Chapter – I

INTRODUCTION

1.1. Introduction and Background

India’s agricultural sector has an impressive long-term record of taking the country out of serious food shortages despite rapid population increase. This was achieved through a favorable interplay of infrastructure, technology, extension, and policy support backed by strong political will. The main source of long-run growth was technological augmentation of yields per unit of cropped area. Further, it resulted in tripling of food grain yields, and food grain production increased from 51 million tons in 1950–51 to 257 million tons in 2010–11. Similarly, production of oilseeds, sugarcane, and cotton also increased more than four-fold over the period, reaching 28 million tons and 365 million tons and 27 million bales, respectively, in 2010–11.

Although GDP from agriculture increased from Rs.337991 crore in 1990–91 to Rs.522755 crore in 2000-01, Rs.610905 crore in 2010-01 and Rs 649454 crore in 2012–13 (at 2004–2005 price), the increase per worker has been rather modest. Current GDP per agricultural worker is around Rs.2000 per month which is only about 75 percent higher in
real terms than in 1950 compared to a four-fold increase in overall real per capita GDP. While slower growth of GDP in agriculture than non-agriculture is expected, the main failure has been the inability to reduce the dependence of the workforce on agriculture significantly by creating enough non-farm opportunities to absorb the surplus labour in rural areas and equipping those in agriculture to access such opportunities. Half of those engaged in agriculture are still illiterate and just five percent have completed higher secondary education. Income and education are of course least among agricultural labourers. Even families operating farms now suffer from much smaller holdings (70 percent below one hectare in 2003 compared to 56 percent in 1982), and farming members in such families are twice as likely to be illiterate as non-farming members. Ensuring food security and farmer welfare thus require support systems to extend technology and scale benefits in a sustainable manner to a huge existing workforce in agriculture that lacks non-farm skills and is also ageing and getting feminized (Ramesh Kumar 2013).

Groundwater is one of the leading inputs for agricultural development in arid and semi-arid regions of India. It may be observed that with rapidly declining public investment in
irrigation and the associated environmental problems and groundwater irrigation emerged as an important input for secured agricultural development in recent years. Institutional changes and technological progress have made it possible to meet the increasing demand for securing irrigation systems through innovative techniques to drill deeper wells and subsidized rural development programmes. The advent and spread of energized pumping technology enabled rapid groundwater development and the emergence of socio-economic systems that depend on reliability (Shah 1993; Dhawan 1995; Burke and Moench 2000).

It could be brought to light that since groundwater was recognized as an alternative source of irrigation, the face of Indian agriculture shifted more to the water-intensive cropping system (Dhawan 1988; Shah 1993).

There is a need for development of well and bore-well irrigation in many droughts prone regions. With the development of irrigation facilities, there was an increase in the net irrigated area and it ultimately led to over-exploitation of groundwater (Janakarajan 1993; Nagaraj et al 1994; Vaidyanathan 1996 Chandrakanth and Arun 1997; Shivakumaraswamy and Chandrakanth1997; Nagaraj 1994;
Reddy 2003; Janakarajan and Moench 2006; Anantha and Raju 2008; Palanisami et al 2008). Currently, in India, about 60 per cent of the cultivated area is irrigated by groundwater. Development helped farmers for ground water use for more intensive production techniques that required higher inputs and associated capital investments (Shah 2007 and Moench 2003). The demand for groundwater irrigation has led to an increase in the number of wells. Since the same aquifer was shared by many users, the extraction rate exceeded its natural recharge rate. Thus, development was inconsistent with investment, resulting in competitive extraction and a concomitant secular lowering of the groundwater. This indicates that as groundwater over-exploitation became severe, agricultural production declined and the overall future of regions became uncertain.

A major portion of India’s irrigation wells is located in the hard rock areas where both recharge and discharge potential face severe stress (Nagaraj and Chandrakanth 1995). The hard rock areas have hard nonporous, igneous and metamorphic rocks, expected to store not more than 10 per cent of the annual rainfall (Radhakrishna 1971). The benefits of irrigation have been highlighted in numerous studies but the negative
impact of declining groundwater on agricultural development has not been adequately analyzed. Economic value of water in agriculture is much lower than that in other sectors (Barker et al., 2003), including manufacturing (Xie et al., 1993). Growing physical shortage of water on the one hand and scarcity of economically accessible water, owing to increasing cost of production and supply of the resource on the other, preoccupied researchers with increasing productivity of water use in agriculture in order to get maximum production or value from every unit of water used (Kijne et al., 2003).

Raising water productivity is the cornerstone of any demand management strategy. Water productivity is scale dependent. Water productivity can be analyzed at the plant level, field level, farm level, system level and basin level, and its value would change with the changing scale of analysis (Molden et al., 2003).

The classical concept of irrigation efficiency used by water engineers omitted economic values and looked at the actual evapo-transpiration (ET) against the total water diverted for crop production (Kijne et al., 2003). Moreover, it does not factor in the “scale effect” (Keller et al., 1996).
At the field level, there is no single parameter to determine the efficiency of water use in crop production. Measures to enhance yield to raise water productivity in biomass per unit of water depleted, might increase the cost of production thereby reducing net return per unit of water depleted. Therefore, crop water productivity needs to be assessed in terms of both kilogram of crop per cubic meter of water diverted or depleted (Kg/m$^3$); and net or gross present value of the crop produced per cubic metre of water (Kijne et al., 2003). While the yield would increase with an increase in actual ET, the water productivity (Rs/m$^3$) would start leveling off and then start declining much before the yield reaches maximum (see for instance Molden et al., 2003). The reason is that the amount of depleted water might increase with increase in irrigation dosage, and beyond a point, it does not result in yield increase (Vaux and Pruitt, 1983). Similarly, while the yield would keep increasing until a point with increase in nutrient inputs, the net return might start decreasing even at the level of nutrient dosage lower than that corresponding to maximum yield. Hence, the challenge is to identify optimum level of water and nutrient inputs to ensure maximum return per unit of land and water. The measure can
be referred to as “water control”; and optimizing nutrient dosage, respectively.

“Water control” refers to supplying water dosages close to the difference between crop water requirement and available soil moisture in the root zone. It ensures greater utilization of applied water for ET, and minimal non-recoverable percolation from the applied water, which is non-beneficial. It also reduces the fraction of non-beneficial evaporation from applied water. Hence, with controlled water delivery, the yield would be more for the same depletion or consumed fraction, resulting in higher water productivity. The measures for this include on-farm water management practices and improving the conveyance of water. Micro irrigation systems take care of water control for many crops, and in certain other crops by farm leveling.

Crop water productivity also depends on the reliability and quality of irrigation water applied in addition to control over water delivery. Improved reliability can ensure better timing of irrigation to ensure crop growth needs (Meinzen-Dick, 1995). With the same amount of water applied, the crop consumptive use (ET) would change depending on the timing of water application. On the other hand, non-availability of
moisture at critical stages of crop growth can significantly reduce crop growth and yield and the reduction would not be proportional to the reduction in water applied or water consumed. Therefore, the quality and reliability of irrigation would affect water productivity, with the same amount of irrigation water applied. Now, opportunities for enhancing water productivity would change when one moves from the field to the basin. Enhancing water productivity at the field through water control may adversely affect the availability of water for downstream uses in a closed basin. The reason is the probable reduction in non-consumptive part of the water applied (Allen et al., 1998; Molle and Turreal, 2004). If those downstream uses have higher return per unit water use, water control measures would result in productivity losses at the basin level. On the other hand, at the basin level, as Abdulleev and Molden (2004) note, opportunities might exist for growing the same crop in areas where their ET values are lower, which result in improved water productivity in both physical and economic terms. Hence, crop water productivity needs to be mapped across different agro climates in the basin.
1.2. **Statement of the Problem**

A decade back the Cauvery water was used mainly to irrigate Cuddalore district, but the lower availability of Cauvery water has resulted in service water shortage in the district, particularly in three blocks viz., Bhuvanagiri, Kurinjipadi and Kammapuram which are located close to Neyveli. To cope with the scarcity of Cauvery water, the farmers in these three blocks are increasingly dependent upon the water pumped out from the first and second mine of the Neyveli Lignite Corporation (NLC), which is drained via the canals for irrigation.

The surplus discharge of Neyveli water is stored in the two tanks (small sized reservoirs) namely, Walajah Tank and Perumal Tank, in Cuddalore District; these tanks receive mine drainage water pumped out contentiously from the open caste lignite mines of the Neyveli Lignite Corporation Limited, Neyveli, Tamilnadu. This water has been used by the beneficiaries in the command areas of both Walajah Tank and Perumal Tank for more than three decades. Recently, they have raised apprehensions on the quality of mine drainage water which they were using for raising crops in the command
areas of both tanks. They tend to feel that the coal dust laden mine water used for irrigation affected the crop yields.

Such surplus water from the first and second mines cuts has helped to increase crop growth per year cropping intensities as well as the yield per acre contributing to increase in income and employment generation especially for the marginal and small farmers, besides benefiting landless agriculturists and other categories of farmers. During the rainy season, floods affected the surrounding areas including the mines at the tank. This rainwater is pumped through the drainage canal to the Walajha tank and Perumal tank. Consequently, large quantity of water is stored in the tank.

Several problems related to irrigation water quality occur. These include high nitrogen concentrations in the water, overhead sprinkler irrigation with high bicarbonate water or water containing gypsum or water with high iron, unusual pH of water, water induced corrosion and incrustation. Vector problems often originate as a secondary trouble related to a low water infiltration rate, to the use of wastewater for irrigation, or to poor drainage. More commonly, sediments tend to fill canals and ditches and cause costly dredging and maintenance problems. Sediment also tends to
reduce further the water infiltration rate of already slowly permeable soil.

From the foregoing discussion, one may notice that there are several problems related to the use of NLC water for irrigation in Cuddalore District, especially in Bhuvanagiri and Kurinjipadi blocks of the district. It is also noticed that there are numerous studies in the area of irrigation viz., exploitation of ground water, impact of declining ground water an agricultural production and also there are studies on environmental aspects of irrigation in agriculture. In this context, the present study makes an attempt to deviate from the previous studies by taking the impact of NLC water for irrigation and comparing this with other sources of irrigation in Bhuvanagiri and Kurinjipadi blocks of Cuddalore district and water conservation programmes.

1.3. Research Questions

1. Is there any relationship between different sources of irrigation and the level of output in paddy cultivation among the different sizes of land holdings?

2. Is there any variation in the cost and return structure among the different sizes of land holdings under different sources of irrigation?
3. Is there any environmental impact of different sources of irrigation on paddy cultivation in the study region?

4. Does any variation exist in the level of output under different sizes of law holdings among the different sources of irrigation?

1.4. Objectives

1. To study the socio economic characteristics of the sample respondents.
2. To examine the relationship between different sources of irrigation and the variation in the level of output of paddy cultivation.
3. To study the variation in the cost and return structure among the farm respondents and sources of irrigation.
4. To analyse the environmental impact of different sources of irrigation on paddy cultivation.
5. To suggest suitable policy measures to improve the different sources of irrigation in the study region.

1.5. Hypotheses

1. The level of output of paddy cultivation varies among the different sources of irrigation and under different sizes of land holdings.
2. The cost and return structure varies among the different sources of irrigation under different sizes of land holdings.

3. The effect of ground water use in paddy cultivation is encouraging as compared to NLC water for irrigation in the study region.

1.6. Concepts

Human Labour

Human labour includes family labour utilized, permanent labour employed and hired labour engaged. In the present study, these categories of labour were treated alike and converted into a common physical unit in terms of mondays equivalent. Also the labour of men, women and juveniles were converted into many units to arrive at a meaningful analysis. In all the villages in study area, prevailing wage rates were Rs.250.00 per male, Rs.100.00 per female and Rs.20 per juvenile labourovers per day. For the purpose of standardization of human labour, the labour of two women and three juveniles each with eight hours of work have been equivalent to one male laborer.
Seeds

The farm produced seed was valued at the market price prevailing in the locality and the purchased seeds and seeding were valued at the actual purchase price plus the transport costs.

Manure, Fertilizers and Pesticides

The farmyard manure was valued at the market rate prevailing in that area and the purchased farmyard manure was valued at the actual cost plus the transport costs. Similarly, fertilizers and pesticides were valued at the actual purchase price.

Irrigation cost

Actual water cost incurred and electricity charges paid were taken into account as irrigation cost.

Transport cost

Actual transport cost incurred for transporting the paddy from the farm to the sales area was considered.

Interest on working Capital

Interest rate on working capital was calculated (12 percent to 15 percent) the rate at which the short term crop loan was provided by the government credit institutions, relatives and friends.
**Variable Cost**

Variable cost was computed by adding the cost incurred towards preparatory cultivation, seeds and sowing, manures and fertilizers, plant protection, weeding, labour, harvesting and transport, interest on working capital and others (irrigation charger).

**Fixed Cost**

Fixed cost includes rental value of own land, interest of fixed investment, assess family laborer and depreciation.

**Total Cost**

Total cost includes variable cost and fixed cost.

**Return**

Gross income is the total income obtained from the main product.

**1.7. Methodology**

The present study is based on both primary and secondary data. The primary data have been collected from the farmers who are involved in the cultivation from four villages of the study blocks by using a well-structured interview schedule. Secondary data have been collected from District Statistical Office of Cuddalore district, NLC water department and other documents published by government. Specifically, it
is concerned with cropping pattern, area irrigated and sources of irrigation, consumption of fertilizer and pesticides, soil types, soil problems, status of soil, forest resources, mineral resources, water resources and water quickly. As far as the sampling design of the study is concerned, the study has employed stratified random sampling technique which involves selection of Cuddalore district, selection of two blocks from the district and selection of four villages from the selected blocks. Regarding selection of villages, two villages have been selected from Bhuvanagiri block and two villages have been selected from Kurinjipadi block. The rationale behind the selection of two villages from each of the blocks selected is that two villages have been chosen which used other sources of irrigation (Bhuthavaranpate and Kuruvappanpte) and other two villages which used NLC water for irrigation (Karaimedu and Komodimunai).

Regarding the size of the sample, this study has taken into account 400 samples farm respondents. Out of this 200 samples are from the farm respondents who used other sources of irrigation for cultivation and the remaining 200 samples are taken from those who used NLC water for irrigation. As far as the period of the study is concerned, it is confined to one agricultural year from 1st July, 2013 to 30th June 2014. In addition, to examine the
environmental impact of NLC water which is used for irrigation.

Regarding water and soil sample, 12 samples were collected from the four sample villages. Water samples were collected in well cleaned one liter polythene sample bottles rinsed by 1:5 HCL (hydrochloric acid) and then by double distilled water. The sample locations were identified and recorded with the help of Agricultural Water and Soil testing laboratory, Cuddalore. The samples collected were analyzed for major cations like, Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K) and Bicarbonate (HCO₃), Sulfate (SO₄), Phosphorus (PO₄), and Electric conductivity (EC) and Power of hydrogen ions (pH) were determined in the field using electrode.

This study has been classified into four important categories, marginal farmers (zero to three acres land), small farmers (three to five acres land), medium farmers (five to ten acres land) and large farmers (above ten acres land).
Table 1.1 discusses the categories of farmers in the NLC irrigation (200 samples) and ground water irrigation (200 samples). In the NLC irrigation area the small farmers consist of 93 respondents (46.50 percent), the medium farmers are 51 respondents (25.50 percent), the marginal farmers are 43 respondents (21.50 percent) and large farmers are 13 respondents (6.50 percent). Under the ground water irrigation the small farmers are 80 respondents (40.00 percent) the medium farmers are 66 respondents (33.00), on large farmers are 38 respondents (19.00 percent and marginal farmers are 16 respondents (8.00 percent).
In the overall sample size, 173 respondents are small farmers, 117 are from medium farmers and 59 respondents are from marginal farmers and 51 respondents are large farmers selected for the purpose of the study. The present study uses both primary data and secondary data to analyse the environmental impact of ground and NLC water. The secondary data have been gathered from the NLC. For analyzing the data, simple percentage analysis, and t-test have been adopted and cost benefits were calculated.

**Cost Benefit Ratio**

This indicator is used to test the worthiness of the research.

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\frac{B}{C} = \frac{\text{Gross Revenue}}{\text{Total Cost}}
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**1.9. Limitations**

1. This study is concerned with the environmental impact of NLC water on agriculture in Bhuvanagiri and Kurinjipadi blocks of Cuddalore District and it does not focus on the sample impact on agriculture in other areas of Cuddalore district.

2. The analysis of the study is confined to only the impact of NLC irrigation on agriculture and it has not taken
into account the impact of NLC water on other aspects of environment in Cuddalore district.

3. The present study is limited to analyse and compare the NLC water for irrigation and other sources of irrigation irrespective of different categories of farmers.

4. Since paddy is a major crop in the study region, the analysis of present study is confined to the farmers who are cultivating paddy crop.

1.10. Plan of the Study

The present study has been structured into five chapters. The introductory chapter brings out introduction and background, statement of the problem, research questions, objectives, hypotheses, concepts, operational definitions, methodology, and tools for analysis and limitations of the study. The second chapter reviews the studies related to the environmental aspects of irrigation in agriculture, and the third chapter provides the description of Cuddalore district as the profile of the study blocks.

The fourth chapter encompasses the results and discussion of the present study and the final chapter offers conclusion, policy implications and scope for further research.