

**AN ECONOMIC ANALYSIS OF IMPACT OF SOIL SALINITY ON  
PADDY PRODUCTIVITY IN CAUVERY DELTA ZONE OF TAMIL NADU**

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**AN ECONOMIC ANALYSIS OF IMPACT OF SOIL SALINITY ON  
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*Thesis submitted in partial fulfillment of the requirements for the award of the degree of*

**DOCTOR OF PHILOSOPHY  
(AGRICULTURAL ECONOMICS)**

*to the Tamil Nadu Agricultural University, Coimbatore – 641 003*

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## CERTIFICATE

This is to certify that the thesis entitled “**AN ECONOMIC ANALYSIS OF IMPACT OF SOIL SALINITY ON PADDY PRODUCTIVITY IN CAUVERY DELTA ZONE OF TAMIL NADU**” submitted in partial fulfillment of the requirement for the degree of **DOCTOR OF PHILOSOPHY IN AGRICULTURAL ECONOMICS** to the Tamil Nadu Agricultural University, Coimbatore is a record of bonafide research work carried out by **Mr. R. PARIMALARANGAN** under my supervision and guidance and that no part of this project has been submitted for the award of any other degree, diploma, fellowship or other similar titles. However, part of thesis work has been published in peer reviewed scientific journal of national / international repute (copy enclosed).

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*(R.Parimalarangan)*

## *Abstract*

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## **ABSTRACT**

### **AN ECONOMIC ANALYSIS OF IMPACT OF SOIL SALINITY ON PADDY PRODUCTIVITY IN CAUVERY DELTA ZONE OF TAMIL NADU**

**BY**

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Agricultural Economics  
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The most important issue in agriculture is the loss of agricultural productivity of farm lands due to water and soil salinity. The target of producing more food grains in developing countries for feeding the burgeoning population in view of the shrinking cultivated area is an uphill task. The degradation of land and water adds to uncertainty in agriculture in terms of employment, environment and economic development. Problems like salinity, alkalinity and water logging all of which leads to productivity decline in short- and medium-terms and land abandonment in the long-run. At farm level, the negative effects have been reported as reduction in farm income, restricted choice of crops and land abandonment.

The present research study examines these issues by carrying out an economic valuation of ecosystem changes due to salinity in Cauvery Delta Zone (CDZ) of Tamil Nadu.

Farmers in the Cauvery Delta Zone form the universe of the study. Multistage stratified random sampling technique was adopted to select ultimate sampling unit. Under this sampling technique selection of districts forms the first stage, selection of taluks as second stage and selection of village as third stage. Musiri, Illupur, Sirkali Taluks of Tiruchirapalli, Pudukottai and Nagappattinam districts, respectively were selected for the present study. Similarly in each

taluk, two villages were selected. In each village, ultimate sampling unit was selected based on simple random sampling. From each village, 10 sampling unit was selected and this leads to the total sample size of 240 farmers which comprises of 120 farmers each under salt affected and non affected production environment.

Tabular analysis was employed to study the cropping pattern, cost and returns and economic losses etc, contributed by saline soils. Cobb-Douglas production function analysis was employed to study the resource use efficiency in the sample farmers. Decomposition analysis was carried out to identify the factors that contributed to the difference in yield levels under saline soils. Data envelopment analysis was employed to prepare the optimal plans and to estimate the technical efficiency under salinity affected farms.

The results sample farm characteristics indicated that the higher involvement of relatively older farmers (more than 41 years) in salinity affected category than non affected category of sample farmers. The average size of family was found to be higher among the farmers of non affected category (5.31 persons) than the farmers of salinity affected category (5.28 persons).

The farmers with more experience was taking up farming in salinity affected soil than the non affected category of sample farmers. The illiterate farmers were higher in share in salinity affected category than the farmers of non affected category which accounted for 15 per cent and 11.67 per cent, respectively.

Among the sample farmers, majority of farmers were comes under the category of marginal and small farmers and the proportion of marginal and small farmers was higher in affected category than non affected category. Among the different salinity affected categories, high level of affected category had maintained larger number of livestock population, followed by medium and low level of affected category.

The total salinity affected area was higher in low level of affected category which accounted for 45.21 per cent, followed by medium and high level of affected category which was accounted for 30.02 per cent and 24.77 per cent, respectively.

The land put under fallow or abandoned was higher affected category (04.97 per cent). An average of 0.78 ha per farmer was abandoned or unutilized in salinity affected than non affected category (0.14 ha per farmer).

The cost of cultivation of paddy was Rs. 59837 per ha in non affected category and the same was Rs 48567 per ha for pooled affected category. The Cost A1 for one hectare of paddy was Rs

46251 in non affected category and the same was Rs. 39050 in pooled category of salinity affected farmers. The percentage change of total cost of cultivation of affected category over non affected category was 18.83 per cent.

The yield realized was varied considerably and it was 40.24 quintals per hectare in non affected category and the same was 30.30 quintals per hectare in affected category.

Among the sample farmers, gross return realized was Rs.70970 per hectare in non affected category and the same was Rs. 54122 per hectare in affected category. The percentage change in net return over Cost A1 of the affected category over non affected category was 39.03 per cent.

Marginal value of damage estimate confirmed that one unit increase in EC for average level of salinity would adversely affect paddy yield by 187 kg per hectare

Decomposition estimates shows that soil salinity was the major cause for the reduction of yield. Contribution of soil salinity to total change in rice yield was estimated at 36.57 per cent for low level of affected category, followed by 45.32 per cent and 56.15 per cent, respectively for medium and high level of affected category.

Data Envelope analysis results confirmed that around 45 per cent of the farmers belonged to the most efficient scale group (90-100 per cent) and 8 per cent of the farmers operated in the least scale efficiency group (less than 80 per cent). Among the different inputs, plant protection chemicals had the highest percentage of slack.

With increased land degradation, the number of farm families temporarily migrated was 36 per cent of the sample farmers and it was ranged between 9 per cent and 15 per cent among the different categories of salinity affected sample farmers.

Poor leaching and development of hard pan (98 per cent) on the soil surface and stunted crop growth and crop failure in early stages (94 per cent) were the major indicators as expressed by farmers

The adverse effects of land degradation were decline in the land value and high incidence of crop pests and diseases were accounted for 90 per cent 72 per cent, respectively.

The coping up strategies adopted by the farmers were cleaning of field irrigation channels and digging of open field drains were practiced by the farmers, which accounted for 28 per cent and 22 per cent, respectively. Among the crop management technique, increase in the seed rate was adopted by 31 per cent of the farmers. Among the amendment strategies, the increased application of organic manure and nitrogenous fertilizers were practiced by few farmers.

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## *Introduction*

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## CHAPTER I

### INTRODUCTION

The world population has reached the seven thousand million people during the year 2011. The United Nations has predicted a population increase up to 8.01 thousand million people in 2025. So, the agriculture strategies for feeding all the people represent one of the most important challenges in the 21<sup>st</sup> century. The food requirements are increasing quicker than crop production. Therefore, there is urgent need to improve alternative agricultural strategies to increase the crop production.

There is enormous demographic and economic pressure to rise, within the next few decades, leading to an increase of the crop production in sustainable manner to fulfill the world food requirements. This will likely be difficult, because extensive areas of irrigated land have been and are increasingly becoming degraded by salinization and water logging resulting from over-irrigation and other forms of poor agricultural management. Available data suggest that the present rate of such degradation has surpassed the present rate of expansion in irrigation (Seckler, 1996). In some places, the very sustainability of irrigated agriculture is threatened by this degradation (Rhodes, 1997). Globally, accelerated land and water degradation caused by acidification, water logging, salinization, alkalization, physical and biological deterioration is expected to affect about 33 per cent of the worlds arable land (i.e. two billion hectares) by 2020. The overall pace of degradation has accelerated in the past 50 years due to economic reasons.

The land resource degradation problems are particularly serious in the hunger belt swathed around the equator, comprising eco system of the tropical and sub tropical countries. (Falkenmark,1987). The most damaging impact is being felt in Asia and Africa, where demographic pressure is high and per head water availability is diminishing. Worldwide, five to ten million hectares of the arable land had been degraded since 1945. If this trend continues, 1.4 to 2.8 per cent of total crop, pasture and forest land will have been lost by 2020.

The degradation of land and water adds to uncertainty in agriculture in terms of employment, environment and economic development. The first law of thermodynamics, Conservation of mass, signifies that the environment is the source of all natural resources and sinks for all wastes. The pursuit of higher rates of economic growth seems to be harmful to the environment as it results in greater depletion of natural resources. The economic development is

always contingent up on environmental sustainability. Historical evidences show that these problems lead to abandonment of land in the long term. In the short terms, there is adverse productivity impact. At farm level, the negative effects have been reported to be (i) the threat to the sustainability of land resources, (ii) decrease in farm production due to abandoned croplands, (iii) decline in resource productivity and (iv) cut back in resource use. At the regional level, the consequences have been (i) displacement of labour from agriculture, (ii) widening of income disparities and (iii) adverse effect on the sustainability of secondary and tertiary sectors (Joshi, *et. al.*, 1994).

The depletion of natural resources and environmental degradation have resulted in the reduction off-farm income, restricted choice of crops, low income and land abandonment (Chopra and Gulati, 1998, Mani, *et. al.*, 2001). Also, the environment has a deep economic value in both production and consumption. In rural areas of developing economies, the environment is the fundamental source of livelihood. The exogenous shocks to the environment such as flooding, drought or the gradual degradation of natural resources associated with the population pressure and human activities such as deforestation or desertification could force people to move and seek better employment opportunities elsewhere. And in turn mass immigration is likely to impose some pressure on the economy and the natural resource base in the regions of settlement (Alessandra, 1997)

The most important issue in agriculture is the loss of agricultural productivity of farm lands due to water and soil salinity. The increase in temperature with low relative humidity resulting in high rates of evaporation leads to deposition and accumulation of salt in the soil profile affecting the growth of plants. Salinity affects about 1000 million hectares of land globally posing a formidable task of taking up agriculture and enhancing productivity in these areas. About 100 million ha in South and South-East Asia are covered by problem soils where rice is the staple crop.

The target of producing more food grains in developing countries for feeding the burgeoning population in view of the shrinking cultivated area is an uphill task. One of the alternative agricultural strategies for increasing agricultural production is to reclaim the salt-affected areas and other waste lands which are hitherto barren or have low productivity. The relationship between crop yield and soil salinity has been quantified for many crops under typical growing conditions which revealed that sodicity typically reduces crop yields (Quirk, 2004).

Presently, salinity affects productivity in about 86 million hectares of the world's irrigated land. Annually three million hectares of irrigated land becomes less productive due to salinity, alkalinity and water logging problems. Productivity has declined substantially in 16 per cent of agricultural land in developing countries. Both in developing and developed countries together, these problems have led to a decline of about 1.1 million tonnes of output every year.

In India, about 170.5 million hectares of land area has been affected by various soil problems (Saxena and Pofali, 1999). The chemical deterioration of soil due to human intervention is estimated at 13.6 million hectares (4.1 per cent) of which, salinization occurs in 10.1 million hectares and nutrient and organic matter losses occur in about 3.5 million hectares. Water logging or land affected by flooding accounts for about 3.5 per cent of the total geographical area. About 18.2 million hectares area is under wastelands, which is not fit for any cultivation. Indiscriminate irrigation has led to water logging, nutrient losses and increased salinization of lands. It has ironically threatened the sustainability of crop yield. Extensive lifting of underground water through tube wells has resulted in lowering of water table during low rainfall period. The area under land degradation has increased from 22.31 million hectares to 31.99 million hectares (Sen, 2003) within the last 15 years. It is obvious from table 1.1 that nearly 16 per cent of cultivable area of country is subjected to various forms of land degradation.

**Table 1.1 State wise extent of salt affected soils in India (000 ha)**

State	Saline	Sodic	Total
Andhra Pradesh	77.60	196.61	274.21
Andaman & Nicobar islands	77.00	0.00	77.00
Bihar	47.30	105.85	153.15
Gujarat	1680.57	541.43	2222.00
Haryana	49.16	183.40	232.56
Jammu and Kashmir	0.00	17.50	17.50
Karnataka	1.89	148.14	150.03
Kerala	20.00	0.00	20.00
Madhya Pradesh	0.00	139.72	139.72
Maharashtra	184.09	422.67	606.76
Orissa	147.14	0.00	147.14
Punjab	0.00	151.72	151.72
Rajasthan	195.57	179.37	374.94
Tamil Nadu	13.23	354.78	368.02
Uttar Pradesh	21.99	134.67	1368.96
West Bengal	441.27	0.00	441.27
Total	2956.81	3770.66	6727.47

(Source: Sharma *et al.*, 2007)

### **Extent of salt affected soils in Tamil Nadu**

In Tamil Nadu, about 469 thousand hectares of land area has been affected by salt affected soils. Chengalpet district has major area under inland alkaline soils, which accounted for 60.27 thousand hectares followed by Vellore and Thiruvannamalai districts together accounting for 42.90 thousand hectares (Table 1.2). Tiruchirappalli district which included the Karur and Perambalur had the area of 21.78 thousand hectares. Saline soil was higher in area in Chengalpet district, which accounted for 22.78 thousand hectares followed by Salem district including Namakkal had 20.52 thousand hectares. Thanjavur district including Thiruvarur and Nagappatinam had the saline area of 17.92 thousand hectares. Area under coastal saline and alkaline soil was higher in Thanjavur district including Thiruvarur and Nagappatinam, which accounted for 90.79 thousand hectares followed by Ramanathapuram and Tirunelveli districts. The total salt affected soil was higher in Thanjavur district including Thiruvarur and Nagappatinam, which accounted for 117.83 thousand hectares, followed by Chengalpet district, which accounted for 94.84 thousand hectares. Vellore and Thiruvannamalai districts together accounted for 51.56 thousand hectares. Tiruchirappalli district which included the Karur and Perambalur had an area of 51.31 thousand hectares.

**Table 1.2 Extent of salt affected soils in Tamil Nadu (000 ha)**

District	Inland Alkaline soils	Saline	Coastal saline and alkaline soil	Total
Chengalpet (Thiruvallur and Kancheepuram)	60.27	22.78	11.80	94.84
North Arcot (Vellore and Thiruvannamalai)	42.90	8.66	0.00	51.56
South Arcot (Villupuram, Cuddalore)	9.22	9.94	9.77	29.18
Dharmapuri	10.54	4.25	0.00	14.79
Salem (Salem and Namakkal)	17.21	20.52	0.00	37.73
Coimbatore (Erode and Coimbatore)	5.51	1.69	0.00	7.20
Tiruchirappalli (Karur, Perambalur, Trichy )	21.78	9.87	19.66	51.31
Thanjavur (Thanjavur, Thiruvarur and Nagapattinam)	9.12	17.92	90.79	117.83
Madurai (Madurai, Dindigul and Theni)	3.04	0.37	0.00	3.40
Ramanathapuram (Ramand, Virudunagar and Sivagangai)	4.45	1.70	19.01	25.16
Tirunelveli (Tuticorin, Tirunelveli)	10.89	9.14	15.01	35.02
Kanyakumari	0.00	0.32	1.42	1.73
Tamil Nadu	194.92	107.13	167.45	469.73

Salinity has emerged as one of the major factors responsible for low crop production in Tamil Nadu. During the last many years, various agricultural regions have significantly lost their productivity due to soil salinity. This situation is very alarming especially for the Cauvery Delta Zone (CDZ) which produces a major share of crops for the state.

As far as the agriculture in Cauvery Delta Zone (CDZ) is concerned, the most important issue is the loss of agricultural productivity of farm lands due to water and soil salinity. Because, these areas face extreme temperatures with low relative humidity, resulting in high rates of evaporation which in turn leads to deposition and accumulation of salt in the soil profile

affecting the growth of plants. Dissolved salts increase the osmotic potential of soil and water. An increase in osmotic pressure on the soil structure increases the amount of energy which plants must expend for absorbing water from the soil. As a result, respiration increases resulting in the growth and yield of most plants declining progressively (FAO, 1985). In such situation, small, and marginal farmers are the worst affected category. With salinisation of water and soil, the surface eco-landscape particularly biodiversity, soils, and vegetative cover also undergo drastic and often irreversible changes. This implies that the salinisation manifests in the reduced agricultural production and loss of biodiversity.

The farming in Cauvery Delta Zone (CDZ) is continuously deteriorating and reached to a point where farmers have become more interested in selling their lands as a result of changed land use rather than practicing agriculture. Salinization of land and groundwater may be the major reason for the present situation. However, besides these reasons, there may be some socio-economic reasons as well that are also operative in the background. Therefore, an analytical study of the socio-economic factors was required to investigate such facts. Such analysis in relation to saline soils will lead to sound conclusions and indicate how the profitability of farms is being affected by these factors.

The second issue is related to the use of saline water for domestic purposes, especially for drinking and its impact on human health. Drinking of saline water can cause health problems like knee pain, kidney stone, tooth decay. Many examples are available in the medical and toxicological literature regarding acute effects of "salt poisoning". It is observed that a relatively small quantity of sodium chloride in solid form may produce profound hypernatremia and critical squeal in pediatric patients. Magnesium salt concentrations in water exceeding 50 mg/L may cause laxative effects in users; however, these effects are likely to be transient. Similarly, sulphates of several forms (e.g., calcium, magnesium, sodium) may cause gastrointestinal irritation and laxative effects at greater than approximately 500 mg/L, coupled with disagreeable taste. The presence of each of these minerals in saline water supplies is likely, with relative quantities being dependent upon the specific geographic area and ancillary sources (WHO, 2003).

In order to avoid these health risks, people either buy fresh water from the market or walk long distances to collect fresh water at the cost of other productive activities. Finally, labour

allocation decisions at household level will also change due to changes in production and consumption. This indicates that the problem of salinisation manifests not only in reduced agricultural production and loss of biodiversity but also increased cost of drinking water and human health care. The present research study examines these issues by carrying out an economic valuation of ecosystem changes due to salinity in Cauvery Delta Zone (CDZ) of Tamil Nadu. Not much has been done so far to explore the impact of salinity on the socio-economic conditions of farmers. Hence in this study specifically focuses on the impact of salinity on the farmers and their strategies to cope with the situation.

The specific objectives of the study are:

- 1) To study the nature and extent of soil salinity in the study area
- 2) To analyse the comparative economics of rice production between salinity affected and normal soil production environments, and
- 3) To examine the efficiency of resources use in rice production and assess the impact of salinity on income and employment and
- 4) To workout the optimal plans for land utilisation and farm returns
- 5) To assess the problems faced by the farmers soil salinity and land degradation and suggest suitable policy measures

In this context, the present study is proposed with the following hypotheses.

- i) Land degradation due to soil salinity leads to reduction in crop productivity and intensity of land use and
- ii) At the farm level, the negative effects of soil salinity are threat to the sustainability of land resources and affects income generation of the farmers.

The overall objective of this study is to make an assessment of the effect of soil salinity on farm productivity and to assess the impact of salinity on income and employment of farm households, suggesting suitable measures for improving production and profit and minimizing environmental problems in the study region.

## **Scope of the study**

Soil salinization is a major cause for loss of productivity in irrigated lands. These saline lands were formed by comprehensive influence of special climate, hydro geology and other natural conditions. Similarly, coastal areas and irrigated lands in the state are affected by salinity due to sea water intrusion and over exploitation of ground water. Irrigation induced salinity is also the major source of soil salinity in the state. Salt accumulation will gradually increase in the root zone due to continuous irrigation of salt water. Other sources of salinity can be parent material, shallow ground water, fertilizer and amendments applied to the soils. Nature of salt affected soils is such that, economic utilization of land resources is restricted, there by adversely affecting rice production.

The present study was taken up with objectives to estimate the impact of saline soils at farm levels in terms of productivity, profitability of crop production. The results of the study relating to crop productivity, income and employment would help the scientists and policy makers to understand the impact of soil salinity on farm productivity and profitability and to design proper reclamation measures to ameliorate such problems. The results also will throw some light on socio economic conditions of the farmers and their ability to invest on reclamation of the problem soil.

This study would help the scientists to evolve cheaper technologies for the reclamation of saline and sodic soils. The study can be used for further modeling of policies for land reclamation. Hence, it will be useful for the planners, policy makers and the researchers to evolve appropriate policies and design remedial measures to bridge the gap and arrest further spread of problem of salinity.

## **Limitations of the study**

Most of the data used in the study may be subject to recall bias. However, such errors were kept at minimum through cross checks. There were some limitations in identifying and comparing affected and non affected sample farmers, but careful attention was paid to select the sample farmers in the similar agro climatic conditions. It hardly needs any emphasis that a study like the present one is bound to be location specific. Hence, the generalizations made out of study to different agro climatic zones should be interpreted with care and caution.

In the light of the response from the farmers, discussion with the scientists and officials and the use of available literature, the approach followed in the study could be the beginning for future research.

### **Organization of the study**

The present study is presented and discussed in detail in six chapters as mentioned below.

#### **Chapter I. Introduction:**

This part of the thesis describes the importance of the research problem, hypothesis, objectives, scope and limitations of the study.

#### **Chapter II. Concepts and Review:**

This chapter presents a brief review and definition of concepts, economic models and results of the related studies.

#### **Chapter III. Methodology:**

This chapter explains the sampling design, data collection, method of analyses and econometric models used in the study.

#### **Chapter IV. Description of the Study Area:**

A brief account of the agro – climatic conditions, land use and other information relevant to the present study is narrated in this chapter.

#### **Chapter V. Results and Discussion:**

Detailed discussion of the results of the study is presented to draw specific inferences in this chapter.

#### **Chapter VI. Summary and Conclusion:**

A summary of work done and the salient findings are presented, inferences are drawn and their implications for policy are presented in this chapter.

## *Concepts and Review*

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## **CHAPTER II**

### **CONCEPTS AND REVIEW**

Review of past studies, besides serving as a basis for conceptualization of ideas and variables, also helps in identifying issues relevant to the study. A thorough understanding of concepts used and the models employed in the earlier studies would help to draw meaningful inferences. A comprehensive review of literature has been carried out in accordance with the objectives of the study. However, some of the most pertinent studies carried out both in India and abroad related to the objectives of the present investigation are included in this chapter and presented under the following heads.

#### **2.1. Review of Concepts**

2.1.1. Problem soils - soil salinity and soil alkalinity:

2.1.2. Cost of cultivation

2.1.3. Net income

2.1.4. Income and employment

2.1.5. Migration

#### **2.2. Review of Econometric Tools**

2.2.1. Decomposition analysis

2.2.2 Data envelopment analysis

#### **2.3. Review of Past Studies**

2.3.1. Impact of salt affected soils on crop productivity

2.3.2. Migration of workforce

2.3.3. Policy Interventions

#### **2.1. Review of Concepts**

##### **2.1.1. Problem soils - Soil Salinity and Soil Alkalinity:**

Michael (1978) classified the salt affected areas into: (i) arid and semi – arid region with low rainfall and irrigated with poor quality ground water, (ii) regions of high water table and areas influenced by temporary water logging and seepage from canals and other sources and (iii) Coastal regions influenced by sea water intrusion. The major causes for the development of salinity and alkalinity in soils are: (i) deposition of salts on soil surface from high sub soil water

table, (ii) arid climate, (iii) use of saline ground water for irrigation, (iv) seepage from canals, (v) poor drainage and (vi) backwater flow (or) intrusion of seawater in to coastal area.

Bhargava (1990) reported that saline soils have a pH value of less than 8.5 (reduced to 8.2 in the Indian system) in saturated soil, an ESP value less than 15 and EC of the soil saturation extraction more than 4 ds/m along with preponderance of neutral salts i.e. chlorides and sulphates of sodium, calcium, magnesium and potassium excluding gypsum.

According to Irvine and Doughton (2001), salinity and sodicity refer to the presence of salts in the land surface, in soil, rocks or in water. The process of dissolidification of rocks brings salt to upper soil surface and led into streams and rivers. It pollutes the ground water further, which deteriorates the soil quality.

Oosterbaan (2003) stated that alkaline soils are soils (mostly clay soils) with a high pH (above 9) and poor soil structure and low infiltration capacity, the total amount of soluble salts, especially sodium chlorides is not excessive ( $EC < 4 - 8 \text{ dSm}^{-1}$ ). Often they have a hard calcareous layer at 0.5 to 1 m depth.

According to Sen (2003), salt affected soils occur in the arid and semi – arid regions where evapo-transpiration greatly exceeds precipitation and such soils are primarily classified as saline and sodic soils.

Saline soils contain excess neutral soluble salts like chlorides and sulphates of sodium, calcium and magnesium with  $EC$  more than  $4 \text{ dSm}^{-1}$ , pH less than 8.2 and ESP less than 15. These soils are fairly permeable due to well flocculated soil structure. In saline soils sodium has a partner in crime namely chlorine, which reduces the availability of water to plants. The higher concentration of salts in water can kill the plants.

Sodic soils are having distinguishing characteristics of high exchangeable sodium per cent, ESP more than 15,  $EC$  less than  $4 \text{ dSm}^{-1}$ , pH more than 8.2 and presence of higher amount of carbonates and bicarbonates of sodium. These soils have poor physical properties. The high Na content results in low permeability, crusting and hardening of the surface soil upon drying. Low organic matter content, toxic concentration of  $\text{CO}_3$  and  $\text{HCO}_3$ , poor microbial activity due to unfavourable pH and reduced availability of N, K, Zn and Fe nutrients also affect the productivity of the soils. Sodic soils are water logged and eroded easily. Sodic top soils in arid and semi – arid regions are subject to dust storms, which create major environmental and human

health problems. The environment is most affected due to land degradation resulting in climatic changes, occurrence of drought and floods, diminishing flora and fauna and an overall ecological imbalance.

Thiruchelvam and Pathmarajah (2003) explained alkali soils as the one having same property as saline soil but varies in pH, usually above 8.5. Soils that contain excessive amount of adsorbed sodium are referred to as alkaline or saline – sodic. Sodium carbonate is the chief soluble salt. Saline soils are soils containing soluble salts in concentration that interfere with the growth of most crop plants. These soils contain mostly neutral salts like chlorides and sulphate of Ca, Mg and Na. The Electrical Conductivity (EC) of soil saturation extract is  $4 \text{ dSm}^{-1}$  or more, pH 8.2 or less and exchangeable sodium less than 15 per cent. The soil, when it is dry, usually have a white layer of salts. Because of the presence of excess neutral salts, these soils are usually flocculated and the soils have good permeability.

Natarajan *et al.*, (2009) in their study estimated that the soils with EC more than  $2 \text{ dSm}^{-1}$  in vertisols and  $> 4 \text{ dSm}^{-1}$  in non vertisols were considered as saline. Increase in soil pH beyond 8.5 results in sodicity or alkalization that results in increase of exchangeable sodium percentage in soils ( $>15$ ). Based on the type of problem, it has been divided into saline (Ssa), sodic(Sso) and saline sodic(Sss).

Satish (2010) observed twin problems of waterlogging and soil salinity in fertile lands serving them unfit for cultivation among sample farmers. The prevalence of black cotton soils with poor porosity due to high clay content (60-65%) further speed up the process of rise in water table and there by induce secondary salinisation.

### **2.1.2 Cost of Cultivation**

Profitability of the crop enterprises can be estimated by finding out the relationship between the cost incurred and the return realized from the crop production. However various methodological issues arise frequently in the estimation of the cost and returns on the account of variability in farms in terms of longevity of enterprises, nature of assets/ resources involved and production structure necessitating clear cut definition of cost and returns for realistic estimation.

Raju and Rao (1990) had used six different cost in rice production namely cost A1, A2, B1, B2, C1 and C2. Cost A1 included all the expenses in cash and kind incurred in the production. Cost A2 included cost A1 plus rent paid for leased in land. Cost B1 included cost A1 plus interest on value of owned capital assets excluding land, cost B2 comprised cost B1 plus rental value of owned land plus rent paid for leased in land (net of land revenue). Cost C1 denoted cost B1 plus imputed value family labour. Cost C2 included cost B2 plus imputed value of family labour.

Gujar and Varghese (2005) who studied the cost of cultivation of Rabi crops in Rajasthan defined operational cost as sum of cost of hired human labour, family labour and machine labour, seed, FYM, fertilizers, insecticides, irrigation charges and interest on working capital. They defined fixed cost as a cost of land, revenue, taxes and depreciation on implements and buildings, rent paid for leased in land, rental value of owned land and interest on fixed investment. They also defined total cost as sum of operational cost and fixed cost.

Thakur and Sharma (2005) studied the organic farming for sustainable agriculture and classified the cost as cost A1, cost A2, cost B, cost C and cost D. Cost A1 included cost of seed and seedling, value of FYM, compost, fertilizer and pesticides, other chemicals used, bullock labour, hired human labour, hired machinery, interest on working capital, depreciation and repairs of farm tools and machinery. Cost A2 included cost A1 plus rent paid for leased in land. Cost B consisted of cost A2 plus imputed rental value of owned land less rent paid on leased in land plus interest on fixed capital. Cost C consisted of cost B plus imputed value of family labour. Cost D constituted of cost C plus management cost at the rate of 10 per cent of cost C.

Sivangaraju (2006) in his comparative analysis of SRI and traditional method cultivation had used cost as Cost A1, Cost A2, Cost B and Cost C. Cost A1 includes the value of casual hired labour, attached labour, imputed value of owned bullock labour, hired machine labour, imputed value of owned machine labour, seeds, manures and fertilizers, plant protection chemicals, irrigation charges, interest on working capital, depreciation and land revenue. Cost A2 includes cost A1 plus rent paid for leased in land. But, the rent paid for leased in land was zero, as none of the sample farmers took land on lease basis. Hence, cost A1 and cost A2 are similar and were simply called as Cost A. Cost B included Cost A2 plus imputed rental value of owned land plus interest on owned fixed capital. Cost C includes Cost B plus imputed value of family labour.

Satish (2010) reported that cost of production per quintal of both maize and wheat crops increased substantially in degraded soils over normal soils due to considerable decrease in productivity.

Rawal and Madhura (2011) had measured cost of cultivation by the cost of A2 (mainly paid-out costs) and net income or farm business income as gross value of output minus cost A2. Cost A2 included cost of hired labour, cost of hired and owned animal labour, cost of owned and hired machinery, value of home produced and purchased seeds, value of plant protection chemicals, value of home produced and purchased manure, value of all fertilizer used, depreciation of fixed capital, irrigation charges, land revenue, interest on working capital, rent paid for leased in land and any other paid out expenses.

### **2.1.3 Net Returns**

Chengappa *et al.*, (2003) in their study used cost and net returns to find the profitability of hybrid rice cultivation. They had taken the value of paddy and straw at market price as gross return. Net return was gross return minus and cost of cultivation.

Gujar and Varghese (2005) studied the cost of cultivation of Rabi crops in Rajasthan defined gross returns as the sum of value of main product and value of byproduct of the crop and also defined net income as gross income minus total cost.

Thakur and Sharma (2005) studied the organic farming for sustainable agriculture defined net income as the gross income minus total cost.

Rawal and Madhura (2011) had measured net income or farm business income as gross value of output minus cost A2.

### **2.1.4. Income and Employment**

#### **2.1.4.1. Farm and Household Income**

National Council of Applied Economic Research (1961) defined household income as the earnings, both in cash and kind that is accrued and realized by the members of the household during the reference period of 12 months.

Kahlon and Johl (1963) estimated the gross income by adding all income from farm and non farm sources and borrowings from institutional and non – institutional sources.

According to Nandal (1972), the farm income included the value of crop and livestock products, sale of farm assets, receipts of land rent, custom hire services, etc.

Sharma (1980) defined gross income as the income derived from the crops grown. The values of both main and by products were considered in estimating the gross income.

According to Kannan (1981) gross income included on farm income, off – farm income consisting of hiring out of labour, bullock pairs, machinery and equipment and non – farm sources including income from services, trade, profession, shop keeping, etc., from all members of the family. He also described it as the sum of income of the family from all the sources accessible to all the members.

Rao and Mary (1985) determined the components of the household income as wage income of the household, the returns from the assets and remittance to the household from outside.

Mani (1994) calculated farm income by adding the value of crop output, income from livestock products, sale of livestock, value of the farmyard manure, wages received for agricultural work from other farms, charges received from hiring out of farm equipments and bullock pairs and non – farm income from such sources as services.

Thanmathi (1995) defined household income as the total amount of current receipts by all members of household during the reference period from wages and salaries, income from currently operating business, profession, services, rent, interest dividend, gifts and bonus.

Hossain *et al.*, (2000) defined household income as money value imputed to receipts in kind at prices which include consumption of self – produced crops, livestock, fishery and forest products and their by products.

Meena (2002) reported that household income consisted of income earned by the members of a family during a specified period and the household income included the income from on – farm, off – farm and non – farm activities.

Satish (2010) studied that the annual production loss due to reduced crop yields on account of soil degradation was very high both at the level of sample farms and on command in different degraded soils scale.

In this study, household income is defined as the summation of on – farm income consisting of value of crop output, income from livestock products, sale of livestock, value of the farmyard manure (livestock income); off – farm income that includes wages received for

agricultural work from other farms, hiring out of farm equipments and bullock power and non farm income from trade, pension, savings and other services other than agriculture received by all members of the family working in different categories during the specified period.

#### **2.1.4.2. Employment**

According to National Sample Survey (1955) a person would be fully employed if he worked for 42 hours or more in the reference week.

Bishnoi (1966) defined employment as, if a person worked for 320 days or more in the year constituted full employment.

Sen (1975) considered employment as one, which would yield income to the employed, yield output and give a person the recognition of being engaged in something worthwhile.

Smith (1976) viewed employment as a state in which a person would combine his or her physical and mental efforts with other resources including human efforts in a production process.

Vaidialingam (1980) remarked that a fully employed person is one who worked for 300 days or more in a year.

Jain (1983) defined employment on daily basis and considered if a person, he or she, worked for four hours or more during a day, as employed for the whole day.

Selvaraj (1985) explained three types of employment for household labour force viz., on – farm, off-farm and non – farm employment. On-farm employment referred the involvement of household members in agricultural operations including livestock. Off-farm employment referred to wage employment of family labourer in agriculture outside their own farm while non-farm employment included wage employment as well as self employment in non agricultural operations.

Jayakumar (1999) defined employment as a state wherein a person works for minimum 200 days to meet out his minimum requirements. In this study, three types of employment for household labour-force have been considered viz., on-farm, off-farm and non –farm labour employment. On-farm employment refers to the involvement of household members in agricultural operations including livestock operations. Off-farm employment referred to wage employment of family labourer in agriculture outside their own farm while non – farm employment included wage employment as well as self employment in non agricultural operations.

Satish (2010) reported that overall labour employment in crop production declined during *kharif* and *rabi*/summer season in waterlogged and severe saline soils when compared to normal soils.

### **2.1.5. Migration**

Epstein (1963) remarked that some village situations encouraged their inhabitants to seek work elsewhere during slack seasons only owing to the ecological situations. In a dry single cropped village of Chengalpattu, Tamil Nadu, a large number of families migrated for two or three months in a year to the irrigated delta region where two rice crops had been grown. (Out migration thus, to other areas from the study villages during the agricultural season is towards seeking income and employment opportunities).

Srivastava and Ali (1981) remarked that seasonal and circular (also known as cyclical, oscillatory) migration has long been a part of the livelihood portfolio of poor people across India.

Natarajan (1981) defined out – migration, seasonal migrant, permanent migrant and temporary migrant. Out migration is the movement of people from the place of origin (where per capita agricultural productivity was low due to resource factors) to the place of destination for a specified period. A seasonal migrant is one who moved out during some seasons in the year and wanted to go back to his/ her place of origin irrespective of his / her duration of stay. The permanent migrant as one, who had moved out from origin and living in the destination for more than three years. A daily migrant is one who moved out every day from the origin to destination for the purpose of employment and income earning. He also defined temporary migrant as one who had moved out under conditions of stress for example during drought period and wanted to go back to his / her place of origin, when it received favourable monsoon.

According to Maier and Weiss (1991), migration was the phenomenon by which people or households move from one place to another, one occupation to another in pursuit of improving their situation, or more precisely, to be better off in the future than they would be in the old.

Rao (1994) defined seasonal and circular labour migration as ‘characteristically short term, repetitive or cyclical in nature, and adjusted to the annual agricultural cycle’.

Mc Dowell and De Haan (1997) revealed that migration is a part of the normal livelihood strategy of the poor and does not occur only during times of emergency or distress.

Chopra and Gulati (1998) revealed through a study conducted in Rajasthan that out – migration in rural area happened due to environmental degradation.

Velmurugan (2001) defined a permanent migrant as one who had moved out from the village to the nearby and far off localities for earning income and seeking employment opportunities for more than one year.

Satish (2010) studied the pattern of migration of farm families to the distant cities, more so among marginal and small farmers was observed. It was found to be perennial and permanent where the entire family had to leave their dwelling places. Inadequate farm size and consequent degradation led the small and marginal farmers to migrate in large proportion when compared to farmers with larger farm size.

Rao (2001) reported that migration is people's coping, survival and livelihood strategy and not just a response to emergencies.

### **2.2.1 Decomposition Analysis**

Decomposition analysis is a technique used to discern the effects of technology or an environmental damage or any other problem on production. To discern the true impact of soil salinity / alkalinity, several analytical approaches have been used.

Pincock (1969) utilized whole farm budgets to analyze the impact of salinity on net farm income.

Moore and Synder (1974) used linear programming based procedure for estimating economic losses on multi crop farms.

Bisaliah (1977 and 1978) applied production function model (Cobb – Douglas form) in wheat farming to find out changes under new production technology and to estimate the contribution of various sectors to the differential employment between new technology farms and old technology farms.

Hussian and Young (1985) and Joshi (1987) estimated loss due to soil salinity using production function approach with the help of dummy variable technique.

Yaron (1985) used dynamic programming models to analyze the long term implications of leaching of salts in annual and perennial crops.

Joshi and Jha (1992) in a study conducted at Sharda Sahayale Irrigation Project area decomposed the total difference in output in salt affected from normal land and water logged land from normal land. The difference in mean income was 88 and 84 per cent in alkaline and waterlogged situation, respectively. The change in output was 63.4 and 64.4 per cent respectively.

A study on Impact of soil alkalinity on farm income in Tiruchirappalli district conducted by Mani (1994), considered the size of holding, cropping pattern, employment generation, cost of cultivation and productivity of crops between normal and alkaline farms. Decomposition analysis was used to assess the land degradation effect due to soil alkalinity. He found that, the income change due to soil alkalinity was 25.20 per cent and the difference due to changes in input use was 72.99 per cent.

Badal and Singh (2001) employed decomposition model as the methodology followed by Bisalialah (1977) and Joshi and Jha (1992) in their studies.

Gummagolmath (2000) used decomposition model to estimate the difference in output due to soil degradation and input changes in Tungabhadra Project command area. The estimated model accounted for 67.85 per cent of the difference in paddy productivity between normal soils and moderately saline soils, and 54.13 per cent between normal and waterlogged soils. The problem of salinity accounted for as much as 63.17 per cent of the difference in productivity between normal and moderately saline soils. The corresponding figure between normal and waterlogged soils was about 29.20 per cent. It was inferred that only about 4.68 per cent of the output difference was attributed to reduced use of inputs in moderately saline soils and reduced inputs in waterlogged soils contributed productivity difference of 24.93 per cent.

Binukumar (2002) decomposed the yield difference (in terms of value) in sorghum and paddy crop due to the effect of industrial effluents. He estimated that in total yield difference of sorghum, the industrial effluent damage accounted for 78.53 per cent and the input effect was only 21.47 per cent. In paddy crop, 59.00 per cent of yield damage was due to industrial effluent and 41.00 per cent of yield damage was due to the input effect.

Datta *et al.*, (2004) analyzed the effect of different levels of soil salinity on crop productivity both in paddy and wheat crops. They estimated the effect of soil salinity on crop productivity through Cobb-Douglas production function by including the variables of salt concentration (dS/m) and seasonal total rainfall (in mm). Multiple regression analysis was also tried by them to combine both physical and management factors in the estimation of gross income fluctuation at various levels of salinity (both saline and alkaline). In the present study, the loss due to soil sodicity in crops (paddy, chillies and sorghum) was estimated using decomposition of output technique by following the methodology used by Joshi and Jha (1992). The change in output (yield) between normal and problem soil was decomposed into changes

due to salt affected Soils and changes due to changes in input use. The production function (Cobb – Douglas type) was estimated for normal and sodic soils separately and the effect was decomposed.

Dhanya (2004) estimated the yield difference due to the effect of salinity and change in inputs use level through decomposition analysis. The study revealed the total estimated difference in productivity to be at 28.76 per cent, of which the effect of salinity was 26 per cent and the yield difference due to input use was only 2.76 per cent.

Kulkarni (2007) studied the decomposition of total productivity differences in paddy. The contribution of salinity (-93.51 per cent) and waterlogging (-60.96 per cent) on yield difference was found to be negative. However, the difference in productivity due to change in input use was found to be negative in the case of waterlogged situation (-24.62 per cent) compared to gain observed in saline soils (6.42 per cent). The major factors that contributed for productivity difference between saline and normal soil were organic manure (-8.93 per cent) followed by human labour (-8.17 per cent), fertilizer (-5.77 per cent) seeds (-3.77 per cent) and plant protection chemicals (-0.42 per cent). But, the negative contribution of these inputs was offset by positive contribution of bullock labour(33.48 per cent).

Thilagavathi and Chandrasekaran (2009) carried out a decomposition analysis to study the productivity differences between affected and non affected farming situation in their study conducted in the Ramanathapuram and Tuticorin districts of southern Tamil Nadu on land degradation and its impact on livelihood security of farm households. The total productivity difference between affected and non affected farms was 30.30 per cent for paddy and 29.27 per cent for chillies. Among different sources responsible for total productivity variation, the effect of sodicity was high in both paddy (27.70 per cent) and chilly (25.84 per cent). The contribution of differences in input use level was only marginal, 2.67 per cent in paddy and 3.43 per cent in chilly. Among various inputs, those contributing positively to the productivity difference between affected and non affected paddy and chilly farms were human labour, machine labour, seeds, manures, fertilizers and pesticides.

Priyanka (2012) in her study on economic analysis of land reclamation measures on rice productivity used the decomposition analysis to reveal the contribution of land degradation and various inputs to the productivity difference between alkaline and non alkaline soils. The total productivity difference in paddy was estimated at -28.40 per cent between alkaline and non

alkaline soils. Alkalinity has negatively influenced the yield and was responsible for the -30.23 per cent variation in yield.

### **2.2.2 Data Envelopment Analysis**

DEA uses linear programming to construct the efficient frontier with best performing observation of the sample used. The frontier surface is done by the solution of a sequence of linear programming problems. For the construction of production function (frontier), the stochastic function fitting or the DEA (Data Envelopment Analysis) is suitable Brummer *et al.*, 2002, Charnes *et al.*, 1978, Coelli, 1996.

Sharma *et al.*, (1999) attempted to compare efficiency measures obtained from the parametric stochastic efficiency decomposition technique and non-parametric /deterministic frontiers / data envelopment analysis (DEA) approaches for technical, allocative and economic efficiencies in swine production in Hawaii, USA. Under the specification of variable returns to scale (VRS), the mean technical, allocation and economic efficiency indices were 75.9 per cent, and 57.1 per cent, respectively for the parametric approach and 75.9 per cent, 80.3 per cent and 60.3 per cent for DEA, while for the constant returns to scale (CRS) they were 74.5 per cent, 73.9 per cent and 54.7 per cent, respectively for the parametric approach and 64.3 per cent, 71.4 per cent and 45.7 per cent for DEA. The results from both approaches revealed considerable inefficiencies in swine production in Hawaii and the estimated mean technical and economic efficiencies obtained from the parametric technique were higher than those from DEA for CRS models but quite similar for VRS models, while allocative efficiencies were generally higher in DEA. However, the efficiency ranking of the sample producers based on the two approaches were highly correlated.

Basanta *et al.*, (2004) studied the efficiency of rice farming in Nepal as a means of exploring the reasons that hinder productivity growth in rice farming. This study used a two step methodology. In the first step, data envelopment analysis (DEA) was used to model efficiencies as an explicit function of discretionary variables. In the second step, farm specific variables such as a farmer's risk attitude, age, education, gender and family labour endowment are used in a Tobit regression framework to explain variations in measured inefficiencies. The results found that Farrell's overall economic efficiency was 66 per cent meaning that the sample farms can potentially reduce their overall cost of rice production by 34 per cent and still achieve the

existing level of output. The results of the Tobit regression method showed that younger farmers are more likely to be inefficient than their older counterparts and more educated farmers are more likely to be efficient as compared to their less educated counterparts.

Debnarayan and Sudpita (2004) examined the extent of technical efficiency of paddy under different types of tenure and different farm sizes in West Bengal using a Data Envelopment Analysis (DEA). Two types of villages – technologically advanced villages having high incidence of irrigational and HYV facilities and technologically backward villages having no irrigational and HYV facilities were selected. The use of high technological inputs in agriculture is not so important in improving the efficiency level of the farms. Similarly, the proportion of efficient farms increase with increase of farm size except the lowest farm size where all the farms are efficient

Rajashekharappa *et al.*, (2004) made a critical study on technical efficiency in arecanut production. The data envelopment analysis programme DEAP- a non- parametric linear programming approach was used for estimating technical efficiency scores. The extent of overall economic efficiency has been expressed in terms of cost inefficiency. Allocative efficiency was calculated by using cost minimization data envelope analysis. Study revealed that mean efficiency has been found to vary widely from 69 to 90 per cent among the sample farms and across regions, which indicates that on an average, the realized output could be raised by 10 to 31 percent without any additional resources. The results also showed that through proper use of existing technology, there was a huge potential in improving productivity of areca nut which can be exploited.

Kumar *et al.*, (2005) estimated the efficiency levels of individual rice farms applying Data Envelopment Analysis (DEA) approach, which is based on linear programming technique. A linear Tobit regression equation was used to identify the factors associated with efficiency. Data were collected from a sample of 50 farmers selected in Bageswer district in Uttaranchal. The study found that the overall technical efficiency in the case of improved rice growing farms was higher than that of rice farms growing local varieties. The study also suggests that efficiency initially increases and eventually declines with age. Moreover, higher education was found to be associated with higher efficiency level.

Curtiss and Jelínek (2012) studied farm-level efficiency measures by means of a deterministic linear programming method, Data Envelopment Analysis (DEA). Correcting for

selection bias using a one-step endogenous switching regression reveals that farms displaying a lower cost efficiency score are less likely to adopt PF technology. Non adopters switching to PF technology were likely be affected by a significant decrease in cost efficiency given their production conditions and/or managerial and technical skills. In line with this, results indicate that human capital and farm size increase the likelihood of PF adoption. Cost (allocative efficiency) implications of PF-related changes in input structure only, on the other hand, are not found to have an impact on the choice of technology. Both technical and allocative efficiency measures represent components of overall cost efficiency, measured in connection to PF technology. A joint feasible production set will be assumed in the cost efficiency model for both production practices (PF and non-PF) to create a joint performance benchmark and thus a comparative basis for the efficiency measures.

## **2.3. Review of Past Studies**

### **2.3.1. Impact of Salt Affected Soils on Crop Productivity**

Several studies were undertaken in India to assess the extent of land degradation. These studies inferred that vast areas of land in India suffer either by salinity or alkalinity and an exact estimate of the area affected by salt-problems is yet to be made available. Apart from these aggregate estimates for the entire country some scattered information about the extent of the area affected by soil salinity and waterlogging is available from various parts of the country and in different irrigated commands. These studies also came out with various causes for waterlogging and soil salinity and also farmers' perceptions on the twin problems. History of secondary salinization and waterlogging in Indian agriculture is about 150 years old. There was no mention about this problem until the 19th century. Obviously, with the extension and improvement of canal irrigation during the 19th century, the twin problems of waterlogging and salinity in the Indian plains began to make appearance.

Joshi and Agnihotri (1984) assessed the impact of canal irrigation on soils in Indian canal system. The study identified two major adverse effects of irrigation viz., soil salinity and waterlogging. These degradation processes are largely responsible for converting fertile irrigated area into unproductive barren lands. The yields of rice were far below the pre irrigation period yields which substantiated that the very objective of canal irrigation to raise the productivity per unit of area was defeated. Aggregate loss in production was estimated to the tune of 9.7 lakh

tones roughly amounting to Rs. 1,803.91 million (1981-82 prices) due to salinity and waterlogging.

Joshi (1987) estimated the losses in yield at about 50 per cent on an average for different crops due to salinity. He also reported 40 per cent yield loss in paddy and 80 per cent yield loss in potato because of water logging problems. The estimated productivity losses ranged from 10 per cent in the case of low salinity to 85 per cent in the case of high salinity for paddy.

Joshi and Jha (1992) made an attempt to study soil alkalinity and waterlogging in Sharada *Sahayak* Irrigation Project. Results on productivity and profitability of crop production indicated that yields of paddy and wheat declined 50 per cent in about 8 years time due to increasing soil degradation. Paddy and wheat yields went down by more than 51 per cent and 56 per cent respectively. Net income declined by 54 per cent in waterlogged and 87 per cent in saline soils for HYV of paddy.

Singh and Nandal (1993) showed that land degradation in the form of soil salinity and waterlogging was assuming alarming proportions in the irrigated tracts of Haryana State. The investigation was based on the primary data collected from a sample of 248 farmers pertaining to agricultural year 1989-90. The study examined the adverse effects of degraded lands on crop productivity. The productivity and returns over variable cost from all crops declined in both types of degraded soils as compared to normal soil partly due to degradation effect and partly due to the reduced input levels. The total estimated loss in the study area due to land degradation was about Rs. 257 crores on account of land unfit for cultivation and lower yields in the study area.

Joshi *et al.*, (1994) estimated the yield of important crops under different soil environment in western Yamuna and Bhakra Canal Command area, Haryana as under:

**Table 2.1. Crop Productivity Differences in Affected Soils**

(Yield in kg/ hectare)

Crop	Normal soil	Salt affected soil	Water logged soil
Paddy	5979	4047	4837
Wheat	3281	2418	2838
Cotton	1022	592	412
Sugarcane	38730	22849	16333

Source: Joshi (1994), salinity management for sustainable Agriculture, Central Soil Salinity Research Institute, Karnal.

Gajja *et al.*, (1995) studied productivity variations in Kakrapar Canal Command area of Gujarat State. The study was mainly based on primary data obtained from 220 farmers distributed over 22 villages during the agricultural year 1989-90. The farmers in the command area allocated more area to water intensive crops like sugarcane and paddy ignoring the suggested cropping pattern. This consequently led to the problem of soil degradation in the form of salinity and waterlogging. The results further showed that highest crop yield observed on normal soils, and the lowest on strongly degraded soils. The yield reduction was 85 per cent lower in case of cotton and paddy in comparison to normal soil. A significant difference in net income per hectare was observed on normal soils as compared to degraded lands.

Gajja *et al.*, (1996) examined the effect of land degradation on productivity and profitability for selected crops of sugarcane and rice under different soil environments in Ukaikakrapar canal command in Gujarat. They reported that crop yields declined with increase in the level of soil degradation and land irrigability class. Highest yield was recorded in normal soils and land irrigability class II, whereas, lowest yield was observed on severely degraded land to an extent of 72 per cent for both the crops. The moderately degraded soils recorded 45 per cent less crop yields compared to normal soils. A significant difference in net income was also noticed between normal and degraded land. Cultivation of crops was not found to be an attractive proposition on severely degraded lands and irrigability classes III and IV.

Studies by Datta and Dayal (2000) revealed that, net income from wheat and mustard dropped by 52 and 34 per cent respectively, in case of high salinity. In case of alkalinity the yield of wheat and mustard dropped by 45 per cent and 28 per cent, respectively. Shishodia Anil (1996) estimated a total loss of Rs. 6,156 crores / annum caused by problems of water logging, salinity and alkalinity.

Gummagolmath (2000) conducted a study to assess economic impact of irrigation induced degradation due to waterlogging and soil salinity in Tungabhadra Project command area in Karnataka. It was concluded that paddy occupied the largest area in the total cropped area on normal and degraded soils. The production activities were highly limited on degraded soils, about 70 per cent of the severe saline area was left fallow and as a result the cropping intensity was low in these soils. The cost of cultivation and returns realized on degraded soils were much less when

compared to normal soils. Farmers applied more of FYM and seeds on waterlogged soils. They applied less of fertilizers, human labour and irrigation on degraded soils. The magnitude of yield reduction was more than 200 per cent in severe saline soils, more than 100 per cent in moderate saline soils and about 95 per cent in waterlogged soils when compared to normal soils. The farmers noticed negative returns on severely degraded soils (Rs. 5419.47/ha). The response behavior with respect to input use was high in normal soils and was low in case of degraded soils. The Marginal Value Product (MVP) and Marginal Factor Cost (MFC) ratios generally indicated under use of resources in degraded soils compared to normal soils. Prevalence of black cotton soils in the command areas, faulty irrigation practice, lack of proper drainage and cultivation of irrigation intensive crops have resulted in land degradation.

Pazhanivelan *et al.*, (2001) found that the conjunctive use of canal and sodic water for rice based cropping systems revealed that, irrigating rice with poor quality sodic water resulted in 36 to 54 per cent yield reduction in grain yield.

Chinnappa (2002) in a study on valuation of irrigation induced soil degradation in Tungabhadra Project reported that, paddy constituted major crop which occupied large proportion of area. The soil degradation reduced the crop productivity of paddy, increased the unit cost of production and reduced the net return on degraded soil, as compared to normal soil. The study also revealed that the cropping intensity reduced by 30 per cent and land value by 50 per cent in case of degraded soil as compared to normal soil. Fallows and abandoning were also increased in degraded land.

Datta *et al.*, (2004) in their study focused mainly on the adverse effects of water logging and soil salinity on crop and land productivity and causes for such problems in semi-arid regions in the north-west. They identified that a high proportion of irrigation water is derived from pumped groundwater of poor quality which accumulate salts at the crop root zone causing degradation of soil. Due to differences in environmental parameters in the farming systems, such as groundwater quality, soil types and uneven distribution of irrigation water, income losses to the farming community are not uniform. The results showed that the net present value of the damage due to waterlogging and salinity in Haryana is Rs. 23900/ ha at 1998-99 prices. The estimated potential annual loss was Rs. 1669 million (US\$37 million) in waterlogged saline area. The major finding of the study was that, it is not the crop intensification which is the root cause of land degradation, but rather the policy environment that encouraged inappropriate land use

and injudicious input use, especially excessive irrigation, trade policies, output price policies and input subsidies all have contributed to the degradation of agricultural land.

Samra and Sharma (2009) in their study on safeguarding natural resources and environment reported that, the land degradation is a major threat to our food and environment security. Degradation of different forms constituted 150 million hectares accounting 45.6 per cent of the total geographical area. The areas under waterlogging, and salinisation and alkalization together are 9.0 and 9.2 million hectares respectively. The development of the major and medium irrigation projects has also caused degradation of large areas with the occurrence of waterlogging and secondary salinity on an area of 4.5 million hectares. The observation of water table data over a period showed that in almost all the irrigation commands the water table has a rising trend after the introduction of canal irrigation. The annual rise in water table is 0.28 meter in Mahi Right Bank Canal Command (Gujarat), 0.29- 0.88 meter in Rajasthan Canal Command (IGNP), 0.30-1.00 meter in Western Yamuna and Bhakra Canal Command (Haryana), 0.10-1.00 meter in Sirhind Canal Command (Punjab), 0.68 meter in Sharda Sahayak Canal Command (Uttar Pradesh), 0.60-1.20 meter in Malaprabha Canal Comand (Karnataka), 0.32 meter in Nagarjun Sagar Irrigation Project (Andhra Pradesh) and 0.26 meter in Sriram Sagar Irrigation Project (Andhra Pradesh).

Verma *et al.*, (2003) found that irrigation with different quality of water revealed that EC and SAR of soils were significantly and positively correlated with EC and SAR of irrigation water. The continuous and indiscriminate use of this water has resulted in build up of excessive sodium in soil. In heavy textured vertisols the rate of deterioration seems to be high than light textured soils.

Datta *et al.*, (2004) analysed the effect of different levels of soil salinity on crop productivity (in paddy and wheat) and income of farm families in Haryana from the year 1994 to 1999. The results indicated that per hectare yield loss was 150 and 337 kg in paddy and wheat crop respectively. The income loss ranged from Rs. 963 to Rs. 2166 per hectare for paddy and for wheat it ranged from Rs. 1146 to Rs. 3851 per hectare.

Chinnappa (2005) studied the economic feasibility of land reclamation technologies adopted by the farmers of Tungbhadra Command Area in Karnataka for amelioration of irrigation induced soil degradation. He used partial budgeting to study the feasibility of each technology. Among different technologies followed by the farmers, adoption of leaching was

found least costly and could result in an incremental output of 14 quintals per hectare on saline soil.

Kulkarni (2007) conducted a study to assess economic impact of waterlogging and soil salinity and the viability of reclamation of such soils using subsurface drainage system (SSD) in Upper Krishna Project command area. It was found that, the farmers of degraded and normal soils allocated more area under water intensive crops like paddy ignoring the suggested cropping pattern. The production activities were highly limited on different degraded soils where, a large (55 to 83 per cent) proportion of the total area was abandoned from production and thereby reducing cropping intensity in these soils. The reduction in yield of paddy over normal soils was high (50 to 60 per cent) due to degradation. The aggregate annual monetary loss due to loss in production for the entire command was estimated at Rs. 201.10 crores.

Thilagavathi and Chandrasekaran (2009) in their study assessed land degradation and its impact on livelihood security of farm households in Ramanathapuram and Tuticorin districts of southern Tamil Nadu. Specifically, the impact of sodic soils at farm level in terms of resource use, productivity and profitability of crop production and income, employment and household consumption behavior were all examined. Sources of productivity differences between affected and non affected farming situations were identified.

Tripathi and Kumar (1999) in his research on economics of alkali land reclamation measures had found that sodic land could be reclaimed successfully in a short period of 3 years at a cost of Rs. 35000 per hectare, out of which highest share was required for purchase of soil amendment gypsum. In addition to initial reclamation cost, an annual operational cost of Rs. 18000 and Rs 15000 were also required for rice and wheat cultivation, respectively.

Priyanka (2012) in her study on economic analysis of land reclamation measures on rice productivity found that the cost of cultivation of paddy in cost A was low in alkaline soil without reclamation condition and higher in alkaline soil with reclamation condition followed by non alkaline soil condition. The net income in alkaline soil with-out reclamation was very low when compared to net return in non alkaline soils. The reclamation when followed increases the yield by 21 per cent and doubles the net returns.

### **2.3.2. Migration of Work Force**

The National Council for Applied Economic Research (NCAER) survey report (1961) revealed that in an economy, where most people earned their living from the lands, the land availability determined the rate of migration. The demand for labourers in agriculture was normally determined by the availability of land for cultivation. A high rate of migration was observed during (out migration for income and employment for more than an agricultural season) lean season.

Brown and Moore (1970) observed that migration movements were the outcome of a multi-stage decision process in which typically an individual had to engage in some form of search before uncovering opportunities for movement, which should be accepted or rejected in turn as they arose. In any case, according to them, the two key decisions were, first, to look for opportunities rather than committing one to migrate and then deciding where to migrate.

Bogue (1977) in his migration studies tried to break down migration motives into various categories, which were further structured by De Jung and Fawcett (1981) stressing different aspects of the general framework namely economic (wages, vacancies, unemployment), social (social mobility, social status), environmental (residential satisfaction) factors etc.

Oberoi and Singh (1980) stated that the rural people migrated in response to unemployment or to contribute to the household income or to attain social mobility. The poor segment migrated from rural to urban areas with the anticipation of better earning potential and standard of living.

Goodman (1981) found that it was people's expectations about their own prospects in various occupations, which guided migration decision. These expectations were based on their past experience, knowledge, contacts, etc.,

Natarajan (1981) studied that migration was the result of dwindling water level in the wells. It deteriorates the level of crop income, living conditions and employment opportunities in the villages. These factors push the small cultivators and agricultural labourer to the new place.

Rogers and Castro (1981) were of the opinion that only patterns of age selectively have gained universal acceptance by population analysts and demographers in the developed world. In this regard, Rossi (1955) postulated that young adults had the highest propensities to migrate for reasons associated with that stage in their life cycle.

Chalmers and Greenwood (1985) noted that migration rates exhibited positive signs on the regional changes in earning and employment variables, since increase in regional income and employment would promote in – migration and slowed down out – migration, while regional unemployment rates had an opposite effect.

According to Roy (1986) occupational mobility of labour, was the rate at which the workers changed occupations or skills in response to the differences in wages or job availability, in addition to other economic, social and physiological factors.

Molho (1986) observed that the process of migration varied a lot between individuals, notably between those planning on ‘speculative’ moves, for whom only a coarse search of sets of possible opportunities would actually precede the migration followed up by more specific search on the spot; and those requiring ‘contracted’ moves, with the assurance of a specific job being a precondition for any commitment to the move. In the human capital mode, he found that, when aggregating over individual decision, migration would be away from areas of lesser opportunities towards those of greater opportunities.

Schubert *et al.*, (1987) observed that migration was generally labour market oriented as the net migration rates were mainly determined by regional labour demand. In effect, increasing labour force participation rate promoted in – migration and retarded out – migration because of their signaling effect and resulting multiplier effect. In areas of expanding job opportunities, there was a high net immigration of labour force and individuals had high labour force participation rates and high employment rates.

Barkley (1990) analysed the flow of labour out of agriculture during the period 1940 – 85 using a two – sector model of occupational choice. The migration equation tested empirically using the aggregate data from the United States, revealed the economic determinants of the migration of the farm workers and farm operators. Farm labour was found responsive to changes in the returns to agricultural labour relative to non – farm returns.

Goyal (1990) stated that the migration and rural development are inter – dependent. Migration from rural areas was viewed as a consequence of lack of development (or) developmental opportunities in rural areas. He also found that the determinants of migration were regional (rural – urban) disparities in income level and economic opportunities. The way, in which these opportunities are structured in rural areas, determines the pattern of permanent and temporary migration.

Reddy (1990) and Rao (1994) identified the main drivers of migration as the worsening situation of dry land agriculture created by drought, crop failure and poor terms of trade in Andhra Pradesh.

Stillwell and Congdon (1991) observed that the central theoretical base underpinning the inter – sectoral migration behaviour of labour had been the distinction between on one hand, the individual's decision to move from one occupation to another and, on the other, the nature and direction of the move itself, once the decision to migrate had been made. The factors bearing on these decisions included both the characteristics of individual persons (such as their age, marital status, household status) or individual housing units (such as their size, structure) and the wider characteristics of areas and markets (such as regional and sectoral relativity of wages and house prices).

Perloff (1991), in his study on the impact of wage differentials on choosing to work in agriculture in the United States, found that in many states and in certain crops half to two – thirds of the agricultural work force were aliens migrated from other places. He came out with a conclusion that one per cent increase in the relative wage in agriculture increased the probability that a non urban male with no more than a ninth grade education worked in agriculture and a 10 per cent increase in wages could increase their share in agriculture by nearly a quarter.

Atibudhi *et al.*, (1992) remarked that the employment per worker varied with the size of the tribal household. The total mandays of employment per worker was 174 man – days. It was found that 58.6 per cent of the income was obtained from wage earning and only 20.7 per cent was contributed by farming.

Shylendra and Thomas (1995) examined the pull and push factors for the occupational diversification in the subsistence farm families of the degraded forest areas in Mahudi Village in Gujarat and found that the increased local demand for different goods and services, expansion of governmental activities (pull factors) and under employment coupled with meager income from farming activities, surplus family labour, small size of holding and indebtedness were the major push factors influencing the occupational diversification in farm families through logit analysis. They also concluded that the non – farm migratory activity would therefore, likely to remain as one of the major sources of employment and livelihood in the study area.

Marothia (1996) analyzed the terms, pattern and composition of non – farm employment both at micro and macro levels and concluded that even though the share of non – farm

employment was increasing with varying degree, the agricultural sector still continued to remain an important sector for rural employment.

Abduali and Delgado (1997) examined the link between household characteristics and the amount of time spent in income oriented non – farm work. The impact of household and locational characteristics on off-farm employment participation decisions was evaluated. They found that several factors beyond household characteristics, on farm income conditioned the household participation in non – farm work. Access to work influenced positively and significantly the probability of participation, as well as supply of labour to the non – farm sectors. The findings suggested that public actions and investment would have implications for the participation of rural farm household in non-farm activities.

Pingali (1997) observed that watershed degradation had imposed negative externalities on low land productivity in Philippines, especially in terms of sediment flow affecting irrigation infrastructure. The author had studied the relationship between environmental degradation and poverty. The author found that higher degradation had correlation with higher out migration, unemployment, higher age dependency ratio and school dropouts and higher infant mortality rate.

Rajeshkumar and Fulspele (1998) analysed time allocation of farmwomen involved in both agriculture and dairying through tobit analysis. They found that herd size had a significant positive influence on the time spent on dairying activities. Family size and educational status of family showed significant negative influence on agriculture and overall activities.

Anandarajakumar (1999) analysed that the rural to rural migration was found mainly in areas where agriculture is relatively seasonal in nature. A large flow of rural in migration often takes place in areas of continuous cropping (or) cash cropping, particularly rice.

Ramasamy (1999) opined that the rate of migration of labourers from rural to the urban sector declined during 1980's largely because of expansion in rural non – farm activities.

Rao (2001) found three kinds of migration in his study conducted at Andhra Pradesh. Type 1 migration is for coping and survival. Type 2 migrations are for additional work/ income and it takes place when the work in the village is over, normally after harvesting all crops. Type 3 migrations are for better remuneration or a better work environment or opportunity to apply learned skills or to acquire new skills.

Destaw *et al.*, (2003) examined the household determinants of non – farm activity participation among the peasant farming (140 peasant households) in Ethiopia. The Logit model was employed by them with the inclusion of age, credit, sex, education, family size, farm income and farm size, access to urban market centre, distance from main road, farm input use and number of animals (oxen) in a household as independent variables. The results of the study revealed that education and access to credit had a positive relationship with participation in non – farm activities with the elasticities at 1.35 and 1.09 respectively.

Navadkar *et al.*, (2003) analysed the employment, income and expenditure pattern of rural families (126 respondents) in resource scarce region of Maharashtra. They found that the wage rate and earners per family had significant influence over the annual employment through multiple regression analysis.

Priya and Start (2003) reported that in Andhra Pradesh, on an average, 25 per cent of the households had at least one migrating member. The magnitude of migration has grown over time both in terms of absolute numbers of migrating and in terms of its importance as a source of household income.

Singh *et al.*, (2003) examined the strategies of employment diversification in farming based on information generated from various farm management studies conducted over time at Kanpur Agricultural University. The study indicated that the shift in employment from farm to non – farm activities due to share of crop production income to household income had declined over time.

Goldsmith *et al.*, (2004) identified that agricultural production factors have a significant impact on rural – urban migration. The results revealed that the greater urban per capita earnings compared to rural per capita earnings (wage differentials) plus degrading economic conditions in the rural sector play key roles in motivating rural out migration.

Satish, (2010) studied the pattern of migration of farm families to the distant cities, more so among marginal and small farmers was observed. It was found to be perennial and permanent where the entire family had to leave their dwelling places. Inadequate farm size and consequent degradation led the small and marginal farmers to migrate in large proportion when compared to farmers with larger farm size. Women-folk were forced to work both at home and off-farm as agricultural and non-agricultural labourers. They shared equal burden of work in unknown living

environment as non-agricultural labourers mainly in the construction sites along with their men counterparts.

### **2.3.3 Policy Interventions towards combating land degradation and promoting land reclamation**

Joshi and Jha (1992) assessed the economic impact of soil alkalinity and waterlogging in Sharda Sahayak Irrigation Project and recommended policy options to combat the degradation problems in surface irrigation system namely (i) in areas throughout India where these problems occur, the adverse effects are substantial, it is therefore important that such areas are identified, (ii) research on development of salt-tolerant varieties has a narrow crop focus and hence it should be expanded to cover more crops; (iii) thrust for adoption of improved technology for salt affected and waterlogged soils as no such evidence of adoption was found and (iv) suggested investment to bring about improvements such as prevention of canal seepage, rationalized irrigation price policy and canal operation and improved drainage.

Raju (1992) revealed the expansion in the development of minor irrigation systems during sixth five year plan (1980-85) mainly because of efficiency and dependability. During this rapid growth period, low priority was given to non-technical aspects which produced some undesirable results like a gap between irrigation potential created and implemented waterlogging and salinity and low participation by water users and their organizations. Hence, the author suggested the need for more emphasis on social, organizational and managerial aspects of water management and the development of joint management with major role of users' organization.

Gajja *et al.*, (1996) examined employment potential of conjunctive use of tube well and canal water as an alternative to canal irrigation. The conjunctive use served as a technology component and a complementary input component in Mahi Right Canal Command in Gujarat and generated employment opportunities and increased agricultural production. This conjunctive management of water not only helps to control problems of water logging but also improves the efficiency of water resource use.

An attempt was made by Gajja *et al.*, (1997) to study the policy options to combat water logging and soil salinity in the Ukai-Kakrapar Canal Command area. It was observed that the present water charges are lower (2-5 per cent) than recommended charges (5-12 per cent) of the gross income of the crop and need to be raised which would encourage farmers to adopt the

recommended cropping pattern and discourage high water requirement crops to arrest degradation problems. Strategies in the form of canal water allocation based on soilwater-crop relationship were suggested.

Pingali *et al.*, (2001) highlighted various factors contributing to decline in productivity growth in recent years in the important rice and rice-wheat systems of the Indo-Gangetic Plains of South Asia. They identified host of agronomic and soil related constraints (salinity waterlogging and soil nutrient deficiencies). In addition the above factors the authors quoted the policy and institutional constraints that have distorted input markets notably groundwater for irrigation and also exacerbated intensification-related problems as constraints.

Datta *et al.*, (2002) in their study conducted in semi-arid region, especially in north west India revealed that considerable recharge to the groundwater leads to waterlogging and secondary salinization. In several sub-areas groundwater is mined, water table falls and salts accumulate at the root zone because a high proportion of irrigation water is derived from pumping groundwater of poor quality. Further they ascertained that the intensification *per se* is not the root cause of land degradation, but rather the policy environment that encouraged inappropriate land use and injudicious input uses, especially excessive irrigation. Trade policies, output price policies and input subsidies all have contributed to the degradation of agricultural land.

The feasibility of differentially pricing irrigation water in normal and problematic soils affected by salinity and water logging within the command area was examined by Nagaraj *et al.* (2003) in Kabini project in the Cauvery basin, Karnataka. It is revealed that farmers in normal soils have realized adequate returns and have the ability to pay for the water used. The water rate paid by the farmers form just 17 per cent of the actual cost of water supplied in the case of rice, 33 per cent in case of sugarcane and 25 per cent in semi-dry crops. This indicated that the surface irrigation water is highly subsidized by the government and is not reflecting the true supply cost of water leading to gross inefficiency in water use. The farmers affected by salinity, alkalinity and waterlogging, however, have not realized adequate returns and hence their ability to pay water rates is also weak and therefore they should be subsidized.

According to Satish (2010), the area under land degradation is on the increase and no systematic efforts are being made to measure its extent in the canal command areas. Therefore, there is a need for periodical assessment of the extent of waterlogged and salt affected areas

using scientific approaches like, Geographical Information System for appropriate policy initiatives towards their reclamation.

Priyanka (2012) put forth that reclamation of alkali soils had contributed to significantly to increased food grain production. For better results of schemes, financial and technical assistance is needed.

## *Design of the Study*

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## **CHAPTER III**

### **DESIGN OF THE STUDY**

Design of the research provides the framework upon which the entire study is built. Hence, a proper design is imperative to channelize the research in the right direction. This chapter provides the sampling design, data collection procedures, valuation methodologies and econometric models employed. The quality of research depends on the variables and the tools of analysis which are selected based up on the objectives of the study.

#### **Sampling frame**

Sampling was defined as the selection of some part of an aggregate or totality on the basis of which a judgment or inference about the aggregate or totality was made. Alkalinity is wide spread throughout the State. Out of 32 districts in Tamil Nadu, the land degraded due to alkalinity is distributed in 23 districts.

The present study was attempted to analyze the impact of soil degradation on crop production in Tamil Nadu. Cauvery Delta Zone is a major food production cluster in Tamil Nadu, It is essential to document the impact of soil degradation on the socio-economic conditions of the farmers of this region. Hence, in this study Cauvery Delta Zone was purposefully selected. Therefore, farmers of the Cauvery Delta Zone formed the universe of the study.

For obtaining the necessary field data from the farmers, multistage stratified random sampling design was adopted. A multistage stratified random sampling technique was adopted to select the ultimate sampling units.

#### **Selection of Districts**

In the first stage, among the districts of Cauvery delta zone, Tiruchirapalli, Pudukottai and Nagappattinam districts has the highest area under soil salinity. It is evident from Table 3.1, the total salt affected area was higher in Tiruchirapalli district (32.47 per cent) followed by Pudukottai (29.99 per cent) and Nagappattinam Districts (19.74 per cent). Hence, these three districts were purposively selected for the present study to analyze the socio-economic impact of soil salinity on the socio-economic conditions of the farmers.

**Table3.1 District wise area under salinity in Cauvery delta zone during 2010-11**

(ha)

Dist (Category)	Slight	Moderate	Severe	Total
Tiruchirappalli (Sodic)	9043.39 (20.54)	11431.50 (78.81)	0.00	20474.87 (32.47)
Thiruvarur (sodic)	273.33 (0.62)	208.00 (1.43)	0.00	481.33 (0.76)
Thanjavur (saline)	8499.31 (19.31)	0.00 (0.00)	0.00	8499.31 (13.48)
Thanjavur (Sodic)	2041.04 (4.64)	201.81 (1.39)	0.00	2242.85 (3.56)
Nagai (Saline)	11026.30 (25.05)	0.00	0.00	11026.27 (17.49)
Nagai (Sodic)	256.47 (0.58)	1162.62 (8.02)	0.00	1419.09 (2.25)
Pudukottai (Saline)	5091.98 (11.57)	0.00 0.00	0.00	5091.98 (8.08)
Pudukottai (Sodic)	7788.36 (17.69)	1500.65 (10.35)	4526.14 (100.00)	13815.15 (21.91)
Total	44020.18 (100.00)	14504.58 (100.00)	4526.14 (100.00)	63050.85 (100.00)

Source: JDA office, Dept of Agriculture, Thanjavur

### **Selection of Taluks and villages**

Selection taluk was the second stage of sampling. Among the selected districts in the first stage, one taluk, from each district, which has the largest area under salt affected soil, was selected. Further, the same was ascertained from the published reports of Government of Tamil Nadu. Accordingly, the taluk which had the highest concentration of the saline soils were chosen from each District. Hence, taluks such as Musuri, Illupur, Sirkali of Tiruchirappalli, Pudukottai and Nagappattinam districts, respectively were selected for the present study. (Table.3.2).

The same procedure was adopted in the third stage for the selection of villages from each taluk. Two villages from each taluk were selected. (Table.3.3).

### **Selection of sample farmers**

The ultimate sampling units were randomly selected from each selected village. In each of the selected villages, 20 farmers each under salt affected and non affected production environment were chosen by adopting simple random sampling method. Thus, a total of 80 farmers were selected as sample farmers from each district, which includes 40 farmers each

under salt affected and non affected production environment. Thus, the total sample size was 240 farmers which comprises 120 farmers each under salt affected and non affected production environment. For the purpose of this, a list of farmers with alphabetical order wise affected with salinity was prepared in consultation with the existing records available with the office of Joint Director of Agriculture, Agricultural Engineering Department and Department of soil survey of each selected districts. From the list, 20 farmers were randomly selected. Similar methodology was followed to prepare a list of farmers under non-affected category. Among the list, 20 farmers were the randomly selected. (Table 3.3). The salinity affected sample farmers were then post stratified in to low, medium and high based on the soil EC level. Thus, from the selected districts and taluks, the sample farmers were selected based on different level of soil salinity, viz., low level (48 farmers), medium level (39 farmers) and high level (33 farmers). Thus, a total of 120 sample farmers were selected for salinity affected category. (Table 3.4)

**Table 3.2 Taluk wise area under salinity in selected districts during 2010-11**

(ha)

District	Taluk	Area (ha)
Tiruchirappalli	Lalgudi	350
	Manachanallur	300
	Manapparai	6600
	Musiri	7870
	Srirangam	1350
	<a href="#">Thiruverumpur</a>	2650
	<a href="#">Thottiyam</a>	254
	<a href="#">Thuraiyur</a>	950
	<a href="#">Tiruchirappalli</a>	150
Pudukottai	Alangudi	2269
	Aranthangi	1853
	Avudaiyar koil	1780
	Gandharvakottai	1556
	Kulathur (Including Illupur)	10479
	Pudukottai	591
	Thirumayam	378
Nagappattinam	Keelvelur	1730
	Mayiladuthurai	788
	Nagappattinam	2697
	Sirkali	3924
	Tharangambadi	1260
	Vedaranyam	2046

Fig 3.1. Taluks of Tiruchirappalli district

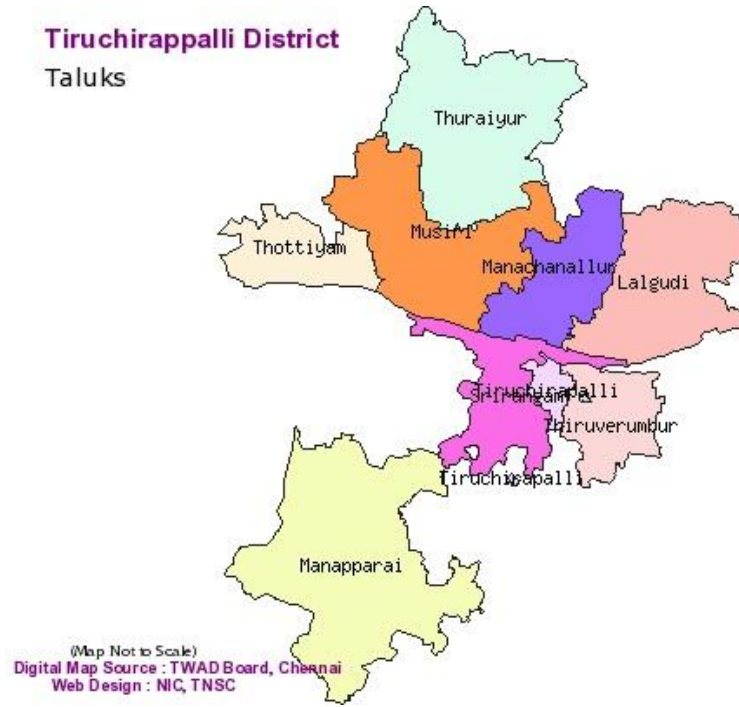


Fig 3.2. Taluks of Pudukkottai district

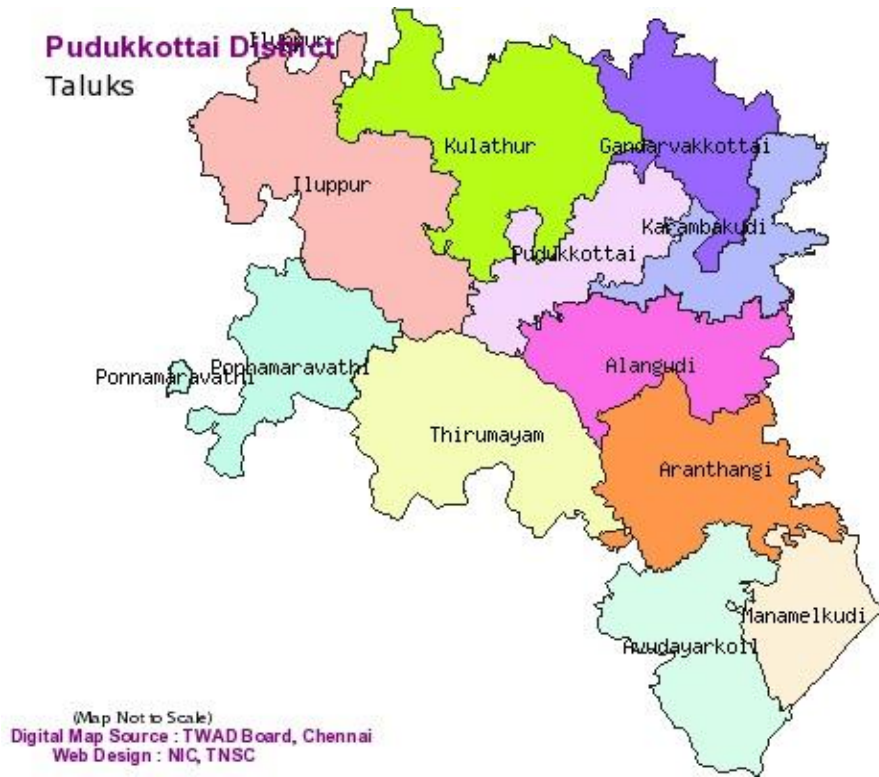


Fig 3.3. Taluks of Nagappattinam district

**Nagapattinam District**  
Taluks



(Map Not to Scale)  
Digital Map Source : TWAD Board, Chennai  
Web Design : NIC, TNSC

**Table 3.3 Selection of sample farmers**

District	Taluk	Villages	Non affected Sample farmers	Affected Sample farmers (based on Ec level)
Tiruchirappalli	Musiri	Thatangar petttai	20	20
		Valaiyeddupu	20	20
Nagapattinam	Sirkali	Thiruvengadu	20	20
		Melaiyur	20	20
Pudukkottai	Illupur	Illupur	20	20
		Thennambadi	20	20
Sub total			120	120
Total sample ( Normal + Affected)				240

**Table 3.4 Post stratified sampling data of soil salinity affected sample farmers**

Districts	Soil salinity level (EC)			
	Low	Medium	High	Total
Tiruchirappalli	21	10	9	40
Pudukkottai	11	16	13	40
Nagappattinam	16	13	11	40
Total	48	39	33	120

### 3. 3. Nature and Source of data

#### 3.3.1 Primary data

Before actual data collection, reconnaissance survey was conducted to gather information related to the problem of soil salinity induced land degradation at Manikandam block of Trichy district. This facilitated in designing comprehensive interview schedule covering all aspects of the problem. Pre-testing was done to ensure completeness of the information according to the objectives of the study. Primary data were collected from the respondent farmers using pre-tested schedule.

The primary data collected included general and demographic information of the household, land holdings, land utilization pattern, cropping pattern, cost and returns structure of crops, crop productivity, area under salinity and their perceptions on problem of soil salinity, coping-up and reclamation strategies taken up to overcome the problem and factors hindering the adoption of reclamation measures and negative externalities of soil degradation. The various

dimensions of each of the issues under study were closely observed and opinions of the sample farmers were documented during the process of data collection.

### **3.3.2. Secondary data**

The secondary data with regard to demographic features, cropping pattern, extent of problematic areas, characteristics of reservoirs and of the canal systems, localization pattern, and groundwater level and data relating to yield realized on degraded soils and other data relating to the study were obtained from the various issues of Season and Crop Reports of Tamil Nadu, Tamil Nadu – Economic Appraisal, Agricultural Statistics at a Glance and other reports and technical bulletins, etc.

### **Period of Study**

The survey method of data collection was employed to gather data by personal contact and interviewing the respondents. The data collected was pertained to agricultural year 2011-12. Data pertained to samba season. Due to salinity, cultivation refrained to Samba season (Wet season). Samba season was a major production season, coincides with North East Monsoon. In the study area, nearly 80 per cent of the samba season area allocated to rice farming. The other field crops such as maize, sorghum, ragi and gingelly and cash crops were grown during the minor season (dry season). Since, rice is the main crop and is largely affected by salinity was chosen for this study.

### **3.4. Tools of Analysis**

Comparative economics was worked out for analyzing yields, cost and returns under normal, salinity affected soils for an effective comparison. Simple statistical measures like averages, percentages, ratios were worked out using the data generated for meaningful discussion. Production function analysis was carried out for major crop rice in different soils. Decomposition model was employed to decompose the change in farm productivity between normal and degraded soils to know impact due to degraded soils and due to change in use of inputs. Costs and returns of other crops occupying negligible area were not considered for functional analysis.

In accordance with the objectives of the study and nature of the data, suitable economic tools were chosen. The chosen economic tools were presented and discussed below in detail. The collected data were tabulated to draw meaningful inferences.

### **3.4.1 Tabular presentation**

Tabular presentation was adopted to compile the general characteristics of the sample farmers, cropping pattern, cost and returns of crops grown on salinity affected and non affected category of sample farmers were worked out and compared with the help of simple percentages and averages.

### **3.4.2 Cost of cultivation and returns**

#### **Cost concepts**

In this study, the cost of cultivation of rice crop at saline soil and normal soil environment were calculated using econometric tools. Paddy was the most cultivated crop in all the three soils conditions during the period of study.

The cost concept approach used was of Commission for Agricultural Cost and Prices (CACP) viz (Cost A1, Cost A2, Cost B , Cost C) which is widely used in India for evaluating crop profitability. The different cost items that were included under each cost concepts are discussed below with their computational procedures.

The cost of cultivation per hectare of paddy cultivated both in saline soil and normal soil production environment were calculated according to cost concepts used in Farm business analysis for the data pertaining to the crop year 2011-12.

Cost-A1 : It includes the value of

- Casual hired labour
- Attached labour
- Imputed value of owned bullock labour
- Hired machine labour
- Imputed value of owned machine labour
- Seeds
- Manures and fertilizers
- Plant protection chemicals
- Irrigation charges
- Interest on working capital
- Depreciation

- Land revenue

Cost-A2 : Cost A1 + rent paid for leased in land, if any

Cost-B : Cost A2 + imputed rental value of owned land + interest on owned fixed capital excluding land.

Cost-C: Cost B + imputed value of family labor

In the present study, the rent paid for leased in land was zero, as none of the sample farmers took land on lease basis. Hence, cost A1 and cost A2 are similar and are simply called as cost-A.

### 3.4.3 Welfare loss

The welfare loss is the extent of loss in economic value incurred by the farmer in the degraded soil as against the normal soil. It is a ratio between the net returns on degraded soil and normal soil subtracted from one.

### 3.4.4 Production Function Analysis

Most of the farm studies have established that Indian agriculture would approximate the Cobb-Douglas type of production function (Heady and Dillon, 1964). Further, constant returns to scale is empirical evidence widely observed in studies on Indian agriculture. Both these were assumed for the present study and hence the per hectare production function of Cobb-Douglas form was specified.

To study resource productivity under salinity affected and non affected soil, Cobb-Douglas type of production function was fitted.

The general form of the function is  $y = ax_i^{b_i}$

where, 'xi' is the variable resource measure,

'y' is the output,

'a' is a constant and

'bi' estimates the extent of relationship between xi and y and when xi is at different magnitudes. The 'b' coefficient also represents the elasticity of production in Cobb-Douglas production function analysis. This type of function allows for either constant or increasing or decreasing returns to scale. It does not allow for total product curve embracing all the three

phases simultaneously. Test was conducted to see if the sum of regression coefficients was significantly different from unity.

**Production function with salinity variable (EC)**

Effects of soil salinity have to be clearly isolated from the other causes of production loss. Several analytical approaches have been used to discern the pure impact of soil salinity from other factors of production. Joshi (1987) and Joshi *et. al.*, (1994) have estimated the crop losses due to soil salinity using the production function approach. While the former used electrical conductivity as one of the explanatory variables, the latter estimated the impact on crop yield using a dummy variable for soil salinity level. Joshi and Dayanantha Jha (1992) used different production functions for normal and saline soils and decomposed the pure effect of change in output due to soil salinity and resource use.

Since rice is the main crop and is largely affected by salinity, it was chosen for the analysis. The approach assumes that salinity build-up directly influences the crop yields. To establish the relationship, a Cobb-Douglas form of production function was employed. Several explanatory variables, defined in different ways, were included to estimate the production function.

The following functional form and variables were selected for further analysis:

$$Q = a H^b ML^c S^d F^e M^g P^h I^j EC^k e^u \dots\dots\dots (1)$$

- Where, Q is yield of rice (kg/ha);
- H is human labour (mandays/ha);
- ML is cost of machine labour (Rs/ha);
- S is seed (Kg/ha);
- F is fertilizer (Kg /ha);
- M is Manures (tonnes/ha);
- P is cost of pesticides (Rs/ha);
- I is cost of irrigation (Rs/ha);

Since fertilizer application has a direct effect on salinity, it was considered separately. a, b, c, d, e, g, h, j and k are the regression coefficients to the respective variables and u is the error term. EC is the electrical conductivity (dS/m) that gives the measure of soil salinity. Rice

production will not be affected when the salinity remains within the threshold level. However, beyond the threshold level of EC, salinity will have a negative effect on yield.

The above equation (1) includes two types of explanatory variables. Labour, Seed, fertilizer, manures, pesticides and irrigation charges are yield-enhancing variables whereas soil salinity is a yield-decreasing variable. The magnitude of elasticities of yield-enhancing variables and elasticity of soil salinity for the rice crop would show which variable affects rice yield more.

### 3.4.5 Production function decomposition analysis

In addition to the production function analysis, a decomposition analysis was used to discern the true impact of soil salinity on crop yield. Decomposition analysis is a mathematical technique that could disaggregate and quantify a difference in an observable quantitative variable into its components. More simply, the technique provides a method to quantify the intervening factors of a difference such as "before and after" or "with and without" situation. Production function decomposition analysis was used to decompose the difference in the changes in gross output between salinity-free soils and salinity-affected soils. Bisalialah in 1977; Joshi *et. al.*, (1992, 1994) used a similar technique for wheat and other crops. The change in gross output between normal and salinity-affected soils was decomposed into: (i) changes due to salinity effect and (ii) changes due to reallocation of inputs. The land use pattern, resource use pattern and crop productivity were also analyzed for different soil salinity levels. For production function decomposition analysis, separate production functions were estimated for different soil salinity levels. These have been specified in a log-linear form as follows:

$$Y = a H^b ML^c S^d F^e M^g P^h I^j E^k e^u$$

Normal soil

$$\text{Log } Y_n = \text{Log } A_n + b_n \text{Log } H_n + c_n \text{Log } ML_n + d_n \text{Log } S_n + e_n \text{Log } F_n + g_n \text{Log } M_n + h_n \text{Log } P_n + j_n \text{Log } I_n \dots\dots\dots(2)$$

Salinity-affected soil

$$\text{Log } Y_s = \text{Log } A_s + b_s \text{Log } H_s + c_s \text{Log } ML_s + d_s \text{Log } S_s + e_s \text{Log } F_s + g_s \text{Log } M_s + h_s \text{Log } P_s + j_s \text{Log } I_s \dots\dots\dots(3)$$

Where Y is yield in Kg per hectare (Kg/ha), (L), (S), (F), (K) in per hectare (Rs/ha).

A is a scale parameter. Others are the same as in the previous production function. Taking the difference between (1) and (2) and adding some terms and subtracting the same terms yield the following:

$$\begin{aligned} \text{Log } Y_s - \text{Log } Y_n &= (\text{Log } A_s - \text{Log } A_n) + \\ &+ (b_s \text{Log } H_s - b_n \text{Log } H_n + b_s \text{Log } H_n - b_s \text{Log } H_n) + \\ &+ (c_s \text{Log } ML_s - c_n \text{Log } ML_n + c_s \text{Log } ML_n - c_s \text{Log } ML_n) + \\ &+ (d_s \text{Log } S_s - d_n \text{Log } S_n + d_s \text{Log } S_n - d_s \text{Log } S_n) + \\ &+ (g_s \text{Log } F_s - g_n \text{Log } F_n + g_s \text{Log } F_n - g_s \text{Log } F_n, \dots) \dots\dots\dots(4) \end{aligned}$$

Rearranging terms in equation (4) yields the following:

$$\begin{aligned} \text{Log}(Y_s/Y_n) &= \text{Log}(A_s/A_n) + [(b_s - b_n) \text{Log } H_n + (c_s - c_n) \text{Log } ML_n + (d_s - d_n) \text{Log } S_n + (g_s - g_n) \text{Log } \\ &K_n] + [b_s \text{Log}(H_s/H_n) + c_s \text{Log}(ML_s/ML_n) + d_s \text{Log}(S_s/S_n) + g_s \text{Log}(F_s/F_n), \dots] \dots\dots(5) \end{aligned}$$

Equation (5) apportions approximately the differences in gross income per hectare between Normal and salinity-affected soils into two components. The sum of the first two bracketed components on the right hand side indicates the land degradation effect. The third bracketed term measures the contribution of changes in input levels between the two situations.

In other words,

$$[\text{Output } \Delta] = [\text{Technology } \Delta \text{ Effect}] + [\text{Input-use Efficiency } \Delta \text{ Effect}] + [\text{Input usage } \Delta \text{ Effect}]$$

The decomposition Equation (5) gives an approximate measure of the percentage change in output due to soil salinity in the production process. The first square bracketed expression on the right hand side of Equation (5) is the measure of percentage change in output due to shift in scale parameter of the production function. The second square bracketed expression is the difference between output elasticities each weighted by natural logarithms of the volume of that input used under non-affected category, a measure of change in output due to shift in slope parameters (output elasticities) of the production function. The third square bracketed expression is the sum of the natural logarithms of the ratio of each input of salinity affected to non affected category, each weighted by the output elasticity of that input. This expression is a measure of change in output due to change in per ha quantities of inputs used in the production process.

### 3.4.6 Data Envelopment Analysis:

The DEA method is a frontier method that does not require specification of a functional or distributional form, and can accommodate scale issues. This approach was first used by Farrell (1957) as a piecewise linear convex hull approach to frontier estimation and later by Boles (1966) and Afriat (1972). This approach did not receive wide attention till the publication of the paper by Charnes *et al.* (1978), which coined the term *data envelope analysis*. A large number of

papers have extended and applied the DEA technology in the western world. Very few studies have used this approach in India, especially in agriculture or horticulture for measuring efficiency.

In the present study, the DEA method was preferred because data noise was less of an issue as most of the variables in paddy production were included and because of its ability to readily produce rich information on technical efficiency, scale efficiency and peers.

The DEA was applied by using both classic models CRS (Constant Returns to Scale) and VRS (Variable Returns to Scale) with input orientation, in which one seeks input minimization to obtain a particular product level. Under the assumption of constant returns to scale, the linear programming model for measuring the efficiency of sample farmers (Coelli *et al.*, 1998):

$$\begin{aligned} & \text{Min}_{\theta, \lambda} \theta, \\ & \text{St} \\ & - y_i + Y \lambda \geq 0 \\ & \theta x_i - X \lambda \geq 0 \\ & \lambda \geq 0 \dots \dots \dots (1). \end{aligned}$$

where,

$y_i$  is a vector ( $m \times 1$ ) of output of the  $i$ th sample farmers of salinity affected category ,

$x_i$  is a vector ( $k \times 1$ ) of inputs of the  $i$ th sample farmers of salinity affected category,

$Y$  is output matrix ( $n \times m$ ) for  $n$  sample farmers of salinity affected category,

$X$  is input matrix ( $n \times k$ ) for  $n$  sample farmers of salinity affected category,

$\theta$  is the efficiency score, a scalar whose value will be the efficiency measure for the  $i$ th sample farmer of salinity affected category.

If  $\theta = 1$ , sample farmer of salinity affected category will be efficient; otherwise, it will be inefficient, and

$\lambda$  is a vector ( $n \times 1$ ) whose values are calculated to obtain the optimum solution.

For an inefficient sample farmer of salinity affected category, the  $\lambda$  values will be the weights used in the linear combination of other, efficient, sample farmers, which influence the projection of the inefficient sample farmers on the calculated frontier.

The specification of constant returns is only suitable when the firms work at the optimum scale. Otherwise, the measures of technical efficiency can be mistaken for scale efficiency, which considers all the types of returns to production, i.e., increasing, constant and decreasing.

Therefore, the CRS model was reformulated by imposing a convexity constraint. The measure of technical efficiency obtained in the model with variable returns is also named as ‘pure technical efficiency’, as it is free of scale effects. The following linear programming model estimated it:

$$\begin{aligned}
 & \text{Min}_{\theta, \lambda} \theta, \\
 & \text{St} \\
 & - y_i + Y \lambda \geq 0 \\
 & \theta x_i - X \lambda \geq 0 \\
 & N1 \lambda = 1 \\
 & \lambda \geq 0 \dots \dots \dots (2).
 \end{aligned}$$

where, N1 is a vector ( $n \times 1$ ) of ones.

When there are differences between the values of efficiency scores in the models CRS and VRS, scale inefficiency is confirmed, indicating that the return to scale is variable, i.e. it can be increasing or decreasing (Fare and Grosskopf, 1994). The scale efficiency values for each analyzed unit can be obtained by the ratio between the scores for technical efficiency with constant and variable returns as follows:

$$\theta_s = \theta_{CRS}(XK, YK) / \theta_{VRS}(XK, YK) \dots \dots \dots (3).$$

$\theta_{CRS}(XK, YK)$  = Technical efficiency for the model with constant returns,

$\theta_{VRS}(XK, YK)$  = Technical efficiency for the model with variable returns, and

$\theta_s$  = Scale efficiency.

It was pointed out that model (2) makes no distinction as to whether a sample farmer is operating in the range of increasing or decreasing returns (Coelli *et al.*, 1998). The only information one has is that if the value obtained by calculating the scale efficiency in Equation (3) is equal to one, the sample farmer will be operating with constant returns to scale. However, when  $\theta_s$  is smaller than one, increasing or decreasing returns can occur. Therefore, to understand the nature of scale inefficiency, it is necessary to consider another problem of linear programming, i.e. the convexity constraint of model (2),  $N1\lambda = 1$ , is replaced by  $N1\lambda \leq 1$  for the case of non-increasing returns, or by  $N1\lambda \geq 1$ , for the model with non-decreasing returns. Therefore, in this work, the following models were also used for measuring the nature of efficiency.

Non-increasing returns:

$$\text{Min}_{\theta, \lambda} \theta,$$

$$\begin{aligned}
& St \\
& - y_i + Y \lambda \geq 0 \\
& \theta x_i - X \lambda \geq 0 \\
& N1 \lambda \leq 1 \\
& \lambda \geq 0 \dots \dots \dots (4).
\end{aligned}$$

Non-decreasing returns:

$$\begin{aligned}
& \text{Min}_{\theta, \lambda} \theta, \\
& St \\
& - y_i + Y \lambda \geq 0 \\
& \theta x_i - X \lambda \geq 0 \\
& N1 \lambda \geq 1 \\
& \lambda \geq 0 \dots \dots \dots (5).
\end{aligned}$$

It is to be stated here that all the above models should be solved  $n$  times, i.e. the model is solved for each sample farmer.

Paddy production (Kg/ha) was used as an output (Y) in the present study and total human labour (man days), machine labour (Rs/ha), seeds (Kg), farm yard manure (t), Fertilizers (kg), capital inputs (Rs) on plant protection as inputs (X). The models were solved using the DEAP version 2.1 taking an input orientation to obtain the efficiency levels.

### 3.4.7 Determinants of Technical Efficiency

Ray (1991) and Worthington and Dollery (1999), used traditional DEA in the first stage to estimate the technical efficiency and in the second stage estimated the determinants of technical efficiency from the factors contributing to this technical efficiency by using econometric procedure.

In the present study, the technical efficiency values obtained from the DEA model considering the CRS input-oriented model were used for examining the relationship between the technical efficiency and factors influencing it. The technical efficiency score from CRS model was chosen as the dependent variable for its high accuracy in discriminating efficiency as compared to variable returns to scale (Gonclaves *et al.*, 2008). The explanatory variables included were of three different types, viz. productivity (land, labour and capital), respondent

farmers (age and education), and institutional-intervention factors (organizational participation, and technical input).

The traditional method of regression was used for this purpose and ordinary least square analysis was carried out to estimate the regression equation. The regression model specified for the present study is given in Equation (6):

$$Y = a X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} X_6^{b_6} X_7^{b_7} X_8^{b_8} U \text{ --- (6)}$$

where,

Y = Technical efficiency scores,

X1 = Land productivity measured in kg of paddy produced in one hectare in sample farmers,

X2 = Labour efficiency measured in terms of total revenue from the paddy divided by the total labour costs,

X3 = Capital-use efficiency estimated by dividing total yield with operating expenses,

X4 = Age of the farmers in years,

X5 = Years of education,

X6 = Dummy variable to define whether farmers participated in any input and output marketing organizations (1) or not (0) over the years,

X7 = Dummy to define whether the farmers used institutional credit (1) or not (0), and

X8 = Dummy to define frequency of technical visits (1) or not (0).

‘a’ and ‘bi’ are the constant and the co-efficients respectively, which were estimated through the ordinary least square analysis after appropriate log conversion.

### **3.4.8 Garrett’s ranking technique**

Problems faced by sample respondents in getting livelihood security were prioritized by using Garrett’s ranking technique in the following manner. For this purpose four problems were first identified as important considered by the majority of respondents. Each of 120 respondents selected were asked to rank the above four problems from rank 1 to 4.

In this analysis, rank 1 meant most important problem and rank 4 meant least important problem. In the next stage rank assigned to each problem by each individual was converted into per cent position using the following formula.

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

Where ,

$R_{ij}$  stands for rank given for the  $i$ th factor ( $i= 1,2,\dots,n$ ) by the  $j$ th individual ( $j = 1,2,\dots,n$ )

$N_j$  stands for number of factors ranked by  $j$ th individual.

Once the percent positions were found, scores were determined for each per cent position by referring Garrett's table. Then, the scores for each problem were summed over the number of respondents who ranked that factor. In this way, total scores were arrived at for each of the twelve factors and mean scores were calculated by dividing the total score by the number of respondents who gave ranks. Final overall ranking of the twelve factors was done by assigning rank 1,2,3... etc in the descending order of the mean scores.

## ***Description of the Study Area***

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## CHAPTER IV

### DESCRIPTION OF THE STUDY AREA

It is imperative that knowledge of basic features of the study area is necessary to understand the problem in its proper perspective. This chapter profiles out some of the unique features of the study area which are relevant to the study; like soils of the districts, agro climatic conditions of the study area, demography, occupational pattern, ground water aquifers, land use pattern, cropping pattern, land degradation and other resource endowments of the study area.

#### 4.1 Geographical Location and Extent

##### **Tiruchirappalli district**

The study is confined to Tiruchirappalli, Pudukkottai, Nagapattinam districts of Cauvery delta zone of Tamil Nadu.

Tiruchirappalli district is located at the Central part of Tamil Nadu surrounded by Perambalur district in the north, Pudukkotai district in the south, Karur and Dindigul districts in the west and Thanjavur district in the east. It lies between 10°10' and 11°20' of the Northern latitudes and 78°10' and 79°0' of Eastern latitudes in the centre part of the Tamil Nadu. The general slope of the district is towards east. It has a number of detached hills, among which Pachamalai Hill is an important one, which has a peak up to 1015m, located at Sengattupatti Rain Forest.

##### **Pudukkottai District**

Pudukkottai District was carved out of Tiruchirappalli and Thanjavur districts in January 1974. The district has an area of 4663 Sq. Km. with a coast line of 39 Kms. The district lies between 78°25' and 79°15' of the Eastern Longitude and between 9°50' and 10°40' of the Northern Latitude. It is bounded by Tiruchirappalli district in the North and West, Sivaganga district in the South, Bay of Bengal in the East and Thanjavur district in the North East.

##### **Nagapattinam district**

Nagapattinam district, the land of communal harmony, was carved out by bifurcating the composite Thanjavur district on 18.10.1991. This district has traditionally been referred to as East Thanjavur and Paddy granary of Tamil Nadu. Nagapattinam District lies on the shores of the Bay of Bengal between Northern Latitude 10.10' and 11.20' East Longitude 79.15' and 79.50'

This is peninsular delta District surrounded by Bay of Bengal on the East, Palk Strait on the South and land on the West and Northern Side. The Nagapattinam district lies on the east coast to the south of Cuddalore district and another part of the Nagapattinam district lies to the south of Karaikkal and Tiruvarur districts. This District is predominantly, a coastal district having a large coast line of 141 kilometres. This District has a numerous places of historical importance. Nagapattinam is an old port town. This District is having an area of 2715.83 Sq. Kms in its fold. The District headquarters is Nagapattinam.

### **Administrative Arrangement in the Districts**

#### **Tiruchirappalli district**

Tiruchirappalli district comprised of nine taluks *viz.* Thuraiyur, Lalgudi, Musiri, Tiruchirappalli, Thottiyam Manachanallur, Srirengam Manapparai and Thiruverumbur, which included 14 blocks, 408 Village Panchayats and 1590 Villages. This district consists of three municipalities namely Thuvagudi, Thuraiyur and Manapparai. The taluk wise map of Tiruchirappalli district is in shown in Figure 4.1

#### **Pudukkottai District**

Pudukkottai district is divided into two revenue divisions and eleven taluks, thirteen blocks consisting of 757 revenue villages. The taluks are Alangudi, Gandarvakottai, Kulathur, Illuppur, Pudukkottai, Thirumayam, Ponnamaravathi, Karambakudi, Aranthangi, Avudayarkoil, Manamelkudi, which includes 13 blocks *viz.*, Pudukkottai, Avudayarkoil, Annavasal Gandarvakkottai, Manamelkudi, Viralimalai Thiruvarankulam, Thirumayam, Kunnandarkoil, Karambakudi, Arimalam, Arathangi and Ponnamaravathi. The taluk wise map of Pudukkottai district is in shown in Figure 4.2

#### **Nagapattinam district**

The Nagapattinam district comprises of 8 Taluks, 11 Blocks and 519 revenue villages. With respect to the hierarchy of administrative arrangement, there are 4 Municipalities, 8 Town Panchayats and 433 Village Panchayats in the district. The taluks are Nagapattinam, Kilvelur, Tirukkuvalai, Vedaranyam, Mayiladuturai, Sirkazhi, Tranqubar and Kutthalam. Names of Blocks are Nagapattinam, Tirumarugal, Kilvelur, Keezhaiyur, Vedaranyam, Talainayiru, Mayiladuturai, Kuttalam, Sirkazhi, Kollidam, Sembanarkoil. The taluk wise map of Nagapattinam district is in shown in Figure 4.3

## **2.4 Meteorological Information**

### **Season**

The variation of temperature throughout the year exhibits hot and dry climate with high temperature and low degree of humidity.

The region experiences four main seasons:

Cool Months - December to February

Hot Months - March to May

Windy Months - June to August and

Rainy Months - September to November

Generally, the region has a long spell of hot climate with a short spell of rainy season and winter.

### **Temperature**

In Tiruchirappalli district, the temperature is low during the month of January with average mean daily temperature of 28°C. The maximum daily temperature recorded during the hot season in the month of May was 42°C.

In Pudukkottai district, the average temperature recorded was lowest during winter season with 18 °C and highest was 38.7°C during summer season.

In Nagapattinam district, the average maximum temperature for the district as a whole is about 32.46°C and the average minimum temperature is 24.75°C.

### **Rainfall Distribution**

Tiruchirappalli district receives seasonal rainfall from September to December. The average annual rainfall during the period 2009-10 was 757.3 mm, of which major quantity of rain was received during the Northeast Monsoon period i.e. from October to December, which accounted for 385.3mm. Southwest monsoon generally sets in at the beginning of June and blows with great force till the end of August. Rainfall received during the southwest monsoon was 231.3 mm during the year 2009-10. The quantity of rainfall received during the year 2008-09 was lower when compared to the year 2008-09 in Tiruchirappalli district.

The table revealed that the Pudukkottai district received medium level of rain. The annual rainfall received was 813.7 mm during the year 2009-10. The major share of rainfall was received during north – east monsoon, followed by summer rain and south west monsoon. The

rainfall received during winter season was negligible. The year 2009-10 recorded low rainfall during all seasons as compared to the normal rainfall of the district.

In Nagapattinam district, The Northeast monsoon contributes to about 60 per cent of the total annual rainfall. The total average rainfall in the district was 1666.9 mm. The Nagapattinam district receives huge amount of rainfall during the North East monsoon when compared to South West. Actual rainfall received was higher than normal rainfall during the year 2009-10. The season wise rainfall distribution for the past two years from 2008-09 to 2009-10 were presented in Table4.1

### **Demographic Details**

The population of Tiruchirappalli district which was 27, 13,858 persons in 2011. Among the sample districts, Tiruchirappalli had the highest population, which was followed by Pudukkottai and Nagapattinam districts as per census 2011. It could be seen that rural population was very high in the Pudukkottai district with 80.61 per cent, which was followed by 77.46 per cent in Nagapattinam district. In Tiruchirappalli district, rural and urban population accounted for about 50 per cent each. The same trend was also noticed at state level. Literacy level was highest in Nagapattinam district with 84. 09 per cent, which was followed by Tiruchirappalli and Pudukkottai districts with 83.5 per cent and 77 per cent, respectively as per 2011 census, where as the state average literacy level was 80 per cent. Population density also registered an increasing trend owing to the phenomenal rise in the population. Among the districts, Nagapattinam and Tiruchirappalli district had higher population density than state average with 668 and 602 persons per square kilometer, respectively. Pudukkottai district has population density of 348 persons per square kilometer. The population density of the Tamil Nadu state was 555 persons per square kilometer as per census 2011. The population details pertaining to sex ratio, density, are depicted in the Table.4.2.

**Table 4.1 District-wise and Season wise Distribution of Rainfall: 2008-09 & 2009-10 (mm)**

Season	Year	Rainfall	Tiruchirappalli	Pudukkottai	Nagapattinam	State Average
South-West (June to September)	2008-09	Normal	270.3	350.7	274.1	316.1
		Actual	259.1	292.0	175.8	333.5
	2009-10	Normal	270.3	350.7	274.1	316.1
		Actual	231.3	204.6	159.1	317.0
North –East (October to December)	2008-09	Normal	356.1	418.0	886.4	431.1
		Actual	575.6	545.0	1222.4	552.7
	2009-10	Normal	356.1	418.0	886.4	431.1
		Actual	385.3	478.7	1340.1	482.6
Winter (January & February)	2008-09	Normal	25.0	38.2	81.5	35.3
		Actual	7.6	13.7	58.3	7.7
	2009-10	Normal	25.0	38.2	81.5	35.3
		Actual	7.5	1.5	57.0	11.5
Hot – Weather (March to May)	2008-09	Normal	110.1	114.6	99.7	129.1
		Actual	51.6	80.9	288.1	129.2
	2009-10	Normal	110.5	114.6	99.7	129.1
		Actual	133.2	128.9	110.7	126.7
Total	2008-09	Normal	761.5	921.5	1341.7	911.6
		Actual	893.9	931.6	1744.6	1023.1
	2009-10	Normal	761.9	921.5	1341.7	911.6
		Actual	757.3	813.7	1666.9	937.8

Source: Season and Crop reports of T.N(various issues), Department of Economics and Statistics, Chennai -06

**Table 4.2 Demographic details in the study area during 2011 (In Numbers)**

Particulars	Tamil Nadu	Tiruchirappalli	Pudukkottai	Nagapattinam
Area (Sq.km)	130058	4511	4651	2417
Rural				
Total	37189229 (51.55)	1377009 (50.74)	1304800 (80.61)	1250291 (77.46)
Male	18663701 (25.87)	684825 (25.23)	646800 (39.96)	618594 (38.33)
Female	18525528 (25.68)	692184 (25.51)	658000 (40.65)	631697 (39.14)
Urban				
Total	34949729 (48.45)	1336849 (49.26)	313925 (19.39)	363778 (22.54)
Male	17495170 (24.25)	663038 (24.43)	156537 (9.67)	178620 (11.07)
Female	17454559 (24.20)	673811 (24.83)	157388 (9.72)	185158 (11.47)
Total population				
Total	72138958 (100.00)	2713858 (100.00)	1618725 (100.00)	1614069 (100.00)
Male	36158871 (50.12)	1347863 (49.67)	803337 (49.63)	797214 (49.39)
Female	35980087 (49.88)	1365995 (50.33)	815388 (50.37)	816855 (50.61)
Literacy Rate	80.33	83.56	77.76	84.09
Density per Sq.Km	555	602	348	668
Females per 1000 Males	995	1013	1015	1025

Note: Figure in parenthesis indicates the percentage to total population

Source: Census of India 2011

## Land Holding Pattern

As per the Agricultural Census (2005-06), there were 3.69, 2.93, and 1.82 lakhs of operational holding in Pudukottai, Tiruchirappalli and Nagapattinam districts respectively, of which, about 90 per cent of the cultivators belonged to marginal and small category. Land holding in terms of area showed that about 55 - 60 per cent of the holding was held by 90 per cent of small and marginal farmers and remaining 40 percent of the holding was held by 10 percent of the medium and large farmers. The details are presented in table 4.3

**Table 4.3 Land holding pattern in the study area**

Classifications of holdings	Tiruchirappalli		Pudukottai		Nagapattinam	
	No of farmers	Area in Ha	No of farmers	Area in Ha	No of farmers	Area in Ha
Marginal	219933 (75.03)	90422 (37.40)	298864 (80.87)	101207 (34.96)	139144 (76.06)	55598 (35.85)
Small	49263 (16.81)	68301 (28.25)	45322 (12.26)	62973 (21.75)	27759 (15.17)	38789 (25.01)
Semi medium	19110 (6.52)	51299 (21.22)	18024 (4.88)	50265 (17.36)	11989 (6.55)	32653 (21.05)
Medium	4508 (1.54)	24943 (10.32)	6319 (1.71)	36152 (12.49)	3598 (1.97)	20131 (12.98)
Large	311 (0.11)	6794 (2.81)	1050 (0.28)	19010 (6.57)	439 (0.24)	7914 (5.10)
Total	293125 (100)	241760 (100)	369579 (100)	289507 (100)	182929 (100)	155085 (100)

Source: Agricultural census, 2005-06, Dept of Economics and Statistics, Chennai- 06

## **Agro-climatic zones of the Tamil Nadu and study area**

Based on soil characteristics, rainfall distribution, irrigation pattern, cropping pattern and other ecological and social characteristics, the State Tamil Nadu has been classified into seven agro-climatic zones. The following are the seven agro-climatic zones of the State of Tamil Nadu.

### **North Eastern Zone**

Districts of Thiruvallur, Vellore, Chinglepattu, Thiruvannamalai, Viluppuram, Cuddalore (excluding Chidambaram and Kattumannarkoil taluks), some parts of Perambalur including Ariyalur taluk and also Chennai.

### **North Western Zone**

Dharmapuri district (excluding hilly areas), Salem, Namakkal district (excluding Tiruchengode taluk) and Perambalur taluk of Perambalur district.

### **Western Zone**

Erode, Coimbatore, Dindugal, Theni districts, Tiruchengode taluk of Namakkal district, Karur taluk of Karur district and some western part of Madurai district.

### **Cauvery Delta Zone**

Thanjavur, Thiruvarur, Nagapattinam districts and Musiri, Tiruchirapalli, Lalgudi, Thuraiyur and Kulithalai taluks of Tiruchirapalli district, Aranthangi taluk of Pudukottai district and Chidambaram and Kattumannarkoil taluks of Cuddalore district.

### **Southern Zone**

Sivagangai, Ramanathapuram, Virudunagar, Tuticorin and Tirunelveli districts and Natham and Dindigul taluks of Dindigul district, Melur, Tirumangalam, Madurai South and Madurai North taluks of Madurai district and Pudukkottai district excluding Aranthangi taluk.

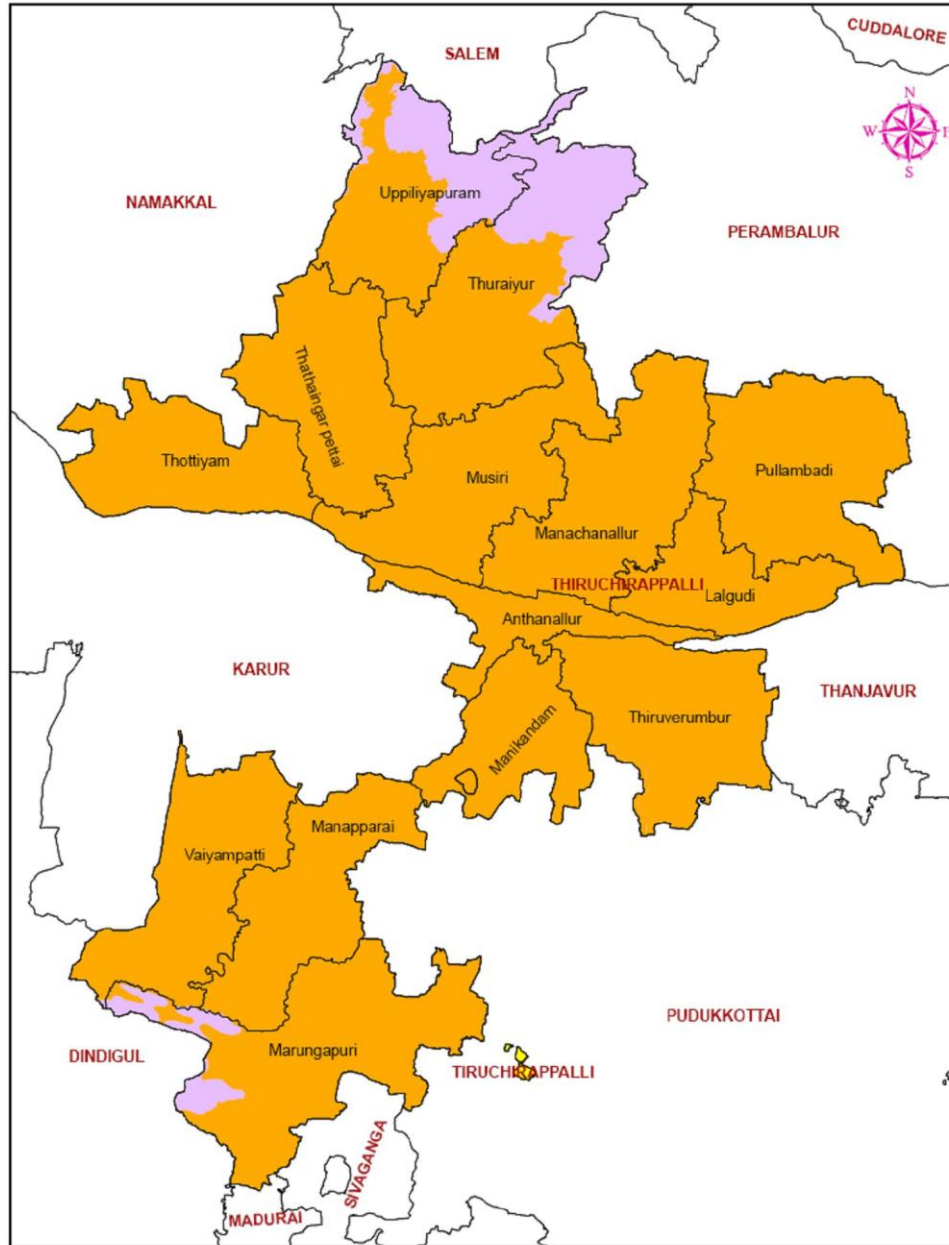
### **High Rainfall Zone**

Kanayakumari district.

### **High Altitude and Hilly Zone**

Hilly regions, namely the Nilgiris, Shevroys, Elagiri-Javvadhu, Kollimalai, Patchaimalai, Anamalais, Palanis and Podhigaimalais. The Agro-climatic zones of the study area are depicted in the fig.

## AGROCLIMATIC ZONES OF THIRUCHIRAPPALLI DISTRICT



0 3 6 12 18 24  
Kilometers

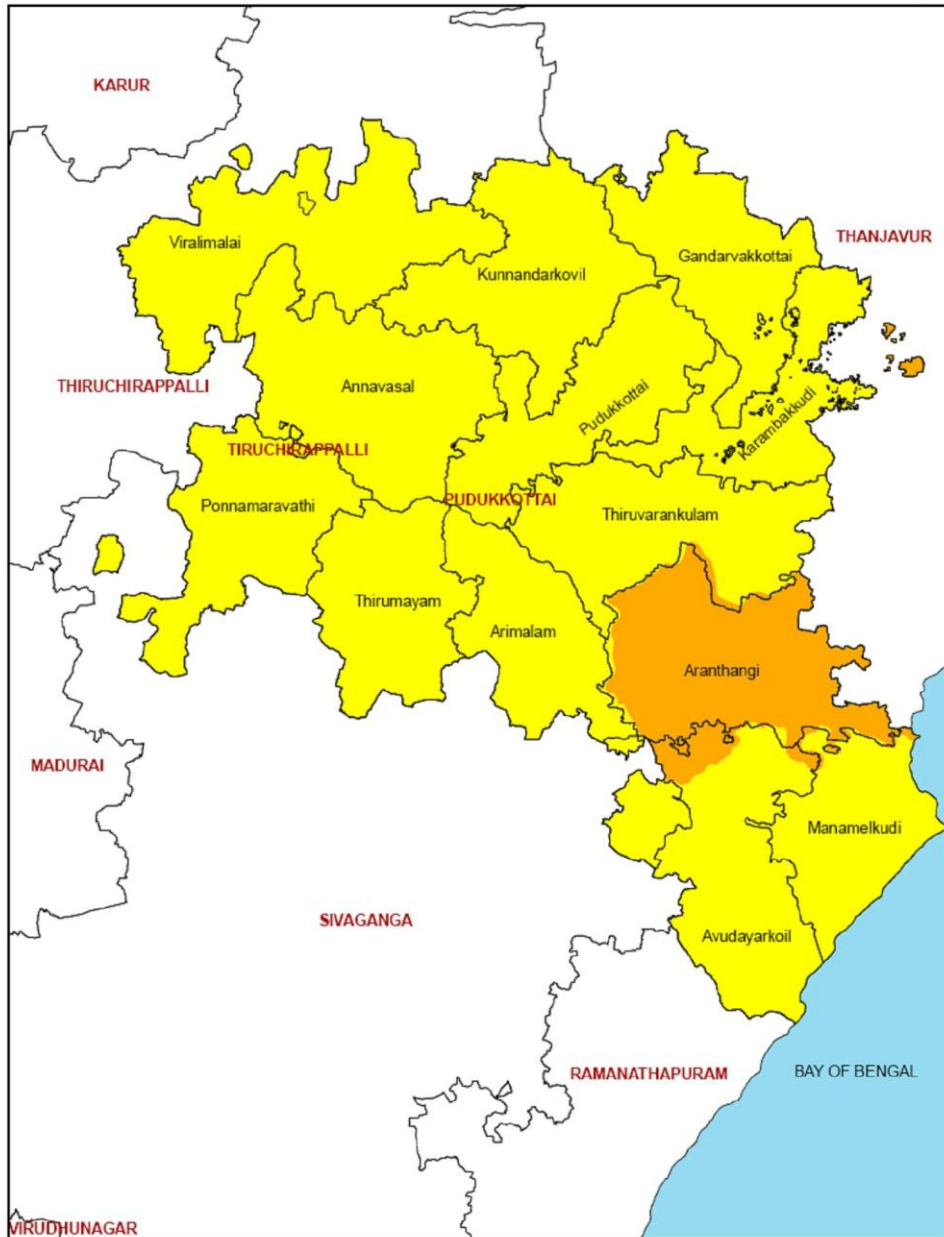
Legend

- Cauvery Delta Zone
- High Altitude and Hilly Zone
- Southern Zone



Generated at  
Remote Sensing and GIS Centre, Tamil Nadu Agricultural University, Coimbatore - 641003.

# AGROCLIMATIC ZONES OF PUDUKOTTAI DISTRICT



- Legend
- Cauvery Delta Zone
  - Southern Zone



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# AGROCLIMATIC ZONES OF NAGAPATTINAM DISTRICT



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Remote Sensing and GIS Centre, Tamil Nadu Agricultural University, Coimbatore - 641003.

**Resources: Land Use pattern**

The land use pattern of selected districts is presented in the table 4.4. The total geographical area was highest for Pudukottai district with 466329 hectares, which was followed by Tiruchirappalli and Nagapattinam districts with 4,40,383 and 271583 hectares respectively. Net area sown was highest for Tiruchirappalli district with 165391 hectares and this accounted for 37.56 per cent of the total area of the district, this was followed by Pudukottai and Nagapattinam districts.

Forest cover was below the optimum level, which was 8.35, 5.05 per cent in Tiruchirappalli and Pudukottai districts and the same was very minimum accounting for only about 1.71 per cent of the land in Nagapattinam district.

The land not available for cultivation covering Barren and Uncultivable land and land put to non-agricultural uses was highest in Pudukottai district and which accounts for 29.96 per cent and the same was 29.89 and 22.16 per cent respectively, in Nagapattinam and Tiruchirappalli districts.

The area coming under fallows including the current fallows was highest in Tiruchirappalli district with 29.55 per cent, which was followed by 23.41 and 7.19 per cent respectively in Pudukottai and Nagapattinam districts. The phenomenal increase in fallow lands indicates that the fallow lands are increasing over the years. The area sown more than once was recorded highest in Nagapattinam followed by Tiruchirappalli and Pudukottai districts.

**Table 4.4 Land Use Pattern in the study area (in Ha)**

Classification	Tiruchirappalli			Pudukkottai			Nagapattinam		
	2007-08	2008-09	2009-10	2007-08	2008-09	2009-10	2007-08	2008-09	2009-10
Total Geographical Area ( village papers)	440383 (100.0)	440383 ( 100.0)	440383 (100.0)	466329 (100.0)	466329 (100.0)	466329 (100.0)	271583 (100.0)	271583 (100.0)	271583 (100.0)
Land Utilisation									
Forests	36773 (8.35)	36773 (8.35)	36773 (8.35)	23535 (5.05)	23535 (5.05)	23535 (5.05)	4633 (1.71)	4633 (1.71)	4633 (1.71)
Barren and Unculturable Land	12745 (2.89)	12620 (2.87)	12598 (2.86)	9863 (2.12)	9863 (2.12)	9863 (2.12)	33419 (12.31)	33419 (12.31)	33419 (12.31)
Land put to Non- Agricultural Use	84965 (19.29)	84975 (19.30)	85083 (19.32)	129807 (27.84)	129819 (27.84)	129836 (27.84)	47710 (17.57)	47709 (17.57)	47720 (17.57)
Culturable waste	7434 (1.69)	7185 1.63	7316 (1.66)	10230 (2.19)	10003 (2.15)	10003 (2.15)	3509 (1.29)	1740 (0.64)	2122 (0.78)
Permanent Pastures and Other Grazing Lands	659 (0.15)	659 (0.15)	659 (0.15)	5124 (1.10)	5124 (1.10)	5124 (1.10)	964 (0.35)	846 (0.31)	846 (0.31)
Land under Miscellaneous Tree Crops and Groves not included in the Net Area Sown	1961 (0.45)	2347 (0.53)	2446 (0.56)	28380 (6.09)	28172 (6.04)	28103 (6.03)	8224 (3.03)	6647 (2.45)	6458 (2.38)
Current Fallows	27400 (6.22)	23227 (5.27)	29239 (6.64)	16277 (3.49)	15528 (3.33)	17073 (3.66)	6912 (2.55)	4558 (1.68)	11363 (4.18)
Other Fallow Lands	94166 (21.38)	97908 (22.23)	100878 (22.91)	91353 (19.59)	90893 (19.49)	92121 (19.75)	12168 (4.48)	8016 (2.95)	8167 (3.01)
Net Area Sown	174280 (39.56)	174689 (39.67)	165391 (37.56)	151760 (32.54)	153392 (32.89)	150671 (32.31)	154044 (56.72)	164015 (60.39)	156855 (57.76)
Area Sown more than once	17702	18892	15752	894	856	994	128208	135069	111860
Gross Cropped Area	191982	193581	181143	152654	154248	151665	282252	299084	268715

Note: Figures in parentheses indicates per cent to total geographical area

Source: Season and Crop reports of T.N (various issues), Department of Economics and Statistics, Chennai -06

## **Agriculture and Horticulture**

### **Cauvery Delta Zone**

This zone includes Thanjavur district, Musiri, Tiruchirapalli, Lalgudi, Thuraiyur and Kulithalai taluks of Tiruchirapalli district, Aranthangi taluk of Pudukottai district and Chidambaram and Kattumannarkoil taluks of Cuddalore and Villupuram district. Total area of the zone is 24,943 sq.km. in which 60.2 per cent of the area i.e., 15,00,680 hectares are under cultivation. And 50.1 per cent of total area of cultivation is the irrigated area. This zone receives an annual normal rainfall of 956.3 mm. It covers the rivers of Cauvery, Vennaru, Kudamuruti, Paminiar, Arasalar and Kollidam. The major dams utilized by this zone are Mettur and Bhavanisagar. Canal irrigation, well irrigation and lake irrigation are under practice. The major crops are paddy, sugarcane, cotton, groundnut, sunflower, banana and ginger. Thanjavur district, which is known as “Rice Bowl” of Tamil Nadu, comes under this zone.

### **Major Crops cultivated in the study area**

#### **i) Crops**

Rice, Banana, Millets and other cereals are the principal crops in the study area.

Important Food Crops	Rice, Banana, Sorghum, Bajra, Red gram, Green gram, Black gram, Horse gram, Turmeric, Sugarcane, Mango, Tapioca, Groundnut & Gingelly
Important Non-food Crops	Cotton, Castor and Fodder Crops

### **Area & Production of Principal Crops**

Paddy was the important staple crop among all the cereals and cultivated more during samba season mainly due to availability of canal irrigation in samba season followed by millets and sugarcane. Among the districts, Nagapattinam occupied major area under paddy, which had around 1.5 lakh hectares of area under paddy cultivation with a production of about 3 lakh tonnes, which was followed by Pudukkottai and Tiruchirappalli, respectively during the year 2010-11.

Among the sample districts, area and production of pulses were recorded highest in Nagapattinam district with 14.72 per cent of the state area and 12 per cent of state production, respectively. This was followed by Trichy and Pudukottai districts. Among the Oil Seeds, groundnut is the most important crop followed by gingelly and the contributions of cotton are

also marked at significant level in Tiruchirappalli district which had about 12 per cent each of the state area and production of cotton. Area and production of sugarcane was highest in Pudukottai with 7.8 thousand hectares and 8.5 lakhs tones, respectively which was followed by Tiruchirappalli and Nagapattinam districts, respectively. The details are presented in table 4.5

**Table 4.5 Area & Production of Principal Crops during 2010-11 in sample districts**

Crops	Trichy		Pudukkottai		Nagapattinam		Tamil Nadu	
	Area (Ha)	Production (tonnes)	Area (Ha)	Production (tonnes)	Area (Ha)	Production (tonnes)	Area (Ha)	Production (tonnes)
Rice	67165 (3.52)	268136 (4.63)	92901 (4.87)	208874 (3.61)	156049 (8.19)	321506 (5.55)	1905726 (100)	5792415 (100)
Sorghum	22795 (9.36)	13258 (5.37)	407 (0.17)	328 (0.13)	0	0	243465 (100)	246981 (100)
Bajra	1892 (3.82)	1276 (1.65)	0	0	0	0	49482 (100)	77369 (100)
Maize	4751 (2.06)	23544 (2.29)	2888 (1.25)	20732 (2.02)	24 (0.01)	93 (0.01)	230489 (100)	1027536 (100)
Pulses	8844 (1.39)	4889 (1.99)	1754 (0.28)	630 (0.26)	93713 (14.72)	29931 (12.21)	636735 (100)	245191 (100)
Sugarcane	4817 (1.52)	493673 (1.44)	7858 (2.49)	853814 (2.49)	3046 (0.96)	289076 (0.84)	315961 (100)	34251796 (100)
Cotton	14479 (11.99)	28519 (11.50)	12 (0.01)	22 (0.01)	261 (0.22)	763 (0.31)	120765 (100)	247930 (100)
Groundnut	10584 (2.75)	19115 (2.13)	16459 (4.27)	25748 (2.87)	2495 (0.65)	7894 (0.88)	385509 (100)	895638 (100)
Gingelly	511 (1.06)	317 (1.25)	451 (0.94)	277 (1.09)	914 (1.90)	338 (1.33)	48189 (100)	25387 (100)

\*\*Sugarcane - In terms of Cane, Yield rate in tonnes per hectare

# Cotton – Production in Bales of 170 Kg lint each

Source: Season and Crop reports of T.N (various issues), Department of Economics and Statistics, Chennai -06

**Table 4.6 Productivity of Principal Crops during 2010-11 in sample districts (Kg/ha)**

Crops	Trichy	Pudukkottai	Nagapattinam	Tamil Nadu
Rice	3992.20	2248.35	2060.29	3039.48
Sorghum	581.62	805.90	0	1014.44
Bajra	674.42	0	0	1563.58
Maize	4955.59	7178.67	3875.00	4458.07
Pulses	552.80	359.18	319.39	385.08
Sugarcane #	102.49	108.65	109.03	108.41
Cotton	1969.68	1833.33	2923.37	2053.00
Groundnut	1806.03	1564.37	3163.93	2323.26
Gingelly	620.35	614.19	369.80	526.82

# in terms of tonnes per Ha

Source: Season and Crop reports of T.N(various issues), Department of Economics and Statistics, Chennai -06

Productivity of principal crops in sample districts was shown in table. 4.6. Productivity of rice was higher than state average productivity in Tiruchirappalli district with 3992 kg per ha, which showed efficient input management and technology adoption by the farmers. Productivity of rice in Pudukottai and Nagapattinam were 2248, 2060kg per ha, respectively.

Productivity of maize were higher than state average productivity in Pudukottai and Tiruchirappalli districts with 7178 and 4955 kg per ha, respectively, where as the state average productivity of maize was 4458 kg per ha. In Nagapattinam district, productivity of cotton and groundnut were recorded higher than state average productivity. The details are presented in table 4.6

#### **Cropping pattern:**

Rice is the main crop of the study area and normally, it is grown three times in a year. The first crop is known as `Kuruvai' (the short-term crop) with duration of three and a half to four months from June-July to October-November. The second crop called the `Thaladi' has duration of five to six months from October - November to February-March. Third is the 'Samba' (the long-term) crop and has duration of almost six months from August to January. The details are presented in table 4.7

Among the sample districts, paddy occupied major share of area under crops. Area under paddy was highest in Nagapattinam district, which accounted for 157 thousand hectares,

followed by 95 and 64 thousand hectares, respectively in Tiruchirappalli and Pudukottai districts during the year 2009-10. Other cereal crops grown in the study area were bajra, ragi and maize.

The pulses grown in the study area were blackgram, redgram, and greengram. Area under pulses was highest in Nagapattinam district, followed by Tiruchirappalli and Pudukottai districts, respectively. Area under edible oils crops such as groundnut, gingelly were highest in pudukkottai district followed by Tiruchirappalli and Nagapattinam districts. The same trend was also noticed for sugarcane crop. Among the non-food crops, cotton was grown mainly in Tiruchirappalli district. Over all area under cultivation declined in the study area.

**Table 4.7 Cropping pattern of the study area by districts during 2009-10**

(ha)

Crop	Season	Tiruchirappalli	Pudukottai	Nagapattinam
Paddy	Kuruvai	6816	417	27252
	Samba	55341	94593	129814
	Navarai	2139	292	789
	Total Paddy	64296	95302	157855
Maize	Irrigated	6827	2945	6
	Un irrigated	491	116	0
	Total	7318	3061	6
Black gram	Irrigated	762	474	0
	Un irrigated	7586	371	51819
	Total	8348	845	51819
Total Pulses	Irrigated	939	504	0
	Un irrigated	10186	1521	81142
	Total	11125	2025	81142
Groundnut	Irrigated	4664	6623	1462
	Un irrigated	6876	12520	924
	Total	11540	19143	2386
Gingelly	Irrigated	508	243	0
	Un irrigated	121	940	683
	Total	629	1183	683
Sugarcane	Irrigated	4478	7133	3958
	Un irrigated	0	0	0
	Total	4478	7133	3958
Cotton	Irrigated	435	13	317
	Un irrigated	8884	0	0
	Total cotton	9319	13	317

Source: Season and Crop reports of T.N (various issues), Department of Economics and Statistics, Chennai -06

**Table 4.8 Area irrigated by districts in the study area (Hectares)**

	Net Area Irrigated				Area Irrigated more than once				Gross Area Irrigated			
	2006-07	2007-08	2008-09	2009-10	2006-07	2007-08	2008-09	2009-10	2006-07	2007-08	2008-09	2009-10
Tiruchirappalli	108788 (3.77)	102264 (3.57)	106973 (3.65)	98740 (3.45)	7363 (1.75)	9030 (2.33)	10669 (2.31)	8480 (2.27)	116151 (3.51)	111294 (3.42)	117642 (3.47)	107220 (3.31)
Pudukkottai	107464 (3.72)	104883 (3.66)	111701 (3.81)	112021 (3.91)	1918 (0.46)	751 (0.19)	703 (0.18)	633 (0.17)	109382 (3.31)	105634 (3.25)	112404 (3.31)	112654 (3.48)
Nagapattinam	128767 (4.46)	123375 (4.31)	131159 (4.47)	124853 (4.36)	31446 (7.48)	26730 (6.89)	34762 (8.96)	28311 (7.56)	160213 (4.84)	150105 (4.62)	165921 (4.89)	153164 (4.73)
Tamil Nadu	2888880 (100.00)	2863823 (100.00)	2931113 (100.00)	2863866 (100.00)	420403 (100.00)	387857 (100.00)	461993 (119.11)	374368 (100.00)	3309283 (100.00)	3251680 (100.00)	3393106 (100.00)	3238234 (100.00)

Source: Season and Crop reports of T.N (various issues), Department of Economics and Statistics, Chennai -06

**Table 4.9 Area irrigated under food and non food crops by districts in the study area (in Ha)**

District/state	Food Crops				Non Food Crops			
	2006-07	2007-08	2008-09	2009-10	2006-07	2007-08	2008-09	2009-10
Tiruchirappalli	100336 (3.75)	149194 (3.52)	150836 (3.53)	93041 (3.61)	15815 (2.51)	42788 (2.71)	42745 (2.75)	14179 (2.14)
Pudukkottai	101976 (3.81)	116645 (2.76)	123448 (2.89)	101189 (3.93)	7406 (1.18)	36009 (2.28)	30800 (1.98)	11465 (1.73)
Nagapattinam	158058 (5.90)	260664 (6.16)	279182 (6.54)	149688 (5.81)	2155 (0.34)	21588 (1.37)	19902 (1.28)	3476 (0.52)
State	2679180 (100.00)	4233713 (100.00)	4268583 (100.00)	2575027 (100.00)	630103 (100.00)	1581461 (100.00)	1555665 (100.00)	663207 (100.00)

Source: Season and Crop reports of T.N (various issues), Department of Economics and Statistics, Chennai -06

**Table 4.10 Source wise area irrigated in the study area (in ha)**

District	Canals				Tanks				Wells			
	Net Area Irrigated		GA Irrigated		Net Area Irrigated		GA Irrigated		Net Area Irrigated		GA Irrigated	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Tiruchirappalli	41510 (5.42)	40776 (5.39)	47263 (5.01)	46026 (5.23)	4850 (0.90)	4054 (0.81)	5176 (0.89)	4160 (0.78)	60613 (3.76)	53910 (3.38)	65203 (3.51)	57034 (3.14)
Pudukkottai	5484 (0.72)	6028 (0.80)	5484 (0.58)	6040 (0.69)	75836 (14.04)	75126 (14.92)	75905 (13.09)	75130 (14.06)	30381 (1.88)	30867 (1.94)	31015 (1.67)	31484 (1.74)
Nagapattinam	130446 (17.04)	123696 (16.34)	165208 (17.51)	152003 (17.28)	0	0	0	0	0	0	0	0
State	765527 (100)	757090 (100)	943703 (100)	879409 (100)	540281 (100)	503491 (100)	579968 (100)	534281 (100)	1614082 (100)	1593968 (100)	1856829 (100)	1813949 (100)

Source: Season and Crop reports of T.N (various issues), Department of Economics and Statistics, Chennai -06

**Table 4.11 Source wise watersupply by districts in study area (in Numbers)**

District	Year	Length of Canals (kms.)			No. of Tanks having Ayacut			No. of wells used for irrigation		
		Government	Private	Total	40 Hect and more	Less than 40 Hect	Total No of Tanks	Tubewells	Ordinary wells	Total
Tiruchirappalli	2007- 08	494	0	494	115	1652	1767	6192	73630	79822
	2008-09	494	0	494	115	1652	1767	6119	73332	79451
	2009-10	494	0	494	115	1652	1767	6212	72505	78717
Pudukkottai	2007- 08	78	0	78	660	4791	5451	11541	24868	36409
	2008-09	78	0	78	660	4791	5451	12287	21113	33400
	2009-10	78		78	660	4791	5451	12201	18910	31111
Nagapattinam	2007- 08	548	0	548	0	0	0	367	4038	4405
	2008-09	548	0	548	0	0	0	367	4019	4386
	2009-10	548	0	548	0	0	0	367	4018	4385
State	2007- 08	9736	11	9747	7982	33278	41260	200306	1532262	1732568
	2008-09	9736	11	9747	7984	33278	41262	201913	1518830	1720743
	2009-10	<b>9736</b>	11	9747	<b>7984</b>	<b>33278</b>	<b>41262</b>	205765	1530089	1735854

Source: Season and Crop reports of T.N (various issues), Department of Economics and Statistics, Chennai -06

## **Area under Irrigation**

Among the sample districts, net area irrigated was highest in Nagapattinam with 1.31 lakh ha, followed by Pudukkottai and Tiruchirappalli districts 1.11 and 1.06 lakh ha, respectively. Same trend were also observed in gross area irrigated of the sample districts. Area under food crops had more area under irrigation when compared to non food crops. Nagapattinam district had larger area under food crops which was followed by Pudukkottai and Tiruchirappalli districts, respectively. With respect to non food crops, Tiruchirappalli district had larger area, followed by Pudukkottai and Nagapattinam districts, respectively. The details are presented in table 4.8 and 4.9

### **Source of irrigation:**

The details of source of irrigation in Tiruchirappalli district presented in table 4.10 & 4.11. The major irrigation source in the study area was canal irrigation and mostly available during south west and north east monsoon period. Most of the farmers relied on canal irrigation alone. The open wells were the next relied source of irrigation. Tank irrigation is usually possible if excess water is stored through a sub canal in artificial ponds. The stored water is then made available up to next cropping season.

Net area irrigated by well irrigation was 53 thousand ha which was followed by canal irrigation accounted for 40 thousand ha and tank irrigation with 4 thousand ha, respectively. Same trend was also observed in gross area irrigated.

Major source of irrigation in Pudukkottai was tank irrigation followed by wells and canal irrigation. Net area irrigated by tanks was 75 thousand ha which was followed by wells with 30 thousand ha and canal irrigation with 6 thousand ha. The same trend was observed in gross cropped area also.

Canal irrigation is the main source of irrigation in Nagapattinam district. Net area irrigated was 1.23 lakh ha and gross area irrigated was 1.52 lakh ha.

Among the sample districts, length of canal was highest in Nagapattinam district with 548 kms followed by Tiruchirappalli and Pudukkottai with 494 and 78 kms, respectively. Number of wells used for irrigation was highest in Tiruchirappalli with about 79 thousand, which was followed by Pudukkottai and Nagapattinam accounted for about 36 thousand and 4 thousand, respectively.

## Forest Resources

Among the sample districts, Tiruchirappalli district had highest area under forest coverage with 36773 hectares which is 8 per cent to the total area of the district, which was followed by Pudukottai and Nagapattinam districts respectively. Tamil Nadu state as whole had a forest area of 16 per cent to geographical area, which is below the optimum level of forest cover to be maintained by every state and central government to maintain ecological balance. (Table 4.12).

**Table 4.12 Area under forest in the study area by district**

( ha)

District/state	Geographic area			Forest area		
	2007-08	2008-09	2009-10	2007-08	2008-09	2009-10
Tiruchirappalli	440383	440383	440383	36773	36773	36773
Pudukkottai	466329	466329	466329	23535	23535	23535
Nagapattinam	271583	271583	271583	4633	4633	4633
State	13026645	13026645	13026645	2105818	2105906	2126672

Source: Season and Crop reports of T.N (various issues), Department of Economics and Statistics, Chennai -06

## Animal resources in the study area

The statistics on livestock population in the sample districts are presented in table below. The population of milch animal (both cattle and buffaloes) was relatively high in Tiruchirappalli, which was followed by Pudukottai and Nagapattinam, respectively. Goat and sheep population was higher in Nagapattinam district followed by Tiruchirappalli and Pudukottai, respectively. However, in both districts, pigs and other had considerable population; these provide subsidiary income to farm households in the study area. The details are presented in Table 4.13.

## Milk, Egg production and Fish catchment by sample districts

Among the sample districts, Tiruchirappalli had higher milk production with 227 thousand tones which was followed by Nagapattinam and Pudukottai districts accounted for 138 and 119 thousand tones, respectively. The same trend was also noticed in egg production. Pudukottai had highest fish production with 9819 tonnes, which was followed by Nagapattinam and Pudukottai districts with 5924 and 720 tonnes, respectively. (Table.4.14).

**Table 4.13 Animal resources in the study area by districts during 2004 (in number)**

District	Cattle	Buffaloes	Sheep	Goats	Pigs	Others	Total
Tiruchirappalli	354301	49577	257271	366753	14164	6719	1048785
Pudukkottai	333326	31958	151078	177816	2022	1464	697664
Nagapattinam	292335	56666	33054	429924	2650	873	815502
State	9141043	1658415	5593485	8177420	320868	50798	24942029

Source: Tamil Nadu - An Economic Appraisal), Govt of Tamil Nadu, Chennai

**Table 4.14 Milk, Egg production and fish catchment by sample districts.**

District	Milk ('000' Tonnes)			Egg (In lakhs)			Inland Fish Catchment (In Tonnes)		
	2006-07	2007-08	2008-09	2006-07	2007-08	2008-09	2006-07	2007-08	2008-09
Tiruchirappalli	236.5	224.6	227.9	713.5	818.9	1160.9	696	701	720
Pudukkottai	109.9	114.0	119.0	121.7	118.7	97.5	9448	9634	9819
Nagapattinam	144.4	150.3	138.5	96.7	102.8	117.9	5701	5812	5924
<b>State</b>	<b>5560.5</b>	<b>5586.2</b>	<b>5673.7</b>	<b>80435.2</b>	<b>83936.6</b>	<b>88097.7</b>	<b>160172</b>	<b>164504</b>	<b>166456</b>

Source: Tamil Nadu - An Economic Appraisal ), Govt of Tamil Nadu, Chennai

## **Land degradation**

Land degradation due to erosion, dunes and barren lands, sodicity are feasibly rectifiable by increase in cost of cultivation. But the application of appropriate package of practice of reclamation is much needed for profitable cultivation under saline/sodic soil.

### **Salinization / Alkalization**

Salinization can result from improper management of canal irrigation water resulting in the rise of water table and consequent accumulation of salts in the root zone in arid, semi-arid and sub humid (dry) conditions and ingress of sea water in coastal regions and/or use of high-salt containing ground water. They also become saline when soils have developed on salt-containing parent materials or have saline ground water. The soils with EC more than 2ds/m in vertisols and >4ds/m in non-vertisols was considered as saline in the present project. Increase in soil pH beyond 8.5 results in sodicity or alkalization that result in increase of exchangeable sodium percentage in soils (> 15). Based on the type of problem, it has been divided into saline, sodic and saline sodic.

### **Area under salinity/ sodicity**

Out of the total area, nearly 20474 hectares of lands are identified as soil problem area with Salinity and Alkalinity, which is 24 per cent to total area of the Tiruchirappalli district and the same were 18907 hectares and 12445 hectares in Pudukottai and Nagapattinam districts, respectively.

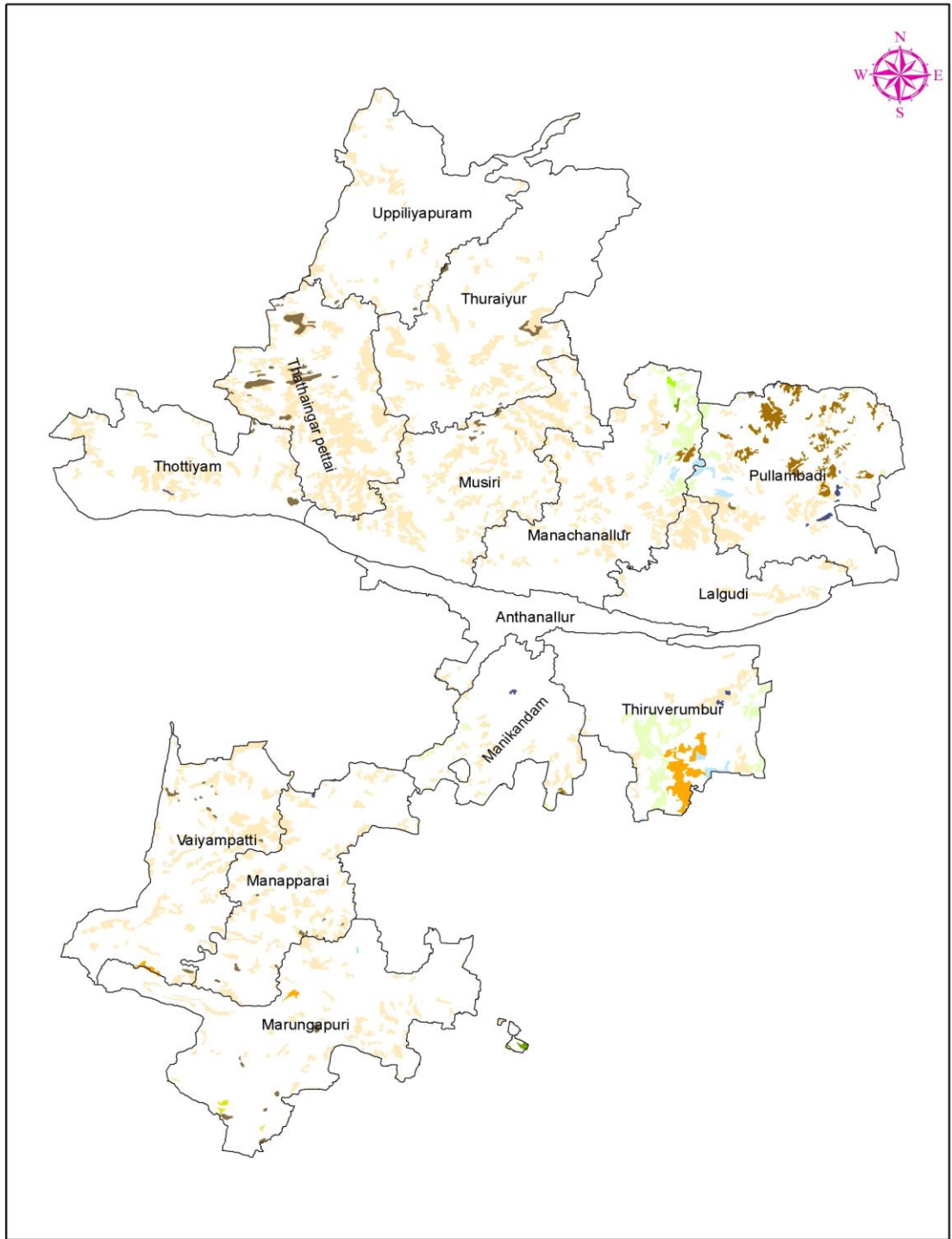
Moreover, nearly 1, 31,785 hectares of lands are identified to be prone to soil erosion in Tiruchirappalli district. It was 67 per cent and 16 per cent, respectively in Pudukottai and Nagapattinam districts. These degraded lands could be put under cultivation only when they are rectified. The details are presented in Tables 4.15 - 4.17; Fig.4.7-4.9.

**Table 4.15 Distribution of area under different categories of degraded land in Tiruchirappalli district during 2010-11**

<b>Land Degradation(LDD) type</b>	<b>LDD code</b>	<b>Extent (ha)</b>	<b>Percent area out of Total Degradation area</b>
Sheet erosion (Water)	Wsh1	44321.90	53.24
Rill erosion	Wri2	405.97	0.49
Sheet erosion (wind)	Esh1	2631.24	3.16
Stabilized dunes	Eds1	2457.48	2.95
Partially stabilized dunes	Edp2	9876.99	11.86
Sodic (slight)	Sso1	9043.39	10.86
Sodic (moderate)	Sso2	11431.48	13.73
Acidity (moderate)	Aac2	2300.92	2.76
Mining	Hmd	221.01	0.27
Brick kiln	Hbk	21.32	0.03
Barren rock / Stony waste	Tbs	491.41	0.59
Riverine sands / sea ingress areas	Tms	52.52	0.06
<b>Total Degradation area</b>		<b>83255.64</b>	18.48
<b>District total area</b>		<b>450509.90</b>	100

Source : Remote sensing and GIS centre, TNAU, Coimbatore -3

# LAND DEGRADATION MAP OF THIRUCHIRAPPALLI DISTRICT



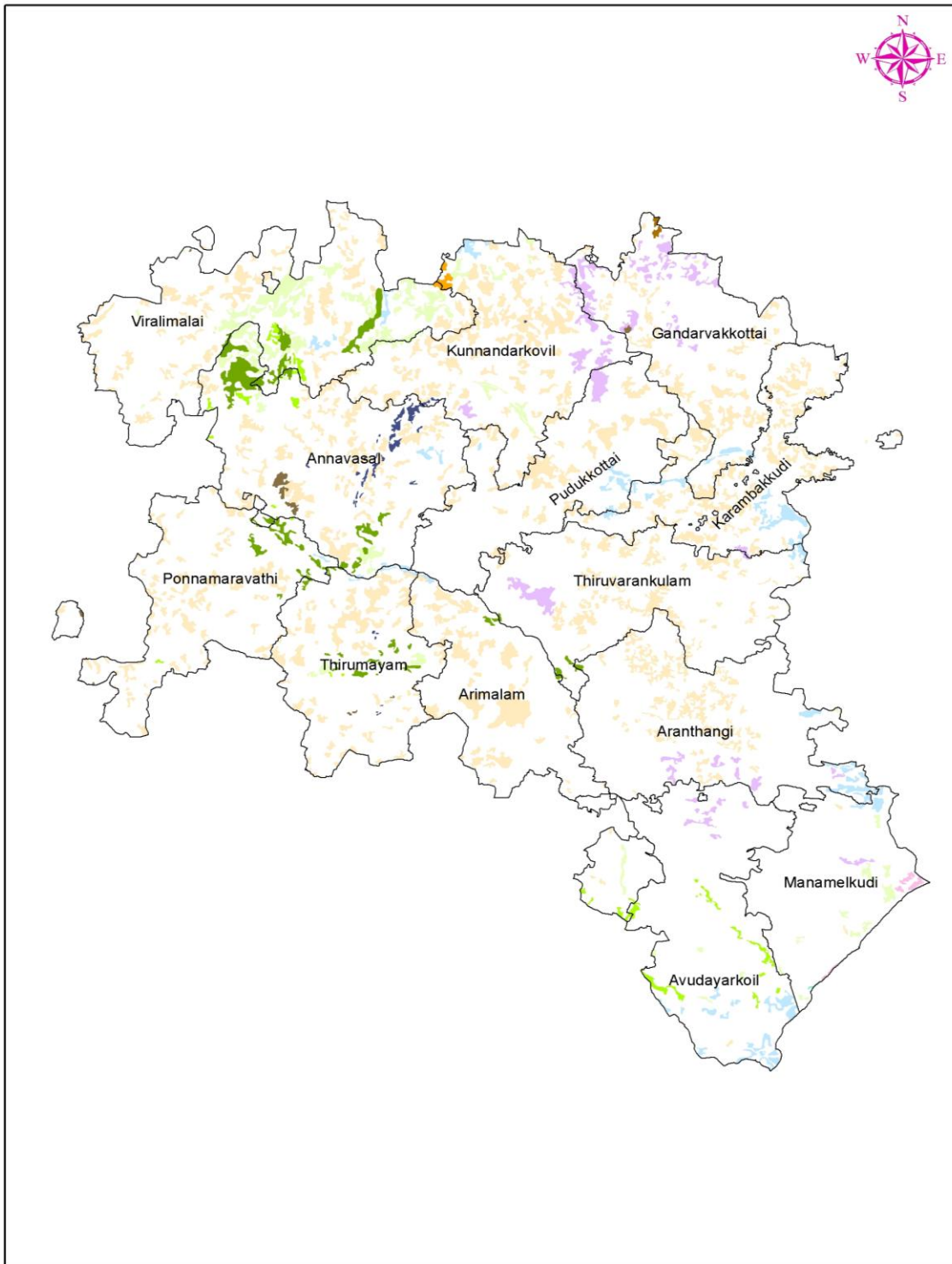
- Legend
- Barren rocky / stony waste
  - Gully erosion
  - Mining / dump areas
  - Rill erosion
  - Riverine sands / Sea ingress areas
  - Saline (slight)
  - Saline-Sodic (severe)
  - Sheet erosion by Water
  - Sodic (moderate)
  - Sodic (severe)
  - Sodic (slight)

**Table 4.16 Distribution of area under different categories of degraded land in Pudukottai district during 2010-11**

<b>Land Degradation (LDD) Type</b>	<b>LDD code</b>	<b>Extent (ha)</b>	<b>Percent area out of Total Degradation area</b>
Sheet erosion (Water)	Wsh1	52833.61	66.48
Rill erosion	Wri2	283.98	0.36
Gully erosion	Wgu3	126.71	0.16
Sheet erosion (wind)	Esh1	262.55	0.33
Saline (slight)	Ssa1	5091.98	6.41
Sodic (slight)	Sso1	7788.36	9.80
Sodic (moderate)	Sso2	1500.65	1.89
Sodic (Severe)	Sso3	4526.14	5.70
Acidity (moderate)	Aac2	5806.13	7.31
Mining	Hmd	763.21	0.96
Barren rock / Stony waste	Tbs	469.44	0.59
Riverine sands / sea ingress areas	Tms	21.56	0.03
<b>Total Degradation area</b>		<b>79474.33</b>	17.08
<b>District total area</b>		<b>465239.27</b>	100.00

Source : Remote sensing and GIS centre, TNAU, Coimbatore -3

# LAND DEGRADATION MAP OF PUDUKOTTAI DISTRICT



0 3 6 12 18 24 Kilometers

**Legend**

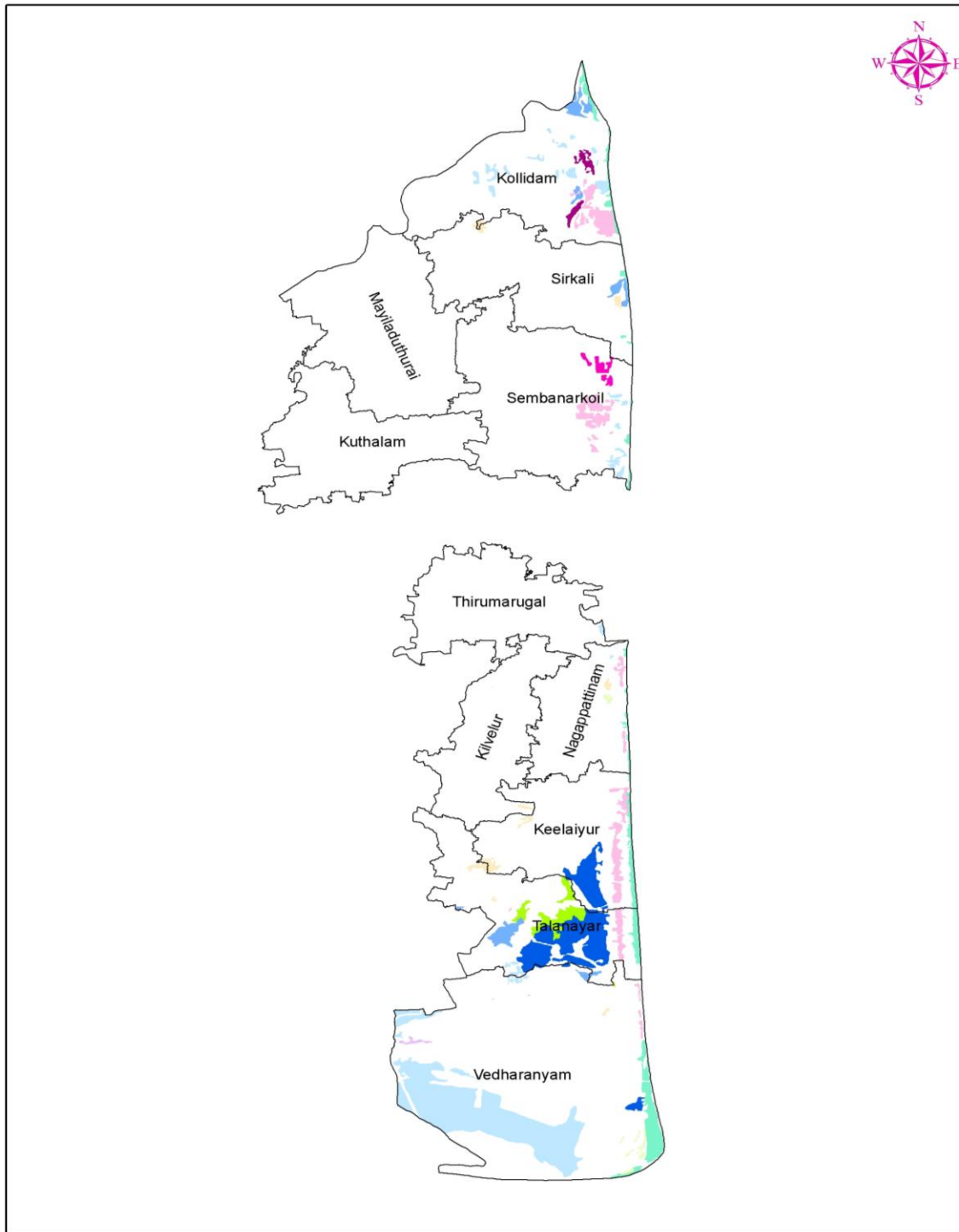
- Acidity (moderate)
- Barren rocky / stony waste
- Gully erosion
- Mining / dump areas
- Rill erosion
- Riverine sands / Sea ingress areas
- Saline (slight)
- Sheet erosion by Water
- Sheet erosion by Wind
- Sodic (moderate)
- Sodic (severe)
- Sodic (slight)

**Table 4.17 Distribution of area under different categories of degraded land in Nagapattinam district during 2010-11**

<b>Land Degradation Type</b>	<b>LDD code</b>	<b>Extent (ha)</b>	<b>Percent area out of Total Degradation area</b>
Sheet erosion (Water)	Wsh1	701.01	2.56
Sheet erosion (wind)	Esh1	3537.50	12.93
Stabilized dunes	Eds1	378.83	1.38
Partially stabilized dunes	Edp2	405.22	1.48
Surface Ponding (slight)	Lsp1	1478.51	5.40
Surface Ponding (moderate)	Lsp2	5171.18	18.90
Saline (slight)	Ssa1	11026.27	40.30
Sodic (slight)	Sso1	256.47	0.94
Sodic (moderate)	Sso2	1162.62	4.25
Acidity (moderate)	Aac2	103.91	0.38
Riverine sands / sea ingress areas	Tms	3140.09	11.48
<b>Total Degradation area</b>		<b>27361.60</b>	10.60
<b>District total area</b>		<b>258136.26</b>	100.00

Source : Remote sensing and GIS centre, TNAU, Coimbatore -3

# LAND DEGRADATION MAP OF NAGAPATTINAM DISTRICT



- Legend
- Acidity (moderate)
  - Partially stabilized dunes
  - Riverine sands / Sea ingress areas
  - Saline (slight)
  - Sheet erosion by Water
  - Sheet erosion by Wind
  - Sodic (moderate)
  - Sodic (slight)
  - Stabilized dunes
  - Surface ponding (Moderate)
  - Surface ponding (Slight)

## ***Results and Discussion***

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## **CHAPTER V**

### **RESULTS AND DISCUSSION**

The primary and secondary data were collected with respect to each of specific objectives with the methods of analysis specified elsewhere. Further, keeping the objectives of the study in view, results are presented and discussed in this chapter under the following sub headings:

5.1 Socio-economic characteristics of sample farmers

5.2 Extent of land degradation due to soil salinity among the sample farmers

5.3 Economic impact of land degradation due to soil salinity at the farm level

5.3.1 Input utilization pattern

5.3.2 Cost of cultivation

5.3.3 Pattern of returns

5.3.4 Resource use efficiency

5.3.5 Decomposition of total differences in yield between affected and non affected soils

5.4 Optimal plans for land utilisation, farm returns and labour employment

5.5 Externalities of soil degradation

5.6 Problems faced by the sample farmers under soil salinity induced soil degradation

5.6.1 Indicators of soil degradation

5.6.2 Adverse effects

5.6.3 Coping-up strategies

5.6.4 Reasons for non-adoption of coping up strategies

#### **5.1 Socio-economic characteristics of sample farmers**

Socio economic status of the farmers has an effect on the adoption behavior of the technology and it is especially important in determining whether households have access to and therefore use different technologies. The soil salinity is expected to be main cause of damages for agricultural land and their yields. The results of the study are presented in the form of three main salinity levels based on the EC value of the soil in the study area, viz., 1. Low salinity (EC value 1 - 2.5 ), 2. Medium salinity (EC value 2.6 - 3.5) and 3. High salinity level (EC value 3.6 and above). Hence, the general farm and personal characteristics of the farm households like age, education, and experience in farming, family particulars, land holding pattern, livestock position and asset position are discussed in detail in the following section.

### 5.1.1 Age - wise distribution of sample farmers

Age of the farmer will have an impact on the adoption behavior of the farmer. The age - wise distribution of sample farmers was presented in Table 5.1. Majority of the farmers were in the age group of 41-50 in the salinity affected category of sample farmers, which accounted for 43.33 per cent and the same was 35 per cent in non-affected category of sample farmers. Among the different salinity affected categories, farmers in the age group of 41-50 was recorded higher in the high level of salinity affected category with 51.52 per cent followed by medium and low level of affected category with 41.03 per cent, 39.58 per cent, respectively. The percentage of farmers in the age group of 51 and above was higher in the salinity affected categories than non - affected category of sample farmers. Among the different salinity affected categories, farmers in the age group of 51 and above were more in medium level of salinity affected category with 35.90 per cent, followed by low and high level of salinity affected category with 33.33 per cent and 21.21 per cent, respectively and the same was 26.67 per cent in non affected category sample farmers. The percentage of farmers in the age group of 31- 40 was higher in non affected category of sample farmers with 31.67 per cent than the farmers under salinity affected category, which accounted for 17.50 per cent in these category. The numbers of farmers in the age group of 20-30 years were more or less same in both affected and non affected category of sample farmers.

**Table 5.1 Age -wise distribution of the sample farmers**

S. No	Age group	Salinity Affected				Non affected
		Low	Medium	High	Pooled	
1	20 - 30	4 (08.33)	3 (07.69)	3 (09.09)	10 (08.33)	8(06.67)
2	31 - 40	9 (18.75)	6 (15.38)	6 (18.18)	21 (17.50)	38(31.67)
3	41 - 50	19 (39.58)	16 (41.03)	17 (51.52)	52 (43.33)	42(35.00)
4	51 and above	16 (33.33)	14 (35.90)	7 (21.21)	37(30.83)	32(26.67)
	Total	48 (100.00)	39 (100.00)	33 (100.00)	120(100.00)	120(100.00)
Paired mean difference of pooled affected over non affected						0.150
Paired Std. deviation difference of pooled affected over non affected						0.403
't' value						4.08***

Note: Figures in parentheses indicate percentages to total

\*\*\* Significance at 1% level

The results of paired t test confirmed that there was a significant mean difference among the affected and non affected category of sample farmers. Overall, the results indicated that the higher involvement of relatively older farmers (more than 41 years) in salinity affected category

than non affected category of sample farmers, where relatively younger farmers (less than 40 years) dominated the farming in the study area. The findings of this study are in agreement with the findings of Kulkarni (2007), Thilagavathi and Chandrasekaran (2009), Satish (2010) and Priyanka(2012).

### 5.1.2 Composition of family of the sample farmers

The composition of family of the sample farmers is presented in Table 5.2. It is evident from the table that the average size of family was found to be higher among the farmers of non affected category (5.31 persons) than the farmers of salinity affected category (5.28 persons). Among the different affected categories of sample farmers, average size of family was higher in the high level of affected category (5.49 persons) followed by medium (5.26 persons) and low level of affected category (5.11 persons). The composition of the family with respect to male, female and number of children showed that, it was almost equal in salinity affected and non affected sample farmers. The paired t test results were also confirmed that there was no significant difference among the salinity affected and non affected category. The findings of this study are in agreement with the findings of Kulkarni (2007), Thilagavathi (2009), Satish (2010) and Priyanka. (2012)

**Table 5.2 Composition of family of the sample farmers**

S.No	Particulars	Salinity affected				Non affected
		Low	Medium	High	Pooled	
1	Male	2.12 (41.49)	2.16 (41.06)	2.24 (40.80)	2.17(41.10)	2.20(41.43)
2	Female	1.86 (36.40)	1.90 (36.12)	1.95 (35.52)	1.90(35.98)	1.98(37.29)
3	Children	1.13 (22.11)	1.20 (22.81)	1.30 (23.68)	1.21(22.92)	1.13(21.28)
	Average size of family	5.11 (100.00)	5.26 (100.00)	5.49(100.00)	5.28(100.00)	5.31(100.00)
Paired mean difference between pooled non affected and affected						0.067
Paired Std. deviation difference between pooled non affected and affected						0.683
't' value						1.070

Note: Figures in parentheses indicate percentages to total

### 5.1.3 Experience in farming of sample farmers

Farmers with more experience in farming has more knowledge in agriculture, thus will help in better resource allocation and finding ways and means to cope with risk and uncertainty in agriculture. The results of experience in farming of sample farmers are presented in Table.5.3.

The paired‘t’ test results confirmed that there was significant difference between the affected and non affected category of sample farmers. Among the sample farm households, the farmers with the experience in the range of 21-35 years was accounted for 43.33 per cent and 44.17 per cent, respectively in affected and non affected categories and the same varied between 39 per cent and 52 per cent among the different affected categories. Among the sample farmers, the farming experience of 36 years and above was higher in pooled affected category (30.83 per cent) than non affected category of sample farmers (17.50 per cent) and the same ranged between 21.21 per cent and 35.90 per cent among the different affected categories. But, the sample farmers with the farming experience of less than 20 years was more in non affected category (38.33 per cent) than the salinity affected category (25.83 per cent). Hence, it is evident from the table that the farmers with more experience was taking up farming in salinity affected soil than the non affected category of sample farmers. The findings of this study are in agreement with the findings of Thilagavathi and Chandrasekaran (2009), and Priyanka (2012).

**Table 5.3 Experience in farming of sample farmers**

S.No	Experience in years	Salinity Affected				Non affected
		Low	Medium	High	Pooled	
1	Less than 20	13 (27.08)	9 (23.08)	9 (27.27)	31 (25.83)	46 (38.33)
2	21-35 years	19 (39.58)	16 (41.03)	17 (51.52)	52 (43.33)	53 (44.17)
3	36 and above	16 (33.33)	14 (35.90)	7 (21.21)	37 (30.83)	21 (17.50)
	Total	48 (100.00)	39 (100.00)	33(100.00)	120(100.00)	120(100.00)
Paired mean difference between pooled non affected and affected						0.167
Paired Std. deviation difference between pooled non affected and affected						0.374
‘t’ value						4.879***

Note: Figures in parentheses indicate percentages to total

\*\*\* Significance at 1% level

### 5.1.4 Educational status of sample farmers

The educational details relating to sample farmers are presented in Table. 5.4. It is evident from the table that majority of the of sample farmers had education up to secondary level

or less, which accounted for 61.67 per cent and 57.50 per cent, respectively in salinity affected and non affected category and the same varied between 58.33 per cent and 63.33 per cent among the different salinity affected categories. The sample farmers, who had education up to higher secondary level accounted for 20 per cent in salinity affected category and the same was 24.17 per cent in non - affected category. The sample farmers, who had graduation accounted for only 6.67 per cent in non affected category and the same was 3.33 per cent in affected category of sample farmers.

**Table. 5.4 Educational status of sample farmers**

S.No	Particulars	Salinity affected				Non affected
		Low	Medium	High	Pooled	
1	Primary	16(33.33)	15(38.46)	14(42.42)	45(37.50)	37(30.83)
2	Secondary	12(25.00)	10(25.64)	7(21.21)	29(24.17)	32(26.67)
3	Higher secondary	11(22.92)	7(17.95)	6(18.18)	24(20.00)	29(24.17)
4	Collegiate	3(06.25)	1(02.56)	0(0.00)	4(03.33)	8(06.67)
5	Illiterate	6(12.50)	6(15.38)	6(18.18)	18(15.00)	14(11.67)
		48(100.00)	39(100.00)	33(100.00)	120(100.00)	120(100.00)
Paired mean difference between pooled non affected and affected						- 0.075
Paired Std. deviation difference between pooled non affected and affected						0.370
't' value						-2.218**

Note: Figures in parentheses indicate percentages to total

\*\* Significance at 5% level

The illiterate farmers were higher in share in salinity affected category than the farmers of non affected category which accounted for 15 per cent and 11.67 per cent, respectively. The findings of this study are in agreement with the findings of Kulkarni (2007), Thilagavathi and Chandrasekaran (2009), Satish (2010) and Priyanka (2012).

### 5.1.5 Occupational pattern of sample farmers

The occupational pattern of the sample farmers is presented in Table. 5.5. It is inferred from the table that majority of the sample farmers had agriculture as primary occupation, which accounted for 63.33 per cent and 70.83 per cent respectively, in salinity affected and non affected category and the same ranged between 54.55 per cent and 68.75 per cent among the sample farmers of different affected categories. The proportion of sample farmers had secondary occupation was higher in salinity affected category than non affected category, which accounted for 36.67 per cent and 29.71 per cent respectively. Sample farmers with secondary occupation

ranged between 31.25 per cent and 45.45 per cent among the different affected categories. The paired 't' test results confirmed that there was significant difference in occupational pattern among the affected and non affected category of sample farmers. Since, majority of the farmers were small and marginal farmers, secondary occupation is essential for their stable income for livelihood security and to make investment towards the reclamation measures of salinity affected soils. The findings of this study are in agreement with the findings of Thilagavathi and Chandrasekaran (2009) and Priyanka (2012).

**Table 5.5. Occupational pattern of sample farmers**

S.No	Particulars	Salinity affected				Non affected
		Low	Medium	High	Pooled	
1	Primary	33(68.75)	25(64.10)	18(54.55)	76(63.33)	85(70.83)
2	Secondary	15(31.25)	14(35.90)	15(45.45)	44(36.67)	35(29.17)
	Total	48(100.00)	39(100.00)	33(100.00)	120(100.00)	120(100.00)
Paired mean difference between pooled non affected and affected						0.075
Paired Std. deviation difference between pooled non affected and affected						0.264
't' value						3.106***

Note: Figures in parentheses indicate percentages to total

\*\*\* Significance at 1% level

### 5.1.6 Land holding wise distribution of sample farmers

The farmers in the study area were classified into various size groups based up on holding size of the farm. The size group classified were marginal (upto 1ha), small (1.1- 2 ha), medium (2.1 - 4 ha), semi medium (4.1 - 10 ha) and large (10 ha and above). The classification used in the present study was as per the classification stated by Gaurav and Mishra (2011) in their study. The holding wise distribution of sample farmers is presented in Table. 5.6. Among the sample farmers, majority of farmers were under the category of marginal and small and their proportion was higher in affected category than non affected category. It accounted for 55.84 per cent and 45 per cent, respectively in salinity affected and non affected category and the same ranged between 43.75 per cent and 66.66 per cent among the different affected categories. The sample farmers belonged to medium size of holding accounted for 29.17 per cent and 38.33 per cent, respectively in affected and non affected category and the same ranged between 18.18 per cent and 41.67 per cent among the different affected categories of the sample farmers. The proportion of farmers under semi medium and large farmer's category was higher in non affected category than the farmers of affected category.

**Table 5.6 Land holding wise distribution of sample farmers**

S.No	Particulars	Salinity affected				Non affected
		Low	Medium	High	Pooled	
1	Marginal (Upto 1 ha)	9 (18.75)	10 (25.64)	7 (21.21)	26 (21.67)	21 (17.50)
2	Small (1.1 - 2 ha)	12 (25.00)	14 (35.90)	15 (45.45)	41 (34.17)	33 (27.50)
3	Medium (2.1 - 4 ha)	20 (41.67)	9 (23.08)	6 (18.18)	35 (29.17)	46 (38.33)
4	Semi medium (4.1 - 10 ha)	3 (6.25)	4 (10.26)	3 (9.09)	10 (8.33)	11 (9.17)
5	Large (10 ha and above)	4 (8.33)	2 (5.13)	2 (6.06)	8 (6.67)	9 (7.50)
	Total	48 (100.00)	39 (100.00)	33 (100.00)	120 (100.00)	120(100.00)
Paired mean difference between pooled non affected and affected						0.175
Paired Std. deviation difference between pooled non affected and affected						0.382
't' value						5.024***

Note: Figures in parentheses indicate percentages to total

\*\*\* Significance at 1% level

The results of paired 't' test confirmed that there was a significant difference in land holding pattern of affected and non affected farmers. From the table we inferred that the proportion of small and marginal farmers was higher in salinity affected category than the non affected category. Hence, a small change in agricultural income of salinity affected area will have greater impact in the livelihood of the farmers either positively or negatively. The findings of this study are in agreement with the findings of Kulkarni (2007), Thilagavathi and Chandrasekaran (2009), Satish (2010) and Priyanka (2012).

### 5.1. 7. Livestock holding of sample farmers

The details of livestock possession in sample households are presented in Table 5.7. Livestock forms the major asset of the farmers in the study area, which would help them in farming and provide a supplementary source of income for their livelihood security. Cattle, goat and sheep are also maintained. The results indicated that the sample farmers of affected category had maintained more number of animal units than the non affected category. The sample farmers of affected category maintained higher proportion of buffaloes than the non affected category, which accounted for 11.11 per cent and 10.88 per cent, respectively. Among the sample farmers,

poultry had a share of 21.69 per cent in affected category and the same was 19.05 per cent in non affected category. Among the different salinity affected categories, high level of affected category had maintained larger number of livestock population, followed by medium and low level of affected category. As per the paired 't' test results revealed there was a significant difference in livestock holding pattern of affected and non affected categories. In the study area, livestock maintaining is a common practice among the sample farmers, since it is major livelihood opportunity available for most of the sample farmers in the affected category and it also supplies the farm yard manure, which used to enrich the quality and fertility status of the soil. Hence, dependence on livestock provides additional employment opportunities to the sample farmers in the study area. The findings of this study are in agreement with the findings of Thilagavathi and Chandrasekaran (2009) and Priyanka(2012).

### 5.7 Livestock holding pattern of sample farmers

(Numbers)

S.No	Particulars	Salinity affected				Non affected
		Low	Medium	High	Pooled	
1	Milch animals					
1.1	Buffaloes	11 (10.89)	14 (11.11)	17 (11.26)	42.00 (11.11)	32(10.88)
1.2	Cows	9 (8.91)	11 (8.73)	13 (8.61)	33.00 (8.73)	34(11.56)
2	Bullock	6 (5.94)	8 (6.35)	10 (6.62)	24.00 (6.35)	12(4.08)
3	Young Cattle	7 (6.93)	9 (7.14)	13 (8.61)	29.00 (7.67)	20(6.80)
4	Goats	21 (20.79)	24 (19.05)	29 (19.21)	74.00 (19.58)	60(20.41)
5	Sheep	24 (23.76)	33 (26.19)	37 (24.50)	94.00 (24.87)	80(27.21)
6	Poultry	23 (22.77)	27 (21.43)	32 (21.19)	82.00 (21.69)	56(19.05)
	Total	101(100.00)	126(100.00)	151(100.00)	378.00(100.00)	294(100.00)
Paired mean difference between pooled non affected and affected						84
Paired Std. deviation difference between pooled non affected and affected						0.16
't' value						793****

Note: Figures in parentheses indicate percentages to total

\*\*\* Significance at 1% level

### 5.1.8 Asset position of the sample farmers

Asset position of the farm household would reflect the financial soundness of the farm. The details of the asset position of sample farmers are presented in the Table 5.8. The total value of assets was computed in monetary terms based on their present value. Among the sample farmers, value of land had the major share of assets with 77.87 per cent in affected category and

the same was 79.65 per cent in non affected category. Value of livestock asset was more in affected category than non affected category. The proportion of value of livestock asset was 14.15 per cent and 6.23 per cent, respectively in affected and non affected category. Among the different affected categories, the value of livestock asset was more in higher level of salinity category, which accounted for 9.64 per cent followed by medium and low level of affected categories with 5.33 per cent and 3.01 per cent, respectively. The value of assets such as wells and tube wells, farm building and cattle shed and machinery and implements was higher in non affected category than the affected category of sample farmers.

**Table 5.8 Asset position of the sample farmers**

(in '000 Rs)

S.No	Particulars	Salinity affected				Non affected
		Low	Medium	High	Pooled	
I.	Land	475.79 (88.08)	331.67 (85.75)	210.75 (81.92)	339.40 (77.87)	716.76 (79.65)
II.	Non-land					
a.	Wells and tube wells	21.85 (4.05)	16.41 (4.24)	11.63 (4.52)	16.63 (3.82)	51.8 (5.76)
b.	Farm building and cattle shed	5.87 (1.09)	3.15 (0.81)	1.73 (0.67)	3.58 (0.82)	16.53 (1.84)
c.	Machinery and implements (including irrigation structure)	20.39 (3.77)	14.93 (3.86)	8.35 (3.25)	14.56 (3.34)	58.73 (6.53)
d.	Livestock	16.25 (3.01)	20.63 (5.33)	24.79 (9.64)	61.67 (14.15)	56.04 (6.23)
III.	Value of total assets					
a.	Value without land	64.36 (11.92)	55.12 (14.25)	46.5 (18.08)	96.44 (22.13)	183.1 (20.35)
b.	Value with land	540.15 (100.00)	386.79 (100.00)	257.25 (100.00)	435.84 (100.00)	899.86 (100.00)
Paired mean difference between pooled non affected and affected						463.92
Paired Std. deviation difference between pooled non affected and affected						0.740
't' value						6.87***

Note: Figures in parentheses indicate percentages to total

\*\*\* Significance at 1% level

It is evident from the table that the total value asset held by the sample farmers of non affected category was higher when compared with sample farmers of affected category. Among the different affected categories, the value of assets was higher in low level of salinity affected than medium and high level of salinity affected category. This clearly indicates that ability of sample farmers with low level of salinity to withstand the risk in agriculture and to adopt coping

up strategies than medium and high level of affected category. The findings of this study are in agreement with the findings of Thilagavathi and Chandrasekaran (2009) and Priyanka (2012).

### 5.1.9 Area under crops in sample farms

The cropping pattern during the year 2011-12 and the average area under each of these crops in the sample farms are given in Table 5.9. It could be seen from the table that the major crops in the study area were rice, sorghum, maize, pulses, cotton and sugarcane. Among the sample farmers of both the affected and non affected categories, rice occupied a major share of area under crops which accounted for 67.12 per cent and 46.64 per cent, respectively in non affected and affected category followed by pulses which had an area of 15.87 per cent 13.21 per cent, respectively in non affected category and affected category.

**Table 5.9 Area under crops in sample farms**

S.No	Crops	Salinity affected				Non affected
		Low	Medium	High	Pooled	
1	Rice	86.40 (58.28)	41.30 (41.96)	25.22 (31.06)	152.92 (46.64)	238.26 (67.12)
2	Sorghum	5.70 (3.85)	3.00 (3.05)	2.00 (2.46)	10.70 (3.26)	9.50 (2.68)
3	Maize	3.40 (2.29)	4.20 (4.27)	3.20 (3.94)	10.80 (3.29)	13.24 (3.73)
4	Green gram	9.00 (6.07)	7.00 (7.11)	6.00 (7.39)	22.00 (6.71)	26.50 (7.46)
5	Black gram	10.40 (7.02)	5.80 (5.89)	5.10 (6.28)	21.30 (6.50)	29.87 (8.41)
6	Cotton	6.00 (4.05)	2.00 (2.03)	0.80 (0.99)	8.80 (2.68)	9.65 (2.72)
7	Sugarcane	4.20 (2.83)	1.16 (1.18)	0.52 (0.64)	5.88 (1.79)	9.10 (2.56)
8	Other crops	0.90 (0.61)	0.50 (0.51)	0.20 (0.25)	1.60 (0.49)	1.23 (0.35)
9	Fallow land	22.24 (15.00)	33.46 (34.00)	38.17 (47.00)	93.87 (28.63)	17.65 (4.97)
	Total	148.24 (100.00)	98.42 (100.00)	81.21 (100.00)	327.87 (100.00)	355.00 (100.00)
Paired mean difference between pooled non affected and affected						28.042
Paired Std. deviation difference between pooled non affected and affected						0.76
't' value						404.017

Note: Figures in parentheses indicate percentages to total

\*\*\* Significance at 1% level

The crops such as maize occupied an area of 3.73 per cent, followed by sorghum, cotton, sugarcane with 2.68 per cent, 2.72 and 2.56 per cent, respectively in non affected category. Among the sample farmers of affected categories, crops such as maize and sorghum occupied an area of 3.29 percent and 3.26 per cent, respectively. Among the different categories of salinity affected sample farmers, area under crops such as rice, sorghum, maize, cotton and sugarcane were higher in low level salinity affected farmers followed by medium level and high level of salinity affected farmers. Thus, the cropping pattern in the study area demonstrated a mix of cereals and pulses which is essential for livelihood security and millets as fodder for livestock and the earnings from cash crops such as cotton and sugarcane would help to meet the cash needs of family and also to maintain the soil quality in the salinity affected fields of the study area. The land put under fallow or abandoned was higher in affected category (04.97 per cent). An average of 0.78 ha per farmer was abandoned or unutilized in salinity affected than non affected category (0.14 ha per farmer). Land put into fallow was varied between 0.46 to 1.15 ha in affected category. The findings of this study are in agreement with the findings of Kulkarni (2007), Thilagavathi and Chandrasekaran (2009), Satish (2010) and Priyanka (2012).

## **5.2 Extent of land degradation due to soil salinity among the sample farmers**

The extent of salinity affected area among the sample farmers is furnished in Table 5.9. Among the sample farmers of affected categories, total salinity affected area was 327.87 ha. The total salinity affected area was higher in low level of affected category which accounted for 45.21 per cent, followed by medium and high level of affected category which accounted for 30.02 per cent and 24.77 per cent, respectively. Similarly, total area under rice was higher in low level of affected category which accounted for 56.50 per cent followed by medium and high level of salinity affected category with 27 per cent and 16.49 per cent, respectively. Incidence of the salinity problem has its impact on land resources in two ways. In extreme situation, it leads to abandonment of cultivation. Secondly even on cultivated land, the intensity of land use declines substantially as the problem intensifies. Under this situation, land degradation due to soil salinity aggregates land scarcity. The total abandoned land due to salinity area was estimated at 93.87 ha in the study area and the same ranged between 23 per cent and 40 per cent in different categories of salinity affected sample farmers. The findings of this study are in agreement with the findings of Kulkarni (2007), Thilagavathi and Chandrasekaran (2009), Satish (2010) and Priyanka (2012).

### 5.3 Economic impact of land degradation due to soil salinity on crop production

#### 5.3.1 Input utilization pattern

Rice is the main crop in the north east monsoon (Samba / Thaladi) a major season. Rice is cultivated in half of the cultivated area in this major season. Cash crops such as cotton and other field crops such as maize, sorghum and gingelly are grown during the summer (dry) season. Since, rice is the main crop and is largely affected by salinity, hence, it was chosen for the analysis in this study. The input utilization pattern in respect rice is presented in Table 5.10. Input utilization pattern in rice clearly indicated that, the extent of different inputs used in salinity affected soils were lower than that of non affected farms.

**Table 5.10. Input utilization pattern of sample farmers**

S.No	Particulars	Salinity affected				Non affected	% Change
		Low	Medium	High	Pooled		
1	Human labour(Mandays/ha)	99.54	95.16	91.47	95.90	107.42	10.72
2	Seeds(Kg/ha)	64.93	68.97	73.32	68.55	70.72	3.07
3	Organic manure (tones/ha)	4.28	4.55	5.25	4.63	4.58	1.09
4	Fertilizers						
a)	Nitrogen (Kg/ha)	135.63	128.51	124.87	130.36	146.13	10.79
b)	Phosphorus (Kg/ha)	44.79	41.67	38.23	41.97	46.87	10.45
c)	Potassium (Kg/ha)	51.83	47.63	43.81	48.26	49.12	1.75
5	Plant protection Chemicals (Rs/ha)	1708.59	1569.62	1328.01	1558.77	1969.88	20.87

It is evident from the table that among the sample farmers of affected category, the quantity of inputs used was higher in low level of affected category, followed by medium and high level of affected category, where as the inputs such as seeds and organic manures was used larger quantity in high level of affected category than low and medium level of affected categories. The percentage change in human labour utilization in affected category over non affected category was 10.72 per cent and the same were worked out to 3.07 per cent and 1.09 per cent, respectively for seeds and organic manures. Among the sample farmers, the usage of different fertilizers showed that the percentage change in utilization of nitrogenous fertilizers of affected category over non affected category was 10.79 per cent and the same was 10.45 per cent and 1.75 per cent, respectively for phosphoric and potash fertilizers. The percentage change in usage of plant protection chemicals in affected category over non affected category was 20.87 per cent. Hence, it is obvious from the results that the sample farmers of affected category used

lower level of inputs than non affected category. The studies conducted by Joshi and Agnihotri (1984), Joshi (1987), Joshi and Jha (1992), Qureshi (2003), Kulkarni (2007), Thilagavathi and Chandrasekaran (2009), Satish (2010) and Priyanka (2012) confirmed the substantial decline in use of inputs on degraded soil as compared to normal soils.

### **5.3.2 Cost of cultivation of Rice under salinity affected and non affected farms**

The details of cost of cultivation of rice in affected and non affected category are furnished in the Table 5.11. In this study, the cost of cultivation of rice crop between salinity affected and non affected farms were analysed using the cost concepts. In the present study, cost A was derived by including cost of hired labour, imputed value of owned bullock labour, hired machine labour, imputed value of owned machine labour, seeds, manuring, fertilizers, plant protection chemicals. Cost B was derived by adding Cost A1 with imputed value of owned land and Cost C was derived by adding cost B with imputed value of family labour.

The cost of cultivation of rice was Rs. 59837 per ha in non affected category and the same was Rs. 48567 per ha for pooled affected category. Among the different affected categories, the total cost of cultivation of rice was higher in low level of salinity affected category and it worked out to Rs. 50696 per ha, followed by medium level and high level of affected categories which accounted for Rs. 48269 per ha and Rs. 45824 per ha, respectively. Input usage was higher in low level of affected category, which includes the value of human labour, hired machine labour, fertilizers, pesticides, the imputed value of land, leading to higher cost of cultivation per hectare in low salinity category than high level of salinity. Among the different affected categories, usage of inputs such as seeds, organic manure and irrigation charges are higher in high level of salinity affected category than the low and medium categories, which clearly indicate that high level of salinity affected category requires higher level of seeds, organic manures and more number of irrigation for maintaining the required level of plant population. Among the sample farmers of both affected and non affected category, human labour was found to be the major input accounting for 37.70 per cent of the total cost in non affected category and the same was 39.84 per cent in affected category pooled sample farmers. It varied between 39.40 per cent and 40.25 per cent of the total cost in different salinity affected categories of sample farmers. The percentage change in human labour of affected category over non affected category was 14.22 per cent.

The cost of machine labour accounted for 15.50 per cent of total cost in non affected category and the same was 14.67 per cent in pooled category of affected sample farmers. The percentage change in the use of hired machine labour of affected category over non affected category was 18.45 per cent. The percentage change in the cost of seeds of affected category over non affected category was 3.06 per cent. The cost of fertilizers accounted for 8.89 per cent in non affected category and the same was 9.05 per cent in affected category. The percentage change in fertilizer use of affected category over non affected category was 17.73 per cent. Cost of manuring and amendments accounted for 5.74 per cent in non affected category and the same was 7.16 per cent in affected category pooled sample farmers. The percentage change in use of manuring and amendments of affected category over non affected category was 1.19 per cent. The percentage change in the cost of pesticide of affected over non affected category was 20.87 per cent.

The Cost A1 for one hectare of rice was Rs. 46251 in non affected category and the same was Rs. 39050 in pooled category of salinity affected farmers. It varied between Rs 37027 and Rs. 40694 among the different affected categories of sample farmers. The percentage change in Cost A1 of affected category over non affected category was 15.57 per cent.

The imputed value of owned land was higher in non affected category than the affected category. The percentage change in imputed value of owned land of affected category over non affected category was 37.80 per cent. The cost of imputed value of family labour was 2.49 per cent in non affected category and the same was 4.11 per cent in affected category of sample farmers. The percentage change in imputed value of family labour of affected category over non affected category was 33.64 per cent. The percentage change of total cost of cultivation of affected category over non affected category was 18.83 per cent. The total cost of cultivation of rice was higher in non affected category of sample farmers than affected category of sample farmers. Among the different affected categories, the total cost of cultivation was higher in low level of affected category, followed by medium and high level of affected category. These findings were in agreement with the findings of Gajja *et al.* (1998), Chinappa (2002), Kulkarni (2007), Thilagavathi and Chandrasekaran (2009), Satish (2010) and Priyanka (2012).

**Table.5.11 Cost of cultivation of Rice under salinity affected and non affected farms**

(Rs/ha)

S.No	Particulars	Salinity affected				Non affected	% change
		Low	Medium	High	Pooled		
I	Labour						
1	Hired human Labour	20405.70 (40.25)	19020.32 (39.40)	18203.06 (39.72)	19349.73 (39.84)	22558.20 (37.70)	14.22
2	Hired machine labour	6641.85 (13.10)	6259.34 (12.97)	5149.77 (11.24)	6107.21 (12.57)	7489.11 (12.52)	18.45
3	Imputed value of machine labour	1152.60 (2.27)	979.69 (2.03)	807.79 (1.76)	1001.58 (2.06)	1784.30 (2.98)	43.87
II	Factor inputs						
1	Seed	1363.45 (2.69)	1448.46 (3.00)	1539.75 (3.36)	1439.56 (2.96)	1485.07 (2.48)	3.06
2	Fertilizers	4650.77 (9.17)	4300.64 (8.91)	4143.91 (9.04)	4397.59 (9.05)	5321.84 (8.89)	17.37
3	Plant protection Chemicals	1708.59 (3.37)	1569.62 (3.25)	1328.01 (2.90)	1558.77 (3.21)	1969.88 (3.29)	20.87
4	Irrigation charges	1560.29 (3.08)	1748.32 (3.62)	1920.99 (4.19)	1720.59 (3.54)	2208.51 (3.69)	22.09
5	Manuring and amendments	3211.70 (6.34)	3412.40 (7.07)	3934.33 (8.59)	3475.65 (7.16)	3434.68 (5.74)	1.19
	Cost A1	40694.95 (80.27)	38738.79 (80.26)	37027.61 (80.80)	39050.68 (80.40)	46251.59 (77.29)	15.57
III	Imputed value of owned land	8215.58 (16.21)	7464.03 (15.46)	6583.18 (14.37)	7522.42 (15.49)	12093.62 (20.21)	37.80
	Cost B	48910.53 (96.48)	46202.82 (95.72)	43610.79 (95.17)	46573.10 (95.89)	58345.21 (97.51)	20.18
	Imputed value of family labour	1785.97 (3.52)	2066.71 (4.28)	2213.67 (4.83)	1994.83 (4.11)	1492.72 (2.49)	33.64
	Cost C	50696.50 (100.00)	48269.53 (100.00)	45824.46 (100.00)	48567.93 (100.00)	59837.93 (100.00)	18.83

Figure :5.1 Human labour use in sample farmers

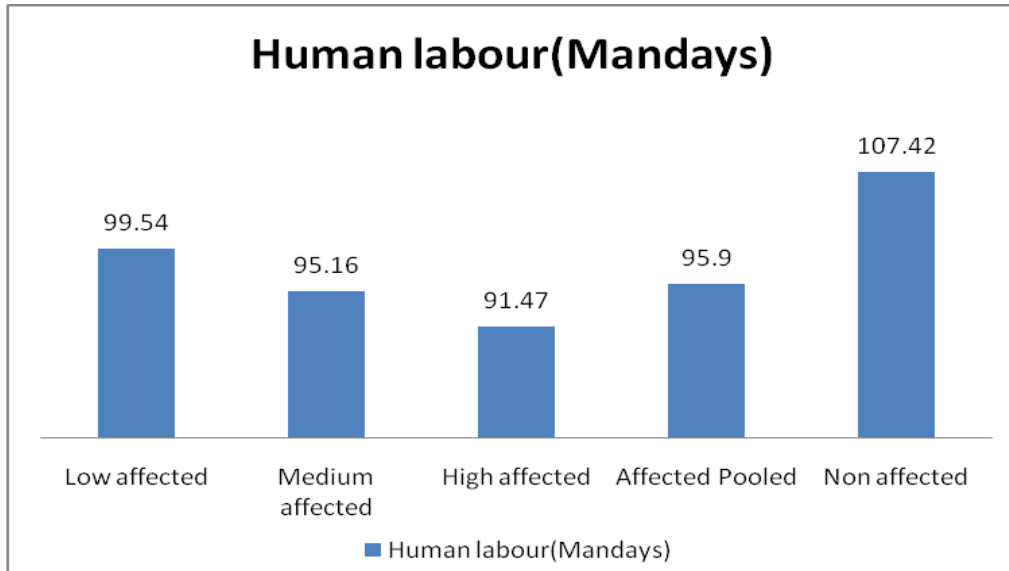


Figure : 5.2 Seed use of sample farmers

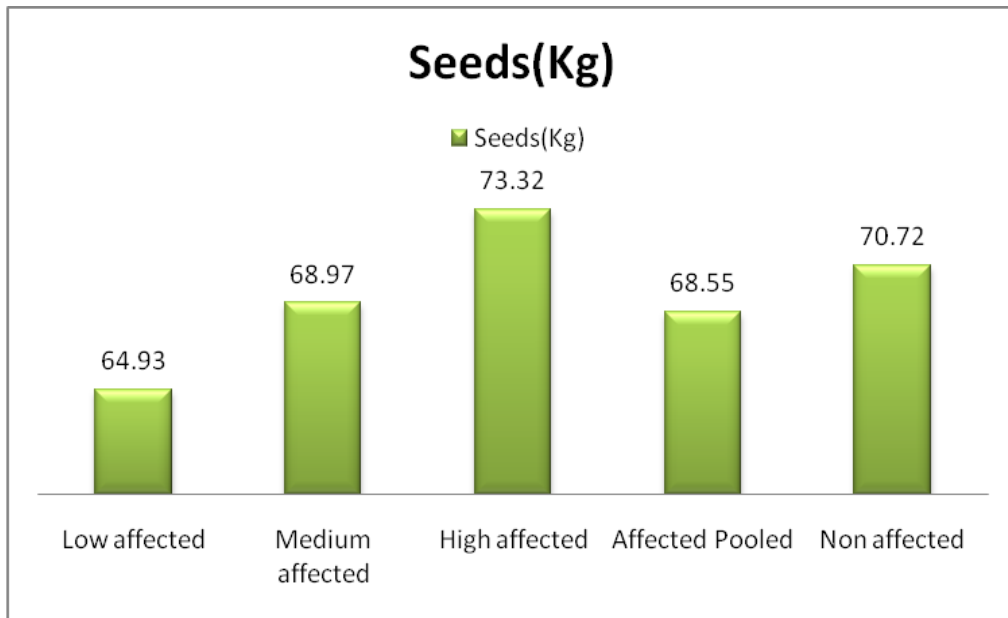


Figure: 5.3 Organic manure use of sample farmers

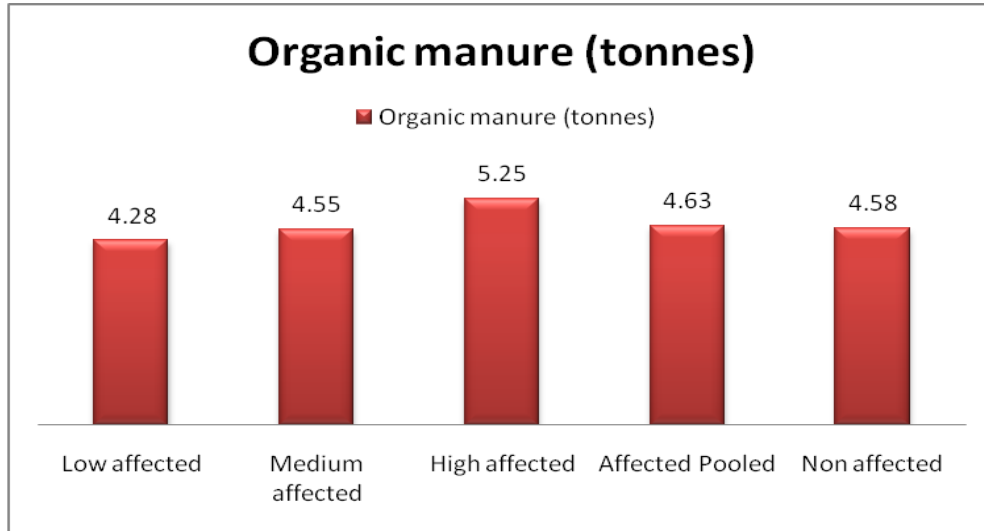
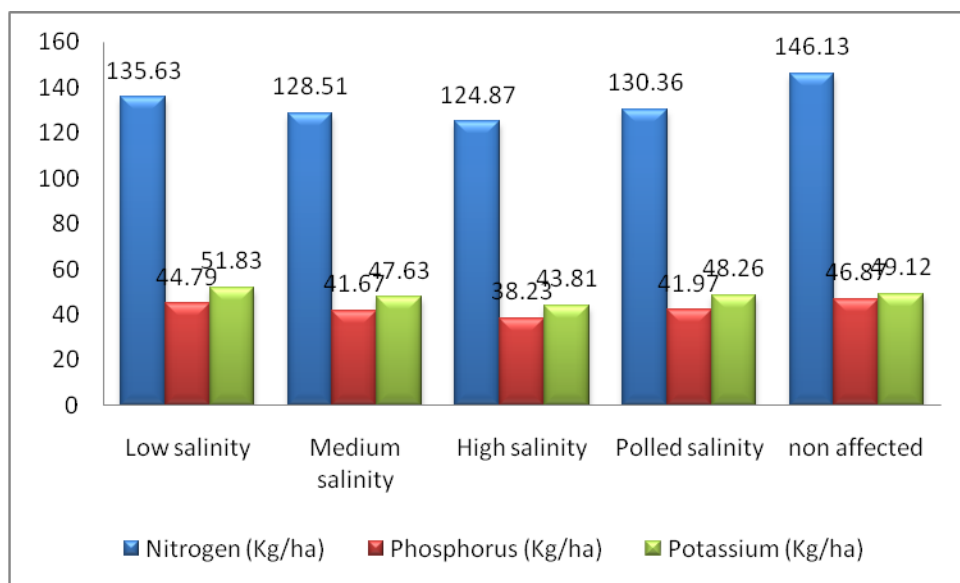


Figure: 5.4 Fertilizer use of sample farmers



### 5.3.3 Pattern of returns in rice farming among the sample farms

The cost and returns realized from rice production on affected and non affected category farmers are furnished in the Table 5.12. There was a wide variability in the returns realized for rice in affected and non affected category owing to variation in the productivity levels of soils as influenced by soil salinity.

The yield realized varied considerably and it was 40.24 quintals per hectare in non affected category and the same was 30.30 quintals per hectare in affected category. It varied between 27.45 quintals and 32.42 quintals per hectare among the different affected categories. The percentage change in yield of affected category over non affected category was 24.70 per cent.

Among the sample farmers, gross return realized was Rs.70970 per hectare in non affected category and the same was Rs. 54122 per hectare in affected category. It varied between Rs. 49032 and Rs. 58129 per hectare among the different categories of affected sample farmers. The percentage change in gross return of affected category over non affected category worked out to be 23.74 per cent.

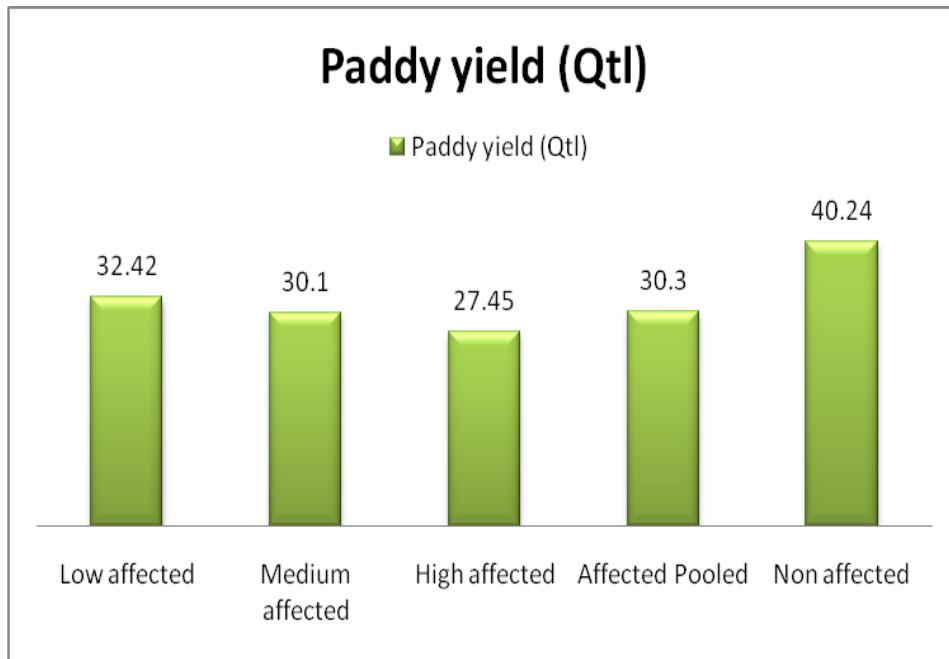
The net return over cost A1 was higher in non affected farms with Rs. 24719 per hectare and the same worked out Rs. 15072 per hectare in affected category of sample farmers. It has varied between Rs. 12004 and Rs. 17434 per hectare among the different affected categories of sample farmers. The percentage change in net return over Cost A1 of the affected category over non affected category was 39.03 per cent. The net return of rice over total cost was higher in non affected category of sample farmers, which worked out to Rs.11132. per hectare and the same worked out to Rs. 5554 per hectare in affected category of sample farmers. It varied between Rs. 3208 and Rs. 7433 per hectare among the different categories of affected sample farmers. The percentage change in net return of affected category over non affected category worked out to 50.10 per cent. Hence, it is evident that the low yield due to soil salinity, affects the livelihood security of the sample farmers. The studies conducted by Joshi and Agnihothri (1984) and Gajja *et al.* (1996), Kulkarni (2007) Thilagavathi and Chandrasekaran (2009), Satish (2010) and Priyanka (2012) confirmed a substantial decline in yield levels of various crops on degraded soils as compared to normal soils.

**Table 5.12 Cost and Return structure of rice cultivation in sample farms**

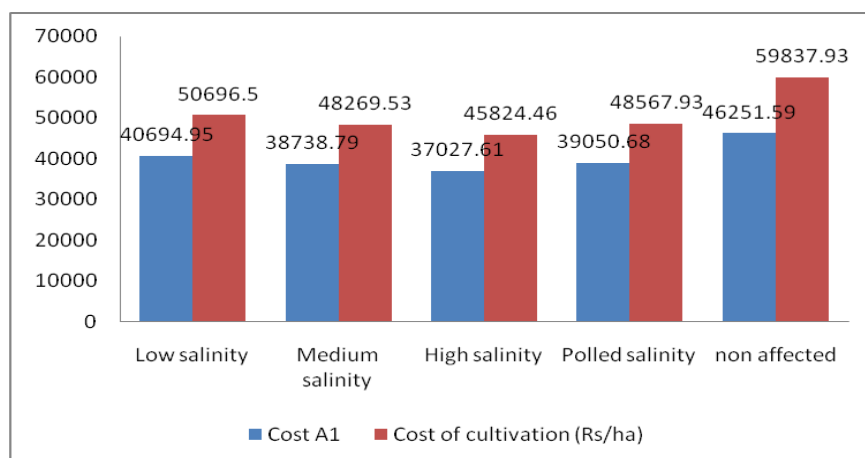
(Rs/ha)

S.No	Particulars	Salinity affected				Non affected	% Change
		Low	Medium	High	Pooled		
I	Rice yield (Qtl)	32.42	30.10	27.45	30.30	40.24	24.70
II	Cost						
a	Cost A1	40694.95	38738.79	37027.61	39050.68	46251.59	15.57
b	Cost of cultivation (Rs/ha)	50696.50	48269.53	45824.46	48567.93	59837.93	18.83
III	Return						
a	Gross returns from main product (Rs)	50251.00	46354.00	42135.75	46722.60	62452.48	25.19
b	Gross return from by product (Rs)	7878.56	7237.23	6896.73	7400.12	8518.16	13.13
c	Gross return added (a+b)	58129.56	53591.23	49032.48	54122.72	70970.64	23.74
d	Net return over variable costs	17434.61	14852.44	12004.87	15072.04	24719.05	39.03
e	Net return over total cost (Cost C)	7433.06	5321.70	3208.02	5554.79	11132.71	50.10
IV	Input – Output ratio	1.15	1.11	1.07	1.11	1.19	

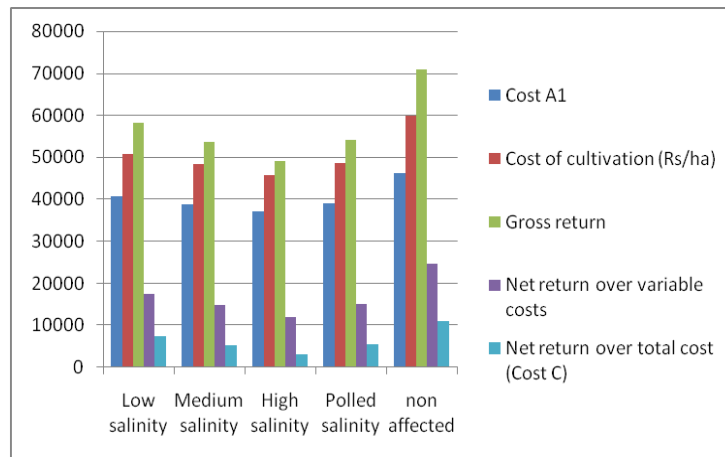
Figure : 5.5 Paddy yield of sample farmers



**Figure 5.6 Cost of cultivation of sample farmers**



**Figure 5.7 Cost and return of sample farmers**



### **5.3.4 Resource use efficiency in salinity affected and non affected farms**

The resource use efficiency in rice cultivation in affected and non affected category of sample farms has been analyzed by computing the production elasticities.

#### **5.3.4.1 Production elasticities and resource use efficiency in rice in sample farms**

The results of the regression analysis to determine the factors influencing the rice yield are presented in the Table 5.13. The co-efficient of multiple determination ( $R^2$ ) indicated that, higher proportion of variation in the rice yield was explained by the independent variables included in the function. The  $R^2$  value indicates that the contribution of independent variables to the output was highest (83.40 per cent) in non affected soils, followed by low level of affected category (81.50 per cent), medium (79.10 per cent) and high level (78.50 per cent) of salinity affected sample farmers.

The production elasticities of production function of non affected category revealed that human labour had an elasticity coefficient of 0.52 indicating that one per cent increase in human labour would bring 0.52 per cent increase in the production. Similarly, the elasticity coefficients indicates that one per cent increase in machine labour, seed, manure, fertilizer and plant protection chemicals variables would bring 0.092 per cent, 0.29 per cent 0.10 per cent and 0.62 per cent increase in production, respectively. These variables were found to have a significant and positive influence on rice yield in non affected category of sample farmers.

While in low level of salinity affected category of sample farmers, human labour had an elasticity coefficient of 0.29 indicating that one per cent increase in human labour would bring 0.29 per cent increase in the production. Similarly, the elasticity coefficient indicates that one per cent increase in manuring and amendments and fertilizers would bring 0.12 per cent and 0.31 per cent increase in production, respectively. Hence, these variables had positive and significant influence on rice yield.

In the case of medium level of salinity affected category of sample farmers, inputs that exerted positive and significant influence in rice yields were human labour and seeds, manuring and amendments and fertilizers. The elasticity coefficient indicates that one per cent increase in human labour, seeds, manuring and amendments and fertilizers would bring 0.33 per cent and

0.26 per cent, 0.09 per cent, 0.48 per cent increase in production, respectively. The elasticity coefficient of plant protection and irrigation was positive but non significant.

Among the sample farmers of high level affected category, the inputs that exhibited positive and significant influence in rice yields were human labour and manuring and amendments, fertilizers and irrigation. The elasticity coefficient indicates that one per cent increase in human labour, manuring and amendments fertilizers and irrigation would bring 0.55 per cent, 0.12 per cent, 0.35 per cent and 0.09 per cent increase in production, respectively. The elasticity coefficient of seed, and plant protection was positive but non significant. The results obtained in the present study were in agreement with those obtained by Gajja *et al.* (1998), Chinappa (2002), Kulkarni (2007), Thilagavathi and Chandrasekaran (2009), Satish (2010) and Priyanka (2012).

**Table 5.13 Resource use efficiency and estimated elasticities for rice in sample farms**

Particulars	Affected			Non Affected
	Low level	Medium level	High level	
Constant	3.692*** (3.953)	1.574 (1.242)	2.229* (1.911)	0.221 (0.387)
Human labour	0.293* (1.647)	0.330* (1.699)	0.558*** (2.515)	0.529*** (3.898)
Machine labour	0.049 (0.549)	0.058 (0.688)	0.080 (0.891)	0.092** (2.407)
Seed	0.145 (0.890)	0.263* (1.785)	0.026 (0.192)	0.291** (1.957)
Manuring and amendments	0.123** (2.078)	0.094* (1.800)	0.126* (1.934)	0.105** (1.997)
Fertilizer	0.317** (2.198)	0.488*** (3.574)	0.359* (1.692)	0.626*** (4.568)
Plant protection chemicals	0.011 (0.247)	0.037 (1.033)	0.005 (0.081)	0.023 (0.444)
Irrigation	0.009 (0.269)	0.033 (0.864)	0.092* (1.65)	0.008 (0.141)
R <sup>2</sup> value	0.815	0.791	0.785	0.834
F value	25.194	16.803	13.073	80.66

Dependant variable: Yield (Kg/ha)

Note: Figures in the parentheses indicate 't' – values of respective coefficients

\*\*\* Significant at 1 per cent level

\*\* Significant at 5 per cent level

\* Significant at 10 per cent level

### **5.3.5 Rice yield response to salinity and estimated elasticities for rice**

The approach assumes that salinity build up directly influences the rice yields. To establish the relationship, a Cobb – Douglas form of production function was employed. Several explanatory variables defined in different ways were included to estimate the production function. The results of the regression analysis to determine the factors influencing the rice yield are presented in Table 5.14. The co-efficient of multiple determination ( $R^2$ ) indicated that, higher proportion of variation in the rice yield was explained by the independent variables included in the function. The ( $R^2$ ) value indicates that the contribution of independent variables to the output was 83 per cent in non affected category of sample farmers, and the same was 75.30 per cent in salinity affected sample farmers. The yield influencing factors included in the production function of rice were significant with expected signs. The expected negative production elasticities of soil salinity indicated the decline in rice yield as the electrical conductivity of the soil increased in sample farms. It was the most important determinant of yield compared to fertilizer, capital and labour inputs. This indicates that a one per cent increase in the electrical conductivity of soil at mean level decrease yield by 0.79 per cent.

#### **Marginal value product and damage**

Marginal value product of yield enhancing factors and marginal value of damage due to soil salinity were derived from the estimated production function. Taking the first derivative of the production function with respect to relevant factors yielded marginal value product/ marginal value damage. In physical term one unit increase in EC for average level of salinity would adversely affect rice yield by 187 kg per hectare. The mean salinity level (EC) was 3.0.

**Table 5.14 Rice yield response to salinity and estimated elasticities for rice**

S.No	Particulars	Affected	Non Affected
i.	Constant	1.446 (0.944)	0.202 (0.349)
ii.	Human labour (Mandays)	0.348* (1.729)	0.529*** (3.883)
iii.	Machine labour (Rs/ha)	0.085 (0.835)	0.091** (2.378)
iv.	Seed (Kg/ ha)	0.148 (0.616)	0.295* (1.969)
v.	Manuring and Amendments (Tonnes)	0.212*** (2.585)	0.101* (1.865)
vi.	Fertilizer (Kg/ ha)	0.524** (2.293)	0.630*** (4.559)
vii.	Plant protection chemicals (Rs/ha)	0.078** (2.153)	0.024 (0.463)
viii.	Irrigation charges	0.062** (2.056)	0.007 (0.116)
ix.	EC	-0.791*** (-7.099)	0.007 (0.322)
	R <sup>2</sup> value	0.822	0.835
	F value	63.897	70.028

Dependent variable: Yield (Kg / ha)

Note: Figures in the parentheses indicate 't' – value of respective coefficients

\*\*\* Significant at 1 per cent level

\*\* Significant at 5 per cent level

\* Significant at 10 per cent level

The response of the yield enhancing factors in influencing rice yield was not as powerful as that of salinity in the sample farms. The positive response of yield increasing variables on yield was completely neutralized by soil salinity. Among the yield increasing factors, human labour, manures, fertilizer, plant protection chemicals, irrigation charges were significant. The significance of elasticity of coefficients for human labour, fertilizer and manures indicates that rice yield would increase by using additional human and fertilizer in these areas. In this study, fertilizer was more responsive among the yield enhancing factors. The results obtained in the present study were in agreement with those obtained by Kulkarni (2007) and Satish (2010).

### 5.3.5 Decomposition of total differences in yield between affected and non affected soils

The decomposition analysis was used to reveal the contribution of various inputs to the productivity difference between salinity affected and non affected sample farms using the production function estimates and geometric mean values of inputs and output. The productivity difference attributed was decomposed into its constituent sources namely, productivity difference due to soil degradation and that due to input use. The results of decomposition analysis are presented in Table 5.15.

Decomposition estimates shows that soil salinity was the major cause for the reduction of yield. Contribution of soil salinity to total change in rice yield was estimated at 36.57 per cent for low level of affected category, followed by 45.32 per cent and 56.15 per cent, respectively for medium and high level of affected category. Changes in inputs contributed only 6.22 per cent in low level of affected category, followed by 5.65 per cent and 3.68 per cent, respectively for medium and high level of affected category of sample farms. Among the sample farms of low, medium and high level of affected category, 36 per cent, 45 per cent and 56.15 per cent of more yields, respectively could be obtained if the soil salinity is averted. The results obtained in the present study were in agreement with those obtained by Chinnappa (2002), Kulkarni (2007), Thilagavathi and Chandrasekaran (2009), Satish (2010) and Priyanka (2012).

**Table 5.15 Decomposition of total differences in yield between affected and non affected soils**

S.No	Source of change	Affected		
		Low	Medium	High
1	Soil salinity	-36.57	-45.32	-56.15
2	Change in input	-6.22	-5.65	-3.68
2.1	Human labour	-2.98	-2.12	-3.30
2.2	Machine	0.03	0.01	0.25
2.3	Seed	-0.42	-0.47	-0.23
2.4	Fertilizer	-2.19	-1.06	-0.66
2.5	Manuring and amendmets	-0.62	-0.83	0.42
2.6	Plant protection chemicals	-0.04	-0.61	-0.27
2.7	irrigation	0.00	-0.59	0.12
3	Total difference in out put	-42.79	-50.97	-59.83

## **5.4 Optimal plans for land utilisation, farm returns and labour employment**

The Optimal plans for land utilisation, farm returns and labour employment of salinity affected farms were developed with the help of the Data Envelopment Analysis (DEA). The DEA is a nonparametric mathematical programming methodology based on the works of Farrell (1957) and Fraser and Cordina (1999). The Data Envelopment Analysis (DEA) involves the use of linear programming to construct an efficiency frontier that provides a means by which all farms can be assessed in terms of relative efficiency. The constant returns to scale (CRS) assumption means that average productivity, denoted by output / input is not dependent on scale of production. However, the most general assumption that can be made in respect of returns to scale is that they are variables. It permits constant and increasing or decreasing returns to scale for different scale sizes. To allow for this possibility, variable returns to scale (VRS) that measure technical efficiency can be decomposed into pure technical efficiency and scale efficiency (SE) (Charnes *et al.*, 1978). The technical efficiency score (in both CRS and VRS models) of one implies full efficiency, and of less than one indicates technical inefficiency.

### **5.4.1 Frequency distribution of Technical efficiency of sample farms under constant return to scale**

The frequency distribution of technical efficiency under constant return to scale for rice farms has been presented in Table 5.16. A perusal of Table reveals that fifty per cent of the low level of affected category of sample farmers belonged to 0.86 - 0.90 level and 33.33 per cent of them belonged to 0.91-0.95 level of frequency distribution. Among the sample farmers of medium level of affected category, 33.33 per cent of them belonged to 0.81-0.85 level of frequency distribution, followed by 23.08 per cent belonged to 0.75- 0.80 level and 12.82 per cent of the sample farmers were comes under the frequency of 0.71-0.74 level of frequency distribution of technical efficiency.

Among the sample farmers of high level of affected category, 48.48 per cent of them belonged to 0.65-0.70 level of frequency distribution, followed by 27.27 per cent belonged to 0.71- 0.74 level and 15.15 per cent of the sample farmers were under the frequency of 0.75-0.80 level of frequency distribution of technical efficiency. Hence, it is evident from the table that among the sample farmers of affected category, low level of affected category had higher

technical efficiency than medium and high level of affected category. The findings of this study are in agreement with the findings of Sirirat (2008), Murthy *et al.* (2009), Nasurudeen (2009), Hussaini (2010) and Abatania *et al* (2012).

**Table 5.16. Frequency distribution of Technical efficiency of sample farms under constant return to scale**

S.No	Frequency interval	Salinity affected category		
		Low	Medium	High
1	0.65-0.70	0	3 (7.69)	16 (48.48)
2	0.71-0.74	0	5 (12.82)	9 (27.27)
3	0.75-0.80	0	9 (23.08)	5 (15.15)
4	0.81-0.85	4 (8.33)	13 (33.33)	2 (6.06)
5	0.86 - 0.9	24 (50.00)	7 (17.95)	1 (3.03)
6	0.91-0.95	16 (33.33)	1 (2.56)	0
7	0.95-1.0	4 (8.33)	1 (2.56)	0
	Total	48 (100.00)	39 (100.00)	33 (100.00)

Note: Figures in the parentheses indicate percentages to total

#### **5.4.2 Frequency distribution of Technical efficiency of sample farms under variable return to scale**

The frequency distribution of technical efficiency under variable return to scale for rice farms has been presented in Table 5.17. It is evident from the Table that 41.67 per cent of the low level of affected category of sample farmers belonged to 0.91 - 0.95 level and 25 per cent of them belonged to 0.95-1.0 level of frequency distribution. Among the sample farmers of medium level of affected category, 35.90 per cent of them belonged to 0.86-0.90 level of frequency distribution, followed by 23.08 per cent belonged to 0.95- 0.10 level and 17.95 per cent of the sample farmers were comes under the frequency of 0.81-0.85 level of frequency distribution of technical efficiency.

Among the sample farmers of high level of affected category, 36.36 per cent of them belonged to 0.71-0.74 level of frequency distribution, followed by 30.30 per cent belonged to 0.65-0.70 level of frequency distribution of technical efficiency. Hence, it is evident from the table that among the sample farmers of affected category, low level of affected category had higher technical efficiency than medium and high level affected category. The findings of this

study are in agreement with the findings of Sirirat (2008), Murthy *et al.* (2009), Nasurudeen (2009), Hussaini (2010) and Abatania *et al* (2012).

**Table 5.17. Frequency distribution of Technical efficiency of sample farms under variable return to scale**

S.No	Frequency interval	Salinity affected category		
		Low	Medium	High
1	0.65-0.70	0	0	10 (30.30)
2	0.71-0.74	0	2 (5.13)	12 (36.36)
3	0.75-0.80	0	3 (7.69)	6 (18.18)
4	0.81-0.85	5 (10.42)	7 (17.95)	4 (12.12)
5	0.86 - 0.90	11 (22.92)	14 (35.90)	1 (3.03)
6	0.91-0.95	20 (41.67)	4 (10.26)	0
7	0.95-1.0	12 (25.00)	9 (23.08)	0
	Total	48 (100.00)	39 (100.00)	33 (100.00)

Note: Figures in the parentheses indicate percentage to total

### 5.4.3 Frequency distribution of scale efficiency of sample farms

The frequency distribution of technical under variable return to scale for rice farms has been presented in Table 5.18. It is evident from the Table that 45.83 per cent of the low level of affected category of sample farmers belonged to 0.86-0.9 level and 27.08 per cent of them belonged to 0.91-0.95 level of frequency distribution. Among the sample farmers of medium level of affected category, 30.77 per cent of them belonged to 0.81-0.86 level of frequency distribution, followed by 25.64 per cent belonged to 0.86- 0.9 level of frequency distribution of technical efficiency.

Among the sample farmers of high level of affected category, 42.42 per cent of them belonged to 0.71-0.74 level of frequency distribution, followed by 30.30 per cent belonged to 0.65-0.70 level of frequency distribution of technical efficiency. Hence, it is evident from the table that among the sample farmers of affected category, low level of affected category had higher scale efficiency than medium and high level of affected category of sample farmers. The findings of this study are in agreement with the findings of Sirirat (2008), Murthy *et al.* (2009), Nasurudeen (2009), Hussaini (2010) and Abatania *et al* (2012).

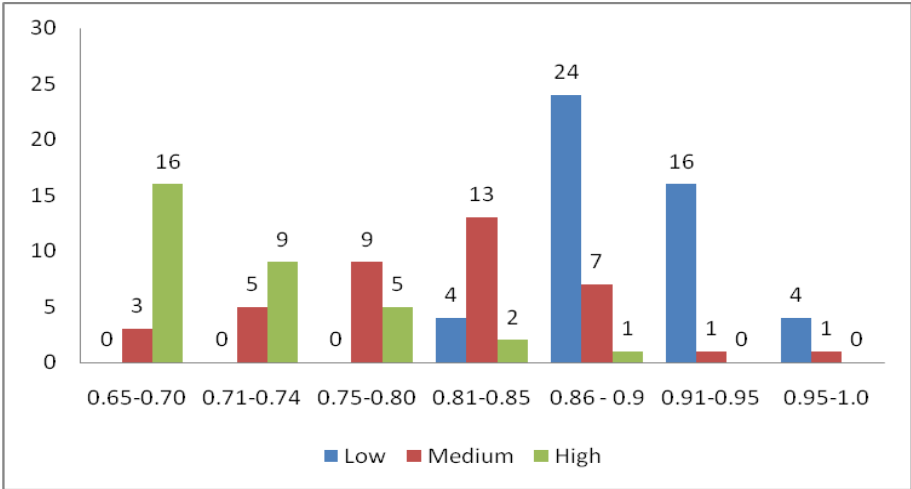
**Table 5.18. Frequency distribution of scale efficiency of sample farms**

(Number)

S.No	Frequency interval	Salinity affected category		
		Low	Medium	High
1	0.65-0.70	0	0	10 (30.30)
2	0.71-0.74	0	3 (7.69)	14 (42.42)
3	0.75-0.80	0	6 (15.38)	6 (18.18)
4	0.81-0.85	3 (6.25)	12 (30.77)	2 (6.06)
5	0.86 - 0.9	22 (45.83)	10 (25.64)	1 (3.03)
6	0.91-0.95	13 (27.08)	6 (15.38)	0
7	0.95-1.0	10 (20.83)	2 (5.13)	0
	Total	48 (100.00)	39 (100.00)	33(100.00)

Note: Figures in the parentheses indicate percentage to total

Figure 5.8 Technical efficiency of sample farmers of affected category



#### 5.4.4 Input slacks for total technical efficiency of sample farmers

Slacks were investigated to determine those inputs that can be decreased proportionately and at the same time achieving same level of output. Input slacks for total technical efficiency of sample farmers are presented in table 5. 19. Among the sample of affected category, human labour had the lowest percentage of slack. The slack value of seed was 7.3 per cent for high level followed by medium and low level with 5.7 per cent and 1.4 per cent, respectively. The sample farmers of high level affected category could reduce plant protection chemicals by 7.3 percent and still achieve the same level of output. The slack value of manure was higher for medium level of affected category followed by high and level of affected category. Similarly, the slack value of fertilizer was higher for medium level of affected category followed by high and level of affected category. The slack value of pesticides was higher for low level followed by medium and high level of affected category. It implies that pesticides could be reduced by 13.5 per cent in low level, 7.5 per cent in medium level and 4.9 per cent in high level of affected category without reduction in the output. Hence, it is obvious that the reduction of slack will increase the technical efficiency of the sample farms.

**Table 5.19 Input slacks for total technical efficiency of sample farmers**

S.No	Variable	Means of input slacks		
		Low	Medium	High
i.	Human labour (Mandays)	1.5	1.2	0.9
ii.	Machine labour(Rs)	2.1	3.1	3.2
iii.	Seed (Kg)	1.4	5.7	7.3
iv.	Manure (tonnes)	1.9	3.6	2.9
v.	Fertilizer(Kg)	2.2	7.8	4.7
vi.	Pesticide(Rs)	13.5	7.5	4.9

Means as percentage of input level used

#### 5.4.5. Nature of returns to scale of the sample farms

The characteristics of farms under various returns to scale with respect to input use were examined. The nature of return to scale was presented in the table 5.20. It is observed from the table that the sample farmers who were operating in increasing return to scale were 52.08 per

cent in low level, 71.79 per cent in medium level and 42.42 per cent in high level. The farmers, who were operating in decreasing return to scale, accounted for 33.33 per cent in low level of affected category and it was 30.30 per cent in high level of affected category. The farmers who were operating in constant return to scale were 27.27 per cent in high level of affected category and the same was 14.58 per cent in low level of affected category. Hence, it is concluded that the average farms operating under increasing return to scale, use less land and spend less on variable inputs but use more household labour compared to those operating under constant return to scale. Constant return to scale is the desirable scale of operation for farms as it both technically and scale efficient. On the other hand, farms operating under decreasing return to scale use more of land and household labour but spend less on variable inputs compared to those operating under constant return to scale. The findings of this study are in agreement with the findings of Murthy *et al.* (2009), Hussaini (2010) and Abatania *et al* (2012).

**Table 5.20. Nature of return to scale of the sample farms**

(Number)

S.No	Return to scale	Salinity affected category		
		low	Medium	High
1	Increasing	25 (52.08)	28 (71.79)	14 (42.42)
2	Decreasing	16 (33.33)	8 (20.51)	10 (30.30)
3	Constant	7 (14.58)	3 (7.69)	9 (27.27)
		48 (100.00)	39 (100.00)	33 (100.00)

Note: Figures in the parentheses indicate percentage to total

#### 5.4.6 Factors affecting technical efficiency of sample farms

The results of the regression analysis to determine the factors influencing technical efficiency of salinity affected category are presented in the Table 5.21. The co-efficient of multiple determination ( $R^2$ ) indicated that, higher proportion of variation in the rice yield was explained by the independent variables included in the function. The  $R^2$  value indicates that the contribution of independent variables to the technical efficiency (84 per cent) salinity affected sample farmers.

The elasticities of production function revealed that yield efficiency had an elasticity coefficient of 0.01 indicating that one per cent increase in yield parameter would bring 0.01 per cent increase in the technical efficiency. Similarly, the elasticity coefficients of education and age variables indicate that one per cent increase in variables would bring 0.23 per cent and 0.13

per cent incur in technical efficiency, respectively. These variables were found to have a significant and positive influence on technical efficiency of affected of sample farmers. The elasticity coefficient of EC was - 0.12 indicating that one per cent increase in EC would bring 0.12 per cent decrease in technical efficiency of sample farmers. The elasticity coefficients of training attended has positive but not significant. The findings of this study are in agreement with the findings of Murthy *et al.* (2009).

**Table 5.21 Factors affecting technical efficiency of sample farms**

S.No	Particulars	coefficients
i.	Constant	0.000 (0.001)
ii.	Yield efficiency	0.013*** (4.117)
iii.	Labour efficiency	0.028 (0.772)
iv.	Capital efficiency	- 0.116*** (-16.913)
v.	Education	0.235*** (5.150)
vi.	Age	0.113* (1.664)
vii.	Training attended	0.079 (1.483)
viii.	EC level	-0.123*** (-3.259)
ix.	R <sup>2</sup> Value	0.84
	F value	83.78

Dependent variable: Technical efficiency (Kg / ha)

Note: Figures in the parentheses indicate 't' – value of respective coefficients

\*\*\* Significant at 1 per cent level

\*\* Significant at 5 per cent level

\* Significant at 10 per cent level

## **5.5 Externalities of soil degradation**

### **5.5.1 Net return and welfare loss**

The annual net returns from cultivation of crops and welfare loss on normal and degraded soils are provided in Table 5.22. The results revealed that, there was a wide difference in the net returns in degraded soils over normal soils.

The net return over cost A1 was higher in non affected farms with Rs. 24719 per hectare and the same was worked out Rs. 15072 per hectare in affected category of sample farmers. It varied between Rs. 17434 and Rs. 12004 per hectare among the different affected categories of sample farmers. The net return of rice over total cost was highest in non affected category of sample farmers, which worked out to Rs. 11132 per hectare and the same was Rs. 5554 per hectare in affected category of sample farmers. It varied between Rs. 3208 and Rs. 7433 per hectare among the different categories of affected sample farmers.

The results of welfare loss in terms of net returns across different degraded soils over normal soils showed that, profits earned by farmers in degraded soils for every one rupee earned in normal soils were very low and it increased marginally with increase in level of salinity. The welfare loss in high level of salinity affected sample farmers was very high and was Rs. 0.71 followed by, Rs. 0.53 in medium level, Rs. 0.33 on low level of salinity affected farms. It was Rs.0.50 in pooled category of salinity affected sample farmers. These findings were in agreement with the results obtained in the studies conducted by Kulkarni (2007) and Satish (2010).

**Table 5.22 Net return and welfare loss**

S.No	Particulars	Salinity affected				Non affected
		Low	Medium	High	Pooled	
1	Net return over variable costs (Cost A1) (Rs/ha)	17434.61	14852.44	12004.87	15072.04	24719.05
2	Net return over total cost (Cost C) (Rs/ha)	7433.06	5321.70	3208.02	5554.79	11132.71
3	Welfare loss	0.33	0.53	0.71	0.50	

### 5.5.2 Labour employment pattern in rice cultivation

The total employment pattern in rice cultivation is provided in Table 5.23. The total labour employed for all cultural operations was worked out and expressed in man days/hectare. It was evident from the table that on an average 107.42 and 95.90 man days of labour was employed in non affected and affected pooled category of sample farmers and the same was varied between 91.47 and 99.54 among different categories of salinity affected sample farmers. There was a declining trend in labour absorption in rice cultivation from non affected and affected category of sample farmers. These findings were in agreement with the results obtained in the studies conducted by Kulkarni (2007) and Satish (2010).

**Table 5.23 Labour employment pattern in rice cultivation**

S.No	Particulars	Salinity affected				Non affected pooled
		Low	Medium	High	Pooled	
1	Human labour (Man days)	99.54	95.16	91.47	95.90	107.42

### **5.5.3 Economic losses due to soil degradation among sample farms**

A perusal of Table 5.24 showed that, there was a decrease in rental value of land over non affected category. The rental value of land in non affected category was Rs. 12093 per hectare and was Rs. 7522 per hectare salinity affected pooled category of sample farmers. It ranged between Rs. 6583 and Rs. 8215 per hectare among the different affected category of sample farmers. The percentage reduction in rental value over non affected soil was 37.80 per cent in affected category pooled sample farmers and the same ranged between 32.07 and 45.56 per cent among the different affected category of sample farmers.

The market price of land in the salinity affected and non affected soil are presented in the table. There was a considerable decline in the land value on account of soil degradation. The prevailing market value of one hectare of non affected land in the study area was around Rs. 1036.76 thousand rupees per hectare while, the market value of salinity affected pooled category of sample farmers was estimated to be around Rs. 339.40 thousand rupees per ha and the same was ranged between Rs. 210.75 and Rs. 475.79 thousand rupees per hectare. Thus, percentage reduction in the market value of land over normal land was 67.26 per cent in affected category of pooled sample farmers and the same was ranged between 54.11 per cent and 79.67 per cent among the different salinity affected categories of sample farmers. Among the sample farmers of affected category, the abandoned land was estimated to 93.87 ha and the same ranged between 22.24 ha and 38.17 ha among the different affected category of sample farmers. These findings of the present study were in agreement with similar findings made with respect to loss in crop production by Scherr and Yadav (1998) Chinnappa (2002), Kulkarni (2007) and Satish (2010).

**Table 5.24 Economic losses due to soil degradation among sample farms**

S.No	Particulars	Salinity affected			Pooled	Non affected
		Low	Medium	High		
1	Rental value of land(Rs/ha)	8215.58	7464.03	6583.18	7522.42	12093.62
2	Reduction in rental value over normal	- 32.07	- 38.28	- 45.56	- 37.80	-
3	Market value of land('000 Rs)	475.79	331.67	210.75	339.40	1036.76
4	Reduction in market value of land over normal (%)	- 54.11	- 68.01	- 79.67	- 67.26	-
5	Abandoned land (ha)	22.24	33.46	38.17	93.87	17.65

**5.5.4 Manifestation of Yield loss**

Manifestation of yield loss is presented in Table 5.25. Among the sample farmers of affected categories, grain shedding was observed by almost 90 per cent of high level of salinity affected farmers and the same was 66.67 per cent and 47.92 per cent, respectively in medium and low level of salinity affected. Eighty per cent of the farmers of high level salinity observed chaffy grain and the same was 43.75 per cent and 56.41 per cent in low and medium level of affected category. Stunted growth was observed by 87.88 per cent of the farmers of high level of affected category followed by medium and low level accounted for 79.49 per cent and 52.08 per cent, respectively.

**Table 5.25. Manifestation of Yield loss**

(Number)

S.No	Particulars	Salinity affected		
		Low	Medium	High
1	Grain shedding	23 (47.92)	26 (66.67)	30 (90.91)
2	Chaffy grain	21 (43.75)	22 (56.41)	27 (81.82)
3	Stunted growth	25 (52.08)	31 (79.49)	29 (87.88)
4	others	10 (20.83)	7 (17.95)	5 (15.15)

Note : Figure in the parentheses indicate percentages to total

### 5.5.5. Migration of farm families among sample farmers due to land degradation

Land deterioration induced farm family migration is presented in Table 5.26. The development of land degradation problems led to labour migration. The results indicated that, with increased land degradation, the number of farm families temporarily migrated was 36 per cent of the sample farmers and it ranged between 9 per cent and 15 per cent among the different categories of salinity affected sample farmers. The total migrated family was 42 per cent. However, the families that permanently migrated were recorded very low and it was only 6 per cent. Majority of the sample farmers migrated within 20 km radius to work as non-agricultural labourers to seek family living in hard working environment especially in the construction industry. Migration also took place to distant cities like Tirupur, Coimbatore and Chennai.

Datta and Jong (1997) in their study also observed similar displacement of labour from agriculture. It was also evident that, women-folk were forced to work both at home and off-farm as agricultural and non-agricultural labourers. They shared equal burden of work in unknown living environment as non-agricultural labourers mainly in the construction sites along with their men counterparts. It was also revealed by the farmers that the work in the construction sites involved constant moves from one site to another with uncertainties of employment.

**Table 5.26 Migration of farm families among sample farmers due to land degradation**

S.No	Particulars	Salinity affected				(Number)
		Low	Medium	High	Pooled	Non affected
I	Number of migrants					
1	Total no of migrants	11	24	38	73	9
2	Temporarily migrated families (%)	9	12	15	36	6
3	Permanently migrated families (%)	0	2	4	6	0
4	Total Families migrated (%)	9	14	19	42	6
II	Distance of migration					
1	less than 20 km	9	21	33	63	6
2	More than 20 km	3	3	4	10	0

In addition, the displacement of families to unknown places away from their natives has psychological dimensions. The farmers had to leave their villages by abandoning the only productive land resource they owned and inherited from forefathers which was once productive to support the entire family. Land degradation due to water logging and salinity threaten the sustainability of irrigated agriculture and the very subsistence of farm families with marginal and small holdings who constituted the major proportion in the rural households. Similar instances of off-farm employment in non-farm sector were reported in the study conducted by Scherr and Yadav (1998), Kulkarni (2007), Thilagavathi and Chandrasekaran (2009) and Satish (2010).

## **5.6 Problems faced by the sample farmers due to salinity induced soil degradation**

### **5.6.1 Indicators of soil degradation**

The farmer's perception on the indicators of soil degradation is depicted in Table 5.27. It can be inferred that, farmers were able to identify indicators of salinity and point towards various field and crop symptoms to identify them. The ranks assigned by farmers for each indicator of salinity were used to prepare frequency.

Poor leaching and development of hard pan (98 per cent) on the soil surface and stunted crop growth and crop failure in early stages (94 per cent) were the major indicators as expressed by farmers followed by low crop yields (92 per cent), salt-encrustation and poor seed germination (76 per cent). Similar causes were reported responsible for land degradation in the study conducted by Umali (1993), Rao and Singh (1997), Kulkarni (2007) and Satish (2010).

**Table 5.27. Farmers' perceptions on indicators of soil degradation in the study area**

S.No	Problem indicators	Per cent of farmers responded	Rank
i.	Poor leaching and development of hard pan	98	I
ii.	Stunted crop growth and crop failure in early stages	94	II
iii.	Low crop yields	92	III
iv.	Salt encrustation and poor seeds germination	76	IV

### **5.6.2 Adverse effects**

The adverse effects of land degradation are presented in Table 5.28. It is evident from the table that large proportion of the families (90 per cent) expressed the decline in the land value due to land degradation. The externalities such as high incidence of crop pests and diseases accounted for 72 per cent of the sample farmers. Farmers, who shifted resources to other fertile

lands accounted for 70 per cent followed by agricultural labour wage earnings accounting for 59 per cent. The migration of farm families to distant cities to work as non-agricultural labourer was significantly influenced by degradation problems and such migration was noticed among 28 per cent of the farm families. Tendency of leasing-out degraded lands accounted for 23 per cent of farm families. Similarly, farmers forced to sell part of their land due to soil degradation accounted for 18 per cent. These findings were in agreement with the results obtained in the studies conducted by Kulkarni (2007) and Satish (2010).

**Table 5.28. Adverse effects of land degradation on sample farms**

S.No	Adverse effects	Per cent of farmers responded
i.	Decline in land value	90
ii.	High incidence of crop pests and diseases	72
iii.	Shifted resources to other fertile land	70
iv.	Increased dependence on agril.labour wage earnings	59
v.	Migration to distant cities to earn living	28
vi.	Leased-out affected land	23
vii.	Forced sale of land	18

### 5.6.3 Coping-up strategies

Various short-term coping up strategies adopted as measures to combat the soil degradation problems were presented in Table 5.29. The coping up strategies were adopted in order to realize yields before they were finally served unfit for cultivation. These strategies classified were irrigation, cultivation and crop choice, amendment and mechanical strategies. Among these strategies, the adoption of cultivation and crop choice of rice, increase in seed rate and abandonment of crop production was considerably higher than other coping-up strategies.

Among the irrigation strategies, cleaning of field irrigation channels and digging of open field drains were practiced by the farmers, which accounted for 28 per cent and 22 per cent, respectively. Among the cultivation of crop measures, cultivation of rice was practiced by 43 per cent farmers. Similarly, increase in the seed rate was adopted by 31 per cent of the farmers. Among the amendment strategies, the increased application of organic manure and nitrogenous fertilizers were practiced by few farmers. Major mechanical strategies such as deep and frequent ploughing and land leveling and bunding accounted for 33 per cent and 39 per cent, respectively.

**Table 5.29. Coping-up strategies adopted by sample farmers**

S.No	Strategy	Measure	Per cent of farmers responded
i.	Irrigation	Cleaning of field irrigation channels	28
		Opening field drains	22
ii.	Cultivation practice	Crop choice (rice)	43
		Increase in seed rate	31
		Abandon crop production	62
iii.	Amendment	Increased use of Organic manure	12
		Increase in the use of nitrogenous fertilizers	18
iv.	Mechanical	Deep and frequent ploughing	33
		Land leveling and bunding	39
v	None	Adopted none of the above	44

**5.6.4 Reasons for non-adoption of coping up strategies**

The various reasons for non-adoption of coping-up strategies are presented in Table 5.30. Among the major reasons, lack of incentives and technical know-how were the major reasons as expressed by the farmers, which accounted for 89.00 per cent and 80 respectively.

**Table 5.30. Reasons for non-adoption of coping strategies to manage soil salinity**

S.No	Reasons	Per cent of farmers responded
i.	Poor economic family background	77
ii.	High capital requirements	69
iii.	Individual actions alone not sufficient	76
iv.	Lack of incentives and subsidies	89
v.	Lack of technical know-how	80
vi.	Family had other income sources	22

Poor economic background and heavy capital requirement were limiting factors for adopting such reclamation measures were the other major reasons felt by the farmers, which accounted for 77 per cent and 69 per cent, respectively. Only 22 per cent of the farmers expressed that, they had alternative income sources as the reason for non-adoption of coping up measures.

### 5.6.5 Institutional contacts by farmers to appraise land degradation problem

The details on farmer's efforts to appraise the degradation problems are presented in Table 5.31. It is revealed that, farmers made sporadic attempts to appraise degradation problems and bring them to the notice of institutions and individuals involved in the development of agriculture. The extent of degradation problems and their severity was brought to the notice of state department of agriculture (64 per cent) followed by Agricultural University (43 per cent), and elected representative including village panchayat president (16 per cent) of the sample farmers.

**Table 5.31 Institutional contacts by farmers to appraise land degradation problem**

S.No	Contact agency	Percentage of farmers
1	State Department of Agriculture	64
2	Agricultural University	43
3	Elected Representatives (Panchayat president/MLA/MP/Minister)	16
4	None	37

## *Summary and Conclusion*

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## CHAPTER. VI

### SUMMARY AND CONCLUSIONS

Salinity has emerged as one of the major factors responsible for low crop production in Tamil Nadu. During the last many years, various agricultural regions have significantly lost their productivity due to soil salinity. This situation is very alarming especially for the Cauvery Delta Zone (CDZ) which is producing a major share of crops for Tamil Nadu. As far as the agriculture in Cauvery Delta Zone (CDZ) is concerned, the most important issue is the loss of agricultural productivity of farm lands due to water and soil salinity. The farming in Cauvery Delta Zone (CDZ) is continuously deteriorating and reached to a point where farmers have become more interested in selling their lands as a result of changed land use rather than practicing agriculture. Salinization of land and groundwater may be the major reason for the present situation. However, besides these reasons, there may be some socio-economic reasons as well that are also operative in the background. Therefore, an analytical study of the socio-economic factors was required to investigate such facts. Such analysis in relation to saline soils will lead to sound conclusions and indicate how the profitability of farms are being affected by these factors. The second issue is related to the use of saline water for domestic purposes, especially for drinking and its impact on human health. In order to avoid these health risks, people either buy fresh water from the market or walk long distances to collect fresh water at the cost of other productive activities. Finally, labour allocation decisions at household level will also change due to changes in production and consumption. This indicates that the problem of salinisation manifests not only in reduced agricultural production and loss of biodiversity but also increased cost of drinking water and human health care. The present research study examines these issues by carrying out an economic valuation of ecosystem changes due to salinity in Cauvery Delta Zone (CDZ) of Tamil Nadu. Not much has been done so far to explore the impact of salinity on the socio-economic conditions of farmers. Hence, this study specifically focuses on the impacts of salinity on the farmers and their strategies to cope with the situation. The specific objectives of the study are (i) To study the nature and extent of soil salinity in the study area (ii) To analyse the comparative economics of rice production between salinity affected and normal soil production environments, and (iii) To examine the efficiency of resources use in rice production

and assess the impact of salinity on income and employment (iv) To workout the optimal plans for land utilisation, farm returns (v) To assess the problems faced by the farmers soil salinity and land degradation and suggest suitable policy measures

Farmers in the Cauvery Delta Zone form the universe of the study. Multistage stratified random sampling technique was adopted to select ultimate sampling unit. Under this sampling technique selection of districts forms the first stage, selection of taluks as second stage and selection of village as third stage. Selection of different stage unit was based on largest area affected under soil salinity in the Cauvery delta zone. Musiri, Illupur, Sirkali Taluks of Tiruchirapalli, Pudukottai and Nagappattinam districts, respectively were selected for the present study. Similarly in each taluk, two villages were selected. In each village, ultimate sampling unit was selected based on simple random sampling. From each village, 10 sampling unit were selected and this leads to the total sample size of 240 farmers which comprises of 120 farmers each under salt affected and non affected production environment.

Tabular analysis was employed to study the cropping pattern, cost and returns and economic losses etc, contributed by saline soils. Decomposition analysis was carried out to study and identify the factors that contributed to the difference in yield levels under saline soils. Further, Cobb-Douglas production function analysis was employed to study the resource use efficiency in the sample farmers. Paired 't' test was employed to test the mean difference between the affected and non affected sample farmers. Data envelopment analysis was employed to prepare the optimal plans under salinity affected farms and to estimate the technical efficiency in affected sample farmers

### **Findings of the study**

The results sample farm characteristics indicated that the higher involvement of relatively older farmers (more than 41 years) in salinity affected category than non affected category of sample farmers. The average size of family was found to be higher among the farmers of non affected category (5.31 persons) than the farmers of salinity affected category (5.28 persons). Among the different affected categories of sample farmers, average size of family was higher in the high level of affected category (5.49 persons) followed by medium (5.26 persons) and low level of affected category (5.11 persons). The farmers with more experience was taking up farming in salinity affected soil than the non affected category of sample farmers

The illiterate farmers were higher in share in salinity affected category than the farmers of non affected category which accounted for 15 per cent and 11.67 per cent, respectively. The proportion of sample farmers having secondary occupation was higher in salinity affected category than non affected category, which accounted for 36.67 per cent and 29.71 per cent respectively.

Majority of sample farmers under the category of marginal and small farmers and the proportion of marginal and small farmers was higher in affected category than non affected category. It accounted for 55.84 per cent and 45 per cent, respectively in salinity affected and non affected category and the same ranged between 43.75 per cent and 66.66 per cent among the different affected categories.

Among the different salinity affected categories, high level of affected category had maintained larger number of livestock population, followed by medium and low level of affected category. The value of assets such as wells and tube wells, farm building and cattle shed and machinery and implements was higher in non affected category than the affected category of sample farmers.

The total salinity affected area was higher in low level of affected category which accounted for 45.21 per cent, followed by medium and high level of affected category which accounted for 30.02 per cent and 24.77 per cent, respectively. The land put under fallow or abandoned was higher in affected category (04.97 per cent). An average of 0.78 ha per farmer was abandoned or unutilized in salinity affected than non affected category (0.14 ha per farmer).

The quantity of inputs used was higher in low level of affected category, followed by medium and high level of affected category, the percentage change in human labour utilization in affected category over non affected category was 10.72 per cent.

The cost of cultivation of paddy was Rs. 59837 per ha in non affected category and the same was Rs. 48567 per ha for pooled affected category. Among the sample farmers of both affected and non affected category, human labour was found to be the major input accounting for 37.70 per cent of the total cost in non affected category and the same was 39.84 per cent in affected category.

The Cost A1 for one hectare of paddy was Rs. 46251 in non affected category and the same was Rs. 39050 in pooled category of salinity affected farmers. It varied between Rs. 37027 and

Rs. 40694 among the different affected categories of sample farmers. The percentage change of total cost of cultivation of affected category over non affected category was 18.83 per cent.

The yield realized varied considerably and it was 40.24 quintals per hectare in non affected category and the same was 30.30 quintals per hectare in affected category. Among the sample farmers, gross return realized was Rs. 70970 per hectare in non affected category and the same was Rs. 54122 per hectare in affected category. The percentage change in net return over Cost A1 of the affected category over non affected category was 39.03 per cent. The net return of paddy over total cost was higher in non affected category of sample farmers, which worked out to Rs. 11132 per hectare and the same worked out Rs. 5554 per hectare in affected category of sample farmers.

Marginal value of damage estimate confirmed that one unit increase in EC for average level of salinity would adversely affect paddy yield by 187 kg per hectare.

Decomposition estimates shows that soil salinity was the major cause for the reduction of yield. Contribution of soil salinity to total change in rice yield was estimated at 36.57 per cent for low level of affected category, followed by 45.32 per cent and 56.15 per cent, respectively for medium and high level of affected category.

Data envelopment analysis results confirmed that around 45 per cent of the farmers belonged to the most efficient scale group (90-100 per cent) and 8 per cent of the farmers operated in the least scale efficiency group (less than 80 per cent). Among the different inputs, plant protection chemicals had the highest percentage of slack. The sample farmers could reduce plant protection chemicals by 7.9 per cent and still achieve the same level of output. The slack value machine labour could be reduced by 7.8 per cent, followed by fertilizers, manures, human labour and seeds could be reduced by 4.1 per cent, 2.8 per cent, 2 per cent and 1.8 per cent.

An average 107.42 and 95.90 man days of labour was employed in non affected and affected pooled category of sample farmers and the same varied between 91.47 and 99.54 among different categories of salinity affected sample farmers. The percentage reduction in rental value over non affected soil was 37.80 per cent in the affected category.

With increased land degradation, the number of farm families temporarily migrated was 36 per cent of the sample farmers and it ranged between 9 per cent and 15 per cent among the different categories of salinity affected sample farmers. The total migrated family was 42 per cent.

Poor leaching and development of hard pan (98 per cent) on the soil surface and stunted crop growth and crop failure in early stages (94 per cent) were the major indicators as expressed by farmers followed by low crop yields (92 per cent), salt-encrustation and poor seed germination (76 per cent) were major indicators as expressed by farmers for salinity soils.

The adverse effects of land degradation were decline in the land value and high incidence of crop pests and diseases accounted for 90 per cent and 72 per cent, respectively.

The coping up strategies adopted by the farmers were cleaning of field irrigation channels and digging of open field drains, which accounted for 28 per cent and 22 per cent, respectively. Among the crop management technique, increase in the seed rate was adopted by 31 per cent of the farmers. Among the amendment strategies, the increased application of organic manure and nitrogenous fertilizers were practiced by few farmers. The extent of degradation problems and their severity was brought to the notice of state department of agriculture (64 per cent) followed by Agricultural university (43 per cent).

### **Specific conclusions**

- Land put in to fallow / abandoned was between 0.46 to 1.15 ha per farmers in affected category. Higher proportion of land put into fallow / abandoned in salinity affected area of (0.78 ha per farmer) than non affected category (0.14 ha per farmer). Among affected category it ranged between 0.46 to 1.15 ha per farmer.
- The proportion of salinity affected area was higher in low level followed by medium and high level among the different categories salinity
- Input utilization pattern in paddy clearly indicated that, the extent of different inputs used in salinity affected soils were lower than that of non affected farms. Among the affected category, the quantity of inputs used was higher in low level, followed by medium and high
- Among the inputs, seeds and organic manures were used in larger quantity in high level of affected category than low and medium level of affected categories.
- The cost of cultivation of paddy was higher in non affected category (Rs. 59837 per ha) than the pooled affected category (Rs. 48567 per ha).
- The yield realized was higher in non affected category (40.24 quintals per hectare) than the affected category (30.30 quintals per hectare). In low salinity areas, the yield loss was

19 per cent; in medium and high soil salinity areas, yield was reduced by about one fourth.

- The net return over cost A1 was higher on non affected farms than the affected category. The percentage change in net return over Cost A1 of the affected category over non affected category was 39.03 per cent.
- In affected category of sample farmers, human labour, manuring and fertilizer has significant influence on yield.
- In affected category, one per cent increase in the electrical conductivity of soil at mean level decrease yield by 0.79 per cent. The response of the yield enhancing factors was not as powerful as that of salinity. The positive response of yield increasing variables on yield was completely neutralized by soil salinity.
- Marginal value of damage estimate confirmed that one unit increase in EC for average level of salinity would adversely affect paddy yield by 187 kg per hectare.
- Decomposition estimates shows that soil salinity was the major cause for the reduction of yield when compared reduction input use.
- Among the affected category, low level had higher technical efficiency than medium and high level of salinity. Similar trend was also noticed in scale efficiency.
- Among the affected category the yield efficiency, age and education level had a significant and positive influence on technical efficiency and EC level had a significant and negative influence on technical efficiency.
- The welfare loss in high level of salinity affected sample farmers was very high and was Rs. 0.71 followed by, Rs.0.53 in medium level, Rs.0.33 on low level of salinity affected farms. It was Rs.0.50 in pooled category of salinity affected sample farmers. It is revealed that, profits earned by farmers in degraded soils for every one rupee earned were very low and this variation increased marginally with increase in level of soil salinity. The profits earned in salinity affected farms for every rupee earned observed to be in the declining.
- There was a considerable decline in the land value on account of soil degradation.
- Among the coping strategies (irrigation), cleaning of field irrigation channels and digging of open field drains in irrigation management, increase in the seed rate in crop

management and deep and frequent ploughing and land leveling and bunding in mechanical strategies were practiced by the farmers.

- The lack of incentives and technical know-how were the major reasons for non-adoption of coping-up strategies by the farmers.

## **Policy Implications**

With reference to the objectives and the analysis of the study, the following broad policy conclusions can be derived:

- In salinity affected areas, the soil salinity is the principal factor that determines rice production. In low salinity areas, the yield loss was 19 per cent; in medium and high soil salinity areas, yield was reduced by about one fourth. One unit increase in EC at mean level would adversely affect paddy yield by 187 kg per hectare. Therefore, it is important to identify such areas in the Cauvery Delta Zone (CDZ) and reclaim the soil from permanent damage. Farmers alone cannot tackle this huge task of rehabilitating degraded land.
- Therefore, governments should take lead in preparing strategic plans to improve the degraded lands through research and extension services. This goal can be achieved by opening a dialogue with farming communities and policy makers to improve their understanding of the problem and its future implications at local, regional and national scale. The management options for salt-prone land will be built on the accumulated wisdom of relevant stakeholders at the community level. Such participatory approaches create a sense of ownership among the farmers. Furthermore, community-based management would help in strengthening linkages among researchers, extension functionaries and farmers
- Farmers change input use as soil salinity increases. The incidence of salinity will result in an increase in cost and reduced production. It will also not be economically viable to cultivate rice in the high saline areas. Therefore, soil salinity should be controlled to realize the benefit from any increase in crop production
- It was painful to know that majority of farmers reported lack of incentives and technical know-how was the major reasons for non-adoption of coping-up strategies for soil

degradation. There is an immediate need to tackle this problem by developing a strategy for the supply of inputs on cost effective basis, if not on subsidized rates.

- Lack of technical guidance was another reason revealed by the farmers. It is the responsibility of the State Department of Agriculture and Agricultural University to create a need for taking up of land reclamation and impart periodical guidance in this regard.
- Finally, effect of salinity on drinking water quality, human health, vegetation and temporary migration was felt in the salinity affected area; this is not substantiated by analytical data. Thus an in-depth study is needed to investigate this problem.

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## ***APPENDICES***

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## *APPENDICES*

### **CONCEPTS IN IMPACT OF LAND DEGRADATION**

Land degradation has numerous environmental, economic, social and ecological consequences. Every ecosystem on the earth is affected by some or other form of land degradation. When land is degraded, the ecology is damaged. There can be rather serious effects in terms of soil erosion, loss of soil fertility and thus reduced plant growth or crop productivity, clogging up of rivers and drainage systems, extensive floods and water shortages.

#### **DEFINITION OF LAND DEGRADATION**

There are numerous terms and definitions that are a source of confusion, misunderstanding, and misinterpretation. A wide range of terms is used in the literature, often with distinct disciplinary-oriented meaning, and leading to misinterpretation among disciplines. Some common terms used are soil degradation, land degradation, and desertification. While there is a clear distinction between 'soil' and 'land' (the term land refers to an ecosystem comprising soil, landscape, terrain, vegetation, water, climate), there is no clear distinction between the terms 'land degradation' and 'desertification'. Desertification refers to land degradation in arid, semi-arid, and sub-humid areas due to anthropic activities (UNEP, 1993; Darkoh, 1995). Many researchers argue that this definition of desertification is too narrow because severe land degradation resulting from anthropic activities can also occur in the temperate humid regions and the humid tropics. The term 'degradation' or 'desertification' refers to irreversible decline in the 'biological potential' of the land. The 'biological potential' in turn depends on numerous interacting factors and is difficult to define.

#### **1.2 LAND DEGRADATION PROCESSES**

Principal processes of land degradation include erosion by water and wind, chemical degradation (comprising acidification, salinization, alkalization etc.), physical degradation (comprising crusting, compaction, waterlogging etc.), human induced degradation and others. Some lands or landscape units are affected by more than one process, of water and wind erosion, salinization, and crusting or compaction. Descriptions of various categories of land degradation are given below.

##### **Water Erosion (W)**

Water erosion is the most widespread form of degradation and occurs widely in all agro-climatic zones. The displacement of soil material by water can result in either loss of top soil or terrain deformation or both. This category includes processes such as splash erosion, sheet erosion, rill and gully erosion. The soil erosion is initiated when raindrops fall onto the bare soil surface. The impact of raindrops breaks up the surface soil aggregates and splashes particles into the air. On sloping land relatively more of the detached material will fall down slope resulting in runoff. This subsequently lead to different types of water erosion depending on the gravity of the problem, susceptibility of land and continuity of the process.

### ***Sheet erosion (Wsh)***

It is a common problem resulting from loss of topsoil. The loss of topsoil is often preceded by compaction and/or crusting, resulting in a decrease of infiltration capacity of the soil. The soil particles are removed from the whole soil surface on a fairly uniform basis in the form of thin layers. The severity of the problem is often difficult to visualize with naked eyes in the field.



### **Sheet erosion by water in**

Pongalur village in Avinashi taluk of Coimbatore district

### ***Rills (Wri)***

When the surface runoff goes in the form a concentric flow, a tiny water channels are formed in the field. These are small rivulets of such a size that they can be worked over with farm machinery. Rills are generally associated with the cultivated lands and are visible in the ploughed soil after first heavy showers. One important feature of rills is that they do not occur at the same place repeatedly. This is a temporary concentric flow of runoff, which could vanish after ploughing the land.



### **Rill erosion in**

Arunachalapuram village in  
Sankarankoil taluk of  
Tirunelveli district

### ***Gullies (Wgu)***

Gullies are formed as a result of localized surface run-off affecting the unconsolidated material resulting in the formation of perceptible channels causing undulating terrain. If rills are neglected and the erosion continues for a long time, it develops in to gullies. They are commonly found in sloping lands, developed as a result of concentrated run-off over fairly long time. They are mostly associated with stream courses, sloping grounds with good rainfall regions and foot hill regions. These are the first stage of excessive land dissection followed by their networking which leads to the development of ravinous land.



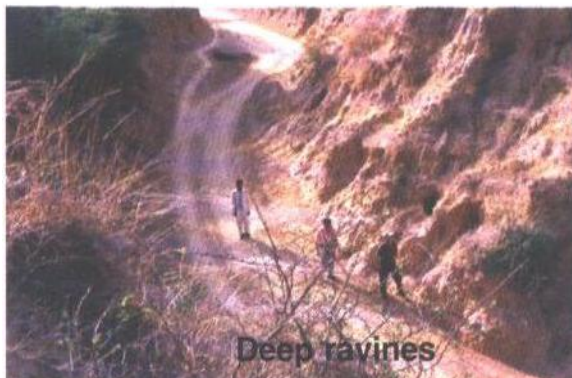
### **Gully erosion in**

Karai village of Perambalur  
district

### ***Ravines (Wrs/Wrm)***

The word ravine is usually associated not with an isolated gully but an intricate network of gullies formed generally in deep alluvium and entering a nearby river, flowing much lower than the surrounding tablelands. Ravines are basically extensive systems of gullies developed along river courses. Further classification of this category is possible based on the depth, width, bed slope, frequency and morphology of bed material of the ravines. Based on the depth of the ravines, which

has a characteristic manifestation on the satellite image, two subcategories are possible for delineation viz., shallow ravinous and deep ravenous lands.



### **Ravines** in Uttar Pradesh

Source: Nationwide mapping of land degradation project book

### **Wind Erosion (E)**

It implies uniform displacement of topsoil by wind action. It can result in loss of topsoil and the deposition of the eroded material elsewhere leads to formation dune complexes. The risk of wind erosion is severe in the arid and semi-arid areas. It includes both the removal and deposition of soil particles by wind action and the abrasive effects of moving particles as they are transported. Not only can the wind remove topsoil from good farmland; it can result in additional damage by burying land, buildings, machinery, etc. with unwanted soil. It occurs when soil is left devoid of vegetation either because of poor rainfall to support any vegetal cover or loss of vegetation due to overgrazing. In the sand deposited areas with rainfall the sand gets stabilized partially or fully depending on vegetal cover it establishes.

During high winds the finer, and commonly more fertile, particles are swept high in the air and are sometimes carried for great distances as dust storms; while coarser particles are rolled or swept along on or very near the soil surface to be piled into depressions. The process is highly dynamic and requires careful evaluation of the site and process.

### ***Sheet Erosion(Esh)***

It implies uniform displacement of topsoil by wind action as thin layers / sheets. During wind storms, the dry finer soil particles which could be suspended into air will be transported longer distances, while the heavier particles creep on the surface and generally will be transported to a shorter distance. It may seriously influence the infrastructures (roads, railway lines, buildings, waterways, etc.). The uneven displacement of soil material by wind action leads to deflation hollows and dunes. The lifted medium to coarse soil particles may reduce the productivity of adjacent fertile land when they are deposited in the form of sand castings.



**Sheet erosion by Wind in**

Sundramandiam village of  
Ramanathapuram district

### ***Stabilized Dunes(Eds) / Partially stabilized Dunes (Edp)***

Depending on the rainfall and protection available from grazing, the bare sand dunes gradually establish a vegetative cover thus making them to get stabilized. In partially stabilized dunes, the erosion / deposition will be still active to some extent. When they establish a good vegetative cover either in the form of grasses, shrubs and scrubs, they get stabilized and the erosion / deposition activity will be at a minimal. By virtue of vegetative cover and physiography, they are discernible on satellite imagery.



### **Stabilized sand dune in**

Idachillai village in  
Sathankulam taluk of  
Thoothukudi district



### **Partially stabilized sand dune in**

Valnokkam village in Kadaladi taluk  
of Ramanathapuram district

### ***Un-stabilized dunes (Edu)***

Due to their inherent vulnerability because of lack of vegetal cover, these are quite active during summer season. The sand starts moving and engulfing the adjoining agricultural lands, engineering structures and demands immediate attention for their stabilization. The unstabilized sand dunes changes their location and shape from season to season and hence they are often called shifting dunes.



### **Unstabilized sanddune in**

Keelaiyur village in  
Rameswaram taluk of  
Ramanathapuram district

### **Water logging (L)**

Water logging is considered as physical deterioration of land. It is affected by excessive ponding / logging of water for quite some period and affects the productivity of land or reduces the choice of taking crops.

### ***Surface Ponding (Lsp)***

This category addresses the water logging caused by flooding of river water, submergence by rainwater and human intervention in natural drainage systems that adversely affect the natural drainage, where the water stagnates for quite a long time. Depending on the number of crops it affects it has been sub-divided into two severity classes, slight- affecting one crop and moderate – affecting more than one crop. Flooding of paddy fields is not included as it is a unique cultural practice rather than degradation of soil.

Waterlogging may be seasonal or permanent. Seasonally waterlogged areas are those low lying or depression areas that get saturated due to heavy rains and are normal in post-monsoon season. Permanent waterlogged areas are those areas where there is continuous surface ponding of water or soil profile is saturated for one or more seasons.

### ***Sub-surface water logging (Lsw)***

If the water table is within 2 m from the surface it adversely affects crop by virtue of saturating the root zone due to capillary rise. These areas are a potential threat to get surface ponded in due course of time, if the water accumulation continues. The sub-surface waterlogged areas can be reclaimed with little ease.

## Salinization / Alkalization (S)

Salinization can result from improper management of canal irrigation water resulting in the rise of water table and consequent accumulation of salts in the root zone in arid, semi-arid and sub humid (dry) conditions and ingress of sea water in coastal regions and/or use of high-salt containing ground water. They also become saline when soils have developed on salt-containing parent materials or have saline ground water. The soils with EC more than 2ds/m in vertisols and >4ds/m in non-vertisols was considered as saline in the present project. Increase in soil pH beyond 8.5 results in sodicity or alkalinization that result in increase of exchangeable sodium percentage in soils (> 15). Based on the type of problem, it has been divided into saline(Ssa), sodic (Sso) and salinesodic (Sss).



### Saline soil at

Kakkam Nagar village in  
Nanguneri taluk of  
Tirunelveli district



### Sodic soil at

Pillankulam village in  
Kallakurichi taluk of  
Villupuram district

## Acidification (A)

pH is one of the most-important soil property that affects the nutrient uptake by plants and there by influencing the crop productivity. Any soil processes or management practices which lead to buildup of hydrogen cations (also called protons) in the soil will result in soil acidification. It also occurs when base cations such as Calcium, Magnesium, Potassium and Sodium are lost from the soil leading to high hydrogen ion concentration. This results in decrease of soil pH below 6.5. It occurs in laterite regions, coastal regions upon drainage or oxidation of pyrite containing soils. If the pH is 4.5 to 5.5 then

they are called *moderate* and if the pH is  $< 4.5$  then they are mapped under *severe* category. The soils respond to lime application, which results in improvement of crop productivity.



**Severe acidic soil at  
(High level laterite)**

Kulicholan village in  
Udagamandalam taluk of



**Moderate acidic soil at  
(Low level laterite)**

Villakalpatti village in  
Omalur taluk of Salem

**Degradation due to Anthropogenic factors (H)**

Human economic activities like mining, industries etc., have also contributed to decreased biological productivity, diversity and resilience of the land. Mining, brick kiln activities and industrial effluent affected areas are included under this type of degradation.

***Industrial effluent affected areas (Hie)***

These are areas where the human activity is observed in the form of industry along with other supporting establishments of maintenance. Heavy metallurgical industry, thermal, cement, leather, petrochemical, engineering plants etc., are included under this. These are the lands which have been deteriorated due to large scale industrial effluent discharge. These areas are seen around urban areas and other areas where industrial activity is prominent.



### **Dye effluent affected area in**

Melapalayam village in Karur taluk of Karur district

### ***Mining and dump areas (Hmd)***

These are the areas subjected to removal of different earth material (both surfacial and sub-surfacial) by manual and mechanized operations. Large scale quarrying and mechanizations results in mining and mine dumps. It includes surface rocks and stone quarries, sand and gravel pits, brick kilns, etc. Mine dumps are those areas where waste debris is accumulated after extraction of required minerals. Generally these lands are confined to the surroundings of the mining area



### **Lime stone mining at**

Rasta village in Tirunelveli taluk of Tirunelveli district

### ***Brick kiln areas (Hbk)***

These areas are associated with human activity and are generally seen in the vicinity of urban activity. The areas include brick kiln per se and area dugged for making bricks.



### **Brick kiln area at**

Kalapanayakanpalayam  
village in Coimbatore North  
taluk of Coimbatore district

### **Others (T)**

Some of the degraded lands, which could not be included in the above type of land degradation, are included here. They are mass mvement/ mass wastage, barren rocky / stony waste areas.

### ***Barren rocky / stony areas (Tbs)***

Barren / rocky / stony areas are the rock exposures of varying lithology often barren and devoid of soil and vegetal cover. They occur in hill forests as openings or as isolated exposures on plateau and plains. These can be easily delineated from other type of degraded land because of their severe nature of degradation and typical spectral signature.



### **Barren rocky area at**

Devanallur village in  
Nanguneri taluk of  
Tirunelveli district

### ***Miscellaneous (Tms)***

This includes riverine sand areas, sea ingression areas mainly with sand deposition excluding the sandy areas of desert region.



**Sea Ingress area at**

Mandapam village of  
Ramanathapuram district