

HighNoon Delivery Report D5.1

Title	Report on sensitivity analysis indicator framework
Work Package Number	WP5
Delivery number	D5.1
Relevant task(s)	Description of the indicator framework Sensitivity analysis of the indicator framework
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Date of completion	30 April 2010
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Submission Date	30 October 2010

Abstract

Work Package 5 develops an indicator framework to characterize the current state and to evaluate impacts of proposed adaptation measures. The current deliverable describes examples of suitable indicators and is a first attempt to apply a few selected water quantity indicators.

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1 Introduction

The HighNoon project assesses the impact of Himalayan glaciers retreat and possible changes of the Indian summer monsoon on the spatial and temporal distribution of water resources in Northern India, and provides recommendations for response strategies that strengthen the cause for adaptation to hydrological extreme events.

Work Package 5 develops an indicator framework to evaluate the impacts of proposed adaptation measures in northern India. The indicators will be used to describe the current status of land and water resources and to assess the effectiveness of adaptation measures across scales and sectors.

Indicators can be used to systematically assess natural resources in a temporal and spatial manner. They can help to understand the extent to which water resources are managed to meet the social, economic and environmental long term needs. The use of indicators in the water sector has become more important in recent years, and legislations have given prominence to indicators as management tools in the water sector. Nowadays a wide range of indicators is available to describe the various aspects of water management such as utilization, production, environment and economy.

The indicator framework that will be developed in Highnoon shall be based on the framework developed under the EU 6th Framework Aquastress project (<http://www.aquastress.net/>), and will be adapted to Highnoon case study conditions. The framework is a combination of two parts:

- An indication of the level of water stress resulting from sectoral demands, and
- An assessment of the available water supply.

Indicators will be calculated at both basin level and case study level. For each case study a specific set of indicators will be selected with stakeholders. The data needed to quantify the indicators will be a combination of model output (SWAT, LPJmL) and collected field data from other work packages. Figure 1.1 illustrates how WP5 is linked to other work packages within Highnoon.

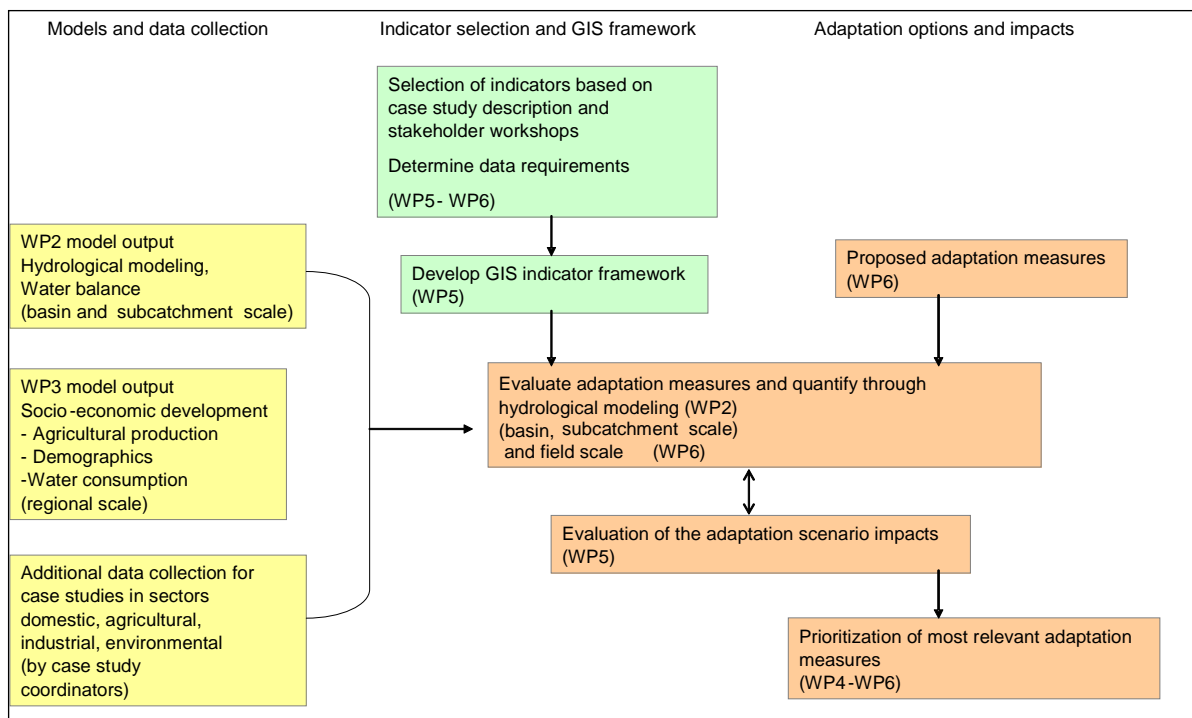


Fig 1.1 WP5 within the project

2 The indicator framework

2.1 Examples from other projects

Within the AquaStress project, an integrated indicator framework was developed. AquaStress is an EU financed integrated project (2005-2008) of the 6th Framework Programme (<http://www.aquastress.net/>). The overarching goal of AquaStress was to improve the understanding of water stress from an integrated multi-sectoral perspective, and for this reason, a Water Stress Framework was developed. Below a short explanation of this framework is given.

The framework is composed of two parts (Figure 2.1): the Integrated Sectoral Water Stress Index (ISWSI), which is the part of the framework able to capture the level of water stress resulting from sectoral demand, and the Potential Margin (PM), which is an assessment of the available water resource supply. The potential margin indicates the degree of dependency on local and imported water, and the safety margins remaining available.

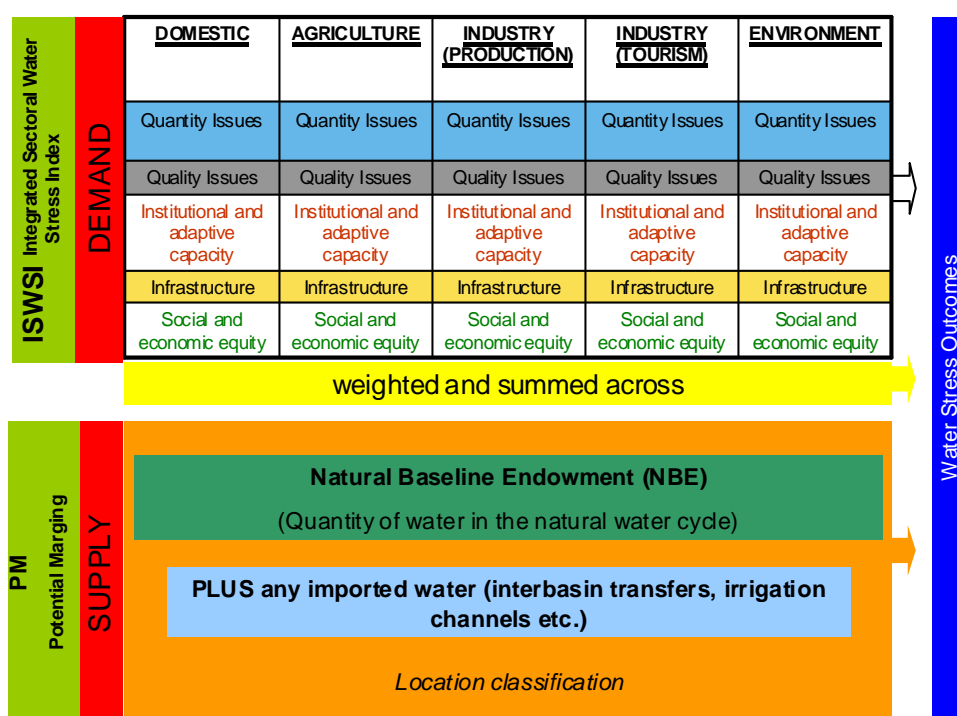


Fig 2.1 The Aquastress indicator framework

The Integrated Sectoral Water Stress Index, (ISWSI) shows the level of water stress across the different sectors and the type of stress associated with each sector. The major anthropogenic sectors to be considered within water management decisions are: domestic, agricultural, industrial, and tourism (which also includes services). In addition to these four sectors the environment is included, to ensure that a certain degree of water is allocated to the environment to enable ecological integrity.

An overview of indicator types for different sectors is given in Table 2.1, whereas Table 2.2 provides an overview of indicators for the agriculture sector.

Table 2.1 Example of indicator types for various sectors

Sector	DOMESTIC	AGRICULTURE	INDUSTRY	TOURISM	ENVIRONMENT
Impact					
Water quantity	Domestic water demand	Crop water demand	Industrial water demand	Water use intensity	Environmental flow
Water quality	Quality norms	Salinity	Water treatment	Quality norms	Waste water pollution load
Adaptive capacity	Water regulation	Water saving technologies	Recycling	Water saving technologies	Protected areas
Social Economy	Economy of water suppliers	Farm size dispersion	Labour-related water intensity	Labour-related water intensity	Nature protection

Table 2.2 Example indicators for agriculture (AquaStress indicator framework)

SECTOR	ACRONYM	INDICATOR NAME	DESCRIPTION
AGRICULTURE	IrrDep	Irrigation Dependability	Irrigation Dependability; percentage of irrigated area over agricultural area
AGRICULTURE	Crop	Crop Water Stress	Crop water stress - ratio of fulfilled crop water requirements: average for the most important crops: (crop water consumption - crop water requirement) / crop water requirement
AGRICULTURE	IrrSeas	Irrigation seasonality	Deviance of peak from average irrigation demand: 1- (average weekly irrigation demand/ higher weekly peak irrigation demand)
AGRICULTURE	Sal	Salinity	Salinity; difference between the actual salinity and the minimum degree of salinity causing problems divided by the range of potential salinity degrees causing problems.
AGRICULTURE	Infil	Infiltration	Infiltration; difference between the actual salinity and the minimum degree of salinity causing problems divided by the range of potential salinity degrees causing problems dependent on the sodium adsorption ratio (SAR).
AGRICULTURE	AgrCoop	%FarmersInCooperations	percentage of farmers member of a cooperation
AGRICULTURE	AgrEd	%FarmersWithSecondaryEducation	percentage of farmers with secondary level of education
AGRICULTURE	AgrSupMan	%AgriAreaWithManagedSupply	percentage of the area under legally managed water supply and the total agricultural area

The outcome of the water stress characterization can be visualized as the example shown in Figure 2.2.

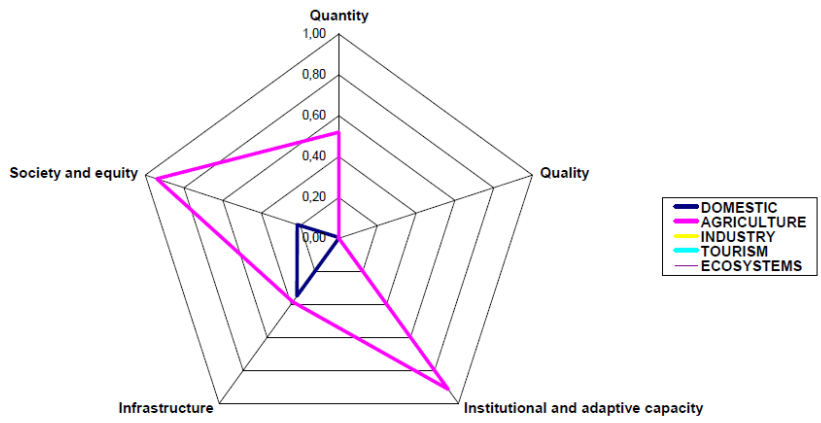


Figure 2.2 Example of Water Stress Characterization for the Agricultural and Domestic Sector

2.2 The Highnoon indicator framework

Conditions for the indicator framework

In Highnoon a set of GIS based indicators will be selected to:

- characterize the water system;
- identify water related problems (flooding, drought etc) in a spatial and temporal manner;
- evaluate the effects of adaptation options (impacts).

As mentioned, the Aquastress indicator framework will be used as a starting point from which indicators will be selected. For the three Highnoon case studies, site-specific indicators will be selected depending on:

- The specific problems in the cases
- Stakeholders preference
- Data availability

The following elements should be reflected in the Highnoon indicator framework:

- Water quantity
- Water quality
- Human uses and health
- Environment
- Infrastructure

So far, the indicator framework has not been tailored yet to the Highnoon case studies. The reason is that the stakeholder analysis is not yet finished and so far sufficient data could not be collected for the case studies. This is indicated as a priority for the next period.

A short description of the case studies characteristics and possible indicators is given below. More details about the case studies and its stakeholders can be found in deliverable D6.1.

The case studies to which the indicators will be applied

Case study site 1: Sub basin scale - Tehri Dam

The Tehri dam is situated on India's Bhagirathi River, the main tributary of the Ganges, and is one of the world's largest hydroelectric projects. Tehri dam is located 320 km north east of Delhi, in the state of Uttarakhand. When finished, the dam will provide an additional irrigation of 270,000 hectares and stabilization to existing irrigation on 600,000 hectares, plus 270 million gallons of drinking water per day to Uttarakhand, Uttar Pradesh and Delhi. Water supply in these areas is currently not sustainable, and groundwater tables are falling. High water demands have resulted in overexploitation of groundwater resources in the Delhi area. The quality of underground water is deteriorating and in several places it is now unfit for human consumption. The sources available are not sufficient to meet demands, which are expected to increase due to a growing population,

rising standard of living and industrialisation. Also climate change is likely to affect water demand. The water shortage could be met through the availability of additional water from the Tehri Dam. In Highnoon, the study shall focus on the implications of the introduction of the dam on the environmental status of the river. The impact of climate change will be studied through simulations using the hydrological modeling and the scenarios generated by the regional climate modeling at the catchment scale.

Case study site 2: Sub basin scale –Jhansi

Jhansi is an urban centre in the Bundelkhand region of Uttar Pradesh. The region occupies a total area of 5024 sq. Km. As per the Uttar Pradesh Planning Atlas (2006), within Bundelkhand region, the district of Jhansi qualifies under the category of “high development” when assessed on the basis of 36 indices covering agriculture, industry, economic and social infrastructure. Located in the central plateau region of India, Jhansi experiences extreme temperatures. The average rainfall for this area is about 900 mm per year, observed almost entirely within the three-and-a-half months of the Southwest monsoon. The primary livelihood options in the region of Bundelkhand are crop production and livestock rearing.

Case Study site 3: Sub-basin scale Kangsabati

Kangsabati River Basin is part of lower Ganga Basin and covers Purulia, Bankura, Medinipur and Hooghly districts of West Bengal State and the Singhbhum district of Jharkhand State, India. Kangsabati river and its main tributaries originate from Chotanagpur Plateau. After flowing in South-Eastern direction, Kangsabati River flows into the Hooghly River. Kansabati reservoir was constructed at the confluence of two rivers (Kangsabati and Kumari) in Purulia District, West Bengal. The reservoir was constructed to facilitate the irrigation requirement in the area and has the gross command around 5568 sq.km. The basin experiences very hot summer with temperature in the region exceeding 45 °C in May and June and approximately 10°C during the month of December. Seasonal drought and severe soil erosion limits optimum crop yields in the area.

Tentative list of indicators for Highnoon

Table 2.2 gives a summary of the main characteristics of the case studies and a tentative list of first cut indicators that can be proposed for the case studies.

Table 2.2 case study characteristics and tentative list of impact indicators

Case study	Site characteristics and main problems to be addressed	Proposed indicators
Case study 1: Sub basin scale - Tehri Dam	Main topics: Hydropower, impact of dam construction, ecosystems, irrigation, domestic water supply, overexploitation groundwater	Changes in river runoff due to climate change Environmental status river (environmental flows, pollution loads)

		Agricultural and domestic water demand and supply
Case study site 2: Sub basin scale –Jhansi	Main topics: Drought, irrigated agriculture, health issues	Drought indicator: crop water stress Health indicator: primary health status Household income: Cost recovery, number of people depending on agriculture
Case Study site 3: Sub-basin scale Kangsabati	Main topic: Seasonal drought, rainfed agriculture, flooding, health issues	Flooding indicator: e.g. detect drops in NDVI (veg index) values after extreme rainfall. Hydrological drought: Standard Precipitation Index (SPI) Water available for agriculture Agricultural drought: seasonal water stress

The indicators will be used to characterize the current status, and to evaluate the effect (impact) of adaptation measures. In the next phase, the indicators will be selected and specified for each case study in terms of spatial and temporal scale and requested data input (data collection). This will be described in deliverable D5.2.

3 Calculation of indicators

3.1 The Soil and Water Assessment Tool (SWAT)

The SWAT model is one of the models used in Highnoon to quantify water balance-related indicators.

The Soil and Water Assessment Tool (SWAT) model (Arnold et al., 1998, Neitsch et al., 2002) is a distributed parameter and continuous time simulation model. The SWAT model has been developed to predict the response to natural inputs as well as the manmade interventions on water and sediment yields in un-gauged catchments. The model (a) is physically based; (b) uses readily available inputs; (c) is computationally efficient to operate and (d) is continuous time and capable of simulating long periods for computing the effects of management changes. The major advantage of the SWAT model is that unlike other conventional conceptual simulation models it does not require much calibration and therefore can be used on ungauged watersheds (in fact the usual situation).

The SWAT model is a long-term, continuous model for watershed simulation. It operates on a daily time step and is designed to predict the impact of management on water, sediment, and agricultural chemical yields. The model is physically based, computationally efficient, and capable of simulating a high level of spatial details by allowing the watershed to be divided into a large number of sub-watersheds. Major model components include weather, hydrology, soil temperature, plant growth, nutrients, pesticides, and land management. The model has been validated for several watersheds.

In SWAT, a watershed is divided into multiple sub-watersheds, which are then further subdivided into unique soil/land-use characteristics called hydrologic response units (HRUs). The water balance of each HRU in SWAT is represented by four storage volumes: snow, soil profile (0-2m), shallow aquifer (typically 2-20m), and deep aquifer (>20m). Flow generation, sediment yield, and non-point-source loadings from each HRU in a sub-watershed are summed, and the resulting loads are routed through channels, ponds, and/or reservoirs to the watershed outlet. Hydrologic processes are based on the following water balance equation:

$$SW_t = SW + \sum_{i=1}^t (R_{it} - Q_i - ET_i - P_i - QR_i)$$

where SW is the soil water content minus the wilting-point water content, and R, Q, ET, P, and QR are the daily amounts (in mm) of precipitation, runoff, evapotranspiration, percolation, and groundwater flow respectively. The soil profile is subdivided into multiple layers that support soil water processes, including infiltration, evaporation, plant uptake, lateral flow, and percolation to lower layers. The soil percolation component of SWAT uses a storage routing technique to predict flow through each soil layer in the root zone. Downward flow occurs when field capacity of a soil layer is exceeded and the layer below is not saturated. Percolation from the bottom of the soil profile recharges the shallow aquifer. If the temperature in a particular layer is 0°C or below, no percolation is allowed from that layer. Lateral subsurface flow in the soil profile is calculated simultaneously with percolation. The contribution of groundwater flow to the total stream

flow is simulated by routing a shallow aquifer storage component to the stream (Arnold, Allen, and Bernhardt 1993).

Advantages of the SWAT model

The SWAT model also satisfied most of the attributes which were identified to be the desirable attributes which a model to be used in a developing country like India, should possess. Some of these attributes are:

The SWAT model is physically based. It requires specific information about weather, soil properties, topography, vegetation, and land management practices occurring in the watershed. The physical processes associated with water movement, sediment movement, crop growth, nutrient cycling, etc. are directly modeled by SWAT using this input data. This approach results in major advantages, such as

- Watersheds with no monitoring data (e.g. stream gage data) can be modeled
- The relative impact of alternative input data (e.g. changes in management practices, climate, vegetation, etc.) on water quantity, quality or other variables of interest can be quantified
- The model uses readily available inputs. The minimum data required to make a SWAT run are the commonly available data from local government agencies.
- The model is computationally efficient. Simulation of very large basins or a variety of management strategies can be performed without excessive investment of time or money.
- The model enables users to study impacts on account of human interventions which makes it very suitable for scenario generation.

Distributed Behaviour of the SWAT model

SWAT allows a number of different physical processes to be simulated in a watershed. For modelling purposes, a watershed may be partitioned into a number of sub-watersheds or sub-basins. The use of sub-watersheds in a simulation is particularly beneficial when different areas of the watershed are dominated by land uses or soils different enough in properties to impact hydrology. By partitioning the watershed into sub-watersheds, the user is able to relate different areas of the watershed to one another spatially. Input information for each sub-watershed can further be subdivided into unique areas of land cover, soil, and management within the sub-watersheds (known as hydrologic response units or HRUs). This facility provides complete distributed behaviour to the model.

No matter what type of problem is studied with SWAT, water balance is the driving force behind everything that happens in the watershed. To accurately predict the movement of water, sediments or nutrients, the hydrologic cycle as simulated by the model must conform to what is happening in the watershed.

3.2 Application of SWAT for indicators

For the current deliverable, the SWAT model was applied by IIT Delhi to assess the water balance in Kangsabati basin. The water balance terms are calculated using WATCH forcing data (WFD, Weedon et al., 2010) for 31 years (1971 - 2001). The water balance is the starting points for many indicators.

Kangsabati basin

The Kangsabati basin represents the lower part of the Ganga basin and covers the states of West Bengal and Jharkhand (Fig 3.1). The basin is an area with agriculture based economy.

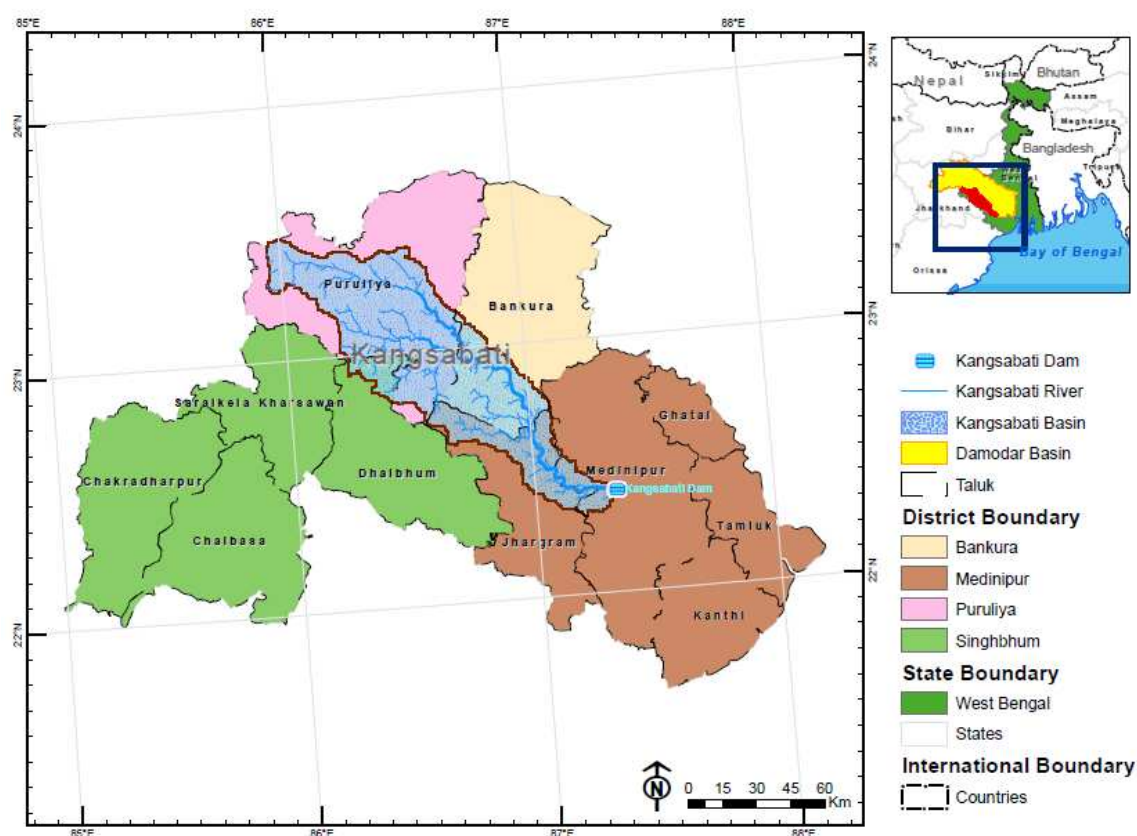


Fig. 3.1 Map of Kangsabati Basin showing state and district boundaries

According to the National Bureau of Soil Survey & Land Use Planning (NBSS&LUP), Kangsabati basin encloses two different agro-ecological regions, (i) sub-humid ecosystem in the western part (district Purulia, East Singhbhum) of the basin, (ii) humid to per-humid in the eastern part (district Bankura, Medinipur, Hoogly).

The western part has a rainfall variation between 1000 to 1600 mm which covers about 80 per cent of the PET leaving deficit of 500 to 700 mm of water per year and 150 to 180 days growing period. The soils are red loamy, non-calcareous and lateritic soil. Seasonal drought and severe soil erosion limits optimum crop yields in the area. Rainfed farming is the traditional practice with cultivation of rice, pulses (moong, blackgram and pigeon pea) and groundnut. In rabi season, rice and wheat are cultivated mostly under irrigated condition.

The eastern part of the basin has rainfall ranging from 1400 to 2000 mm. The growing period is more than 270 days. The soils are alluvial derived and slightly acidic in nature. Flooding, water logging and acidity are the major problems. The water balance shows that precipitation exceeds the PET requirement in this area during June to October followed by a period of utilization till mid-February in most of the years. In view of the high rainfall, the rice based cropping system is common in this part of the basin. The rice and jute are main crops grown in rainy season under rainfed condition whereas rice, jute, pulses, oilseeds (mustard) are grown on residual soil moisture during rabi season.

Climatic trends in the Kangsabati Basin

Mishra, et al., 2005 studied the temporal and spatial extents of droughts in the Kansabati River basin using Standard Precipitation Index (SPI) as an indicator of drought severity. It is observed that the short-term drought oscillations are common in the Kangsabati basin. The short-term drought was high in 1979 where the return period is between 80 to 100 years covering whole basin. The medium and long-term drought is found to be frequent in 1980's with return periods between 50 to 100 years covering the whole basin.

Mazumdar et al., 2009 calibrated Soil and Water Assessment Tool (SWAT) over the Khatra sub basin of the Kangsabati River watershed in Bankura district of West Bengal, India. In this study, all the chosen projected parameters, for future, namely transmission losses, soil water content and PET showed a decreasing trend whereas ET and lateral flow to reach showed an increasing trend for the time period 2041 - 2050.

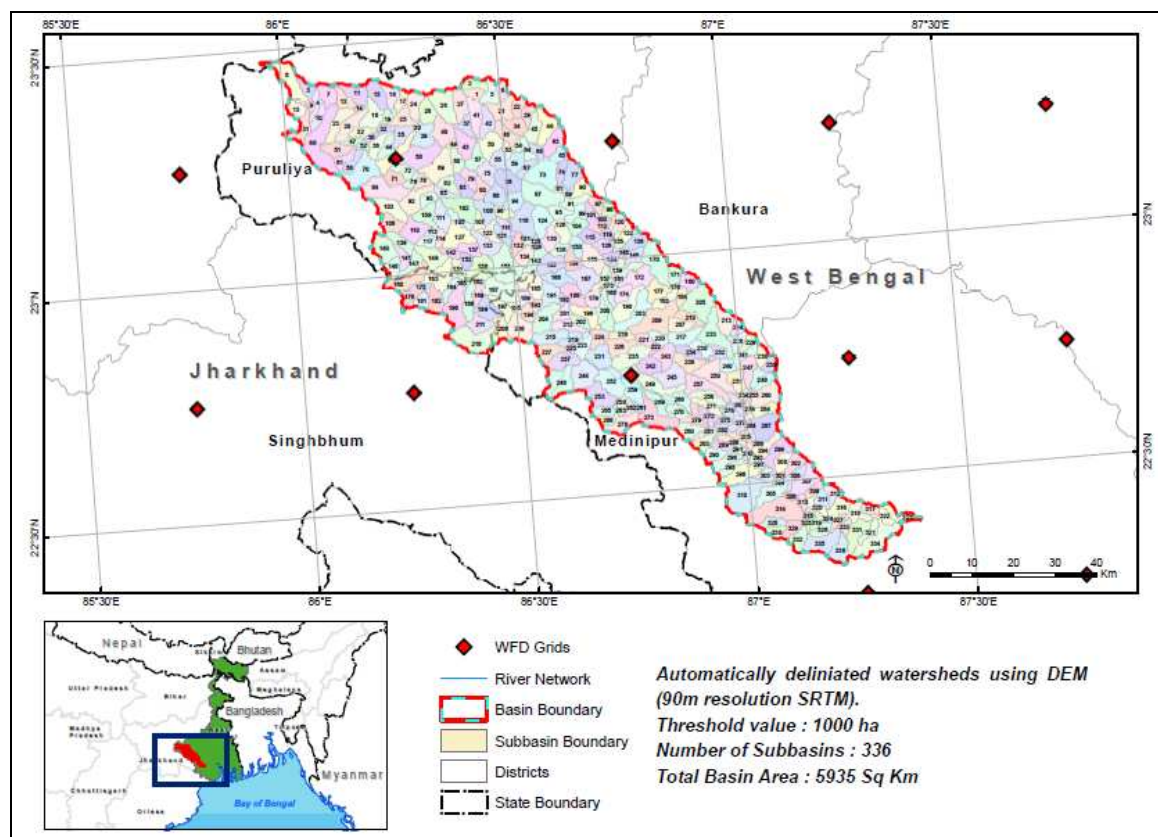


Fig 3.2 Kangsabati subbasins simulated in SWAT

A number of 336 sub-basins of Kangsabati are simulated (Fig 3.2), which covers the two agro-ecological regions of Kangsabati.

For computing water balance components, SWAT has been run for the study area using Watch Forcing data (1971-2001). It is to be pointed out that agricultural data is not readily available for this area; therefore, general crop system is adopted for the present computations. The landuse used for the current SWAT runs is shown in Table 3.1.

Table 3.1 Landuse in Kangsabati in percentage of total area

Rice	66
Tomato	13
Sugarcane	9
Forest	8
Corn	3
Ponds	1

The average annual rainfall distribution within the basin is shown in Figure 3.3. A higher precipitation can be seen in the south-eastern part of the basin.

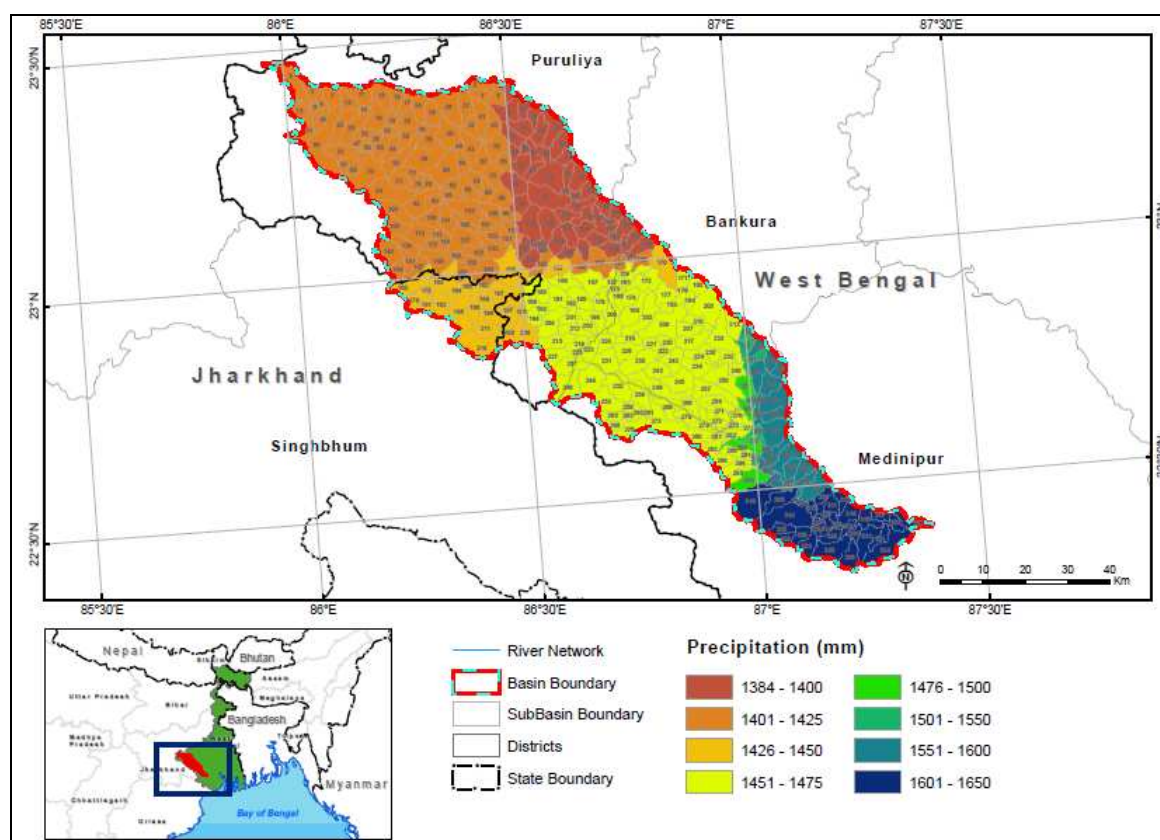


Fig 3.3 Kangsabati average annual precipitation in mm (SWAT results using Watch Forcing datasets 1971 - 2001)

Figure 3.4 shows a comparison of the monthly precipitation to the potential evapotranspiration (PET) for the Kangsabati basin. The figure shows that precipitation

exceeds the PET requirement in this area during June to October. Rice is the main crop grown in kharif season (June-December) under rainfed condition, where crops such as rice, jute, pulses, oilseeds (mustard) are grown on residual soil moisture during rabi season (January-April).

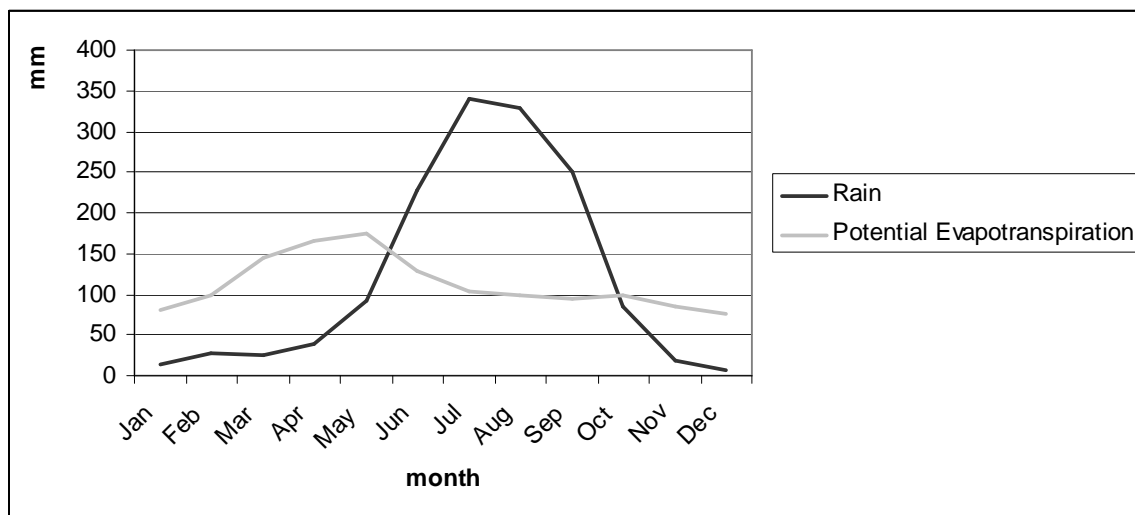


Figure 3.4 Rainfall and potential evapotranspiration in mm for the Kangsabati basin (SWAT results using Watch Forcing datasets 1971 - 2001)

Agricultural water stress as indicator

Agriculture faces water stress if the water requirements of crops are not met. In the Kangsabati basin, seasonal water stress affects agriculture in the area. To detect the severity and spatial occurrence of water stress in the basin, the relative evapotranspiration (ET_{rel}) is selected as indicator. This indicator is part of the Aquastress framework and is expressed as the ratio of actual evapotranspiration (ET_a) to potential evapotranspiration (ET_p):

$$ET_{rel} = \frac{ET_a}{ET_p}$$

The indicator expresses the degree to which a certain land use type suffers from water shortage.

Evaluation of indicator results

To evaluate the indicator, the values have to be compared to target values or acceptable ranges. For relative evapotranspiration, it is generally recommended that this ratio does not drop below 0.70 throughout the year (Bos et al., 2005). Bastiaanssen et al. (2001) used an 'operational range' and an 'acceptable range' for this indicator. If the indicator remains within the operational range, crop yield will deviate less than 10% from the target value. If the indicator moves out of the acceptable range yield reductions of over 20% occur. For ET_{rel}, the operation range was set at 0.8-1, and the acceptable range at 0.7-1.

More differentiation on the effects of water scarcity is given by Petrassovits (1990), who made a classification of water scarcity for different ETrel values, see table 3.1.

Table 3.1 Classification of relative evapotranspiration (Petrassovits, 1990, www.iwmi.cgiar.org)

ETrel range	Interpretation
1.0-0.8	water scarcity of the plant is only theoretical, because the water supply to the plants is continuous and not limited
0.8-0.5	The water demand is still continuous, but it is getting increasingly restricted
0.5-0.3	Water scarcity is high, the water supply to the plants is periodical and restricting, therefore water-stress develops
<0.3	Strong water stress occurs, causing considerable biomass and yield deficiency, and when this stage lasts long also the death of the plant

Indicator results for Kangsabati

The relative evapotranspiration (ETrel) is calculated for the 336 sub-basins in Kangsabati. The results are presented in Figure 3.5 as a yearly average.

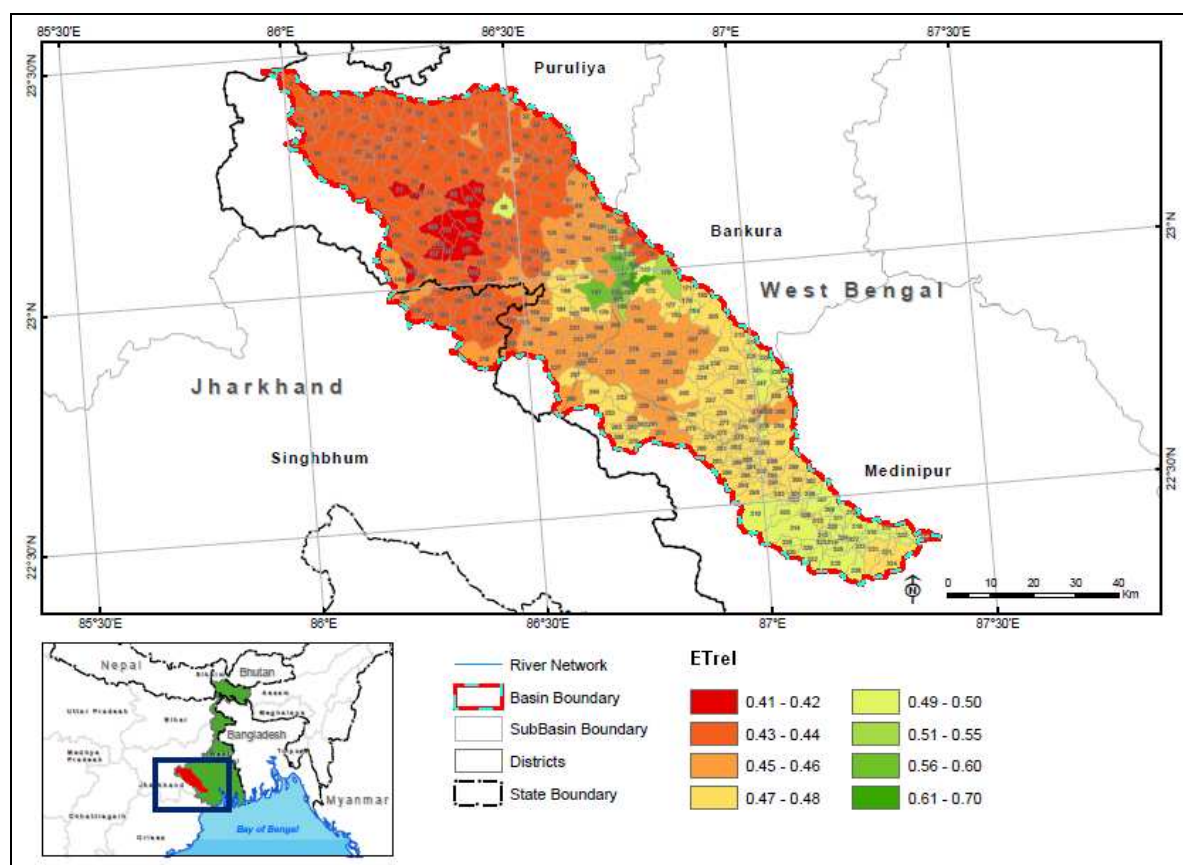


Fig 3.5 Yearly average of relative evapotranspiration (ETrel) for the Kangsabati subbasins (SWAT results)

The figure shows that water stress is higher in the upper part of the basin with less average annual precipitation (red tones) when compared to the lower parts of the basin (yellow tones).

Water stress indicators are more meaningful if they are addressed on a seasonal or monthly basis, because the real effects of water stress depend on the crop stage at which they occur. Figure 3.6 shows the monthly water stress for sub-basins in the upper, middle and lower part of the basin, compared to the “allowable range”. When the indicator drops below the allowable range, water stress occurs.

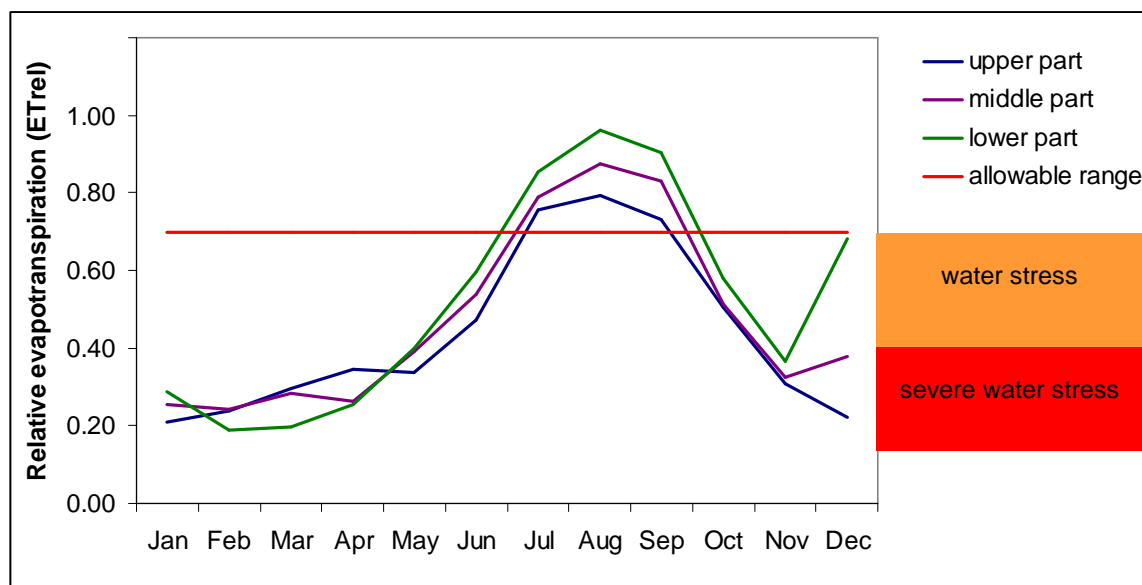


Figure 3.6 Monthly representation of water stress for sub-basins in the upper, middle and lower part of the Kangsabati basin compared to the allowable range (SWAT calculations).

From the figure it can be seen that severe crop water stress occurs throughout the basin between December and April, and moderate water stress occurs between April and June, and again in October-November. Crops are without water stress in the period July-September.

The subbasins show a similar temporal pattern in crop water stress but differ a lot in intensity. It can be concluded that the sub-basin scale is a suitable scale for water stress assessment in the Kangsabati.

The stress in rice (the main crop) should be compared with Figure 3.6 to see if the critical crop stages coincide with the water stress periods. The effects of dry seasons to rice yield in Kangsabati is currently being addressed by TERI (Dr Mishra) and will be incorporated.

The next step is to introduce adaptation measures to reduce the water stress for the areas for which water stress are identified. An adaptation option can be to change the current cropping pattern. Consequently, the impact of such adaptation measures will be evaluated (quantified) using the water stress indicator.

4 Conclusions and next steps

To assess the temporal and spatial availability of water resources in Northern India, an indicator framework needs to be developed. This report describes the set-up and conditions for the set of indicators that is being developed within Work package 5 of the Highnoon project. The framework will characterize the current status of natural resources and will be used to evaluate the impacts of improvements (adaptation options). The indicator framework will be developed for the three case study areas and will be a GIS based framework. A preliminary list of indicator for the case studies is given, based on the site specific problems to be addressed. A preview of the GIS visualization is available at <http://gisserver.civil.iitd.ac.in/natcom/>.

For the current deliverable, the SWAT model is applied by IIT Delhi to assess the water balance in Kangsabati basin. The water balance will be the starting point for most of the indicators. The water balance terms are calculated using Watch Forcing datasets for 31 years (1971 - 2001).

SWAT results show that precipitation exceeds the crop requirements in the Kangsabati during June to October. Rice is the main crop grown in this period (kharif season), under rainfed conditions. In the period January to May (rabi season), rainfall is not sufficient to meet the crop demand and most crops (Jute, pulses, oilseeds) are grown on residual soil moisture with supplementary irrigation.

The relative evapotranspiration (ETrel) is demonstrated as an indicator for water stress. To evaluate the indicator, values have to be compared to target values or acceptable ranges. ETrel is calculated for 336 sub-basins in the Kangsabati basin as a yearly average, and on a monthly basis. The application of ETrel as a water stress indicator is more meaningful when it is addressed on a detailed temporal scale, i.e. monthly basis. The effects of water stress depend largely on at which stage of crop development the stress conditions occur. Looking at a monthly scale, the water stress indicator reveals severe crop water stress between December and April, and moderate water stress occurs between April and June, and again in October-November. Crops are without water stress in the period July-September. To further evaluate the impact of water stress, the current results will be combined with the rice production (yield) analysis that is currently being done by TERI. The combination will imply a drought sensitivity analysis for the various growth stages of rice in relation to relative evapotranspiration and water stress.

The insights from the calculation of the water stress indicator will enable to formulate suitable adaptation measures for the area (e.g. changes in cropping patterns), as to “where and when” measures have to be taken to reduce water stress.

Although the title of the report suggests sensitivity analysis of indicators, such analysis could not be carried out at this stage because the required inputs from the field surveys are not yet available and shall be taken up once the surveys are completed by respective groups.

The next step in WP5 is a selection of indicators for each case study, determine the scale at which the indicator will be addressed, and the data that need to be collected. This will

be described in the next deliverable (D5.2). There is a delay in the indicator selection process since the collection of the case study information and stakeholder analysis is under way by the respective groups.

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