CHAPTER 1: INTRODUCTION

'Our entire society rests upon and is dependent upon our water, our land, our forests and our minerals. How we use these resources influences our health, security, economy and well-being.'

-John F. Kennedy

The development and the continual growth of any region depend very much on two important environmental resources viz. the land and water. Gujarat is one such state bestowed with the vast stretch of fertile land and ample water resources. Perhaps, owing to these factors and the entrepreneur nature of the people at large; the state has been considered to be one of the fastest developing states of the country. Further, its 1600 km long coastline dotted with ports and jetties facilitate industries for far-off trading in other parts of the continents. Therefore, Gujarat in its true sense is "*the Land of Opportunities*"**,** providing livelihood to large scale population that includes migrants from other states too.

The rapid pace of industrial and agricultural development leading to large scale growth of urban and semi-urban centres with ever-lasting demand of

land & water resources are causing tremendous stress on the fragile physical and biological environments. The proposed study of Kim River Basin, south Gujarat represents one such case example where in, the carrying capacity of the area is drastically impacted due to rapid industrial growth and other anthropogenic interventions.

RESEARCH BACKGROUND

As of August 2016, the estimated global population was estimated at 7.4 billion. It will further increase to 11.20 billion by the year 2100 (UN, 2016). The growing pressure on land for food, fuel and fodder along with industrial expansion and consequent need for various infrastructural facilities due to increasing population have given rise to competing and conflicting demands on our finite land and water resources. Thus, various frameworks and indicators of sustainable development like Carrying Capacity and Footprint Concepts are being applied for better management of these natural resources.

The term Carrying Capacity refers to the human population in an area relative to its resources and the capacity of the environment to sustain human activities without degrading the natural, social, cultural and economic environment for present and future generations. Leopold (1934), first applied this concept of carrying capacity, to study the population dynamics in different species. Later, Odum (1953) used the term carrying capacity to describe the burden of human population on the available natural resources. He further stated that the key to understand over population is not population density but the numbers of people in an area relative to its resources and the capacity of the environment to sustain human activities; that is, to the area's carrying capacity.

The carrying capacity for any given area is not fixed. It can be modified by improved technology, but mostly it is veered for the worse by pressures which accompany a population increase. As the environment is degraded, carrying capacity actually shrinks, leaving the environment incapable

to support the inhabitants who could formerly have lived in the area on a sustainable basis. No population can live beyond the environment's carrying capacity for very long.

The footprint concept on other hand translates human consumption into direct natural resources used and computes direct and indirect utilization of all natural resources for human activities. Footprint analysis encompasses two indicator scales viz. 1.Water Footprint and 2.Ecological Foot print that are independently and combinedly used for measuring sustainability of any product, region or even ecosystem.

The Water Footprint Concept was introduced in 2002 by A.Y.Hoekstra in Netherlands. The WF concept is primarily rooted in the search to illustrate the hidden links between human consumption and water use and between global trade and water resources management.(Hoekstra 2003). The WF concept has primarily been introduced in the water science community in order to demonstrate that both a consumer dimension and a global dimension should be added in considerations of good water governance. The WF of an individual or community is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community on annual basis (Hoekstra and Chapagain, 2008). A WF can be calculated for any well-defined group of consumers, including a family, village, city, province, state or nation (Ma et al., 2006; Hoekstra and Chapagain, 2007b; Kampman et al., 2008). The total WF of an individual or community is divided into three components: the blue, green and grey WF. The blue WF is the volume of freshwater that evaporated from the global blue water resources (surface water and ground water) to produce the goods and services consumed by the individual or community. The green WF is the volume of water evaporated from the global green water resources (rainwater stored in the soil). The grey WF is the volume of polluted water that associates with the production of all goods and services for the individual or community.

The Ecological Footprint (EF) was introduced in early 1990's by William Rees and Mathis Wackernagel. It is a measure of the human appropriation of the globe's biologically productive areas needed to sustain a population. (Rees, 1992, 1996; Rees and Wackernagel, 1994, 1996; Wackernagel and Rees, 1996, 1997).The concept is rooted in the search for indicators of sustainable development and more in particular the wish to measure how the human appropriation of the earth's resources relates to the carrying capacity of the earth. The EF measures how much nature, expressed in the common unit of 'bio-productive space with world average productivity' and is used exclusively for producing all the resources a given population consumes and absorbing the waste they produce, using prevailing technology (Chambers et al., 2000). An EF is generally expressed in hectares. EFs can be calculated for individuals as well as for any well-defined community, including villages, towns, cities, provinces, nations or the global population as a whole.

Thus, both, the Water as well as the Ecological Footprint calculations, focus on direct relationship of availability and consumption of land and water resources at individual and also at global levels. Water resource management usually is simply seen as a river basin issue while dimensions like production, consumption and policy making are merely considered for overall management of water as a resource. While for management of land resources, only the land use pattern and its productivity index are accounted. This study, presents the author's endeavour to analyse the indicators of sustainability viz. the Water and the Ecological Footprints of a river basin in conjunction with its bio capacity i.e. carrying capacity.

AIM AND OBJECTIVES

The presented study aimed at assessment of the status of water and ecological footprints of the Kim River Basin and envisaging strategies for development and management of the land and water resources on sustainable basis. The aforesaid aim has been fulfilled through the following objectives –

1) Geological and Geomorphic characterization of watershed region.
2) Land capability categorization and assessment of change in Land use systems.
3) Assessment of human resources, socio-economic and other infra-structural parameters.
4) Quantitative and qualitative assessment of the pollution load in the basin area.
5) Assessment of natural resources (Land & Water) of the watershed region using the Concepts of Water and Ecological Footprints**.**
6) To work out an overall carrying capacity of the watershed region encompassing its physical, biological and anthropogenic environments.
7) To envisage appropriate model for planning – development and management of the watershed region on sustainable basis.

Study incorporates the Kim River Basin that represents an independent basin, located between two mega fluvial systems viz. Narmada River in the north and Tapi River in the south, Gujarat state. The Kim River Basin is bounded between the geographical co-ordinates N - 21^0 19': 21^0 38' and E – 72^0 40': 73^0 27', and falling in the jurisdiction of Bharuch and Surat districts of South Gujarat.

OUTLINE OF THE STUDY

An integrated inter & multi-disciplinary approach on meso-watershed basis has been adopted to achieve the cited objectives. Entire research study has been carried out in **03** Phases –

Phase – I: Data Collection and Critical Review:

a) Demographic data of the watershed basin area and amenities with a view to assess socio-economic status of the people and resource demand in the study area.
b) Collection of secondary data related to the geological aspects and land use pattern in the area to understand the role of geological environment on land use system and resource availability including secular changes in land use.

c) Soil regime of the study area viz. the distribution of various soil types, soil characterization and impact on land use system and crop production.

d) Development of various thematic maps of the watershed region viz. geology (litho-stratigraphy, structure & tectonism); geomorphology (drainage, landforms, soils, slope attributes, land use systems etc.); water resources (surface & groundwater) using secondary data, Survey of India toposheets and satellite imageries on GIS environment.

Phase – II: Detailed Fieldwork and Sampling:

a) Field validation of various thematic maps prepared during Phase – I

b) Collection of soil samples on the defined grids (3x3km) up to the depth of 1 meter to study the nutrient properties (C, K, N, P), physical and hydraulic properties viz., texture, color, density, porosity, permeability, chemical characteristics etc.

c) Groundwater Regime: Seasonal monitoring of groundwater levels through on established network of observation wells, to study seasonal-annual changes in groundwater storage. Groundwater sampling to measure various-physico-chemical parameters and their seasonal behavior.

d) Surface water Regime: Sampling from existing water bodies with a view to analyze the pollution load on existing surface water resources and water quality characterization for drinking and irrigation purpose using measured physico-chemical and biological parameters.

e) Assessment of air quality through data collection from existing Government Observatory in the study area on daily-monthly and seasonal basis.

Phase ***– III: Data Analysis, Interpretation and Report Writing:***

a) Descriptive representation of various soil and water quality data and interpretation.

b) Estimating the pollution load on the river basin.

c) Assessment of the long-term changes in the land use system and causative factors.

d) Computation of water and ecological footprints of the basin area.

PROBABLE OUTCOMES OF THE STUDY

- Impacts of anthropogenic activities on the basin area.
- Establishing correlation between the present human demands of basic resources in the study area and its biocapacity.
- Establishing secular changes in the land use system and its causative factors.
- Accomplishing a comprehensive database of various environmental parameters of the basin area and their status.
- Quantitative assessment on the Water and Ecological Footprints of the study area.
- To envisage various strategies for resource planning, development and management of the basin resources on a sustainable basis.