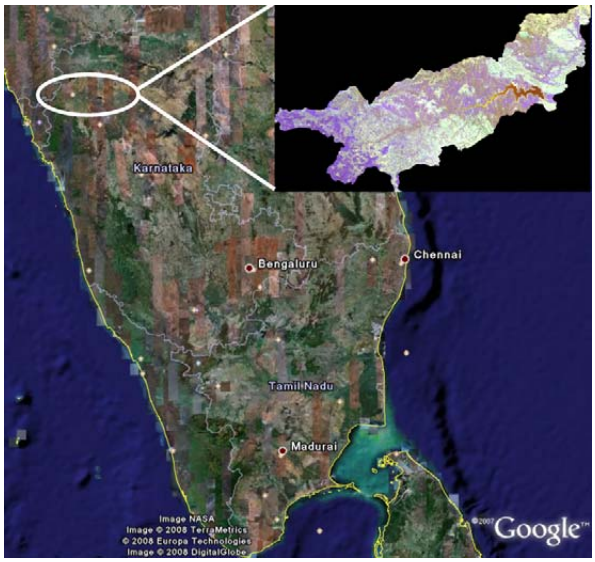


Figure 1 Malaprabha river basin situated in Karnataka, India. Source: Google Earth.

Mike Basin in general (Source: DHI Website)

MIKE Basin is a software package developed by Danish Hydrologic Institute, DHI. MIKE Basin uses the ESRI software ArcEditor as a basis

The model is a versatile, GIS-based decision support tool for integrated water resources management and planning. Mike Basin is used for addressing water allocation, conjunctive use, reservoir operation, or water quality issues.

Mike Basin couples the power of ArcGIS with comprehensive hydrological modelling to provide basin-scale solutions. The Mike Basin philosophy is to keep modelling simple and intuitive, yet provide in-depth insight for planning and management.

For hydrological simulations, Mike Basin builds on a network model in which branches represent individual stream sections and the nodes represent confluences, diversions, reservoirs, or water users.

Typical areas of the Mike Basin application are:

- Water availability analysis: conjunctive surface and groundwater use, optimization thereof.
- Infrastructure planning: irrigation potential, reservoir performance, water supply capacity, waste water treatment requirements.
- Analysis of multisectoral demands: domestic, industry, agriculture, hydropower, navigation, recreation, ecological, finding equitable trade-offs.
- Ecosystem studies: water quality, minimum discharge requirements, sustainable yield, effects of global change. Regulation: water rights, priorities, water quality compliance.

Input data for a Mike Basin simulation.

The following elements can be given as input to Mike Basin:

- Rivers represented by river reaches and nodes
- Catchment area represented by an area
- Reservoirs of 3 different types: lakes, rule curve reservoirs and allocation pool reservoirs
- Water users, including irrigation, represents any user that abstract, consumes and returns surface and/or groundwater.
- Hydrological information

Calibration of the model is based on observed discharge.

Malaprabha river basin

The Malaprabha river basin is situated in the state Karnataka. The basin rises in the Western Ghats to an altitude of 792 meters above sea level.

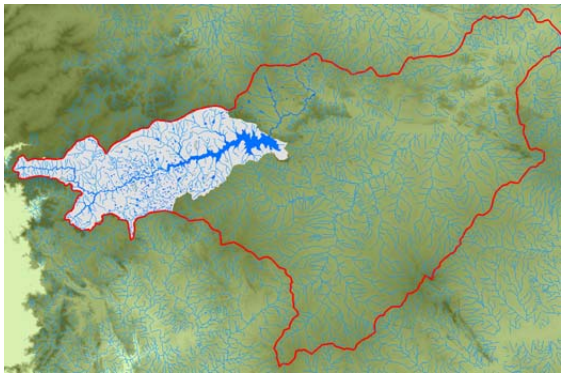


Figure 2 Malaprabha river basin and the Mike Basin modelling area

The Malaprabha modelling area in the PES India project ends in the Malaprahba Dam in the outlet of Malaprabha reservoir. The Malaprabha River is approximately 110 km long, and the total catchment area of Malaprabha reservoir is 2204 km^2.

There are an extensive number of irrigation schemes in the basin. To make the model more userfriendly and simple – irrigation schemes have been grouped according to crops and water use in addition to the geographic placement of the scheme.

In MIKE Basin, the Malaprabha river basin has been divided in two main parts regarding grouping of irrigated agriculture: upstream Kanaphur and downstream Kanaphur km2. In addition, the irrigated command areas withdraw water directly from Malaprabha reservoir are included in the model.

Upstream Kanaphur 85% of the area has no irrigation at all, and the area is mostly covered by forest. 11 % of the area has irrigation intensity of 12.5% and 5% of the area has irrigation intensity of 50%. Downstream Kanaphur 86% of the area has no irrigation. 8% of the area has irrigation intensity of 12.5%, 6% has irrigation intensity of 50% and 1% has 25% irrigation intensity.

The command area withdraws water from Malaprabha reservoir by The Malaprabha Right Bank Canal (MRBC) and Malaprabha Left

Bank Canal(MLBC). MRBC has irrigation area of 1280 km2 and the MLBC has an area of 530 km2. Malaprabha reservoir is also the water source for lift- irrigation schemes located on the foreshore of the reservoir (Figure 2).

FIgure 3 shows land use and the spatial distribution of land use. The western parts of the basin are mostly covered by forests. The area marked red/pink is where there is irrigated agriculture land.

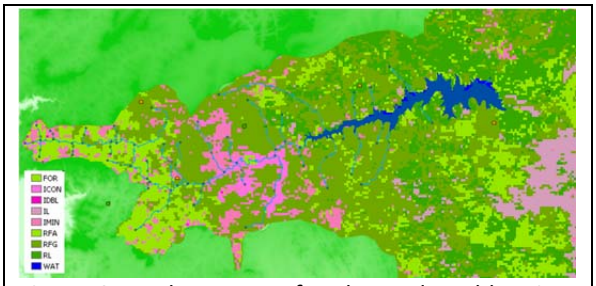
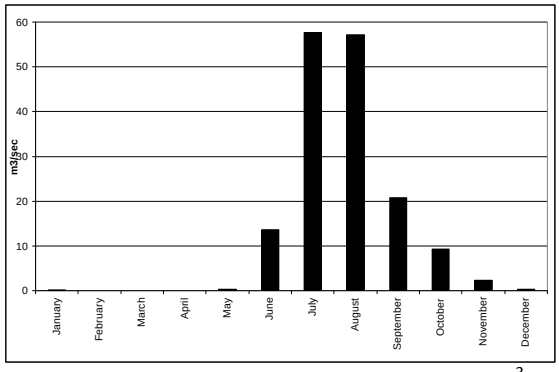


Figure 3 Land use map for the Malaprabha river basin as a whole

Cat. Code	Descriptive name	Irrigation intensity
Not given	Unknown land use	No irrigation
FOR	Forests	No irrigation
RFG	Rainfed and groundwater Agriculture	No irrigation
IMIN	Minor Irrigation	12.5 % irrigation
IL	Supplemental Irrigation	25 % irrigation
ICON	Continuous Irrigation	50 % irrigation
RL	Range Land (grazing)	No irrigation
RFA	Rain fed Agriculture	No irrigation
WAT	Water Body	No irrigation
IDBL	Irrigated Area with Double Cropping	100 % irrigation

There is only one discharge station in the modelling area called Kanaphur. In our modelling we use monthly average discharge for the period 1973-2003.



Figur 4 Long term monthly average flow [m^3/s]. Timeperiod 1973-2003

Mike Basin for Malaprabha river basin

There challenge in Malaprabha river basin is to distribute water for upstream versus downstream irrigation while satisfying domestic water demand.

Malaprabha river basin has been divided in 3 sub-catchments regarding runoff inflow to the modelling area; upstream Kanaphur, downstream Kanaphur and Malaprabha reservoir. The map below shows the approximate catchments. These areas will be updated according to results in the hydrological model SWAT. The main river channel runs from west to east and the model ends in the Malaprabha reservoir. Model river reach is marked in blue.

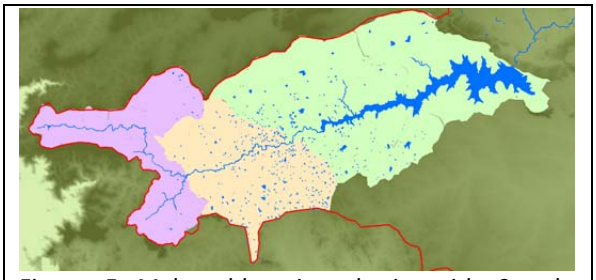


Figure 5 Malaprabha river basin with 3 sub-catchments

Figure 5 gives the schematic map of the basin. Green points are irrigation schemes, orange points are water users like drinking water. Irrigation schemes upstream the Malaprabha reservoir have been grouped and are represented by a single water user. The same

applies to irrigation schemes downstream Kanaphur. Lift irrigation is also represented as a water user in the model . These three irrigation water users withdraw water according to a water demand time series. If there is not enough water to meet the demand, the deficit will be given as a modelling result.

Included in the Mike Basin model are the two large irrigation schemes that extract water from the Malaprabha reservoir, respectively Malaprabha Right Bank Canal (MRBC) and Malaprabha Left Bank Canal (MLBC). These schemes extract water according to irrigation water demand. Irrigation water demand is calculated based on precipitation, evapotranspiration, soil information and crops and crop patterns.

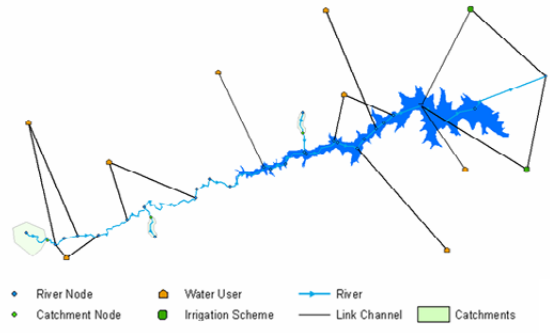


Figure 6 Schematic overview of the Mike Basin model for Malaprabha river basin

Domestic water users are Kanaphur, Hubli-Dharwad, Sampgao, Bailhongal and Saundatti

The Karnataka State Policy recommends 100 lpcd (liters pr capita pr day) for domestic uses. This amount also includes groundwater extraction. However, we do not know the exact proportioning of this. In the Malaprabha model we will try to make an approximate proportioning of 1/3 as groundwater and 2/3 of river or reservoir extraction.

Water balance in the basin has been investigated based on hydrologic conditions and different kinds of water use. The Mike Basin model has been calibrated to meet the discharge timeseries at Kanaphur.

Challenges

Like all models the quality of the output/results are determined by the quality of the input. Bad quality of input parameter will always give bad quality results, but good quality of input parameters will not always give good quality results. The quality of the results is determined by both input data and by the modelling procedures. Input data is the main challenge for the Malaprabha river basin. Lack of observed measures and updated landuse maps will result in uncertainty regarding the results. Input runoff is in the Malaprabha river basin given in monthly values and the results will therefore not give detailed results on daily basis. High or low values will not be seen since measures and results will be given as average values.

Data

To construct a water allocation model that can reflect the nature as good as possible, the following inputdata is required:

- Digitalized river reaches with correct river lengths
- Inflow to the model for the different catchments.
- Correct amount of water used for waterusers

With these a simple water allocation model can be constructed. To improve the quality of this model the following objectives can be included:

- evaporation
- seepage
- lakes and reservoirs (including the operation of reservoirs)

Practical information about the programme:

Mike basin work on a GIS platform developed by ESRI and requires a valid license for Arc GIS Editor in addition to a valid license for DHI Mike Basin.

The licenses can be bought from local DHI offices and from local ESRI offices.

www.esri.com
www.dhigroup.com

There exists user guides for both programmes and a user with basic knowledge about GIS and water allocation modelling should be able to set up a simple Mike Basin model.

ESRI provides training courses in many levels and DHI has training courses in Mike Basin. It is “å anbefale” to attend these courses to learn the different possibilities that the model contains.

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References:
Shrinivas Badiger (CISED), Tor Haakon Bakken (NIVA) (2007). Integrated River Basin Modeling Framework to support Payments for Watershed Services.