ECONOMIC VALUE OF IRRIGATION WATER: A CASE STUDY OF NEYYAR IRRIGATION PROJECT, THIRUVANANTHAPURAM

by

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(2019-11-024)

THESIS

Submitted in partial fulfillment 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

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KERALA, INDIA

2022

DECLARATION

I, hereby declare that this thesis entitled **"ECONOMIC VALUE OF IRRIGATION WATER: A CASE STUDY OF NEYYAR IRRIGATION PROJECT, THIRUVANANTHAPURAM"** 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.

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ACKNOWLEDGEMENT

First and foremost, praises and thanks to the God, the Almighty for giving me the strength and health to complete my research work successfully.

I feel immense pleasure to express my sincere gratitude and personal thankfulness to my research guide ***Dr. Aswathy Vijayan,*** *Assistant Professor, Department of Agricultural Economics, for her patience, immense knowledge, expert guidance, valuable advice, constant encouragement and co-operation that she has given me throughout the course of my research work. It was a great privilege and honor to work and study under her guidance. Without her support and motivation this thesis would not have been possible.*

I sincerely express my everlasting gratitude to the revered members of my advisory committee, ***Sri. T. Paul Lazarus****, Assistant Professor& Head, Department of Agricultural Economics,* ***Dr. Thasnimol F.****, Department of Agricultural Economics,* ***Dr. Pratheesh P. Gopinath****, Department of Agricultural Statistics and* ***Smt. Linitha Nair****, Department of Agricultural Meteorology for offering their valuable suggestions, affectionate guidance and keen interest throughout my study. Also, I acknowledge with great pleasure the manifold assistance rendered by* ***Dr. Durga A.R.****, Assistant Professor, Department of Agricultural Economics, College of Agriculture Vellayani.*

Last but not the least, I express my sincere thanks to all my respected teachers, M.sc collegues ***Venkatrao, Krishnendu, Akhila, Meera Raj, Jerin, Prasanna,*** *my beloved* ***seniors, juniors*** *and non-teaching staffs for rendering all possible help. I also feel immense pleasure in thanking* ***Akshay*** *for his constant encouragement and affectionate support throughout the course of my research work.*

Words cannot express my indebtedness to my ***parents and brothers*** *for being there for me always. Innumerable number of persons have provided their help in course of this work. Some of them might have been missed, but none of them have been forgotten.*

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LIST OF ABBREVIATIONS

AE	Allocative Efficiency
B-C Ratio	Benefit-Cost Ratio
CADA	Command Area Development Authority
CVM	Contingent Valuation Method
et al	Co-worker
GCA	Gross Command Area
GOI	Government of India
GOK	Government of Kerala
HS	Higher Secondary
KWRD	Kerala Water Resources Department
LBC	Left Bank Canal
MFC	Marginal Factor Cost
MNREGS	The Mahatma Gandhi National Rural Employment Guarantee Scheme
MPP	Marginal Physical Product
MVP	Marginal Value Product
NIP	Neyyar Irrigation Project
OLS	Ordinary Least Squares
PIM	Participatory Irrigation Management
R^2	Coefficient of Multiple Determination
RBC	Right Bank Canal
VIF	Variance Inflation Factor
WTA	Willingness to Accept
WTP	Willingness to Pay
WUA	Water Users' Association

LIST OF SYMBOLS

^{0}	Degree
^{0}C	Degree Celsius
%	Per cent
Rs.	Rupees
<	Less than
>	Greater than
ha	Hectare
kg	Kilogram
Km	Kilometre
mm	Millimetre
qtl	Quintal
Sq km	Square kilometre
Mha	Million hecare
BCM	Billion Cubic Metre

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CHAPTER I

INTRODUCTION

Water is one of the critical inputs for obtaining sustainable agricultural production and plays a prominent role in assuring food security. Irrigation stands as the backbone for obtaining optimum crop yield. Realising its strategic importance in increasing the crop production many irrigation projects had been commissioned in India (Neelima *et al.*, 2018). With the growing demand for food due to increase in population, it is necessary to increase the food production. This has to be achieved by bringing more area under cultivation, improving existing technology and by increasing the availability of limited resources per unit area. Since the availability of irrigation water is limited, there is growing competition for water between various sectors. Hence it is necessary to have an accurate review as well as improved efficiency in the use of irrigation water of existing irrigation projects. This can be acheived through the implementation of consistent as well as optimal irrigation planning and demand based water management policies rather than investing on new projects (Prasad *et al.*, 2011).

Traditionally, the execution of irrigation projects is known to be a highly time consuming process having long gestation periods. Further, improper water management at the farm level leads to inefficient management and utilization of irrigation water which ultimately leads to a huge gap between created and utilized irrigation potential. To bring about a transformation in the irrigation sector, Government of India and various state governments had taken a number of steps such as increasing area under irrigation by accelerating ongoing projects, encouragement to adopt efficient canal automation systems, extensive use of micro irrigation across all varieties of crops, watershed management approach in rainfed areas, implementation of command area development works and participatory irrigation management (Franklin and Vohra, 2020).

1.1. IRRIGATION SECTOR OF INDIA

India receives annual precipitation of about 4000 Billion Cubic Meter (BCM) and the average water availability is 1869 BCM. The current annual consumption of water in the country is estimated to be 710 BCM. It consists of irrigation (78%), domestic use (6%), industrial use (5%), power development (3%) and other activities (8%) (GoI, 2016).

The irrigation potential created in the country is 112 Mha while the ultimate irrigation potential is 140 Mha. The gross irrigated area is merely 93 Mha, creating a gap of 19 Mha between created irrigation potential and utilized irrigation potential. Out of this 19 Mha gap, about 13 Mha gap falls under major and medium irrigation projects. Poor maintenance of canals system, lack of participatory management, changing land use pattern, deviation from originally envisaged cropping pattern, poor command area development and absence of field channel are the major reasons for this gap (Franklin and Vohra, 2020).

1.2. IRRIGATION SECTOR OF KERALA

Kerala, even though receives heavy rainfall the distribution is not uniform. Ninety percent of rainfall is received during the monsoon seasons. This erratic behaviour of rainfall causes damage to crops by floods during monsoon and drought during summer. Hence irrigation is very much essential for Kerala (GoK, 1974).

Table 1 shows the crop wise gross irrigated area in Kerala over years. It is clear that the major crops receiving irrigation in Kerala were paddy and coconut which account for around 29.08 and 30.75 per cent of gross irrigated area respectively, followed by banana (10.09%) and vegetables (6.06%) in that order. Though coconut and paddy have been continuing to be the major benefitted crops, the irrigated area of both of these crops had declined over years. The share of paddy has declined from 41.06 per cent in 2002-03 to 29.08 per cent in 2019-20, while the share of coconut has declined by almost 6 per cent during the same time period. Shift of cultivation from food crops to cash crops, conversion of farm lands for non-agricultural purposes, lack of adequate and timely irrigation water, high labour cost associated with shortage of labour, fragmented landholdings and reluctance of people to pursue agriculture as a means of livelihood may be the major reasons behind this.

Table 1. Crop wise gross irrigated area in Kerala (ha)

Sl. No.	Crops	2002-03	2017-18	2019-20
1	Paddy	183700 (41.06)	145398 (26.93)	150009 (29.08)
2	Vegetables	9790 (2.19)	24348 (4.5)	31256 (6.06)
3	Coconut	163550 (36.55)	158965 (29.44)	158584 (30.75)
4	Arecanut	34210 (7.65)	32610 (6.0)	33093 (6.41)
5	Banana	29210 (6.53)	48632 9.0)	52044 (10.09)
6	Betel Vine	990 (0.22)	252 (.04)	252 (.04)
7	Sugar cane	3430 (0.77)	1048 (0.19)	950 (0.18)
8	Others	22540 (5.03)	128621 (23)	89501 (17.3)
9	Total	447490 (100)	539874 (100)	515689 (100)

Note: Figures in parentheses represent percentage to the gross irrigated area

Source: GoK, 2021

The net irrigated area in the state showed an increase over the period from 2002-03 to 2019-20, from 3.93 lakh hectares to 5.15 lakh hectares by as seen in Table 2. The gross irrigated area, as a percentage of the gross cropped area (GCA) almost increased by around 5 per cent during the same period.

The major source of irrigation in the state was wells during 2002-03. Its share almost remained the same when compared to 2019-20. It can be observed that the share of canal irrigation declined from 26 per cent to 20 per cent from 2002-03 to 2019-20. The share of other irrigation sources increased from 26 per cent to 37 per cent during the same period. This may be due to the fact that even though canal irrigation system is controlled by the government, farmers are forced to seek other alternative irrigation sources.

Table 2. Source wise net irrigated area in Kerala (in ha)

Sl No	Source	2002-03	2017-18	2019-20
1	Canals	105410 (26.81)	77373 (19.73)	85860 (20.95)
2	Tanks	66730 (16.97)	49773 (12.6)	49853 (12.1)
3	Wells	117490 (29.88)	123115 (31.4)	119212 (29.09)
4	Other sources	103540 (26.33)	141745 (36.15)	154769 (37.7)
5	Total	393170 (100.00)	392006 (100.00)	409694 (100.00)
6	Gross irrigated area	447490	539874	515688
7	Gross irrigated area as percent of GCA	14.77	21	20

Note: Figures in parentheses represent percentage to the net irrigated area

Source: GoK, 2021

In Kerala, currently there are fourteen completed major irrigation projects and twelve medium irrigation projects (GoK, 2017). Command Area Development Authority (CADA) was launched in the state in 1985 with the emphasis on integrated management, conservation of soil energy and biological resources (Chackacherry and Chandran, 2016). The importance of participation of farmers in operation and maintenance of irrigation systems was then recognised for increasing the utilization of water resources and crop production from command areas and a number of Water Users' Associations (WUA) were formed under which irrigation management could be done.

Thirteen irrigation projects in Kerala were included under CADA from 1974-75 to 1992-93 and Neyyar Irrigation Project (NIP) in Thiruvananthapuram district was one among them. NIP was later excluded from CADA in 2003-04 as the targeted objectives were achieved (NITI AAYOG, 2015). Later Participatory Irrigation Management (PIM) was introduced on pilot basis in NIP during 2005-2007 (Chackacherry and Chandran, 2008). Over the years, weakening of PIM occurred due to lack of well-maintained organisational set up and it resulted in the disintegration of WUAs. But the role of NIP as main source of irrigation and enhancement of ground water recharge for wells in the command area cannot be ignored. It is against this background, the present study is making an attempt to estimate the economic value of irrigation water in the command area of NIP.

1.3. OBJECTIVES OF THE STUDY

The present study entitled "Economic value of irrigation water: A case study of Neyyar Irrigation Project, Thiruvananthapuram" is carried out with the following objectives.

1) Estimation of economic value of irrigation water
2) Assessment of impact of irrigation on crop yield of selected crops under the ayacut area of Neyyar Irrigation Project
3) Identification of the operational problems in irrigation management.

1.4. LIMITATIONS OF THE STUDY

The research findings are based on data which were collected using survey method. Only a few among the respondents kept farm records. The information collected from others who did not maintain any records may have been affected by the recall bias which is caused by differences in the accuracy of the recollections retrieved by them. Another limitation of this study is in the aspect of collecting data, which was difficult to some extent in the context of the Covid-19 pandemic. Physical proximity was prohibited and detailed discussions with some respondents could not be carried out. In spite of these, utmost care and effort had been taken to ensure the accuracy of collected information and authenticity the research findings.

1.5. ORGANISATION OF THE THESIS

The entire study is organized into six chapters including the present chapter. Chapter two is the review of literature which provides an overview of the previous research works related to the study. The third chapter describes the profile of the study area, the methodological framework and analytical tools used for the empirical evaluation of research objectives. The results of the study and their discussion are presented in chapter four. The fifth chapter is devoted to summarize the major research findings and conclusions, along with the policy implications, references, abstract and appendices.

CHAPTER II

REVIEW OF LITERATURE

Every scientific study needs to be supported by a systematic and comprehensive review of the existing literature in order to have a base of knowledge and to identify the gaps in current research. It offers a critical analysis of the current topic that direct the objectives of our research and place it within the context of existing literature, justifying the need of further study.

A detailed review of past research works related to the current topic was done as presented under the following heads:

2.1. Impact of irrigation on crop production and farm income.

2.2. Performance of major irrigation projects

2.3. Economic value of irrigation water

2.4. Operational problems in on-farm irrigation

2.1. IMPACT OF IRRIGATION ON CROP PRODUCTION AND FARM INCOME

Hanumantha Rao (1965) compared yields in Telangana between partially irrigated and dry farmers. Among partially irrigated farmers output showed, on an average, a greater degree of response to a given percentages increase in land output than to a similar increase in labour input. The converse of it held true among dry farmers; greater the intensity of utilization of land, larger the elasticity of output that could be expected with respect to this factor.

Water is one of the essential inputs for crop production as it affects plant development by influencing its vital physiological processes. For realizing potential yield of any crop it must not be allowed to suffer from water stress at any of the critical growth stages. Water stress, especially at reproductive stages, may substantially reduce the yield (O'Toole, 1982).

Vekariya (1997) in his study on differential impact of irrigation projects on farmers of South Saurashtra zone revealed that there existed differences in the cropping pattern and gross cropped area between beneficiaries of command area and non-beneficiaries. A reduction in unit cost of production and a positive impact of irrigation project on yields were also noticed in the beneficiary group.

Karunakaran and Palaniswami (1998) analysed the impact of irrigation, particularly different sources of irrigation on cropping intensity for the period of 1993-94 in Tamilnadu. The results revealed that canal, tank and dug-well irrigation showed significantly positive impact on the cropping intensity.

Economic analysis on resource use efficiency of paddy cultivation in Peechi Command area of Thrissur, conducted by Suresh and Reddy (2006) showed that the water stress especially during critical days had a depressing influence on crop yield and this is mainly observed in fields which were in the tail reach of the project command area. The education level of the farmers and the supplementary irrigation provided have depicted statistically significant positive influence whereas the presence of water-stress has negative influence on the technical efficiency of rice farmers.

Improvement in irrigation water management leads to increased cropping intensity resulting in increased overall production, productivity levels per unit of land and water, and eventually farmers' gross income (GoI, 2012).

Irrigation has strong impact on land productivity. The productivity impact tends to vary by type of irrigation as well as quality of irrigation and this provides strong support for continuing investment in irrigation projects in India (Songqing *et al.*, 2012).

Melaine and Nonvide (2017) conducted an examination of the impact of irrigation on rice production in Benin and adoption of irrigation positively affected rice yield. Other variables such as soil fertility, labour, fertilizer and herbicide application also had a positive effect on rice yield.

Mishra *et al.* (2018) studied the effect of irrigation sources on yield of wheat crop in selected canal command area of Rani Avanti Bai Sagar irrigation project in Uttar Pradesh. A trend of decreasing water yield with distance from canal was observed in the fields irrigated by pumping water from canal. This may be attributed to a better irrigation management using pumped water nearer to canal rather than away from the canal.

Kumar (2020) assessed the impact of irrigation infrastructure on socio-economic development in North Bihar plain and found that improved access to irrigation infrastructure has increased crop yield, agricultural production and farm income which has indirectly contributed significantly to improving the list of literacy rate in irrigated command area. In addition to these, it increased crop production and farm and family incomes. It also contributed to rural poverty reduction through employment and livelihoods in the study area due to improved irrigation access. In addition to yield improvement and intensive production practices, better irrigation infrastructure and reliable water supply also enhanced uses of other indirect input such as fertilizers and HYV.

Scaria (2020) conducted a study on public irrigation and well-being of women in North-east Karnataka, India. The fieldwork revealed that access to public irrigation has facilitated cropping-pattern changes in favour of profitable crops in the canal-irrigated village. The important crops cultivated in Janiwar village were commercial crops, including cotton, along with food crops, such as tur dal, jowar and chilli. On the other hand, in the non-canal-irrigated village, the cropping pattern was largely restricted to low value water-saving food crops. The important crops cultivated in Basawantawadi village are tur dal and jowar. The farmers in this village were largely dependent on private sources of irrigation, including open wells and bore wells.

Chand and Kishore (2021) conducted a study on the influence of source of irrigation on the technical efficiency of wheat growers in the canal command areas of Uttar Pradesh and Haryana and found that the quantum of water application for wheat cultivation was found to be higher in canal users' area as compared to ground water users. The cropping intensity was found to be significantly higher for canal water users. It was observed in this study that canal irrigated area attained higher yield than ground water irrigated areas. The study empirically analysed the data and the results indicated that canal irrigated farms attain higher (Haryana) technical efficiency as compared to ground water (UP) irrigated farms. Flood canal irrigation provided more water and time of moisture availability to the crop which might have resulted in higher efficiency.

2.2 PERFORMANCE OF MAJOR IRRIGATION PROJECTS

Singh and Singh (1962) studied the extent to which irrigation by Bakra Dam has contributed in ameliorating the economic and social conditions of inhabitants of this tract. They had observed that crop pattern, pattern of cultivation, cropping intensity have changed in the villages under Bakra, with more secure agriculture condition and with more returns. The standard of living of farmers had gone up. So far as family budget was concerned, it was observed that the total average income per family per annum (source wise) had gone up in the villages under the dam. A shift in the standard of living, as reflected by food habits, had also been observed.

Gajjar and Joshi (2011) studied the socio-economic impact of Suhagi minor irrigation project of Orissa state and observed that after the completion of project, utilization of labour force in command area changed from 2.5 man months to 5.5 man months while per capita income exceeded from Rs. 808 to Rs. 2056 and family income exceeded from Rs. 2467 to Rs. 6729. Fertilizer consumption also increased from 12 per cent to 35 per cent in case of Nitrogenous fertilizer and from 2 per cent to 20 per cent in case of other fertilizers.

Ahmed *et al.* (2019) studied the socioeconomic impact of Mirani Dam in Pakistan and concluded that the Mirani dam played an essential role in the development of living standard of the local population and the study area. Due to Mirani dam irrigation water became available for farmers and their livestock. As a result the area under cultivation, standard of living and literacy ratio also increased in the study area. Availability of irrigation water contributed to increase cropping and land use intensity in the study area. The income level consumption expenditure and saving of the inhabitants also increased significantly.

It is a reality that canal irrigation has lost its importance to the ground water irrigation. There are several reasons for the loss of importance of canal irrigation to the well irrigation but one of the most causes is poor management of major and medium irrigation projects (Gulati *et al*., 2005).

Bainda and Malhotra (2021) studied the impact of the Sidhmukh canal irrigation project (SCIP) on landscape modification and agriculture at Bhadra tehsil segment, District Hanumangarh, Rajasthan found that The introduction of the Sidhmukh Canal Irrigation Project (SCIP) converted the barren and rain-fed agricultural land to canal irrigated fertile land and caused a systematic frameshifting in the cropping pattern of the study area. Furthermore, agriculture productivity also increased from 2-4 quintal/ha to 6-7 quintal/ha. Indeed, this addition was caused by improved irrigation and command area development.

2.3 ECONOMIC VALUE OF IRRIGATION WATER

In the dichotomous choice format prepared for the valuation of an environmental good, respondents are presented with a hypothetical environmental change, the amount of money necessary to achieve the change and asked whether they are willing to pay the amount. The biases that occur in other formats, such as starting point bias and range bias do not occur in this format (Hoehn and Randall, 1987).

The economic values of non-marketed goods measured by Contingent Valuation Methods (CVM) are theoretically consistent with economic benefit measures that arise from market data (Mitchell and Carson, 1990).

CVM is a survey method employed to elicit the preferences of the individuals and households towards environmental goods and services that are mostly non-marketed in nature (Freeman, 1993).

CVM is a demand based method widely used to determine economic values for non-marketed goods and services. It relies on the creation of hypothetical market-like scenarios in which the non-marketed good or service could be provided to generate experimental contexts that provide data that are used to estimate benefits (Kopp *et al*., 1997).

Suresh (2000) estimated the economic value of irrigation water of Peechi Irrigation Project and revealed that farmers were willing to pay Rs.138 per ha per year for adequate, timely and assured irrigation supply, which was 122 percent higher than the water charge.

Marothia (2001) estimated the Willingness to Pay (WTP) for upkeep of Lake Vivekanand of Raipur city and revealed that the CVM or stated preference method could be used to estimate WTP of the respondents for environmental goods and the linear form of the WTP equation provided better results in terms of level of variation explained.

Vijayan (2004) in her study on the economic analysis of NIP reported that the WTP for water among the farmers differed according to their proximity to the reservoir. Farmers who could easily access the irrigation water were not willing to pay more than the current water rates and those who experience more scarcity of water were willing to pay higher charges than the current rates.

Devi and Mani (2006) in their study on the valuation of canal water of Peechi Irrigation Project stated that the valuation of water for irrigation purpose could be taken as the basis for evolving pricing strategies which are economically viable and socially justified, as the true value of water can be a reflection of its productivity.

Chandrasekharan *et al.* (2009) determined the economic value of irrigation water in South India through CVM and found that farmers were willing to pay considerably more than the average O&M costs incurred by state on tanks and were also willing to pay almost equal or slightly lesser amount than the marginal productivity of water.

Ijaz *et al.* (2009) estimated the economic value of irrigation water from a Punjab canal and found that the economic value of water was much higher than its market price. The existed water charges were extremely low and hardly covered the cost of operation and maintenance of irrigation and there was a need of reflecting water scarcity through water charges.

Tang *et al.* (2012) determined farmers' WTP for irrigation water in Shiyang River basin, northwest China using the contingent valuation method. The results showed that the average WTP for irrigation water was 80.4 RMB/mu/yr and was substantially higher than existed irrigation water price (58 RMB/mu/yr). Explanatory factors such as bid level, family size, household's income, area of irrigation land, the major source of irrigation water, respondents' satisfaction with the management and the farmers' attitude towards whether current waters price could recover the water supply cost, included in the model of WTP turned out to be statistically significant. The study revealed that under existing pricing structure, farmers are charged much lower price than what they are willing to pay in a region where irrigation water is a scarce resource.

Biswas and Venkatachalam (2014) estimated the WTP for irrigation water of Malaprabha Irrigation Project in Karnataka and revealed that the mean WTP value stood at INR 144/acre/year and the farmers were willing to pay more for improved irrigation than the existed rates.

Eritrea *et al*. (2019) in their study on smallholder farmers' WTP for irrigation water revealed that in areas where irrigation water charges have not been applied, enhancing farmers understanding about the economic properties of water is an important prerequisite for effective implementation of irrigation water charge scheme.

Qamar *et al.* (2019) in their study on water pricing and implementation strategies for the sustainability of an irrigation water system in the command area of Rakh branch canal in Pakistan found that irrigation water was severely undercharged in the study area and the economic value of irrigation water covered only one-third of the infrastructure maintenance cost of the canal system.

Aman *et al*. (2020) estimated the economic value of improved irrigation water use in the Meskan district of Southern Ethiopia using CVM. The result of the study that all of the households were willing to pay for improved irrigation water use. The mean willingness to pay was Birr 829. 46 per 0.25 ha per year (1 Birr = 1.49 INR). The respective economic value of improved irrigation water was 33,421,300 birr which showed that there existed the opportunity for improving irrigation water through a cost recovery mechanism.

2.4. OPERATIONAL PROBLEMS IN ON-FARM IRRIGATION

Ahamed and Kutcher (1992) noted that with the canal irrigation, the hazard of soil salinization existed. Lining canals was the technical solution to the problem. The authors suggested a combination of measures like investment in horizontal drainage, canal lining in saline area, on farm water management in all the zones to mitigate these problems.

According to Dhawan (1993), poor drainage in canal irrigated tracts had been the bane of major irrigation works in the Indian sub-continent. Absence of investment in canal lining compounded the problem. There was a tendency on the part of farmer to over use water during the course of crop growth.

Government of Kerala (1996) conducted a *post facto* evaluation of the Neyyar Irrigation project. The farmers in the command area were not getting sufficient quantity of water. Most of the irrigation structures and sluices were defective and conveyance losses were common. No effective measures were undertaken for the treatment of silts. The agricultural extension services were found to be poor.

The inadequate attention to on-farm irrigation water management and utilization has been one of the main reasons for the poor performance of irrigation projects. The most severe problem in indian canal irrigation has been the rapid deterioration and degradation of the existing network systems. This has also resulted in waterlogging and salinity problems in canal command areas (Panigrahi and Panda, 2003).

Rao and Rajput (2006) assessed the mismatch between supplies and demands of canal water in a major distributory command area of the Nagarjunasagar left canal in Andhrapradesh. They revealed that inadequate and unreliable water supply created a wide gap between created and utilized irrigation potential. This leads to temporal imbalance of water demands and supplies, excessive seepage loses and rise of groundwater table, resulting in problems of waterlogging and salinity.

Kalra *et al*. (2014) studied the farmers' perception on water management and land degradation in the tail reach of Western Yamuna Canal Command (WYCC) and found that majority of the respondents strongly endorsed that the poor maintenance of irrigation channels, canal siltation and weed growth, seepage from the distributaries and irregular supply of canal water were the major constraints in the command area. It resulted in severe water logging and land degradation which impacted crop growth negatively.

Durga *et al.* (2018) on their study on canal irrigation and collective action in case of water user associations in Southern India observed that one of the most important factors that influenced the farmers in their irrigation behavior was the location of their land within the command area. Farmers in the head reach were normally considered as privileged since they got water more regularly; the tail-end farmers were really deprived of water. It had been also found that those farms located far away from the canal were least benefitted from water distribution. For farmers who were far away from the head reach, revenues were lower, as water scarcity appeared to impose a cost on them.

Geeta and Anbazhakan (2019) conducted a perception study on Water Resource Management in Sathanur Command area of Tiruvannamalai District in Tamilnadu, and observed that in most of the places, lining of field channel are damaged and left unattended by the field engineers even after repeated complaints. Damages in the structure caused leakages of water. Hence, there were problems of water logging in the head reach and shortage in the tail end.

Jha (2020) in her study on farmer's participation in canal management in Uttar Pradesh's Rai Barrelly district observed that unequal level of land and high cost of fetching water from canal due to the distance between farm and canals were the main reasons for low participation of farmers in irrigation management.

Wali *et al*. (2020) studied the constraints faced by farmers in canal command areas of Krishna project in Karnataka. The study revealed that lack of cement lining of canals, untimely release of water from the canal, lack of summer irrigation and no installation of water meters at field gates were the major constraints prevailed in the study area.

Disparity of water distribution between head and tail ends is the major concern in most of the irrigation systems and it is closely associated with poor production and salinity problems (Culas and Baig, 2021).

Fahad *et al.* (2021) conducted a study on the water availability and productivity in the command area in Peshwar district of Pakistan. They suggested that installation on lined watercourse to avoid leakage, desiltation of the canal and establishment of Water User Associations may help in having best water management practices.

CHAPTER III
MATERIALS AND METHODS

This chapter throws light to the methodological framework regarding the research and explains the research design employed in the study to draw meaningful inferences. The present study entitled “Economic value of irrigation water: A case study of Neyyar Irrigation Project, Thiruvananthapuram was under taken with the objective of estimating the economic value of irrigation water in the command area of Neyyar Irrigation Project (NIP) and to identify the operational problems in irrigation management. Contents of this chapter are presented under the following heads:

3.1 Area of the study

3.2 Sampling framework

3.3 Empirical measurement of variables and tools for analysis

3.1 AREA OF STUDY

The study was conducted in Thiruvananthapuram district of Kerala where Neyyar irrigation Project is located. An overview of the socio-demographic characteristics of Thiruvananthapuram district and command area NIP are presented in this section.

3.1.1 Thiruvananthapuram district

Thiruvananthapuram is the southernmost district in the Kerala state and is located between 8.17 to 8.54°N latitude and 76.41 to 77.17°E longitude. The district was created in 1949, with its headquarters at Thiruvananthapuram, which is also Kerala's capital and is home to more than 9 per cent of total population of the state. The district covers an area of 2,192 square kilometres and it is the second most populous district in Kerala after Malappuram district (GoK, 2021). The district is divided into six sub districts: Thiruvananthapuram, Chirayinkeezhu, Neyyattinkara, Nedumangadu, Varkala, and Kattakada. The urban bodies in the district are the Thiruvananthapuram Corporation, Varkala, Neyyattinkara, Attingal, and Nedumangad municipalities.

3.1.2. Demographics

As per provisional 2011 census data, the total population of the district is 33,07,284 with a population density of 1509 persons/ sq.km. As per census 2001, the rural and urban population as percentage to the total population are 66.21 per cent and 33.78 per cent respectively. The literacy rate of the district is 92.66 per cent (GoK, 2021).

3.1.3. Soil types

The major types of soil found in Thiruvananthapuram district are red loam, coastal alluvium, riverine alluvium, lateritic soil, brown hydromorphic soil and forest loam. Most predominant soil in the district is lateritic soil and is mainly found along the midland, which are mostly reddish brown to yellowish red in colour (GoK, 2021).

3.1.4. Land utilization pattern

Land utilization pattern of Thiruvananthapuram district in 2018-19 is presented in the table 3. The district has a cropping intensity of 124 with its net cropped area accounting for 58 per cent of the total geographic area.

Table 3. Land utilization pattern of Thiruvananthapuram district

Sl No.	Category	Area in hectares	Percentage to total geographical area
1	Gross cropped area	1,60,055	73
2	Net cropped area	1,29,139	58
3	Land put to non-agricultural uses	32,516	14.8
4	Current fallow (upto 1 year)	2,760	1.2
5	Other fallow land	907	0.41
6	Cultivable waste	596	0.27
7	Total geographical area	2,19,200	100

Source: GoK, 2020

3.1.5. Climate and rainfall

The climate of Thiruvananthapuram district is tropical. Rainfall is significant in most months of the year, and the short dry season has little effect. The average temperature of the district is 25.7 °C. About 2197 mm of precipitation falls annually. The driest month is January, with 34 mm of rain. Most of the precipitation falls in June, averaging 319 mm. April is the warmest month of the year with an average temperature of 26.9 °C. August is the coldest month, with an average temperature of 25.0 °C (GoK, 2021).

3.1.6. Neyyar Irrigation Project-An overview

NIP, one of the commissioned major irrigation projects in Kerala, aims at harvesting the Neyyar river for the purpose of irrigation (Plate 1). This was the first major irrigation project taken up in the Travancore Cochin state under the First Five Year Plan.

The dam was constructed across Neyyar River at Chempilamodu near Kattakkada in Thiruvananthapuram district, approximately 29 kilometres east of Thiruvananthapuram City. The construction of the project was started in 1951 and completed in 1973. The project has Gross Command Area (GCA) of 18095 ha. This project consists of (1) Straight gravity rubble masonry dam of 56m height across Neyyar river, (2) a reservoir having water spread area of 9.1 sq. km at Full Reservoir Level and (3) water distribution system consisting of two main canals and its branch canals and distribution planned to irrigate two crops of paddy in the area of 15380 ha. The canal network consists of Right Bank Canal (RBC) of length 33.4 km with its entire command area lying in Kerala state, Left Bank Canal (LBC) of length 33.82 km (plate 2, plate 3 and table 4) with its command area lying in Kerala and Tamilnadu and branch canals of length 277.78 km (GoK, 2020).

Table 4. Index for main channels and distributaries

Sl No.	Left Bank Canal system	Length (km)	Right Bank Canal system	Length (km)
1	Main channel	33.32	Main channel	34.35
2	Perumkadavila branch	5	Vadacode branch	8
3	Chaikottukonam branch	8	Perumbazhuthoor tributary	1
4	Kollayil branch	12	Vizhinjam branch	22
5	Chenkal minor branch	5	Vellayani branch	10
6	Chenkal major branch	5	Marukil branch	2
7	Karumanoor right branch	8	Vellayani east branch	4
8	Kollamkode branch	8	Vellayani west branch	12
9	Chulliyoor branch	2	Poovar east branch	118
10	Veeyanoor sub channel	23	Olathanni branch	6
11	Vadakara sub channel	150	Kodangavila branch	3
12	Kulathamel sub channel	2	Poovar west branch	21
13	Chaikottukonam sub channel	150	Mayilkadavu field boothie	
14	Palapally sub channel	500	Chowara branch	21
15	Vlathankara field boothie	150		

Source: GoK, 2020

3.2 SAMPLING FRAME WORK

The research was carried out in the Thiruvananthapuram district. As NIP is the only major completed irrigation project in the district, it was purposefully chosen for the study.

3.2.1 Selection of Study Area and Sampling Design

The research was based on both primary and secondary sources of information. The secondary data relevant to the study was collected from the Office of the Chief Engineer, Investigation and Planning, Irrigation Projects-2, Thiruvananthapuram and the Office of the Assistant Engineer, Neyyar Irrigation Project, Thiruvananthapuram.

Plate 1. View of Neyyar Irrigation Project

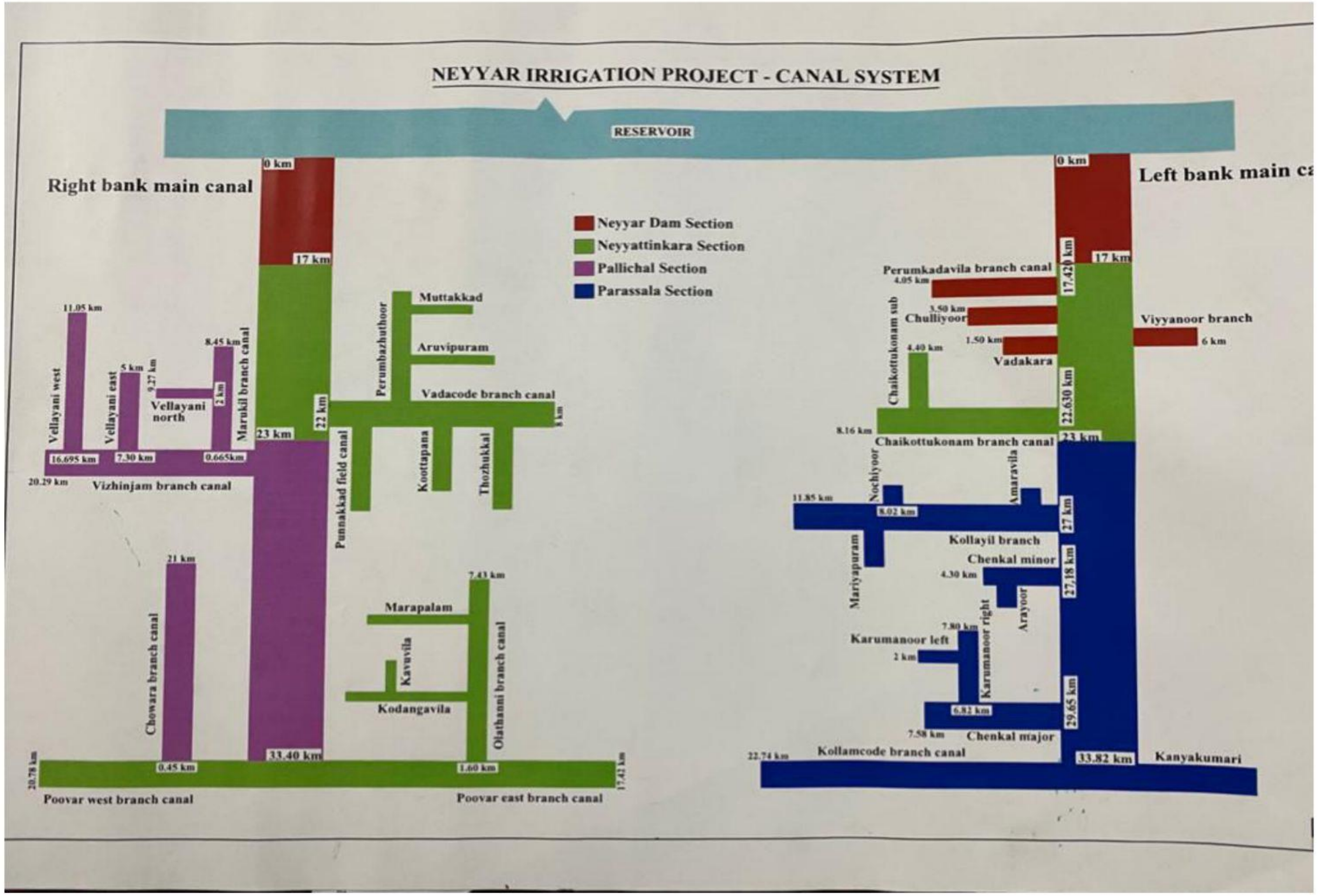

Plate 2. Canal system of Neyyar Irrigation Project

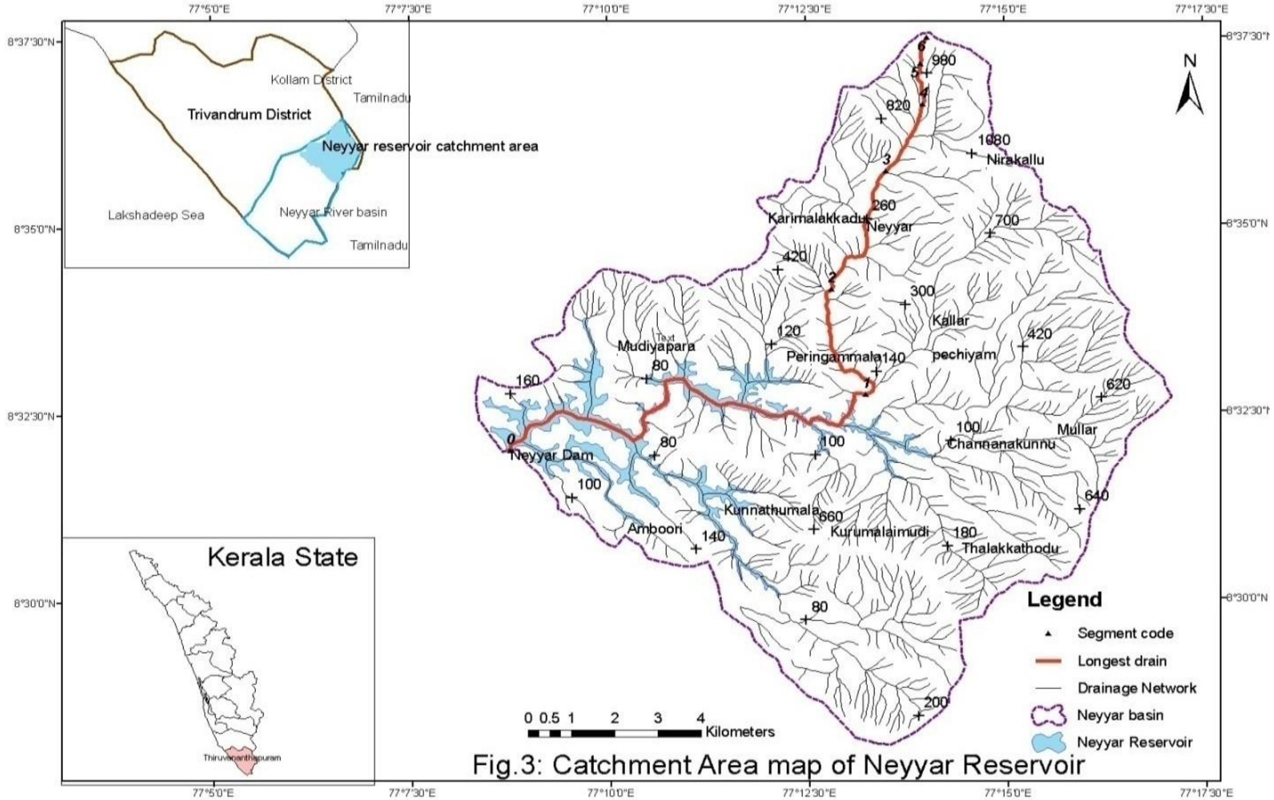

Plate 3. Catchment area of Neyyar Irrrigation project

The primary data was collected by interviewing the respondent farmers using a well-structured, pre-tested schedule of questions. As the entire command area is located in Kerala, the Right Bank Canal (RBC) was purposively chosen for the study. The data was collected using a two-stage stratified random sampling procedure and stratification was done based on the length of the canal. Thiruvananthapuram, Neyattinkkara, and Nedumangadu taluks of Thiruvananthapuram district were covered by ayacut of RBC. Head reach, middle reach, and tail reach were the three strata of the RBC. One panchayat (table 5) was selected randomly from each reach and lists of beneficiary farmers from the corresponding panchayats were collected from Krishibhavans. The selected panchayats were Kallikkadu, Maranalloor and Kalliyoor respectively in three reaches. Twenty beneficiary farmers were selected from each strata making sixty beneficiary farmers in the sample. Non-beneficiary farmers were chosen at random from the surrounding area from the same panchayats, who had no access to NIP making sixty non-beneficiary farmers in the sample. Thus the sample size of the study was one hundred twenty, consisting sixty beneficiary farmers and sixty non-beneficiary farmers (figure 1).

Table 5. Panchayats selected from the three reaches

Sl no	Name of panchayat	Strata
1	Kallikkadu	Head
2	Maranalloor	Middle
3	Kalliyoor	Tail

3.2.2 Period of Study

The secondary data pertained to the period from 2011-12 to 2021-22 was collected from various sources. The primary data collection was carried out during the period of July-August 2021.

3.2.3 Main Items of Observations

Main items of observations made were,

1. Socio-economic parameters of farmers such as family size, income of households, landholding size, level of education, farm and non-farm income.

2. Type of crops cultivated, their varieties and the area under each crop.

3. Production expenses of major crops

4.Water charges paid or payable.

5. Crop yield

6. Willingness to Pay

7. Weather parameters

8. Constraints faced by farmers.

9. Quantity and price of inputs and outputs.

3.3 EMPIRICAL MEASUREMENT OF VARIABLES AND TOOLS FOR ANALYSIS

The data concerned to the study were collected under the following heads and further analysis was carried out using various statistical tools.

3.3.1 Socio Economic Profile of Farmers

Percentage analysis was used to study the socio economic characteristics of respondents such as age, gender, educational status, family size, size of land holdings, occupation, annual income and experience in farming.

3.3.2 Economic Value of Irrigation Water

Contingent Valuation Method (CVM) is a technique used for the valuation of natural resources (Brookshire *et al.*, 1983). In CVM the Willingness to Pay (WTP) or Willingness to Accept (WTA) change in provision of an environmental good will be elicited from the respondents using a well framed questionnaire survey. The present study followed CVM to elicit the WTP from the beneficiary farmers in order to estimate the economic value of NIP. The steps followed are given below.

1) The respondents were provided a scenario, explaining adequate and timely irrigation services provided by NIP to individual fields.

2) The respondents were invited to consider the proposal where the dam and canals were well maintained and conserved by the government with the help of beneficiary contribution.

3)The respondents were asked to provide their statement regarding their WTP.

In order to obtain a prior idea regarding socio economic profiles of respondents and major constraints in on-farm irrigation, a pilot study was conducted. On the basis

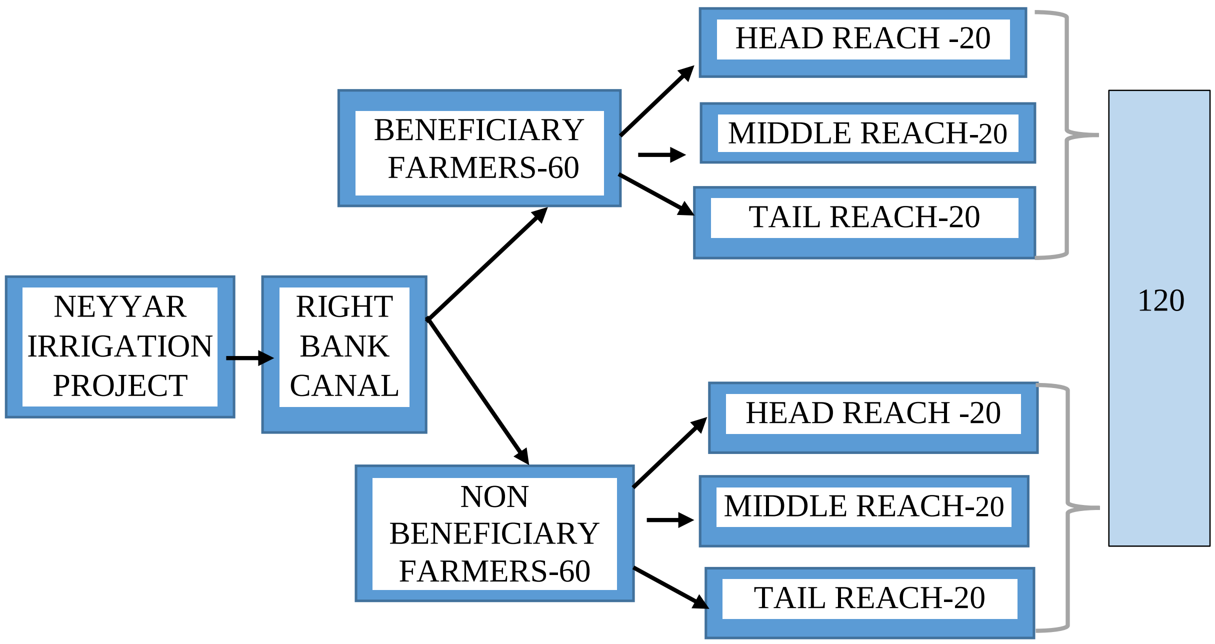

Figure 1. Sampling framework of the study

of it, a Double Bounded, Dichotomous Choice (DBDC) schedule of questions with an initial and follow up bid for WTP elicitation was finalised. In DBDC, respondents were asked whether they were willing to pay or not at presented price. Respondents who answered “yes” to the initial amount were presented a higher amount and asked whether they were willing to pay the higher amount. Respondents who answered “no” to the initial amount were presented with a lower amount and asked whether they were willing to pay it. Repeating the questions revealed the level of WTP (Aikoh *et al*., 2018; Arrow *et al*., 1993).

Data collection regarding WTP was based on the assumption that each sample farmer has a maximum WTP. Bidding game was started with an initial amount of Rs.50 per month (arrived after pilot study). The respondents who answered “yes” to the initial amount were presented a higher amount (Rs.60). The bidding game continued till it reached a maximum amount of Rs. 125. Respondents who answered “no” to the initial bid of Rs. 50 were presented with a lower amount of Rs. 25 and the bidding game continued till it reached the lowest amount, i.e. non-wllingness to pay. The initial bid of Rs. 50 was carefully arrived after the pilot study to avoid starting point bias. The statistical efficiency of DBDC format has been given by Hanemann *et al*. (1991). Use of DBDC for effective estimation of WTP has been proven by Mc Leod and Bergland, 1999; Yoo and Yang, 2001; Aikoh *et al*., 2018; Kassahun and Taw, 2022).

Factors influencing the WTP of the respondents were estimated using multiple regression with WTP as dependent variable with a set of other relevant explanatory variables. Economic value of irrigation water was determined by multiplying the estimated WTP of sample respondents with the total number of beneficiary households in the command area of NIP.

3.3.3. Estimation of Cost of Cultivation of Major Crops

Based on the pilot study, it was concluded that banana and cowpea were the major crops in selected panchayats. So, these crops were selected for the study. Data were collected under the following heads for estimating the cost of cultivation of both the crops.

3.3.3.1 Quantity of inputs

Information regarding quantity of inputs such as seed, fertilizers, plant protection chemicals and soil ameliorants were collected and used for calculating the cost of cultivation and resource use efficiency.

3.3.3.2 Cost of planting material, manures, fertilizers, plant protection chemicals and soil ameliorants

All the purchased planting materials were valued at the market price. Planting materials raised in the farm were imputed using prevailing market price. Cost of manures, fertilizers, and plant protection chemicals were calculated on the basis of prevailing market prices in the area. Most of the respondents were using lime as soil ameliorant. Existing market price of lime was used for the estimation of cost.

3.3.3.3 Cost of staking

Staking is the practice of tethering the banana plants to ensure that they remain upright. In the study area ropes and poles were used for staking. Prevailing market prices of these materials were used for estimating the cost of staking.

3.3.3.4 Pandal / Bower charges

Pandal charges were incurred by cowpea farmers and it includes the cost of providing supports to plants using stakes, poles and ropes. Prevailing market prices of these materials were used for estimating *pandal* charges.

3.3.3.5 Cost of labour

Labour employed for various farm operations included both family labour and hired labour.

Family labour costs: Family labour costs were estimated on the basis of prevailing wage rates in the locality.

Hired labour costs: It is the prevailing wage rate paid to the hired labour for performing various farm operations and the standard wage rate in the command area were Rs. 800 and Rs. 450 for male labourers and female labourers respectively.

3.3.3.6 Machine labour:

None of the respondents were using animal labour for performing any farm operations and only a few were using machine labour such as JCB for land preparation. The prevailing rate of hiring machine labour, in the study area was Rs. 500 per hour.

3.3.3.7 Depreciation

Depreciation is defined as the reduction in the monetary value of an asset due to its constant use over period of time. The straight-line method was employed for working out the depreciation (CSO, 2008). The amount of depreciation to be charged during a year is estimated as:

$$\text{Depreciation} = \frac{(\text{Purchase cost} - \text{salvage value})}{\text{Life of the asset}}$$

3.3.3.8 Irrigation charges

Here irrigation charges refers to the fuel charges incurred in running irrigation pumps. It was estimated on the basis of operational cost per hour.

3.3.3.9 Land revenue

Land revenue is the payment received or claimable by or on behalf of the Government, from any person on account of land held by or vested in him as fixed at a survey settlement in the area in which the land is situated (Ray, 1915). Data was collected regarding the amount money paid by the farmers on the basis of land they own.

3.3.3.10 Interest on working capital

Interest on working capital was charged at 12.5 per cent per annum for half of the crop period, on the basis of short term loans provided by the institutional agencies to farmers.

3.3.3.11 Rental value of leased-in land

It was calculated on the basis of actual rent paid by the farmers.

3.3.3.12 Rental value of owned land

It was calculated on the basis of prevailing lease rates for a similar land in the given area.

3.3.3.13 Interest on fixed capital

Interest on the present value of fixed assets such as land, farm, building, implements, machinery, irrigation structure, equipments and livestock at the rate of 10 per cent per annum has been calculated.

3.3.3.14. Miscellaneous expenses

Expenses incurred on bringing inputs from collection centre to farm/home, expenses on maintenance and repair of farm implements etc. were included in this.

3.3.3.15 Quantity of output

Quantity of output is given in tonnes per hectare.

3.3.4 Cost concepts

Cost concepts used by CSO (2008) were followed for calculating the cost of cultivation banana and cowpea. Cost incurred for growing the selected crops are classified under, cost 'A_1' cost 'A_2', cost 'B_1', cost 'B_2', cost 'C_1', cost 'C_2' and cost 'C_3' and the analysis of the data is made as:

Cost 'A_1': It approximates the actual expenditure incurred in cash and kind and includes the following items.

i. Value of hired human labour.

ii. Value of bullock labour (hired & owned).

iii. Value of Machine labour (hired & owned).

iv. Value of Seed/seedlings (both farm produced and purchased).

v. Value of Farm manure (owned and purchased).

vi. Value of fertilizers.

v. Value of plant protection chemicals.

vi. Depreciation on implements and farm buildings.

vii. Irrigation charges.

vii. Land revenue, cesses and other taxes.

viii. Interest on working capital

ix. Miscellaneous expenses

Cost 'A_2': Cost 'A_1' + rent paid for leased in land

Cost 'B_1': Cost 'A_1' + interest on value of owned fixed capital assets (excluding land).

Cost 'B_2': Cost 'B_1' + rental value of owned land and rent paid for leased-in land

Cost 'C_1': Cost 'B_1'+ imputed value of family labour

Cost 'C_2': Cost 'B_2'+ imputed value of family labour

Cost 'C_3': Cost C_2+ value of management of input at 10 per cent of total cost (C_2)

3.3.5 Returns

3.3.5.1 Gross return

It was worked out as the product of average yield of banana and cowpea produced per year by the respondents with the corresponding market price.

3.3.5.2 Net return

Net return for each crop was calculated by deducting its cost of cultivation from the estimated gross returns.

3.3.5.3 Benefit-cost ratio

It was worked out as the ratio of the gross returns to the cost of cultivation

3.3.6 Resource Use Efficiency

3.3.6.1 Resource productivity:

The production function approach was used to find out the productivity of resources used in cultivation of banana and cowpea by farmers in the command area. For this purpose, the Cobb-Douglas production function was employed separately for both crops (Mukul and Rahman, 2013; Kumar *et al*., 2015; Dave *et al*., 2016; Bajracharya and Sapkota, 2017; Sakamma *et al*., 2018). The single most advantage of this production function has been that the input coefficients constituted the respective elasticities (Suresh and Reddy, 2006). The Cobb-Douglas production function employed in the present study for banana and cowpea was,

$Y= a X_1^{b1} X_2^{b2} X_3^{b3} X_4^{b4} X_5^{b5} X_6^{b6} X_7^{b7} X_8^{b8} e^{\mu}$

Where, Y = Quantity of output/yield from crop cultivation (kg)

X_1 = Quantity of seed /planting material (kg/No.)

X_2 = Quantity of human labour (Man days)

X_3 = Quantity of machine labour (Hours)

X_4 = Quantity of manures (kg)

X_5 = Quantity of fertilizers (kg)

X_6 = Quantity of soil ameliorants (kg)

X_7 = Irrigations (No.)

X_8 = Sprayings of plant protection chemicals (No.)

μ = Random-error

This Cobb-Douglas function was estimated using ordinary least square (OLS) approach after converting it into log linear form (Doll and Orazem, 1985). The estimable form of the equation is given below:

$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + b_7 \ln X_7 + b_8 \ln X_8 + \mu.$

3.3.6.2 Marginal productivity analysis

Allocative efficiency (AE) was determined by calculating the ratio of the marginal value product to the marginal factor cost (Konja *et al*., 2019; Pandey *et al*., 2020).

i.e. AE = MVP/ MFC

$MVP = MPP_i \times P_y$

where, MVP = Marginal Value Product

MFC = Marginal Factor Cost (Price of input)

MPP_i = Marginal Physical Product of the i^{th} input P_y = Price of output

$MPP_i = b_i\ Y/ X_i$

where, b_i = Elasticity coefficient of the i^{th} independent variable

Y = Geometric mean of the output,

and X_i = Geometric mean of the i^{th} input

3.3.7 Constraint Analysis

In order to analyse the constraints faced in receiving adequate irrigation water supply by farmers of the command area, ranking technique formulated by Henry Garrett was used (Kumar *et al*., 2010; Vijayan, 2015; Wali *et al*., 2020; Roy *et al*., 2021). After conducting a pilot study and based on the existing literature, constraints prevailing in the study area were finalised and enlisted in tabular form. During the main survey respondents were asked to assign the rank for those constraints. Outcomes of such ranking had been converted into score value with the help of the following formula:

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

Where R_{ij} = Rank given for the i^{th} variable by j^{th} respondent

N_j = Number of variable ranked by j^{th} respondent

(Garrett and Woodworth, 1969)

With the help of Garrett’s table, the per cent position estimated was converted into score. For each constraint, the total and mean value of individual scores were obtained. The constraint having highest mean score value was identified as the most severe one.

CHAPTER IV
RESULTS AND DISCUSSION

The present study was intended to estimate the economic value of irrigation water and to identify operational problems in irrigation management in the command area of Neyyar Irrigation Project, Thiruvananthapuram. The results obtained from the empirical evaluation of each objective through analysing primary and secondary data pertaining to the study are presented under the following heads.

4.1 Socio-economic characteristics of the sample farmers
4.2 Economic value of irrigation water
4.3 Economics of crop cultivation
4.4 Resource use efficiency
4.5 Operational problems in irrigation water management

4.1 SOCIO-ECONOMIC CHARACTERISTICS OF THE SAMPLE FARMERS

Detailed description of the socio-economic characteristics of sample farmers such as age, gender, educational status, family size, experience in farming, occupation, annual income and pattern of land holding are included in this section.

4.1.1 Age

The classification of sample farmers was done based on age into four groups based on the study by Newman and Newman (1999) i.e. <30 years (youth), 30-45 years (adulthood), 45-60 years (middle adulthood) and >60 years (old age). Details are furnished in Table 6.

It was observed that, out of the 120 respondent farmers, only one farmer belonged to the group of <30 years. Majority of the farmers were in the age group of 45-60, followed by the group >60 years. The average age of beneficiary and non-beneficiary farmers was 56.23 and 56.00 years respectively. The average age of respondents was found to be 56.15 years. The lack of interest of among generation towards farming could be clearly seen in the study area.

Table 6. Age wise classification of the sample farmers

Sl No.	Category of farmers	Age (Years)				Total	Average
		<30	30-45	45-60	>60		
1	Beneficiaries	0 (0)	9 (15)	30 (50)	21 (35)	60 (100)	56.23
	i) Head reach	0 (0)	1 (5)	13 (65)	6 (30)	20 (100)	58.10
	ii) Middle reach	0 (0)	5 (25)	9 (45)	6 (30)	20 (100)	53.65
	iii) Tail reach	0 (0)	3 (15)	8 (40)	9 (45)	20 (100)	56.95
2	Non Beneficiaries	1 (1.60)	7 (11.60)	32 (53.33)	20 (33.33)	60 (100)	56.00
3	Total	1 (0.08)	16 (13.33)	62 (51.66)	41 (34.10)	120 (100)	56.15

Note: Figures in parentheses represent percentage to the row total

The observations were in line with the results of the study conducted by Durga *et al*. (2018) on the canal irrigation and collective action of Water User Association in Southern India in which it was found that the average age of the farmers in the canal command area was 55.67 years.

4.1.2 Gender

The classification of sample farmers based on gender is given in table 7. It WAS observed that more than 85 per cent of the total sample respondents were male among both beneficiary and non-beneficiary farmers. The percentage of female members in both the groups was less than ten. The reasons for the low participation of females in farming may be their involvement in MNREGS or self-employment activities like tailoring, running grocery shops and the likewise.

Similar results were obtained in a study conducted by Jha (2020) on farmers' participation in canal management in Uttar Pradesh's Rai Bareilly district. It was observed that the participation of males in agriculture was 81.67 per cent while that of women was 18.33 per cent which showed the less participation of women in farming activities.

Table 7. Gender wise distribution of the sample farmers

Sl No.	Category of farmers	Gender		Total
		Male	Female	
1	Beneficiaries	53 (88.30)	7 (14.70)	60 (100)
	i) Head reach	17 (85)	3 (15)	20 (100)
	ii) Middle reach	18 (90)	2 (10)	20 (100)
	iii) Tail reach	18 (90)	2 (10)	20 (100)
2	Non-beneficiaries	52 (86.60)	8 (13.40)	60 (100)
3	Total	105 (87.50)	15 (12.50)	120 (100)

Note: Figures in parentheses represent percentage to the row total

4.1.3 Educational status

Educational status of the respondent farmers is of utmost importance in order to identify the institutional environment in which the farm units operate. Sample farmers are classified into three groups based on their educational status as presented in Table 8.

Table 8. Educational status of the sample farmers

Sl No.	Category of farmers	Education			
		Primary	Secondary	Pre-degree /HS	Total
1	Beneficiaries	36 (60)	20 (33.33)	4 (6.66)	60 (100)
	i) Head reach	13 (65)	7 (35)	0 (0)	20 (100)
	ii) Middle reach	11 (55)	7 (35)	2 (10)	20 (100)
	iii) Tail reach	12 (60)	6 (30)	2 (10)	20 (100)
2	Non-beneficiaries	36 (60)	21 (35)	3 (5)	60 (100)
3	Total	72 (60)	41 (34.10)	7 (5.83)	120 (100)

Note: Figures in parentheses represent percentage to the row total

It was seen that all the respondent farmers were literate and majority of them had at least primary level of education. A small per cent were having an education level of Pre-degree/Higher Secondary (HS). None of the respondents were having educational qualification above pre-degree/HS. There was not much difference between the educational status of beneficiary and non- beneficiary farmers.

Geetha and Anbazhakan (2019) in a similar study on water resource management in Sathanur command area in Tamilnadu observed that majority of the respondent farmers were literate (82%) and were educated upto primary or secondary level.

4.1.4 Family size

Family size was categorised into three based on the study by Rahman and Khatun (2014) i.e. small (≤3 members), medium (4-6 members) and large family (>6 members). The details are furnished in table 9.

Table 9. Family size of the respondents

Sl No.	Category of farmers	Family size			Total	Average size
		≤3 (Small)	4-6 (Medium)	>6 (Large)		
1	Beneficiaries	23 (38)	24 (40)	13 (22)	60 (100)	5.20
	i)Head	8 (40)	8 (40)	4 (20)	20 (100)	5.15
	ii)Middle	8 (40)	8 (40)	4 (20)	20 (100)	5.30
	iii)Tail	7 (35)	8 (40)	5 (25)	20 (100)	5.15
2	Non-beneficiaries	18 (31)	34 (56)	8 (13)	60 (100)	5.05
3	Total	41 (34)	58 (48)	21 (18)	120 (100)	5.12

Note: Figures in parentheses represent percentage to the row total

Majority of the respondents belonged to medium sized family. Average family size of the beneficiary farmers was found to be 5.20 and that of non-beneficiary farmers was found to be 5.05. Among beneficiaries, the average family size of the head and tail reach farmers was found to be 5.15 while that of the middle reach farmers was found to be 5.30. Average family size of the total sample farmers was found to be 5.12.

Durga *et al.* (2018) also observed on their study on the Water User Associations in Southern India that the average family size of the sample farmers was five.

4.1.5 Experience in farming

Table 10 represents the classification of respondents based on their experience in farming into three groups i.e. ≤10 years, 11-20 years and >20 years. It was found that majority of farmers belonged to the group of >20 years.

Table 10. Classification of respondents based on farming experience

Sl No.	Category of farmers	Experience in farming (years)			Total	Average years of experience
		≤10	11 to 20	>20		
1	Beneficiaries	1 (1.66)	5 (8.33)	54 (90)	60 (100)	37.36
	i)Head reach	0 (0)	1 (5)	19 (95)	20 (100)	40.20
	ii)Middle reach	1 (5)	2 (10)	17 (85)	20 (100)	33.80
	iii)Tail reach	0 (0)	2 (10)	18 (90)	20 (100)	38.11
2	Non-beneficiaries	3 (5)	6 (10)	51 (85)	60 (100)	36.21
3	Total	4 (3.33)	11 (9.16)	105 (87.51)	120 (100)	36.78

Note: Figures in parentheses represent percentage to the row total

The average years of experience was higher for the beneficiary farmers (37.36 years) than that of non-beneficiary farmers (36.20 years). It was found that among beneficiary farmers, average years of farming experience was higher for head reach farmers (40.20 years) followed by tail (38.11 years) and middle (33.80 years) reach farmers. The average years of experience of total sample respondents was found to be 36.78 years which indicated that majority of the sample respondents were well-experienced in farming.

4.1.6 Occupation

Occupational status was categorised into two i.e. farmers with agriculture as main occupation and agriculture as subsidiary/part-time occupation. Part-time farmers were grouped under those having public employment, private employment and self-employment. The details are furnished in Table 11.

Table 11. Classification of respondents based on occupational status

Sl No.	Category of farmers	Agriculture as main occupation	Agriculture as subsidiary occupation			Total
			Public	Private	Self employed	
1	Beneficiaries	49 (81.66)	2 (3.33)	4 (6.66)	5 (8.33)	60 (100)
	i)Head reach	18 (90)	0 (0)	0 (0)	2 (10)	20 (100)
	ii)Middle reach	16 (60)	2 (10)	2 (10)	4 (20)	20 (100)
	iii)Tail reach	15 (75)	0 (0)	2 (10)	3 (15)	20 (100)
2	Non-beneficiaries	42 (70)	0 (0)	6 (10)	12 (20)	60 (100)
3	Total	91 (75.83)	2 (1.66)	10 (8.33)	17 (14.10)	120 (100)

Note: Figures in parentheses represent percentage to the row total

Among the beneficiary and non-beneficiary farmers, it was observed that, majority of them had agriculture as their main occupation. It was observed that beneficiary farmers (81.66 %) were more into agriculture and practised it as main occupation compared to non-beneficiary farmers (70 %).

Similar pattern was observed in the study conducted by Vijayan (2004) on the economic analysis of NIP. It was found the that majority of the beneficiary farmers were full time farmers whereas among non-beneficiaries, the percentage of full time farmers was less when compared to that of part time farmers.

4.1.7 Annual income

Respondents were grouped into three categories on the basis of their gross average annual income. The categorisation was based on percentiles (UN, 2011) i.e., low (below 50th percentile i.e., <Rs. 1,15,000), middle (50th-75th percentile i.e., Rs. 1,15,000-1,50,000) and high (above 75th percentile i.e., >Rs. 2,50,000). The details are furnished in table 12.

Table 12. Classification of respondents based on gross average annual income

Sl No	Category of farmers	Gross annual income (Rs)			Total	Average annual income (Rs)
		Low <1,15,000	Middle 1,15,000-1,50,000	High >1,50,000		
1	Beneficiaries	19 (32)	18 (30)	23 (38)	60 (100)	2,40,053
	i) Head reach	9 (45)	6 (30)	5 (25)	20 (100)	2,34,150
	ii) Middle reach	6 (30)	8 (40)	6 (30)	20 (100)	2,45,410
	iii) Tail reach	4 (20)	4 (20)	12 (60)	20 (100)	2,40,600
2	Non-beneficiaries	39 (65)	18 (30)	3 (5)	60 (100)	2,13,983
3	Total	58 (48)	36 (30)	26 (22)	120 (100)	2,27,018

Note: Figures in parentheses represent percentage to the row total

It was found that 48 per cent of the respondents were receiving low gross average annual income i.e., below Rs.1,15,000. Thirty per cent of the respondents fell under middle income category while 22 per cent of the sample farmers received high average annual income. Average annual income of beneficiary farmers (Rs. 2,40,053) was found to be greater than that of non- beneficiary farmers (Rs.2,13,983).

4.1.8 Source wise classification of annual income

On the basis of income source, average annual income of the sample farmers were classified into on-farm income and non-farm income as presented in table 13. It was found that the average annual farm income was higher for beneficiary farmers (Rs.1,89,811) than non-beneficiary farmers (Rs.1,48,896). Among beneficiaries, head and middle reach farmers were having relatively higher farm income than that of tail reach farmers. It can be clearly seen that non-beneficiary farmers were earning higher non-farm income (Rs.65,087) when compared to beneficiary farmers (Rs.50,242) due to their relatively high dependence on self-employment and private sector jobs as additional/major sources of income.

Table 13. Source wise classification of annual income of respondents

Category of farmers	Average annual farm income (Rs)	Average annual non-farm income (Rs)
Beneficiaries	1,89,811 (79%)	50,242 (21%)
i)Head	1,87,816 (80%)	46,334 (20%)
ii)Middle	1,93,484 (79%)	51,926 (21%)
iii)Tail	1,81,460 (75%)	59,140 (25%)
Non-beneficiaries	1,48,896 (70%)	65,087 (30%)
Average income	1,69,354 (75%)	57,664 (25%)

Note: Figures in parentheses represent percentage to gross average annual income

Similar results were obtained in the study conducted by Deole *et al*. (1972), on the income of farmers in the command area of Purna project in Maharashtra. The study revealed that in case of non-beneficiaries, crop production accounted for 68 per cent of gross annual income while it accounted for about 76 per cent of gross income of beneficiaries.

4.1.9 Cropping pattern

Cropping pattern refers to the proportion of land under cultivation of different crops at different points of time. Table 14 provides an overview of the cropping pattern followed by sample farmers in the study area. It can be seen that banana crop occupied the maximum area (35.37 %), followed by vegetables (23.58 %) and coconut (22.01 %). Area occupied by banana was higher for beneficiary farmers (0.26 ha) as compared to non-beneficiary farmers (0.19 ha).

Share of banana were almost similar for both beneficiaries and non-beneficiaries while share of vegetables were higher for beneficiaries. It can also be seen that head and middle reach farmers were more into banana and vegetable cultivation than tail reach farmers. Popular varieties of crops cultivated by the respondents were Nendran for banana, Komadan and West Cost Tall for coconut, Sambar vellari for cucumber, Kanakamani and Vellayani Jyothika for cowpea, Renusree and Krishnasree for maranthus, Kalpaka and Uthama for tapioca and Thejus for chilli.

Table 14. Cropping pattern of respondent farmers (ha)

Sl No.	Crop	Beneficiaries	i)Head reach	ii)Middle reach	iii) Tail reach	Non beneficiaries	Total
1	Banana	0.26 (35.71)	0.30 (38.07)	0.25 (34.34)	0.20 (29.94)	0.19 (34.92)	0.225 (35.37)
2	Coconut	0.14 (19.23)	0.12 (15.22)	0.15 (20.60)	0.15 (22.45)	0.14 (25.73)	0.140 (22.01)
3	Vegetables	0.20 (27.47)	0.22 (27.91)	0.20 (27.47)	0.19 (28.44)	0.10 (18.38)	0.150 (23.58)
4	Tubers	0.07 (9.61)	0.06 (7.61)	0.08 (10.98)	0.08 (11.97)	0.05 (9.19)	0.060 (9.43)
5	Arecanut	0.05 (6.86)	0.02 (2.53)	0.01 (1.37)	0.02 (2.99)	0.04 (7.35)	0.045 (7.07)
6	Paddy	0.0001 (0.01)	0.00 (0.00)	0.01 (1.37)	0.00 (0.00)	0.01 (1.83)	0.005 (0.78)
7	Others	0.06 (8.24)	0.06 (7.61)	0.02 (2.74)	0.10 (14.97)	0.01 (1.83)	0.035 (5.50)
8	Total	0.728 (100)	0.788. (100)	0.728 (100)	0.668 (100)	0.544 (100)	0.636 (100)

Note: Figures in parentheses represent percentage to the row total

4.1.10 Size of Land holding

Table 15 represents the classification of sample farmers on the basis of the size of land holding into four groups namely, marginal (below 1 ha), small (1-2 ha) and medium (>2 ha) (GoI, 2019). It was found that 71.67 per cent of the beneficiaries were marginal farmers while it was 81.67 per cent in case of non-beneficiaries. The average size of land holdings was higher for beneficiary farmers (0.72 ha) than that of non-beneficiary farmers (0.54 ha).

Similar attempt by Devi and Mani (2006) also revealed that in Peechi command area in Thrissur, majority of the respondents were small and marginal farmers and the major crops cultivated by them included coconut, arecanut, pepper, banana, vegetables and fruit crops.

4.1.11 Ownership

Table 16 provides details on the type of ownership of land holdings and the classification of sample farmers into three groups i.e. those who cultivate in owned land, leased in land and in both owned and leased in land. It was found that majority of the respondents (64%) cultivated in leased in land followed by cultivation in owned land (27.50%). Seventy per cent of the beneficiary farmers cultivated in leased in land while only 58.33 per cent of non-beneficiary farmers did the above. In case of beneficiary farmers those who are in head and middle reaches were more into leasing in (75% and 70% respectively) compared to that of non-beneficiary farmers (65%).

Similar pattern in leasing was observed during the economic analysis of NIP conducted by Vijayan (2004). It was found that among the beneficiary farmers, the tendency to lease-in was more in head reach and this may be due to the assured supply of irrigation water from the project.

Table 15. Classification of respondents based on size of land holdings

Sl No.	Category of farmers	Classes of holdings (in ha)						Total	Average size of holdings (ha)
		Marginal (< 1 ha)		Small (1-2 ha)		Medium (>2 -ha)			
		Number	Size (ha)	Number	Size (ha)	Number	Size (ha)		
1	Beneficiaries	33 (71.67)	0.53	17 (28.33)	1.20	0 (0)	0	60 (100)	0.728
	i) Head reach	13 (65)	0.55	7 (35)	1.21	0 (0)	0	20 (100)	0.788
	ii) Middle reach	10 (75)	0.56	5 (25)	1.22	0 (0)	0	20 (100)	0.728
	iii) Tail reach	15 (75)	0.50	5 (25)	1.19	0 (0)	0	20 (100)	0.668
2	Non-beneficiaries	49 (81.67)	0.41	11 (18.33)	1.12	0 (0)	0	60 (100)	0.544
3	Total	92 (76.67)	0.46	28 (23.33)	1.17	0 (0)	0	120 (100)	0.636

Note: Figures in parentheses represent percentage to the row total

Table 16. Details on the ownership of holdings of the respondents

Sl No.	Category of farmers	Cultivating in Owned land (ha)		Cultivating in Leased land (ha)		Cultivating in both lands (ha)		Total
		Number	Average size (ha)	Number	Average size (ha)	Number	Average size (ha)	
1	Beneficiaries	11 (18.33)	0.28	42 (70)	0.84	7 (11.66)	0.73	60 (100)
2	i) Head	4 (20)	0.30	15 (75)	0.94	1 (5)	0.54	20 (100)
3	ii) Middle	4 (20)	0.24	14 (70)	0.82	2 (10)	1.0	20 (100)
4	iii) Tail	3 (15)	0.27	13 (65)	0.76	4 (20)	0.65	20 (100)
5	Non-beneficiaries	22 (36.67)	0.20	35 (58.33)	0.75	3 (5)	0.6	60 (100)
6	Total	33 (27.50)	0.24	77 (64.16)	0.80	10 (8.33)	0.69	120 (100)

Note: Figures in parentheses represent percentage to the row total

4.2. ECONOMIC VALUE OF IRRIGATION WATER

Valuation of natural resources can be defined as an attempt to put monetary values to environmental goods and natural resources. The basic aim of valuation is to determine the preferences of people by gauging how much they are willing to pay for given benefits of certain environmental attributes (Hailu, 2013). The present study employed Contingent Valuation Method (CVM) for the valuation of irrigation water from NIP. The Willingness to Pay (WTP) of farmers for the provision of assured and timely supply of irrigation water was elicited using double bounded dichotomous choice question. An appropriate multiple regression model was specified using WTP as dependant variable and a set of socio-economic and individual characteristics of the respondents as explanatory variables. In the present study, data for employing CVM were collected from twenty beneficiary farmers from each stratum: head reach, middle reach and tail reach.

The respondents from each stratum were provided with the hypothetical scenario of proper maintenance of canals by the government with the co-operation of beneficiary farmers in order to assure an adequate and timely supply of irrigation water. Questions were asked to elicit their WTP per year for the same. The number of respondents willing to pay and the mean WTP of those who were wiiling to pay in each strata is given in Table 17.

Table 17. Mean WTP of the respondents in the NIP command area

Sl No.	Strata	No. of respondents having WTP	No. of respondents not willing to pay	Total number of respondents	Mean stated WTP (Rs./year)
1	Head reach	7 (35)	13 (65)	20 (100)	651.42
2	Middle reach	10 (50)	10 (50)	20 (100)	714.00
3	Tail reach	15 (75)	5 (15)	20 (100)	800.00
4	Total Beneficiaries	32 (53.33)	28 (46.67)	60 (100)	721.80

Note: Figures in parentheses represent percentage to the row total

Figure 2 gives the diagrammatic representation of the WTP of respondents in the study area. It was revealed from the study that only 53.33 per cent of the respondents were willing to pay for the conservation of the dam and canals and for the improved supply of irrigation water. The stated mean WTP of the beneficiaries was Rs. 721.80 per year which represents only 0.3 per cent of their average annual income. WTP of the farmers in the tail reach of the RBC (Rs. 800 per year) was found to be higher than that of the farmers in the middle (Rs. 714 per year) and head (Rs. 651 per year) reaches. It can be seen that farmers having WTP are more in the tail reach (75%) when compared to the head (35%) and middle (50%) reaches. It is evident from the study that WTP varies inversely with the distance from the reservoir. Tail reach farmers experienced more water shortage compared to head reach and middle reach farmers and hence they were willing to pay comparatively more amount than others. The maximum WTP was Rs. 1200 per year and the minimum WTP was Rs. 600 per year with a mean WTP of Rs. 721.80 per year.

Vijayan (2004) also reported that the farmers in head reach of the NIP command area had not experienced scarcity of irrigation water and were not willing to pay more than the current water rate. Middle and tail reach farmers who experienced water shortages were willing to pay more as compared to head reach farmers.

The reasons for attributed to the low WTP in the present study may be the following. Most of the farmers who were not willing to pay believed that it is the duty of the government to maintain dam and canals and to provide adequate water supply to the public without charging money. Some of them were not willing to pay, as they believe that water cess was already being charged by the revenue department along with the land cess and they do not consider it as necessary to pay for irrigation services separately. The beneficiary farmers in the study area were not paying anything for irrigation water except a meagre amount along with land cess. Majority of them were not even aware of pricing of irrigation water. The low willingness to pay may also be due to the adequate rainfall received for past two years, which gave the feeling to the respondents that water is a free good. The shift in cropping pattern from paddy to other crops which require less water may be another reason for low WTP. Besides being an irrigation source the role of NIP in ground water recharge is significant. It is noteworthy that the role of NIP in ground water recharge in the command area was also ignored by farmers while eliciting the WTP. Thus it can be concluded that the economic value of irrigation water was not realised completely by many respondents as indicated by low WTP.

Table 18 represents the summary statistics of WTP of the respondents who were willing to pay.

Table 18. Summary statistics of WTP

Sl No.	Statistic	Value
1	Mean (Rs/year)	721.80
2	Standard error	32.28
3	Median (Rs/year)	600
4	Mode (Rs/year)	600
5	Standard deviation	182.63
6	Coefficient of variation (%)	25%
7	Sample variance	33,354.44
8	Minimum (Rs/year)	600
9	Maximum (Rs/year)	1200
10	Sum (Rs/year)	23,700
11	No. of beneficiaries having Willingness to Pay	32

A multiple linear regression model was fitted with WTP as dependent variable and the variables which affected the WTP as independent variables. Table 19 represents the results of multiple linear regression model employed in estimating the WTP of the respondents.

The independent variables are explained as the following. Education was a dummy variable with a value of zero if illiterate and one if educated. The monthly income of the respondents was presented in rupees. Dummy variable of one was given if there was assured supply of irrigation water and zero was given if it was not available. Similarly, dummy variables of one and zero were assigned for the presence and absence of adequate rainfall respectively. The average holding size or area of the respondents was given in hectare and the age of respondents were presented in years.

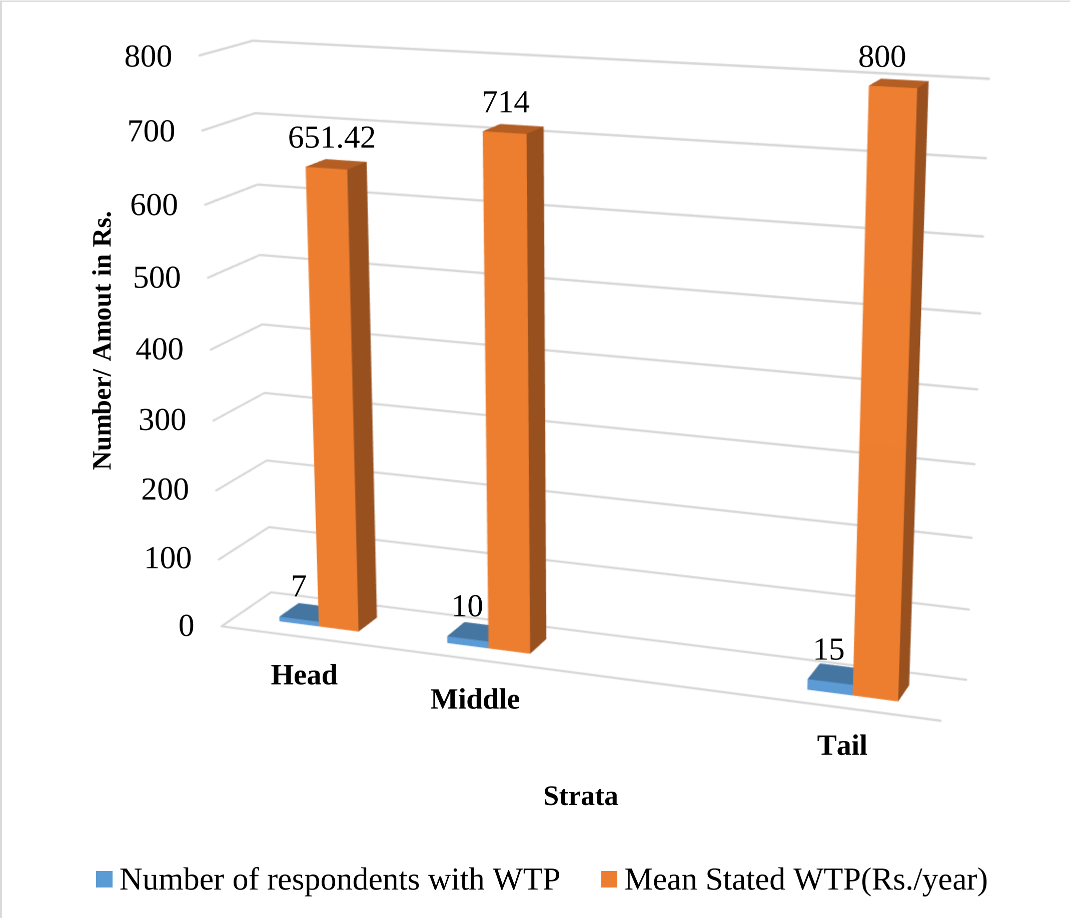

Figure 2. Stated Mean WTP of the respondents in the command area

Table 19. Model parameters for WTP of the respondents

Sl No.	Variable	Parameter estimate	Standard error	p-value	VIF
1	Intercept	610.392	512.44	0.2393	
2	Education	246.231***	90.04	0.0086	1.21
3	Annual income	0.0015***	0.0004	0.0018	2.33
4	Availability of assured water supply	-467.541***	101.88	0.0003	1.41
5	Availability of adequate rainfall	-327.394***	116.37	0.0070	1.81
6	Size of land holding	108.8	102.8	0.295	2.45
7	Age	-17.68	12.39	0.158	2.20
8	R^2	0.63			
9	Adjusted R^2	0.56			
10	No. of observations	60			

*** Significant at 1 per cent level

The R^2 value of 0.63 indicates that 63 per cent of variation in WTP could be explained by the selected dependent variables. The variables which were significantly influencing the WTP of respondents were education, annual income, availability of assured water supply and availability of adequate rainfall. Education and annual income affected WTP positively while rest of the variables had negative impact on WTP. The VIF values for independent variables were less than 10, indicating negligible multicollinearity between them.

From the study, the estimable form of the equation for WTP obtained is given below:

$Y= 610.392+ 246.231\ X_1 +0.0012\ X_2 - 467.541\ X_3 + 327.394\ X_4 +108.8\ X_5 -17.68\ X_6 + \mu$.

Where, Y=Willingness to Pay

X_1= Education

X_2= Annual income

X_3= Availability of assured water supply

X_4= Availability of adequate rainfall

X_5= Size of land holding

X_6= Age

μ= Random error

It was reported by Yang *et al*. (2008) in their study conducted in China that higher the education and income of the people higher will be the WTP. Halkos and Matsiori (2013) also reported from Greece that the individual WTP towards river protection and characteristics such as education and income are highly associated. A study by Mamat *et al*. (2013) on the willingness to pay for protecting natural environments in Pulau Redang Marine Park, Malaysia also indicated that age, education and gross income were the important factors that affected the WTP.

From the fitted regression model, the estimated value of WTP is Rs. 395 per household per year. The economic value of irrigation water in the command area, which is the product of estimated WTP of the respondents (Rs. 395/year) and the total number of beneficiary households in the command area of NIP stood at Rs. 1.5 Crore per year. Since there were no official records on the number of beneficiary households, data obtained through discussion with the dam officials after cross-checking with the data obtained from different panchayats lying in the command area was used for the above purpose. The operational and maintenance costs of the dam and its canals in the year 2020-21 (as given by the office of the Assistant Engineer, NIP) was Rs. 3.2 crores. The economic value of irrigation water covered only 47 per cent of it. In addition to that the estimated WTP of the respondents was found to be only a small percentage of their annual income.

Chandrasekharan *et al*. (2009) conducted a similar study on tank irrigation systems in South India. The results revealed that the mean WTP value of farmers for irrigation water was INR 218.50 per ha per year. The state average operations and maintenance expenditure on tanks was Rs.55 per year per ha, indicating that farmer were willing to pay considerably more than the average operation and maintenance costs incurred by the states on tanks.

In a similar attempt by Tang *et al*. (2013) to study the WTP for irrigation water in Northwest china revealed that the supply cost of irrigation water was higher than the farmers' WTP. The main reason of low WTP was not farmers' inability to pay, but their unwillingness to pay.

Biswas and Venkatachalam (2014) conducted a study on farmers' willingness to pay in the command area of Malaprabha irrigation project in Karnataka. They found that the mean WTP was only 0.7 percentage of their average annual income. But the estimated economic value of irrigation water covered the entire costs of operation and maintenance of Malaprabha canals implying that farmers can gain a significant amount of producer surplus even after paying for the cost of implementing the programme.

Thus it can be concluded that the low realisation of economic value of irrigation water by the respondents is the major reason for their low WTP. NIP is the only major irrigation project of Thiruvananthapuram district. Proper maintenance of canals with assured and adequate water supply to farmers may improve the WTP of the farmers.

4.2.1 Irrigation charges

It was observed from the study that the farmers were not aware of any irrigation charges. Some of them opined that irrigation cess is paid along with the land revenue. Enquiry with the dam authorities revealed that no separate irrigation cess was collected.

4.3. ECONOMICS OF CROP CULTIVATION

Economics of crop cultivation of selected crops in the command area of NIP was estimated in order to compare the relative performance of beneficiary and non-beneficiary farmers. Banana and cowpea (trailing type) were the main crops cultivated in the area. Cost of cultivation of both crops was worked out and discussed separately using the ABC cost concepts viz., cost A_1, cost A_2, cost B_1, cost B_2, cost C_1, cost C_2 and cost C_3. The popular varieties among farmers were *Nendran* for banana and *Kanakamani* for cowpea.

4.3.1 Comparison of cost of cultivation of banana for beneficiary and non-beneficiary farmers

The average annual cost of cultivation per hectare of banana *(Nendran)* was estimated for beneficiaries and non-beneficiaries and compared. Table 20 gives the detailed cost of cultivation of banana for both beneficiary and non-beneficiary farmers.

The total cost of cultivation at cost C_3 worked out for beneficiary farmers was Rs. 4,71,248 per hectare while cost A_1 was estimated to be Rs. 2,58,316,43 per hectare. Cost A_2 constituted Rs. 3,16,233 per hectare, to which cost incurred for organic manure had the highest contribution (25.51%). Since banana takes 10 months to yield, quantity of organic manure applied was also more. It included mainly cow dung followed by wood ash, poultry manure, neem cake and compost. Cost of hired human labour (23.19%) and rental value of leased-in land (18.31%) occupied second and third positions respectively. Cost of planting material accounted for 10.15 per cent of cost A_2 while cost of staking and cost of chemical fertilizers accounted for 5.26 per cent and 3.95 per cent respectively. Cost of staking and cost of planting material were higher for beneficiaries when compared to non-beneficiaries because of the relatively higher density of planting adopted by beneficiary farmers which could be due to more availability irrigation water for them. Cost of machine labour, soil ameliorants, fuel charges, land revenue, depreciation and interest on working capital together constituted 12.5 per cent of cost A_2 and the remaining items were included under miscellaneous costs.

Majority of the farmers in the study area cultivated in leased-in lands due to which land rent was apparently more and stood at Rs. 57,917 per hectare. Cost B_2 for beneficiaries was estimated to be Rs. 3,74,620 per hectare.

The total cost of cultivation at cost C_3 worked out for non- beneficiary farmers was Rs. 4,95,114 per hectare while cost A_1 was estimated to be Rs. 2,71,784 per hectare. Cost A_2 constituted Rs. 3,27,064.88 per hectare, to which cost incurred for hiring human labour had the highest contribution (27.21%). Since the duration of banana crop relatively higher than other crops its cultivation is labour intensive. Cost of organic manure (22.27%), rental value of leased in land (16.90%) and cost of planting material

(9.58%) occupied second, third and fourth positions respectively. Cost of staking accounted for 3.37 per cent of cost A_2 while cost of chemical fertilizers accounted for 3.59 per cent of it. It was found that cost A_1 of non-beneficiary farmers was higher when compared to that of non-beneficiaries. Cost of soil ameliorants, fuel charges, land revenue, depreciation and interest on working capital together constituted 9.82 per cent of cost A_1 and the remaining items were included under miscellaneous cost. It was observed that fuel charges for irrigation and cost of soil ameliorants was comparatively higher for non-beneficiaries when compared to that of beneficiaries. Land rent was slightly low when compared to that paid by beneficiary farmers and stood at Rs. 55,281 per hectare. Cost B_2 was found to be Rs. 3,87,529 per hectare and was slightly higher than that of beneficiary farmers.

From the analysis, it was found that the cost of cultivation of banana for beneficiary farmers was slightly lower than that of non-beneficiary farmers. Major shares of total operational expenses were contributed by cost of organic manure and cost of hired human labour for both beneficiaries and non-beneficiaries. It was observed that non-beneficiaries incurred higher costs for hiring human labour than beneficiary farmers. This may be due to the difference in labour use pattern. Since the use of motor pumps for irrigation was higher among non-beneficiaries, fuel charges were also higher for them and caused a marked difference between the costs of cultivation of both groups.

Similar results were obtained from the study conducted by Arun *et al. (*2012*)* on the impact of canal irrigation management in Tamilnadu. It was observed that canal irrigated participating farms incurred lesser cost of cultivation on crops in comparison to non-participating farms on account of higher costs of tube-well and other means of irrigation.

In another attempt by Rohit *et al.* (2015) to study the cost of irrigation water, it was found that the cost of cultivation of crops using groundwater irrigation were higher than that of canal irrigated crops.

Table 20. Cost of cultivation of banana for beneficiary and non-beneficiary farmers

Sl No.	Item	Cost incurred by beneficiaries(Rs/ha)	Cost incurred by non-beneficiaries (Rs/ha)
1	Hired human labour	73,357.96 (23.19)	89,026.59 (27.21)
2	Machine labour	12,170.00 (3.84)	16,837.50 (5.14)
3	Animal labour	0.00 (0.00)	0.00 (0.00)
4	Seeds	32,125 (10.15)	31,346.67 (9.58)
5	Chemical fertilizers	12,495.65 (3.95)	11,749.96 (3.59)
6	Organic manure	80,694.17 (25.51)	72,855.21 (22.27)
7	Plant protection chemicals	1,303.90 (0.41)	2,760.00 (0.84)
8	Soil ameliorants	6,934.37 (2.19)	9,383.33 (2.86)
9	Staking	16,660.00 (5.26)	11,052.42 (3.37)
10	Fuel charges	2,942.30 (0.93)	4,996.48 (1.52)
11	Land revenue	500.00 (0.15)	500.00 (0.15)
12	Depreciation	1,958.15 (0.61)	1,577.19 (0.48)
13	Interest on working capital	15,071.34 (4.76)	15,755.33 (4.81)
14	Miscellaneous	2,103.50 (0.66)	3,947.33 (1.20)
15	**Cost A_1**	**2,58,316.43 (81.00)**	**2,71,784.00 (83.09)**
16	Rental value of leased in land	57,916.67 (18.31)	55,280.88 (16.90)
17	**Cost A_2**	**3,16,233.07 (100)**	**3,27,064.88 (100)**
18	Interest on fixed capital	1,567.79	1,010.44
19	**Cost B_1**	**2,59,884.19**	**2,72,794.44**
20	Rental value of owned land	56,818.80	57,234.07
21	**Cost B_2**	**3,74,619.66**	**3,87,529.29**
22	Imputed value of family labour	53,788.04	62,574.00
23	**Cost C_1**	**3,13,672.23**	**3,35,368.40**
24	**Cost C_2**	**42,8,407.70**	**4,50,103.29**
25	**Cost C_3**	**4,71,248.47**	**4,95,113.61**

Note: Figures in parentheses indicate percentage to cost A_2

4.3.2 Returns from banana cultivation by beneficiary and non-beneficiary farmers

Net returns obtained by both beneficiary and non-beneficiary farmers at cost A_1, cost B_2 and cost C_3 from banana *(Nendran)* cultivation were worked out separately to evaluate their profits. It was found that the yield, gross returns and net returns were higher for beneficiaries as compared to that of non-beneficiaries as given in table 21. The yield showed a significant difference between both groups as shown by the t-test.

Table 21. Returns from banana cultivation of beneficiary and non-beneficiary farmers

Sl No.	Particular	Category	
		Beneficiaries	Non beneficiaries
1	Yield (kg/ha)*	23,537	21,780
2	Price (Rs/kg)	30.80	31.35
3	Gross returns (Rs/ha)	7,24,924	6,82,807
4	Net returns at cost A_1 (Rs/ha)	4,66,608	3,55,742
5	Net returns at cost A_2 (Rs/ha)	4,08,690	3,97,859
6	Net returns at cost B_2 (Rs/ha)	3,50,305	2,95,278
7	Net returns at cost C_3 (Rs/ha)	2,53,676	1,87,693

*****Significant at 5% level of significance

Average yield of banana obtained by beneficiary farmers was 23,537 kg per ha while it was 21780 kg per ha for non-beneficiary farmers. Net returns at cost A_1 for beneficiaries and non-beneficiaries was found to be Rs.4,66,608 per hectare and Rs. 3,55,742 per hectare respectively thus pointing out the fact that beneficiaries could translate their agronomic advantage of having more supply of irrigation water to economic advantage.

Chand and Kishore (2021) also obtained similar results in their study on the influence of source of irrigation on the technical efficiency of wheat growers in the canal command areas of Uttar Pradesh and Haryana. They found that in canal irrigated area attained higher yield than ground water irrigated areas. Figure 3 represents the comparison of yield and gross income from banana cultivation between beneficiary and non-beneficiaries in the command area.

4.3.3. Benefit-Cost ratio of banana cultivation

The returns generated by farmers per rupee invested in banana cultivation was worked out at cost A_1, cost B_2 and cost C_3 for beneficiary and non-beneficiary farmers as given in table 22. B-C ratio of beneficiary farmers at cost A_1, cost A_2, cost B_2 and cost C_3 was 2.80, 2.29, 1.93 and 1.53 respectively while it was 2.51, 2.08, 1.76 and 1.37 respectively in case of non-beneficiary farmers. It was found that the B-C ratio of beneficiary farmers was higher than that of non-beneficiary farmers, thus indicating the positive impact of irrigation in enhancing the returns of farmers in the command area.

Table 22. Benefit-Cost ratio of banana cultivation

Sl. No	Cost	B-C ratio	
		Beneficiaries	Non beneficiaries
1	Cost A_1	2.80	2.51
2	Cost A_2	2.29	2.08
3	Cost B_2	1.93	1.76
4	Cost C_3	1.53	1.37

4.3.4. Comparison of cost of cultivation of cowpea by beneficiary and non-beneficiary farmers

The average annual cost of cultivation per hectare of cowpea (*Vigna ungiculata)* for beneficiaries and non-beneficiaries were estimated and compared with each other. Table 23 depicts the detailed cost of cultivation of cowpea for both beneficiary and non-beneficiary farmers. The total cost of cultivation at cost C_3 worked out for beneficiary farmers was Rs. 3,24,770 per hectare while cost A_1 was estimated to be Rs. 1,29,771 per hectare. Cost A_2 constituted Rs. 1,87,688 per hectare, to which cost incurred for hired human labour had the highest contribution (31.93%) followed by rental value of leased-in land (30.85%) and the cost of organic manure (32.73%). Cost of machine labour, seeds, chemical fertilizers, plant protection chemicals, soil ameliorants, fuel charges, land revenue, depreciation and interest on working capital together constituted around 11.78

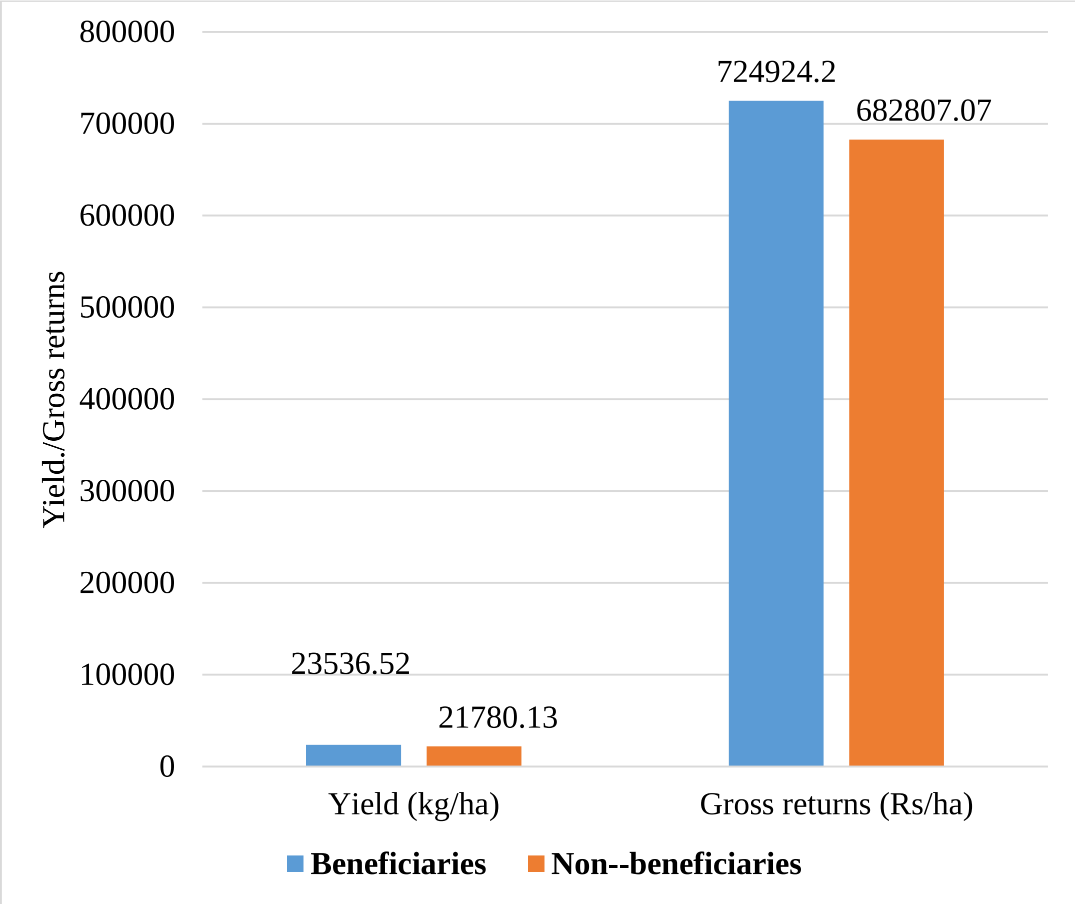

Figure 3. Comparison of yield and gross returns from banana cultivation by beneficiaries and non-beneficiaries

per cent of cost A_2 and the remaining items including panthal charges were included under miscellaneous costs. Cost B_2 was estimated to be Rs. 2,46,074 per hectare.

The total cost of cultivation at cost C_3 worked out for non-beneficiary farmers was Rs. 3,19,014 per hectare while cost A_1 was estimated to be Rs. 1,18,281 per hectare. Cost A_2 constituted Rs. 1,73,562 per hectare to which rental value of leased-in land had the highest contribution (31.85%) followed by cost incurred for hired human labour (31.07%) and the cost of organic manures (22.15%). Cost of machine labour, seeds, chemical fertilizers, plant protection chemicals, soil ameliorants, fuel charges, land revenue, depreciation and interest on working capital together constituted only 13.17 per cent of cost A_2 and the remaining items including panthal charges were included under miscellaneous costs. Cost B_2 was estimated to be Rs.1,73,562 per hectare.

It was found that costs of seeds, chemical fertilizers, plant protection chemicals, panthal and miscellaneous charges were lesser for non-beneficiary farmers when compared to that of beneficiaries. It was due to relatively lower seed rate in case of non-beneficiary farmers due to the shortage of assured water supply. It was also noted that the non-beneficiaries had to incur more fuel costs for pumping water as compared to that of beneficiaries.

From the analysis, it was found that the cost of cultivation of cowpea was slightly higher for beneficiary farmers when compared to that of non-beneficiary farmers. Cost of hired human labour, and organic manure had major shares in the operational expenses incurred by both beneficiaries and non-beneficiaries and were found to be relatively higher for beneficiaries. Costs of seeds, chemical fertilizers, *pandal* and plant protection chemicals were also higher for beneficiaries and these altogether caused the cost of cultivation of cowpea to be higher for them.

Table 23. Cost of cultivation of cowpea for beneficiary and non-beneficiary farmers

Sl No.	Item	Cost incurred by beneficiary farmers (Rs/ha)	Cost incurred by non-beneficiary farmers (Rs/ha)
1	Hired human labour	59,947.06 (31.93)	53,936.47 (31.07)
2	Machine labour	1,315.00 (0.70)	3,250.00 (1.87)
3	Animal labour	0.00 (0.00)	0.00 (0.00)
4	Seeds	2,346.25 (1.25)	2,246.04 (1.29)
5	Chemical fertilizers	1,729.19 (0.92)	1,632.45 (0.94)
6	Organic manures	42,479.17 (22.63)	38,460.13 (22.15)
7	Plant protection chemicals	2,296.19 (1.22)	1,480.35 (0.85)
8	Soil ameliorants	3,842.91 (2.04)	4,057.5 (2.33)
9	Fuel charges	713.46 (0.38)	1,300.11 (0.74)
10	Land revenue	500.00 (0.26)	500.00 (0.28)
11	Depreciation	1,985.15 (1.05)	1,577.19 (0.90)
12	Interest on working capital	7,443.08 (3.96)	6,777.51 (3.90)
13	Miscellaneous	3,238.58 (1.72)	3,063.19 (1.76)
14	**Cost A_1**	**12,9771.14 (69.00)**	**1,18,281.23 (68.14)**
15	Rental value of leased in land	57,916.67 (30.85)	55,280.88 (31.85)
16	**Cost A_2**	**1,87,687.80 (100)**	**1,73,562.11 (100)**
17	Interest on fixed capital	1,567.79	1,010.41
18	**Cost B_1**	**131338.79**	**1,19,291.64**
19	Rental value of owned land	56,818.80	5,7,234.07
20	**Cost B_2**	**24,6,074.26**	**2,31,806.59**
21	Imputed value of family labour	49,170.83	58,205.72
22	**Cost C_1**	**1,80,509.6**	**1,77,497.36**
23	**Cost C_2**	**2,95,245.1**	**2,90,012.31**
24	**Cost C_3**	**3,24,769.61**	**3,19,013.54**

Note: Figures in parentheses indicate percentage to cost A_2

4.3.5. Returns from cowpea cultivation by beneficiary and non-beneficiary farmers

Net returns obtained by the beneficiary and non-beneficiary farmers from cowpea production were worked out at cost A_1, cost B_2 and cost C_3 to evaluate their profits. It was found that despite of incurring a relatively higher cost of cultivation, the yield, gross returns and net returns were still higher for beneficiaries as compared to that of non-beneficiaries as given in Table 24.

Table 24. Returns from cow pea cultivation of beneficiary and non-beneficiary farmers

Sl No	Particular	Category	
		Beneficiaries	Non beneficiaries
1	Yield (kg/ha)	13,975	13,437
2	Price (Rs/kg)	33.67	32.36
3	Gross returns (Rs/ha)	4,70,538	4,34,828
4	Net returns at cost A_1 (Rs/ha)	3,40,767	3,16,547
5	Net returns at cost A_2 (Rs/ha)	2,82,850	2,61,265
6	Net returns at cost B_2 (Rs/ha)	2,24,464	2,03,021
7	Net returns at cost C_3(Rs/ha)	1,45,769	1,15,814

Average yield of cowpea obtained by beneficiary farmers was 13,975 kg per hectare while it was 13,437 kg per hectare for non-beneficiary farmers. Net returns at cost A_2 for beneficiaries and non-beneficiaries was found to be Rs. 2,82,850 per hectare and Rs. 2,61,265 per hectare respectively which again pointed out the economic advantage possessed by beneficiary farmers due to assured water supply.

Hussain and Hanjra (2003) also observed during their study on the impact of irrigation on poverty alleviation that better access to irrigation infrastructure enables farmers to improve crop productivity and earn higher economic returns.

Similar results were observed by Arun *et al*. (2012) in their study on canal irrigation in Tamilnadu. They found that the gross income and net income from crop production were impressively higher for farms which participate in canal irrigation when compared to those of non-participating farms.

Figure 4 represents the comparison of yield and gross income from cowpea cultivation between beneficiary and non-beneficiary farmers in the command area.

4.3.6. Benefit-Cost ratio of cowpea cultivation

The returns generated by farmers per rupee invested in cowpea cultivation were worked out for beneficiary and non-beneficiary farmers. It was found that the B-C ratio of beneficiary farmers were slightly higher as compared to that of non-beneficiary farmers as given in table 25. The B-C ratio at cost C_3 was 1.44 for beneficiaries while it was 1.36 for non-beneficiaries. It indicates that even though the cost of cultivation of cowpea was lesser for non-beneficiaries they could not fetch more returns than beneficiaries due to relatively lesser yield. It explains the advantage of canal irrigation enjoyed by beneficiary farmers. But it was clear that only a small difference existed between the B-C ratio of both groups. It pointed out the fact that even though adequate irrigation was available for the beneficiaries, it could not bring much difference in the level of returns between the two groups in NIP command area and there is a need to study the allocation of other inputs too.

Table 25. Benefit-Cost ratio of cow pea production

Sl. No	Cost	B-C ratio	
		Beneficiaries	Non beneficiaries
1	Cost A_1	3.62	3.67
2	Cost A_2	2.50	2.49
3	Cost B_2	1.91	1.87
4	Cost C_3	1.44	1.36

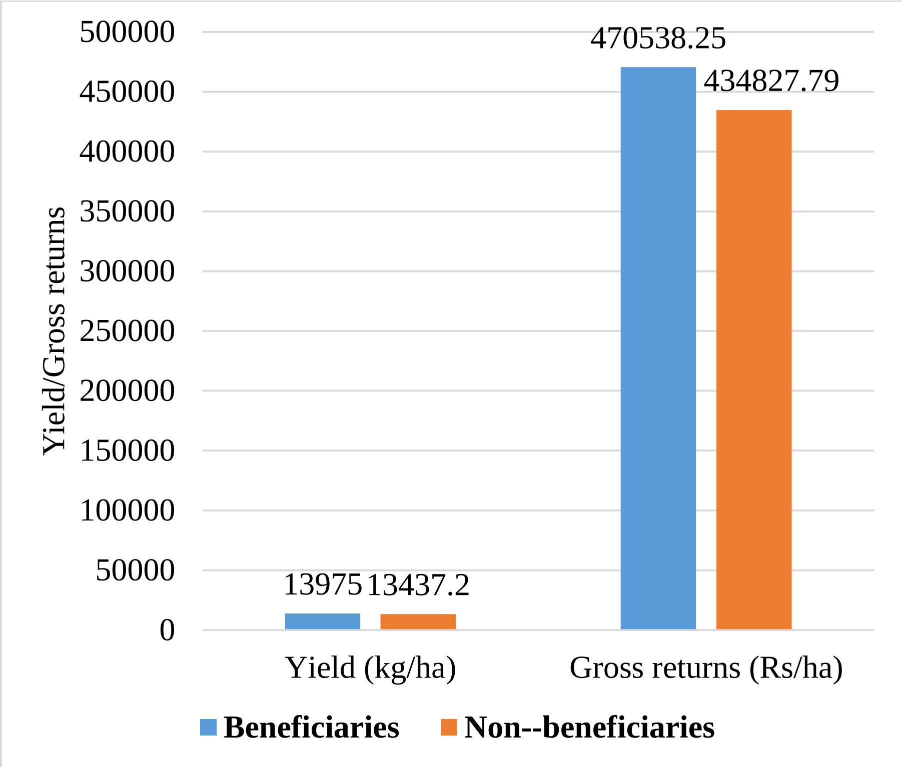

Figure 4. Comparison of yield and gross returns from cowpea cultivation by beneficiary and non-beneficiary farmers

4.4. RESOURCE USE EFFICIENCY

Understanding the efficiency with which farmers use their resources with the objective of attaining maximum yield would be helpful to evaluate the current performance of crop production and to improve the production. In the present study the resource use efficiency of banana and cowpea cultivation were examined by fitting Cobb-Douglas production function separately for both beneficiaries and non-beneficiaries. Physical quantities of the dependent and independent variables were used for regression analysis (ordinary least squares method) and the parameters corresponding to respective production functions for both crops were estimated and were used for generating conclusions. Multicollinearity between the independent variables was checked by estimating the Variance Inflation Factor (VIF).

4.4.1 Resource use efficiency in banana cultivation by beneficiary farmers

The resource use efficiency in banana cultivation by beneficiary farmers was estimated and the results are furnished in Table 26. Urea, Single Super Phosphate and Muriate of Potash were the popular fertlizers used by the beneficiary farmers and lime was used as soil ameliorant for controlling soil acidity in the fields. The R^2 value obtained from regression analysis was 0.89 indicating that 89 per cent variation in the yield of banana was explained by the inputs such as planting material, fertilizers, organic manure, soil ameliorants, human labour, machine labour, number of irrigations and number of sprayings of plant protection chemicals.

It was found that among the independent variables, quantity of planting material, fertilizers and number of irrigations were found to be significantly influencing the yield of banana at 1 per cent level of significance. One per cent increase in the quantity of above inputs were found to be enhancing the yield of banana by 0.82, 0.02 and 0.22 per cent respectively. Quantity of applied organic manure and human labour were found to be significantly influencing the yield of banana at 5 per cent level of significance. One per cent increase in the quantity of human labour and organic manure used were found to be enhancing the yield of banana by 0.21 and 0.16 per cent respectively. Quantity of soil ameliorants, machine labour and number of sprayings of plant protection chemicals were observed to be non-significant with positive co-efficients. *Σ bi* value stands for returns to scale and indicates the per cent change in output resulting from a simultaneous change in the quantity of all inputs. For beneficiary farmers, the value of *Σ bi* was found to be 3.69 in the cultivation of banana. It could be interpreted that a simultaneous increase in all the inputs by one per cent would increase the yield of banana by 3.63 per cent, thus having increasing returns to scale. The VIF values for independent variables were less than 10, indicating negligible multicollinearity between them.

Kumar *et al.* (2015) in their study on resource use efficiency and sucker propagated banana also found that regression coefficients for sucker, manure and fertilizers, and human labour were significant while regression co-efficient of plant protection chemicals was found to be statistically non-significant. The production function was showing increasing returns to scale

Choudhari *et al.* (2020) also observed in their study on resource use efficiency and constraints in Banana cultivation in Uttar Pradesh that among various independent variables affecting yield, seed was found significant statistically in the case of small and medium farmers. Manure and fertilizer left most effective response at one per cent level of probability in all categories of farms. Irrigation was also found significantly different from zero at 5 per cent probability level at marginal and small farms.

Table 26. Estimated production function of banana production by beneficiaries

Sl No.	Particulars	Coefficient	Standard Error	P value	VIF
1	Intercept	2.289	0.267	0.298	
2	Planting material (no. of suckers)	0.824***	0.085	0.005	3.24
3	Fertilizers (kg)	0.025***	0.016	0.001	1.78
4	Organic manure (kg)	0.216**	0.002	0.039	2.13
5	Soil ameliorants (kg)	0.019	0.031	0.534	2.81
6	Human labour (man days)	0.163**	0.080	0.048	1.36
7	Machine labour (hours)	0.002	0.024	0.823	1.45
8	No. of irrigations	0.225***	0.032	0.007	4.21
9	No. of Sprayings of plant protection chemicals	0.027	0.018	0.159	3.22
10	R^2	0.89			
11	Adjusted R^2	0.87			
12	Calculated F	2424.04			
13	Σ bi	3.693			
14	No. of observations	60			

*** Significant at 1 per cent level

** Significant at 5 per cent level

Estimable form of the production function obtained from the above analysis is given below:

$$Y= 2.289+ 0.824 \ln X_1+ 0.025 \ln X_2 +0.216 \ln X_3 + 0.019 \ln X_4 + 0.163 \ln X_5 + 0.002 \ln X_6 +0.225 \ln X_7 +0.027 \ln X_8 + \mu$$

Where,

Y= yield of banana

X_1= quantity of planting material

X_2= quantity of fertilizers

X_3= quantity of organic manure

X_4= quantity of soil ameliorants

X_5= human labour

X_6= machine labour

X_7= No. of irrigations and

X_8= No. of sprayings of plant protection chemicals

μ= Random error

4.4.2. Resource use efficiency in banana cultivation by non-beneficiary farmers

The resource use efficiency in banana cultivation by non-beneficiary farmers was estimated and the results are furnished in table 27. Among non-beneficiaries also Urea, Single Super Phosphate and Muriate of Potash were the popular fertilizers. Lime was used as soil ameliorant. The R^2 value obtained from regression analysis was 0.92 indicating that 92 per cent variation in the yield of banana was explained by the quantity of inputs such as planting material, fertilizers, organic manure, soil ameliorants, human labour, machine labour, number of irrigations and number of sprayings of plant protection chemicals.

It was found that among the independent variables, quantity of planting material, organic manure and human labour were found to be significantly influencing the yield of banana at 1 per cent level of significance. One per cent increase in the quantity of above inputs were found to be enhancing the yield of banana by 0.69,0.14 and 0.55 per cent respectively. The quantity of soil ameliorants had significant influence on the yield of banana at 5 per cent level of significance. One per cent increase in the quantity of soil ameliorants used were found to be enhancing the yield of banana by 0.01 per cent respectively. Quantity of machine labour, fertilizers, number of irrigations and number of sprayings were observed to be non-significant with positive co-efficients. For non-beneficiary farmers the value of $\Sigma\, bi$ was found to be 1.755 in the cultivation of banana, thus having increasing returns to scale. It can be inferred that a simultaneous increase in all the inputs by one per cent would increase the yield of banana by 1.75 per cent. The VIF values for independent variables were less than 10, indicating negligible multicollinearity between them.

Table 27. Estimated production function of banana production by non-beneficiary farmers

Sl No.	Particulars	Coefficient	Standard Error	P value	VIF
1	Intercept	0.971	0.327	0.004	
2	Planting material (no. of suckers)	0.698***	0.006	0.001	4.65
3	Fertilizers (kg)	0.032	0.038	0.284	2.14
4	Organic manure (kg)	0.142***	0.062	0.001	1.24
5	Soil ameliorants (kg)	0.010**	0.023	0.037	1.12
6	Human labour (man days)	0.551***	0.068	0.003	2.02
7	Machine labour (hours)	0.010	0.039	0.259	2.00
8	No. of irrigations	0.063	0.073	0.390	2.96
9	No. of Sprayings of plant protection chemicals	0.004	0.047	0.917	1.47
10	R^2	0.92			
11	Adjusted R^2	0.90			
12	Calculated F	678.36			
13	Σ bi	1.755			
14	No. of observations	60			

*** Significant at 1 per cent level

** Significant at 5 per cent level

Estimable form of the production function obtained from the above analysis is given below:

$Y = 0.971 + 0.698 \ln X_1 + 0.032 \ln X_2 + 0.142 \ln X_3 + 0.010 \ln X_4 + 0.551 \ln X_5 + 0.010 \ln X_6 + 0.063 \ln X_7 + 0.004 \ln X_8 + \mu$

Where, Y= yield of banana

X_1= quantity of planting material

X_2= quantity of fertilizers

X_3= quantity of organic manure

X_4= quantity of soil ameliorants

X_5= human labour

X_6= machine labour

X_7= No. of irrigations and

X_8= No. of sprayings of plant protection chemicals

μ= Random error

4.4.3. Resource use efficiency in cow pea cultivation by beneficiary farmers

The resource use efficiency in cow pea cultivation by beneficiary farmers was estimated and the results are furnished in table 28. Urea, Single Super Phosphate and Muriate of Potash were the popular fertlisers used by the beneficiary farmers for the cultivation of cowpea and lime was used as soil ameliorant. The R^2 value obtained from the regression analysis was 0.90 indicating that 90 per cent variation in the yield of cow pea was explained by the quantity of inputs such as planting material, fertilizers, organic manure, soil ameliorants, human labour, machine labour, number of irrigations and number of sprayings of plant protection chemicals.

It was found that among the independent variables, quantity of seed, human labour and number of irrigations were found to be significantly influencing the yield of banana at 1 per cent level of significance. One per cent increase in the quantity of above inputs were found to be enhancing the yield of banana by 0.38, 0.43 and 0.24 per cent respectively. Quantity of organic manure was found to be significantly influencing the yield of cow pea at 5 per cent level of significance. One per cent increase in the quantity of organic manure was found to be enhancing the yield of banana by 0.67 per cent. Quantity fertilizers, soil ameliorants, machine labour and number of sprayings of plant protection chemicals were observed to be non-significant with positive co-efficients. For beneficiary farmers the value of *Σ bi* was found to be 1.265 in the cultivation of cow pea. It could be interpreted that a simultaneous increase in all the inputs by one per cent would increase the yield of cow pea by 1.26 per cent, reflecting increasing returns to scale. The VIF values for independent variables were less than 10, indicating negligible multicollinearity between them.

Table 28. Estimated production function of cow pea cultivation by beneficiary farmers

Sl No.	Particulars	Coefficient	Standard Error	P value	VIF
1	Intercept	5.304	0.409	0.001	
2	Seed (kg)	0.387***	0.128	0.003	1.28
3	Fertilizers (kg)	0.181	0.121	0.142	1.82
4	Organic manure (kg)	0.670**	0.035	0.039	2.32
5	Soil ameliorants (kg)	0.002	0.006	0.656	1.44
6	Human labour (man days)	0.437***	0.060	0.002	1.51
7	Machine labour (hours)	0.063	0.023	0.099	1.26
8	No. of irrigations	0.248***	0.059	0.000	1.35
9	No. of Sprayings of plant protection chemicals	0.012	0.027	0.664	2.72
10	R^2	0.90			
11	Adjusted R^2	0.88			
12	Calculated F	590.43			
13	Σ bi	1.265			

14	No. of observations	60

*** Significant at 1 per cent level

** Significant at 5 per cent level

Estimable form of the production function obtained from the above analysis is given below:

$Y = 5.304 + 0.387 \ln X_1 + 0.181 \ln X_2 + 0.670 \ln X_3 + 0.002 \ln X_4 + 0.437 \ln X_5 + 0.063 \ln X_6 + 0.248 \ln X_7 + 0.012 \ln X_8 + \mu$

Where, Y= yield of cowpea

X_1= quantity of planting material

X_2= quantity of fertilizers

X_3= quantity of organic manure

X_4= quantity of soil ameliorants

X_5= human labour

X_6= machine labour

X_7= No. of irrigations

X_8= No. of sprayings of plant protection chemicals

μ= Random error

4.4.4. Resource use efficiency in cowpea cultivation by non-beneficiary farmers

The resource use efficiency in cowpea cultivation by non-beneficiary farmers was estimated and the results are furnished in table 29. The R^2 value obtained from regression analysis was 0.92 indicating that 92 per cent variation in the yield of cowpea was explained by the quantity of inputs such as planting material, fertilizers, organic manure, soil ameliorants, human labour, machine labour, number of irrigations and number of sprayings of plant protection chemicals.

It was found that among the independent variables, quantity of seed, organic manure and human labour were found to be significantly influencing the yield of cow pea at 1 per cent level of significance. One per cent increase in the quantity of above inputs were found to be enhancing the yield of banana by 0.21, 0.23 and 0.73 per cent respectively. Quantity of machine labour used was found to be significantly influencing the yield of cow pea at 5 per cent level of significance. One per cent increase in the quantity of machine labour was found to be enhancing the yield of cow pea by 0.25 per cent. Quantity fertilizers, soil ameliorants, number of irrigations and number of sprayings of plant protection chemicals were observed to be non-significant with positive co-efficients. For non-beneficiary farmers the value of $\Sigma\ bi$ was found to be 1.714 which could be interpreted that a simultaneous increase in all the inputs by one per cent would increase the yield of cow pea by 1.71 per cent, reflecting increasing returns to scale. The VIF values for independent variables were less than 10, indicating negligible multicollinearity between them.

From the study it was found that beneficiary farmers could reap higher yields and returns than non-beneficiaries and irrigation has positively influenced the yields of both banana and cowpea. But in case of non-beneficiary farmers irrigation was found to be non-significant.

This implied that access to irrigation infrastructure and implementation of better water management practices brought higher returns in the command area.

Table 29. Estimated production function of cow pea cultivation by non-beneficiary farmers

Sl No.	Particulars	Coefficients	Standard Error	P value	VIF
1	Intercept	4.820	0.743	0.414	
2	Seed (kg)	0.214***	0.285	0.001	3.21
3	Fertilizers (kg)	0.313	0.291	0.274	1.34
4	Organic manure (kg)	0.229***	0.051	0.004	2.54
5	Soil ameliorants (kg)	0.009	0.010	0.385	1.21
6	Human labour (man days)	0.733***	0.108	0.001	1.34
7	Machine labour (hours)	0.247**	0.103	0.021	4.01
8	No. of irrigations	0.039	0.072	0.583	1.08

9	No. of Sprayings of plant protection chemicals	0.065	0.053	0.225	2.10
10	R^2	0.92			
11	Adjusted R^2	0.90			
12	Calculated F	231.79			
13	Σ bi	1.714			
14	No. of observations	60			

*** Significant at 1 per cent level

** Significant at 5 per cent level

Estimable form of the production function obtained from the above analysis is given below:

$Y= 4.820 + 0.214 \ln X_1+ 0.313 \ln X_2 + 0.229 \ln X_3 + 0.009 \ln X_4 + 0.733 \ln X_5 + 0.247 \ln X_6 + 0.039 \ln X_7 + 0.065 \ln X_8 + \mu$

Where, Y= yield of cowpea

X_1= quantity of planting material

X_2= quantity of fertilizers

X_3= quantity of organic manure

X_4= quantity of soil ameliorants

X_5= human labour

X_6= machine labour

X_7= No. of irrigations

X_8= No. of sprayings of plant protection chemicals

μ= Random error

4.4.5. Marginal productivity analysis

Allocative efficiency in crop production explains the ability of farmers to allocate resources efficiently, by producing maximum output at minimum cost. Increasing allocative efficiency requires an understanding of the specific resources of inefficiency in a farm enterprise (Okello *et al.,* 2019). It can be examined by calculating the ratio (K) of Marginal Value Product (MVP) and Marginal Factor Cost (MFC) of each inputs. Resources having k value of more than one could be identified as under-utilized while those having k value of less than one could be identified as over-utilized. For optimally utilized resources the ratio will be one. In the present study marginal productivity analysis of banana and cow pea was done for both beneficiaries and non-beneficiaries.

4.4.6. Marginal productivity analysis of banana cultivation

The results of marginal productivity analysis of banana production by beneficiary and non-beneficiary farmers are given in table 30 and 31 respectively. It was found that the geometric mean values of planting material and organic manure which were the major inputs for banana production were relatively higher in case of beneficiary farmers. This is in agreement with the results obtained by Reddy (2005) in his study on the impact of water management on production of rice in Balipatna command area of Orissa.

The K value obtained for each independent variable in the analysis showed that all the significant inputs for banana production were under-utilized by both beneficiaries and non-beneficiaries. It indicates that there is scope of enhancing production through more allocation of resources.

Table 30. Marginal productivity analysis of banana cultivation by beneficiary farmers

Sl No.	Particulars	Geometric mean	Regression coefficient	MVP	MFC	K	Decision rule
1	Planting material	948.35	0.824	184	10	18.4	Underutilized
2	Fertilizers	119.57	0.025	6.87	5.25	1.31	Underutilized
3	Organic manure	7784.42	0.216	5.89	2.87	2.05	Underutilized
4	Human labour	24.44	0.163	1425	850	1.67	Underutilized

Table 31. Marginal productivity analysis of banana cultivation by non-beneficiary farmers

Sl No.	Particulars	Geometric mean	Regression coefficient	MVP	MFC	K	Decision rule
1	Planting material	513.61	0.698	204.8	10	20.4	Underutilized
2	Organic manure	5456.19	0.142	9.46	2.87	3.29	Underutilized
3	Human labour	29.47	0.551	3700	850	4.53	Underutilized
4	Soil ameliorant	4.656	0.010	377.7	25.35	14.8	Underutilized

4.4.7. Marginal productivity analysis of cowpea cultivation

The results of marginal productivity analysis of cow pea production by beneficiary and non-beneficiary farmers are given in table 32 and 33 respectively. The K value obtained for each independent variable in the analysis showed that all of the significant inputs for cow pea production except organic manure were under-utilized by beneficiaries thus indicating that there is scope of enhancing production through more allocation of those resources. It was also found that all of the significant inputs were under-utilized by non-beneficiaries. Organic manure was over-utilized by beneficiary farmers and its use could be reduced to improve the allocative efficiency. Reducing the application of organic manures by beneficiary farmers may also bring down their cost of cultivation of cowpea which was found to be higher when compared to non-beneficiary farmers.

The results of efficiency analysis of this study implied that even though both beneficiaries and non-beneficiaries underutilized most of the inputs of crop production, beneficiary group of farmers were better allocators which is evident from their higher yields and income levels. It was also clear that beneficiary farmers were not fully realizing the advantage of having adequate water supply and there existed a huge scope for them to make their farming more profitable by improving their efficiency of input allocation coupled with irrigation management.

Table 32. Marginal productivity analysis of cowpea cultivation by beneficiary farmers

Sl No.	Particulars	Geometric mean	Regression coefficient	MVP	MFC	K	Decision rule
1	Seed	0.601	0.387	30662.05	518.33	59.15	Under Utilized
2	Organic manure	1913.54	.067	1.68	2.875	0.58	Over Utilized
3	Human labour	5.196	0.437	4010.95	850	4.71	Under Utilized

Table 33. Marginal productivity analysis of cowpea cultivation by non-beneficiary farmers

Particulars	Geometric mean	Regression coefficient	MVP	MFC	K	Decision rule
Seed	0.452	0.214	30662.05	518.33	59.15	Under Utilized
Organic manure	1487.2	0.229	5.339	2.87	1.86	Under Utilized
Human labour	4.844	0.733	5305.3	875	6.24	Under Utilized
Machine labour	0.304	2.43	3835.96	500	7.67	Under Utilized

4.5. OPERATIONAL PROBLEMS IN IRRIGATION MANAGEMENT

The operational problems faced by farmers in on farm irrigation, identified during the study are presented in table 34.

Table 34. Garrett's score and rank for operational problems in the command area

Strata	Inadequate amount of water supply	Lack of timely release	Siltation due to Improper canal maintenance	Water scarcity during dry months	Lack of proximity Between canal and field
Head	35.75 (5)	68.25 (1)	44.75 (4)	48.5 (3)	52.75 (2)
Middle	49 (4)	62.5 (2)	65.25 (1)	44 (5)	51.5 (3)
Tail	55.75 (2)	54.75 (3)	54.5 (4)	61 (1)	33.25 (5)
Beneficiaries	140.5 (4)	185.5 (1)	171.5 (2)	159.5 (3)	137.5 (5)

Note: Figures in parentheses indicate the rank of constraints

Lack of timely release of water was the major problem faced by farmers in the command area, irrespective of their strata. Sometimes the canals were closed even in the dry months on account of maintenance and farmers had to depend solely on rainfall and supplementary sources, if available. Farmers opined that there is a need for proper and systematic communication between dam officials and beneficiaries so that they could get accurate prior information regarding release of water. It will also enable them to demand release of water during contingencies such as unforeseen drought and crop loss.

Wali *et al*. (2020) also reported that untimely release of water from the canal was perceived as one of the most serious constraints faced by the farmers in the Krishna project command area in Karnataka. Some farmers suggested that framing of proper schedule of water release and proper dissemination of it among entire beneficiaries would be helpful for them in planning various farm operations accordingly. The schedule should be flexible too in order to cope up with environmental conditions such as unexpected heavy rainfall and accidental drought.

Siltation in the canals due to lack of proper and timely maintenance was identified as the second major problem. It caused accumulation of mud in the canals and destruction of canal ayacuts during rainy months. Encroachment of canals, waste water diversion and sluice damage worsened the issue (plate 4 and 5). Farmers in the middle and tail reaches were most affected by this. Most of the farmers in the head reach were always getting enough water due to sluice leakages and improper shutter construction. Even though initiatives were taken recently for the cleaning and maintenance of canals in coordination with MNREGA and Kudumbashree, they were not successful due to lack of proper participation from panchayats and supervision. Unscientific maintenance of slope of main canals and sub canals due to the lack of skilled labourers was identified as another reason behind siltation, which in turn disrupts the smooth flow of canal water up to the tail reach, thus leading to water scarcity.

Unavailability of adequate amount of water was another identified problem which was mostly faced by farmers in the tail reach. They complained that farmers from head reach sometimes damage sluices and illegally tap water which result in shortage of water in the tail reach even during the times when the canal is open. Several studies conducted in different regions of India also highlighted similar operational problems in the canal irrigation system, including lack of water and maintenance throughout the year and illegal water outlets (Wade, 1980; Lele and Patil, 2006; Talati and Pandya, 2007).

Lack of proximity between canal and farmland was another problem faced mainly by head and middle reach farmers. They complained that fields nearer to the canal receive more water than those located away. Durga *et al*. (2018) also reported that in the canal command areas, farms located far away from the canal are least benefitted from water distribution. Same issue was raised by farmers whose fields were located above the main canal and sub canals. They had to bear additional fuel expenses for lifting water from channels and boothies into fields using motor pumps. Even though subsidised loans are provided to farmers for purchasing pump sets, lack of timely issue of funds remains as a major disruption. Some farmers complained that the chances of loan availability are very less for farmers aged sixty five years and above.

Most of the farmers from the head reach cited lack of timely release of water as the major problem in on-farm irrigation while siltation in the canals and water scarcity during dry months were cited as major problems by middle reach and tail reach farmers, respectively. It could be clearly seen that effective supervision and coordination in facilitating smooth supply of irrigation water were lacking from the Department of Irrigation. Lack of farmers' participation in irrigation management worsened the issues. Earlier, farmers enjoyed more benefits of effective water distribution through the Beneficiary Farmers' Associations (BFAs) which existed as the major component of CADA which was implemented in 1980s. They played leading roles in repairing and maintenance of canals and distribution of water in their concerned ayacuts (Joseph, 2001). Later BFAs disintegrated as majority of them did not function as expected, thus leading to less participation of beneficiary farmers in management of water distribution.

SUGGESTIONS TO IMPROVE THE IRRIGATION MANAGEMENT

- Since the economic value of irrigation water was found to be covering only 47 per cent of annual operation and maintenance cost of dam and the canals, action plan for irrigation management in the command area with the contribution from the beneficiaries alone would not be beneficial. Public expenditure made on major irrigation projects can be justified only if its benefits reach the farmers. Reorganisation and revitalisation of WUAs and ensuring farmers' participation may improve the present situation.
- Effective supervision and coordination in facilitating smooth supply of water may be enhanced from the institutional side.
- Proper as well as flexible schedule of water release may be maintained by dam authorities and it should be disseminated among the beneficiary farmers.
- Efficient and systematic communication system between dam officials and farmers may be ensured.
- Proper identification of beneficiaries has to be done.
- Desilting and cleaning of canals may be carried out periodically.
- Scheduling and release of water may be done as per the requirements of the beneficiary farmers.
- Timely subsidies for purchasing motor pumps may be a help to those farmers who has to bear additional fuel expenses for lifting water from the canal, in order to boost their potential.

Plate 4. Siltation in Neyyar Irrigation Project canal

Plate 5. Poorly maintained canal of Neyyar Irrigation Project

CHAPTER V

SUMMARY

The present study entitled “Economic value of irrigation water: A case study of Neyyar Irrigation Project, Thiruvananthapuram was conducted during 2020-21 in Thiruvananthapuram district. The specific objectives of the study were to estimate the economic value of irrigation water, assess the impact of irrigation on crop yield of selected crops under the ayacut area of Neyyar Irrigation Project and to identify the operational problems in irrigation management.

The study was based on both primary and secondary data. Neyyar Irrigation Project was (NIP) selected for the study as it is the only completed major irrigation project in Thiruvananthapuram district. Right Bank Canal (RBC) of the project was selected because its entire command area lies within Kerala, while Left Bank Canal (LBC) has its command area lying in the Kanyakumari district of Tamilnadu state also. Primary data was collected through pre-tested, well-structured interview schedule. Respondent farmers were selected using stratified random sampling and the stratification was done based on the length of the canal i.e. head reach, middle reach and tail reach. One panchayat was selected randomly from each reach and list of beneficiary farmers from panchayat were collected from corresponding Krishibhavans. Twenty beneficiary farmers were selected from each strata thus making sixty beneficiary farmers in the sample. Sixty non-beneficiary farmers were also chosen at random from the surrounding area from the same panchayats. Thus the total sample size of the study was one hundred twenty. Secondary data related to the study were collected from various Krishibhavans, Gramapanchayat offices and Irrigation Design and Research Board (IDRB) Thiruvananthapuram. Data regarding climatic and physiographic factors were collected from the official website of the Department of Groundwater and annual reports of Government of Kerala.

The socio-economic characteristics of the sample farmers were analysed and it was found that majority of them (62%) were aged between 45 and 60 years, indicating the lack of participation of younger generations in farming activities. The average age of beneficiary farmers was found to be 56.23 years while that of non-beneficiary farmers was found to be 56 years. It was observed that more than 80 per cent of sample respondents were males in both groups and all the respondents were literate with 72 per cent of them having primary education. Only 5.8 per cent of total respondents were having pre-degree or higher secondary level of education. Majority of the sample farmers (65.83%) belonged to medium sized families having average family size of 5.12. The average family size of beneficiary farmers was found to be 5.20 while that of non-beneficiary farmers was found to be 5.05. More than 85 per cent of respondents had an experience of more than twenty years in farming in both groups. The proportion of sample farmers who chose agriculture as their main occupation was found to be higher among beneficiaries (81.66 %) when compared to that of non-beneficiaries (70 %). It was found that the average annual income of beneficiary farmers (Rs.2,40,053 per hectare) was higher than that of non-beneficiary farmers (Rs. 2,13,983 per hectare).

The average size of land holdings was also found to be higher for beneficiary farmers (0.728 ha) than that of non-beneficiary farmers (0.544 ha) and only 18.33 per cent of beneficiaries cultivated in owned land while it was 36.67 per cent in case of non-beneficiaries. It was observed during the study that the beneficiary farmers were more into leasing in as compared to non-beneficiary farmers and among beneficiaries the percentage of farmers who cultivated in leased land was higher in head reach as compared to that in middle and tail reaches. It can be seen that banana crop occupied the maximum area (35.37) per cent, followed by vegetables (23.58 per cent) and coconut (22.01) per cent. Area occupied by banana and vegetables was higher for beneficiary farmers as compared to non-beneficiary farmers.

Contingent Valuation Method (CVM) was employed to elicit the Willingness to Pay (WTP) of beneficiary farmers for the assured and timely supply of irrigation water and the stated mean WTP per year for beneficiaries who were willing to pay was found to be Rs 721.80 per year per farmer which was only 0.3 per cent of their average annual income. The WTP of the farmers ranged between Rs 600 and 1,200 per year. Among the beneficiaries the WTP of tail reach farmers (Rs 800) was found to be the higher than that of middle (Rs 651.41) and head reach (Rs 714) farmers due to the fact that tail reach farmers, often had to face water scarcity and assumed more value for water. Hence they were willing to pay more than that by head and middle reach farmers. The economic value of irrigation water was calculated by multiplying the total number of beneficiary households and their estimated WTP (Rs 395 per household year) and it was found to be Rs 1.5 crore per year which covered about 47 per cent of annual operation and maintenance cost of the dam in the year 2020-21.

The average annual cost of cultivation per hectare of banana incurred by beneficiary farmers (Rs.4,71,248.47 per hectare) was found to be less than that of non-beneficiary farmers (Rs 4,95,113.619 per hectare) while the average annual cost of cultivation per hectare of cowpea was found to be slightly less for non-beneficiaries (Rs. 3,24,769.61 per hectare) than that of beneficiaries (Rs. 3,19,013.54 per hectare). For both groups, cost of hired human labour, rental value of leased in land and cost of organic manure were found to be having major shares in cost A_2. It was observed for banana cultivation that non-beneficiaries incurred higher cost for hired human labour than beneficiary farmers while it was lower in case of cowpea. Fuel charges and cost of soil ameliorants were also found to be relatively higher for non-beneficiaries which in turn caused marked difference between their costs of cultivation in both crops. Yield and net returns obtained from banana and cowpea cultivation were also higher for beneficiary farmers as compared to that of non-beneficiaries. Benefit-cost ratios of beneficiaries and non-beneficiaries for banana cultivation at cost C_3 were found to be 1.53 and 1.37 respectively while they were 1.44 and 1.36 for cowpea cultivation.

Resource use efficiency of banana and cowpea cultivation were examined through fitting Cobb-Douglas function separately for both beneficiaries and non-beneficiaries. Physical quantities of the dependent and independent variables were used for regression analysis. It was found that quantity of planting material, fertilizers, organic manure, human labour and number of irrigations were found to be significantly and positively influencing the yield of banana for beneficiary farmers while quantity of planting material, organic manure, quantity of soil ameliorants and human labour were found to be significantly and positively influencing the yield of banana for non-beneficiary farmers. For cowpea production by beneficiaries, quantity of seeds, organic manure, human labour and number of irrigations were found to be significantly and positively influencing the yield while the significant and positive variables were quantity of seed, organic manure, human labour and machine labour in case of non-beneficiary farmers.

Marginal productivity analysis for examining the allocative efficiency showed that, all the resources in production of banana were found to be underutilized for both beneficiaries and non-beneficiaries indicating that there is scope for improving the production potential by increasing the use of inputs. For cow pea, organic manure was over-utilized by beneficiary farmers while all other resources were underutilized by both beneficiaries and non-beneficiaries.

Lack of timely release of water was identified as the major problem faced by farmers in the command area irrespective of strata. Siltation in the canals and water scarcity during dry months were cited as other major constraints especially by middle and tail reach farmers. In order to tackle these issues and have a better and equitable distribution of irrigation water, effective supervision and coordination in facilitating smooth supply of water should be enhanced from the Department of Irrigation. Proper as well as flexible schedule of water release should be maintained by dam authorities and the information should be disseminated among the beneficiary farmers by forming their whatsapp groups. Proper identification of beneficiaries may also be done. Conducting frequent on-farm training and providing of timely subsidies for purchasing pump sets for farmers could be helpful in boosting the production potential in command area. Since the economic value of irrigation water was found to be covering only 47 per cent of annual operation and maintenance cost of dam and the canals, action plan for irrigation management in the command area with the contribution from the beneficiaries alone would not be beneficial.

CHAPTER VI

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APPENDIX-1

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF AGRICULTURE

DEPARTMENT OF AGRICULTURAL ECONOMICS

Vellayani, Thiruvananthapuram- 695522

SURVEY SCHEDULE FOR PRIMARY DATA

ECONOMIC VALUE OF IRRIGATION WATER: A CASE STUDY OF NEYYAR IRRIGATION PROJECT, THIRUVANANTHAPURAM

Block: Panchayat:

Stratum : Upper reach/Middle reach/Tail reach

Type of farmer : Beneficiary/ Non beneficiary

Date of interview :

I.Socio economic profile of farmers:

1. Name of the farmer:

2. Age:

3. Gender:

4. Marital status:

5. Address:

6. Phone no:

7. Experience in farming:

8. (a) Do you have assured supply of irrigation water? Yes/No
 If yes, give the source:

 (b) Do you have motor pump for irrigation? Yes/No

(c) Whether electrical supply is subsidised or not?

(d) Purpose for which it is used

II. Family Details

Name	Gender (M/F)	Age	*Education	**Occupation		Annual Income	
				Primary	Secondary	Primary	Secondary

*01- Primay, 02-Secondary, 03- Pree-degree&HSC, 04- Diploma, 05-Graduate, 06-Post Graduate
**01-Agriculture&allied activities, 2- Public sector, 3- Private sector, 4- Self employed

III.A. Details of land holdings

Particulars	Owned (ha)	Leased in (ha)	Leased out (ha)	Total (ha)
Wet land				
Garden land				
Permanent fallow				
Total (ha)				

Rental value of leased in land (Rs./ ha for 1 year):

Land revenue of leased out land (Rs. / ha for 1 year):

Value of land (Rs./ha):

III. B Details of fixed assets (except land)

Sl. No	Particulars	Nos.	Year of construction	Present value (Rs)	Remarks
1	Farm house				
2	Store house				
3	Cattle shed				
4	Pump shed				
5	Others (specify)				

III.C Machineries/Implements

Sl No.	Particulars	Number	Year of purchase	Purchase price(Rs)	Expected life (Years)
1	Spades				
2	Sprayers				
3	Vaakathi/Knife				
4	Others 1. 2. 3. 4.				

IV. Crop particulars and cropping pattern:

Cropping pattern: Sole cropping
Mixed cropping
Relay cropping
Crop rotation

Season	Crop	Variety	Area (ha)	Main product		By-product		Income
				Qty (Kg)	Value (Rs)	Qty (Kg)	Value (Rs)	

V. Details of allied activities:

Sl No	Activities	Area/No.	Annual maintenance expenses	Gross returns
1	Livestock activities			
2	Poultry			
3	Self-employment			
4	Others			

VI. Source of seeds:

Sl No	Source	Variety	Quantity	Price (Rs/Kg)

VIII. Cost of cultivation:

Crop I-Banana

Crop: Bullock power cost (Rs/pair/day) Yield:

Season Machine power cost (Rs/hr/ha):

Variety: Wage rate (Rs/day): Main product (Kg):

Area: (1) Male (2) Female By product (Kg):

Input and Operation-wise expenses

Variable inputs	Quantity	Rate/unit	Total cost
Seed(Kg/ha)			
FYM (Kg/ha)			
Urea (Kg/ha)			
SSP (Kg/ha)			
MOP (Kg/ha)			
Other fertilizers (Kg/ha)			
1.			
2.			
3.			
Plant protection chemicals (unit)			
1.			
2.			
Soil ameliorant (unit)			
1.			
2.			
Fuel cost (Rs)			
Total input cost			

Input and operation-wise expenses

Operations	Machine labour		Human labour (Days)		Total labour cost	Total cost (Machine+Human)
	Hours	Cost	M	F		
Land preparation						
Sowing						
Fertilizer application						
Sowing						
Organic manure application						
Weeding&Gap filling						
Plant protection operation						
Staking						
Intercultural operation						
Harvesting						
Loading						

Are you practicing mechanization in the fields?

If Yes, for which all operations:

Sl No	Operation	Cost involved (Rs)
1	Land preparation	
2	Harvesting	

Crop II-Cow-pea

Crop: Bullock power cost (Rs/pair/day) Yield:

Season Machine power cost (Rs/hr/ha):

Variety: Wage rate (Rs/day): Main product (Kg):

Area: (1) Male (2) Female By product (Kg):

Input and Operation-wise expenses

Variable inputs	Quantity	Rate/unit	Total cost
Seed(Kg/ha)			
FYM (Kg/ha)			
Urea (Kg/ha)			
SSP (Kg/ha)			
MOP (Kg/ha)			
Other fertilizers (Kg/ha)			
1.			
2.			
3.			
Plant protection chemicals (unit)			
1.			
2.			
Soil ameliorant (unit)			
1.			
2.			
Fuel cost (Rs)			
Total input cost			

Input and operation-wise expenses

Operations	Machine labour		Human labour (No's)		Total labour cost	Total cost (Machine+Human)
	Hours	Cost	M	F		
Land preparation						
Sowing						
Fertilizer application						
Sowing						
Organic manure application						
Panthal charges						
Weeding&Gap filling						
Plant protection operation						
Intercultural operation						
Harvesting						
Loading						

Are you practicing mechanization in the fields?

If Yes, for which all operations:

Sl No	Operation	Cost involved (Rs)
1	Land preparation	
2	Harvesting	

IX A. Harvesting

Crop I- Banana

Operations	Human labour days					Machinery		Material costs		
	Permanent		Casual		Wage rate	Hrs	Operating charges	Item	Qty	Price/unit

Crop II- Cow-pea

Operations	Human labour days					Machinery		Material costs		
	Permanent		Casual		Wage rate	Hrs	Operating charges	Item	Qty	Price/unit

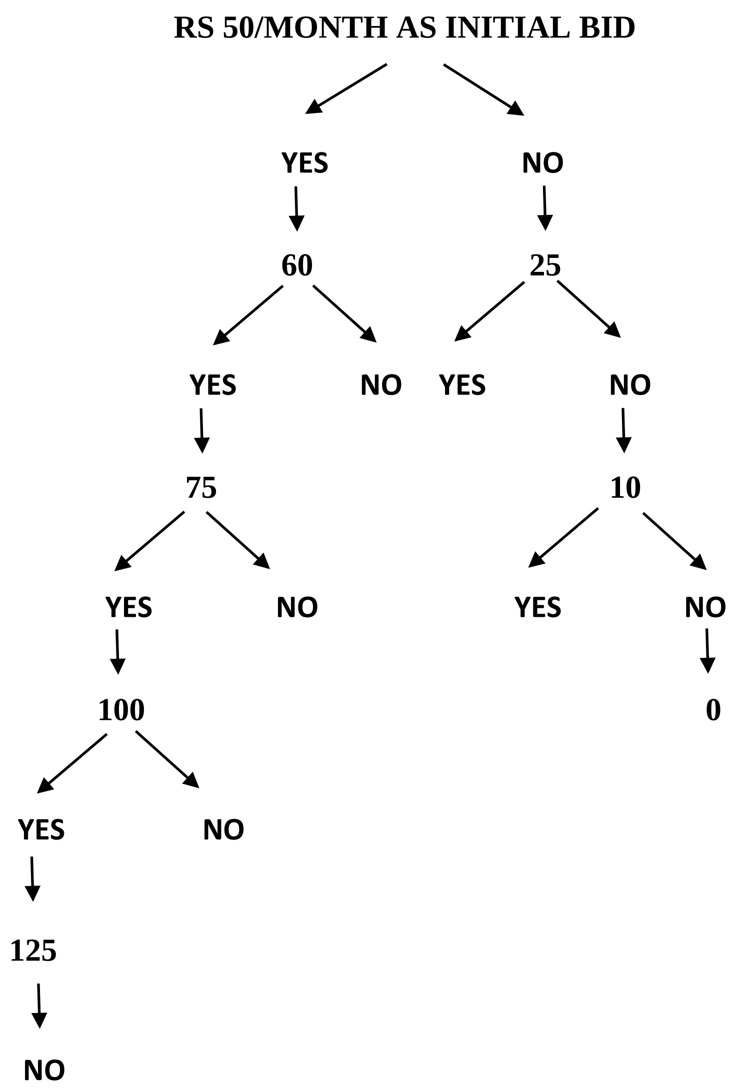
IX B. Yield details

Crop	Yield	Price prevailed/prevailing

X. Willingness to pay

1) Neyyar Irrigation Project is an integral part of the lives of the people of Neyyattinkara Taluk and its surroundings, since it is the main source of water for agricultural and drinking purpose. But nowadays the dam and its canals are not properly maintained and it causes problems in the assured supply of water to the people who mostly depend on the dam water especially for irrigational purpose. Suppose the government makes a request for a voluntary contribution from people for the assured water supply, better management and conservation of the dam and canals with the assurance that the fund will be properly utilized for the same, are you willing to contribute for the same to get the services uninterrupted? **Yes/ No**

<u>**Format for WTP elicitation**</u>



2)What is the highest WTP per year your household would pay for the irrigation water?

3) If you are willing to pay, would you like to effect payment

a. one time

b. Instalments, specify

4) Give the reasons for not Willing to pay

5) Did you receive adequate rainfall during the crop season? **Yes/ No**

6) Whether WTP is affected by the amount of rainfall received? **Yes/ No**

XI. Irrigation water pricing

1) Are you aware of irrigation water pricing? **Yes/ No**

2) Are you paying for irrigation water? **Yes/ No**

If yes, Where do you pay?

Rate of payment :

XII. Constraints in on-farm irrigation.

Ranking of constraints

Sl No	Problem	Occurrence of problem (Yes/No)	Rank
1	Inadequate amount of water supply		
2	Lack of timely release		
3	Siltation due to improper maintenance		
4	Water scarcity during dry months		
5	Lack of proximity between canal and field		

APPENDIX-II

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		

APPENDIX-III

Average monthly rainfall data of NIP command area from the period of 01-07- 2020 to 31-08-2021

Sl No.	Month	Rainfall (mm)
1	July 2020	7.62
2	August 2020	9.27
3	September2020	5.50
4	October 2020	8.27
5	November 2020	6.63
6	December 2020	3.80
7	January 2021	4.99
8	February 2021	0.15
9	March 2021	1.86
10	April 2021	8.85
11	May 2021	30.79
12	June 2021	8.76
13	July 2021	7.97
14	August 2021	7.09

ECONOMIC VALUE OF IRRIGATION WATER: A CASE STUDY OF NEYYAR IRRIGATION PROJECT, THIRUVANANTHAPURAM

by

Harsha. M.B.
(Admn No. 2019-11-024)

Abstract of the thesis
Submitted in partial fulfilment of
the requirements for the degree of

MASTER OF SCIENCE IN AGRICULTURE
Faculty of Agriculture
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DEPARTMENT OF AGRICULTURAL ECONOMICS
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KERALA, INDIA

2022

ABSTRACT

The present study entitled “Economic value of irrigation water: A case study of Neyyar Irrigation Project, Thiruvananthapuram was conducted during 2020-21, with specific objectives of estimating the economic value of irrigation water, assessing the impact of irrigation on crop yield of selected crops under the ayacut area of Neyyar Irrigation Project and identifying the operational problems in irrigation management.

The study was conducted in the command area of Right Bank Canal (RBC) Neyyar Irrigation Project (NIP) in Thiruvananthapuram district with the help of both primary and secondary data. Primary data was collected from farmers using a pre-tested interview schedule. Secondary data related to the study was collected from Krishibhavan, Gramapanchayat and other governmental and non-governmental agencies. Respondent farmers were selected using stratified random sampling and stratification was done based on the length of canal (Head reach, middle reach and tail reach). Total sample size was one hundred twenty, consisting of sixty beneficiary respondent farmers and sixty non beneficiary respondent farmers.

Contingent Valuation Method (CVM) was employed to elicit the Willingness to Pay (WTP) of beneficiary farmers for the assured and timely supply of irrigation water and the mean WTP per year was found to be Rs 721.80 per year which was only 0.3 per cent of their average annual farm income. The WTP of the farmers was found to be ranged between Rs 600 to 1200 per year. Among the beneficiaries the WTP of tail reach farmers was found to be the higher than that of middle and head reach farmers due to the fact that tail reach farmers, often had to face water scarcity and were willing to pay more than head and middle reach farmers if adequate supply of water is ensured. The economic value of irrigation water was calculated by multiplying the total number of beneficiary households and their estimated WTP and was found to be Rs 1.5 crore per year which covered only 47 per cent of annual operation and maintenance cost of the dam in the year 2020-21. The low economic value realised was due to the poor WTP of farmers.

The costs of cultivation of banana and cowpea which were the major crops in the study area were calculated for both beneficiary and non-beneficiary farmers. The

cost of cultivation of banana was found to be slightly higher for non- beneficiaries than beneficiaries while cost of cultivation of cowpea was higher for beneficiary farmers when compared to non-beneficiary farmers. For both crops, per cent share of hired labour and organic manure had highest contribution in total cost A_1.

Cobb-Douglas production function was fitted for banana and cow pea production among beneficiaries and non-beneficiaries to examine the resource use efficiency. Yield of both banana and cow pea were higher for beneficiaries than non-beneficiaries. Only yield of banana had significant difference between beneficiaries and non-beneficiaries. Irrigation was found to be significant in both banana and cow pea production by beneficiary farmers. Marginal productivity analysis for examining the allocative efficiency showed that, all the resources of production of banana were found to be underutilized for both beneficiaries and non-beneficiaries. For cow pea, organic manure was over-utilized by beneficiary farmers while all other resources where underutilized by both beneficiaries and non-beneficiaries.

Lack of timely release of water was identified as the major problem faced by farmers in the command area irrespective of strata. siltation in the canals and water scarcity during dry months were cited as other major constraints especially by middle and tail reach farmers. To tackle these issues effective supervision and coordination in facilitating smooth supply of water may be enhanced from the institutional side. Proper as well as flexible schedule for release of water have to be maintained by dam authorities and it should be disseminated among the beneficiary farmers. For this efficient and systematic communication between dam officials and farmers may also be ensured. Formation of Water Users' Association may be encouraged in order to improve farmer’s participation. Timely subsidies for purchasing motor pumps would also be helpful to those farmers who have to bear additional fuel expenses for lifting water from the canal.

സംഗ്രഹം

"ജലസേചന ജലത്തിന്റെ സാമ്പത്തിക മൂല്യം: നെയ്യാർ ജലസേചന പദ്ധതിയുടെ ഒരു കേസ് പഠനം, തിരുവനന്തപുരം" എന്ന തലക്കെട്ടിൽ ഉള്ള പ്രസ്തുത പഠനം 2020-21 കാലയളവിൽ നടന്നു. ജലസേചന വെള്ളത്തിന്റെ സാമ്പത്തിക മൂല്യം കണക്കാക്കുക, നെയ്യാർ ജലസേചന പദ്ധതിയുടെ അയകട്ട് പ്രദേശത്തിന് കീഴിൽ ഉള്ള തിരഞ്ഞെടുത്ത വിളകളുടെ ഉത്പാദനത്തിൽ ജലസേചനത്തിന്റെ സ്വാധീനം വിലയിരുത്തുക, ജലസേചന പരിപാലനത്തിലെ പ്രവർത്തന പ്രശ്നങ്ങൾ തിരിച്ചറിയുക എന്നീ പ്രത്യേക ലക്ഷ്യങ്ങളോടെയാണ് ഈ പഠനം നടത്തിയത്.

തിരുവനന്തപുരം ജില്ലയിൽ സ്ഥിതിചയ്യുന്ന നെയ്യാർ ജലസേചന പദ്ധതിയുടെ (എൻഐപി) വലതുകര കനാൽ (ആർബിസി) കമാൻഡ് എരിയയിൽ പ്രാഥമിക, ദ്വിതീയ വിവരങ്ങളുടെ സഹായത്തോടെയാണ് പഠനം നടത്തിയത്. മുൻകൂട്ടി പരിശോധിച്ച അഭിമുഖ ഷെഡ്യൂൾ ഉപയോഗിച്ച് കർഷകരിൽ നിന്ന് പ്രാഥമിക വിവരങ്ങൾ ശേഖരിച്ചു. പഠനവുമായി ബന്ധപ്പെട്ട ദ്വിതീയ വിവരങ്ങൾ കൃഷിഭവൻ, ഗ്രാമപഞ്ചായത്ത്, മറ്റ് സർക്കാർ, സർക്കാരിതര ഏജൻസികൾ എന്നിവയിൽ നിന്ന് ശേഖരിച്ചു. കനാലിന്റെ നീളം (ഹെഡ് റീച്ച്, മിഡിൽ റീച്ച്, ടെയിൽ റീച്ച്) അടിസ്ഥാനമാക്കി സ്ട്രാറ്റിഫൈഡ് റാൻഡം സാമ്പ്ലിങ് വഴിയാണ് പ്രാഥമിക വിവരശേഖരണത്തിനായി കർഷകരെ തിരഞ്ഞെടുത്തത്. 60 ഗുണഭോക്താക്കളായ കർഷകരും 60 ഗുണഭോക്താക്കളല്ലാത്ത കർഷകരും അടങ്ങുന്ന മൊത്തം സാമ്പിളിന്റെ വലുപ്പം 120 ആയിരുന്നു.

ഉറപ്പുള്ളതും സമയബന്ധിതവുമായ ജലസേചന-ജലവിതരണത്തിനായി ഗുണഭോക്താക്കളായ കർഷകരുടെ പണം നൽകാനുള്ള സന്നദ്ധത (WTP) ഉന്നയിക്കാൻ കണ്ടിജന്റ് വാല്യൂവേഷൻ രീതി (CVM) ഉപയോഗിച്ചു, ശരാശരി WTP/വർഷം 721.80 രൂപ, ആണെന്ന് കണ്ടെത്തി. ഇത് അവരുടെ ശരാശരി വാർഷിക കാർഷിക വരുമാനതിന്റെ 0.3 ശതമാനം മാത്രമാണ് എന്നും മനസ്സിലാക്കി. ഗുണഭോക്താക്കളിൽ ടെയിൽ റീച്ച് കർഷകരുടെ WTP ഹെഡ് റീച്ചിലും മിഡിൽ റീച്ചിലും ഉള്ള കർഷകരെ അപേക്ഷിച്ച് ഉയർന്നതായി കണ്ടെത്തി. മൊത്തം ഗുണഭോക്തൃ കുടുംബങ്ങളുടെയും അവരുടെ കണക്കാക്കിയ ഡബ്ല്യുടിപിയുടെയും ഗുണനത്തിലൂടെ ജലസേചന വെള്ളത്തിന്റെ സാമ്പത്തിക മൂല്യം പ്രതിവർഷം 1.5 കോടി രൂപ ആണെന്ന് കണക്കാക്കി. ഇത് 2020-ൽ അണക്കെട്ടിന്റെ വാർഷിക പ്രവർത്തനത്തിനും

അറ്റകുറ്റപ്പണികൾക്കും ചെലവായ തുകയുടെ 47 ശതമാനത്തോളം ഉൾക്കൊള്ളുന്നുണ്ട്.

പഠനമേഖലയിലെ പ്രധാന വിളകളായിരുന്ന വാഴ, പയർ എന്നിവയുടെ കൃഷിച്ചെലവ് ഗുണഭോക്താക്കൾക്കും അല്ലാത്തവർക്കും കണക്കാക്കുകയും ഗുണഭോക്താക്കളല്ലാത്തവർക്ക് വാഴകൃഷിയുടെ ചെലവ് അൽപ്പം കൂടുതലാണെന്ന് കണ്ടെത്തുകയും ചെയ്തു. അതേസമയം ഗുണഭോക്താക്കളല്ലാത്ത കർഷകരെ അപേക്ഷിച്ച് ഗുണഭോക്താക്കളായ കർഷകർക്ക് പയർ കൃഷിക്ക് ചെലവ് കൂടുതലാ യിരുന്നു.

ഗുണഭോക്താക്കളുടെയും അല്ലാത്തവരുടെയും ഇരുവിളകളുടെയും വിഭവ വിനിയോഗ കാര്യക്ഷമത പരിശോധിക്കുന്നതിനായി കോബ്-ഡഗ്ലസ് പ്രൊഡക്ഷൻ ഫങ്ഷൻ ഉപയോഗിച്ചു. ഗുണഭോക്താക്കൾ അല്ലാത്തവരേക്കാൾ ഗുണഭോക്താക്കൾക്ക് വാഴയുടെയും പയറിന്റെയും വിളവ് കൂടുതലായിരുന്നു. വിഭവ വിഹിത കാര്യക്ഷമത പരിശോധിക്കുന്നതിനുള്ള മാർജിനൽ പ്രൊഡക്ടിവിറ്റി വിശകലനം വഴി, ഇരുവിളകളുടെയും ഉൽപാദനത്തിനുപയോഗിക്കുന്ന എല്ലാ പ്രധാനവിഭവങ്ങളും ഗുണഭോക്താക്കളാലും അല്ലാത്തവരാലും വേണ്ടവിധം ഉപയോഗിക്കപ്പെട്ടിരുന്നില്ല എന്ന് മനസ്സിലാക്കി.

യഥാസമയം വെള്ളം തുറന്നുവിടാത്തതാണ് കമാൻഡ് ഏരിയയിലെ കർഷകർ നേരിടുന്ന പ്രധാന പ്രശ്നമായി കണ്ടെത്തിയത്. കനാലുകളിലെ ചെളി അടിയൽ, വരണ്ട മാസങ്ങളിലെ ജലദൗർലഭ്യം എന്നിവ മറ്റ് പ്രധാന പരിമിതികളായി ചൂണ്ടിക്കാണിക്കപ്പെട്ടു. ഈ പ്രശ്നങ്ങൾ പരിഹരിച്ച് സുഗമമായ ജലവിതരണം നടപ്പാക്കുന്നതിന് ഫലപ്രദമായ മേൽനോട്ടവും ഏകോപനവും ജലസേചനവകുപ്പിന്റെ ഭാഗത്ത്നിന്ന് ഉണ്ടാകേണ്ടത് അത്യാവശ്യമാണ്. വെള്ളം തുറന്നുവിടുന്നതിനുള്ള ശരിയായതും വഴക്കമുള്ളതുമായ ഷെഡ്യൂൾ ഡാം അധികൃതർ പരിപാലിക്കുകയും അത് കർഷകർക്കിടയിൽ പ്രചരിപ്പിക്കുകയും വേണം. കർഷകരുടെ പങ്കാളിത്തം മെച്ചപ്പെടുത്തുന്നതിന് വാട്ടർ യൂസേഴ്സ് അസോസിയേഷൻ രൂപീകരിക്കുന്നത് പ്രോത്സാഹിപ്പിക്കണം. കനാലിൽ നിന്ന് വെള്ളം ഉയർത്തുന്നതിന് അധിക ഇന്ധനച്ചെലവ് വഹിക്കേണ്ടിവരുന്ന കർഷകർക്ക് മോട്ടോർ പമ്പുകൾ വാങ്ങുന്നതിന് സമയബന്ധിതമായി സബ് സിഡി നൽകുന്നതും ഉപയോഗപ്രദമാ യിരിക്കും.