Introduction

CHAPTER I

INTRODUCTION

A watershed is a geo-hydrological unit or a piece of land that drains at a common point. It controls the occurrence, movement and availability of water in that area. It involves socio-economic, human-institutional and biophysical inter-relationships among soil, water, land use and the connection between upstream and downstream areas. It serves as a fundamental unit for planning and implementing developmental projects (Wang *et al*., 2016).

Land and water are most vital natural resources essential for sustaining life and supporting various developmental activities. As the world's population increases, the demand for these resources increases, leading to significant challenges such as resource depletion, environmental degradation, land use conflicts and water scarcity. Watershed management plays a major role in tackling these issues by promoting the sustainable use of natural resources, balancing human needs with environmental health (Choudhari *et al*., 2018).

India is an agrarian nation. According to the Census of India 2011, out of the total working adult population of 482 million, 263 million (54.6 percent) depends on agriculture for their livelihood, including 144 million (30 percent) as wage labourers. Of the net-cultivated area, around 56 percent is rainfed (GOI, 2023). Agriculture in India faces several challenges, such as land degradation and depletion of groundwater. India is also vulnerable to climate change, which is projected to affect agriculture through increase in mean temperature, precipitation and a decrease in number of rainy days. These challenges are of particular concern to marginalised and small farmers. In order to address these challenges in semi-arid areas, several pathways have been suggested, including watershed development programmes.

The Government of India has defined Watershed development programme as "*the conservation, regeneration and the judicious use of all the resources—natural (land, water, plants, and animals) and human—within the watershed area. Watershed management tries to bring about the best possible balance in the environment between natural resources on the one side and man and animals on the other*" (GOI, 2011).

The main objectives of the watershed development programme are to restore the ecological balance by harnessing, conserving and developing degraded natural resources such as soil, vegetative cover and water. This can be accomplished through the implementation of soil and water conservation measures. The results are prevention of soil loss through runoff, regeneration of natural vegetation, rain water harvesting and recharging of ground water. This enables multi-cropping and the introduction of diverse activities, which help provide sustainable livelihoods to the people residing in the watershed area.

In general, soil and water conservation measures are classified into two types. They are mechanical (engineering or structural) measures and biological (agronomic) measures. Mechanical measures include permanent and semi-permanent structures such as contour bunds, graded bunds, terraces, trenches, check dams, gabion structures, loose or stone boulders, crib wall, etc. Biological measures, on the other hand involve vegetative practices such as forestry, agroforestry, horticulture and agricultural or agronomic practices like contour farming, crop rotation, intercropping, strip cropping, mulching, conservation tillage etc. These interventions have been implemented by the Government of India and Non-Governmental Organisations (NGOs) through various schemes over decades. Watershed development projects are in operation since the early 1990s and common guidelines were reissued in 2008 (revised in 2011), which are the basis for the watershed development projects (Pradyumna *et al*., 2020).

The watershed development approach is indeed an integrated strategy that requires the collaboration of multiple departments and a significant allocation of resources. Given its complexity and the various dimension of economic, environmental and social impact, it is essential to assess the programme’s effectiveness in a holistic manner and evaluate its long-term impact through reliable methods. Detailed planning, continuous monitoring and evaluation of project activities are essential for the success of all developmental projects. Monitoring helps to make mid-term adjustments in ongoing projects and provides a better understanding of the effects of interventions on water availability and groundwater recharge. Evaluation ensures the effectiveness of these interventions and aids in improving future strategies. It also justifies investments by showing tangible environmental and economic benefits.

The advancement of a watershed development project in achieving its objectives can be evaluated and monitored at the local community level using specific indicators. Common indicators for assessing watershed development projects include bio-physical indicators, hydrological indicators, economic indicators and indirect indicators. Bio-physical indicators encompass changes in biomass, forest area, crop area, irrigation, crop yield and land use patterns. Hydrological indicators reflect changes in runoff depth, stream flow and water availability (such as surface water storage, groundwater levels and well yield). Indirect indicators include the number of wells, irrigated area and the time required for wells to recuperate. Economic indicators are Net Present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate of Return (IRR). All these indicators help to assess the overall impact of the project (Palanisami *et al*., 2009)

Remote Sensing (RS) and Geographical Information System (GIS) have proven to be powerful tools for monitoring and managing natural resources, as well as for assessing the impact of watershed interventions during pre- and post-treatment phases. The periodic coverage provided by remote sensing satellites over specific areas enables effective monitoring of land resources. It also facilitates the evaluation of Land Use Land Cover (LULC) changes by comparing images captured at different time intervals. Changes such as the area under cultivation, conversion of cropland, changes in surface water bodies, afforestation, etc. can be monitored through satellite remote sensing. These technologies can be utilized to detect and determine the extent and nature of changes over time (Reddy *et al*., 2021). GIS is particularly effective for interpreting and visualizing spatial data. It plays a crucial role in understanding spatial and temporal variations in groundwater levels (Kumar, 2022).

The study area of the project is Olanthichira watershed spread over an area of 814 ha in Edayoor & Melmuri villages of Marakkara & Edayoor panchayats in Kuttippuram block of Malappuram district, Kerala, India. The watershed lies between 76^0 02’ 45” to 76^0 04’ 30” East longitude and 10^0 55’ 15” to 10^0 58’ 30” North latitude. The major problems in the study area were streambank erosion, degradation of cropland and severe drought during summer. Streambank erosion caused flooding in adjoining areas and reduced crop production. Severe drought during summer led to an overdependence on tube wells, resulting in the overexploitation of groundwater.

This watershed was treated with soil and water conservation measures under the Rural Infrastructure Development Fund (RIDF) XXI project, with financial assistance from the National Bank for Agriculture and Rural Development (NABARD), implemented by the Department of Soil Survey and Soil Conservation (DSSSC), Malappuram. The objectives of this project were to protect the watershed area from erosion hazards, achieve sustained agricultural production, minimize sediment transport from sub-drains to the main drain, improve agricultural productivity and drinking water availability, control gully formation, stabilize existing gullies and conserve rainwater at its point of fall, thereby enhancing groundwater recharge.

These soil and water conservation measures have significant effects on Land Use Land Cover (LULC) as well as groundwater resources. To effectively assess the impact of these watershed interventions, analysing the changes in LULC and vegetation along with groundwater levels in the watershed during pre-treatment and post-treatment periods is a comprehensive method.

In this context, this study has been planned to find the effects of soil and water conservation measures on LULC and groundwater in Olanthichira watershed using geospatial techniques. The project is envisaged with the following specific objectives:

i) Identification of soil and water conservation measures adopted in Olanthichira watershed and study of geomorphological parameters of watershed;

ii) Assessment of impact of soil and water conservation measures on LULC and NDVI in Olanthichira watershed using RS and GIS;

iii) Assessment of impact of soil and water conservation measures on groundwater level.