

## CHAPTER 9: ENVIRONMENTAL STATUS AND MANAGEMENT STRATEGIES

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*'We're reaching the point where the Earth will have to end the burden we've placed on her, if we don't lift the burden ourselves.'*

*-Vandana Shiva*

Environmental status of any region outlines the state of its available natural resources along with the approach to maintain them at a level where the overall environmental system is resistant as well as resilient to the adverse effects of anthropogenic activities, delivering ecosystem services in a sustainable way.

The EF that was developed in the early 1990's and the WF introduced a decade after that, have different roots of origin and suggests different methods for measuring sustainability; the one thing that they have in common is transforming the human consumption into natural resource use. The EF uses everything in terms of space (land area) while the WF measures the total use of freshwater resources (Hoekstra, 2009). With this background and adopted methods for the WF and EF computations, the author has carried out a comprehensive sustainability analysis of the Kim River Basin.

## WATER FOOTPRINTS

The concept of WF acts as a pointer of water use in various sectors by the people as it gauges the quantity of water needed for production of goods and services required to support a population. The WF of the Kim River basin is computed on the basis of overall water demand (MCM/year) for all the activities occurring within the basin and it doesn't not account the direct water required for per unit production of goods (commodity or crop); instead it aggregates the total water requirement of the basin (MCM/year) and compares it over a period of 15 years (1998-2013).

The WF of the study area gives the inclusive idea regarding the total water consumption (blue + green + grey) of the Kim River basin. Thus,

$$\mathbf{WF_{Total}} = \mathbf{WF_{Agriculture}} + \mathbf{WF_{Domestic}} + \mathbf{WF_{Forest}} + \mathbf{WF_{Industry}} + \mathbf{WF_{Livestock}}$$

(MCM/Year)

The analysis of  $\mathbf{WF_{Domestic}}$  of the study area over 15years, indicates the impact of growing population on the water consumption pattern of the study area from 1998 to 2013.  $\mathbf{WF_{Forest}}$  , since it only accounts the green water footprint has reduced in the span of 15 years due to decrease in the total forest area from 1998 to 2013 (Table 4.2). Though, the numbers of industrial units in the study area have almost doubled in the period of 15 years and the water consumption has also increased, the  $\mathbf{WF_{Industry}}$  has reduced from 20.43MCM (1998) to 17.6 MCM (2013). This is on account of reduction in the grey water by the industries leading to overall decrease in the total WF. On account of reduction in the agricultural production of the study area, the total  $\mathbf{WF_{Agriculture}}$  is also seen reducing. Since agricultural water consumption is almost 85% of the total water consumption of the study area; the  $\mathbf{WF_{Total}}$  has shown gradual decrease from 1998 to 2013.

When considering the per capita WF of the study area, as seen in individual sectors of domestic and livestock, the per capita WF has increased since 1998. On similar grounds, associating the total available water and the

consumption patterns of all the existing sectors in the study area, it can be seen that the  $WF_{Total} / \text{Capita}$  has increased from 1998 to 2013. Thus, taking appropriate steps for water consumption and treatment of generated wastewater in the study area, the per capita WF can also be reduced.

#### Water Availability:

The water Availability in the study area is determined using the Water Balance Approach. The water balance study aims at computing total water resources in any area for appropriate planning and management of these available resources. It actively plays a role in estimating surplus or shortfall of water resources against the demand and helps in taking necessary steps for resource management and planning.

The primary source of blue water availability in the study area is rainfall. Of the internal sources of blue water are the Kim River, irrigation schemes of Pingut & Baldeva as surface resource and groundwater while the external sources include the irrigation canal network of KRBC & URBC. For estimation of the total water availability and its status, the following Water Balance equation is applied-

$$R = (P + I) - (ET + Q)$$

$R$  = Storage /Recharge       $P$  = Precipitation       $I$  = imported Water  
 $ET$  = Evapotranspiration       $Q$  = Runoff

This equation was applied over a period of 15 years to understand the status of existing water resources in the study area (Table 9.1)

Water Attribute (MCM)	YEAR			
	1998	2003	2008	2013
Precipitation	1465	1465	1465	1465
Evapotranspiration	2216.3	1878.4	1773.7	1604.8
Runoff	343	343	343	343
Imported Water	1134.8	1113.1	1141.8	1085.2
<b>R (Storage)</b>	<b>40.5</b>	<b>356.7</b>	<b>490.1</b>	<b>602.4</b>

**Table 9. 1 Water Balance of the Kim River Basin (1998-2013)**

It is clearly visible from the water balance quantification that the total surplus water remaining in the study area has gradually increased from 40.5 MCM in 1998 to 602 MCM in 2013, over a period of 15 years. This is on account of gradual reduction in the agriculture potential of the study area due to increasing water-logging & saline water intrusion leading to deterioration of soil and groundwater. The imported water that reaches the study area in form of irrigation canals is a primary source for sustaining agriculture in the study area. In absence of this water, the study area does not have the potential to support agriculture at such a large scale since rainfall is the only input. Also, the consumption of agriculture alone exceeds the total internal water available in the area. Moreover, the storage in the study area takes care of its other sectors like domestic and industrial, where groundwater is the major source to sustain local needs.

Quality of groundwater is one of the important aspects for water resource development and planning. Taking into account the groundwater resources of the study area, it is evident from the previous results that the groundwater quality in the study area has deteriorated over time (1998-2013), particularly in terms of its dissolved constituents. Also, examining the groundwater throughout the study area, it was observed that in the central and lower parts of the basin, most of the groundwater available is unsuitable for irrigation purpose but in the upstream, the groundwater is better and is the only source of water.

The quantification of groundwater (Table 6.8) using specific yield approach, suggests the available storage for groundwater annually. The existing aquifers in the study area (especially the alluvium and sedimentary) have adequate potential of groundwater storage but due to excessive canal irrigation, the quality of groundwater is deteriorating making its use restricted.

The study area thus, being an importer of virtual water (canals) for its largest consumer sector of agriculture, there is no scarcity of blue water in the study area. But, considering only the internal blue water as a sole source, it

can be concluded that the area is water stressed and requires suitable planning for better management of existing water resources.

### **ECOLOGICAL FOOTPRINTS**

As stated earlier the EF expresses the amount of land required to sustain a population in a given set of available natural resources. EF is a comprehensive index reflecting the general ecological security of any region. The long term study of EF from 1998 to 2013 points out a visible increasing trend in industrialization and urbanization on account of population rise. The EF which was 0.85gha/capita in 1998 has reduced to 0.6gha/capita in 2013. This change in land use pattern is ascribed to the sprawling urbanization where in the agricultural or forest area is transformed into human settlements. Majority of the agricultural fields in the central part of the study area around the towns of Kim, Kosamba and Mangrol have been diverted to construction sites for residential or industrial complexes. This has led to the pressure on the remaining forest and agricultural areas that has accounted for the depletion in per capita EF. To reduce this pressure on the existing land-use, no more conversion of the agriculture land or forest area to settlement and industrial zones should be allowed. The biocapacity of the study area has also reduced from 0.3gha/capita to 0.27gha/capita. This clearly indicates that per capita availability of finite natural resources in the study area has reduced per capita. A further increase in population will led to decline in the biocapacity causing a more negative impact on the existing resources. The gap between the biocapacity and EF (Fig 8.2) has also reduced since 1998, which indicates that the population rise is faster than the assimilative capacity/ biocapacity of the study area to support the population sustainably. Thus, The  $EF > EC$  of the study area, it can be accomplished that the total Kim River watershed is unstable and that the ecosystem services provided by the basin are insufficient to meet the need of the growing population within the basin boundary.

## **FOOTSTEPS TO SUSTAINABILITY**

The WF and EF calculations have laid down a track towards monitoring the natural resources and their sustainability status for the study area over a time span of 15 years. Although, the derived values are just indicatives of the consumption patterns of land and water resources in the Kim River basin, they reveal undoubtedly about the improper management of the existing resources that are need to be addressed by adopting appropriate remediation.

The recommended management strategies, first, aims at classifying the study area into three physiographic units viz. Upper rocky upland region, Middle parts as sedimentary plains and Lower parts as alluvium plain region (Chapter 4). The following are the recommendations by the author, based on her study for improvising the deteriorating Footprints of the Kim River basin:

### **i) Upper Eastern Highlands:**

This part of the Kim River basin is characterized by dissected hills and forests. It supports very little population and only a small fraction of plain land is available for agriculture. The Baldeva and Pingut Irrigation schemes along with groundwater support the population in this region. On account of growing demand from increasing population, deforestation and basalt quarrying has extensively led to reduction in the forest cover of this region. Thus, the following measures can be helpful to regain back the sustainability of this part:

- Afforestation practices should be followed to increase the forest cover and reduce soil erosion.
- The empty quarries of basalts can be used as temporary water storage structures which can serve as source of water to locals as well as facilitate recharge to the groundwater thereby, resolving the problem of dry wells in the lean monsoon season.

- The canals of Baldeva and Pingut schemes should be lined in order to prevent the loss of water due to canal seepage and their network should be effectively improved covering a larger area under cultivation.
- Small water holding structures should be constructed on the tributaries of Kim to delay the run-off period and enhanced recharge to bank area regions; so as to increase the net irrigation potential of the area.

ii) **Central Alluvium Plains:**

This physiographic unit is characterised by a gentle westward slope and comprising an integral part of fluvial domain. It accounts for a vast accumulation of riverine sediments (floodplain). It is dominated by the Black Cotton soil, thus, forming a part of the most productive agricultural land in the study area. Maximum population density, increasing settlements and industrial units, waterlogging, high dissolved salts in groundwater, improper crop cultivation, etc. are some of the major concerns of this part that are indirectly reducing the EF and increasing the WF of the study area. Suggestive measures for this region are enlisted below:

- The groundwater in this region being high in TDS, can be utilized for irrigation after proper blending with the excellent quality surface water.
- This can help in lowering the water-table leading to reduction in the area affected by water logging.
- On account of growing population, much of the available land is converted to settlements, thus increasing the burden on the available land area.
- In order to reduce the WF, industrial units should carry out proper treatment of their generated wastewater and reusing it back in other industrial process by following zero discharge techniques.
- In spite of growing population, the area completely lacks the Sewerage system and Sewage Treatment Plant. This has a great impact on the grey water footprint of the study area. Hence,

adequate provisions of STPs be made at the semi-urban locations like Tadkeshwar, Kim, Kosamba and Mangrol.

- The industries should be enforced to have a green belt around their premises to increase the canopy cover of the area as well as increase the overall EF of the region.
- Cultivation of water intensive crops like Paddy and Sugarcane is prominent in the area due to availability of canal water. This has accounted for rapid rise in groundwater table. There should be a massive awareness drive on the problem of water logging and farmer community should be convinced about crop rotation; taking water intensive crops once in two years, in order to avoid rising water table and to lower the WF of the region.
- Cyclic use of groundwater and canal water should be done to irrigate the fields in order to avoid water table rise as well as taking advantage of the available canal water.
- Sprinklers and drip irrigation techniques should be practiced to increase the irrigation efficiency and water conservation.
- To establish well point systems along the branch canal system for pumping the groundwater to the water table. Pumped water shall be discharged in the canal so as to pass the irrigation benefits to the tail end command area.
- Development of surface drainage/ditches of at least 3m depth and connecting them to the natural streams. This would enable the agricultural fields to cause groundwater run-off and restricting its depth below 3.00 m.

**iii) Western Coastal Plains:**

This unit is represented by an extremely gentle planation surface characterised by the coastal alluvial soils. Waterlogging and salinity ingress are the two main environmental issues prominent in this part of the basin. Below are some remediation steps to overcome the listed problems that can help to maintain the sustainability in this part:



- Provide proper drainage for the agricultural runoff since the soils are poor in their natural drainability.
- Salt tolerant crops should be grown along with normal crops to reduce the salt content of soil and maintaining its fertility.
- Tube well irrigation should be encouraged to check the rising water table and to minimize the water logged area.
- Mangrove cultivation can be increased near the river mouth to increase the forest area under cover and support better aquatic life for aquaculture practices.
- The canal water in this region should also be regulated in the region in order to lower the WF.
- Flood irrigation practices should be avoided. Instead use of drip irrigation techniques should be implemented to make optimum use of blue water and thus reducing the blue WF.
- Mulching should be followed after every crop cycle to reduce the concentration of salts in the root zone, thereby conditioning the soils and maintaining their fertility.
- Better management of soil fertility and adequate use of water for irrigation will increase the crop production with minimum WF, thus achieving sustainability in agricultural practices.

Thus, implementation of suggested steps of soil and water management practices will lead to improving the biocapacity of the study area and also reducing the Total Water Footprints of the Kim River Basin at large.