ECONOMIC ANALYSIS OF WATERSHEDS IN WAYANAD DISTRICT

by

NEETHU MOL JACOB
(2017-11-090)

THESIS

Submitted in partial fulfilment of the

requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF AGRICULTURAL ECONOMICS
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM – 695522
KERALA, INDIA
2019

DECLARATION

I, hereby declare that this thesis entitled "**ECONOMIC ANALYSIS OF WATERSHEDS IN WAYANAD DISTRICT**" is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Place: Vellayani
Date: 19/08/2019

NEETHU MOL JACOB
(Admn. No. 2017-11-090)

CERTIFICATE

Certified that this thesis entitled "**ECONOMIC ANALYSIS OF WATERSHEDS IN WAYANAD DISTRICT**" is a record of research work done independently by **Ms. Neethu Mol Jacob (Admn. No. 2017-11-090)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Place: Vellayani
Date: 19/08/2019

T. Paul Lazarus
Major Advisor, Advisory committee
Assistant Professor (SS) & Head
Department of Agricultural Economics
College of Agriculture, Vellayani,
Thiruvananthapuram - 695522.

CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. Neethu Mol Jacob (Admn. No. 2017-11-090)**, a candidate for the degree of **Master of Science in Agriculture** with major in Agricultural Economics, agree that the thesis entitled "**ECONOMIC ANALYSIS OF WATERSHEDS IN WAYANAD DISTRICT**" may be submitted by **Ms. Neethu Mol Jacob (Admn. No. 2017-11-090)**, in partial fulfilment of the requirement for the degree.

T. Paul Lazarus
Major Advisor
Assistant Professor (SS) & Head
Department of Agricultural Economics
College of Agriculture, Vellayani,
Thiruvananthapuram - 695522.

Dr. Durga A. R.
Member, Advisory Committee
Assistant Professor
Department of Agricultural Economics
College of Agriculture, Vellayani
Thiruvananthapuram - 695522.

Dr. Brigit Joseph
Member, Advisory Committee
Associate Professor & Head
Department of Agricultural Statistics
College of Agriculture, Vellayani,
Thiruvananthapuram - 695522.

V. Jayakrishnakumar
Member, Advisory Committee
Associate Professor
Department of Agronomy,
College of Agriculture, Vellayani,
Thiruvananthapuram - 695522.

ACKNOWLEDGEMENT

I thank Lord Almighty for his immense blessings upon me in each and every moment in my life and working his way through my parents, teachers, friends and each and every person in my life.

I would like to express my gratitude to Sri. T Paul Lazarus, Chairperson of the advisory committee, Assistant Professor (SS) and Head, Department of Agricultural Economics, for his guidance, support, encouragement and made me confident to do all my works by myself. I am very thankful, for helping me in my academics and also to complete my research work.

I am very much grateful to Dr. Santha A M, Rtd. Associate Professor, Department of Agricultural Economics, for her valuable guidance and noteworthy suggestions during the course of my study and also for my research work.

I am profoundly thankful to Dr. Durga A R, member of advisory committee, Assistant Professor, Department of Agricultural Economics, for her encouragement for the new ideas, support for the study in newer areas of the subject and critical valuation of the works and also the research.

I take this opportunity to extend gratitude to Dr. Brigit Joseph, member of advisory committee, Associate Professor and Head, Department of Agricultural Statistics, for her valuable suggestions, timely support in doing statistical analysis and critical evaluation during the course work.

I am very much thankful to Sri. V Jayakrishnakumar, member of advisory committee, for his valuable guidance, suggestions, encouragement and critical evaluation of my research work.

I accord my sincere thanks to Dr. Aswathy Vijayan, Assistant Professor, Department of Agricultural Economics and Smt. Thasnimol, Assistant Professor, Department of Agricultural Economics, for their valuable support and encouragement for successful completion of this work.

I sincerely express my gratitude to Sri. Arun Kumar S, District Soil Conservation Officer, State Department of Soil Survey and conservation,

Kalpetta, Wayanad, Smt. Renu P D and Smt. Sindu S Assistant Director, Soil Survey, State Department of Soil Survey and conservation, Vazhuthacadu, Thiruvanathapuram, for providing me the necessary secondary data.

I take this opportunity to thank Agricultural officers Mr. Thomas (Poothadi), Mr. Alex (Meenangadi), Mr. Arun (Muttil), Ms. Dhanya (Kanniayambetta) and Agricultural Assistants of all the panchayats, for providing me with all essential details and data related to my research topic.

I am also thankful to my batch mates Ajmal and Priyanga and my seniors Mohandas, Kshama A V, Stephy, M A and Abhinav, M C and my juniors Nithin, Elizebeth and Supriya for their selfless help, encouragement, moral support and fulfilment of classroom environment during the entire course of study.

I am very much thankfull to my dear sir Dr. A S Anil Kumar, ADR, RARS (SZ), Vellayani, for his support, care, encouragement and guidance.

I thank all my dear ones Ache, Achachan, Daddy, Mommy, Navi, Cipla, Lekshmietti, Reni, Vadake, Namitha, Thadiyan, ML, Ayshu, Alan, Sarna, Kaju, Tiju, Akhil P, Settu, Hari, Anki, Melvin, Thirteen B, Dhana chechi, Lakshmi chechi, Nihala thatha, Kari Chechi, Pinky Mol, Chinju Chechi, Grittu Chechi, Greeshma Chechi, Amrithechi, Anjana Chechi, Panju, Rehana, Geethu, Anju Chechi, Amala Chechi, Veni, Dundu, Aneetta, Jyothi, Big Jose, Suresh, Athulya, Dhanya, Murugesh, Sibi, Siju, Reshma, Sherin and Shobin for their support and guidance for completing my M. Sc. programme.

I am most gratefull to my dear Pappa, Mummy, Chechi, Achachan, Shijuchan, Bincy Chechi, Tattoo and Kenz for their guidance, constant encouragement, moral support and blessings without which I would not have completed this research work. I would also like to express my sincere apologies, if I ever failed to mention any names.

Neethu Mol Jacob

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVATIONS

BHS	Brown Hydromorphic Soil
CARD	Centre for Agriculture and Rural Development
CCA	Climate Change Adaptation
CSO	Central Statistical Organization
DDP	Desert Development Programme
DPAP	Drought Prone Area Programme
GOK	Government of Kerala
GOI	Government of India
HADA	Hill Area Development Agencies
HYV	High Yielding Varieties
IWMP	Integrated Watershed Management Programme
IWDP	Integrated Wasteland Development Programme
KAWAD	Karnataka Watershed Development
KSLUB	Kerala State Land Use Board
MFC	Marginal Factor Cost
MP	Marginal Product
MVP	Marginal Value Product
NABARD	National Bank for Agriculture and Rural Development
NCA	National Commission on Agriculture
NWDPRA	National Watershed Development Programme for Rainfed Area
OLS	Ordinary Least Square Regression
PRA	Participatory Rural Appraisal
RVP	River Valley Project
SHGs	Self Help Groups
SWC	Soil and water conservation
VIF	Variance Inflation Factor
WHS	Water harvesting structures
WDF	Watershed Development Fund
WSD	Watershed Development
WDP	Watershed Development Programme

LIST OF SYMBOLS

^{0}C	Degree Celsius
>	Greater than
ha	Hectares
kg	Kilogram
<	Less than
m	metre
mm	Millimeter
m ha	Million hectares
MT	Million tonnes
%	Per cent
ha^{-1}	Per hectare
kg^{-1}	Per Kilogram
q	Quintal
₹	Rupees
km	kilometer

Introduction

1. INTRODUCTION

Water resource is a prime natural resource and its management is an essential component of sustainable development in agriculture. An assessment commissioned by World Bank, reported that the Ganga river basin could see three-fold rise in crop failures and drinking water shortage would go up by 39 per cent in some states between 2019 and 2040 and if there is no intervention, Uttarakhand (28 per cent), Himachal Pradesh (10 per cent), Uttar Pradesh (10 per cent) and Bihar (15 per cent) are more likely to witness a deficit in irrigation water in 2040 as compared to the current levels. Madhya Pradesh (39 per cent), Delhi (22 per cent) and Uttar Pradesh (25 per cent) would see a deficit in drinking water during the same period (Koshy, 2019). Thus the conservation and management of water resources had garnered a lot of importance in the current scenario and watershed development (WSD) programmes plays a major role in it.

A watershed is a piece of the land area bounded by a natural ridge line from which all the surface runoff drains to a common drainage point such as stream, river, pond, lake or estuary. The term watershed has been derived from two words water and shed which means the line that separates two river basins. The word catchment area is also often used to represent a watershed. The size and shape of the watershed are determined by the topography of that area (Thomas, 2010).

Water resource management is an essential component of sustainable development in agriculture. Proper watershed management has triple benefits such as it maintains productive capacity in the watershed area, prevents the degrading processes and it is more profitable than the rehabilitation of degraded lands (Thomas, 2010). The main objective of a WSD programme is to increase the economic and the social well-being of the beneficiaries of the basin in particular and of the whole nation. The watershed-based development programme had resulted in increased employment generation, crop production, productivity, farm income, groundwater status and overall rural development in the watershed area. In hilly and undulating topographic areas watershed management assumes more importance.

1.1 WATERSHED DEVELOPMENT PROGRAMMES IN INDIA

After independence, India made a tremendous improvement in agriculture but there was a mismatch between the irrigated and the rainfed areas. Earlier, agricultural developmental schemes in the five-year plans were confined to the irrigated area which was justified in view of acute food shortage and needs to attain self-sufficiency in agriculture production especially in food grain production. Degradation of the rainfed area had increased due to soil erosion and related hazards causing great ecological imbalances. In India watershed management was started during 1962-63 with the RVP (River Valley Project) scheme and the main objective of the scheme was the construction of huge reservoirs to provide irrigation for agriculture and to produce electricity. Earlier, dams were constructed only for preventing flood and storing rainwater but now it became multipurpose RVP. Some of the major multipurpose RVP in India were Baspa and Idukki hydro-electric project, Beas, Bhadra reservoir, Bhakra-Nangal, Chambal valley, Damodar valley, Hirakud, Nagarjunasagar, Sardar Sarovar, Periyar valley and Parambikulam-Aliyar project (Thomas, 2010).

DPAP (Drought Prone Area Programme) was implemented during the fourth five-year plan for the development of small and marginal farmers, livestock, pastures and irrigation sources, soil and water conservation measures, changing agronomic practices, and afforestation. HADA (Hill Area Development Agencies) was started in fifth five-year plan with different strategies such as watershed development, improvement of crop and animal husbandry and horticultural and infrastructural development in the rural areas. During 1977-78 as per the recommendation of NCA (National Commission on Agriculture), DDP (Desert Development Programme) was implemented with an aim to achieve integrated development in the desert areas. NWDPRA (National Watershed Development Programme for Rainfed Area) was launched in 1986 under the Ministry of Agriculture with the following objectives such as sustainable management, development and conservation of natural resource, to boost agricultural production and productivity in a sustainable way, restoration of

ecological balance in degraded rainfed eco-systems, to reduce the regional disparity between the rainfed and irrigated areas and to create sustained livelihood opportunities for the rural population (Thomas, 2010).

IWDP (Integrated Wasteland Development Programme) under the Ministry of Rural Areas and Employment was implemented for improving the productivity of waste and degraded lands and in turn, alleviate poverty, backwardness and the gender gap in rural areas. Now all the previous watershed development programmes such as RVP, DPAP, DDP, Hariyali, NWDPRA, IWDP, etc. were brought under a single WSD programme known as Integrated Watershed Management Programme (IWMP), under the Ministry of Land Resources, Department of Rural Development, Government of India (GOI). The main objective of the programme is efficient utilization of every drop of rainwater received, livelihood activities are also provided through this scheme (GOK, 2019).

1.2 WATERSHED DEVELOPMENT PROGRAMMES IN KERALA

Kerala is known as the land of abundant natural resource, especially water. The state has 44 rivers, 27 backwaters, 7 lagoons, 18681 ponds and more than 30 lakh wells (GOK, 2019). Soil and water conservation (SWC) activities were initiated in the state during the first five year plan period in 1955. In Kerala, conservation and management of soil and water resource is under the State Department of Soil Survey and Soil Conservation established during 1963. The department provides scientific database on the soil and land resource, suitable soil and land management practices, implement a variety of projects aimed at conserving and managing natural resource, which in turn ensures sustainable development and food security of the state (GOK, 2019). In Kerala, Kerala State Land Use Board (KSLUB) under the State Department of Planning and Economic Affairs also provide support to the state Government to frame policies for optimum use of land and natural resource such as soil, water, plant and animal system (GOK, 2019).

17

In Kerala, Idukki district has more number of watersheds (984) followed by Palakkad (744), Kannur (709), Malappuram (708) and Kottayam (621). Table 1 represents the number and area of watersheds in different districts of Kerala and the table reveals that the total area and number of watersheds in Kerala is about 38,83,789 ha and 7,493 respectively. Alappuzha district has the least number of watersheds (229). Palakkad district (451602.94 ha) ranks first in the area under watershed whereas, Alappuzha district has the least area under watershed (126647.36 ha).

Table 1. Area and number of watersheds in Kerala

S. No.	Name of the District	Area (ha)	Number
1	Thiruvananthapuram	218590.15	425
2	Kollam	242566.41	463
3	Alappuzha	126647.36	229
4	Kottayam	216381.7	621
5	Idukki	434238.05	984
6	Pathanamthitta	262584.27	469
7	Ernakulam	294835.57	414
8	Thrissur	300996.8	566
9	Palakkad	451602.94	744
10	Kozhikode	237208.96	423
11	Kannur	351322.96	709
12	Malappuram	327692	708
13	Wayanad	219852.09	374
14	Kasaragod	199270.47	364
15	Total	3883789.73	7493

Source: Department of Soil Survey and Soil Conservation, Thiruvananthapuram, 2018.

Watershed management and watershed-based developments assume greater importance in hilly and undulating topographic areas. As per the State Department of Soil Survey and Soil Conservation, more number of well-implemented and maintained watersheds was located in Wayanad district as the district is located in the hilly region, watershed-based development programmes assumes more importance. In this context, present research was conducted in Wayanad district with the following objectives:

1. To assess the impact of watershed development programme on cropping pattern and farm income.
2. To examine the variation in benefits in upper, middle and lower reaches of watershed.
3. To ascertain the problems of farmers in the watershed.

1.3 SCOPE OF THE STUDY

This is an important study to analyze the economic impact of WSD programme on farmers. Soil and water conservation plays a vital role in attaining sustainable agricultural production and productivity. Since, Kerala has a peculiar climate and topography SWC assumes more importance in the state. Watershed based development programmes aims to improve the agricultural productivity by conserving the natural resource, to mitigate the impact of drought on crops and livestock, to control desertification and to improve the livelihood of rural population. Hence this study may help the planners and policymakers to extend WSD programmes to the untreated watersheds and to rectify the problems faced by the beneficiaries.

1.4 LIMITATION OF THE STUDY

As there is a constraint of time and other resources, the study was confined only to two watersheds in Wayanad district. Lack of data on market and non-market benefits made quantification of those benefits impossible. As the respondents were not practicing scientific package of practices on crop cultivation

and since no other enterprises were associated along with the farming except cattle rearing, it was unable to analyse the impact of WSD programme on the extent of adoption of the scientific package of practices and on the development of agriculture allied enterprises. In the case of primary data collection, the estimates were provided by the respondents by recall memory because of non-availability of farm records. In spite of these limitations, efforts were taken by the researcher to make the study as accurate as possible.

1.5 ORGANIZATION OF THE THESIS

This thesis contains five chapters which are:

1. Introduction: This chapter comprises objectives, scope and limitation of the study.
2. Review of literature: This chapter contains the results and findings of the past studies related to the research topic.
3. Materials and methods: This includes the description of the study area, source of data, method of data collection and different statistical tools used for the analysis of collected data and different variables.
4. Results and discussion: This chapter contains the results from the analysis and interpretation of the study.
5. Summary: This chapter pointed out the result findings and policy implications.

1.6 FUTURE LINE OF WORK

The study was conducted in Wayanad district. Similar studies can be extended to other districts also. The study was confined only to RVP project in future similar studies can be extended to other watershed projects within the district and the state. In this study, a comparison between the treated and untreated watershed was done. Similarly comparative study between different watershed projects can be done.

Review of literature

2. REVIEW OF LITERATURE

Management of water resource is an essential component of sustainable development in agriculture. Watershed is a geographical unit that collects, store and releases water or an area of internal drainage above a common point of outlet, where water flows to a creek, a stream, a wetland, a pond, a lake or a river. Watershed is also known as drainage basins, hydrographic basins or catchments because they drain and trap the rain and snowmelt water that falls on the ground. A critical review of previous work is essential to have a deep understanding of the research topic. Revisions of previous studies were compiled based on the objectives of the study and are presented in the following sections:

2.1. Studies on impact of watershed development programme on cropping pattern and yield

2.2. Studies on impact of watershed development programme on income and employment

2.3. Studies on impact of watershed development programme on soil and water conservation

2.4 Studies on market and non-market benefits of watershed development programmes

2.5 Studies on constraints faced by the beneficiaries in the watershed

2.1. STUDIES ON IMPACT OF WATERSHED DEVELOPMENT PROGRAMME ON CROPPING PATTERN AND YIELD

Romina Cavatassi (2004) examined completed World Bank watershed projects in Gujarat, Orissa and Rajasthan and found that the project activities increased fodder availability, combined with project intervention in animal husbandry had a beneficial impact on livestock production and milk production. Also found that WSD project had a positive impact on the rainfed crop yield, the yield obtained at the watershed area was 10 per cent more than that of without-project situation.

Charan (2005) observed a positive and significant difference in the case of production and productivity of paddy in the project area between, before and after implementation of Sujala watershed project in Karnataka.

Kumar *et al.,* (2006) examined Chhajawa watershed in south eastern Rajasthan and the results revealed a shift in cropping pattern of beneficiary farmers towards high value crops especially oilseeds. The consumption of nitrogenous (72 per cent) and phosphatic (63 per cent) fertilizers were more in the case of the inside watershed area and the overall productivity improvement ranged from 20.93 per cent in case of gram to 60.2 per cent in soybean, whereas average productivity was 42 per cent more in the inside watershed area than that of the outside watershed area.

Porras and Neves (2006) reported that the Sukhomajri WSD activities in Chandigarh had generated more returns in the form of improved agricultural productivity due to the increased availability of water in the check dam and reduced soil erosion. Between 1977 and 1986, agricultural productivity had increased yields of wheat (500 per cent), maize (400 per cent) and milk production (30 per cent).

Sreedevi *et al.*, (2006) reported that in Rajasamadhiyala watershed area in Gujarat there was 15 per cent increase in yield per unit area irrigated (kg ha^{-1}) in 2004 compared to that in 1995 for pulses (mungbean, blackgram, pigeonpea and chickpea), cereals (wheat, maize, sorghum and pearl millet), oil seeds (groundnut and til), vegetables (cluster bean, brinjal, chilly, coriander and tomato), cash crops (cotton, sugarcane and cumin) and green fodder (lucerne and maize).

Kumar (2007) examined Sujala and NWDPRA watershed project in Karnataka and indicated that there was change in cropping pattern after the implementation of the WSD project, the farmers had adopted traditional crops in both of the watershed areas and the extent of total cultivated area in the post-implementation of the project was considerably greater than prior to the implementation of WSD project. Similarly, the yields of crops were also increased

during the post-implementation period as compared to that of the pre-implementation period of WSD project. The output and returns obtained from all the selected crops under the watershed area were more compared to that of the pre-implementation period of WSD project.

Palanisami *et al.,* (2009) had found that the WSD activities in Coimbatore district of Tamil Nadu had altered the cropping pattern, increased the crop yield and crop diversification and thereby enhanced the employment and farm income in the treated watersheds. The change in yield was due to the watershed-based interventions, across the crops it varied between 31 per cent in maize to 36 per cent in cotton. It was the maximum change in the yield due to the watershed-based intervention.

Palanisami and Kumar (2009) pointed out that the WSD activities under the DPAP (Drought Prone Areas Programme) and IWDP (Integrated Wasteland Development Programme) projects in Coimbatore district of Tamil Nadu had made significant positive impacts on cropping pattern, crop yields and crop diversification and thereby provided enhanced employment and farm income. They also recommended that alternative farming system combining agricultural crops, trees and livestock components with comparable profit should be evolved and demonstrated to the farmers.

Thomas *et al.,* (2009) found that the productivity of all the major crops in the Elanad watershed in Thrissur district of Kerala had significantly improved due to the NWDPRA project. The increase in productivity was more for coconut (26.92 per cent), increase in productivity for pepper, banana and arecanut was equal (18-21 per cent). In the case of rubber, the yield was increased by 13.54 per cent. There was no significant difference in cropping pattern between the beneficiary and the non-beneficiary farms. The project could not have significant impact on the cropping pattern and the cropping intensity in the watershed area.

Singh *et al.*, (2009) found that rainfed environments in India have great potential to contribute in increasing agricultural production as evidenced by the

large yield gaps between potential and actual yields. They also found thar WSD activities had enhanced the crop productivity and efficient usage of natural resources under both on-station and on-farm watersheds with local community participation. Increased productivity was due to the adoption of improved crop varieties, integrated nutrient management and their interaction with soil and water conservation practices. They also found that the crop diversification and intensification took place due to the increased water availability, which in turn enhanced the system productivity and rainwater use efficiency.

Singh *et al.*, (2010) found that WDPs had improved the cropping pattern, land use pattern, cropping intensity, crop diversification and agricultural productivity in different states like Rajasthan, Maharashtra, Tamil Nadu, Karnataka, Gujarat, Uttar Pradesh, Assam, Madhya Pradesh, Nagaland, Jammu and Kashmir, Himachal Pradesh and Andhra Pradesh.

Gray and Srinidhi (2013) in Kumbharwadi watershed of Maharashtra found that the rainwater harvesting through watershed management had doubled the productivity of groundwater and other major crops. They also found that WSD programme had increased the cropping intensity in the watershed area by 32 per cent within eight years. Climate Change Adaptation (CCA) interventions such as agro-meteorology, sustainable climate smart agriculture, water budgeting and biodiversity also enhanced the crop.

Mondal *et al.*, (2013) found that in the Bundelkhand region of Madhya Pradesh, the implementation of WSD programmes had caused significant differences in the productivity of major crops. The cumulative effect of all the interventions in the watershed area had generated changes in different bio-physical indicators such as irrigation status, cropping pattern and cropping intensity which in turn increased the productivity of all the crops grown in the region. They also observed greater changes in the productivity of sesame (66 per cent) grown during the kharif season and wheat (64 per cent) grown during the rabi season.

Painuli *et al.,* (2014) evaluated the impact of WSD programmes in Jaisalmer district of Rajasthan and found that after the execution of WSD programme area, production and average yield of both kharif and rabi crops were increased. In the watershed area, there was also introduction of new crops such as moth bean (50.80 ha) and castor (3.20 ha). They also observed that with the adoption of high yielding varieties in the watershed area, the yield was increased by 6 to 15 per cent during the post-project period compared to that of the pre-project period (8.66 per cent). The WSD programme had a positive impact on the availability of additional agricultural land for cultivation, increased area under various crop, availability of drinking water and irrigation water.

Thakur *et al.*, (2014) analyzed the impact of IWDP in Swan Catchment area of Una district in Himachal Pradesh and observed a change in the cropping pattern. Before the implementation of the project, majority of the area was under maize and wheat (85 per cent) cultivation which had decreased by 6 per cent in the post-project implementation period. After the implementation of IWDP, area under vegetable cultivation was increased (3 to 9 per cent). They also observed an increase in the productivity of horticultural crops such as mango (147 to 201 q ha^{-1}), orange (72 to 85 q ha^{-1}) and lemon (115 to 122 q ha^{-1}). New crops introduced in the study area due to the project interventions were the fruit crops such as guava, papaya, pomegranate, litchi and kinnoo.

Chavan (2015) found that in Hivare Bazar watershed project area, there was an increase in net irrigated area, which in turn created a change in cropping pattern and gross cropped area in the watershed area. They also observed that in the watershed area there was a substitution of high productivity crops for the low productivity crops and high-value crops such as onion, potato, other vegetables and flowers were introduced.

IWMI (2016) evaluated watershed management activities in Ethiopia and reported that watershed management activities had increased the availability of irrigation water, improved agronomic practices practiced in the watershed area, which in turn increased the crop productivity. There was an increase in crop

productivity (200-300 per cent) due to the implementation of the watershed management programme in Abraha-Atsbaha, Kereba and Bechyti watersheds.

Manjunath *et al.*, (2016) reported that in Sujala watershed area in Karnataka there was an increase in total yield of different crops by about 68 per cent due to various WSD activities. The increase in yield was more for pomegranate (24.71 per cent) followed by sapota (17.71 per cent), groundnut (15.67 per cent) and ragi (13.88 per cent). They also observed that there was an increase in the yield and income obtained from dairy farming. The increased crop yield was due to the various WSD interventions such as the strengthening of the existing bunds, construction of field bunds, ploughing across the slope and use of improved agricultural implements. Watershed treatments also enhanced the soil moisture content, groundwater level and reduced soil and water erosion and hence increased the productivity of the crops in the farms located in the watershed area.

Shilpa *et al.,* (2017) examined the effect of various WSD programmes on agriculture in different states in India and the study revealed that the WSD programmes had a positive impact on cropping pattern, land use pattern and crop productivity.

Bera *et al.,* (2017) evaluated Damodar command area of West Bengal and conducted comparative yield evaluation study on the selected crops in the watershed area. The yield equivalent to rice in midland and upland was greater for potato (12,098 kg ha^{-1}) followed by chilli (7,315 kg ha^{-1}).

Khan *et al.,* (2018) evaluated the impact of IWMP in four districts of Maharashtra which were mostly affected by the drought. They found that the farmers in Maharashtra who received watershed treatment under IWMP, harvested higher yields of cotton and soybean in the years of normal rainfall and suffered fewer losses during drought year. Thus, in Maharashtra IWMP had increased both crop productivity and resilience to drought.

NABARD (2018) reported that in Kombaipatty, Mallanampatty and Ammapatti watersheds in Dindigul district of Tamil Nadu, there was an increase

in the gross cropped area (103.9 ha) and net sown area (520.04 ha). The net irrigated (561 per cent) and gross irrigated (718 per cent) area were also increased. During the post-project period, cropping intensity was also increased by 14.28 per cent.

2.2. STUDIES ON IMPACT OF WATERSHED DEVELOPMENT PROGRAMME ON INCOME AND EMPLOYMENT

Cavatassi (2004) examined completed World Bank watershed projects in Gujarat, Orissa and Rajasthan and found that the project interventions had increased the agricultural production which in turn increased the income of the farmers. Other important benefit enjoyed by the project beneficiaries were increased employment opportunities which is vital to the poor rural communities.

Goel and Kumar (2005) evaluated the mountain watersheds in Himalaya and found that the different watershed management plans in the catchment area of mountain watersheds created a total additional net annual income (1.18 – 3.86 million dollar). Total expenditure incurred for the storage of water in harvesting structures was about $20 million. However the project cost will be recovered only within fifteen years.

Vishnudas *et al.,* (2005) observed a change in the employment opportunities, agricultural productivity and overall quality of life in Amachal watershed in Trivandrum. He also reported that there was an increase in livelihood of the rural people in the watershed area due to the utilization of indigenous technology and local labours for the execution of work. Women empowerment was also brought through labour, income generation activities and neighborhood groups.

Kumar *et al.,* (2006) reported that the overall annual average gross income per household was more in the watershed area (₹ 74,264.68) when compared to that of the outside watershed area (₹ 54,694.40) in Chhajawa watershed in south eastern Rajasthan. They also revealed that the average income from crop production obtained by the households inside watershed area was greater than that

of the outside watershed area. Increase in income was due to the improved package of practices for crops and better moisture availability as a result of the WSD project. The study revealed that the WSD programme had enabled the farmers inside the watershed area to improve their household income.

Kumar (2007) examined Sujala and NWDPRA watershed projects in Karnataka and found that the total human labour employment generated during the post-watershed programme period (22,603 man days) was greater than that in the pre-watershed programme period (13,407 man days). The total income generated was also more after the implementation of watershed project (₹ 14,93,251) when compared to the period before the implementation of watershed project (₹ 10,14,583).

Lakshmi (2007) evaluated the WSD programme in Visakhapatnam district of Andhra Pradesh and observed that both income levels and employment opportunities were more for the beneficiaries than that of the non-beneficiaries. The percentage increase in gross income of the beneficiaries over the non-beneficiaries was more for medium farmers (52.39 per cent) followed by small (45.18 per cent) and large farmers (41.88 per cent). The overall change in employment levels was more for medium farmers (21.87 per cent) followed by small (20.06 per cent) and large (16.83 per cent) farmers.

Shaheen *et al.,* (2008) evaluated the WSD projects in the north-east region of India and found that there were no much changes in the composition of crops, except an improvement in existing cultivation of crops which changed to settled crop cultivation system. Crop productivity had increased by 40 per cent due to the introduction of HYV (High Yielding Varieties) seeds and better irrigation. There was an increase in the household income (23 per cent) from the farming. In order to address the equity problem, WSD program also targeted the poor and landless farmers through activities such as bee-keeping, tailoring, piggery, pisci-culture and vermin-composting, by formation of SHGs which in turn increased the income and the standard of living of the beneficiaries.

Palanisami *et al.,* (2009) had found that there was greater labour force (60 per cent) participation rate in the WSD activities in Coimbatore district of Tamil Nadu. They also found that the higher labour force participation was due to the increased agricultural, livestock and other farm production activities. It is evidenced from the analysis that the labour force participation rate among farmers in watershed villages was higher, implying that the enhanced agricultural production was due to watershed treatment activities.

Thomas *et al.,* (2009) revealed that in the Elanad watershed in Thrissur district of Kerala, there was a substantial increase in labour utilization (10.34 per cent) in the beneficiary farms, after the implementation of the WSD project. The increase in labour use was greater and equal for rubber and coconut (20 per cent) followed by arecanut (16.88 per cent) and pepper (15.96 per cent). There was an increase in the employment generation due to the increased labour use in agriculture and related activities after the implementation of the WSD project. The farm income of the farmers was also increased by 4.63 per cent. The crop-wise analysis of farm income per hectare revealed that the increase was more in coconut (11.82 per cent) compared to other crops such as paddy, rubber, pepper and banana. The increase in crop productivity was due to various factors such as increased labour utilization, manure application and moisture availability which in turn created more farm income.

Singh *et al.,* (2010) evaluated IWDP, DPAP and DDP watershed development programmes in Rajasthan, Maharashtra, Tamil Nadu, Karnataka, Gujarat, Uttar Pradesh, Assam, Madhya Pradesh, Nagaland, Jammu and Kashmir, Himachal Pradesh and Andhra Pradesh. They found that the WSD programmes had improved the income, the employment opportunities and the socio-economic conditions of the resource-poor sections of the people inhabited in the project areas through natural resource enhancement. They also concluded that over the years there will be much visible impact of WSD programmes among the different communities across various regions.

Amale *et al.,* (2011) examined the impact of the WSD project in Bahirwadi in Nagar tehsil of Ahmednagar district in Maharashtra. They found an increase in the crop production, productivity, irrigation facilities and dairy animals which in turn increased the annual employment of both male (43.19 per cent) and female (51.73 per cent).

Biradar *et al.,* (2012) evaluated the impact of employment and income generation in Karnataka Watershed Development (KAWAD) project in Bijapur and Bellary districts of Karnataka. The study revealed that among the income generating activities promoted under the WSD project, more number of the respondents (25.83 per cent) had preferred cattle rearing as the source of income, followed by buffalo (20.83 per cent), sheep (17.50 per cent) and goat rearing (10.83 per cent). The average annual income of the beneficiaries had increased from ₹ 13,590 to ₹ 25,697 after undertaking various income generating activities. The WSD project had increased the average annual income of the beneficiaries by ₹ 12107 and employment by 119 man days per annum.

Koul *et al.,* (2012) found that agriculture was the major source of income for the majority of the rural households in the semi-arid villages of Ratlam and Mandsaur districts of Madhya Pradesh. The SWC interventions through Sunehra Kal had increased the cropping area due to the increased availability of irrigation water and the number of irrigations applied to the crop. The WSD activities had increased the cropping area, crop productivity and farm income which in turn improved the livelihood of the beneficiary farm families.

Pathak *et al.,* (2012) found that the WSD program implemented in Gokulpura-Goverdhanpura watershed of Bundi district in Rajasthan had increased the employment opportunities of all the farmers. Increase in employment was due to the various activities such as activities related to agriculture, afforestation, floriculture, animal husbandry, horticulture and other enterprises. The SWC measures adopted in the watershed area such as water storage structures, gully control structures, gabion structures, mini percolation pits and other activities also provided additional employment to the small and marginal farmers in the

watershed area. In the case of agriculture, number of working days generated for the small farmers (43 per cent) was more than that of the marginal farmers (20 per cent). Afforestation activities became the major source of income as it provided more than 24 man-days employment in a year. Animal husbandry also generated additional daily income to the farmers which in turn improved their livelihood.

Kumari *et al.,* (2014) conducted a study in Parasai-Chhatpur WSD project in Bundelkhand region of Maharashtra. The study revealed that the employment generation was more in wheat (77 man-days ha^{-1}), followed by groundnut (69 man-days ha^{-1}) and maize (54 man-days ha^{-1}). The total labour requirement had significantly increased due to the agroforestry interventions in the watershed area which in turn generated more income to the rural population and improved their livelihood.

Painuli *et al.,* (2014) evaluated the impact of WSD programs in Jaisalmer district of Rajasthan and found that through the micro-watershed activities the sample households generated more income by livestock and crop production. The post-project (₹ 50,641) annual income was significantly greater than that of pre-project (₹ 38,153) period. It was found that during the project period the income and expenditure of individual farm families had increased.

NABARD (2018) reported the major findings of the impact evaluation study conducted by CARD (Centre for Agriculture and Rural Development) on the watershed projects in Tamil Nadu, Kerala, Odisha and Karanataka. The study revealed that the WSD project created an increase in the availability of the groundwater throughout the year, increase in the crop production, cropping intensity, net irrigated area, crop diversification, level of income of the farmers, livestock population due to increased fodder availability and generated additional employment.

2.3. STUDIES ON IMPACT OF WATERSHED DEVELOPMENT PROGRAMME ON SOIL AND WATER CONSERVATION

Wani *et al.,* (2003) revealed that soil and moisture conservation measures adopted in Adarsha watershed of Kothapally village in Ranga Reddy district of Andhra Pradesh had reduced the runoff and soil erosion. A significant reduction in the runoff was more in the treated watershed (45 per cent) than in the untreated watershed area. They also observed an increase in the groundwater level in the open wells and the estimated mean average rise of groundwater was 415 cm.

Cavatassi (2004) examined completed World Bank watershed projects in Gujarat, Orissa and Rajasthan and found that the project interventions prevented soil erosion, reduced water run-off, reduced soil-loss, improved soil fertility and increased groundwater table. The level of water tables had increased from 0.85 to 3.5 metres in the selected locations in the three states. The natural vegetation was also recovered due to the increased soil moisture content and reduced soil loss and fertility.

Nasurudeen and Mahesh (2006) evaluated the environmental aspects of watershed eco-system in Pondicherry and found that in the watershed area the soil fertility status was better than that of the control areas. The farmers in the watershed area (15-20 t ha^{-1}) applied more farm yard manure to the crops than that of the farmers in the control plots (10-12 t ha^{-1}). They also reported that the watershed system had more quantity of the available nutrients than that of the conventional system. The watershed area had more organic matter in the soil that improved the soil structure and productivity.

Shaheen *et al.*, (2008) evaluated the WSD projects in the north-east region of India and found that with the adoption of the contour bunding, more than three fourth of soil erosion (95 per cent) was controlled. They also reported that in the WSD project area there was an improvement in the soil moisture content, water infiltration, groundwater table, quality of drinking water and water retention capacity.

Thomas *et al.,* (2009) conducted a study in Elanad watershed in Thrissur district of Kerala and found that the beneficiary samples had greater organic

matter (1.3 6.1 per cent) than that of the control plots (1.5 to 3.5 per cent). They also found that the average height of water column was higher in the beneficiary farm (21.78 per cent) than that of the non-beneficiary farm. They also found that the SWC measures such as construction of contour bunds, earthen bunds, terraces and rain pits and mulching were adopted by more number of farmers in the watershed area than that of control plots. They concluded that the positive impact of the WSD programme was reflected in the increase in number of beneficiaries adopting the SWC measures.

Palanisami *et al.,* (2009) found that the WSD activities had significant impact on the groundwater recharge which in turn increased the drinking water availability and area under irrigation in Coimbatore district of Tamil Nadu. They also concluded that the construction of rainwater harvesting structures especially percolation ponds and construction of farm ponds helped to harvest available rainwater and hence increased groundwater level.

Singh *et al.*, (2010) reported that the WSD programmes in the different states of India had improved the ground water level, increased the availability of surface water, improved stream flow, soil moisture retention capacity and water infiltration and reduced soil erosion and runoff.

Mondal *et al.*, (2012) revealed that the gully control measures adopted in the watershed area in Bundelkhand Region of Madhya Pradesh had improved the topography of the farms and hence the soil fertility of the land was increased. Land levelling, terracing and construction of contour bunds were some of the soil conservation measures adopted by the farmers which in turn made a significant change in the productivity of various crop in the treated watershed area.

Sudhishri and Dass (2012) evaluated the impact of the site specific SWC measures adopted in Kokriguda watershed in Eastern Ghats of India. They found that the cost effective SWC measures such as the construction of contour and stone bunds, planting of vegetative barriers and hedge rows, construction of sunken ponds and loose boulder check dams, bio-engineering measures and land

treatments had reduced soil loss (82 per cent) and runoff (51 per cent). The WSD activities had increased the level of the water table by 0.32 meter which in turn increased the crop yield by 15 to 38 per cent.

Mishra and Rai (2013) evaluated indigenous SWC measures adopted by the farmers in Sikkim Himalaya region of India. They found that runoff more was in the barren and cultivated land followed by mixed cropped area, mandarin and large cardamom–based cropping system and terrace cultivation. They also found greater soil loss was in the barren land, followed by mixed cropped area, mandarin-based cropping system and terrace cultivation.

Pathak *et al.,* (2013) evaluated Gokulpura-Goverdhanpura watershed in Bundi district of Rajasthan and found that due to the WSD activities implemented in the watershed the soil loss (64 per cent) and annual runoff (52 per cent) was reduced. They also reported the silvipastoral practices in the watershed had helped in the conservation of vegetation, soil and nutrients and also provided forage, fuel timber and livelihood for the rural population. They also found that there was a significant increase in the groundwater level due to the SWC measures adopted in the watershed area. Height of water column was higher in the wells in the treated watershed than that in the untreated watershed.

Painuli *et al.,* (2014) analyzed the impact of the WSD programmes in Jaisalmer district of Rajasthan and found that there was a significant rise in the water table (23 ft). The depth of the water table was more in the post project period (262.5 ft) than that in the pre-project period (239.5 ft). They also concluded that the rise in the water table was due to the SWC measures adopted by the farmers.

Bhattacharyya *et al.,* (2016) conducted a macro-level evaluation study on 636 micro-watersheds through meta-analysis and found that the benefits of WSD programmes had increased the annual income, rural employment (151 man-days ha^{-1}) and cropping intensity (36 per cent), decreased runoff (45 per cent) and soil loss (1.1 t ha^{-1} $year^{-1}$). They also found that the WSD programmes had augmented

groundwater level and decreased poverty. They concluded that in the changing climate scenario problems such as land degradation, soil erosion, soil loss, ground water depletion and reduced quality of irrigation and drinking water were expected to increase due to the forecasting of high-intensity storms.

2.4 STUDIES ON MARKET AND NON-MARKET BENEFITS OF WATERSHED DEVELOPMENT PROGRAMMES

Cavatassi (2004) evaluated watershed projects implemented by World Bank in Maharashtra and found that in comparison to the without project situation there were greater availability of water and firewood in the project area which in turn reduced the travel cost for water and fuel wood and in turn reduced the womens' labour. The project also had multiple positive impacts on the environment, including improved biodiversity and carbon sequestration which have positive regional impacts. In the project area migration of labours to the cities were reduced and also there was a reduction in the public expenditure over the operation and maintenance of rural infrastructure such as road, drain and dam due to the reduction in flooding.

Arya and Yadav (2006) conducted a study on the economic viability of the rainwater harvesting structures by renovating the ponds in a watershed in Johranpur in Himachal Pradesh. They also found that the conservation of land, water, nutrients and vegetation had intangible benefits. The agricultural fields were subjected to sheet and rill erosion in the pre-project period but after the implementation of the WSD project, soil erosion was reduced and stabilized by the construction of earthen diversion channels and land levelling activities. The WSD project had improved the availability of drinking and irrigation water due to the groundwater recharge, improvement in grass vegetation and biomass production.

Porras and Neves (2006) reported that in Sukhomajri watershed of Chandigarh the WSD activities had reduced the siltation in Sukhna Lake (95 per cent). They also reported that watershed protection activities reduced the cost of

saving the city of Chandigarh. The vegetation cover on the hillside was also increased.

Shaheen *et al.,* (2008) evaluated the WSD projects in the north-eastern region of India and found that the watershed projects had brought many market and non-market benefits such as improved crop sale, improved livestock sale, provided protection to the natural resource base, improved the availability of drinking and irrigation water in watersheds, improved women empowerment, biomass production and community development.

Arya (2010) conducted a study on the topic impact of WSD projects on the seasonal livestock migration in Shivalik foothill villages of Haryana. The study had found that WSD project had a significant role on income generation and cattle migration. A significant decline in the livestock migration was observed when the availability of the drinking and irrigation water had increased. She concluded that the availability of irrigation had increased the cropping intensity, crop and fodder productivity and reduced livestock and labour migration.

Singh *et al*., (2010) found that WSD programmes such as IWDP, DPAP and DDP in different states of India had brought several non-market benefits the beneficiaries such as women empowerment, poverty alleviation, improved standard of living, reduced soil erosion, runoff reduction, improved quality of drinking water, increased ground water level and enhanced the biodiversity. Market benefits of WSD projects were reduced travel cost of fetching drinking water, collecting fuel wood and fodder for livestock, improved crop and livestock sales, improved agricultural output and increased farm output.

Pathak *et al.,* (2012) conducted a study in Gokulpura-Goverdhanpura watershed in Rajasthan and found that the WSD project had reduced the overall migration from the rural to urban area by providing additional employment opportunities to the farmers in the watershed. Several WSD measures were undertaken to minimize soil loss, runoff and land degradation which in turn improved the surface and groundwater resource, flora and other ecological factors.

Gray and Srinidhi (2013) found that the farmers in Kumbharwadi watershed of Maharashtra had enjoyed several market and non-market benefits from the watershed. Market benefits in the watershed are those benefits due to the WSD programme that can be marketed which includes improved crop sales, improved livestock sales, reduction in cost for fetching drinking water, less dependence on government water tankers, improved availability of irrigation and drinking water and improved fuel wood and fodder supply. Non-market benefits are those benefits due to the WSD programme which cannot be marketed which includes improved carbon sequestration, scenic beauty, air quality, nutrition, diversity in diet, resilience to drought, health, pollination and water filtration, habitat or biodiversity improvement, increased enrolment in education, improved female empowerment and increased community development.

Painuli *et al.,* (2014) evaluated the impact of the WSD programs in Jaisalmer district of Rajasthan and majority of the respondents reported that there was an increase in availability of fodder and fuel and rise in water table due to the watershed project activities.

NABARD (2018) reported that in Thumberi watershed of Vellore district in Tamil Nadu around 14 women Self Help Groups (SHGs) were formed and strengthened through capacity building programme under WSD project. The women in the watershed had started various micro-enterprises and hence the women empowerment was achieved which was a non-market benefit of the WSD project.

2.5 STUDIES ON CONSTRAINTS FACED BY THE BENEFICIARIES IN THE WATERSHED

Nirmala (2003) studied the impact of WSD programme on the socio-economic status of farmers in Ranga Reddy district of Andhra Pradesh and found that the major constraint faced by the farmers in the watershed were lack of capital (51.6 per cent) followed by lack of technical knowledge (46.60 per cent) and fragmented size of holding (45 per cent). She also found that other problems

faced by the farmers were the problems of irrigation, inadequate input availability, unavailability of labour, lack of extension services and poor quality of land.

Vishnudas *et al.,* (2005) observed the constraints faced by the farmers in the Amachal watershed in Trivandrum. They found that the major constraint faced by the farmers were transfer of the officers to other departments during the project period, lack of awareness, lack of coordination between the officials and farmers, political interference and lack of technical guidance.

Lakshmi (2007) evaluated WSD programme in Visakhapatnam district of Andhra Pradesh and found that lack of proper infrastructural and marketing facilities and lack of involvement of all the farmers in the WSD programme were the major constraints in the watershed areas.

Sisodia *et al.,* (2007) conducted a study on the constraints in adoption of technologies for WSD Programme in Sangath and Charana watersheds of Rajsamand district in Rajasthan. The results revealed that the lack of irrigation facilities was one of the major constraint faced by the beneficiaries, followed by lack of recommended practices for agricultural and horticultural crops in the case of dry farming practices. Non-availability of the recommended planting material of fruit plants was another problem in the adoption of horticulture and agro-forestry practices.

Thomas *et al.,* (2009) conducted a study in Elanad watershed of Thrissur district in Kerala and found that the major constraint faced by the beneficiary farmers was lack of supervision and follow-up by the authorities followed by lack of technical guidance and awareness about the programme, inadequacy of the sanctioned amount and lack of marketing facilities.

Kulshrestha *et al.,* (2010) evaluated the extent of adoption of different watershed technologies by the farmers in Kheri Nala watershed in Pahargarh block of Morena district of Madhya Pradesh. They found that illiteracy, lack of capital, complexity of loan procedures, high input cost, lack of training, lack of

transport, irrigation, marketing and infrastructure facilities were the major constraints faced in the adoption of watershed technologies.

Sagitra (2015) conducted a study on watershed project in Dhar district of Madhya Pradesh. The study revealed that the major constraint faced by the farmers were lack of proper resource and wealth, low market price for the products, higher price for agricultural inputs, lack of risk bearing capacity and lack of training and technical support by the authorities.

Chand *et al.,* (2016) conducted a study to identify the constraints faced by the watershed functionaries while implementing the IWDP and DPAP in Coimbatore district of Tamil Nadu. They reported the constraints faced by the farmers in the watershed and major problems were some activities were not carried out at proper time, unable to contribute for community work, people had fear of taking land, difficulty in maintaining common property resources, difference in wage rate, some works or activities were not useful and improper site selection for some of the construction works. They also found the problems faced by the WSD project implementing officials which included unclear guidelines, delay in starting the project, insufficient salary, lack of training, lower project wage rate, difficulty in running SHGs, suspicion over watershed functionaries, difficulty in getting contribution for common works, fear of taking land by government, less involvement of technical personnel, lack of people's participation and cooperation and difficulty in utilizing Watershed Development Fund (WDF).

NABARD (2018) reported that different watershed projects provided by NABARD had helped in augmentation of surface and ground water resources, enhanced cropping intensity and crop productivity and also promoted the water governance through participatory irrigation management and water budgeting. But lack of understanding of hydrological conditions and poor infrastructure management are the constraints in harnessing full potential. The interventions have, however, sustainably reduced the farmer's distress in rainfed areas, stabilized crop yield and improved the farmer's income levels.

Materials and Methods

3. MATERIALS AND METHODS

To make meaningful conclusions from the collected data, selection of appropriate methodology plays a significant role. In this section the method involved in the collection of data and the tools used for analysis are discussed based on the review of literature.

3.1 Description of the study area

3.2 Source of data

3.3 Method of data collection

3.4 Variables and their measurement

3.5 Tools for analysis

3.1 DESCRIPTION OF THE STUDY AREA

A brief description about the study area is essential to understand the research background and importance of study. Description of the study area includes different aspects like topography, climate and rainfall, soil types, land utilization pattern, land holding pattern, agriculture and major crops grown, demography, occupation and administration. It will definitely help in understanding the physical and economic environment of selected region which have a policy implication.

3.1.1 Location

Kerala

Kerala known as God's own country is located in the south-western region of Indian subcontinent. Geographically, Kerala is located between east longitudes 74° 52' and 72° 22' and north latitudes 8° 18' and 12° 48'. Kerala is situated between Western Ghats in the east and Arabian Sea in the west with an area of 38,863 sq. km (Kumar, 2017). The state experiences a tropical climate with mild winds and rapid monsoon showers. As per the census of India, the population of Kerala is 3,34,06,061 (2.76 per cent of India's population). Out of the total

population, women population (52 per cent) is more than that of men (48 per cent) (GOI, 2011). Kerala has unique and diverse agro-climatic features, which enables the cultivation of different types of crops like coconut, rubber, rice, arecanut, pepper, coffee, tapioca, banana, cashew, cardamom, tea, ginger, turmeric, vegetables and other plantains. Political map of Kerala is given in figure 1.

3.1.2 Wayanad – topography

Wayanad, known as the green paradise is located between the mountains of Western Ghats. Wayanad district falls within the tropical forest having significant bio-diversity and rare species of plants. Wayanad district is located on the southern tip of the Deccan plateau and in the north-eastern part of Kerala. The total geographic area of the district is 2131 sq. km and more than half of the total area is under forest cover (1699 sq. km) (GOK, 2018). The district is headquartered at Kalpetta with three taluks Mananthavady, Sulthan Bathery and Vythiri. Geographically, the district lies between 11° 27' and 15° 58' north latitude and east 75° 47' and 70° 27'. The district shares border with both Karnataka and Tamil Nadu. Wayanad is the least populated district in Kerala (8,17,420) with a population density of 384. In Kerala, Wayanad is one of district with lowest literacy rate (89 per cent) but it is greater than that of national average (GOK, 2018). Political map of Wayanad and watershed atlas of Wayanad is given in figure 2 and 3 respectively.

3.1.3 Climate and Rainfall

Wayanad enjoys a salubrious tropical humid monsoon climate and the high altitude regions experiences severe cold. The district received normal rainfall of 2632.1 mm during 2017 south west monsoon (GOK, 2018) and during 2018 normal rainfall was more than 3000 mm (GOK, 2019). Lakkidi, Vythiri and Meppadi are the high rainfall areas in the district and annual rainfall of this region ranges between 3,000 and 4,000 mm (Kumar, 2017). The mean annual temperature of the district is 22.6 °C. The maximum temperature ranges from 28.9 to 36.2 °C and the minimum temperature range from 17 to 23.4 °C (GOK, 2016).

Figure 1. Political Map of Kerala

Figure 2. Political Map of Wayanad district

Figure 3. Watershed atlas of Wayanad district

3.1.4 Soil types

Mainly four types of soil such as laterite, brown hydromorphic (BHS), forest loam and riverine alluvium were found in the district. Laterite soil seen in some areas of Wayanad is reddish brown in colour and formed under tropical monsoonal climate due to alternate wet and dry seasons. BHS mainly seen in the undulating topographic area is formed by transportation and sedimentation of material from hill slopes, which is very deep brownish in colour and have sandy loam to clayey texture. Forest soils are formed due to the weathering process under forest cover which is dark reddish brown in colour, rich in organic matter, nitrogen and humus and have loamy to silty loam texture. Alluvial soils are found along the banks of rivers such as Kabani and its tributaries. Riverine alluvium is very deep soil with sandy loam to clayey loam texture. Majority of the area under riverine alluvium was once utilized for cultivating paddy. Those areas are now utilized for cultivating other crops especially banana (GOK, 2016).

3.1.5 Land utilization pattern

Total geographical area of the district is 2,131 sq.km and more than three fourth (79.73 per cent) of the total geographic area is under forest cover (1,699 sq. km) (GOK, 2018). Gross cropped area in the district is 1,66,875 ha and net cropped area is more than half (67.66 per cent) of the gross cropped area. Less than 10 per cent land is under non agricultural uses (11,789 ha) and cultivable waste land is about 1098 ha (GOK, 2019).

3.1.6 Agriculture

Cropping intensity of the district is 148 per cent. Area under coffee (67,426 ha) is more followed by arecanut (12079 ha), rubber (10,800 ha), pepper (10,565 ha) and coconut (10,322 ha). Production of banana is more (71,357 MT) followed by tapioca (61,696 MT), coffee (52416 MT), paddy (20,647 MT), Mango (15,517 MT) and Tea (12,438 MT) (GOK, 2019).

3.1.7 Major crops

Major portion of the cultivated area in Wayanad district is under plantation crops. Coffee, arecanut, tea, rubber, pepper, coconut, banana, paddy, jack, tea, mango, cardamom, ginger, tapioca, plantain, cashew, papaya and turmeric were the major crops cultivated. The fertile soil supports the cultivation of spices like cardamom, turmeric and ginger. Natural forest area is depleting due to encroachment and conversion to plantation land. Availability of arable land was limited and confined to the narrow valleys that were used for paddy, horticulture, coconut and arecanut cultivation.

3.1.8 Demography

As per GOI census 2011, population of Wayanad district is 8,17,420 with female population (51 per cent) more than that of male (49 per cent). As per GOK (2019) literacy rate of the district is 89 per cent and population density of the district is 384 inhabitants per square kilometre.

3.1.9 Occupation

In Wayanad district, number of people employed in private sector (0.21 lakh) is more than that of public sector (0.14 lakh) (GOK, 2018). In the district number of agricultural labourers (69,133) is more than that of main cultivators (37,555) (GOK, 2019).

3.1.10 Administration

The district is headquartered at Kalpetta with one revenue division and three taluks Kalpetta, Mananthavady and Sulthan Bathery. The district comprises fourty nine villages, four block panchayat (Kalpetta, Mananthavady, Sulthan Bathery and Panamaram), 23 grama panchayat and 3 muncipalities (GOK, 2019).

3.2 SOURCE OF DATA

The study is based on both primary and secondary data. Micro level study was conducted in Wayanad district. From the district one well maintained and

implemented watershed was selected as the treated watershed.

3.2.1 Primary Data

For the micro level study, Poothadi and Aavayal watersheds from Wayanad district is selected as the treated and untreated watersheds respectively. Then the list of beneficiaries is obtained from the watershed implementing agency and the respondents are selected based on the percentage of slope of the watershed, from the list. The watershed area is classified into three regions based on height above MSL (Mean Sea Level) as upper, middle and lower region, 15 beneficiaries from each region is selected and primary data is collected.

3.2.1.1 Poothadi watershed

Poothadi watershed project is a centrally sponsored River Valley Project (RVP) for soil and water conservation implemented by Department of soil survey and conservation, Kerala. The project was implemented during 2010 and completed in 2013 and total watershed area was 4,428 ha. Poothadi watershed includes Poothadi, Kaniambetta, Meenangadi and Muttil panchayaths of the district. Watershed development activities carried out in agricultural land were construction of contour bunds, trenches and farm ponds and planting of vegetative hedges and horticultural development.

3.2.1.2 Aavayal waterhed

Aavayal watershed is located in Meenangadi panchayath of Wayanad district. It is located nearby Poothadi watershed and has agro climatic condition and slope similar to that of Poothadi watershed. In this watershed, watershed development activities were not implemented by any agency.

3.2.2 Secondary Data

Secondary data for the study is collected from different offices under the State Department of Soil Survey and Conservation, Kerala. Secondary data regarding Poothadi watershed project is collected from the Office of the Assistant

Director of Soil Conservation, RVP Kabani, Kaniambetta sub division, Meenangadi.

3.2.3 Sampling frame

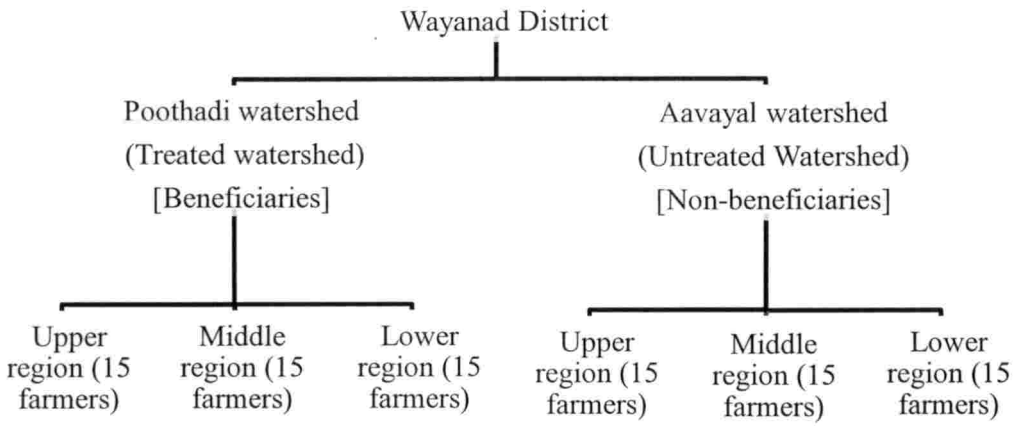


Figure 4. Sampling Frame

The treated watershed is the watershed in which the watershed development activities were carried out by the State Department of soil survey and conservation. The untreated watershed is the control watershed and watershed development activities were not undertaken by any agencies or department.

3.3 METHOD OF DATA COLLECTION

Data was collected, by personally interviewing the respondents using a pretested structured interview schedule. The information related to the crops cultivated by the respondents, yield of different crops grown, costs and returns involved in the cultivation, watershed activities, source of irrigation, market and non market benefits enjoyed and the constraints faced by the beneficiaries in the watershed was collected.

3.4 VARIABLES AND THEIR MEASUREMENT

3.4.1 Cost of planting material

The planting material used for the production may be farm produced or purchased. In the case of purchased planting material, we consider the market price and farm produced planting material is valued at market price.

3.4.2 Cost of manures, fertilizers and soil ameliorants

Manures produced in the farm were evaluated based on the price prevailing in that locality. The cost incurred in the purchase of manures and other fertilizers were calculated based on the purchased price.

3.4.3 Cost of plant protection chemicals

The cost incurred in the purchase of plant protection chemicals were evaluated at the market price.

3.4.4 Cost of labour

3.4.4.1 Cost of family labour

The cost involved in using family labour was calculated at the wage rate paid to the hired labour in that locality.

3.4.4.2 Cost of hired labour

Cost of hired labour mainly refers to the wages that was actually paid to the work rendered by them in the farm. The wage rate for men is ₹ 500 and the wage rate for women ₹ 350 in the locality.

3.4.4.3 Cost of machine labour

It involves the cost incurred in the maintenance of the machineries by employing some workers to carry the maintenance work of the machines like fuel, power, lubricants, repair and other expenses which are included under the annual maintenance and repairs. Straight line method was used to find the depreciation of the machineries.

3.4.5 Land revenue

This is the actual revenue rate that was paid by the farmers to the revenue department for their land that they possess. The revenue paid by farmers in the locality was ₹ 200 per acre per year.

3.4.6 Interest on working capital

Working capital refers to paid out cost. Interest on the working capital was worked out at the rate of 7 per cent per annum. It is the rate at which farmers get crop loans from the financial institutions.

3.4.7 Interest on fixed capital

Interest on fixed capital was calculated at the rate of 11 per cent per annum as the long term loans were provided at this rate by the commercial banking institutions.

3.4.8 Rental value of the leased in land

It was the rent paid by the farmers to the leased land for cultivating crops for a year, so the rental value of the leased land was calculated as the rent paid per year.

3.4.9 Rental value of owned land

It was computed by taking the rent of land prevailed in that locality.

3.4.10 Depreciation

Straight line method was used to calculate annual rate of depreciation of each of the machinery and implements, then the total depreciation allowance was calculated by aggregating.

3.4.11 Miscellaneous expenses

This includes other costs like transportation of manures and fertilizers, rent of sprayers and purchase of small accessories like basket, gunny bags etc.

3.5 TOOLS FOR ANALYSIS

Appropriate statistical tools were used to evaluate the collected data and to draw a meaningful conclusion. Tools used for the analysis were the following

3.5.1 Percentages and averages

Percentages and averages were used to evaluate the watershed project details, socio-economic characteristics of the respondents, soil and water conservation measures adopted by the farmers, market and non-market benefits in the treated watershed, variation in benefits in the upper, middle and lower reaches of the watershed and suggestions given by the farmers for improving the project.

3.5.2 Annual cost of maintenance (Cost of cultivation)

Cost of cultivation was worked out as the sum total of cost incurred on various inputs that are used in the production of the commodity. In this study cost concepts were used to calculate the cost of cultivation.

3.5.2.1 Cost concept

Cost A_1 includes

1. Cost of hired labour
2. Cost of manures, fertilizers and soil ameliorants
3. Cost of plant protection chemicals
4. Land revenue
5. Depreciation
6. Maintenance cost of equipment and machineries
7. Interest on working capital
8. Miscellaneous

Cost A_2

Includes the sum of Cost A_1 and rental value of leased in land

Cost B

It is the sum of Cost A_2 and rental value of owned land and interest on owned fixed capital excluding land.

Cost C

Includes the sum of Cost B and imputed value of family labour

(CSO, 2008)

3.5.2.2 Resource use efficiency

Cobb-Douglas production function was used to find the resource use efficiency of the various resources used in the production process by the watershed beneficiaries and non-beneficiaries. This was carried out in order to know how the beneficiaries are allocating the resources that they possess compared to that of non-beneficiaries, so that we can say who is allocating the resource more efficiently.

Cobb-Douglas production function is given by:

$$Y = aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}e^n$$

This is modified into a log-log model by application of logarithm.

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + e^n$$

Where,

Y= Yield (kg ha^{-1}).

X_1 = Quantity of hired labour (ha^{-1})

X_2 = Quantity of family labour (ha^{-1}).

X_3 = Quantity of fertilizers, manures and soil ameliorants (ha^{-1}).

X_4 = Quantity of plant protection chemicals (ha^{-1}).

a = Intercept

$b_1 \ldots b_4$ = Regression coefficients of explanatory variables.

e^n = Stochastic error term

Cobb-Douglas production function was estimated by OLS method assuming the error term (e) to be independently and normally distributed with homogenous error variance (Reddy *et al.*, 2004).

3.5.3 Estimation of marginal products and marginal value products

In this study marginal product (MP) and marginal value product (MVP) were calculated by comparing MVP of each resource with the marginal factor cost (MFC). The marginal product of input was calculated at geometric mean levels of variables by using the following formula

$$\text{Marginal product of input } (MP_i) = b_i \times \overline{Y}/\overline{X_i}$$

Where,

$\overline{Y}$ = geometric mean of output

$\overline{X_i}$= geometric mean of i^{th} independent variable

b_i= the regression coefficient of the i^{th} independent variable

The formula used for calculating MVP was

$$\text{Marginal value productivity of } X_i = b_i P_Y \overline{Y}/\overline{X_i} = P_Y \times MP_i$$

P_Y = price of crops grown by the respondents

The comparison of ratios (MVP/MFC = k) for judging the efficiencies are

k > 1 indicating under use or sub optimal use of resources

k = 1 optimum use of resources (allocative efficiency)

$k < 1$ indicating excess use of resources (Reddy *et al.*, 2004)

3.5.4 Impact of watershed development programme on farm income

To study the impact of WSD programme on farm income, the ordinary least square regression (OLS) model was used. This was carried out by keeping farm income as the dependent variable and different watershed development activities as independent variables. The functional form of regression is as follows.

$$Y = f(X_1, X_2, X_3, X_4)$$

The above function can be modified as log- log model,

$$\log Y = b_o + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + u$$

Where,

Y = Farm income

X_1 = Soil moisture content (per cent)

X_2 = Soil organic matter content (per cent)

X_3 = Length of contour bund (m)

X_4 = Region of watershed (code)

u = Error term

b_0 = Intercept

$b_1 \ldots b_4$ = Regression coefficients of independent variables

3.5.6 Constraint analysis - Garrett's Ranking Technique

Garrett's ranking technique was adopted to ascertain the constraints faced by the farmers in the watershed. The respondents were asked to rank the different aspects of constraints and the rank was converted into per cent position by using the following formula:

$$\text{Per cent position} = \frac{100\ (R_{ij} - 0.5)}{N_j}$$

Where,

R_{ij} = Rank given for i^{th} constraint by j^{th} farmer

N_j = Number of constraints ranked by the j^{th} farmer

The per cent position of each rank was converted to Garrett score. The score of the individual respondent for each constraint was added. The sum value of scores and the mean values of score were calculated. The mean score for all the constraints were arranged in ascending order and the constraints having highest mean value is considered to be the most important constraints (Garret, 1969).

Results and Discussion

4. RESULTS AND DISCUSSION

Data collected from the survey were tabulated and analyzed to draw meaningful conclusions. Results drawn from the analysis of the data collected were described and discussed in this chapter in detail under the following headings.

4.1 Details of Poothadi watershed project

4.2 Socio-economic status of the respondents

4.3 Economics of the major crops grown by the respondents

4.4 Soil and water conservation measures adopted by the farmers

4.5 Market and non-market benefits in the treated watershed

4.6 Impact of watershed development project on cropping pattern and farm income

4.7 Variation in benefits in upper, middle and lower reaches of the watershed

4.8 Constraints faced by the beneficiaries and suggestions to improve the project

4.1 DETAILS OF POOTHADI WATERSHED PROJECT

4.1.1 Basic information about Poothadi watershed project

Poothadi watershed project (Ka4f Poothadi) was a river valley project (RVP) under RVP Kabani river project. It was a three year project, started in September 2010 and completed in November 2013. Prior to the implementation of the project, extensive field visits were conducted in the watershed to identify and analyze the problems faced by the farmers. Major problems faced by the farmers in the watershed were heavy runoff of the topsoil, low income from agricultural crops due to the depletion of soil fertility, drinking water scarcity during summer months, soil erosion and erosion permitting crops like cassava and ginger were grown and groundwater table depletion. The resources in the watershed and the requirements by the farmers were identified and mapped

using PRA techniques. Representatives of the local bodies, progressive farmers and officials of the other line departments like the forest, dairy, fisheries agriculture, and animal husbandry were involved in the project formulation. To reduce the soil erosion and to increase the available moisture content contour vegetative hedges, contour graded bunds and staggered trenches were adopted. Construction of retaining walls and stream bank protection works were carried out to reduce the velocity of water as wells as sliding of stream banks. Water harvesting structures and farm ponds were constructed in order to harvest more rainwater and for ensuring drinking and irrigation water availability. Horticultural plants were planted to improve the flora of the area and to prevent soil erosion.

4.1.2 Location of Poothadi watershed

Poothadi watershed is located in Wayanad district of Kerala, in Kalpetta and Sulthan Bathery blocks. The watershed includes Poothadi, Kaniyambetta, Meenangadi and Muttil panchayats. Villages under Poothadi watershed is Poothadi, Kaniyambetta, Purakkadi, Krishnagiri and Muttil. Poothadi watershed comes under the catchment of river Chundappuzha, with undulating topography and comes under high prioritized watershed. The longitude and latitude of the watershed are WE 76 6` 10" – 76 12` 16" and SN 11 39` 28" – 11 43` 33" respectively.

4.1.3 Status of land use in the watershed

The land utilization pattern of Poothadi watershed is depicted in table 2. The total watershed area is 4428 ha, in which majority of the area is with private individuals (4288 ha) followed by the Government (140 ha). Among the total area owned by the Government, more area is under the road and other public areas (90 ha) followed by area under forest (40 ha) and wasteland (10 ha). Since more than 90 per cent area was under the private individuals most of the WSD activities were done in the farmers' field. Since the farmers had low income, they could not adopt SWC measures for reducing soil erosion and runoff, but through the project they were able to adopt various SWC measures.

Table 2. Land utilisation pattern in Poothadi watershed

S. No.	Particular	Government (ha)	Private (ha)	Total (ha)
1	Agriculture	-	4288 (100)	4288 (96.83)
2	Forest	40 (28.57)	-	40 (0.90)
3	Wasteland	10 (7.14)	-	10 (0.23)
4	Others	90 (64.29)	-	90 (2.03)
5	Total	140 (100)	4288 (100)	4428 (100)

Source: Office of Assistant Director of Soil Conservation, RVP Kabani Kaniambetta sub division, Meenangadi, 2019

Note: Figures in parentheses indicate per cent to total.

4.1.4 Physical information

4.1.4.1 Rainfall details

Average rainfall of the watershed was 2696 mm, maximum rainfall intensity is more during 60 minutes duration (165 mm) followed by 30 (100 mm) and 15 (80 mm) minutes of duration. Table 3 depicts the average rainfall and maximum rainfall intensity in Poothadi watershed.

Table 3. Average rainfall and maximum rainfall intensity in Poothadi watershed (2013-14)

S. No.	Particular		Rainfall (mm)
1	Average rainfall		2696
2	Maximum rainfall intensity	15 minutes duration	80
		30 minutes duration	100
		60 minutes duration	165

Source: Office of Assistant Director of Soil Conservation, RVP Kabani Kaniambetta sub division, Meenangadi, 2019

Poothadi watershed area receives abundant rainfall during the rainy season and if possible to harvest all the rainwater, the availability of water for crop and

livestock rearing can be enhanced. Thus the annual income of the farmers can be enhanced which in turn can improve the standard of living of the farmers.

4.1.4.2 Temperature

Details regarding the maximum and minimum temperature of Poothadi watershed during 2013-14 in different seasons are represented in table 4. Average maximum and minimum temperature in the treated watershed were 29.35 °C and 13.89 °C respectively.

Table 4. Maximum and minimum temperature during different seasons (2013-14) (°C)

S. No.	Season	Maximum temperature	Minimum temperature
1	Summer	29.72	14.72
2	Rainy	29.44	15
3	Winter	28.88	11.94
4	Average	29.35	13.89

Source: Office of Assistant Director of Soil Conservation, RVP Kabani Kaniambetta sub division, Meenangadi, 2019

4.1.4.3 Soil profile

Table 5 represents the soil profile of Poothadi watershed. Majority of the area comes under the alluvial and colluvium (70 per cent) classification of the soil and remaining falls under laterite, red and brown soils (30 per cent).

Table 5. Soil profile of Poothadi watershed

S. No.	Soil class	Area (ha)
1	Alluvial and colluvium soil	3100 (70)
2	Laterite, red and brown soils	1328 (30)
3	Total	4428 (100)

Source: Office of Assistant Director of Soil Conservation, RVP Kabani Kaniambetta sub division, Meenangadi, 2019
Note: Figures in parentheses indicate per cent to total.

Alluvial soils are formed by the deposition by the river hence they are highly fertile, more than half of the watershed area is under alluvial soil and its efficient utilization can increase the yield of the crops and annual income of the farmers.

4.1.4.3 Soil depth

The soil depth of Poothadi watershed is indicated in table 6. Majority of the area had a deep soil (92.59 per cent) with a soil depth greater than 45 cm and few areas had a shallow soil with depth less than 7.5 cm (0.63 per cent).

Table 6. Soil depth of Poothadi watershed

S. No.	Depth (cm)	Area (ha)
1	0-7.5	28 (0.63)
2	7.5-45	300 (6.76)
3	>45	4100 (92.59)
4	Total	4428 (100)

Source: Office of Assistant Director of Soil Conservation, RVP Kabani Kaniambetta sub division, Meenangadi, 2019

Note: Figures in parentheses indicate per cent to total.

4.1.4.4 Slope of the watershed

The slope of Poothadi watershed is depicted in table 7. Majority of the area lies in a slope ranging 8 to 25 per cent (2083 ha), followed by 0 to 3 (1665 ha), 3 to 8 (524 ha) and greater than 25 per cent (156 ha) slope.

Table 7. Slope of Poothadi watershed

S. No.	Slope (%)	Area (ha)
1	0-3	1665 (37.60)
2	3-8	524 (11.83)
3	8-25	2083 (47.04)
4	>25	156 (3.52)
5	Total	4428 (100)

Source: Office of Assistant Director of Soil Conservation, RVP Kabani Kaniambetta sub division, Meenangadi, 2019

Note: Figures in parentheses indicate per cent to total.

4.1.4.5 Water resources

Table 8 represents the number of water resources in Poothadi watershed and area irrigated by it. Number of dug well (98.3 per cent) was more than that of the shallow (1.5 per cent) and deep tube well (0.19 per cent). Area irrigated by the surface water resources (74 per cent) was more compared to that of dug wells (17.36 per cent) and tube wells (8.69 per cent).

Table 8. Number of water resources in Poothadi watershed

S. No.	Water resource	Number	Area irrigated (ha)
1	Surface	-	1065 (73.96)
2	Dug wells	4212 (98.30)	250 (17.36)
3	Shallow tube wells	65 (1.52)	45 (3.13)
4	Deep tube wells	8 (0.19)	80 (5.56)
5	Total	4285 (100)	1440 (100)

Source: Office of Assistant Director of Soil Conservation, RVP Kabani Kaniambetta sub division, Meenangadi, 2019

Note: Figures in parentheses indicate per cent to total.

In Poothadi watershed number tube wells was very less compared to that of dug wells and area irrigated by surface water resource was more compared to all other resources which indicates that there was no much groundwater exploitation.

4.1.5 Cropping pattern in Poothadi watershed area

Cropping pattern in Poothadi watershed is depicted in table 9. Major crop in Poothadi watershed was rice (1665 ha) followed by coffee and pepper (1585 ha), arecanut and cardamom (300 ha), coconut (260 ha), ginger and turmeric (200 ha), rubber (150 ha), banana (108 ha) and vegetables (20 ha).

Table 9. Cropping pattern in Poothadi watershed

S. No.	Crop	Area (ha)
1	Rice	1665 (38.83)
2	Coconut	260 (6.06)
3	Coffee and pepper	1585 (36.96)
4	Arecanut and cardamom	300 (6.70)
5	Rubber	150 (3.50)
6	Ginger and turmeric	200 (4.66)
7	Vegetables and tapioca	20 (0.47)
8	Banana	108 (2.52)
9	Total	4288 (100)

Source: Office of Assistant Director of Soil Conservation, RVP Kabani Kaniambetta sub division, Meenangadi, 2019

Note: Figures in parentheses indicate per cent to total.

4.1.6 Project expenditure

Expenditure of Poothadi watershed project is depicted in table 10. The total expenditure of Poothadi watershed project was ₹ 93,44,025. Construction of farm pond had a greater expenditure (₹ 34,90,939) followed by the WHS (₹ 24,83,629) and Contour graded bunds (₹ 22,27,218). For all other works, the expenditure was less than four lakh rupees. Planting of vegetative hedges across contour had the least expenditure (₹ 2,340).

Planting of vegetative hedges across the contour had less expenditure hence it can be adopted in the untreated watershed area hence the plant population and greenery of the watershed can be improved and can also reduce soil erosion and runoff at a low cost.

Table 10. Expenditure of Poothadi watershed project

S. No.	Particular	Expenditure (₹)
1	Survey, entry point activities and maintenance of previous work	92,499 (0.99)
2	Contour graded bunds	22,27,218 (23.84)
3	Contour/ staggered trenches	48,616 (0.52)
4	Farm pond	34,90,939 (37.36)
5	Contour vegetative hedges	2,340 (0.03)
6	Horticultural development	3,82,592 (4.09)
7	Retaining wall	1,62,058 (1.73)
8	Water harvesting structures (WHS)	24,83,629 (26.58)
9	Farmers training	36,000 (0.39)
10	Demonstrations	50,000 (0.54)
11	Contingencies	3,68,134 (3.94)
12	Total expenditure	93,44,025 (100)

Source: Office of Assistant Director of Soil Conservation, RVP Kabani Kaniambetta sub division, Meenangadi, 2019

Note: Figures in parentheses indicate per cent to total.

4.1.7 Employment generated by Poothadi watershed development project

Total employment generated by Poothadi watershed development project was 9,060 man-days and it is represented in table 11. The number of labours utilized for the construction of WHS (36.79 per cent) was more compared to that of construction of the retaining wall (22.49 per cent) and contour graded bunds (20.84 per cent). Other development works, such as the construction of farm ponds (9.17 per cent), contour vegetative hedges (8.79 per cent), trenches and horticultural development work had utilized less than 10 per cent of the total labours.

Table 11. Employment generated by Poothadi watershed development project

S. No.	Particular	Employment generated (Man-days)
1	Contour graded bunds	1,888.5 (20.84)
2	Contour or staggered trenches	39.6 (0.44)
3	Farm pond	831 (9.17)
4	Contour vegetative hedges	796.5 (8.79)
5	Horticultural development	84 (0.93)
6	Retaining wall	2,038 (22.49)
7	Water harvesting structures (WHS)	3,333 (36.79)
8	Total	9,060.6 (100)

Source: Office of Assistant Director of Soil Conservation, RVP Kabani Kaniambetta sub division, Meenangadi, 2019

Note: Figures in parentheses indicate per cent to total.

4.2 SOCIO-ECONOMIC STATUS OF THE RESPONDENTS

Primary data was obtained from 90 respondents and they were divided into two categories such as beneficiaries and non-beneficiaries. The primary socio-economic characteristics such as age, sex, education, family size, occupation and family income were tabulated and analyzed with percentage analysis. The results of the analysis are presented below.

4.2.1 Age

The distribution of respondents on the basis of age was classified into five groups such as less than 40, 40 – 50, 50 – 60, 60 – 70 and above 70 years of age. Table 12 shows the age wise classification of the respondents. The average age of the beneficiaries (54.6 years) was more than that of non-beneficiaries (50.98 years). The average age of the total respondents was 52.79 years. In case of beneficiaries more number of respondents fall under the age group 50 – 60 years (37.78 per cent) followed by 40 – 50 (22.22 per cent), 60 -70 (20 per cent), greater

than 70 (11.11 per cent) and less than 40 years (8.89 per cent). Among non-beneficiaries more number of respondents fall under the age group 40 – 50 years (37.78 per cent) followed by 50 - 60 and 60 – 70 (20 per cent) years age group. In case of the total respondents more number of respondents fall under the age group 40 – 50 years (30 per cent) followed by 50 – 60 (28.89 per cent), 60 – 70 (20 per cent), less than 40 (12.22 per cent) and more than 70 (8.89 per cent) years age group.

Table 12. Distribution of respondents based on age

Particular	**<40 Years**	**40-50 Years**	**50-60 Years**	**60-70 Years**	**>70 Years**	**Total**	**Average age (Years)**
Beneficiaries	4 (8.89)	10 (22.22)	17 (37.78)	9 (20)	5 (11.11)	45 (100)	54.6
Non-beneficiaries	7 (15.56)	17 (37.78)	9 (20)	9 (20)	3 (6.67)	45 (100)	50.98
Total	11 (12.22)	27 (30)	26 (28.89)	18 (20)	8 (8.89)	90 (100)	52.79

Note: Figures in parentheses indicate per cent to total.

In the case of the non-beneficiaries more number of farmers was in the age group 40-50, since they were in a younger age compared to that of beneficiaries, implementation of the WSD programme in the untreated watershed is quite easier.

4.2.2 Gender

In the study area, it was found that more number of respondents were male (80 per cent) and only 20 per cent of the total respondents were female. The distribution of respondents based on gender, presented in table 13, revealed that among the beneficiaries, male respondents were more (66.67 per cent) than that of female respondents (33.33 per cent). Similarly, in the case of non-beneficiaries also more number of respondents were male (93.33 per cent) compared to that of female (6.67 per cent).

Table 13. Distribution of respondents based on gender

Gender	Beneficiaries	Non-beneficiaries	Overall
Male	30 (66.67)	42 (93.33)	72 (80)
Female	15 (33.33)	3 (6.67)	18 (20)
Total	45 (100)	45 (100)	90 (100)

Note: Figures in parentheses indicate per cent to total.

4.2.3 Educational status

The educational status of the respondents is given in table 14 and it was classified into six classes such as primary, upper primary, high school, higher secondary, graduation and post-graduation. It was evident that more number of respondents had a high school education (32.22 per cent) followed by higher secondary (25.56 per cent), graduation (17.78 per cent), upper primary (15.56 per cent), post-graduation (5.56 per cent) and primary (3.33per cent) level of education. Among the respondents, more number of beneficiaries had higher secondary (35.56 per cent), high school (33.33 per cent) and upper primary (17.78 per cent) level of education. Whereas in the case of non-beneficiaries, number of respondents with post-graduation (8.89 per cent) level of education was more than that of number of respondents with graduation (24.44 per cent) and primary school (6.67 per cent) level of education.

Table 14. Distribution of respondents based on educational status

S. No.	Educational Status	Beneficiaries	Non-beneficiaries	Overall
1	Primary school	0 (0)	3 (6.67)	3 (3.33)
2	Upper primary	8 (17.78)	6 (13.33)	14 (15.56)
3	High school	15 (33.33)	14 (31.11)	29 (32.22)
4	Higher secondary	16 (35.56)	7 (15.56)	23 (25.56)
5	Graduation	5 (11.11)	11 (24.44)	16 (17.78)
6	Post-graduation	1 (2.22)	4 (8.89)	5 (5.56)
7	Total	45 (100)	45 (100)	90 (100)

Note: Figures in parentheses indicate per cent to total.

4.2.4 Family size

The respondents were classified into three groups based on family size, such as small (less than four members), medium (4-6 members) and large (more than 6 members). The distribution of respondents in terms of family size is presented in table 15. The average family size of the total respondents was found to be 4.35 and average family size in case of beneficiaries (4.6) was greater than that of non-beneficiaries (4.09). In case of both beneficiaries (57.78 per cent) and non-beneficiaries (55.56 per cent) more than half of the families were medium sized.

Table 15. Distribution of respondents based on family size

S. No.	Family size	Beneficiaries	Non-beneficiaries	Overall
1	Small (<4)	8 (17.78)	13 (28.89)	21 (23.33)
2	Medium (4-6)	26 (57.78)	25 (55.56)	51 (56.67)
3	Large (> 6)	11 (24.44)	7 (15.56)	18 (20)
4	Total	45 (100)	45 (100)	90 (100)
5	Average	4.6	4.09	4.35

Note: Figures in parentheses indicate per cent to total.

Palanisami *et al.,* (2009) found similar results in Coimbatore district of Tamil Nadu that the average family size in watershed village was 4.07 and that of control village was 4.2.

4.2.5 Occupational status

The occupational status of respondents was classified into two categories such as agriculture as the main occupation and as subsidiary occupation. The results are presented in table 16. Considering the total number of respondents, about more than half (51.11 per cent) of the respondents had agriculture as the main source of income and remaining respondents (48.88 per cent) considered agriculture as the secondary source of income. Those respondents who had agriculture as subsidiary occupation were government employees, had their own

business, pensioned or private employees. More number of non-beneficiaries (55.56 per cent) had agriculture as the main occupation than that of beneficiaries (46.67 per cent).

Table 16. Distribution of respondents based on occupational status

Particular	Agriculture as main occupation	Agriculture as subsidiary occupation		
		Service	Own business	Others
Beneficiaries	21 (46.67)	12 (26.67)	5(11.11)	7(15.56)
Non-beneficiaries	25 (55.56)	10 (22.22)	5 (11.11)	5 (11.11)
Total	46 (51.11)	22 (24.44)	10 (11.11)	12 (13.33)

Note: Figures in parentheses indicate per cent to total.

4.2.6 Annual income

The annual income of the respondents was calculated by aggregating the income from agriculture and also from other sources. The results of the distribution of farmers based on annual income are presented in table 17. The annual income of the farmers has been classified into five categories such as less than ₹ 1 lakh, ₹ 1 to 3 lakhs, ₹ 3 to 5 lakhs, ₹ 5 to 10 lakhs and above ₹ 10 lakhs. Among the total respondents, more number of individuals belonged to ₹ 5 to 10 lakhs (32.22 per cent) income category, followed by ₹ 1 to 3 lakhs (30 per cent) and ₹ 3 to 5 lakhs (23.33 per cent). In the case of the beneficiaries, more number of respondents belongs to the ₹ 1 to 3 lakhs (40 per cent) income category followed by the ₹ 3 to 5 lakhs (20 per cent) and ₹ 5 to 10 lakhs (17.78 per cent). Among the non-beneficiaries greater number of respondents fall in the ₹ 5 to 10 lakhs (46.67 per cent) income category followed by ₹ 3 to 5 lakhs (26.67 per cent) and ₹ 1 to 3 lakhs (20 per cent). The average annual income of the beneficiaries (₹ 5,41,322.22) was more than that of non-beneficiaries (₹ 5,16,111.1) and that of all respondents was ₹ 528716.66.

Table 17. Distribution of respondents based on annual income

S. No.	Particular	Beneficiaries	Non-beneficiaries	Overall
1	Less than ₹ 1 lakh	4 (8.89)	1 (2.22)	5 (5.56)
2	₹ 1 -3 lakh	18 (40)	9 (20)	27 (30)
3	₹ 3-5 lakh	9 (20)	12 (26.67)	21 (23.33)
4	₹ 5-10 lakh	8 (17.78)	21 (46.67)	29 (32.22)
5	More than ₹ 10 lakh	6 (13.33)	2 (4.44)	8 (8.89)
6	Total	45 (100)	45 (100)	90 (100)
7	Average (₹)	541322.22	516111.1	528716.66

Note: Figures in parentheses indicate per cent to total.

4.2.7 Experience in farming

Based on the experience in farming, farmers were classified into four groups such as farmers with farming experience less than 10 years, 10 to 20 years, 20 to 30 years and more than 30 years. The results of the distribution of farmers based on the experience in farming are presented in table 18. Average experience in farming was more for beneficiaries (28.38 years) than that of non-beneficiaries (22.87 years) and average experience in farming in case of all respondents was 25.63 years. Among beneficiaries (48.89 per cent) and non-beneficiaries (33.33 per cent) more percentage of farmers had 20 to 30 years of experience in farming.

Table 18. Distribution of respondents based on experience in farming

Particular	Beneficiaries	Non-beneficiaries	Overall
Less than 10	2 (4.44)	6 (13.33)	8 (8.89)
10-20	14 (31.11)	10 (22.22)	24 (26.67)
20-30	22 (48.89)	15 (33.33)	37 (41.11)
More than 30	7 (15.56)	14 (31.11)	21 (23.33)
Total	45 (100)	45 (100)	90 (100)
Average	28.38	22.87	25.63

Note: Figures in parentheses indicate per cent to total.

4.2.8 Land holdings

In order to understand the land holding pattern of the respondents they were classified into four categories based on the total land holding and they were respondents with less than 3, 3 to 5, 5 to 10 and more than 10 acres of land. Distribution of respondents based on land holdings is depicted in table 19. Among the total respondents more percentage of respondents fall in the category of 3 to 5 acres of land (37.78 per cent) followed by less than 3 (33.33 per cent), 5 to 10 (24.44 per cent) and more than 10 acres (4.44 per cent) respectively. In the case of beneficiaries, more number of respondents had less than 3 acres of land (44.44 per cent) followed by 5 to 10 (24.44 per cent), 3 to 5 (22.22 per cent) and more than 10 acres (8.89 per cent) respectively. Among the non-beneficiaries, more number of the respondent had 3 to 5 acres (53.33 per cent) of land followed by less than 3 (22.22 per cent) and 5 to 10 acres (24.44 per cent) respectively. The average size of land holdings was more in the case of beneficiary farmers (4.38 acres) than that of non-beneficiary farmers (3.89 acres) and the average size of land holdings for the total respondents was 4.14 acres.

Table 19. Distribution of respondents based on land holdings

Particular	Size of land holding (acres)				Total	Average size of holdings (acres)
	<3	3-5	5-10	>10		
Beneficiaries	20 (44.44)	10 (22.22)	11 (24.44)	4 (8.89)	45 (100)	4.38
Non-beneficiaries	10 (22.22)	24 (53.33)	11 (24.44)	0	45 (100)	3.89
Total	30 (33.33)	34 (37.78)	22 (24.44)	4 (4.44)	90 (100)	4.14

Note: Figures in parentheses indicate per cent to total.

4.2.9 Livestock details

Livestock details were presented in table 20. It reveals that about 40 per cent of the total beneficiaries possessed cattle. Among the beneficiaries and non-beneficiaries, an equal number of respondents had cattle and it was a source

of additional income. Cattle were only raised by all the respondents. Average annual income obtained from livestock by the non-beneficiaries (₹ 1,68,156.7) was more than that of beneficiaries (₹ 84,993.33) and average annual income obtained by the total respondents was ₹ 2,53,150.03. Average annual expenditure on livestock production by the non-beneficiaries (₹ 1,10,200) was more than that of beneficiaries was (₹ 41,333.28). Average annual net income obtained by the non-beneficiaries (₹ 57,956.7) from livestock production was more than that obtained by the beneficiaries (₹ 43,661.05). The average number of cattle owned by the non-beneficiaries (3.28) was more compared to that of the beneficiaries (1.24).

Table 20. Livestock details of the respondents

S. No.	Particular	Beneficiaries	Non-beneficiaries	Aggregate
1	Number of farmers owning cattle	18 (50)	18 (50)	36 (100)
2	Average number of cattle	1.24	3.28	2.26
3	Average annual income (₹/year)	84,993.33 (33.57)	1,68,156.7 (66.43)	2,53,150.03 (100)
4	Average annual expenditure (₹/year)	41,333.28 (27.28)	1,10,200 (72.72)	1,51,533.28 (100)
5	Average annual net income (₹/year)	43,661.05 (42.97)	57,956.7 (57.03)	1,01,617.75 (100)

Note: Figures in parentheses indicate per cent to total.

4.2.10 Area under different crops

Coffee, pepper, arecanut, banana, tubers (cassava, yam and taro), paddy, ginger and vegetables were the different crops cultivated by the respondents and it is depicted in table 21. In the case of total respondents, the area under coffee (118.1 ha) and pepper (118.3 ha) was almost equal followed by arecanut (92.36 ha), banana (13.4 ha), paddy (11.01 ha), tubers (1.58 ha), ginger (1.04 ha) and vegetables (0.22 ha). Among the beneficiaries, the area under pepper (61.98 ha) was more followed by coffee (61.78 ha), arecanut (45.28 ha), banana (7.8 ha), paddy (6.61 ha), ginger (0.52 ha), tubers (0.4 ha) and vegetables (0.22 ha). In the

case of non-beneficiaries, area under coffee was equal to the area under pepper (56.32 ha). It was followed by arecanut (47.08 ha), banana (5.6 ha), paddy (4.4 ha) tubers (1.18 ha) and ginger (0.52 ha). Coffee, pepper and arecanut were the major crops among the beneficiary and non-beneficiary farmers. Pepper-based cropping pattern was prominent among the beneficiaries whereas, among the non-beneficiaries, coffee and pepper-based cropping pattern were familiar.

Table 21. Total area under different crops (ha)

S. No.	Crop	Beneficiaries	Non-beneficiaries	Total
1	Coffee	61.78 (33.47)	56.32 (32.85)	118.1 (33.17)
2	Pepper	61.98 (33.58)	56.32 (32.85)	118.3 (33.23)
3	Arecanut	45.28 (24.53)	47.08 (27.46)	92.36 (25.94)
4	Banana	7.8 (4.23)	5.6 (3.27)	13.4 (3.76)
5	Tubers	0.4 (0.22)	1.18 (0.69)	1.58 (0.44)
6	Paddy	6.61 (3.58)	4.4 (2.57)	11.01 (3.09)
7	Ginger	0.52 (0.28)	0.52 (0.30)	1.04 (0.29)
8	Vegetables	0.22 (0.12)	0 (0)	0.22 (0.06)
9	Total	184.59 (100)	171.42 (100)	356.01 (100)

Note: Figures in parentheses indicate per cent to total.

Thomas *et al.*, (2009) revealed that in Elanad watershed of Thrissur district there was no significant difference between the cropping pattern of beneficiary and non-beneficiary farmers. The study also found that NWDPRA project could not create any significant impact on cropping pattern and cropping intensity in the watershed area.

4.2.11 Watershed development works implemented in the beneficiary farms

Construction of contour graded bunds, staggered trenches and farm ponds, planting of contour vegetative hedges and horticultural development works were the watershed development works implemented by the State department of Soil

Survey and Conservation in the beneficiary farms. Table 22 represents the details of type of watershed development work carried out among beneficiaries of the treated watershed. Contour graded bunds were constructed in all the beneficiary farms. In more than three-fourths of the beneficiary farms farm ponds (77.78 per cent) were constructed followed by staggered trenches (60 per cent). Contour vegetative hedges were planted in more than half (55.56 per cent) of the beneficiary farms, whereas horticultural development works (distribution of planting materials of fruits and trees) took place only in one-fourth (28.89 per cent) of the beneficiary farms.

Table 22. Details of watershed development works implemented in the beneficiary farms

S. No.	Particular	Number of beneficiaries
1	Contour graded bunds	45 (100)
2	Contour or staggered trenches	27 (60)
3	Farm pond	35 (77.78)
4	Contour vegetative hedges	25 (55.56)
5	Horticultural development	13 (28.89)

Note: Figures in parentheses indicate per cent to total number of beneficiaries.

4.2.12 Area under irrigation

Average area under irrigation is represented in table 23. Among the total respondents, average area under irrigation was more in coffee (2.31 ha) followed by banana (0.44 ha). Average area under irrigation was more in case of beneficiaries (1.06 ha) when compared to that of non-beneficiaries (0.61 ha). In the case of beneficiaries, the average area under irrigation was more in coffee (2.98 ha), followed by pepper (0.88 ha), banana (0.66 ha) and vegetables (0.01 ha).

Table 23. Crop-wise average area under irrigation (acres)

S. No.	Crop	Beneficiaries	Non-beneficiaries	Total
1	Coffee	2.98	1.65	2.31
2	Pepper	0.88	0	0.44
3	Banana	0.66	0.77	0.72
4	Vegetables	0.01	0	0.005
5	Total	1.06	0.61	0.87

4.2.13 Sources of irrigation

The area under various methods of irrigation is presented in table 24. Different methods of irrigation practised in the study area were farm pond and well irrigation connected with pump-set and micro-irrigation. The area under rainfed condition was more in case of non-beneficiaries (50 per cent) than that of beneficiaries (21.13 per cent). In case of beneficiary farms, more than half (55.21 per cent) of the area was irrigated by farm ponds followed by wells (23.66 per cent). Whereas among the non-beneficiaries, only one-fourth of the area was irrigated with water from the well (32.5 per cent) followed by farm ponds (16.62 per cent). The total area under irrigation was more in case of beneficiary farms than that of non-beneficiary farms.

Table 24. Area under various methods of irrigation

S. No.	Method of irrigation	Area under irrigation (acres)		
		Beneficiaries	Non-beneficiaries	Total area
1	Rainfed	40.85 (21.13)	87.68 (50)	128.53 (34.86)
2	Well (pump-set)	45.74 (23.66)	56.99 (32.50)	102.73 (27.87)
3	Farm pond (pump-set)	106.73 (55.21)	29.15 (16.62)	135.88 (36.86)
4	Micro irrigation	0 (0)	1.53 (0.87)	1.53 (0.42)
5	Total	193.32 (100)	175.35 (100)	368.67 (100)

Note: Figures in parentheses indicate per cent to total.

4.3 ECONOMICS OF THE MAJOR CROPS GROWN BY THE RESPONDENTS

4.3.1 Economics of coffee cultivation

4.3.1.1 Cost of cultivation of coffee

The cost of cultivation of coffee was computed for the beneficiaries and non-beneficiaries of watershed development programme and represented in table 25 and figure 5 and 6. From the data analysed it was found that, the total cost of cultivation (Cost C) for the beneficiaries (₹ 1,13,295.23 ha^{-1}) was more than that of non-beneficiaries (₹ 1,07,291.68 ha^{-1}). Cost A_1 (₹ 50,673.85 ha^{-1}) for the beneficiaries was more than that of non-beneficiaries (₹ 45,108.02 ha^{-1}). In the case of Cost A_2, it was more for beneficiaries (₹ 50,673.85 ha^{-1}) compared to that of non-beneficiaries (₹ 45,108.02 ha^{-1}). Cost B was also greater for beneficiaries (₹ 94,728.81 ha^{-1}) when compared to that of non-beneficiaries (₹ 89,465.86 ha^{-1}). Out of the total Cost A_1 incurred to the beneficiaries more than half (52.62 per cent) was accounted by hired labour followed by manures and fertilizers (25.98 per cent) and soil ameliorants (4.04 per cent). Similarly, in the case of the total Cost A_1 incurred to the non-beneficiaries more than half (56.89) per cent was accounted by hired labour followed by manures and fertilizers (22.97 per cent) and soil ameliorants (2.98 per cent).

4.3.1.2 Returns from coffee cultivation and B:C ratio

The yield obtained from the coffee cultivation by the beneficiaries was more (3,625 kg ha^{-1}) than that of the non-beneficiaries (3,250 kg ha^{-1}). The returns obtained from the coffee cultivation are presented in table 26. The gross returns obtained by the beneficiaries (₹ 2,03,000 ha^{-1}) was greater when compared to that of non-beneficiaries (₹1,82,000 ha^{-1}). The net returns at Cost A_1 and Cost A_2 were equal and it was more for beneficiaries (₹ 1,52,326.15 ha^{-1}) than that of non-beneficiaries (₹ 1,36,891.98). Similarly, the net returns at Cost B (₹ 1,08,271 ha^{-1})

Table 25. Cost of cultivation of coffee

S. No.	Particular	Beneficiaries		Non-beneficiaries	
		Cost (₹/ha)	Percentage to cost A_1	Cost (₹/ha)	Percentage to cost A_1
1	Hired labour	26665.98	52.62	25661.39	56.89
3	Manures and fertilizers	13164.54	25.98	10363.09	22.97
4	Soil ameliorants	2045.97	4.04	1344.28	2.98
5	Plant protection chemicals	602.14	1.19	519.35	1.15
6	Land revenue	637.91	1.26	622.69	1.38
7	Irrigation charges	1668.8	3.29	924	2.05
8	Depreciation	3321.57	6.55	3916.66	8.68
9	Interest on working capital	2162.28	4.27	1515.08	3.36
10	Miscellaneous expenses	404.66	0.79	241.48	0.54
11	Cost A_1	50673.85	100	45108.02	100
12	Rental value of leased in land	0	-	0	-
13	Cost A_2	50673.85	-	45108.02	-
14	Interest on owned fixed capital excluding land	4185.67	-	5439.60	-
15	Rental value of owned land	39869.29	-	38918.24	-
16	Cost B	94728.81	-	89465.86	-
17	Imputed value of family labour	18566.42	-	17825.82	-
18	Cost C	113295.23	-	107291.68	-

Figure 5. Per cent share of components at Cost A_1 of coffee cultivation by the beneficiaries

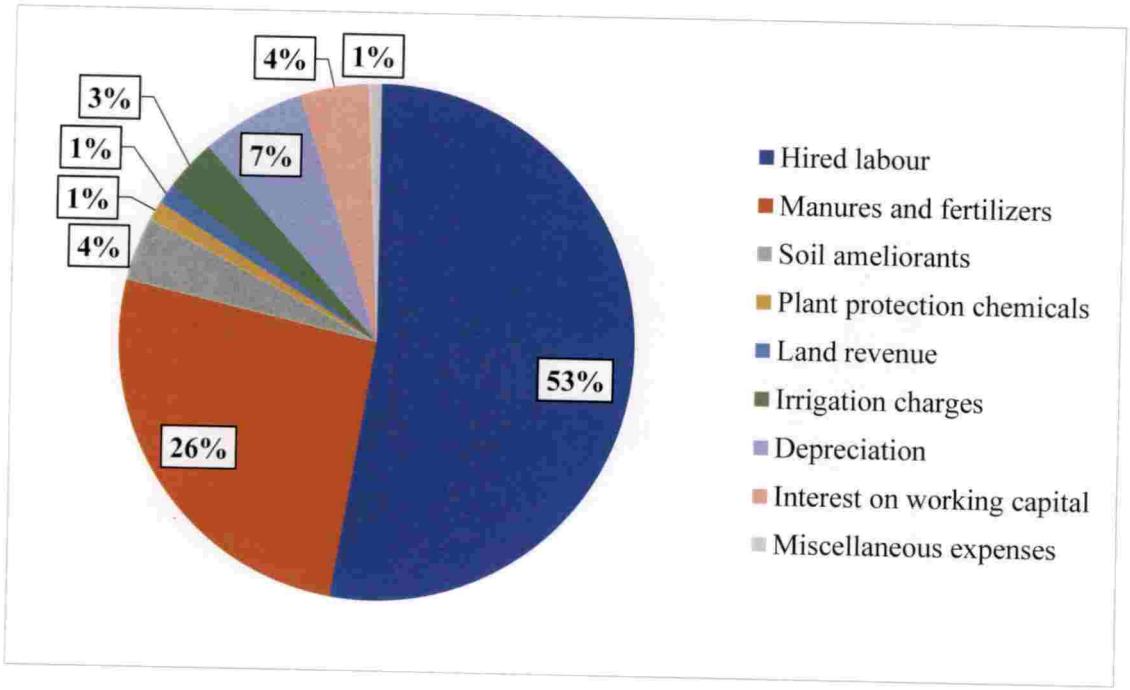
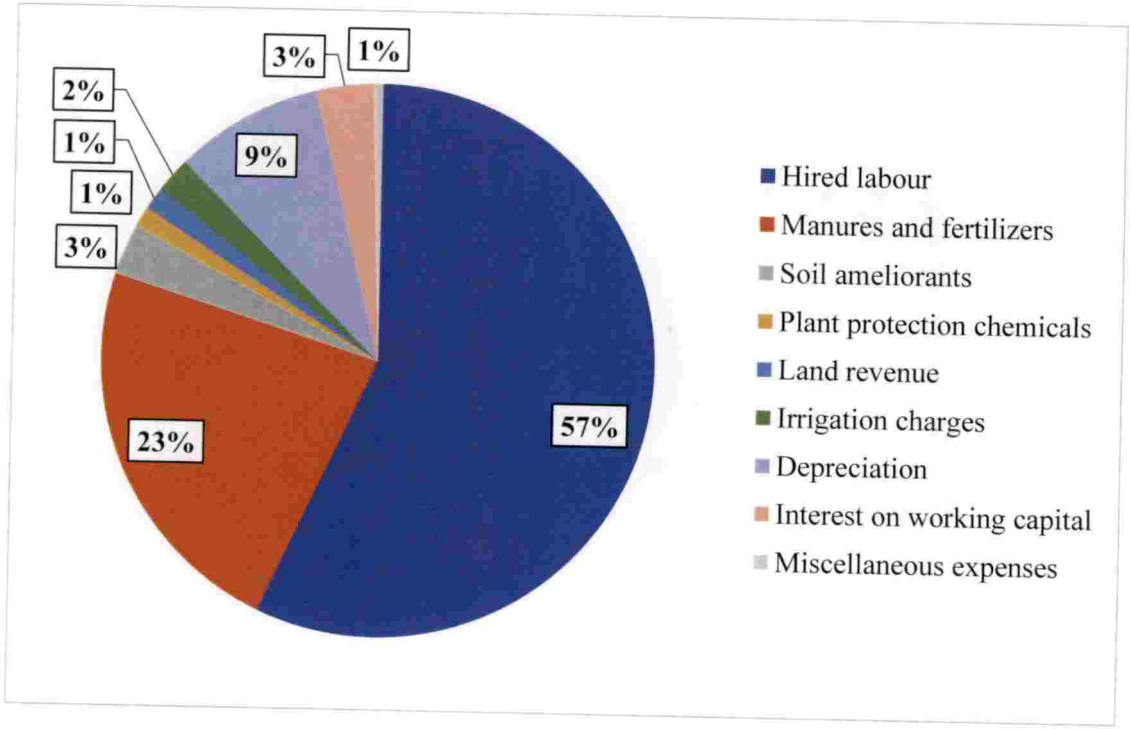


Figure 6. Per cent share of components at Cost A_1 of coffee cultivation by the non-beneficiaries



and Cost C (₹ 89,704.77 ha^{-1}) were also greater for beneficiaries compared to that of non-beneficiaries The profitability was found using the B:C ratio and results are presented in table 27. For the beneficiaries B:C ratio was found to be as 4.01, 4.01, 2.14 and 1.79 respectively at Cost A_1, Cost A_2, Cost B and Cost C. In the case of non-beneficiaries B:C ratio at Cost A_1, Cost A_2, Cost B and Cost C were 4.03, 4.03, 2.03 and 1.69 respectively. The B:C ratio of the beneficiaries were more than that of non-beneficiaries.

Table 26. Returns from coffee

S. No.	Particular	Beneficiaries	Non-beneficiaries
1	Yield (ha^{-1})	3625	3,250
2	Price (₹ kg^{-1})	56	56
3	Gross return (₹ ha^{-1})	2,03,000	1,82,000
4	Net returns at Cost A_1 (₹ ha^{-1})	1,52,326.15	1,36,891.98
5	Net returns at Cost A_2 (₹ ha^{-1})	1,52,326.15	1,36,891.98
6	Net returns at Cost B (₹ ha^{-1})	1,08,271.19	92,534.14
7	Net returns at Cost C (₹ ha^{-1})	89,704.77	74,708.32

Table 27. Benefit cost ratio of coffee

S. No.	Particulars	Beneficiaries	Non –beneficiaries
1	Cost A_1	4.01	4.03
2	Cost A_2	4.01	4.03
3	Cost B	2.14	2.03
4	Cost C	1.79	1.69

4.3.1.3 Resource use efficiency of coffee

Cobb-Douglas production function was used to find the resource use efficiency for coffee cultivation. It can be fitted separately for beneficiary and non-beneficiary farmers by using the below function.

$$Y = aX_1^{b1}X_2^{b2}X_3^{b3}X_4^{b4}e^{u_i}$$

The above function can be modified into log-log form.

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + u_i$$

Where,

Y = Yield of coffee

X_1 = Quantity of hired labour

X_2 = Quantity of family labour

X_3 = Quantity of manures, fertilizers and soil ameliorants

X_4 = Quantity of plant protection chemicals

a = Intercept

$b_1, b_2, \ldots, b_4$ = Regression coefficients of explanatory variables

e = base of natural logarithm

u = stochastic disturbance term

The co-efficient of multiple determination (R^2) explained the variation in the dependent variable caused by the independent variables included in the production function. The elasticity of production was given by the estimated regression coefficients (b_i) of respective inputs (X_i). The regression coefficient (b_i) indicates the percentage change in the yield (Y) if the input quantities (X_i) changes by one per cent while all other factors remain constant at their geometric mean levels. Variance Inflation Factors (VIF) was also calculated to determine the level of multicollinearity between the independent variables involved in the analysis.

The resource use efficiency of coffee was worked out and tabulated in table 28. The R^2 values of 0.91 and 0.94 explain that 91 and 94 per cent of the variation in the yield was due to the independent variables included in the model

for beneficiary and non-beneficiary farmers respectively. In the case of beneficiaries, among the different variables studied quantity of hired labour was found to be significant at one per cent level of significance, followed by quantity of manures and fertilizers and plant protection chemical (significant at 1 per cent level) and they were positively influencing the yield. Among the non-beneficiaries, the quantity of manures and fertilizers were significantly influencing the yield at one per cent level of significance and it was positively influencing the yield. All the other variables considered in the study were also positive except for hired variables in case of non-beneficiaries, but not significantly influencing the yield.

Among beneficiaries one per cent increase in the use of hired labour, family labour, manures and fertilizers and plant protection chemicals is found to increase yield by 0.31, 0.04, 0.25 and 0.31 per cent. The Σb_i value was found to be 0.9, means a simultaneous increase in all the independent variables by one per cent will increase the yield by 0.9 per cent which in turn is showing decreasing returns to scale. In the case of non-beneficiaries, one per cent increase in the use of family labour, manures and fertilizers and plant protection chemicals is found to increase yield by 0.01, 0.94 and 0.031per cent. The Σb_i value was found to be 0.96, means a simultaneous increase in all the independent variables by one per cent will increase the yield by 0.96 per cent which in turn is showing increasing returns to scale. The VIF value for all the independent variables were found to be less than 10, hence the problem of multicollinearity was not there.

4.3.1.4 Marginal productivity analysis of coffee

Marginal value productivity analysis was done and allocative efficiency was calculated to measure the resource use efficiency and the results are tabulated in table 29. The table reveals that among the beneficiary farmers the allocative efficiency was greater than one for all inputs except quantity of family labours which means all resources except quantity of family labours were under-utilized. In case of non-beneficiaries allocative efficiency was greater than one for quantity of manures, fertilizers and soil ameliorants and plant protection chemicals which

Table 28. Estimated production function of coffee cultivation

S. No.	Particular	Beneficiaries				Non-beneficiaries			
		Coefficient	Standard error	P value	VIF	Coefficient	Standard error	P value	VIF
1	Intercept	4.75	0.524	0.000	-	0.593	0.391	0.137	-
2	Quantity of hired labour	0.307***	0.055	0.000	1.38	-0.031	0.018	0.098	1.38
3	Quantity of family labour	0.037	0.027	0.208	2.90	0.009	0.013	0.496	1.37
4	Quantity of manures, fertilizers and soil ameliorants	0.246***	0.084	0.005	4.28	0.944***	0.048	0.000	1.58
5	Plant protection chemicals	0.311***	0.084	0.001	3.38	0.034	0.332	0.312	1.59
6	R^2	0.91				0.94			
7	$\overline{R^2}$	0.89				0.93			
8	Calculated F	98.24				164.97			
9	$\sum b_i$	0.9001				0.956			
10	No. of observations	45				45			

***Significant at 1 per cent level of significance

Table 29. MVP and MFC of different inputs for coffee cultivation

S. No.	Particular	Beneficiaries				Non-beneficiaries			
		Geometric mean	MVP	MFC	K = MVP/MFC	Geometric mean	MVP	MFC	K = MVP/MFC
1	Yield	3533.82	-	-	-	3765.38	-	-	-
2	Quantity of hired labours	47.84	1264.86	437.61	2.89	48.22	-134.62	454.04	-0.29
3	Quantity of family labours	26.94	267.86	461.92	0.58	27.73	67.43	458.83	0.15
4	Quantity of manures, fertilizers and soil ameliorants	2134.73	22.71	6.22	3.65	3522.95	56.29	3.85	14.63
5	Quantity of plant protection chemicals	2.078	29454.05	261.97	112.43	1.82	3929.39	300	13.09

indicates that those resources were under-utilized, where as quantity of hired labour had a negative allocative efficiency which means it was over utilized and by reducing its use optimum production can be achieved.

4.3.2 Economics of black pepper cultivation

4.3.2.1 Cost of cultivation of black pepper

The cost of cultivation of black pepper was computed for beneficiaries and non-beneficiaries of watershed development programme and represented in table 30 and figure 7 and 8. From the data analysed it was found that, the total cost of cultivation (Cost C) for the beneficiaries (₹ 1,19,109.34 ha^{-1}) was more than that of non-beneficiaries (₹ 1,12,930.61 ha^{-1}). Cost A_1 (₹ 56,357.39 ha^{-1}) for the beneficiaries was more than that of non-beneficiaries (₹ 51,560.16 ha^{-1}). In the case of Cost A_2, it was more for beneficiaries (₹ 56,357.39 ha^{-1}) compared to that of non-beneficiaries (₹ 51,560.16 ha^{-1}). Cost B was also greater for beneficiaries (₹ 1,00,270.19 ha^{-1}) when compared to that of non-beneficiaries (₹ 95,918.00 ha^{-1}).Out of the total Cost A_1 incurred to the beneficiaries more than one-fourth (37.18 per cent) was accounted by the hired labours followed by manures and fertilizers (34.82 per cent) and plant protection chemicals (10.98 per cent). Similarly, in the case of the total Cost A_1 incurred to the non-beneficiaries more than one-fourth (35.79per cent) was accounted by hired labour followed by manures and fertilizers (35.15 per cent) and plant protection chemicals (10.18 per cent).

4.3.2.2 Returns from black pepper and B:C ratio

The yield obtained from the black pepper cultivation by the beneficiaries was more (403.59 kg ha^{-1}) than that of the non-beneficiaries (332.63 kg ha^{-1}). The returns obtained from the black pepper cultivation are presented in table 31. The gross returns obtained from the black pepper was more for beneficiaries (₹ 1,41,259.28) when compared to that of non-beneficiaries (₹ 1,16,422.23). The net returns at Cost A_1 and Cost A_2 were equal and it was more for beneficiaries

Table 30. Cost of cultivation of black pepper

S. No.	Item	Beneficiaries		Non-beneficiaries	
		Cost (₹/ha)	Percentage to cost A_1	Cost (₹/ha)	Percentage to cost A_1
1	Hired labour	20955.95	37.18	18456.14	35.79
2	Manures and fertilizers	19625	34.82	18125	35.15
3	Plant protection chemicals	6187.5	10.98	5250	10.18
4	Land revenue	635.85	1.13	622.69	1.21
5	Depreciation	3310.86	5.88	3916.66	7.59
6	Interest on working capital	3180.15	5.64	2892.44	5.61
7	Miscellaneous expenses	2462.08	4.37	2297.23	4.46
8	Cost A_1	56357.39	100	51560.16	100
9	Rental value of leased in land	0	-	0	-
10	Cost A_2	56357.39	-	51560.16	-
11	Interest on owned fixed capital excluding land	4172.16	-	5439.60	-
12	Rental value of owned land	39740.64	-	38918.24	-
13	Cost B	100270.19	-	95918.00	-
14	Imputed value of family labour	18839.14	-	17012.61	-
15	Cost C	119109.34	-	112930.61	-

Figure 7. Per cent share of components at Cost A_1 of black pepper cultivation by the beneficiaries

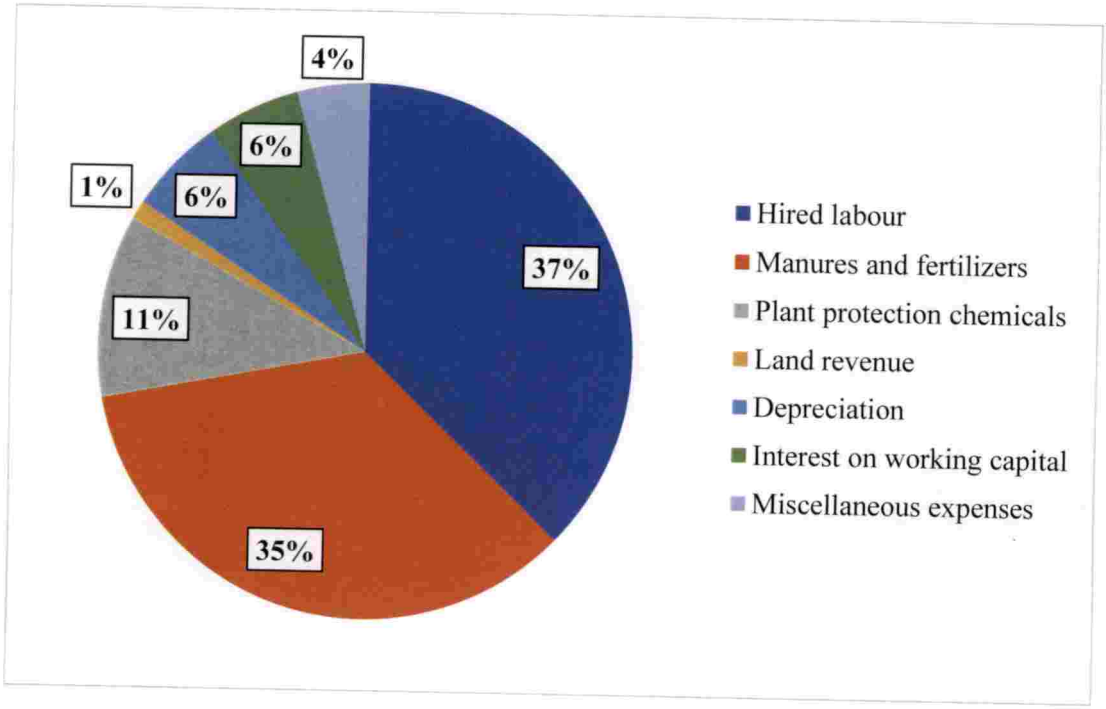
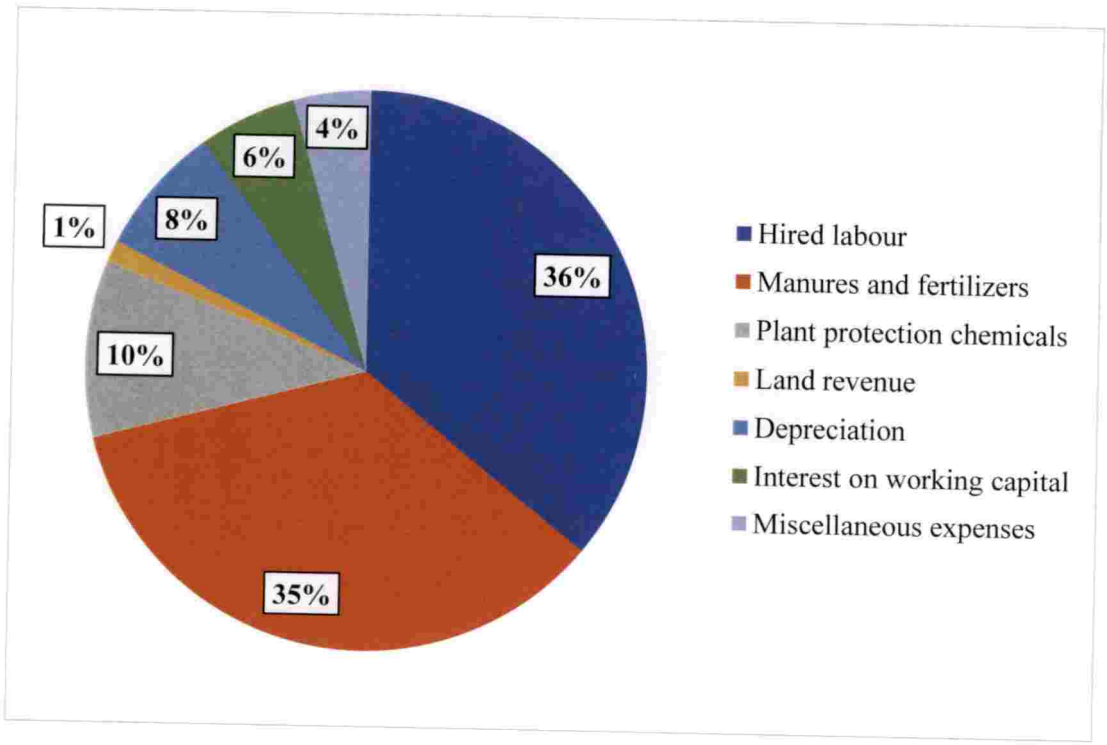


Figure 8. Per cent share of components at Cost A_1 of black pepper cultivation by the non-beneficiaries



(₹ 84,901.89 ha^{-1}) than that of non-beneficiaries (₹ 64,862.07 ha^{-1}). Similarly, the net returns at Cost B (₹ 40,989.08 ha^{-1}) and Cost C (₹ 22,149.94 ha^{-1}) were also greater for beneficiaries compared to that of non-beneficiaries.

The profitability of black pepper cultivation was found by using the B:C ratio and results are presented in table 32. For the beneficiaries B:C ratio was found to be 2.51, 2.51, 1.41 and 1.19 respectively at Cost A_1, Cost A_2, Cost B and Cost C. In case of non-beneficiaries B:C ratio at Cost A_1, Cost A_2, Cost B and Cost C were 2.26, 2.26, 1.21 and 1.03 respectively. The B:C ratio of the pepper cultivation obtained by the beneficiaries were more than that of non-beneficiaries.

Table 31. Returns from black pepper

S. No.	Particular	Beneficiaries	Non-beneficiaries
1	Yield (ha^{-1})	403.59	332.63
2	Price (₹ kg^{-1})	350	350
3	Gross return (₹ ha^{-1})	141259.28	116422.23
4	Net returns at Cost A_1 (₹ ha^{-1})	84901.89	64862.07
5	Net returns at Cost A_2 (₹ ha^{-1})	84901.89	64862.07
6	Net returns at Cost B (₹ ha^{-1})	40989.08	20504.23
7	Net returns at Cost C (₹ ha^{-1})	22149.94	3491.62

Table 32. Benefit cost ratio of black pepper

S. No.	Particulars	Beneficiaries	Non-beneficiaries
1	Cost A_1	2.51	2.26
2	Cost A_2	2.51	2.26
3	Cost B	1.41	1.21
4	Cost C	1.19	1.03

4.3.2.3 Resource use efficiency of black pepper

In the case of pepper also Cobb- Douglas production function was used to find the resource use efficiency. The resource use efficiency of pepper was worked out and tabulated in table 33. The R^2 values of 0.89 and 0.9 explain that 89 and 90 per cent of the variation in the yield was due to the independent variables included in the model for beneficiary and non-beneficiary farmers respectively. In case of beneficiaries, among the different variables studied quantity of manures and fertilizers were found to be significant at one per cent level of significance and positively influencing the yield. Among the non beneficiaries the quantity of plant protection chemicals was significantly influencing the yield at one per cent level of significance and positively influencing the yield.

Among beneficiaries one per cent increase in the use of quantity of manures and fertilizers was found to increase the yield by 1.146 per cent. The Σb_i value was found to be 0.79, means a simultaneous increase in all the independent variables by one per cent will increase the yield by 0.79 per cent which in turn is showing decreasing returns to scale. In case of non-beneficiaries one per cent increase in the use of plant protection chemicals were found to increase yield by 1.006 per cent. The Σb_i value was found to be 0.98, means a simultaneous increase in all the independent variables by one per cent will increase the yield by 0.98 per cent which in turn is showing decreasing returns to scale. The VIF value for all the independent variables were found to be less than 10, hence problem of multicollinearity was absent.

4.3.2.4 Marginal productivity analysis of black pepper

Marginal value productivity analysis was done and allocative efficiency was calculated to measure resource use efficiency and the results are given in table 34. Table reveals that among beneficiary farmers the allocative efficiency was greater than one for quantity of manures and fertilizer which means that those resources were under-utilized, where as all other factors had allocative efficiency less than

Table 33. Estimated production function of pepper cultivation

S. No.	Particular	Beneficiaries				Non-beneficiaries			
		Coefficient	Standard error	P value	VIF	Coefficient	Standard error	P value	VIF
1	Intercept	-0.073	0.9277	0.938	-	-0.0196	0.0534	0.714	-
2	Quantity of hired labour	-0.118	0.0788	0.142	1.61	-0.0111	0.0126	0.385	6.36
3	Quantity of family labour	-0.131	0.1663	0.435	6.87	-0.0142	0.0072	0.056	2.12
4	Quantity of manures and fertilizers	1.146 ***	0.1432	0.000	5.79	0.0045	0.0077	0.566	4.84
5	Plant protection chemicals	-0.109	0.1223	0.377	1.02	1.0056 ***	0.0085	0.000	1.41
6	R^2	0.89				0.998			
7	$\overline{R^2}$	0.879				0.9978			
8	Calculated F	80.88				90.88			
9	$\sum b_i$	0.7875				0.9848			
10	No. of observations	45				45			

***Significant at 1 per cent level of significance

Table 34. MVP and MFC of different inputs for pepper cultivation

S. No.	Particular	Beneficiaries				Non-beneficiaries			
		Geometric mean	MVP	MFC	K = MVP/MFC	Geometric mean	MVP	MFC	K = MVP/MFC
1	Yield	354.11	-	-	-	385.37	-	-	-
2	Quantity of hired labours	46.21	-313.81	459.77	-0.68	42.99	-34.82	449.98	-0.077
3	Quantity of family labours	44.56	-364.38	466.50	-0.78	40.50	-47.29	458.01	-0.103
4	Quantity of manures and fertilizers	1872.27	75.86	12.34	6.15	1737.87	0.35	12.08	0.029
5	Quantity of plant protection chemicals	341.85	-39.52	15	-2.63	405.50	333.49	15	22.29

one which means that those resources were over utilized. In case of non-beneficiaries allocative efficiency was greater than one for quantity of plant protection chemicals which indicates that it was under-utilized, where as all other factors had allocative efficiency less than one which means that those resources were over utilized and by reducing its use optimum production can be achieved.

4.3.3 Economics of arecanut cultivation

4.3.3.1 Cost of cultivation of arecanut

The cost of cultivation for arecanut was computed for the beneficiaries and non-beneficiaries of the watershed and represented in table 35 and figure 9 and 10. From the data analysed it was found that, the total cost of cultivation (Cost C) for the beneficiaries (₹ 1,25,436.38 ha^{-1}) was more than that of non-beneficiaries (₹ 1,10,783.67 ha^{-1}). Cost A_1 and Cost A_2 were equal and it was more for the beneficiaries (₹ 65,327.82 ha^{-1}) than that of non-beneficiaries (₹ 57,720.09 ha^{-1}). Similarly, Cost B was also greater for the beneficiaries (₹ 1,25,436.38 ha^{-1}) when compared to that of the non-beneficiaries (₹ 1,10,783.67 ha^{-1}).

Out of the total Cost A_1 incurred to the beneficiaries more than three-fourths (77.07per cent) was accounted by the hired labours. Similarly, in the case of the total Cost A_1 incurred to the non-beneficiaries more than half (68.61 per cent) was accounted by the hired labours.

4.3.3.2 Returns from arecanut and B:C ratio

The yield obtained from the arecanut cultivation by the beneficiaries was more (3172.48 kg ha^{-1}) than that of the non-beneficiaries (2,997.88 kg ha^{-1}). The returns obtained from the arecanut cultivation are presented in table 36. The gross returns obtained from the arecanut cultivation was more for beneficiaries (₹ 1,77,659.0 ha^{-1}) when compared to that of non-beneficiaries (₹1,67,881.05 ha^{-1}). The net returns at Cost A_1 and Cost A_2 were equal and it was more for beneficiaries (₹ 1,12,331.19 ha^{-1}) than that of non-beneficiaries (₹ 1,10,160.97 ha^{-1}). Similarly, the net returns at Cost B and Cost C were equal and it was greater for non-beneficiaries (₹ 57,097.38 ha^{-1}) compared to that of beneficiaries

Table 35. Cost of cultivation of arecanut

S. No.	Item	Beneficiaries		Non-beneficiaries	
		Cost (₹/ha)	Percentage to cost A_1	Cost (₹/ha)	Percentage to cost A_1
1	Hired labour	50347.84	77.07	39602.80	68.61
2	Manures, fertilizers and soil ameliorants	3809.63	5.83	4792.48	8.30
3	Plant protection chemicals	4330.83	6.63	5904.84	10.23
4	Land revenue	870.36	1.33	744.90	1.29
5	Depreciation	4531.95	6.94	4685.35	8.12
6	Interest on working capital	949.14	1.45	1490.77	11.27
7	Miscellaneous expenses	488.07	0.75	498.94	0.86
8	Cost A_1	65327.82	100	57720.09	100
9	Rental value of leased in land	0	-	0	-
10	Cost A_2	65327.82	-	57720.09	-
11	Interest on owned fixed capital excluding land	5710.92	-	6507.19	-
12	Rental value of owned land	54397.64	-	46556.39	-
13	Cost B	125436.38	-	110783.67	-
14	Imputed value of family labour	0	-	0	-
15	Cost C	125436.38	-	110783.67	-

Figure 9. Per cent share of components at Cost A_1 of arecanut cultivation by the beneficiaries

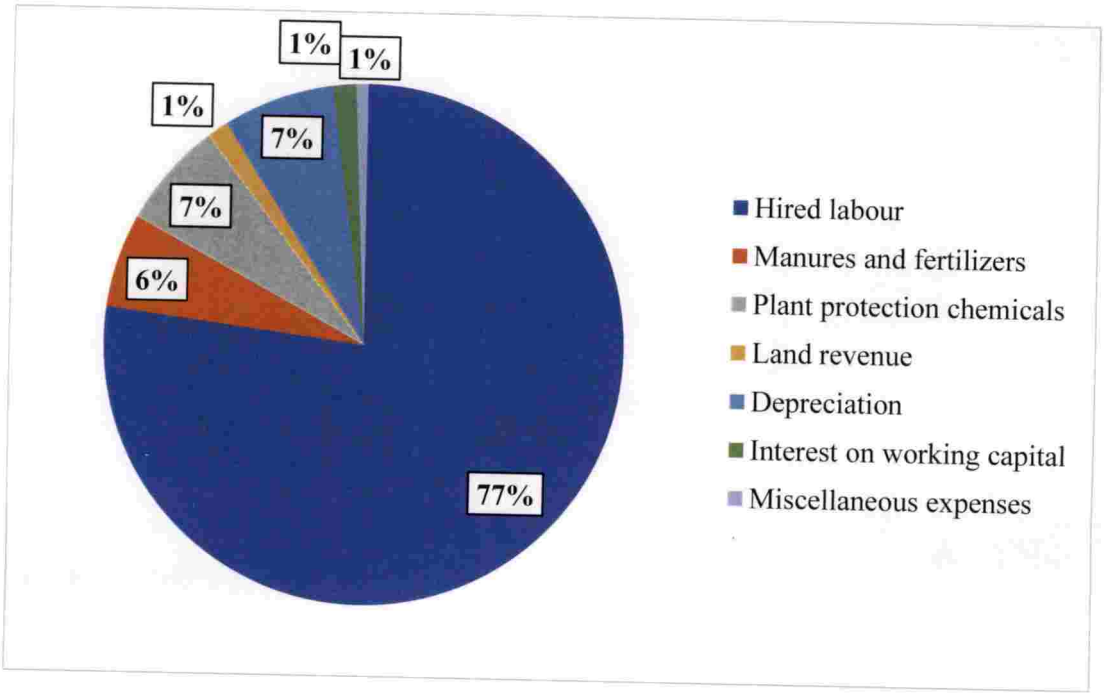
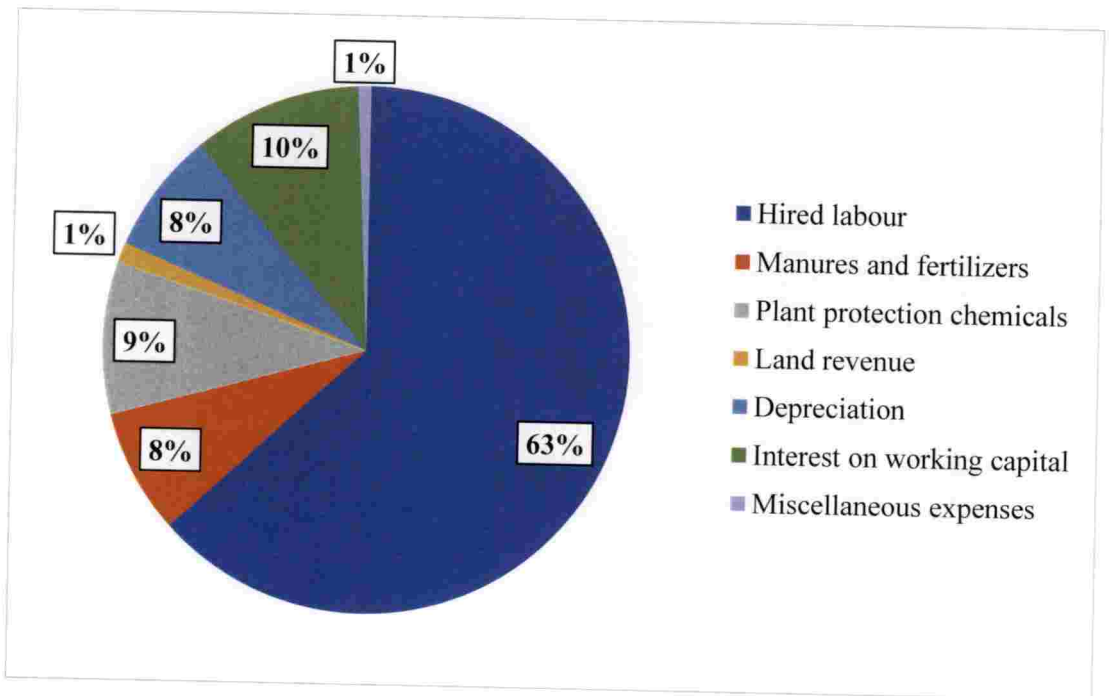


Figure 10. Per cent share of components at Cost A_1 of arecanut cultivation by the non-beneficiaries



(₹52,222.63 ha^{-1}). The profitability of arecanut cultivation was found by using the B:C ratio and results are presented in table 37. The B:C ratio for the arecanut cultivation obtained by the non-beneficiaries were more than that of beneficiaries at all cost.

Table 36. Returns from arecanut

S. No.	Particular	Beneficiaries	Non-beneficiaries
1	Yield (ha^{-1})	3172.48	2997.88
2	Price (₹ kg^{-1})	56	56
3	Gross return (₹ ha^{-1})	177659.01	167881.05
4	Net returns at Cost A_1 (₹ ha^{-1})	112331.19	110160.97
5	Net returns at Cost A_2 (₹ ha^{-1})	112331.19	110160.97
6	Net returns at Cost B (₹ ha^{-1})	52222.63	57097.38
7	Net returns at Cost C (₹ ha^{-1})	52222.63	57097.38

Table 37. Benefit cost ratio of arecanut

S. No.	Particulars	Beneficiaries	Non-beneficiaries
1	Cost A_1	2.72	2.91
2	Cost A_2	2.72	2.91
3	Cost B	1.42	1.52
4	Cost C	1.42	1.52

4.3.3.3 Resource use efficiency of arecanut

In the case of arecanut also Cobb-Douglas production function was used to find the resource use efficiency. In this case quantity of family labour was not included. The resource use efficiency of arecanut was worked out and tabulated in table 38. The R^2 values of 0.99 and 0.31 explain that 99 and 31 per cent of the variation in the yield was due to the independent variables included in the model for beneficiary and non-beneficiary farmers respectively. In the case of both

beneficiaries and non-beneficiaries among the different variables studied the quantity of hired labours were found to be significant at one per cent level of significance and positively influencing the yield. All other independent variables were positive except for quantity of manures and fertilizers in the case of non-beneficiaries, but they were not significant.

Among the beneficiaries one per cent increase in the use of quantity of labours, was found to increase the yield by 0.99 per cent. The Σb_i value was found to be 2.94, means a simultaneous increase in all the independent variables by one per cent will increase the yield by 2.94, per cent which in turn is showing decreasing returns to scale. In case of non-beneficiaries one per cent increase in the use of quantity of labours, was found to increase yield by 0.345 per cent. The Σb_i value was found to be 0.34, means a simultaneous increase in all the independent variables by one per cent will increase the yield by 0.34 per cent which in turn is showing increasing returns to scale. The VIF value for all the independent variables were found to be less than 10, hence problem of multicollinearity was not present.

4.3.3.4 Marginal productivity analysis of arecanut

Marginal value productivity analysis was done and allocative efficiency was calculated to measure resource use efficiency and the results are given in table 39. Table reveals that among the beneficiary farmers, the allocative efficiency was greater than one for all the inputs which means that those resources were under-utilized. In the case of non-beneficiaries also the allocative efficiency was greater than one for all the factors except for quantity of manures and fertilizers it indicates that that those resources were under-utilized, where as for quantity of manures and fertilizers allocative efficiency was less than one which means that it was over utilized and by reducing its use optimum production can be achieved.

Table 38. Estimated production function of arecanut cultivation

S. No.	Particular	Beneficiaries				Non-beneficiaries			
		Coefficient	Standard error	P value	VIF	Coefficient	Standard error	P value	VIF
1	Intercept	3.9512	2.372	0.000	-	6.919	1.643	0.000	-
2	Quantity of hired labour	0.99***	1.333	0.000	1.75	0.3459***	0.096	0.001	1.03
3	Quantity of manures and fertilizers	0.9619	1.348	0.154	1.89	-0.1268	0.084	0.140	1.59
4	Quantity of plant protection chemicals	0.9910	4.028	0.558	2.05	0.1232	0.259	0.637	1.55
5	R^2	0.99				0.3135			
6	$\overline{R^2}$	0.98				0.2470			
7	Calculated F	2.94				4.72			
8	$\sum b_i$	3.159				0.3432			
9	No. of observations	25				35			

***Significant at 1 per cent level of significance

Table 39. MVP and MFC of different inputs for arecanut cultivation

S. No.	Particular	Beneficiaries				Non-beneficiaries			
		Geometric mean	MVP	MFC	K = MVP/MFC	Geometric mean	MVP	MFC	K = MVP/MFC
1	Yield	3144.71	-	-	-	3772.91	-	-	-
2	Quantity of hired labours	78.62	2237.76	825.23	2.71	49.78	1467.99	811.36	1.81
3	Quantity of manures and fertilizers	1571.59	107.79	3	35.93	3001.53	-8.93	2	-4.46
4	Quantity of plant protection chemicals	1494.86	116.75	5	23.35	1572.99	16.57	5	3.32

4.4 SOIL AND WATER CONSERVATION MEASURES ADOPTED BY THE FARMERS

The watershed area has an undulating topography, hence soil and water conservation measures are essential to control soil erosion, sedimentation, transportation and depletion of essential nutrients, to maintain soil fertility, moisture content and beneficial microorganisms. Construction of contour bunds, rain pits and earthen bunds, trenching, live fencing, terracing and mulching were some of the soil and water conservation measures adopted by the farmers.

Table 40. Adoption of soil and water conservation measures by the farmers

S. No.	Particulars	Beneficiaries	Non-beneficiaries	Overall
1	Contour bunding	0 (0)	9 (20)	9 (10)
2	Trenching	36 (80)	22 (48.89)	58 (64.44)
3	Live fencing	9 (20)	7 (15.56)	16 (17.78)
4	Rain pit	45 (100)	38 (84.44)	83 (92.22)
5	Terracing	13 (28.89)	0 (0)	13 (14.44)
6	Mulching	45 (100)	37 (82.22)	82 (91.11)
7	Earthen bunds	18 (73.33)	38 (84.44)	56 (62.22)

Note: Figures within the parentheses indicate per cent to the respective total

Among the total respondents more number of respondents adopted rain pit (92.22 per cent) followed by mulching (91.11 per cent), trenching (64.44 per cent), construction of earthen bunds (62.22 per cent), live fencing (17.78 per cent), terracing (14.44 per cent) and contour bunding (10 per cent). In the case of beneficiaries equal number of respondents adopted rain pit and mulching (100 per cent) followed by trenching (80 per cent), construction of earthen bunds (73.33 per cent), terracing (28.89 per cent) and live fencing (20 per cent). Among the non-beneficiaries, equal number of farmers adopted construction of rain pit and earthen bunds (84.44 per cent) followed by mulching (82.22 per cent), trenching

(48.89 per cent), contour bunding (20 per cent) and live fencing (15.56 per cent). Adoption of SWC measures by the respondent farmers is depicted in table 40. Positive impact of the watershed development programme was reflected in the increase of number of beneficiaries adopting the soil and water conservation measures such as construction of rain pits, trenching, live fencing, terracing and mulching. The adoption of such measures by the non-beneficiaries was less when compared to that of the beneficiaries of the treated watershed.

Thomas *et al.,* (2009) in Elanad watershed of Thrissur district found that the practice of mulching, contour bunding, earthen bunds and rain pitting were the more adopted practices among the respondents. The adoption of such measures by non-beneficiaries was only nominal compared to that of beneficiaries. They also reported that the positive impact of the WSD programme was reflected in the increase in the number of beneficiaries adopting the SWC measures like contour bunding, construction of earthen bunds, terracing and mulching.

4.5 MARKET AND NON-MARKET BENEFITS IN THE TREATED WATERSHED

Market benefits in the watershed are those benefits due to the WSD programme that can be marketed which includes improved crop sales, improved livestock sales, reduction in cost for fetching drinking water, less dependence on government water tankers, improved availability of irrigation and drinking water and improved fuel wood and fodder supply. Non-market benefits are those benefits due to the WSD programme which cannot be marketed which includes the following improved carbon sequestration, scenic beauty, air quality, nutrition, diversity in diet, resilience to drought, health, pollination and water filtration, habitat or biodiversity improvement, increased enrolment in education, increased female empowerment and community development. The market and non-market benefits enjoyed by the beneficiaries in the treated watershed were tabulated and analyzed with percentage analysis based on the farmers' perception and the results of the analysis are presented below.

4.5.1 Market benefits in the treated watershed

Market benefits enjoyed by the beneficiaries in the treated watershed are tabulated in table 41. All the beneficiaries in the treated watershed responded that the WSD programme had reduced the cost for fetching drinking water. All the farmers in the lower reaches of the treated watershed responded that the WSD programme had improved crop sales, availability of irrigation water and fuel wood supply, reduced cost of fetching drinking water and dependence on government water tankers. In the case of the upper and lower reaches of the watershed equal (66.67 per cent) number of respondents had improved livestock sales and it was more than that of the middle reaches (53.33 per cent). Among the three reaches of the treated watershed more number of farmers in the lower reaches had responded that the WSD programme had brought many market benefits to them. Almost equal number of farmers in the upper and middle reaches of the treated watershed had responded that the WSD programme had brought many market benefits to them.

Table 41. Market benefits of the WSD programme

S. No.	Particulars	Number of respondents			
		Upper reaches	Middle reaches	Lower reaches	Overall
1	Improved crop sales	14 (93.33)	14 (93.33)	15 (100)	43 (95.56)
2	Improved livestock sales	10 (66.67)	8 (53.33)	10 (66.67)	28 (62.22)
3	Reduction in cost for fetching drinking water	15 (100)	15 (100)	15 (100)	45 (100)
4	Less dependence on government water tankers	13 (86.67)	13 (86.67)	15 (100)	41 (91.11)
5	Improved availability of irrigation water	13 (86.67)	13 (86.67)	15 (100)	41 (91.11)
6	Improved fuel wood supply	13 (86.67)	13 (86.67)	15 (100)	41 (91.11)

Note: Figures within the parentheses indicate per cent to the respective total

Gray and Srinidhi (2013) revealed that in Kumbharwadi watershed of Maharashtra, WSD programme had brought changes in the number of government supplied water tankers, wells, depth of water table, area under irrigation and various crops and cropping pattern which in turn generated several market benefits such as improved crop sales, improved livestock sales, avoided travel cost for migratory work and drinking water, avoided expenditure on government supplied water tankers, irrigation water and drinking water and improved fuel wood and fodder supplies.

4.5.2 Non-market benefits in the treated watershed

Non-market benefits enjoyed by the beneficiaries in the treated watershed are tabulated in table 42. All the respondents from the treated watershed responded that the WSD programme had improved carbon sequestration, scenic beauty, resilience to drought, pollination, water filtration, women empowerment, community development and biodiversity or habitat improvement. More number of respondents in the lower reaches of the treated watershed responded that the WSD programme had improved air quality (100 per cent), nutrition (86.67 per cent), diversity in diet (86.67 per cent) and health (100 per cent) than that of upper and middle reaches of the treated watershed. Equal number of the farmers in the upper and middle reaches of the treated watershed had responded that the WSD programme had improved air quality, nutrition, diversity in diet and health. Among the three reaches of the treated watershed more number of farmers in the upper reaches (26.67 per cent) had responded that the WSD programme had increased enrolment in education than that of middle (13.33 per cent) and lower reaches (13.33 per cent).

Table 42. Non-market benefits of the WSD programme

S. No.	Particular	Number of respondents			
		Upper reaches	Middle reaches	Lower reaches	Overall
1	Improved scenic beauty	15 (100)	15 (100)	15 (100)	45 (100)
2	Habitat improvement or biodiversity	15 (100)	15 (100)	15 (100)	45 (100)
3	Improved air quality	13 (86.67)	13 (86.67)	15 (100)	41 (91.11)
4	Improved nutrition	11 (73.33)	11 (73.33)	13 (86.67)	35 (77.78)
5	Improved diversity in diet	11 (73.33)	11 (73.33)	13 (86.67)	35 (77.78)
6	Increased female empowerment	15 (100)	15 (100)	15 (100)	45 (100)
7	Improved community development	15 (100)	15 (100)	15 (100)	45 (100)
8	Improved resilience to drought	15 (100)	15 (100)	15 (100)	45 (100)
9	Increased water filtration	15 (100)	15 (100)	15 (100)	45 (100)
10	Improved health	13 (86.67)	13 (86.67)	15 (100)	41 (91.11)

Note: Figures within the parentheses indicate percentages to the respective total

Gray and Srinidhi (2013) found that in Kumbharwadi watershed of Maharashtra, various WSD activities had created several non-market benefits such as improved carbon sequestration, scenic beauty, air quality, nutrition, diversity in diet, resilience to drought, health, pollination and water filtration, habitat or biodiversity improvement, increased enrolment in education, female empowerment and community development.

4.6 IMPACT OF WATERSHED DEVELOPMENT PROGRAMME ON CROPPING PATTERN AND FARM INCOME OF THE BENEFICIRIES

4.6.1 Cropping pattern

Cropping pattern of the beneficiary and non-beneficiary farmers are presented in table 43. Coffee, pepper and arecanut were the major crops and there was no much difference in cropping pattern between the beneficiary and non beneficiary farmers. Coffee and pepper based cropping pattern were common in the watersheds.

Table 43. Cropping pattern in the watershed area

S. No.	Crops	Beneficiaries	Non-beneficiaries
1	Coffee + Pepper	5 (11.11)	9 (20)
2	Coffee + Pepper + Arecanut	4 (8.89)	14 (31.11)
3	Coffee + Pepper + Banana	5 (11.11)	0 (0)
4	Coffee + Pepper + Arecanut + Banana	5 (11.11)	8 (17.78)
5	Coffee + Pepper + Arecanut + Rice	14 (31.11)	7 (15.56)
6	Coffee + Pepper + Arecanut + Banana + Tuber + Ginger + Vegetables	12 (26.67)	0 (0)
7	Coffee + Pepper + Arecanut + Banana + Tuber + Ginger	0 (0)	7 (15.56)
8	Total	45 (100)	45 (100)

Note: Figures in the parentheses indicate per cent to total number of respondents

Among the beneficiaries, Coffee + Pepper + Arecanut + Rice (31.11 per cent) cropping pattern was observed in more number of farms followed by Coffee + Pepper + Arecanut + Banana + Tuber + Ginger + Vegetables (26.67 per cent). Among the beneficiaries equal number of farmers (11.11 per cent) had the Coffee + Pepper, Coffee + Pepper + Banana and Coffee + Pepper + Arecanut + Banana cropping pattern. In the case of non-beneficiaries, more of farmers had Coffee + Pepper + Arecanut (31.11 per cent) cropping pattern followed by Coffee + Pepper (20 per cent) and Coffee + Pepper + Arecanut + Banana (17.78 per cent). Among the non-beneficiaries, equal number of farmers (15.56 per cent) had Coffee + Pepper + Arecanut + Rice and Coffee + Pepper + Arecanut + Banana + Tuber + Ginger cropping pattern.

Thomas *et al.*, (2009) revealed that in Elanad watershed of Thrissur district, there was no significant difference between the cropping pattern of beneficiary and non-beneficiary farmers. The project could not make any significant impact on cropping pattern and cropping intensity in the watershed area.

4.6.2 Farm income

In order to know the impact of the watershed development programme over the farm income a log-log regression model was carried out. The independent variables used were soil moisture content (percentage), soil organic matter content (percentage), length of contour bund (m) and region of watershed (code) and dependent variable was farm income (₹). Results obtained are presented in table 44.

Table 44. Impact of the watershed development programme on farm income

S. No.	Variables	Coefficient	Standard error	P value	VIF
1	Intercept	1.33	0.351	0.000	-
2	Soil moisture content	0.11	0.107	0.321	1.08
3	Soil organic matter content	0.06	0.068	0.419	1.36
4	Length of contour bund	0.53***	0.027	0.000	1.11
5	Region of watershed	0.02	0.045	0.699	1.44
6	R^2	0.92			

*** Significant at 1 per cent level of significance

The table reveals that length of contour bund was significant at one percent level of significance, it was positively influencing the farm income and one unit increase in length of contour bund can cause 0.53 per cent increase in yield. All other variables were positive but they were not significant. The R^2 value obtained was 0.92 which indicates that 92 per cent variation in farm income is due to the

independent variable. The VIF value for all the variables were less than ten, hence the problem of multicollinearity was avoided.

The results obtained from the study indicates that the SWC measures adopted in the treated watershed had positive impact on the farm income, hence WSD programmes have to be implemented in the untreated watersheds. Similarly, in an evaluation study done on impact of SWC measures on doubling farmers' income also concluded that the efficient water and soil management activities can improve and sustain agricultural production and productivity and hence farmer's income can be increased. (Mishra *et al.,* 2018).

4.7 VARIATION IN BENEFITS IN UPPER, MIDDLE AND LOWER REACHES OF THE WATERSHED

4.7.1 Organic matter content of soil

The organic matter content of the soil samples collected from the respondents were analysed in the laboratory and the results are presented in table 45. The table reveals that the average organic matter content in the beneficiary farms (4.23 per cent) was more than that of the non-beneficiary farms (3.22 per cent) and) and it was significant, since calculated t value (4.682) was greater than that of t table value (1.658). In the case of beneficiaries, upper reaches of the watershed had more organic matter (5.36 per cent) content followed by lower (4.04 per cent) and middle (3.29 per cent) reaches of the watershed. Among the non-beneficiaries also, the upper reaches (4.31 per cent) had greater average organic matter content followed by lower (2.72 per cent) and middle (2.62 per cent) reaches of the watershed. The highest and lowest per cent of organic matter content in the beneficiary samples was 6.22 and 1.68 per cent respectively, whereas in the case of non-beneficiary samples it was 5.04 and 1.75 per cent respectively.

Table 45. Organic matter content of the soil in the upper, middle and lower regions (%)

S. No.	Particular	Beneficiaries	Non-beneficiaries	Difference
1	Upper	5.36	4.31	1.05
2	Middle	3.29	2.62	0.67
3	Lower	4.04	2.72	1.32
4	Average	4.23	3.22	1.01
5	Highest	6.22	5.04	1.18
6	Lowest	1.68	1.75	-0.07

High altitude regions experience higher rainfall and have low temperature compared to that of the other regions. Since the temperature is low, organic matter decomposition process gets slowed down and there was more organic matter content in the soil. The upper reaches of the watershed had coffee and pepper-based cropping pattern, hence the number of shade trees were more and leaf litterfall was more compared to that of other reaches of the watershed. For shade management, lopping was also practised and the leaves after lopping were left in the soil itself. These are the probable reasons for the increased organic matter content in upper reaches of the watershed.

Thomas *et al.*, (2009) analyzed the organic matter content of the soil in both beneficiary and control plots in Elanad watershed of Thrissur district. They found that the organic matter content in the beneficiary samples ranged from 1.3 to 6.1 per cent, with a mean of 3.0 per cent. Whereas, in the control plots, it ranged from 1.5 to 3.5 per cent and the mean was 2 per cent. The average content of organic matter in the soil was more for beneficiaries than that of the non-beneficiaries. They also reported that the implementation of the watershed programme could be a major reason for the greater level of organic matter content in the soil of beneficiary farmers.

4.7.2 Soil moisture content

The soil moisture content of the soil samples collected from the respondents was analysed in the laboratory and the results are presented in table 46. Average soil moisture content of the beneficiaries (18.26 per cent) was more than that of non-beneficiaries (16.04 per cent) and it was significant, since calculated t value (3.075) was greater than that of t table value (1.658). In the case of beneficiaries, average moisture content of the soil was more in the upper reaches (19.64 per cent) followed by lower (18.83 per cent) and middle (16.31 per cent) reaches of the watershed. Among the non-beneficiaries, the average soil moisture content was more in the lower reaches (18.64 per cent) followed by middle (15.19 per cent) and upper (14.28 per cent) reaches of the watershed. The highest and lowest per cent of soil moisture content in the beneficiary farms was 25.39 and 11.97 per cent respectively, whereas in the case of non-beneficiary farms it was 23.30 and 10.24 per cent respectively.

Table 46. Soil moisture content in the upper, middle and lower regions (%)

S. No.	Particulars	Beneficiaries	Non-beneficiaries	Difference
1	Upper	19.64	15.19	4.45
2	Middle	16.31	14.28	2.03
3	Lower	18.83	18.64	0.19
4	Average	18.26	16.04	2.22
5	Highest	25.39	23.30	2.09
6	Lowest	11.97	10.24	1.73

The upper reaches of the watershed had coffee and pepper-based cropping pattern, during the survey period irrigation was provided in the coffee plantations and also high altitude region experiences more rainfall compared to low altitude regions, these could be the probable reasons for more soil moisture content in the upper reaches of the treated watershed.

4.7.3 Height of water column

The average height of water column in the wells of the watershed area is depicted in table 47. The table reveals that the average height of water column in the wells of beneficiaries (4.31 m) was higher than that of non-beneficiaries (3.92 m) but it was not significant, since calculated t value (1.194) was less than that of t table value (1.658). In the case of beneficiaries, average height of water column in the lower reaches (5.13 m) of the watershed was higher than that of the middle (4.83 m) and upper (2.97 m) reaches. Similarly, among the non-beneficiaries also the average height of water column in the lower reaches (4.63 m) of the watershed was higher when compared to middle (4.33 m) and upper (2.8 m). The highest and lowest height of the water column in the beneficiary plots were 7.5 and 1.5 m respectively and that of non-beneficiaries were 6.5 and 1 m respectively.

Table 47. Height of water column in the wells, in the upper, middle and lower regions (m)

S. No.	Particulars	Beneficiaries	Non-beneficiaries	Difference
1	Upper	2.97	2.8	0.17
2	Middle	4.83	4.33	0.5
3	Lower	5.13	4.63	0.5
4	Average	4.31	3.92	0.39
5	Highest	7.5	6.5	1
6	Lowest	1.5	1	0.5

Thomas *et al.*, (2009) revealed that in Elanad watershed the average height of water column had a 21.78 per cent increase in the wells of beneficiary farmers after the implementation of the programme. They also found that water harvesting techniques like rain pitting, digging and renovation of wells were instrumental in raising the depth of water table in the watershed by around 20 per cent. They also found that there was a significant rise in the water levels of the beneficiaries, indicating a positive impact on the moisture regime and groundwater recharge.

4.8 CONSTRAINTS FACED BY THE BENEFICIARIES AND SUGGESTIONS TO IMPROVE THE PROJECT

4.8.1 Constraints faced by the beneficiaries

The major constraints experienced by the beneficiaries are identified and presented in table 48. The major problem faced by the farmers was lack of supervision and follow-up by the authorities with a Garrett score of 78.93, followed by lack of technical guidance (73.02), lack of awareness about the beneficial programme (64.27), inadequacy of sanctioned amount (59.36), lack of marketing facilities (47.82), insufficient credit availability (47.24), non-availability of inputs and subsidy on time (46.13), non-availability of irrigation water (45.33), political interference (27.04) and inappropriate construction work at inappropriate place (19.96).

Table 48. Constraints faced by the beneficiaries in the treated watershed

S. No.	Constraint	Garrett's Score	Rank
1	Non-availability of irrigation water	45.33	8
2	Non-availability of inputs and subsidy on time	46.13	7
3	Lack of awareness about the beneficial programme	64.27	3
4	Lack of supervision and follow-up	78.93	1
5	Lack of technical guidance	73.02	2
6	Political interference	27.04	9
7	Inadequacy of sanctioned amount	59.36	4
8	Insufficient credit availability	47.24	6
9	Lack of marketing facilities	47.82	5
10	Inappropriate construction works at inappropriate place	19.96	10

4.8.2 Suggestions to improve the project

Suggestions given by the beneficiaries to improve the watershed development programme are tabulated in table 49. The table reveals that the most common suggestion by the beneficiary farmers was that to ensure diversified farming activities (84.44 per cent) such as goat rearing, apiary, poultry unit and aquaculture, followed by biodiversity conservation (75.56 per cent), better marketing and infrastructural facilities (73.33 per cent), continuity and follow-up by the authorities (73.33 per cent), create awareness among people towards watershed management and their benefits (71.11 per cent), ensure efficient utilization of funds(68.89 per cent), rainwater harvesting (64.44 per cent), coordination between farmers and authorities (64.44 per cent) and to increase the project period from five to ten years (62.22 per cent).

Table 49. Suggestions given by the beneficiary farmers to improve the project

S. No.	Suggestion	Number	Percentage
1	Increase the project period from 5 to 10 years	28	62.22
2	Ensure better marketing facilities	33	73.33
3	Ensure better infrastructure facilities	33	73.33
4	Create awareness among people towards watershed management and their benefits	32	71.11
5	Ensure continuity and follow-up	33	73.33
6	Ensure coordination between authorities and farmers	29	64.44
7	Ensure diversified farming activities	38	84.44
8	Efficient utilization of funds	31	68.89
9	Ensure more thrust on rain water harvesting	29	64.44
10	Ensure biodiversity conservation	34	75.56

Lakshmi (2007) evaluated the WSD programmes in Visakapattanam district of Andhra Pradesh. She reported that the common suggestions given by the

farmers in the watershed area to improve the WSD programme were to increase the project duration from 5 to 8 years, ensure appropriate construction work at appropriate place, to provide awareness to the farmers about the importance of the watershed management and to provide training to the farmers regarding improved agricultural technologies.

Summary

5. Summary

Water resource management is an essential component of sustainable development in agriculture. Proper watershed management has triple benefits such as it maintains productive capacity in the watershed area prevents, the degrading processes and it is more profitable than the rehabilitation of degraded lands. The main objective of a watershed development programme is to increase the economic and the social well-being of the beneficiaries of the basin in particular and of the whole nation. The watershed-based development programme had resulted in increased employment generation, crop production, productivity, farm income, groundwater status and overall rural development in the watershed area. In hilly and undulating topographic areas watershed management assumes more importance.

In this context the research work entitled "Economic analysis of watersheds in Wayanad district" was carried out with the objectives to assess the impact of watershed development programme on cropping pattern and farm income, to examine the variation in benefits in upper, middle and lower reaches of watershed and to ascertain the problems of farmers in the watershed. Secondary data was collected from the Office of the Assistant Director of Soil Conservation, RVP Kabani, Kaniambetta sub division, Meenangadi. The treated watershed (beneficiaries) selected for the study was Poothadi watershed in Poothadi Panchayat and untreated watershed (non-beneficiaries) was Aavayal watershed in Meenangadi Panchayat of Wayanad district. Primary data was collected randomly from 45 farmers each from the treated and the untreated watershed comprising of 15 farmers each from upper, middle and lower reaches and thus the total sample size was 90.

Poothadi watershed is located in Wayanad district of Kerala, in Kalpetta and Sulthan Bathery blocks. The watershed includes Poothadi, Kaniyambetta, Meenangadi and Muttil panchayats. Villages under the Pootahdi watershed are Poothadi, Kaniyambetta, Purakkadi, Krishnagiri and Muttil. Poothadi watershed comes under the catchment of the river Chundappuzha, with an undulating

topography and comes under high prioritized watershed. Poothadi watershed project (Ka4f Poothadi) was a river valley project (RVP) during 2010-13 with an area of 4,428 ha. The total expenditure of the project was ₹93,44,025 and major portion was spent for construction of farm ponds, WHS (Water Harvesting Structures) and contour bunds. The project had generated an employment of 9,060 man days during the project period.

The beneficiary respondents had more annual income, family size, land holdings, area under different crops and irrigation when compared to that of non-beneficiaries. Thus WSD programme had a positive impact on the socio-economic status of the beneficiaries of the treated watershed. Major crops cultivated in watershed area were coffee, black pepper and arecanut. Coffee and pepper based cropping pattern were common in the both treated and untreated watersheds. There was no much variation in cropping pattern between the treated and untreated watersheds. Area under irrigation was more in treated watershed than the untreated and the average area under irrigation was more in coffee (2.98 ha).

Cost of cultivation of coffee, black pepper and arecanut was worked out using the cost concepts and total cost was more for beneficiaries than the non-beneficiaries. The yield obtained by the beneficiaries from the coffee (3,625 kg ha^{-1}), pepper (403.59 kg ha^{-1}) and arecanut (3,172.48 kg ha^{-1}) were greater compared to that of non-beneficiaries. In the case of coffee (₹ 89,704.77 ha^{-1}) and pepper (₹ 22,149.94 ha^{-1}) the net returns obtained at total cost was more for beneficiaries than that of non-beneficiaries. Whereas in the case of arecanut, net return obtained by the non-beneficiaries (₹ 57,097.38 ha^{-1}) was more than that of beneficiaries (₹ 52,222.63 ha^{-1}). The profitability was found using the B:C ratio and at Cost C, B:C ratio was more for beneficiaries in case of coffee (1.79) and black pepper (1.19), whereas in the case of arecanut (1.42) it was more for non-beneficiaries.

Cobb-Douglas production function was used to find the resource use efficiency of coffee, black pepper and arecanut cultivation. From the results of regression analysis it was evident that the coefficient of multiple determination of

beneficiaries and non-beneficiaries had values ranging from 0.89-0.99 and 0.31-0.99 respectively, indicating 89-99 and 31-99 per cent of the variation in the gross returns was due to the independent variables considered. In the case of the coffee, for both the beneficiaries and non-beneficiaries quantity of manures, fertilizers and soil ameliorants were significant at one per cent level of significance. For the black pepper cultivation quantity of manures and fertilizers were significant at one per cent level of significance for the beneficiaries, whereas in the case of non-beneficiaries quantity of plant protection chemicals were significant at one per cent level of significance. In the case of arecanut cultivation, for both the beneficiaries and non-beneficiaries quantity of hired labours was significant at one per cent level of significance.

Marginal value productivity analysis was done and allocative efficiency was calculated. In the case of coffee, beneficiary farmers had allocative efficiency greater than one for all inputs except quantity of family labours which means all resources except quantity of family labours were under-utilized. Whereas in the case of non-beneficiaries allocative efficiency was greater than one for quantity of manures, fertilizers and soil ameliorants and plant protection chemicals which indicates that those resources were under-utilized, where as quantity of hired labour had a negative allocative efficiency which means it was over utilized and by reducing its use optimum production can be achieved.

In the case of black pepper, beneficiary farmers had allocative efficiency greater than one for quantity of manures and fertilizer which means that those resources were under-utilized, where as all other factors had allocative efficiency less than one which indicates that those resources were over utilized. In the case of non-beneficiaries allocative efficiency was greater than one for quantity of plant protection chemicals which indicates that it was under-utilized, where as all other factors had allocative efficiency less than one which means it was over utilized and by reducing its use optimum production can be achieved.

In the case of arecanut, beneficiary farmers had allocative efficiency greater than one for all the inputs which means that those resources were under-utilized.

In the case of non-beneficiaries also the allocative efficiency was greater than one for all the factors except for quantity of manures and fertilizers which indicates that those resources were under-utilized, where as for quantity of manures and fertilizers allocative efficiency was less than one which means that it was over utilized and by reducing its use optimum production can be achieved.

Construction of contour bunds, rain pits and earthen bunds, trenching, live fencing, terracing and mulching were some of the soil and water conservation measures adopted by the farmers. Positive impact of the watershed development programme was reflected in the increase of number of beneficiaries adopting the soil and water conservation measures such as construction of rain pits, trenching, live fencing, terracing and mulching. The adoption of such measures by non-beneficiaries was less compared to that of beneficiaries of the treated watershed.

Beneficiaries in the selected treated watershed experienced several market and non-market benefits. The market and non-market benefits enjoyed by the beneficiaries in the treated watershed were analyzed with percentage analysis based on the farmers' perception. Market benefits enjoyed by the farmers in the treated watershed were improved crop sales, livestock sales, reduced cost of fetching drinking water and dependence on government water tankers, increased availability of irrigation water and fuel wood supply. Non-market benefits enjoyed by the farmers in the treated watershed were improved carbon sequestration, scenic beauty, air quality, nutrition, diversity in diet, resilience to drought, health, pollination and water filtration, habitat or biodiversity improvement, increased enrolment in education, female empowerment and community development.

In order to know the impact of watershed development programme over the farm income a log-log regression model was carried out. The independent variables used were soil moisture content (percentage), soil organic matter content (percentage), length of contour bund (metre) and region of watershed (code) and dependent variable was farm income (₹). The analysis of impact of watershed development programme on farm income revealed that the length of contour bund

had increased the farm income at 1 per cent level of significance. The coefficient of multiple determination (R^2) was 0.92, which indicated that 92 per cent of the variation in farm income was explained by the independent variables such as length of contour bund, soil moisture content, organic matter content and region of the watershed.

The watershed area has an undulating topography hence soil and water conservation measures (SWC) are essential to control soil erosion, sedimentation, transportation and depletion of essential nutrients, maintain soil fertility, moisture content and beneficial microorganisms. Organic matter content (4.23 per cent), soil moisture content (18.26 per cent) and depth of water column in wells (4.31 m) were more in treated watershed than the untreated watershed. In treated watershed organic matter and soil moisture content was more in upper reaches followed by lower and middle reaches. Height of water column in the wells of treated watershed was higher in lower reaches (5.13 m) followed by middle (4.83 m) and upper reaches (2.97m).

Garrett's ranking technique was used to analyze constraints faced by the farmers in the treated watershed. Major constraints faced by the beneficiaries in treated watershed were lack of supervision, follow-up and technical guidance by the authorities. Other problems faced by the farmers in the treated watershed were lack of awareness about the beneficial programme, inadequacy of sanctioned amount, lack of marketing facilities, insufficient credit availability, non-availability of inputs and subsidy on time, non-availability of irrigation water, political interference and inappropriate construction work at inappropriate place. Suggestions given by the beneficiaries to improve the project were to ensure diversified farm activities, continuity and follow-up of development and maintenance activities in watershed by the authorities, marketing and infrastructural facilities and biodiversity conservation.

5.1 SUGGESTIONS

WSD programme had a positive impact on the socio-economic status of the beneficiaries of the treated watershed, hence WSD programme have to be extended to the untreated watersheds.

Paddy fields act as the site of in-situ rain water harvesting and conservation, but among the respondents area under paddy cultivation was less compared to other crops hence strategies to improve the area under paddy have to be incorporated in the WSD project.

Positive impact of the WSD programme was reflected in the treated watershed, in the case of number of farmers adopting SWC measures, hence WSD programmes have to be implemented in the untreated watersheds to improve the adoption of SWC measures by the farmers.

Watershed development programme improved the livelihoods of the farmers in the treated watershed and it also had a positive impact on the farm income of the beneficiaries hence WSD programmes have to be extended to the untreated watersheds.

Organic matter content, soil moisture content and depth of water column in wells were more in the treated watershed compared to that of untreated watershed. Therefore, WSD programmes have to be implemented in the untreated watersheds for improving soil fertility, moisture content and groundwater status.

References

6. REFERENCES

Amale, A. J., Kalhapure, S. P. and Yadav, D. B. 2011. Impact of Watershed Development Project on Farm Economy: A Case Study. *Agric. Situ. India*, *68*(3): 137-144.

Arya, S. L. 2010. Impact of Watershed Development Projects on Seasonal Livestock Migration - A Study on Shivalik Foothill Villages in Haryana. *Agric. Econ. Res. Rev. 23*: 359-366.

Arya, S. L. and Yadav, R. P. 2006. Economic Viability of Rainwater Harvesting by Renovating Village Ponds in Small Agricultural Watershed of Johranpur (HP). *Agric. Econ. Res. Rev.* 19: 71-82.

Bera, R., Seal, A., Das, T. H., Sarkar, D. and Chatterjee, A. K. 2017. Production Potential and Economics of Different Crops Under Varying Physiographic Conditions in Damodar Command Area (Part), West Bengal, India. *Res. Rev. J. Crop Sci. Technol. 6*(3): 1-9.

Bhattacharyya, R., Ghosh, B., Dogra, P., Mishra, P., Santra, P., Kumar, S., Fullen, M., Mandal, U., Anil, K., Lalitha, M. and Sarkar, D., 2016. Soil conservation issues in India. *Sustainability*. *8*(6): 1-37.

Biradar, B. N., Manjunath, L., Doddamani, A. and Binkadakatti, J. S. 2012. Impact of Employment and Income Generation by the Initiation of KAWAD Project for Sustaining Rural Livelihoods. *Mysore J. Agric. Sci.* 46(3): 619-623.

Cavatassi, R. 2004. Valuation Methods for Environmental Benefits in Forestry and Watershed Investment Projects [on-line]. Available: https://ssrn.com/abstract= 3307569 or http://dx.doi.org/10.2139/ssrn. 3307569 [25January 2019].

Chand, S., Sikka, A. K. and Srivastava, S. 2016. Constraints Faced by Functionaries in Watershed Management: A Case Study. *Indian Res. J. Ext. Educ.*, *9*(2): 68-71.

Charan, V.C. 2005. Profile of Sujala Watershed Project Beneficiary Farmers in Dharwad District. M.Sc.(Ag) thesis, University of Agriculture Science, Dharwad. 71p.

Chavan, Y. A. 2015. Economic Evaluation of Watershed Development Project of Hivre Bazar in Ahmednagar District: A Case Study. P. hd. thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra. 140p.

CSO (Central Statistical Organisation). 2008. *Manual on cost of cultivation surveys.* Central Statistical Organisation, New Delhi, 25p.

Garrett, H. E. 1969. Statistics in Psychology and Education. Feffer and Simans Pvt. Ltd. 329p.

Goel, A. K. and Kumar, R. 2005. Economic Analysis of Water Harvesting in a Mountainous Watershed in India. *Agric. Water Manag.* 71(3): 257-266.

GOI [Government of India]. 2011. Annual Report 2010-2011. Government of India, New Delhi, 101p.

GOK [Government of Kerala]. 2016. District Survey Report of Minor Minerals [on-line]. Available: http://dmg.kerala.gov.in/docs/pdf/dsr/dsr_way.pdf [02 Mar. 2019].

GOK [Government of Kerala]. 2016. *Economic Review 2015* [on-line]. Available: https://kerala.gov.in/documents/10180/ad430667-ade5-4c62-8cb8-a89d27d396f1 [02 Dec. 2018].

GOK [Government of Kerala]. 2018. *Economic Review 2017* [on-line]. Available: http://spb.kerala.gov.in/ER2017/web_e/ch16.php?id=1&ch=16 [02 Dec. 2018].

GOK [Government of Kerala]. 2019. Commissionerate of Rural Development Home Page [on-line]. Available: http://rdd.kerala.gov.in/index.php/schemes/78-rdd/112-integrated-watershed-management-programme-iwmp [02 Mar. 2019].

122

GOK [Government of Kerala]. 2019. Department of Soil Survey and Soil Conservation Home Page [on-line]. Available: http://www.keralasoils.gov.in/ [02 Mar. 2019].

GOK [Government of Kerala]. 2019. *Economic Review 2018* [on-line]. Available: http://spb.kerala.gov.in/images/pdf/whats_new/Vol1_E.pdf [04 April 2019].

GOK [Government of Kerala]. 2019. Ecostat Kerala [on-line]. Available: http://www.ecostat.kerala.gov.in/index.php/agriculture [02 Mar. 2019].

GOK [Government of Kerala]. 2019. Kerala State Land Use Board Home Page[on-line]. Available: http://kslub.kerala.gov.in/ [02 Mar. 2019].

Gray, E. and Srinidhi, A. 2013. Watershed Development in India: Economic Valuation and Adaptation Considerations [on-line]. Available: https://www.wri.org/sites /default/files/ watershed_development_india.pdf [25December 2017].

IWMI [International Water Management Institute]. 2016. An Assessment of Integrated Watershed Management in Ethiopia [on-line]. Available: http://www.iwmi.cgiar.org/Publications/Working_Papers/working/wor 170.pdf [28 July 2018].

Khan, M. T., Joshi, P. K., Khurana, R. and Kishore, A. 2018. Evolving Watershed Clusters into Drought-Proof, Climate-Resilient Areas: An Impact Evaluation Study in Maharashtra, India [on-line]. Available: https://ageconsearch.umn.edu/record/277385/ [26 April 2019].

Koshy J. 2019. Ganga basin states stare at three-fold rise in crop failures by 2040. *The Hindu,* 24 Feb. 2019, p.1,12.

Koul, D. N., Shukla, G. and Chakravarty, S. 2012. Change in Extent of Irrigation Due to Sunehra Kal Initiated Soil And Water Conservation Interventions in Two Semi-Arid Districts of Madhya Pradesh. *J. Agric. Ext. Rural. Dev.* 4(19): 504-511.

123

Kulshrestha, A., Kushwaha, T. S., Singh, Y. K. and Rai, D. P. 2010. Adoption of watershed technologies by the farmers in Morena district of Madhya Pradesh. *Indian Res. J. Ext. Educ.*, *10*(2): 58-60.

Kumar, A. P. 2017. Economic Impact of Climate Change and Adaptation Strategies in Black Pepper Cultivation in Kerala. M.Sc.(Ag) thesis, Kerala Agricultural University, Thrissur, 124p.

Kumar, A., Singh, S. V., Singh, K. D. and Prasad S. N. 2006. Changes in socioeconomic status of resource poor farmers through watershed management in rainfed area of South-Eastern Rajasthan. *An. of Arid Zone* 45(1): 75-82.

Kumar, K. B. M. 2007. An Economic Evaluation of NWDPRA and Sujala Watershed Programme in Northern Karnataka – A Comparative Study. M.Sc.(Ag) thesis, University of Agriculture Science, Dharwad. 84p.

Kumari, R., Sharma, B., Kushwah, A., Singh, R., Singh, R. M., Tewari, R. K. and Dhyani, S. K. 2014. Construction of Rainwater Harvesting Structures and Economics of Crops in Parasai-Chhatpur Watershed in Bundelkhand Region of Central India. *Agric. Econ. Res. Rev.* 27(2): 327-333.

Lakshmi, V. V. 2007. Economic evaluation of watersed development programme in Vishakapatnam distict of Andhra Pradesh. M.Sc.(Ag) thesis, ANGRAU, Andhra Pradesh, 83p.

Manjunath, M., Kowsalya, K. and Vidyadhara, B. 2016. Impact on Crop Productivity and Problem Faced by Beneficiaries of Sujala Watershed Project in Chitradurga of Karnataka. *Adv. Life Sci.* 5(6): 2278 - 2281.

Mishra, P. K. and Rai, S. C. 2013. Use of Indigenous Soil and Water Conservation Practices among Farmers in Sikkim Himalaya. *Indian J. Tradit. Knowl.* 12 (3): 454-464.

Mishra, P. K., Singh, M. and Kumar, G. 2018. *Water Management and Conservation Innovations for Doubling Farmers' Income*. Bulletin of the

124

Indian Society of Soil Science No. 32, : Indian Society of Soil Science 116p.

Mondal, B. 2011. Assessing the impact of watershed development programmes in Bundelkhand region of Madhya Pradesh: An institutional perspective. P. hd. thesis, IARI, New Delhi. 150p.

Mondal, B., Singh, A. and Jha, G. K. 2012. Impact of Watershed Development Programmes on Farm-specific Technical Efficiency: A Study in Bundelkhand Region of Madhya Pradesh. *Agric. Econ. Res. Rev.* 25(2): 299-308.

Mondal, B., Singh, A., Singh, S. D., Sinha, M. K. and Kumar, D. S. 2013. Decomposition of Productivity Growth in Watersheds: A Study in Bundelkhand Region of Madhya Pradesh, India. *Acad. J.* Available: http://www.academicjournals.org /journal/SRE/article-abstract/ED4999 142663 [20 December 2017].

NABARD [National Bank for Agriculture and Rural Development]. 2018. *Annual Report 2017-18* [on-line]. Available: https://www.nabard.org/auth/ writereaddata/tender/ 0908181051NABARD-AR_2017-18%20English.pdf [10 Jul. 2019].

Nasurudeen, P. and Mahesh, N. 2006. Socio-economic and Environmental Perspectives of Sustainable Watershed Eco-system in Union Territory of Pondicherry. *Agric. Econ. Res. Rev.* 19(3): 49-58.

Nirmala, B. (2003). Impact of Watershed Development Programme on Socio-economic Dimensions of Beneficiaries in Rangareddy District of Andhra Pradesh. M. Sc.(Ag) thesis, University of Agriculture Science, Dharwad, 129p.

Painuli, D., Goyal, R. K., Singh, B., Kalia, R. K. and Roy, M. M. 2014. Impact Evaluation of Watershed Programs in Jaisalmer District of Rajasthan [on-

line]. Available: http://www.cazri.res.in/publications/RKGoyal.pdf [28 February 2019].

Palanisami, K. and Kumar, D. S. 2009. Impacts of watershed development programmes: Experiences and evidences from Tamil Nadu. *Agrl. Econ. Res. Rev.* 22: 387-396.

Palanisami, K., Kumar, D. S., Wani, S. P. and Giordano, M. 2009. Evaluation of Watershed Development Programmes in India Using Economic Surplus Method. *Agrl. Econ. Res. Rev.* 22 : 197-207.

Pathak, P., Chourasia, A. K., Wani, S. P. and Sudi, R. 2012. Multiple Impact of Integrated Watershed Management in Low Rainfall Semi-arid Region: A Case Study from Eastern Rajasthan, India. *J. Water Resour. Prot.* 5(1): 27-36.

Porras, I. T. and Neves, N. 2006. *India–Sukhomajri Community Watershed Management* [on-line]. Available: http://www.watershedmarkets.org/ documents /India_ Sukhomajri _eng.pdf [29 April 2019].

Reddy, S. S., Ram, P. R., Sastry, T. V. N., and Devi, I. B. 2016. Agricultural Economics (2nd Ed.). Oxford & IBH publishing Co. Pvt. Ltd., New Delhi, 697p.

Sagitra, N. 2015. Impact of capital generating activities on sustainable rural livelihoods of Watershed project beneficiaries in Dhar District (MP). M.Sc.(Ag) thesis, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, 99p.

Shaheen, F. A., Joshi, P. K. and Wani, S. P. 2008. Watershed development in north-east: problems and opportunities [on-line]. Available: http://publications.iwmi.org/pdf /h042932. pdf [08 April 2018].

Shilpa, V. C., Daya, S. and Rameshchandra, S. P. 2017. Watershed development programmes: an evaluation and its impact in India. *Int. Res. J. Social Sci.* 6(2): 5-17.

Singh, P., Behera, H. C. and Singh, A. 2010. Impact and Effectiveness of Watershed Development Programmes in India [on-line]. Available: http://centre.lbsnaa. gov.in/crs/admin/upload/Publication_Int/Final_ Watershed_Dvelopment_prog_Web.pdf. 55p [25 February 2019].

Singh, P., Pathak, P., Wani, S. P. and Sahrawat, K. L. 2009. Integrated Watershed Management for Increasing Productivity and Water-use Efficiency in Semi-arid Tropical India. *J. Crop Improv. 23*(4): 402-429.

Sisodia, S. S. and Sharma, C. 2007. Constraints in People's Participation in Watershed Development Programme. *Indian Res. J. Ext. Educ.*, *8*(1): 60-63.

Sreedevi, T. K., Wani, S. P., Sudi, R., Patel, M. S., Jayes, T., Singh, S. N. and Shah, T. 2006. On-site and off-site Impact of Watershed Development: A Case Study of Rajasamadhiyala, Gujarat, India. *J. SAT Agric. Res. 2*(1): 1-44.

Sudhishri, S. and Dass, A. 2012. Study on the Impact and Adoption of Soil and Water Conservation Technologies in Eastern Ghats of India. *J. Agric. Eng.* 49(1): 51-59.

Thakur, D. R., Pathania M. S. and Thakur, R. K. 2014. Impact Analysis of Integrated Watershed Project in Swan Catchment, Una District of Himachal Pradesh [on-line]. Available: https://hpforest.nic.in/files/ DEPARTMENT%20OF%20AGRICULTURAL%20ECONOMICS.pdf [5 March 2018].

Thomas, C. G. 2010. *Land Husbandry and Watershed Management*. Kalyani Publishers, Ludhiana, 716p.

Thomas, K. J., Babu, K. S. and Thomas, E. K. 2009. Watershed based Development for Rural Prosperity: Evidences from Kerala. *Agrl. Econ. Res. Rev.* 22: 407-414.

Vishnudas, S., Savenije, H. H. G. and Zaag, P. V. 2005. Participatory Watershed Development Practices in India: A Case Study in Kerala. ASCE Watershed management conference, Virginia, USA [19-22 July 2005].

Wani, S. P., Pathak, P., Sreedevi, T. K., Singh, H. P. and Singh, P. 2003. Efficient Management of Rainwater for Increased Crop Productivity and Groundwater Recharge in Asia. [on-line]. Available: https://s3.amazonaws.com/academia. edu.documents/35416556/085199 6698 ch12.pdf [8 April 2018].

Appendices

Appendix I

APPENDIX I

Kerala Agricultural University

College of Agriculture, Vellayani

Department of Agricultural Economics

Economic analysis of watersheds in Wayanad district

Survey Schedule – Primary data

Student: Neethu Mol Jacob Major advisor: T Paul Lazarus

Treated/Untreated watershed:

Upper/Middle/Lower region:

I. Details of the farmer:

a) Name of the farmer:

b) Address:

c) Name of the Krishi Bhavan:

d) Village:

e) Panchayat:

f) Block:

g) Age and education:

h) Phone number:

i) Family details:

S. No.	Relation with head	Sex	Age (Years)	Education	Occupation		Income	
					Main	Subsidiary	Main (₹)	Subsidiary (₹)
1								
2								
3								
4								
5								
6								

Relation with Head:

1.Head, 2.Wife, 3.Son, 4.Daughter, 5.Son in law, 6.Daughter in law, 7.Sister, 8.Brother, 9.Grandson , 10.Grand daughter, 11.Others (specify)

Sex: 1. Male 2. Female

Education: 1.No schooling, 2.Primary school, 3.Upper primary, 4.High school (up to tenth), 5.Higher secondary, 6.Graduate, 7.Post graduate, 8.Others (specify)

Occupation: 1.Agriculture only 2.Govt. Employee, 3.Private employee, 4.Own business, 5.Agricultural labourer, 6.Non Agricultural labourer, 7.Not working, 8.House wife, 9.Student

a) Wet land (cents) :
b) Garden land (cents) :

II. Details on land holding:

S. No.	Type of land holding	Upper /Middle /Lower region	Own land (cents)	Leased land (cents)	Land revenue (₹)
1	Wet land				
	a. Cultivated land				
	b. Fallow land				
2	Garden land				
	1) Rainfed				
	a. Cultivated				
	b. Fallow				
	2) Irrigated				
	a. Cultivated				
	b. Fallow				

III. Cropping pattern:

S. No.	Crops	Variety	Area under cultivation (cents)	No. of plants	Quantity produced (in kg)	Price of the product (₹ / kg)	Crop expenditure (₹)	Net income (₹)
1								
2								
3								
4								

IV. Implements:

S. No.	Particulars	Number	Year of purchase	Value (₹)	Expected life (Years)	Depreciation (₹)
1	Plough					
2	Pick axe					
3	Spades					
4	Sprayers					
5	Vaakathi/ Knife					
6	Ladder					

V. Value of assets :

S. No.	Assets	Number	Value (₹)	Year of purchase	Present value (₹)	Depreciation (₹)	Maintenance cost (₹)
1	Land value						
2	Own house						
3	Farm implements						
4	Store house						

VI. Family expenditure pattern :

S. No.	Purpose	Expenditure (₹ /month)
1	Food expenditure	
2	Education expenses	
3	Medical expenses	
4	Recreation	
5	Transportation	
6	Clothing	
7	Others	

VII. Details of livestock:

S. No.	Type of animal or bird	Number	Annual income (₹)	Expenditure (₹)	Net Income (₹)
1					
2					
3					
4					
5					
6					

VIII. Annual income:

S. No.	Particulars	Quantity	Price per unit (₹)	Total income (₹)
1				
2				
3				
4				
5				
6				
7				

IX. Input costs:

S. No.	Input used	Quantity applied		₹/Unit	Total expenses
		Unit	Quantity		
1	Seeds				
2	Fertilizer Application 1. Urea 2. DAP 3. MOP 4. Complex 5. Others				
3	Manures 1. Cow dung 2. Sheep Manure 3. Poultry Manure 4. Green Manure 5. Others				
4	Soil ameliorants 1. Lime 2. Dolomite 3. Others				
5	Weedicides 1. 2. 3.				
6	Pesticides 1. 2. 3.				
7	Bio pesticides				
8	Fungicides 1. 2. 3.				
9	Bio fungicides				
10	Total				

X. Labour cost

Wage rate: Men (₹/day) _____ Women (₹/day) _____

Machinery rent (₹/hour) _____ Total cost (₹) _____

S. No.	Particulars		Family labour (man days)		Hired labour (man days)		Machine Labour (hours)
			Men	Women	Men	Women	
1	Digging pits						
2	Organic manure						
3	Fertilizers						
4	Liming materials						
5	Plant protection operations	Bio control					
		Chemical					
6	Weeding						
7	Irrigation						
8	Intercultural operations						
9	Harvesting						
10	Post harvest operations						
11	Transportation						
12	Others						

XI. Irrigation status of treated or untreated watershed:

S. No.	Source	Number	Area of each crop under irrigation (acres)					
			Total					
1	Canal							
2	Tanks/ Ponds							
3	Wells/ Bore wells							
4	Pumpset (Electric/ Diesel/ Solar)							
5	Micro irrigation (Sprinkler/ Drip)							
6	Others							

134

XII. Impact of watershed on the land/well in treated watersheds:

S. No.	Type of watershed development work	Number of wells	Length of contour bund	Height of water column in the well	Soil organic matter content	Soil moisture content
1						
2						
3						
4						
5						

XIII. Marketing facilities:

1. VFPCK/Farmers market
2. Direct marketing
3. Contract marketing
4. More than one marketing channel
5. Others

XIV. Do you practice KAU Package of practice (Yes/ No)

1. Less than recommended:
2. Recommended:
3. More than recommended:

XV. Market benefits in treated watershed:

S. No.	Particulars	Yes/ No
1	Improved crop sales	
2	Improved livestock sales	
3	Reduction in cost for fetching drinking water	
4	Less dependence on government water tankers	
5	Improved availability of irrigation water	
6	Improved fuel wood supply	

137

XVI. Non market benefits in treated watershed:

S. No.	Particular	Yes/ No
1	Improved scenic beauty	
2	Habitat improvement or biodiversity	
3	Improved air quality	
4	Improved nutrition	
5	Improved diversity in diet	
6	Increased female empowerment	
7	Improved community development	
8	Improved resilience to drought	
9	Increased water filtration	
10	Improved health	

XVII. Whether any other enterprise is associated along with agriculture? Yes/No

If yes mention it:

XVIII. What are the soil and water conservation measures adopted by the farmer?

S. No.	Particulars	Yes/ No
1	Contour bunding	
2	Treching	
3	Live fencing	
4	Rain pit	
5	Bunds	
6	Terrace	
7	Centripetal terrace	
8	Mulching	
9	Earthen bunds	
10	Others	

XIX. Constraints:

S. No.	Constraint	Rank
1	Non-availability of irrigation water	
2	Non-availability of inputs and subsidy on time	
3	Lack of awareness about the beneficial programme	
4	Lack of supervision and follow-up	
5	Lack of technical guidance	
6	Political interference	
7	Inadequacy of sanctioned amount	
8	Insufficient credit availability	
9	Lack of marketing facilities	
10	Inappropriate construction works at inappropriate place	

XX. Suggestions given by the farmers in the treated watershed to improve the project

S. No.	Suggestion	Yes/ No
1	Increase the project period from 5 to 10 years	
2	Ensure better marketing facilities	
3	Ensure better infrastructure facilities	
4	Create awareness among people towards watershed management and their benefits	
5	Ensure continuity and follow-up	
6	Ensure coordination between authorities and farmers	
7	Ensure diversified farming activities	
8	Efficient utilization of funds	
9	Ensure more thrust on rain water harvesting	
10	Ensure biodiversity conservation	

Appendix II

APPENDIX II

Kerala Agricultural University

College of Agriculture, Vellayani

Department of Agricultural Economics

Economic analysis of watersheds in Wayanad district

Survey Schedule – Secondary data

Student: Neethu Mol Jacob Major advisor: T Paul Lazarus

I. General information of selected watershed:

a) Name of the watershed:

b) Watershed code:

c) District:

d) Tehsil/ Block:

e) Agroclimatic zone:

f) Total area under watershed (ha):

g) Treatable area:

h) Total project cost:

i) Panchayaths included:

j) Villages included:

k) Longitude of watershed:

l) Latitude of watershed:

m) Average annual rainfall:

n) Monthly rainfall:

o) Temperature :

p) Area according to soil type of watershed:

1. Shallow (ha)
2. Medium (ha)
3. Heavy (ha)

q) Slope of watershed:

S. No.	Slope %	Area
1		
2		
3		
4		

r) Actual expenditure of watershed development project (Rs.):

s) Work started of watershed:

a) Month :

b) Year :

t) Work completed of watershed:

a) Month :

b) Year :

II. Land utilization pattern:

S. No.	Particulars	Area (Ha)
1	Agriculture	
2	Forest	
3	Wasteland	
4	Others	
5	Total	

III. Soil type

a) Alluvial soil

b) Laterite soil

c) Red soil

d) Black soil

IV. Water resources

S. No.	Water resource	Number	Area irrigated (ha)
1	Surface		
2	Dug wells		
3	Shallow tube wells		

4	Deep tube wells		
5	Total		

V. Cropping pattern in Poothadi watershed area

S. No.	Crop	Area (ha)
1	Rice	
2	Coconut	
3	Coffee and pepper	
4	Arecanut and cardamom	
5	Rubber	
6	Ginger and turmeric	
7	Vegetables and tapioca	
8	Banana	
9	Total	

VI. Project expenditure

S. No.	Particular	Expenditure (₹)
1	Survey, entry point activities and maintenance of previous work	
2	Contour graded bunds	
3	Contour/ staggered trenches	
4	Farm pond	
5	Contour vegetative hedges	
6	Horticultural development	
7	Retaining wall	
8	Water harvesting structures (WHS)	
9	Farmers training	
10	Demonstrations	
11	Contingencies	
12	Total expenditure	

VII. Employment generated by the watershed development project

S. No.	Particular	Employment generated (Man-days)
1	Contour graded bunds	
2	Contour or staggered trenches	
3	Farm pond	
4	Contour vegetative hedges	
5	Horticultural development	
6	Retaining wall	
7	Water harvesting structures (WHS)	
8	Total	

Appendix III

APPENDIX III

GARRETT RANKING CONVERSION TABLE

The conversion of orders of merits into units of amount of "socres"

Percent	Score	Percent	Score	Percent	Score
0.09	99	22.32	65	83.31	31
0.20	98	23.88	64	84.56	30
0.32	97	25.48	63	85.75	29
0.45	96	27.15	62	86.89	28
0.61	95	28.86	61	87.96	27
0.78	94	30.61	60	88.97	26
0.97	93	32.42	59	89.94	25
1.18	92	34.25	58	90.83	24
1.42	91	36.15	57	91.67	23
1.68	90	38.06	56	92.45	22
1.96	89	40.01	55	93.19	21
2.28	88	41.97	54	93.86	20
2.69	87	43.97	53	94.49	19
3.01	86	45.97	52	95.08	18
3.43	85	47.98	51	95.62	17
3.89	84	50.00	50	96.11	16
4.38	83	52.02	49	96.57	15
4.92	82	54.03	48	96.99	14
5.51	81	56.03	47	97.37	13
6.14	80	58.03	46	97.72	12
6.81	79	59.99	45	98.04	11
7.55	78	61.94	44	98.32	10
8.33	77	63.85	43	98.58	9
9.17	76	65.75	42	98.82	8
10.06	75	67.48	41	99.03	7
11.03	74	69.39	40	99.22	6
12.04	73	71.14	39	99.39	5
13.11	72	72.85	38	99.55	4
14.25	71	74.52	37	99.68	3
15.44	70	76.12	36	99.80	2
16.69	69	77.68	35	99.91	1
18.01	68	79.17	34	100.00	0
19.39	67	80.61	33		
20.93	66	81.99	32		

Abstract

ECONOMIC ANALYSIS OF WATERSHEDS IN WAYANAD DISTRICT

by

NEETHU MOL JACOB
(2017-11-090)

Abstract of thesis

Submitted in partial fulfilment of the

requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF AGRICULTURAL ECONOMICS
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM – 695522
KERALA, INDIA
2019

ABSTRACT

The research work entitled "Economic analysis of watersheds in Wayanad district" was carried out during 2017-19 with the objectives to assess the impact of watershed development programme on cropping pattern and farm income, to examine the variation in benefits in upper, middle and lower reaches of watershed and to ascertain the problems of farmers in the watershed. Secondary data was collected from the Office of the Assistant Director of Soil Conservation, RVP Kabani, Kaniambetta sub division, Meenangadi. The treated watershed (beneficiaries) selected for the study was Poothadi watershed in Poothadi Panchayat and untreated watershed (non-beneficiaries) was Aavayal watershed in Meenangadi Panchayat of Wayanad district. Primary data were collected randomly from 45 farmers each from the treated and the untreated watershed comprising 15 farmers each from upper, middle and lower reaches and thus the total sample size was 90.

Poothadi watershed project (Ka4f Poothadi) was a River Valley Project (RVP) during 2010-13 with an area of 4,428 ha. The total expenditure of the project was ₹93,44,025 and major portion was spent for construction of farm ponds, WHS (Water Harvesting Structures) and contour bunds. The project had generated an employment of 9,060 man days during the project period.

The beneficiary respondents had more annual income, family size, land holdings, area under different crops and irrigation when compared to that of non-beneficiaries. Major crops cultivated in watershed area were coffee, black pepper and arecanut. There was no much variation in cropping pattern between the treated and untreated watersheds. Area under irrigation was more in treated watershed than the untreated and the average area under irrigation was more in coffee (2.98 ha).

Cost of cultivation of coffee, black pepper and arecanut was worked out using the cost concepts and total cost was more for beneficiaries than the non-beneficiaries. The profitability was found using the B:C ratio and at Cost C, B:C

ratio was more for beneficiaries in case of coffee (1.79) and black pepper (1.19), whereas in the case of arecanut (1.42) it was more for non-beneficiaries. From the results of regression analysis it was evident that the coefficient of multiple determination of beneficiaries and non-beneficiaries had values ranging from 0.89-0.99 and 0.31-0.99 respectively, indicating 89-99 and 31-99 per cent of the variation in the gross returns was due to the independent variables considered.

Positive impact of the watershed development programme was reflected in the increase in the number of beneficiaries adopting soil and water conservation measures such as construction of rain pits, trenching, live fencing, terracing and mulching. Adoption of such measures by non-beneficiaries was less compared to that of beneficiaries of treated watershed. Several market and non-market benefits derived from treated watershed resulted in increase in income due to increase in yield and livestock rearing, increased groundwater recharge and increase in aesthetic value of watershed.

The analysis of impact of watershed development programme on farm income revealed that the length of contour bund had increased the farm income at 1 per cent level of significance. The coefficient of multiple determination (R^2) was 0.92, which indicated that 92 per cent of the variation in farm income was explained by the independent variables such as length of contour bund, soil moisture content, organic matter content and region of the watershed.

Organic matter content (4.23 per cent), soil moisture content (18.26 per cent) and depth of water column in wells (4.31 m) were more in treated watershed than the untreated watershed. In treated watershed organic matter and soil moisture content was more in upper reaches followed by lower and middle reaches. Height of water column in the wells of treated watershed was higher in lower reaches (5.13 m) followed by middle (4.83 m) and upper reaches (2.97m).

Major constraints faced by the beneficiaries in treated watershed were lack of supervision, follow-up and technical guidance by the authorities. Suggestions given by the beneficiaries to improve the project were to ensure need based

activities in farm, continuity and follow-up of development and maintenance activities in watershed, marketing and infrastructural facilities and biodiversity conservation. Watershed development programme improved the livelihood of the farmers in the treated watershed. Hence watershed development programmes and strategies like rain water harvesting structures should be extended to the untreated watersheds.