Challenges of Ecological and Economic Factors to Food Security in Kanyakumari District – A Supply Side Analysis

By
Dr. J. Cyril Kanmony MA. ,MPhil., MEd., BGL., PhD
Associate Professor of Economics
PG & Research Centre, Department of Economics
Scott Christian College (Autonomous)
Nagercoil-629003
Kanyakumari District, Tamil Nadu
Ph: +91 4652 236228 (R) +91 4652 231807 (O)
Mobile: +91 9943869198
Email: jcyril@dataone.in, cyrilkanmony@ymail.com

&

Mr. G. Gnana Elpinston MA., MPhil
Research Scholar
Mobile:+91 9442334508
Email: gnanaelphinstone@yahoo.com

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ABSTRACT

The right to have enough food is a basic human right. It is emphasized in the Universal Declaration of Human Rights 1948. Making a minimum quantity of food available, accessible, affordable and absorbable to everyone is called food security. Availability of food is the function of production. Production is influenced by the area under cultivation and yield. Area under cultivation depends on many ecological and economic factors. Among ecological factors, rainfall and temperature are the most influencing factors. They may act synergistically or antagonistically with other factors in determining yields. Agriculture is most vulnerable to climate change. Net return, input cost, output price, availability of farm laborers and finance and marketability of produce are the main economic factors influencing food supply.

Objectives

The objectives of this study are:

1. To identify the role of ecological factors, particularly rainfall and temperature, in rice production.
2. To assess the importance of various economic factors in rice cultivation.
3. To suggest ways and means to solve problems encountered by farmers of Kanyakumari district.

Hypotheses

The following hypotheses have also been formulated:

- Decline in rainfall is not the cause for the receding area under rice and the decreasing rice production.
- Rising temperature has no influence on rice cultivation.
- Economic factors have no role in deciding area under rice and production of rice.

This paper makes use of both primary and secondary data. The secondary data regarding rainfall, temperature, area under rice and production and productivity of rice for 18 years have been collected from various secondary sources. Information regarding the influence of rainfall and temperature, reasons for shifting crops and future plan of farmers has been collected from farmers. Kanyakumari district was

once called ‘the Rice Granary’ of the erstwhile Travancore State. However, the present situation is completely different. The exponential growth rates show a sharp fall in area, production and productivity of rice. In absolute term, between 1957-’58 and 1991-’92 the reduction of area under rice per year was 532.76 hectares and between 1999-‘00 and 2008-’09 the reduction was 1328.80 hectares. It can be deduced that there will be no rice cultivation in the district after 2025. In Thiruvattar block, cultivation of rice came to an end in 2008-’09. In the other four blocks (total 9 blocks), it is on the verge of extinction. Kanyakumari district, which produced 14 percent more than the national per capita availability of rice in 1991, has produced 32.28 percent less in 2008. If this situation persists, every grain will be purchased from other states.

Data analysis shows a falling trend of rainfall but a steady increase of temperature. Rainfall data and calculated values prove that decline in rainfall is the reason for decrease in production but fail to prove that decline in rainfall is the cause for decrease in area under rice. Temperature data and calculated values show that rise in temperature is the cause for reduction in area under rice but it affects production insignificantly. But, the primary data collected from field experts show that decline in rainfall is a reason for decrease in area under rice. Insufficient rainfall in 2002-’03 led to the subsequent decrease in area under rice in 2003-’04, which confirms the view of farmers. R^2 indicates that 96 percent of rice production is contributed by the four identified factors, rainfall, temperature, area and productivity. The main economic factor that affects rice cultivation adversely is price. Support prices for rice increased marginally while cost of cultivation rose steeply. Hence, net return from rice decreased while for crops like rubber and coconut increased. It decreased from 46 to 42 for rice while it increased from 220 to 256 for rubber between 1987-’88 and 2004-‘05. It means that, economic factors also have significant role in rice cultivation. Unpredictable ecological factors contribute to uncertainty in rice production while economic factors make it non-profitable. So farmers quit rice cultivation; already 62% quitted rice farming and 60% of the remaining is ready to quit. The paper goes on analyzing problems and future plans of farmers and the steps to be taken by authorities concerned.

Challenges of Ecological and Economic Factors to Food Security in Kanyakumari District – A Supply Side Analysis

Food security refers to a situation where all people at all times have access to sufficient, safe and nutritious food that meets their dietary need to lead an active and healthy life (FAO in Ghosh 2010). Swaminathan (2011) says that food security can only be attained by making available adequate quantity of quality food, by ensuring access to adequate food at affordable prices and by providing facilities such as clean drinking water, sanitation and healthcare to allow absorption of food in the body. The simple meaning of these interpretations is that everyone has the right to get an adequate quantity of food to have a dignified life. It is emphasized in every Human Rights Declaration, Covenant and Convention particularly in the Universal Declaration of Human Rights 1948, (Article 25), and in the Indian Constitution (Articles 21 & 47). Article 25 of the UDHR says "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control". Article 47 of the Indian Constitution says, "The state shall regard the rising of the level of nutrition and the standard of living of its people...". Article 21 guarantees right to life and personal liberty. The article reads as follows, "No person shall be deprived of his life or personal liberty except according to procedure established by law". Based on this article, the Supreme Court of India has rightly pointed out that the right to food is a fundamental requirement for the right to life.

Food security, thus, involves four components, availability, accessibility, affordability and absorbability. Availability is the function of production. More production means more availability and vice versa. Production of food is highly influenced by the area under cultivation and yield. High productivity means high output. If productivity remains constant, the area under cultivation is the deciding factor of availability of food. While productivity depends on the availability of high-yielding variety seeds, technology, modern methods of cultivation, new ways of treating crops, fertility of the soil and so many factors, area under cultivation depends on many ecological and economic factors. Ecological factors include changes in climate i.e., rainfall, temperature and wind direction and speed, soil quality, water quality, intensity of light and moisture content in the atmosphere.

Climate change has become very serious at the end of the 20^{th} century, due to uncontrolled emission of carbon-dioxide and other unwanted pollutants in the atmosphere by both developed and developing countries. The change in climate can be known from the occurrence of a number of very hot years in succession, frequent and more intensive cyclonic storms and hurricanes, flash floods and droughts due to abnormal rainfall pattern, ocean warming and breaking off Arctic ice. Among the climatic factors, rainfall and temperature are the most influencing factors. It is said that climate change influences every economy by delayed monsoon, unexpected rains, heavy downpours and rising temperature {Dar (2009) Joseph (2009) Krugman (2009) Middleton (2009) Monbiot (2009) Panda (2009) Sample (2009) Sanwal (2008).

Agricultural production, particularly cereal production, is adversely influenced by these environmental factors. They may act synergistically or antagonistically with other factors in determining yields. Biophysical simulation models applied in Latin American and North American countries show that climate conditions decrease considerably the yield of wheat, maize and soyabean (Adams, 1998). Its vulnerability also varies from country to country. Some countries in temperate zones are expected to be benefited while many countries in the tropical and subtropical zones are expected to be adversely affected by climate change (Rosenzweig and Martin, 1994). According to Cramer (2008) South Asia is the most vulnerable to climate change and among the various sectors; agriculture is the most vulnerable sector.

Factors such as net return, cost of input, price of output, availability of farm laborers and finance and marketability of produce are the main economic factors determining the area under cultivation and thereby the production of food. Apart from these factors, policies adopted by governments particularly price policy and subsidy policy, social setup, and views of the modern society are also have some influence.

Objectives

The objectives of this study are:

1. To identify the role of ecological factors, particularly rainfall and temperature, in rice production.
2. To assess the importance of various economic factors in rice cultivation.
3. To suggest ways and means to solve problems encountered by farmers in Kanyakumari district.

Hypotheses

To make the study scientific and analytical, the following hypotheses have been formulated:

- Decline in rainfall is not the cause for the receding area under rice and the decreasing production.
- Rising temperature has no influence on rice cultivation.
- Economic factors have no role in deciding area under rice and production of rice.

Limitations of the Study

Though there are a number of ecological and economic factors, rainfall and temperature of ecological factors and minimum support price (MSP) and net income over the cost of production of economic factors are taken for analysis. As far as area under rice cultivation is concerned, it is available from 1957-'58 to 2008-'09 with some gaps. However, continuous data are available only from 1991-'92 and so the data available continuously are taken for analysis. For analyzing some other factors like reasons for shift in cultivation, farmers' opinion has been collected and analyzed.

Methodology

This paper makes use of both primary and secondary data. The secondary data regarding rainfall and temperature, area under rice and production and productivity of rice for 18 years have been collected from various published and unpublished sources. The main sources are G – Returns, Season and Crop Reports, and other reports available in Meteorological Department, Chennai, District Statistical Office, Nagercoil and various libraries. The primary data have been collected directly from field experts. The oldest farmers' society called Kumari Mavatta Vivasaygal Sangam (Kanyakumari District Farmers' Development Society) was selected for identifying farmers. Out of 1045 registered members of the society, 105 were selected at random. Information regarding the influence of rainfall, temperature, net return, availability of farm workers and finance, occurrence of pests and diseases, disturbance of wild animals, irrigation problems, and reasons for shifting crops and future plan of farmers was collected from the field experts through a scientifically prepared interview schedule. The collected data were processed, analyzed and interpreted with the help of Mathematical tools such as percentage and rate and Statistical tools such as correlation coefficient, coefficient of determination and multiple regression and testing tools have also been used wherever necessary.

Review of Related Literature

A brief review of related literature is necessary to understand important concepts and areas covered by earlier studies to have proper directions for the present research and to know the research gap.

Mathi (2011) points out that globally the production of wheat and maize declined by 5.5 percent and 3.8 percent respectively from 1980 to 2008 due to unfavorable weather. During this period, in Russia, wheat production declined by 15 percent. As a result of the unfavorable weather, the prices of crops like maize, wheat, rice and soyabean have risen up by 20 percent.

Prabu (2011) observes that the main reason for a sharp decline in the area under cultivation is the unbridled real estate business. He points out the view of Murugesan, a farmer from Tamil Nadu that there was no problem as there was good yield, a sure market and good price. The income from farm is coming down and even that income is not certain due to vagaries of nature while the price of fertile cultivable land increases as there is high demand for land from realtors. Hence, most of cultivable lands that have good air and plenty of water are converted into housing plots. It is also expected that within 10 years, all fields in Pollachi area, Tamil Nadu will become housing plots or barren or uncultivated land. Another reason pointed by him is that farmers are not willing to cultivate their land, because they are finding difficulty in sourcing labor.

Kanda (in Swaminathan 2011) points out that the factors responsible for the decision of a large number of farmers not to grow rice during the kharif season of 2011 are (a) the minimum support prices offered does not cover the cost of production (b) the procurement is sluggish (c) the late release of canal water, (d) non availability of credit and other essential inputs and (e) the non settlement of crop insurance dues.

Sainath (2011) asserts that between 1991 and 2001, over seven million people for whom cultivation was the mainly livelihood, quit farming. It means that on an average, every day about 2000 people abandon farming in the country.

Sambrani (2010) highlights that 2002-03 and 2009-10 are the two recent major drought years in India. The rainfall deficit was 19 percent during 2002-03 and 23 percent during 2009-10. During these drought periods, there was a considerable decline in the food grain production.

Kumar (2010) finds out that as a result of climate change, the yield of food grains such as rice and wheat have been affected very much adversely. Further, by seeing the past monsoon patterns, the author says that after 150 years, there will be no south-west monsoon in India and it will create more food shortage after 150 years.

Singaraj and Kumar (2010a) bring to light that the four dimensions of food security would be affected by the changes in climate and weather conditions. The stability of food supply and the availability of food are affected by declining agricultural production. The ability of consumption and utilization of food is badly affected by the occurrence of vector-borne, food-borne and water-borne diseases due to the frequent increase in temperature and extreme rainfall. As the agricultural production declines, it tends to raise price of food and reduce the real purchasing power. Ultimately it badly hit the accessibility of food.

Natarajan et al (2010) narrates that the sudden and unexpected rainfall in the state of Karnataka during October 2009 damages the soil, crops, and infrastructure. The highest excess rainfall was 924 percent more than the normal level. It was estimated that, flood water washed away 287 million tons of top fertile soil, 8.17 lakh tons of soil nutrient, 8 lakh tons of organic matter from the red soil and 30 lakh tons of organic matter from the black soil. The total soil nutrient loss was estimated as 16250 million in Indian rupees. The total cost required to bring back the soil to the original level was 8530 million rupees. The most affected sector was the agricultural sector and rice was the most affected crop.

Padukone (2010) notices that climate changes damage the natural resources, particularly agriculture and allied activities. Poor people are more affected by the climatic changes as they depend much upon the climate–sensitive resources such as agriculture, forests and river water. The estimation of Indian Agriculture Research Institute shows that, if the global temperature rises by 1°C, India will lose four to five million tons of wheat production.

Pachuri (2010) laments that climate extremes such as increase in air and ocean temperature, melting of glaciers, rise in sea level, frequent occurrence of droughts, floods, heat waves and high precipitation cause serious impacts on the availability of water and food. Further, the author states that in Africa, by 2020 over 75 to 250 billion people will be affected by water problem and less availability of food. In some countries, by 2020, the yield from agriculture will be reduced by 50 percent.

Mandal (2010) observes that farmers in the state of Assam have been facing risk and uncertainty in producing the agricultural commodities due to the occurrence of frequent floods. In Assam, where rice is the dominant crop, every year flood damages a large area under crops, properties and lives of people. The damages are very high during the winter season. The most affected crop is rice. Flood destroyed the standing crops, created water-logging, eroded fertile soil and adversely affected area under crops and production.

Sule (2010) views that wheat and rice crops are heavily damaged both by drought and untimely rainfalls and so their prices move up and it makes food security and health care more complicated.

Patnaik (2010) reports that the level of per head cereal supply and consumption in India by 2007 was 174 kg and 156 kg in 2008, while in the United States of America, it was nearly 900 kg in 2007. In India, cereals account for nine tenth of total food grains. He concludes that if cereal supply decreases further, it means that India is moving towards food insecurity.

Singh, Amar (2009) observes that farmer gets only 30 rupees per kg of arhar daal, while the sale price in the market is 100 rupees. As farming is unprofitable, more than 80 per of farmers like to leave farming.

According to Pereira (2009) changes in climatic conditions such as heavy rain and drought, affect the natural ecosystems and the socio-economic conditions of farmers and the poor who are unable to pay for their food. Samal and Sushil (2005) also uphold this view.

Chand and Raju (2009) view that drought and crop failures ultimately affect the agricultural laborers, farmers and consumers. A 19 percent decline in rainfall leads to 3.12 to 12.8 percent decline in crop output. The decline in crop output affects the economic condition of farmers and producers by reducing their income. Further, due to the non-availability or less availability of food, there is a hike in food prices. This affects food security ultimately. By taking the trend of long term climate data, they indicate that from 1972-73 to 2002-03, except in the north eastern states, drought occurs frequently once in five years. In states like Rajasthan, Andhra Pradesh, Haryana, Tamil Nadu, Gujarat, Jammu & Kashmir and west Uttar Pradesh drought is experienced once in three years. In 1972-73, due to a 24 percent decline in rainfall, there was 24 percent decline in total crop output and during 1979-80, 1987-88 and

2002-03, due to a decline of 19 percent rainfall; there was a decline in crop output to the extent of 8.12 to 12.8 percent

Gahukar (2009) claims that increase in Co_2 concentration and temperature and variations in rainfall tend to decrease crop production and net income from agriculture. Less crop output makes it difficult to get food for farmers and rural poor.

Somanathan (2009) explains that as there is a negative correlation between crop yield and poverty rate, the poverty in a part of Bihar state increases due to the decline in crop yield, as the flood water dumped the alluvial soil into the cultivable land.

Swaminathan (2009a) points out that, not only the rainfall but also the distribution of rainfall is very important for the survival of crops, cattle and to maintain food security. Temperature variation, frequent droughts and floods are caused by climate changes. In India, as climate is not consistent, regions facing drought during the month of June and July face floods in August and September. Moreover, most of the rainfall occurs within 100 hours in a year. This does adversely affect the livelihood of farmers and poor.

Panda (2009) cautions the developing countries that they will be more prone to the adverse impact of climate changes than the developed countries. Agriculture and allied activities are the most affected sector by climate changes than any other sector. Indian agriculture basically depends upon temperature and rainfall, and variation in any one of these affects the production and productivity of crops. Ultimately, it leads to the in the GDP growth rate and creates adverse effect on the food security of rural poor and farmers. It is expected that, by 2100, the global mean temperature may increase between 1.4ºC and 5.8ºC and create more damages to the agricultural sector.

Parsai (2009) estimates that by 2025 in some parts of Asia and Africa, the crop yield will decline by 20 to 40 percent as a result of rise in temperature. Moreover, climate change makes land unfit for cultivation and crops are affected by pests and diseases. Ultimately, with water shortage and low food production, there will be food insecurity. He also says that due to just three days of heavy downpour at the end of 2009 in Karnataka and Andhra Pradesh, millions of acres of crops were damaged. It raises the price of important cereals like rice and wheat and other commodities like onion, vegetables and fruits. The result of this is food and water insecurity.

Swaminathan (2009b) points out that, according to the FAO report 2009, in India, if the temperature increases by one degree centigrade, it leads to a decline in six million tons of wheat per year. Like wheat, the yield of other crops will also decline and the poor farmers will lose their income by US$ 20 billion each year. The 2009 drought and flood show that there is a hike in the prices of essential food items, which is a form of food insecurity. It is mainly due to low agricultural yield.

Sud (2009) establishes that climate change and global warming became a great challenge to Indian agriculture. The adverse impact of global warming was severe for developing countries than developed countries. The International Food Policy Research Institute predicts that by 2020, agricultural production will decline by 20 percent in developing countries and by 6 percent in developed countries. Climate change tends to reduce the crop yield due to pests and diseases. The study conducted by Indian Agricultural Research Institute states that for every one degree rise in temperature during the wheat growing period, there is a loss of four to five million tons of wheat production. The prices of agricultural commodities will increase by 40 percent if the temperature increases by more than three degree Celsius. Thus, climate change affects the world food security.

Kapur et al (2009) say that climate change causes more damage to Indian agriculture than to other sectors and to other countries. It was projected that climate change could decrease the crop yield by 30 percent during 2050s.

Ludwig and Marcus (2009) indicate that climate change has direct impact on water resources and irrigation. Higher the temperature, higher will be the evaporation and more will be the drought and water shortage. It also increases the depth of ground water level and leads to poor ground water recharge. Higher rainfall results in good ground water recharge, but excess rainfall increases water loss through runoff. A small fall in rainfall causes the rivers to dry up substantially in dry regions. As there is high evaporation and high demand for water and low rainfall in western Africa, the water level in lakes declined. As far as India is concerned, fifty percent of the irrigation depends upon ground water. Rainfall variability and poor ground water recharge drop down the water level and affect the irrigation. Thus, climate change is being a great challenge to ground water level and irrigation, and thereby food security.

Bhatta (2009) states that the occurrence of extreme rainfall increases while the occurrence of moderate rainfall decreases. Moderate rainfall is needed for crop growth. Extreme rainfall above 150 mm per day has increased by 10 percent per decade for the past 50 years. Besides, after 1980, the temperature in the winter is more than in the summer. The maximum winter temperature is 1.25º Celsius, summer temperature is 0.7º Celsius and the minimum temperature is 0.7º Celsius in winter and 0.3º Celsius in summer across the country. Increase in temperature due to higher carbon-dioxide level stunts the growth of crops and reduce the yield. A rise in temperature by 1º Celsius reduces the crop yield by 25 kg per hectare.

It is estimated that in India the cumulative rainfall was very much deficient in the 2009 monsoon season. Till 30th of September 2009, the overall deficiency in rainfall is 23 percent, the highest after 1972. The warmest year in India is 2009 since 1901. Due to the failure of south-west monsoon, the decrease in the area under cultivation is estimated at 5.92 million hectares and the production loss is estimated at 10 percent (Sundarajan, 2009).

Mehdudia (2009) tells that the area under cultivation for important crops declined during the 2009 Kharif season when compared with 2008. It declined from 483.37 lakh hectares in 2008 to 432.26 lakh hectares in 2009. Area under rice alone declined from 145.21 lakh hectares to 114.63 lakh hectares respectively.

Boyd and Maria (2008) bring to light the impacts of drought on Mexico. The production of food grains during the drought period declines by 11.56 percent and livestock by 13.78 percent. As a result, the import of food items rises and ultimately it creates unfavorable balance of payment and balance of trade. It affects the poor, increases government debt and slowdowns the Mexican economic growth.

Intensification of seasonal rains in equator caused floods and landslides that affected 70,000 hectares of farm land. In Bangladesh, rice crops are destroyed by flood followed by a cyclone. Extreme cold, ice and snow have damaged various crops like cereals, rapeseeds, vegetables, fruits and 190,000 hectares of winter wheat in Southern China. In Vietnam, 150,000 hectares of rice fields were destroyed by a cold spell. The most affected crops are rice, maize, cocoa plantations, banana and sugarcane (The Hindu 2008).

The impact of climate change on the Indian economy will be very serious and more than in any other country. Therefore, India has reasons to worry about the problem of climate change {Dar (2009) Kumar (2007) Mehdudia (2009) Panda (2009) Sanwal (2008)}.

Streitfled (2008) observes that the American farmers are suffering from too much rainfall, while Australian farmers are being affected by drought. Due to heavy rain in certain parts of the USA, corn in many areas has been submerged in water and it forces many farmers to replant it. The seeds survived are also not much productive as it was before. On the other hand, in Australia, drought greatly reduces the food production, especially wheat production. Due to the reduction in the production of rice, wheat and other food materials, it is expected that the price of food articles may increase by 30–35 percent within the next ten years and those who live in extreme poverty have to spend nearly 90 percent of their income on it. In other words, the worsening food situation will lead to an increase in malnutrition. The worst affected countries due to food insecurity are sub-Sahara countries, some Pacific island countries and some of the developing nations.

Cramer (2008) asserts that there is a significant drop in the production of important cereal crops like rice and wheat. Decline in the crop output reduces the farm income. It is estimated that a 5 percent increase in climate variation results in 10 percent drop in the farm income and an increase of 2^{o} C temperature and 7 percent rainfall reduces the farm net income to an extent of 8 percent. It is reported that in the Central and South Asia, crop yields will decline up to 30 percent and it will lead to a very high risk of hunger in several countries (Boer, 2009; Sanwal, 2008).

Schmidhuber and Francesco (2007) emphasize that climate change creates negative impact on food security. Due to adverse climate change, the cultivable land becomes unsuitable for cultivation. It reduces the production and availability of food. Unexpected changes in weather create fluctuations and instability in food production. Because of low real income among agricultural laborers and farmers and unstable production, it is difficult to maintain food security. Food safety is also being affected by weather caused water and food-borne diseases among human beings. Thus, all dimensions of food security are affected by climate change.

King (in Jha 2006) reports that a 3ºC rise in temperature causes problems such as a worldwide drop in production of cereal crops between 20 and 400 million tons, 400 million more people will be at risk of hunger and up to 3 billion people will be at risk of flooding and without access to fresh water supply.

According to Kumar (2007), if there is a 2°C rise in temperature and increase in excess rainfall over 7 percent, the farmer loses 8 percent of net income from farming. Similarly, a five percent increase in climate variation leads to a 10 percent decline in the net income from farming. Agriculture is a climate sensitive sector, which provides livelihood for 60 percent of the Indian population. Cereal crops like rice and wheat are the most affected crops due to climate change.

Srinivasan (2005) says that the area of cultivation, production and productivity of rice in the Cauvery delta region in 2004-’05 were about 50 percent less than what it was during the normal period due to the occurrence of drought and floods alternatively. Farming is no longer profitable and farmers are struggling for sustaining their livelihood.

Sharma (2005) points out the report of UNCTAD and asserts that the price farmers get today for their products is the same at which they sold their produce 20 years ago. In West Bengal, rice farmers earned in 2002-’03, 28 percent less than what they earned in 1996-’97. The income of sugarcane farmers decreased in Uttar Pradesh by 32 percent and in Maharastra by 40 percent during the same period.

Singh et al (2005) asserts that in Uttar Pradesh during 2002-03, due to the failure of monsoon, soil loses its moisture. As a result, the yield of crops like rice, sorgam, millets, urd, wheat, rapeseed and pulses decreased significantly. Hence, the supply of food and the availability of food have declined much.

In India, it is expected that farmers’ income declines between 9 to 25 percent if there is 2 to 3.5 percent rise in temperature accompanied by 15 to 25 percent change in precipitation (Achanta, 1993 in Gupta, 2005).

According to Rajendran (2001) drought due to the failure of south-west monsoon created hardships to the agricultural sector in Karnataka. Ten districts received a deficit rainfall of 20 percent to 59 percent and the remaining 17 districts received a deficit rainfall of 60 percent to 99 percent. As a result, the bore wells were dried; water level in the reservoirs came down and created water shortage both for drinking and for irrigation purposes. Half grown rice crops were withered and caused heavy loss to farmers. There was 50 percent decrease in the area under cultivation of crops. The total estimated economic loss to the exchequer of the central government was 8600 million rupees.

Makadho (1996) portrays the simulated effect of climate change on corn production in Zimbabwe through Geographical Fluid Dynamic Laboratory model (GFDL) and Canadian Climate Centre Model (CCCM). These two models state that the development of irrigation increases corn production in Zimbabwe. However, the yield of corn declined by 11 to 17 percent due to the variation in climatic conditions and lack of irrigation.

Dubhashi (1992) illustrates that drought is a major problem in India during the post-independence period. Drought affects not only agriculture but also creates fluctuation in employment and rural income. In India, there are two to three bad seasons for every good season.

Sinha and Swaminathan (1991) in Singaraj and Kumar (2010b) estimated that when the air temperature increased by 2º Celsius, rice yield in high yielding areas would decrease by 0.75 ton/hectare and in the low yielding coastal areas, by 0.06 ton/hectare. A 0.5º Celsius increase in winter temperature would lead to reduction in the crop duration by seven days and the yield by 0.45 ton/hectare.

Parry (1990) portrays that the impact of temperature on agriculture varies from crop to crop and from region to region. In Eastern England, a three degree Celsius rise in temperature reduces the yield of winter wheat by 10 percent.

Hale and Orcutt (1987) in Roasenzweig and Daniel (1998) explain that, excess precipitation is not good for the growth of crops. Very high rainfall causes leaching and water-logging in agricultural land. Flood affected soil blocked the respiratory action of the plant and so the crop is not able to obtain the oxygen needed for it. Pests and diseases also affect the plant growth in the flooded area.

It is understandable from the above review that the important ecological factors affecting crop output are rainfall and temperature and the economic factors are price, cost of inputs, availability of inputs such as labors and net income over the cost of production. This paper tries to measure the impact of all these factors on rice cultivation in Kanyakumari district.

A Brief Profile of Kanyakumari district

Based on the State Reorganization Committee's recommendations, the district came into existence as one of the districts of Tamil Nadu on the 1st of November 1956 with Nagercoil as its headquarters. It has a total geographical area of 167184 hectares and a population of 1863174 in 2011. Ecologically the district is considered as a 'hotspot' of diversity as it is having tropical forests, ponds, riparian, estuarine, marine and arid zone ecosystems (Raj ADS in Daniel et al (Ed) 2001). Generally on earth, in a small area, such diversity cannot be seen. The Joint Director of Agriculture has listed 356 species of flora and 75 species of fauna and under each species many genotypes are available. For example, there were 40 different genotypes in banana, 64 in rice and 300 in mango. It is also reported that there were nearly 3500 plant species in this region (Raj ADS in Raj J (Ed) 2007). Topographically, the district has three divisions while the north-eastern portion of the district constitutes a mountainous division and in the extreme west and south-west there is a long flat seacoast. In between these divisions, there is a narrow mid-land division of river valleys and fertile plains. In terms of area, the mountainous division occupies 45.8 percent, the low-land 29.7 percent and the mid-land 24.4 percent of the total area (Vellappan & Sankar in Daniel et al (Ed) 2001).

The district was once called 'the Rice Granary' of the erstwhile Travancore State and 'Nanjil Nadu'. 'Nanjil' means 'plough' and 'Nadu' means 'region'. Kanyakumari district is the region where the main occupation is associated with plough. In the district, for many years, more than 50 percent of the total geographical area is under cultivation and this puts the district's primary occupation as farming and farm-based avocations. Of the total area under cultivation, rice occupied the first place up to 2002-03 and now it occupies the third place. The district has a good number of reservoirs, ponds and tanks and wells for irrigation and a substantial length of canals and channels and so a vast area of the district is under cultivation. The annual rainfall of the district varies from place to place. It was 80 cm at Kanyakumari and 250 cm at Pechiparai in the 1960s and 1970s with an average rainfall of 230 cm for the whole district (Henry and Swaminathan in 1981); but, it decreased to 144 cm in the 2000s (Season and Crop report). Table 1 shows the details regarding the sources of irrigation in the study area.

Table 1
SOURCES OF IRRIGATION IN KANYAKUMARI DISTRICT

Reservoirs	Ponds and Tanks	Canals & Channels	Wells
Pechiparai (1906) Perunchani (1953) Chittar I (1970) Chittar II (1970) Poihayaru (20000) Mambazhathuraiaru (2011)	188 (Agasteeswaram) 213 (Thovalai) 1078 (Kalkulam) 970 (Vilavacode) 2449 (Total)	540 km (Total length)	1304 (Tube wells) 2057 (Open wells)

Source: Season and Crop Reports of Tamil Nadu, Gazetteers of India & News papers

Thus, the district is having a good number of reservoirs, ponds and tanks, irrigation wells and a good length of canals and distributaries to cultivate even high water requiring crops such as rice and sugar cane.

Rice Cultivation in Kanyakumari District – Trend and Tendency

In Kanyakumari district, on the basis of area under cultivation, rice topped the list among crops up to 2002-'03 and in 2003-'04, it was pushed to the third place due to deficiency in rainfall in the previous year, 2002-'03. In 2003-'04, first place goes to coconut with an area of 23664 hectares, rubber occupies second place with 18296 hectares and rice third with 17320 hectares. In 2004-'05, as there was an increase in the area under rice, rice was placed in the second place. After 2007-'08, rice once again occupied the third place. It is sure that it cannot occupy the lost glory as the area under rubber has continuously been increasing from 1997-'98 (18063 hectares) and area under coconut from 1979-'80 (15461 hectares) and conversion of rice field into rubber estate and coconut grove takes time and conversion of the opposite is a huge waste. The table given below shows the area under rice cultivation in Kanyakumari district in different decades.

Table 2
RICE CULTIVATION IN DIFFERENT DECADES IN KANYAKUMARI DISTRICT

(in hectares)

Crop	1957-'58	1960s	1970s	1980s	1990s	2000s
Rice	58686	58167	53265	42124	34847	21909

Source: Calculated from Various Season and Crop Reports

The above table shows that the area under rice cultivation is declining decade after decade. The average area under cultivation of rice decreased from 58167 hectares in the sixties to 21909 hectares in the 2000s. The year-wise data show that the area under rice decreased from 58686 hectares in 1957-'58 to 18187 hectares in

2008-’09 and the rice production decreased from 95300 tons in 1957-’58 to 83657 tons in 2008-‘09. The yearly data of area, production and productivity of rice from 1991-92 to 2008-’09 are given in table 3.

Table 3
AREA, PRODUCTION AND PRODUCTIVITY OF RICE IN KANYAKUMARI DISTRICT FROM 1991-’92 to 2008-‘09

Year	Area	% Change*	Production (in tons)	% Change*	Productivity (in kg)	% Change*
1991-92	40572	-1.59	143220	12.05	3530	13.86
1992-93	38794	-4.38	118920	-16.97	3065	-13.16
1993-94	38541	-0.65	139260	17.10	3613	17.87
1994-95	37565	-2.53	151650	8.90	4037	11.73
1995-96	36020	-4.11	148730	-1.93	4129	2.28
1996-97	33659	-6.55	138930	-6.59	4128	-0.04
1997-98	31244	-7.17	118640	-14.60	3797	-8.00
1998-99	32004	2.43	152800	28.79	4774	25.73
1999-00	31475	-1.65	149480	-2.17	4749	-0.53
2000-01	28594	-9.15	135000	-9.69	4721	-0.59
2001-02	28229	-1.28	121390	-10.08	4300	-8.92
2002-03	26052	-7.71	98469	-18.88	3780	-12.10
2003-04	17320	-33.52	52897	-46.28	3054	-19.20
2004-05	22016	27.11	86486	63.50	3928	28.62
2005-06	21709	-1.39	82523	-4.58	3801	-3.23
2006-07	21406	-1.40	94130	14.07	4397	15.68
2007-08	20349	-4.94	90210	-4.16	4433	0.81
2008-09	18187	-10.62	83657	-7.26	4599.82	3.76

Source: Season and Crop Reports and calculated figures

It is obvious from the above table that the area under rice cultivation declines year after year, except in two years, 1998-’99 and 2004-‘05. The percentage of change in area under rice cultivation shows a decline in all other years except that two years. Production shows a reduction, in comparison with the previous year, in all the years, except four years while the productivity shows a decrease in nine years i.e., half of the period taken for analysis.

The figures given below show both the linear (A & A) and the exponential (B & B) trend lines drawn both for area and production of rice. It is easy to understand from the graph that the rate of change of area per year is – 1377.7 hectares (R^2 = 0.94), and the rate of change of production per year is – 4295.5 tons (R^2 = 0.58). The rate of change of productivity per year is very small (0.37 quintals per year) and the R^2 value is also very small (0.14) and so the details are not presented in diagram.

Figure 1

AREA UNDER RICE IN KANYAKUMARI DISTRICT

(A) **(B)**

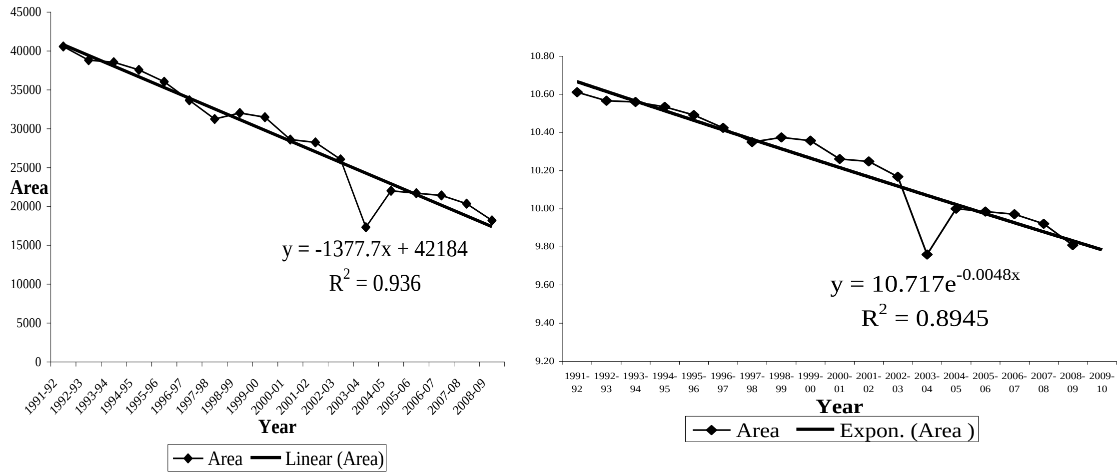
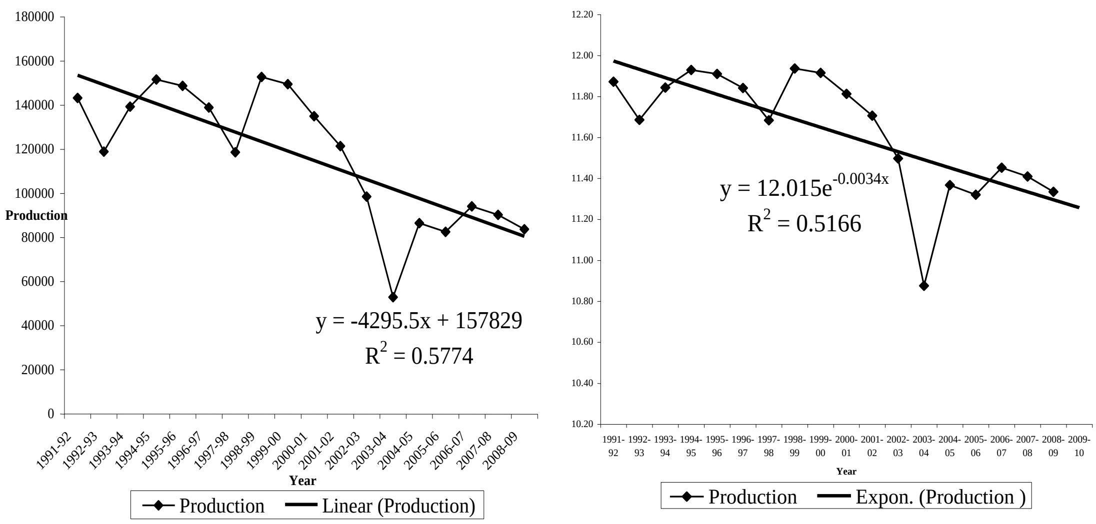


Figure 2

PRODUCTION OF RICE IN KANYAKUMARI DISTRICT

(A) **(B)**



Calculation of growth rates is helpful for scientific analysis and so the growth rates are calculated and presented in the table given below.

Table 4

GROWTH RATES OF AREA, PRODUCTION AND PRODUCTIVITY OF RICE

Growth Rates	Area (%)	Production (%)	Productivity (%)
Exponential	–0.48	–0.34	–0.15
Average Annual	–3.07	–2.31	1.68
Per year Fall/ Rise	–3.06	–3.25	1.68

Source: Calculated from the Table 2

It is obvious from the above table and figures that the area under rice cultivation declines at a rate of 0.48 percent between 1991-’92 and 2008-’09. The same pattern can be observed in exponential growth rates for production and productivity. While the average annual growth rates show a decline of 3.07 and 2.31 respectively for area and production, productivity shows a rise of 1.68. Reduction for one year in the area under rice is 3.06 percent and it is 3.25 for the decline in the production of rice between 1991-’92 and 2008-’09. The productivity increases at a rate of 1.68 percent for the same period.

It is better to find the falling pattern of area under rice at different periods of time. The overall per year reduction of area under rice is 1.35 percent between 1957-’58 and 2008-‘09, while the per year reduction is 0.91 percent between 1957-‘58 and 1991-‘92, 3.16 percent between 1995-’96 and 1999-’00 and 4.45 percent between 2001-‘02 and 2008-’09. It means that the decrease in area under rice between 2001-‘02 and 2008-’09 is about 5 times more than the rate of decrease between 1957-’58 and 1991-’92. In absolute term, between 1957-’58 and 1991-’92, the reduction of area under rice per year was 532.76 hectares, between 1957-’58 and 2008-’09, 794.09 hectares, between 1991-’92 and 2008-’09, 1316.76 hectares and between 1999-‘00 and 2008-’09, for the last 10 years, the reduction was 1328.80 hectares. It can be deduced that there will be no rice cultivation in the district after 2025. It is further confirmed by the block-wise data of area under cultivation, which are presented in table 5.

It is also clear from the table 3 that the rice production in the district increased up to 1998-’99 i.e., from 95300 tons in 1957-’58 to 152800 tons in 1998-’99, a per year rise of 1.44 percent. After 1998-’99, rice production decreased and reached 83657 tons in 2008-’09, a per year fall of 4.25 percent. The productivity also moves in the same manner, a per year rise of 3.94 percent between 1957-’58 and 1998-’99 and a per year fall of 0.33 percent between 1998-’99 and 2008-’09. Between 1998-’99 and 2007-’08, production decreases at a rate of 4.25 percent while productivity decreases at a rate of 0.33 percent. It means that rice production decreases much due to the decline in the area under rice.

Table 5
BLOCK-WISE CULTIVATION OF RICE IN KANYAKUMARI DISTRICT

(Area in hectares)

Year	Thov alai	Agastees waram	Rajakkam angalam	Kurunth encode	Thuc kalay	Thiru vattar	Mel puram	Killi yoor	Munch irai
1997-98	7787	7180	4634	4313	3914	495	853	1257	811
1998-99	7980	6988	4868	4816	3843	556	857	1276	826
1999-00	8277	7565	4506	4460	3438	207	878	1315	822
2000-01	8322	6652	4178	4390	2270	124	651	1170	837
2001-02	8145	6246	4190	4467	2280	130	690	1218	864
2002-03	8291	5662	3546	3870	1971	113	647	1138	814
2003-04	5539	3797	2363	2393	1298	56	443	863	568
2004-05	7319	4916	2993	2810	1796	114	473	968	627
2005-06	7317	5149	2897	2805	1302	87	461	1022	669
2006-07	7280	5081	2906	2736	1303	78	402	977	521
2007-08	7281	4889	2867	2606	1079	20	305	831	471
2008-09	6551	4681	2608	2327	896	0	210	538	377
2009-10	6718	4443	2608	2202	686	0	103	306	241

Source: Various issues of 'G' Return

Table 5 clearly shows how the cultivation of rice in Thiruvattar block came to an end in 2008-'09. In the other four blocks of Melpuram, Munchirai, Killiyoor and Thuckalay, where rubber cultivation is viable, it is on the verge of extinction. The only block where there is not much reduction in the area under cultivation is Thovalai. It is sure that within a short period of time the area under rice may be used for cultivating other crops or for other purposes such as housing, as its demand is very high and fetches a very high price from realtors.

The tables given below show how the use of land for agricultural purposes decreases and non-agricultural purposes increases in the district.

Table 6
AREA UNDER AGRICULTURAL AND NON-AGRICULTURAL USES

(Area in hectares)

Year	Food - crops	Non – food crops	Total cultivated Area	Area under non Agricultural use
1991-92	67386	42433	109819	15923*
1992-93	66721	42442	109163	16579*
1993-94	65576	43149	108725	17017*
1994-95	64568	43795	108363	17379*
1995-96	61411	45148	106559	19183*
1996-97	58520	42801	101321	24421*
1997-98	57696	41422	99118	25073
1998-99	59065	41588	100653	25089
1999-00	58747	42300	101047	25095
2000-01	55362	43086	98448	25163
2001-02	55137	43187	98324	25313
2002-03	51389	42985	94374	25435
2003-04	43528	44276	87804	26287
2004-05	46795	44712	91507	26337
2005-06	45982	45825	91807	26890
2006-07	46113	46439	92552	28178
2007-08	43593	47407	91000	28255
2008-09	41105	47687	88792	28331

Source: Various issues of ‘G return’ and Season and Crop Reports

*Estimated figures

Table 7
PERCENTAGE SHARE OF AREA UNDER AGRICULTURAL AND NON-AGRICULTURAL PURPOSES IN THE DISTRICT

(Percentage to total geographical area)

Year	Food – crops	Non – food crops	Total cultivated Area	Area under Non-agricultural use
1991-92	40.30	25.38	65.68	9.52
1992-93	39.91	25.38	65.29	9.92
1993-94	39.22	25.81	65.03	10.18
1994-95	38.62	26.19	64.81	10.39
1995-96	36.73	27.00	63.73	11.47
1996-97	35.00	25.60	60.60	14.61
1997-98	34.51	24.77	59.28	15.00
1998-99	35.33	24.87	60.20	15.01
1999-00	35.14	25.30	60.44	15.01
2000-01	33.11	25.77	58.88	15.05
2001-02	32.98	25.83	58.81	15.14
2002-03	30.74	25.71	56.44	15.21
2003-04	26.03	26.48	52.51	15.72
2004-05	27.99	26.74	54.73	15.75
2005-06	27.50	27.41	54.91	16.08
2006-07	27.58	27.77	55.35	16.85
2007-08	26.07	28.35	54.43	16.90
2008-09	24.58	28.52	53.11	16.94

Source: Calculated figures from table 6

From the above tables, it is very easy to understand that the share of area under food crops shows a sharp decline while the share of area under non-agricultural purposes shows a sharp rise. The decrease in area under food crops is 39 percent against a rise of 78 percent for the area under non-agricultural purposes. It means that within a short period of time all the area under food crops may be used for non-agricultural purposes or for cultivating some other crops. In the district the number of cultivators also decreased considerably. In 1961, there were 72865 cultivators and in 1991, there were only 61547 cultivators. The number further decreased to 13434 in 2001 (Census Reports).

Table 8 shows the share of rice to total geographical area and the total cultivated area from 1991-'92 to 2008-'09 in the district.

Table 8
SHARE OF AREA UNDER RICE TO THE TOTAL GEOGRAPHICAL AND CULTIVAED AREA IN THE DISTRICT

(in percentage)

Year	Share to total Geographical Area	Share to total Cultivated Area
1991-92	24.27	36.94
1992-93	23.20	35.54
1993-94	23.05	35.45
1994-95	22.47	34.67
1995-96	21.54	33.80
1996-97	20.13	33.22
1997-98	18.69	31.52
1998-99	19.14	31.80
1999-00	18.82	31.15
2000-01	17.10	29.04
2001-02	16.88	28.71
2002-03	15.58	27.61
2003-04	10.36	19.73
2004-05	13.17	24.06
2005-06	12.98	23.65
2006-07	12.80	23.13
2007-08	12.17	22.36
2008-09	10.88	20.48

Source: Calculated figures

The share of area under rice cultivation to total geographical area decreased from 24.27 percent in 1991-'92 to 10.88 percent in 2008-'09, i.e., nearly 14 percent decrease within a period of 18 years. In the same way, the share of area under rice to total cultivated area decreased from 36.94 percent to 20.48 percent in the same period, i.e., nearly 17 percent decline within 18 years. All these details are available in table 8. The percentage change of area under rice to total geographical and cultivated area shows a different trend. The share of area under rice to total geographical area decreased by 55.17 percent while to total cultivated area, it shows a decrease of 44.56 percent between 1991-'92 and 2008-'09.

The per capita production of rice, which is the most reliable estimate of self-sufficiency in food security, is the best indicator of real situation of rice production as population is increasing while rice production goes on decreasing. In Kanyakumari district, population increased from 1591174 in 1991 to 1825746 in 2011. Production of rice decreased from 143220 tons in 1991-'92 to 83657 tons in 2008-'09. So a comparison of per capita rice production in the district is made with the national per capita availability and consumption of rice and is presented in the table 9

Table 9
PER CAPITA RICE PRODUCTION IN COMPARISON WITH THE NATIONAL PER CAPITA AVAILABILITY OF RICE DURING 1991, 2001 & 2008

Year	Per capita Net Availability of Food Grains (kg)	Per capita Net Availability of Rice (kg)	Population in KK District	Rice Production (in Tons)	Per Capita Rice Production ♠ (in kg)	% Share to National Food Grains♠	% Share to National Rice♠
1991	171.1	79.2 (46.29)	1591174	143220	90.01	52.61	113.65
2001	180.4	83.5 (46.29)	1676034	13500	80.55	44.65	96.47
2008	162.1	68.8 (42.44)	1795774♦	83657	46.59	28.74	67.72

Source: Statistics at a Glance 2010-11
♦ Calculated from Census Figures ♠ Calculated Figures

It is very clear from the table 9 that Kanyakumari district, which produced nearly 14 percent excess rice in 1991, has produced 32.28 percent less than the national average in 2008. Its share to national availability of food grains also decreased from 52.61 percent in 1991 to 28.74 percent in 2008 just like the per capita production of rice, which decreased from 90.01kg to 46.59 kg in the same period. This situation is very dangerous symptom to food security of Kanyakumari district where rice is still the staple food. It is already observed that in 2000, 74 percent of arrivals of rice to the Kottar market, the main purchasing centre for the whole district, are out-station purchases made by the local merchants. It is sure that in the near future every grain must be purchased from other districts and states.

Influencing Factors of Rice Cultivation

To avoid the situation of no-rice cultivation in the near future in Kanyakumari district, one must know the reasons. Unless knowing the actual reasons, the problem cannot be solved. Here, an attempt is made to find out the real reasons for the decrease in the area under cultivation and production of rice in the study area.

Ecological Factors

There are many ecological factors. But, rainfall and temperature are the two recognized ecological factors causing disturbances in crop cultivation. The table given below shows the rainfall pattern and the average of the highest maximum temperature prevailing in the district from 1991-’92 to 2008-’09.

Table 10
RAINFALL AND TEMPERATURE IN KANYAKUMARI DISTRICT FROM 1991-’92 TO 2008-’09

Year	Rainfall (in mm)	Temperature (in °C)
1991-92	1882.0	32.94
1992-93	1744.3	32.85
1993-94	1877.4	32.93
1994-95	1776.7	33.33
1995-96	1343.8	32.96
1996-97	1519.3	33.43
1997-98	1656.0	33.50
1998-99	2248.4	33.58
1999-00	1535.3	33.22
2000-01	1750.5	33.62
2001-02	1526.5	33.93
2002-03	1207.0	33.47
2003-04	1208.2	34.10
2004-05	1436.9	33.34
2005-06	1694.8	33.31
2006-07	1553.5	33.11
2007-08	1795.3	33.58
2008-09	1551.3	33.40

Source: Records, Assistant Director, District Statistical Office, Nagercoil
& Meteorological Department of Tamil Nadu, Chennai.

Figure 3

RAINFALL IN KANYAKUMARI DISTRICT

(A) **(B)**

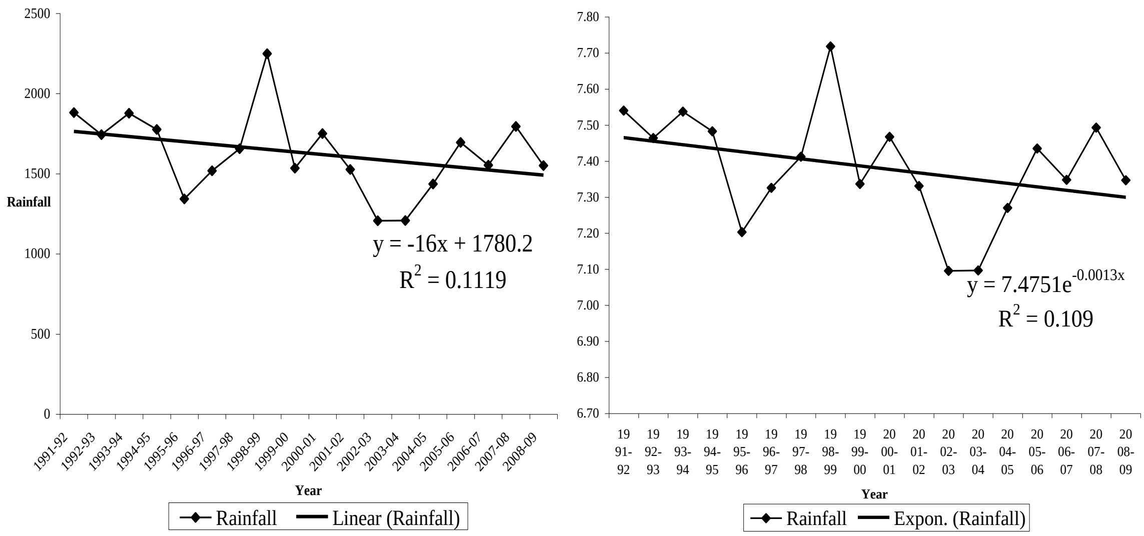
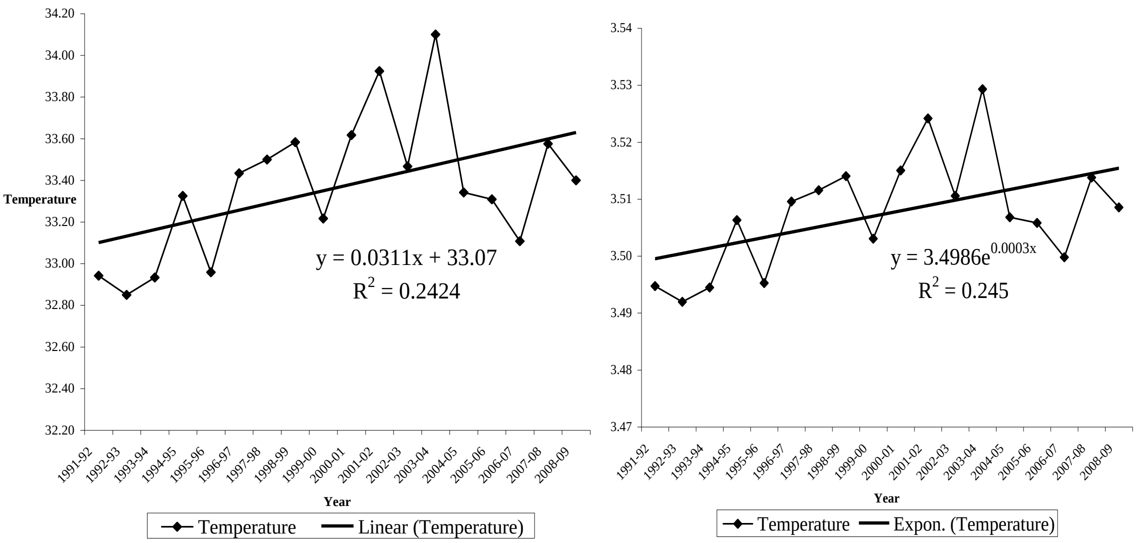


Figure 4

TEMPERATURE IN KANYAKUMARI DISTRICT

(A) **(B)**



It is easily understandable from table 9 and figures 3 & 4 that rainfall has a declining trend while temperature shows a small but steady increase. Hence, the standard deviation for rainfall is 255.34 mm and for temperature it is only 0.34^{o}C. The rate of change for rainfall per year is –16 mm (R^2 = 0.11) and the rate of change of temperature is 0.03ºC (R^2 = 0.24). The exponential growth rate calculated for rainfall shows – 0.13 (R^2 = 0.11) percent while for temperature it is 0.03 (R^2 = 0.25).

To understand the impact of one factor on another, anyone, who has a limited knowledge in Statistics and Econometrics, can depend on correlation and regression coefficients. Hence, correlation coefficients between area under rice cultivation and rainfall and temperature, between production of rice and rainfall and temperature, and between productivity and rainfall and temperature and multiple regression coefficients have been calculated. Table 11 explains the correlation existing between area, production and productivity of rice and climate factors.

Table 11
CORRELATION BETWEEN RAINFALL, TEMPERATURE AND AREA, PRODUCTION AND PRODUCTIVITY OF RICE

Factors	Area	Production	Productivity
Rainfall	0.421 NS	0.498*	0.253 NS
Temperature	–0.584*	–0.413 NS	0.163 NS

Source: Calculated figures

* Significant at 5% level. NS = Not Significant.

From the above table, it is very clear that there is significant positive correlation between rice production and rainfall and significant negative correlation between area under rice and temperature. While correlation between area under rice and rainfall shows a positive value of 0.421, which is significant neither at 1% level nor at 5% level, the correlation between production and temperature is – 0.413 that is also not significant. The correlation between productivity and rainfall as well as temperature shows only very poor relation. Thus, the hypothesis that decline in rainfall is not the cause for the receding area under rice and the decreasing rice production is partially accepted. The second hypothesis that temperature has no influence on rice production is fully accepted but it has significant adverse effect on the area under cultivation. The two main inferences drawn from the above data analysis are area under rice cultivation decreased significantly due to rise in temperature, and production decreased significantly due to decline in rainfall. Simply saying, the two climate factors played a dominant role in affecting rice cultivation adversely and thereby created food insecurity in the district.

As the rainfall in a particular season/year has its own impact for the coming season or year, Lag and Lead correlation is calculated to know this effect. The Lag and Lead correlation also shows the same trend except a small variation in the size of the number. The correlation values between rainfall and area under rice cultivation and rainfall and production show a small rise from 0.421 to 0.482 and from 0.498 to

0.575 respectively. The productivity value for rainfall also shows a rise. However, other values show a small decrease. The details are given in table 11

Table 12

LAG AND LEAD CORRELATION BETWEEN RAINFALL, TEMPERATURE AND AREA, PRODUCTION AND PRODUCTIVITY OF RICE

Factors	Area	Production	Productivity
Rainfall	0.482^{NS}	0.575*	0.345^{NS}
Highest Maximum Temperature	–0.532*	$–0.383^{NS}$	0.161^{NS}

Source: Calculated figures
* Significant at 5% level. NS = Not Significant.

The coefficient matrix given below shows the correlation existing among all the variables discussed so far.

Table 13

COEFFICIENT MATRIX (Factor Analysis)

Factors	Rainfall	Temperature	Area	Production	Productivity
Rainfall	1				
Temperature	$–0.237^{NS}$	1			
Area	0.421^{NS}	–0.584*	1		
Production	0.498*	$–0.413^{NS}$	0.864*	1	
Productivity	0.253^{NS}	0.163^{NS}	$–0.314^{NS}$	0.312^{NS}	1

Source: Calculated figures
* Significant at 5% level. NS = Not Significant.

It is easy to understand that there is significant positive correlation between area under rice and production of rice and rainfall and production of rice. There is significant negative correlation between temperature and area. Other factors have only insignificant correlation, though correlation coefficient values between area and rainfall and temperature and production are nearing 0.5. Multiple regression analysis is very helpful to know the influence of each factor on the dependent factor. The regression equations given below show the contribution of each factor.

$A = 355918.17 + 0.34X_1 – 0.44X_2 – 0.23X_4,\quad R^2 = 0.473$ *(significant at 0.26 level)*

$P = –336168.87 + 0.033X_1 + 0.081 X_2 + 1.04 X_3 + 0.46 X_4,\quad R^2 = 0.957$ *(significant at 1% level)*

$P = 1136881.19 + 0.386X_1 – 0.381X_2 + 0.222X_4,\quad R^2 = 0.385$ *(significant at 0.071% level)*

$P = – 424191.45 + 0.16X_1 + 0.14X_2 + 0.88X_3,\quad R^2 = 0.781$ *(significant at 1% level)*

$Pt = – 15872.89 + 0.15 X_1 + 0.36 X_2, + 0.39 X_5,\quad R^2 = 0.212$ *(significant at 0.319 level)*

A = Area. P = Production, Pt = Productivity

X_1 = *Rainfall*, X_2 = *Temperature*, X_3 = *Area*, X_4 = *Productivity*, X_5 = *Production*

It is clear from the regression equations that the four identified factors, namely rainfall, temperature, area and productivity, contributed to the variation in output of rice to the extent of 96 percent and among the factors, area is the main factor, whose regression coefficient is 1.04. If area is dropped, then coefficient of determinant is only 38.5 percent. It means that area is the deciding factor of rice production to the extent of nearly 58 percent. The simple inference drawn from the analysis is that if the area under rice cultivation declines in this rate, then certainly it will lead to a situation of food insecurity. If the fourth factor, productivity is dropped, then the coefficient of determinant is 78 percent, i.e., affecting rice production 18 percent. It means that area under rice is the main deciding factor of rice production and so it should not be allowed to be reduced.

The‘t’ and ‘F’ values calculated also show the same. The tables given below present the calculated values.

Table 14

‘t’ & ‘F’ VALUES OF AREA AND RAINFALL, TEMPERATURE AND PRODUCTIVITY OF RICE

Factor	‘t’ Values	Significant at	‘F’ Values	Significant at
Constant	2.261	0.040	4.194	0.026
Rainfall	1.669	0.117		
Temperature	–2.118	0.053		
Productivity	–1.122	0.281		

Source: Calculated values

Table 15

‘t’ & ‘F’ VALUES OF PRODUCTION AND RAINFALL, TEMPERATURE, AREA AND PRODUCTIVITY OF RICE

Factor	‘t’ Values	Significant at	‘F’ Values	Significant at
Constant	–1.554	0.144	72.41	0.00
Rainfall	0.503	0.623		
Temperature	1.140	0.275		
Area	13.165	0.00		
Productivity	7.296	0.00		

Source: Calculated values

Table 16

‘t’ & ‘F’ VALUES OF PRODUCTION AND RAINFALL, TEMPERATURE AND AREA OF RICE

Factor	‘t’ Values	Significant at	‘F’ Values	Significant at
Constant	–0.903	0.382	16.67	0.00
Rainfall	1.170	0.262		
Temperature	0.891	0.388		
Area	5.313	0.00		

Source: Calculated values

Table 17
't' & 'F' VALUES OF PRODUCTIVITY OF RICE AND RAINFALL, TEMPERATURE AND PRODUCTION

Factor	't' Values	Significant at	'F' Values	Significant at
Constant	–1.147	0.271	1.283	0.319
Rainfall	0.531	0.304		
Temperature	1.373	0.191		
Production	1.329	0.205		

Source: Calculated values

It is also clear from the above tables that production is significantly affected by the identified factors, particularly area and productivity. The area under rice cultivation is affected by temperature rather than by other identified factors.

Collected rainfall data and calculated values prove that the decrease in rainfall is the cause for the decrease in the production of rice but fail to prove that decline in rainfall is the reason for reduction in the area under rice. Collected temperature data and calculated values show that area under rice cultivation is significantly affected by temperature and the production insignificantly. But, the primary data collected from field experts show a different picture (Refer table 20). Farmers opined that less rainfall is one of the main reasons for the receding area under rice cultivation. The district is one of the wettest districts of India and the high rainfall region of Tamil Nadu and so farmers have no difficulty in finding water for irrigation. However, farmers shift from high water requiring crops to less water requiring crops, particularly area under rice irrigated by canals, in the years that follow the years of scanty rainfall. For example, the area under rice declined sharply in 2003-'04, from 26052 in 2002-'03 to 17320 hectares in 2003-'04 due to insufficient rainfall in 2002-'03, from 1526.5 mm in 2001-'02 to 1207.02 mm in 2002-'03 (Refer tables 2 & 9).

Economic Factors

Quantifiable information available regarding economic factors are only the minimum support price offered by the central government and the net income over the cost of production. Minimum support prices are available from 2000-'01 to 2010-'11. But, comparison can only be made for nine years as data for other factors are available only up to 2008-'09. The cost of production and net income are available only for two different years 1987-'88 and 2004-'05, with which one can compare the net return as there is enough distance between two years. The minimum support prices (MSP) offered by the Central government are illustrated in table 18.

Table 18
MINIMUM SUPPORT PRICES OFFERED FROM 2000-'01 TO 2010-'11

(in Indian rupees)

Year	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
MSPC	510	530	530	550	560	570	580	850	850	950	1000
MSPA	-	-	-	-	590	600	610	880	880	980	1030

Source: Economic Survey 2010-11

MSPC = minimum support price for common varieties
MSPA = minimum support price for 'A' Grade

From the above table it is easy to understand that support prices increased marginally and the correlation between area under rice and the minimum support price is –0.566 with R^2 value of 0.32 and between production and the MSP is –0.264 with R^2 value of 0.07. However, the cost of cultivation rose steeply. For example, the cost of production of rice (common variety) has increased from 1450 rupees in 1987-'88 to 13540 rupees in 2004-'05. The increase in cost of production is 833.79 percent between 1987-'88 and 2004-'05, per year rise of nearly 49.05 percent, while it is 96.07 percent, per year rise of only 8.73 percent, for the support price between 2001-'02 and 2010-'11. It is reported by Swaminathan (2011) that the cost of production of rice was 1270 rupees and the support price is only 1080 rupees. In Maharastra, the price of sugarcane was only 1200 rupees per ton against the cost of 2200 rupees in 2007 (Sainath 2007). The cost of production of rice calculated by farmers' societies (ranges between 15500 and 18300 rupees) is also much higher than the cost calculated by the agricultural department. It is merely an institutional failure.

The share of net income to total cost of production for all crops except common rice and banana of ordinary variety increased from 1987-'88 to 2004-'05, for tapioca from 63 to 186 percent, for coconut from 90 to 106 percent, for banana (Nendran) from 57 to 116 and rice (HYV) from 50 to 52 and for rubber from 220 to 256 percent. The net return decreased for rice (common) from 46 to 42 percent and for banana (ordinary) from 105 to 80 percent in the same period. The net return over the cost of production for rubber increased from 220 in 1987-'88 to 256 percent in 2004-'05 while for rice it decreased from 46 to 42 for common variety (as per the calculation of farmers' societies it ranges from 10 to 29 percent), though the net return for high yielding variety increased from 50 to 52. It is a sort of market failure and it is the nature of all human beings to go after the highest net revenue yielding project. Hence, there is no wonder in moving of farmers towards rubber cultivation. Farmers cultivate rubber whenever and wherever possible. In five blocks of Thiruvattar, Melpuram, Munchirai, Killiyoor and Thuckalay, which are suitable to cultivate rubber also, farmers shifted for rubber from rice. In other blocks they shifted for coconut or banana or used rice fields for non-agricultural purposes. Further, rice is highly labor intensive and it is reported that in 2001 nearly 70 percent of production cost of rice was labor cost. Though the net income of coconut is not much, farmers prefer coconut as it is a less labor intensive crop. It means that economic factors also have significant role in reducing area under rice cultivation and rice production. The third hypothesis that economic factors have no role to play in deciding area under rice and production of rice is rejected. It is confirmed further by the farmers' opinion, which is presented in table 20. The details regarding cost of production, gross income, net income and percentage of net income to the cost of production are portrayed in table 19.

Table 19
COST OF PRODUCTION, GROSS INCOME AND NET INCOME OF IMPORTANT CROPS IN KANYAKUMARI DISTRICT IN 1987-'88 AND 2004-'05

(in rupees per hectare)

Crops		1987-'88				2004-'05			
		Cost	GI	NI	% to cost	Cost	GI	NI	% to Cost
Rice	HYV	1838	2757	919	50	13265	20130	6865	52
	Common	1450	2120	670	46	13540	19240	5690	42
Banana	Common	3120	6400	3280	105	25000	45000	20000	80
	Nendran	6120	9600	3480	57	37000	80000	43000	116
Tapioca		1640	2660	1020	63	7000	20000	13000	186
Coconut		2625	5075	2450	90	14125	29140	15015	106
Rubber		2250	7200	4950	220	22500	80000	57500	256

Source: Joint Director of Agriculture, & Deputy Director of Horticulture, Nagercoil
Note: GI = gross income, NI = net income

The net return from rubber is the highest in comparison with other crops. But, there are other reasons also to farmers to change their crop or to quit rice cultivation. The reasons for changing crops by farmers are available in table 20.

Table 20
REASONS FOR CHANGING THE CROP

Reasons for Shift	No. of Respondents
Rainfall	12
Non-remunerative price	20
Rainfall and Low price	47
Low profit and Labor shortage	28
Disturbance of wild animals	6
Irrigation problem	12
Less involvement of other members of family	7
Diseases	2

Source: Primary Data

The main economic factor that affects rice cultivation adversely is the non-remunerative price existing in the market in comparison with the cost of production. It is indicated by the farmers' opinion that 20 farmers have expressed the low price as the sole reason and 47 farmers, rainfall and low price as the reason and 28 farmers pointed out that low profit and labor shortage are the reasons for shift in cultivation. The other factors that have some influence in bringing down the area under rice are irrigation problem and labor shortage. The hesitation of other members of the family is also one of the reasons for the reduction in the area under rice cultivation. Table 21 shows how many members of the family are involved in rice cultivation in the district.

Table 21
AGE GROUP AND NUMBER OF PEOPLE ENGAGED IN AGRICULTURE

Age Group	No. of People Engaged in Agriculture					
	1		2		3	
	No. of respondents	Percentage	No. of respondents	Percentage	No. of respondents	Percentage
21 – 40	10	15.62	3	9.37	0	0
41 – 60	28	43.75	16	50	7	77.78
61 – 80	26	40.63	13	40.63	2	22.22
Total	**64**	**100**	**32**	**100**	**9**	**100**

Source: Primary Data
Note: 1 - Only the respondent is engaged in agriculture.
2 - The respondent and one family member have participation in agriculture.
3 - Three members were engaged in agriculture.

From the above table, it is observable that only in nine families two other members of the family, in 32 families, one more member of the family and in 64 families no other member, except the respondent, have involved in cultivation. In the age group of 21 – 40 years, there are only 10 members in the one-man cultivation and three members in the two-man cultivation. In total, only 13 members (12.38%) below the age of 40 are involved in cultivation. It means that the future generation is not ready to involve in farming. The details of the present crop and the previous crop are depicted in table 22.

Table 22
PRESENT AND PREVIOUS CROPS OF THE RESPONDENTS

Present crop	Previous crop	No. of Respondents
Rice	Rice	35
Banana	Rice	7
Tapioca	Rice	8
Rubber	Rice	15
Coconut	Rice	11
Coconut and Rubber	Rice	6
Banana and Tapioca	Rice	4
Banana and Coconut	Rice	8
Rice and Coconut	Rice	6
Total		**105**

Source: Primary Data

It is very clear from the above table that 65 farmers have changed their crops out of 105 surveyed and all from rice crop to some other crops. The period, when they shifted to other crops from rice is presented in table 23.

Table 23
WHEN THE RESPONDENTS CHANGED THEIR CROPS

Before (in years)	No. of Respondents	Percentage
30	4	6.15
25	3	4.62
20	5	7.70
15	9	13.85
10	8	12.30
6	7	10.77
5	11	16.92
2	13	20.00
1	5	7.69
Total	**65**	**100**

Source: Primary Data

The above table shows that out of 65 farmers who have changed their crops, 44 (67.69) farmers shifted their crops within 10 years. The reasons for having the present crop are presented in the following table.

Table 24
REASONS FOR HAVING THE PRESENT CROP

Reasons	Rice	Banana	Tapioca	Coconut	Rubber	Total
More profit	–	–	–	–	5	5
Less labor intensive	–	–	5	2	–	7
More profit & less labor intensive	-	15	4	21	18	58
Others	35	-	-	0	0	35
Total	**35**	**15**	**9**	**23**	**23**	**105**

Source: Primary Data

As it is clear from the above table 35 farmers cultivate rice because they do it traditionally and to meet the rice requirement of their families and fodder needs of their cattle. Fifty five percent of farmers (58) cultivate those crops that give more profit but at the same time less labor intensive.

To know whether the farmers will continue in the same crop or change their crop in the future, opinion is sought from them and the information collected is presented in table 25.

Table 25
FUTURE PLAN OF RESPONDENTS

Purposes	No. of Respondents	Percentage
Rice	14	13.33
Banana	9	8.57
Tapioca	4	3.80
Coconut	16	15.23
Rubber	21	20.00
Coconut and Rubber	2	1.90
Banana and Tapioca	5	4.76
Banana and Coconut	5	4.76
Non-agricultural	29	27.61
Total	**105**	**100**

Source: Primary Data

It is very sad to observe that only 14 farmers (13.33%) are ready to continue in rice cultivation in the future and 29 farmers have the intention of using their land for non-agricultural purposes. The remaining 62 farmers (59.04%) are ready to continue in cultivation but crops other than rice. It is, further, observed that 21 farmers (60%)

out of 35 farmers, who are cultivating rice, are ready to quit rice cultivation. It means that the district is moving towards a very serious food insecurity condition.

From the analysis made above, it is easy to conclude that unpredictable ecological factors contribute to uncertainty in rice production, while economic factors make it non-profitable and so farmers are quitting rice farming. Area under rice cultivation is not much adversely affected by rainfall but by temperature. Rainfall affected rice production significantly. Temperature significantly influenced area under rice but insignificantly production of rice. Area under rice strongly influenced production of rice while productivity of rice was affected neither by rainfall nor by temperature. The economic factors affecting rice cultivation are low price in comparison with cost of production, non-availability of inputs particularly labor, irrigation problems particularly in tail-end farms and wild animals' disturbances mainly in farms adjacent to forest area. The minimum support prices offered by governments are also not attractive. All these factors finally cause food insecurity. Hence, suitable steps should be taken in a war footing way. Otherwise the poor and other vulnerable groups bear the brunt.

Policy Implications

To ensure food security, production can be enhanced and consumption capacity of the poor people can be raised. As discussed above, food security can only be achieved if all people have enough food at all times. It is achievable neither only by enhancing supply but by making all people to be able to consume enough food as indicated by the nutritious standards. The following ideas may help the authority to overcome the challenges of ecological and economic factors to attain food security.

A policy called 'zero hunger' introduced in Brazil can be implemented in India also. In the zero hunger program a holistic view of food security is taken for adoption. The measures adopted include enhancement of productivity of small holding and the consumption capacity of the poor. The recent food inflation in India tells much upon the living standard of poor and middle class people. Hence, such a program may help not only the poor and middle class people but also the poor farmers.

Farmers can produce more and more area can be brought under cultivation if proper steps are being taken by the government. As told by Swaminathan (2010), through integrated measures, the soil health can be enhanced by improving organic matter and macro and micro nutrient content as well as the physics and the micro biology of the soil. The program of soil health cards can be introduced in all states as it is in Gujarat.

In water scarce area, promotion of water harvesting, conservation and efficient and equitable use of water by empowering gram ‘sabhas’ to function as ‘Pani Panchayats’ will benefit the farming society and favors food security.

Immediately credit reforms and insurance literacy must be initiated. The crop insurance dues must be immediately settled. Universal coverage of farmers by crop insurance favors farmers who are at the risk of crop failures due to fluctuations of rainfall, drought and flood, and temperature.

To increase productivity, the growing gap between scientific know-how and field level do-how, both in production and post-harvest cases of farming should be bridged.

In the present century both producers and consumers are exploited by the middle men. The gap between what the rural producer gets and the urban consumer pays should be narrowed down. It was reported that farmers got 10 to 15 rupees while consumers paid 80 to 100 rupees per kg of onion in 2009-‘10.

As farmers shift from less remunerative to more remunerative crops, it is the duty of the government to make rice also remunerative either by fixing a high support price or by giving subsidy as it is in the USA and in some other countries. It is reported that in 1999, the per-farmer subsidy in the USA was US$ 21000. But, in India it was only US$ 66 at that period. In France each beet-root farmer got a subsidy of US$ 23000 per acre. It is also reported that in the USA, more than US$ 75 billion is being given every year as farm subsidy. The per-hectare subsidy in Japan was US$ 11792 against US$ 53 in India in 1999. In these three countries, USA, Japan and France, the subsidies given are more than what the farmers produced. In India, agricultural subsidies stood at about 3 to 6 percent of the total output, whereas in Japan it was 72 percent, 37 percent in EU and 27 percent in the USA (Sharma 2004).

The minimum support price offered by the government did not cover even the cost. And so the minimum support price must be increased to cover the cost of production as well as a sumptuous margin.

To remove labor shortage, steps should be taken to mechanize all the processes of rice cultivation or educate the youth to involve in agriculture that is the backbone of the Indian economy.

The conversion of land meant for food crops into housing plots and shopping complexes and other non-agricultural purposes should be stopped in other states of India as it is stopped in the state of Kerala.

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