Chapter 4
Productivity Issues of Hill Agriculture in the Idukki District

Agriculture sector in the state of Kerala as well as Idukki district faces severe productivity crisis since 1994-95. “The deceleration in the growth of agricultural output was not witnessed for such a long period as seen in recent years” (Economic Review 45). The increasing vulnerability in the agricultural sector is contributed by a drastic fall in the productivity of major crops in the state. The Eleventh Five Year Plan of the state and the country was launched in 2007-08 with a special focus to address this agrarian crisis (Economic Review 45).

4.1 Pepper Productivity

The estimates of pepper productivity available are not useful for any meaningful analysis in districts like Idukki where pepper is grown as a major crop. The Spices Board Data covers the nation as a whole in which the methods of growing pepper are different. The data published in the Economic Review also hold the same criticism. These estimates show that pepper productivity per hectare during the last four and a half decades has been a three digit number expressed in kilograms ranging from 217 to 353. In the Idukki district the picture is entirely different. There were instances of
farmlands which had produced annually 5 tones of pepper per hectare (local communication during primary data collection). However 2.5 to 3 tones per hectare were very common during early years of production. It was reported that there were pepper plants trialed on forest trees giving 142 Kg. of fresh fruits (Ravindran 493) (1/3 of the weight of the fresh fruits = the weight of dried fruits, that is 140/3 = 46.67). In normal situation, pepper plants of 10-15 m high yield 50 kg. of fresh fruits (16.67 kg. of dry fruits) (Ravindran 493). Usually 375 to 400 such plants can be trialed on standards in an acre of land (local communication). Therefore the normal productivity would range between 6250 kg. and 6667 kg. per acre.

Productivity of pepper, the major crop in the study area, had declined from 376 kg per hectare in 1998-99 284 kg per hectare in 2006-07 (Economic Review 62). Pepper is grown as an inter-crop in many parts of the state except in Idukki and Wynad district. The productivity deceleration is acute in areas where it was grown as a major crop. The statistics released by the Expert Committee appointed by Government of India for studying the productivity crisis in the survey area indicates that the productivity loss of pepper per hectare was about 44% (estimated based on data released by the Committee) over the reference period of the study conducted by the Committee. The situation found by this researcher in Idukki was more
pathetic and severe than as estimated by the Committee. The mean of Peak Production (MPP) during the first planting and the mean of Current Average Production (CAP) in respect of the sample respondents in the survey area have been analysed to estimate the Mean Range of Productivity Decline for all respondents. Estimating the Mean Range of Productivity Decline as a percentage of the Mean Peak Production, it was found that the productivity declined about 70 per cent during the last 45 years. This may be illustrated as follows.

\[
MRPD = \frac{\sum_n PP_{ac}}{n} - \frac{\sum_n CAP_{ac}}{n} \tag{4.1}
\]

Where, MRPD = Mean Range of Productivity Decline

\[
\frac{\sum_n PP_{ac}}{n} = \text{Mean Peak Production per acre (MPP)}
\]

\[
\frac{\sum_n CAP_{ac}}{n} = \text{Mean of Current Average Production per acre (MCAP)}
\]

\[
n = \text{number of farmers surveyed} = 360
\]

Per cent of Productivity Decline \(= \frac{MPP - MCAP}{MPP} \times 100\)

The primary data collected shows that

\[
MRPD = \frac{366217}{360} - \frac{108980}{360} \ast
\]

\[
= 1017 - 303 = 714
\]
Per cent of Productivity Loss = \frac{714}{1017} \times 100 = 70\%

Source: Primary Data collected from the Idukki district

* Productivity data are expressed per acre, the common measure of land area.

This is a mean analysis, in which it is possible that, if the variable Peak Production is normally distributed, about 50% of the items possess a value below the mean. Productivity loss for these farmers exceeds 70%. Referring to the productivity decline one farmer opined that “he regrets having four acres of land as it is the single cause that made me economically un-sustainable”.

The productivity decline needs to be evaluated in the light of technological advancement. The intensity of productivity loss must be understood in the face of the technological advancement such as the development of High Yielding Verities of Vines like Panniyoor 1, and Panniyoor 2.

4.2 Nature of Farming

The farmers in the survey area follow family based, subsistence, and traditional agriculture. People of the survey area, each of them compete for exploiting the agricultural land. They never bother about the consequences of their doings. They bother only about the output per plant or output per
acre. None can blame them because they can just see the present generation and the present of their children—a short sighted view. They alternatively trial one crop instead of other if the latter are not sustainable or profitable, even in the short-run. Intensive input application was very common when the price of these crops begin to rise. The interest of planting a particular crop is also volatile as the relative prices of many alternative crops that the farmers can trial vary very frequently. One crop, which fetch attractive price this year, may be the least attractive one in the coming years. Prices of other crops may become more attractive. Farmers always work for maximizing their current earnings.

### 4.3 Agricultural Practices in the Survey Area

Agricultural practices in the Idukki district can be explained under the following heads.

### 4.4 Cropping Pattern

40 years or so ago when farmers came to Idukki for the first time as migrants, they first cultivated rice and tapioca as these crops can be harvested within four months and nearly one year respectively. During the same year they began to plant pepper as a semi permanent crop. Fortunately, most of the farmers had a good crop in the initial years of the first planting.
In the meantime, farmers were also growing some permanent tree crops such as jack, mango tree, coconut etc. in limited numbers which were considered essential for their subsistence living.

However, recently, pepper productivity per acre decelerated to its worst level. Farmers had no alternative other than to leave from pepper cultivation and turn to other less earning crops for maintaining their subsistence. Now the cropping pattern in the survey area is mixed cropping. The era of pepper mono-cropping has come to an end. Now farmers grow coffee, cardamom, coco and vegetables as inter-crops with pepper. Productivity of pepper per acre is not only affected by the number of total plants per acre but also the percentage of pepper plants to the total number of plants per acre. The crowding of plants in a certain specified area adversely affects the productivity of a particular crop.

4.5 Labour Employment

The term ‘family agriculture’ is more suitable to describe the nature of labour employment performed in the smallholder farmlands. In most cases, all family members engage in agricultural work irrespective of men or women; adults or teenagers. One may qualify this as ‘family employment’. The smallholder farmers who possess comparatively low areas of land, around one acre or less used to sell their labour outside. The smallholder
farmers having land area above two acres often buy workers occasionally during the seasons of weed clearing, harvesting, and cutting unnecessary growth of pepper standards and fertilisation. Above all, the income level and family prestige determine how each farmer determines to engage in outside ‘coolee’ work. In respect of labour employment, the smallholder farmers may be categorized into the following groups.

1. Smallholder farmers who work in own land and work outside also (Category 1)

2. Smallholder farmers who are engaged in own land only (Category 2)

3. Smallholder farmers who are engaged in own land and employ agricultural labourers (Category 3).

4. Smallholder farmers who employ agricultural labourers and manage them (Category 4).

Data regarding the nature of labour employment in the survey area is presented in Table 4.1 and Chart. 4.1. It clearly indicates that among the sample respondents more than one third of the farmers (39.44 per cent) are engaged in their own farm-lands and employ hired labour occasionally. Farmers who manage their farm-lands using only hired labour amount to 29.44 per cent. About 70 per cent of the farmers belong (category 1, 2 and 3)
to the major category of those who undertake agriculture as family employment.

Table 4.1

<table>
<thead>
<tr>
<th>Category</th>
<th>1 Self work and work Outside</th>
<th>2 Self work only</th>
<th>3 Self work and Hired labour</th>
<th>4 Only Hired labour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Farmers</td>
<td>75</td>
<td>37</td>
<td>139</td>
<td>106</td>
</tr>
<tr>
<td>Percentage</td>
<td>20.83</td>
<td>10.28</td>
<td>39.44</td>
<td>29.44</td>
</tr>
</tbody>
</table>

Source: Survey conducted in the Idukki district

Chart 4.1

Farmer Categories

Legend

1. Self work and work outside
2. Self work only
3. Self work and hired labour
4. Only Hired labour
4.6 Tillage of Soil

Though tilling of the entire land was not common, most probably almost all areas of a farmland are subject to tilling in some way or other during the last 40 years. During the initial years, for cultivating rice and tapioca, the practice of land preparation had a tillage effect. For cultivating rice in the hill areas, first the land was to be prepared. For it the farmers adopted a ‘slash and burn’ system. The sawing was effected by tilling of the prepared land. For growing tapioca also land need to be tilled.

During the initial years of planting pepper, usually, platforms are constructed by tilling the soil using spades one meter radius around the standards on which pepper vines are planted. The purpose of tilling was to get the soil loose, at least one feet depth or more to facilitate the growth and movement of the root system. It was also argued that tilling is useful to keep moisture in the land that might protect the plants from the sun heat during the summer season. In the latter years tilling takes another form. Tilled loose soil is brought near to the pepper plants to remake the platform already constructed one and a half meter away from it depending on the size of the plant. This is done once in two or three years depending on requirement.
One of the noted disadvantages of tilling the slopy farm-lands is that it is subject to soil erosion, the single largest factor that contributes to the deterioration of the land fertility. World Development Report 2008 stated that:

One of agriculture’s major success stories in the past two decades is conservation (or zero) tillage. This approach has worked in commercial agriculture in Latin America, among smallholders in South Asia’s rice-wheat systems, and in Ghana (16).

4.7 Weed Clearing/Control

Weed clearing is an essential practice of farming which saves the plants from weeds. This practice ensures the nutrients and water to the growing plants otherwise might be used by the weeds. In the survey area the possible ways of weed clearing are four fold.

1. Slashing weeds using sickles
2. Clearing off weeds using spades
3. Spraying herbicides
4. Manual clearing

Weed growth in the survey area is much intense after the beginning of south west monsoon during May-June. During monsoon season, the only practical way of controlling weed is slashing it using sickles. It actually does not clear the weeds, instead cutting it off leaving the growth
generating portion in the soil and further growth of the same weeds is possible. This practice is done more than once during the south west monsoon itself. Some farmers who rear cattle make use of such weeds as food for cattle. One advantage of this method of weed controlling is that it does not lead to soil erosion.

Weed clearing using spades has been practised during November and December immediately after the showers of south west monsoon and before the harvest period starts. This method has a minute tillage effect in the sense that the soil up to a depth of one inch get loose. Very often this method is applied twice in a year; the second is during April-May before the Pre-Monsoon showers start. Farmers claim some advantages of using this method

1. It facilitates easy harvesting. The berries falling to the ground while gathering it from the pepper plants can be easily collected without loss.

2. Keeps moisture and water content in the soil. The loose soil at the surface of land acts as a cover to prevent the acute sun heat. Only the loose soil gets heated due to sun beams.

However, this method results in erosion of soil in large quantities. Most part of the ‘one inch thick’ fertile top soil is washed away every year with severe pre-monsoon and monsoon showers. However, it is
rather difficult to estimate the quantity of top soil lost which nature had created and kept for centuries for sustaining the human being on this earth. The value of soil erosion is as great as the lives of the farmers as at the sever stage of erosion they will have to abandon their prime asset, the farmland.

Another method of controlling weeds is to destroy it by spraying herbicides. Herbicides are poisonous chemicals hazardous to the plant health as well as the health of other living organisms on this earth. The use of herbicides is not advocated as it kills crores of micro living organisms in the soil and the nearby covering atmosphere. In the survey area only 11 per cent of the sample respondents were using herbicides for weed clearing. About 97 per cent (349/360) of farmers among the sample respondents were aware of the ill consequences of using such chemicals. As many of them are rearing cattle, application of herbicides may affect the health of animals.

The manual method of weed clearing is quite impractical in the high range. Clearing weeds in two acres of land will take much time say months.

4.8 Soil Erosion

Erosion is the natural process of removal of soil by water or wind. Soil erosion becomes a problem when the natural process is accelerated.
by inappropriate land management, such as clearance of forest and grasslands followed by cropping which results in inadequate ground cover, inappropriate tillage and overgrazing. It is also caused by activities such as mining, infrastructural and urban developments without well-designed and well-maintained conservation measures. Loss of topsoil means loss of organic matter, nutrients, water holding capacity and biodiversity leading to reduced production on-site. Eroded soil is often deposited where it is not wanted. The off-site costs of erosion, such as damage to infrastructure, sedimentation in reservoirs, streams and estuaries, and loss of hydropower generation, may be much higher than the losses in farm production.

For example:

Professor K. Mahmood of George Washington University in Washington, DC, "roughly estimated" for a 1987 World Bank study that around 50 cubic kilometers of sediment-nearly one percent of global reservoir storage capacity-is trapped behind the world’s dams every year. In total, calculated Mahmood, by 1986 around 1,100 cubic kilometers of sediment had accumulated in the world’s reservoirs, consuming almost one-fifth of global storage capacity. (McCully 4)
Now the Government of Kerala, as a first step, prepares to collect Rs. 800 crore from the sale of sand extracted from the sediments in the Malampuzha Irrigating dam which was commissioned in 1964. It was estimated that roughly 30 million cu. meter of sediment would need to be removed from an area of around 15 sq. km and the storage capacity loss was about 12 per cent. State finance minister Thomas Isaac had said during his budget presentation earlier this year (2009-10) that silt deposits had reduced the water storage capacity in major dams by 30-40 per cent (The Hindu Daily, June 3, 2009).

In the survey area soil erosion is the result of farming practices on the one hand and due to natural processes on the other. A major part of the survey area is hill sides, prone to soil erosion. A variety of factors such as frequency of soil tillage, frequency of weed clearing using spades, land inclination, rainfall during the period and preventive measures adopted all affect soil erosion. Rainfall and land inclination are ‘passive’ factors in the sense that they themselves do not cause erosion. These factors start to operate in the presence of other factors such as tilling of the soil and weed clearing. The latter two may be termed as ‘active’ factors. For example, even if land inclination is greater than 20 degree in a forest, erosion might be zero. If the weeds and herbs were fully cleared away and the soil is tilled, even then erosion might be zero if there are no
rainfalls at all. When monsoon showers start, the entire picture changes; there might be severe erosion depending upon the rain fall and land inclination. In the survey area, some of the sample respondents took preventive measures. They adopted land terracing using mud and granites. Land terracing systematically or here and there which suit the land topography and leveling the soil make land inclination zero.

Terracing using granites lasts long whereas the terracing using mud needs to be repaired in alternative years. However, if the number of terracing in a farmland is not sufficient, soil erosion could not be tackled. The number of terracing required is a positive function of the land inclination.

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Farmland s with Hill Terrain</strong></td>
<td><strong>Farmers adopted Terracing</strong></td>
<td><strong>Farm-Land prone to soil Erosion</strong></td>
<td><strong>Farmlands with insufficient Terracing</strong></td>
<td><strong>Farmlands with no Terracing</strong></td>
<td><strong>Farmlands with sufficient Terracing</strong></td>
</tr>
<tr>
<td>219</td>
<td>92</td>
<td>195</td>
<td>68</td>
<td>127</td>
<td>24</td>
</tr>
<tr>
<td>100%</td>
<td>42%</td>
<td>89%</td>
<td>31%</td>
<td>58%</td>
<td>11%</td>
</tr>
</tbody>
</table>

Source: Primary data collected from the Idukki district

Among the sample respondents, a total of 219 farmers have land with hill terrain. Among them, only 92 (41%) farmers have adopted soil erosion preventive techniques. Among those who have adopted
preventive techniques, 18 farmers resorted to both type of terracing such as using mud and granites. However, for many farms, the number of terracing was not sufficient to check soil erosion. This is made clear in table 4.2. Naturally, farmlands with hill terrain are prone to soil erosion. Among the sample respondents, farm-lands of 195 (89%) farmers were found to be prone to soil erosion. Even though, 92 farmers had resorted to land terracing out of 226 farmers with hill terrain to prevent erosion, only 24 (11%) farmers had succeeded in their effort. The number of farmers who cultivate land area with hill terrain without terracing is 127 (58%). More over, 31% of the hill terrain farmers had insufficient terracing.

**Chart.4.2 Effectiveness of land Terracing**

Legend: X axis – Categories as shown in table 4.2  
Y axis – Number of farm-lands as shown in table 4.2  
Source: Table 4.2.
They did not undertake any significant effort to protect farm-lands from erosion. Any effort to avert soil erosion becomes successful only with huge capital investments. Farmers did not have a sincere desire to undertake capital investments as the result of such investment takes decades to appear. However, the cost of investments must be borne now.

4.9 Cost of Terracing

The cost of terracing consists of material costs including transportation and labour charges which include charges for both skilled and unskilled labour. The skilled labour called ‘masthaniri, and unskilled helper called ‘mycad’ together form a unit for undertaking granite works associated with terracing and charges Rs.8 per square feet as the contract rate of such work. The cost of granite required is calculated for those farmlands to which carriers (Lorry) with a capacity of 220 cubic feet can reach. The cost of granite per load is Rs.1800 (local communication). With one load of granite about 120 square feet (with one feet thickness) of wall can be constructed. Therefore the material cost per square feet is Rs. 15. Therefore the cost of terracing per square feet is estimated as Rs. 23. This is the minimum rate applicable in farmlands which are accessible by vehicles mentioned above. In other farmlands the cost of terracing increases as the mode of transportation such as ‘mini lorry’, ‘Jeep’, and manually picking on head changes. It is noticed that only 6.11 (22/360)
per cent of the respondents surveyed have farm-lands accessible by heavy lorry.

4.10 Fertilisation or Manuring

Fertilisation is the act of making land fertile by putting natural or man-made substances into the soil. Even though man undertakes some efforts to prepare natural substances for using in the soil, they are termed as natural as the ingredients of such substances are purely of natural origin and are created through a natural process. Examples may be cited as cow-dung, chicken excreta, compost etc. Man-made fertilisers are purely chemicals, artificially created in the laboratories and factories. Factom-phose, urea, potash etc and other mixture fertilisers containing these chemicals are called man-made fertilisers. Some fertilisers available in the market which are termed as organic also contain chemicals. Some farmers in the survey area opined that even using these organic fertilisers is also harmful to plants.

Though natural and man-made fertilisers do the same thing, accelerate plant growth, the mechanism through which it is attained is different. Every application of natural fertilisers or manures adds bio-mass content into the soil whereas the application of chemical fertilisers helps to decompose it and causes depletion of bio-mass content otherwise added through other mechanisms. It is a proven fact that excessive
application of chemical fertilisers in agriculture is a threat to long-run agricultural productivity.

The farmers in the survey area began to apply chemical fertilisers with the inception of ‘Green Revolution’ and the propaganda relating to productivity advantages of crops in using low cost high inputs. We may summarise the following points.

1. The emergence of a new technology called Green revolution and high input based cultivation.

2. The urge for larger and larger productivity of pepper. For the migrant farmers, it was a craze for raising productivity and production. They did whatever they could do for it.

3. Even when the availability of such fertilisers is limited across the tropical countries, the farmers were attracted by high value cost ratio. Application of grams of chemical fertilisers was translated into high quantities of output the value of which was many times greater than the value of fertiliser inputs applied.

4. Amazing income earned from the pepper crop encouraged farmers to promote chemical based cultivation and they abandoned less earning activities which was once the means of subsistence for a short time such as cattle rearing etc. Hence, as a consequence organic fertilisation decreased.
4.11 Contaminating Soil-The Use of Chemical Fertilisers

The application of chemicals has far reaching consequences on soil fertility, human and animal health and the surrounding environment. Unsustainable land use drives land degradation through contamination and pollution, soil erosion and nutrient depletion. The use of chemical fertilisers and pesticides has not always been accompanied by adequate safety measures. Releases, by-products and degradation of such chemicals contaminate the environment, and there is growing evidence of their persistence and their detrimental effects on ecosystems and on human and animal health. Currently, there is insufficient information on the amounts applied, their toxic properties, effects on human health and safe limits for exposure to fully evaluate their environmental and human health impacts. The magnitude of chemical contamination can be measured or estimated by the residue levels, concentration in drinking and/or other water sources. However, “data are incomplete globally and for many regions” (GEO-4-126). Proxies that provide some indication include total quantity of chemical pesticides and fertilisers sold in a region.
4.12 Nutrient Depletion

Application of chemical fertilisers without sufficient combination of organic manures in cultivation leads to nutrient depletion. Nutrient depletion is the decline in the levels of plant nutrients, such as nitrogen, phosphorous and potassium, and in soil organic matter, resulting in declining soil fertility. The causes and consequences of nutrient depletion are well established; application of inorganic fertilisers and pesticides is the major cause and the result is depletion of soil fertility. We may describe the situation as nutrient mining which refers to high levels of nutrient removal with no inputs. “Deficiency of plant nutrients in the soil is the most significant biophysical factor limiting crop production across very large areas in the tropics, where soils are inherently poor” (GEO-4-128). Nutrient Depletion can be any of the following types.

1. Soil acidification is a particular type of nutrient depletion. It occurs when the nutrients mainly potassium, calcium and magnesium are depleted, and are replaced by the acidic hydrogen and aluminum, which are released from the soil particles. The process occurs naturally, due to leaching by rainfall and is intensified by the natural acids generated during the decomposition of organic matter.
2. Other types of chemical degradation occur when different chemical fertilisers are applied in excess of crop needs. For example, over application of Potassium fertilisers lock up other nutrients in forms that are not available to crops, and induce deficiencies of zinc and iron.

3. Due to the application of these chemicals and pesticides, land loses its fertility and capability and destroys the various types of micro-organism like bacteria and fungi in the soil.

There is no unanimity of opinions about the basis of conclusions derived above and the debate on the extent and impact of nutrient depletion (GEO-4-129). It has been argued that:

   In some areas, nutrients have been depleted because of reduced fallow periods in shifting cultivation systems, and little or no inorganic fertiliser inputs. In other areas, soil fertility of cropland may be maintained or improved through biomass transfer at the expense of land elsewhere. Where such differences are explored in more detail, there are complex explanations including non-agronomic factors, such as infrastructure, access to markets, political stability, security of land tenure and investments. (GEO-4-129)
4.13 Application of Chemical Fertilisers in the Idukki District

Pepper farmers in the Idukki district usually apply chemical fertilisers such as urea, factom-phose, potash and mixtures of these items. Primary data collected show that about 35.28 per cent of farmers surveyed do not use any chemical fertilisers in their farm-lands for pepper cultivation; the remaining 64.72 per cent of farmers use such fertilisers in varying quantities even up to 0.75kg. per plant per year. Majority of farmers (19.44 per cent) apply chemical inputs in the range 100 to 200g per plant every year. Comparatively a low percentage of farmers (5.28 per cent) apply above 0.5kg. per plant annually. The distribution of farmers who use chemical fertilisers are presented in table 4.3

<table>
<thead>
<tr>
<th>Chemical Fertiliser Use</th>
<th>Zero Use 0-100g</th>
<th>100-200g</th>
<th>200-300g</th>
<th>300-400g</th>
<th>400-500g</th>
<th>Above 500g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Farmers</td>
<td>127</td>
<td>34</td>
<td>70</td>
<td>44</td>
<td>40</td>
<td>26</td>
</tr>
<tr>
<td>Percentage of Farmers</td>
<td>35.28</td>
<td>9.44</td>
<td>19.44</td>
<td>12.22</td>
<td>11.11</td>
<td>7.22</td>
</tr>
</tbody>
</table>

*Upper class limit is included in a particular class

Source: Primary data collected from the Idukki district

4.14 APPLICATION OF ORGANIC MANNURES IN THE IDUKKI DISTRICT

The major item of organic manure that pepper farmers in the Idukki district apply is the cow-dung. They also use compost and chicken excreta as organic manures in limited quantities. The distribution of
farmers who apply organic manures among the respondents is shown in table 4.4. Roughly 8 per cent of the surveyed farmers use no organic inputs. About 38.89 per cent apply 4 to 6 kg. to a pepper plant annually. There are some ‘progressive’ farmers whose number constitute only 1.39 per cent apply such inputs to the extent of 14 to 16 kg. per plant every year.

<table>
<thead>
<tr>
<th>Organic Manure Use</th>
<th>Zero Use 0kg-2kg.</th>
<th>2kg-4kg</th>
<th>4kg-6kg</th>
<th>6kg-8kg</th>
<th>8kg-10kg</th>
<th>10kg-12kg</th>
<th>12kg-14kg</th>
<th>14kg-16kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Farmers</td>
<td>27</td>
<td>11</td>
<td>93</td>
<td>140</td>
<td>35</td>
<td>39</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>Percentage of Farmers</td>
<td>7.5</td>
<td>3.06</td>
<td>25.83</td>
<td>38.89</td>
<td>9.72</td>
<td>10.83</td>
<td>2.5</td>
<td>0.28</td>
</tr>
</tbody>
</table>

*Upper limit is included in a particular class
Source: Primary data collected from the Idukki district.

4.15 Use of Chemical Pesticides

Pepper farmers in the Idukki district uses chemical pesticides rarely. Only 3 per cent of the surveyed farmers (11/360) use pesticides such as ‘Ecalux’, ‘Phytolan’ etc. to save pepper plants from insects and pests at the beginning of the monsoon showers in June.

4.16 USE OF ORGANIC PESTICIDES

Pepper farmers in the Idukki district are found to be not using any bio-pesticides for the control of insects and pests. Farmers are unaware of
the details of bio-pesticides which can be used to successfully control the pests and insects.

4.17 Global Warming and Climate Change

The earth is warming which is a global phenomenon. It is now recognized as a universal public issue that will dominate global attention for at least a generation. In the words of Tom Tietenberg “one class of global pollutants, the so called green house gases, absorb the long wave length (infrared) radiation from the earths surface and atmosphere, trapping heat that would otherwise radiate in to the space” (404). He added that:

The current concern over the effect of this class of pollutants on climate arises because emissions of these gases are increasing over time, changing their mix in the atmosphere. Evidence is mounting that by fossil fuels, leveling tropical forests, and injecting more of the other greenhouse gases in to the atmosphere, humans are creating a thermal blanket capable of trapping enough heat to raise the temperature of the earth’s surface. (Tom Tietenberg 404).

United Nation’s Development Programme reminds the world humanity that during the industrial era the world heat level increased by 0.7%. This is really a threat to this planet irrespective of who have been
instrumental to the emissions of green house gases; the developed or the developing world.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Place/ State/Country</th>
<th>Trend rate of Increase</th>
<th>Period Under Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Andra Pradesh, India</td>
<td>0.6°C</td>
<td>Per Century</td>
</tr>
<tr>
<td>2.</td>
<td>Nepal</td>
<td>0.6°C</td>
<td>Since 1970</td>
</tr>
<tr>
<td>3.</td>
<td>Taiwan</td>
<td>1 – 1.4°C</td>
<td>Last 100 years</td>
</tr>
<tr>
<td>4.</td>
<td>Afghanistan</td>
<td>1 – 2°C</td>
<td>20th century</td>
</tr>
<tr>
<td>5.</td>
<td>Tibet</td>
<td>0.16°C</td>
<td>Per Decade</td>
</tr>
<tr>
<td>6.</td>
<td>Mongolia</td>
<td>0.7°C</td>
<td>Last 50 years</td>
</tr>
<tr>
<td>7.</td>
<td>Idukki, India</td>
<td>0.2 – 0.4°C</td>
<td>1978 - 2008</td>
</tr>
</tbody>
</table>

Source: [www.climatehotmap.org/asia.html](http://www.climatehotmap.org/asia.html) *Annual increase
*Source: [http://kerenvis.nic.in/new/2008/05/html](http://kerenvis.nic.in/new/2008/05/html)

Climate change is one of the most complex, multifaceted and serious threats the world now faces in its endeavor to maintain sustainability. The U.N Secretary General Ban Ki-moon reminds the world that “we cannot continue with business as usual. The time has come for decisive action on a global scale” (Ban, 2007).

Climate change is a threat to human freedoms and it limits human choice. None can predict that future climatic condition would be better than the present in the course of human progress. In developing countries, millions of the world’s poorest people are already being forced to cope with the impacts of climate change. The world lacks neither the financial resources nor the technological capabilities to act against this un-freedom.
If we fail to prevent climate change it will be because we were unable to foster the political will to cooperate. Such an outcome would represent not just a failure of political imagination and leadership, but a moral failure on a scale unparalleled in history.

Poor people who depend on agriculture are most vulnerable to climate change. Productivity decline in the survey area is also attributable to climate change. Important climate change noticed is listed below.

1. The district is warming. The temperature chart kept at the Spices Board research station, Pampadumpara shows that the temperature in the Idukki district has been increasing, on an average by 0.2 to 0.4 degree Celsius every year.

2. The normal favourable distribution of rainfall across any one particular year is disturbed recently (Table 4.6).

The manifold increase in human population and people’s aspirations to pursue higher standards of living that require more products across the globe are the economic reasons that contribute to increased emissions and global warming. Man’s urge for a better quality life which he has now misunderstood as the real quality of life is a threat to this generation itself and to future generations. Application of chemicals which contain Nitrogen causes the emission of nitric oxide, a green house gas. A major share of the nitrogen in the nitrogen based fertilisers applied
in the soil may not dissolve into the soil immediately. This nitrogen interacts with oxygen and forms nitric oxide which is an ozone depleting greenhouse gas.

4.18 Rainfall Disorder

In the Idukki district, during south western monsoon, actual rainfall exceeded by about 33 per cent the favourable rain fall expected whereas during the north eastern monsoon the actual rainfall fell short of the favourable rainfall by 5% in 2007 (Table 4.6). A group of meteorologists suspects that the normal distribution of monsoon showers in Kerala has been affected by the impact of ‘Brown Asian Clouds’ and this is the prime reason for rainfall disorder, (Manorama Daily, June 05-2009). Dr. C.K Rajan, Atmospheric scientist and director of Cochin University’s Centre for Monsoon Studies asserted that Global warming is causing violent changes in climate; rise in the temperature affects the moisture content in the air which directly influence monsoon and hence rainfall (The Hindu Daily, Sept-23, 2007). Heavy and meagre rainfall during unwanted occasions affects plant growth and productivity especially in the case of pepper.

Many farmers in the Erattayar Panchayath expressed their doubt that the severe climate change they now experience began after the ‘Mathikettan’ deforestation due to illegal occupation of forest area by
some greedy farmers during the latter half of the 1990s. The actual area of forest cover in the district is much less than the official statistics.

<table>
<thead>
<tr>
<th>South Western Monsoon</th>
<th>North Eastern Monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Rainfall (mm)</td>
<td>Favourable Rainfall (mm)</td>
</tr>
<tr>
<td>3435.5</td>
<td>2584.5</td>
</tr>
</tbody>
</table>


In addition to the productivity issue, more frequent droughts and increasing water scarcity devastate large parts of the region and undermine drinking water for the already poor and vulnerable people. The international community must urgently scale up its support to the farming systems of the poor and affected areas. Based on the polluter-pays principle, it is the responsibility of the richer countries to compensate the poor for costs of adaptation. Unfortunately, the global commitment so far to existing adaptation funds has been grossly inadequate to revive the farming systems in poor countries. The national government is responsible for negotiating for the ignorant, illiterate and unorganised farmers in the international sphere and make available to farmers a good deal of help to revive the farming system and to compensate the damage due to climate change.
However, in this study climate change does not enter as an explanatory variable. Climate change affects agricultural production in different areas of the region with similar results. In other words the productivity decline due to climate change in different parts of the district will be uniform by assumption. In this study, we analyze the differences of farm productivity estimated as Phased Aggregates of Average Production of sample farmlands with respect to the differences in agricultural practices as the explanatory variables.

4.19 Diseases

Another factor that affects pepper productivity is the diseases such as the foot rot disease, ‘Pollu’ disease, Stunted Disease and quick wilt disease. These are all caused by the fungal or bacterial infection. Progressive farmers can effectively manage these diseases as various bio-control measures are available at present (Package of Practices Recommendations 123). If diseases were effectively controlled, production loss could be minimized. Thus production loss due to diseases is a phenomenon in the short-run. The impact of diseases on the productivity in the long-run is assumed to be the minimum.

4.20 Normal Age of Plantation

It is difficult to find a unanimous view about the normal age of pepper plants. In countries where pepper is grown as a mono-crop, on
dead standards, the life span is 10-15 years. In India, since pepper is trialed on living standards the life span is much greater. The scientific research reveals that the regular yielding last for about 20 years. “After regular bearing for about 20 years, the vines of most varieties start declining in yield” (Package of Practices Recommendations Crops 119).

During survey, this researcher found that there are many plantations in the Chakkupallom Panchayath having age more than 20 years with good yielding. In the Kumily Panchayath also, there were instances of farmlands having crossed the period of 25 years of continuous good yield.

4.2.1 Productivity Analysis

Land fertility is expressed in terms of the crop output produced. The long term weighted average productivity as defined by the Phased Aggregates of Average Productivity (PAAP) for the purpose of this study definitely indicates the strength of the soil fertility. The different values of PAAP in different farm-land are due to differences in Soil Erosion, Fertilisation, Plant Intensity and Crop Mixing Percentage in respect of the major crop. Land productivity in respect of pepper, the major crop in the survey area, is a function as shown below.

\[ Y = f(D_1, X_1, X_2, X_3) \]

Specifically

\[ Y_i = \beta_0 + \beta_1 D_{i1} + \beta_2 X_{i1} + \beta_3 X_{i2} + \beta_4 X_{i3} \]  

...............(4.2)
Where, \( Y_i \) = Phased Aggregates of Average Productivity in ‘\( i \)’th farmland

\[ D_i = \] a dummy variable which Indicates whether a particular farmland is prone to soil erosion; ‘1’ if prone to soil erosion and ‘0’ if not prone to soil erosion.

\[ X_{i1} = \] Total Quantity of Fertilisers which is the sum of the quantities of organic and inorganic fertilisers applied

\[ TQF = qOF + qIF \]

\[ X_{i2} = \] Intensity of Inorganic Fertilisation (IIF) which is the ratio of the quantity of inorganic Fertilisers applied to the Total quantity of Fertilisers expressed as a percentage

\[ IIF = \frac{qIF}{qIF + qOF} \times 100 \]

\[ X_{i3} = \] Crop Mixing Percentage which is the percentage of the major crop to the total plants

\[ CMP = \frac{NOP_{mc}}{NOP_{mc} + NOP_{nc}} \times 100 \]

The subscript ‘\( i \)’ denotes a particular farmland

\( \beta_0, \beta_1, \beta_2, \beta_3 and \beta_4 \) are regression parameters

\( \beta_0 \) is the intercept term
**Results:** Running regression ($Y$ versus $D$, $X_1$, $X_2$ and $X_3$) the following results were obtained.

\[
Y_i = 339 - 104D_i + 19.3X_{1i} - 3.76X_{2i} + 2.14X_{3i} \quad \ldots \ldots \ldots \ldots (4.3)
\]

<table>
<thead>
<tr>
<th>Model Summary (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

a Predictors: (Constant), $X_4$, $X_1$, $X_2$, $D$, $X_3$
b Dependent Variable: $Y$

<table>
<thead>
<tr>
<th>Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model 1</strong></td>
</tr>
<tr>
<td>Constant</td>
</tr>
<tr>
<td>$D$</td>
</tr>
<tr>
<td>$X_1$</td>
</tr>
<tr>
<td>$X_2$</td>
</tr>
<tr>
<td>$X_3$</td>
</tr>
</tbody>
</table>

**ANOVA**

<table>
<thead>
<tr>
<th>Source</th>
<th><strong>DF</strong></th>
<th><strong>Sum of Squares</strong></th>
<th><strong>Mean square Sum</strong></th>
<th><strong>F</strong></th>
<th><strong>P</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>4</td>
<td>5885947</td>
<td>1471487</td>
<td>45.28</td>
<td>0.000</td>
</tr>
<tr>
<td>Residual Error</td>
<td>355</td>
<td>11536330</td>
<td>32497</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>359</td>
<td>17422276</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Primary data collected from the Idukki District
In order to continue the analysis, it is essential to ensure that the error terms or residuals of the above regression are normally distributed. The distribution of the residuals is presented in a histogram (fig.4.3) which is approximately normal. If the residuals are normally distributed, one can test the statistical significance of the parameters and the over all significance of the model by using 't' and 'F' tests respectively.

4.22 Impact of Soil Erosion on Productivity

The first predictor, $D_1$, is a dummy variable which takes values ‘0’ or ‘1’; ‘0’ if a particular farmland is not prone to soil erosion and ‘1’ if it is prone to soil erosion. All the estimated values of productivity in the long-run (PAAP) will be grouped into two categories, those which are
prone to soil erosion and not prone to soil erosion. The coefficients attached to the dummy variables are ‘differential intercept coefficients’. These values tell us by how much the value of the intercept that receives the value of ‘1’ differs from the intercept coefficient of the benchmark category. In our analysis the benchmark category is those farmlands which are not prone to soil erosion. If we allow any of the independent variables with positive coefficient, except the dummy variable to change keeping others constant we will have the following two regression lines (fig.4.4). The first one will have intercept, 339; the mean of the bench

Fig. 4.4 Differential Intercept Regression Lines

Source: Drawn based on the regression results
*The diagram is only a representative tool. The angle need not represent the exact value of $\tan \alpha$. 

mark category and the second one will have the intercept 339 - 104 = 235, the mean value of the other category. It is clear that the soil erosion prone category has a lower mean value of productivity compared to the other category for each value of the independent variable.

The coefficient of the dummy variable has a negative sign. The hypothesis $\beta_i = 0$ can be tested using the confidence interval approach.

$$H_0: \beta_i = 0 \quad \text{and} \quad \beta_i = -104$$

The confidence interval is defined as follows.

$$\hat{\beta}_i - t_{\alpha/2} se(\hat{\beta}_i) \leq \beta_i \leq \hat{\beta}_i + t_{\alpha/2} se(\hat{\beta}_i)$$

$$\alpha = 5\%$$

In this case, the confidence interval is

$$-104 - 1.96(20.89) \leq \beta_i \leq -104 + 1.96(20.89)$$

$$-104 - 40.9444 \leq \beta_i \leq -104 + 40.9444$$

$$-144.9444 \leq \beta_i \leq -63.0556$$

This confidence interval does not include the hypothesized value of $\beta_i = 0$. Therefore the null hypothesis can be rejected with 95% confidence. The alternative hypothesis $H_1$ is true, that is $\beta_i \neq 0$. The estimated value of $\beta_i$ is statistically significant as the ‘p’ value of this estimate is very small. Thus soil erosion significantly affects productivity in the long-run.
In this analysis $\beta_i < 0$

This result implies that if the farmlands were not prone to soil erosion, average productivity in the long-run would have been high.

4.23 The Impact of Total Quantity Fertilisation

The marginal impact of the total quantity of fertilisers and/or manures applied in production can be estimated by keeping all other independent variables constant and allowing the former to change. The

![Fig. 4.5 Productivity in the Long-run and Total Quantity of fertilisers Applied](image)

*The diagram is only a representative tool. The angle need not represent the exact value of $\tan \alpha$*
marginal impact or the first derivative of the long-run productivity \( Y \) in respect to total quantity of fertilisers applied \( X_1 \) is measured as the coefficient \( \beta_2 \). \( \beta_2 = 19.3 \). As we have used a dummy variable, the first two coefficients \( \beta_0 \) and \( \beta_1 \) are differential intercept coefficients. Hence, we have two regression lines with slope coefficient 19.3 (fig. 4.5). These lines are parallel to each other to the extent of how much soil erosion affects productivity in the long-run. The value of \( \beta_2 \) implies that if the farmer did increase total quantity of fertilisers applied by 1 kg., productivity in the long-run might have increased by 19.3 kg. per acre.

The statistical significance of the estimate \( \beta_2 = 19.3 \) may be tested with the null hypothesis \( H_0 : \beta_2 = 0 \) using the confidence interval constructed for it (\( t \) statistic). The true value of \( \beta_2 \), with 95% confidence (5% level of significance), lies within the confidence interval defined in respect of the estimated value of \( \beta_2 = \hat{\beta}_2 = 19.3 \).

The confidence interval is defined as

\[
\hat{\beta}_2 - t_{a/2} \text{se}(\hat{\beta}_2) \leq \beta_2 \leq \hat{\beta}_2 + t_{a/2} \text{se}(\hat{\beta}_2)
\]

\( \alpha = 5\% \)

In this case, this confidence interval is

\[
19.3 - 1.96(3.751) \leq \beta_2 \leq 19.3 + 1.96(3.751)
\]

\[
19.3 - 7.352 \leq \beta_2 \leq 19.3 + 7.352
\]
This confidence interval does not include the hypothesized value of $\beta_2 = 0$. Therefore the null hypothesis can be rejected with 95% confidence. The alternative hypothesis $H_1$ is true, that is $\beta_2 \neq 0$. The estimated value of $\beta_2$ is statistically significant as the ‘p’ value of this estimate is very small. Hence Total Quantity Fertilisation significantly affects productivity in the long-run.

In this analysis $\beta_2 > 0$

This result is, of course confidence among farmers that they could raise productivity, if they have been managing their farmlands in line with nature and ecology. Perhaps they might not have been properly guided or educated to undertake fertility enhancing and ecologically friendly practices in their farmlands. One should evaluate this result with the Intensity of Inorganic Fertilisation as shown in table 4.7.

<table>
<thead>
<tr>
<th>Table 4.7</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Distribution of Farmers Based on Intensity of Inorganic Fertilisers</strong></td>
</tr>
<tr>
<td>Value (Per cent) of IIF</td>
</tr>
<tr>
<td>Number of farmers</td>
</tr>
<tr>
<td>Percentage of farmers</td>
</tr>
</tbody>
</table>

*zero for those farmers who do not use any fertiliser quantity.
Source: Primary data collected from the Idukki district.

About 87.2 per cent of farmers apply fertilisers with a low Intensity of Inorganic Fertilisation of 10 per cent or below 10 per cent. Only 9.7
per cent of farmers apply fertilisers with a comparatively high Intensity of Inorganic Fertilisers of over 10 per cent. Therefore the result in favour of Total Quantity Fertilisers does not imply that increased application of inorganic fertilisers is favourable to productivity.

4.24 The Impact of Chemical Fertilisers

The extent of chemical fertilisers applied in cultivation is measured as a percentage of the total quantity of fertilisers applied (Intensity of Inorganic Fertilisers, IIF). The impact of IIF \( (X_1) \) on the productivity in the long-run, while \( X_2 \) is changing is measured by keeping all other independent factors constant, as \( \beta_3 = -3.758 \). The resulting regression lines are shown in fig. 4.6. The graph explicitly shows that as the chemical fertilisers applied to the total quantity of fertilisers increase by one per cent, the long-run productivity declines by 3.76 kg. per acre. Therefore productivity in the long-run and IIF are inversely related. Here it turns up as a clear message to the farmers to control the use of chemical fertilisers.

The statistical significance of the estimate \( \beta_3 = -3.758 \) is evident from the very small ‘p’ value of the estimate as given in the regression coefficient table. The remaining question is to decide whether one must
accept the null hypothesis $H_0$ or reject it. The confidence interval method using the 't' test statistic is useful.

**Fig. 4.6 The Impact of Chemical Fertilisers On Productivity in the Long-run**

Productivity

<table>
<thead>
<tr>
<th>IIF</th>
<th>Without Soil Erosion</th>
<th>With soil Erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>339</td>
<td></td>
<td></td>
</tr>
<tr>
<td>235</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$\tan \alpha = 75.1$

**Source:** Drawn based on the regression results

*The diagram is only a representative tool. The angle need not represent the exact value of $\tan \alpha$*

$H_0 : \beta_3 = 0$

$\hat{\beta}_3 = -3.758$

The confidence interval is defined as

$\hat{\beta}_3 - t_{\alpha/2}se(\hat{\beta}_3) \leq \beta_3 \leq \hat{\beta}_3 + t_{\alpha/2}se(\hat{\beta}_3)$

$\alpha = 5\%$

In this analysis this confidence interval is
\[-3.758 - 1.96(0.6471) \leq \beta_3 \leq -3.578 + 1.96(0.647)\]
\[-3.758 - 1.268 \leq \beta_3 \leq -3.758 + 1.268\]
\[-5.03 \leq \beta_3 \leq -2.49\]

This confidence interval does not contain the hypothesized value of \( \beta_3 = 0 \). Therefore one must reject the null hypothesis. Thus we accept the alternative hypothesis \( H_1 \) with 95% confidence (5% level of significance).

\[ H_1 : \beta_3 \neq 0 \]

In this analysis, the coefficient \( \beta_3 \) has a negative sign which implies that \( \beta_3 < 0 \)

### 4.25 The Impact of Crop Mixing

The mixing of minor crops with the major crop is entered in the model as a percentage of the number of plants of the major crop to the total number of plants including major and minor crops in an acre of farmland. Allowing the Crop Mixing Percentage (CMP), to vary and all other explanatory variables held constant; one can measure the marginal impact of the Crop Mixing Percentage on the productivity in the long-run. The first derivative of the function \( Y \) with respect to the variable \( X_3 \), the coefficient \( \beta_4 \), is measured as the marginal impact of the variable \( X_3 \). In the regression model \( \beta_4 = 2.14 \) which is the slope
coefficient of the variable $X_3$. As in earlier cases, we have two regression lines as shown in fig.4.7.

The statistical significance of this estimate also can be tested with the help of the confidence intervals created with the 't' test statistic as illustrated in testing the significance of the impact of $X_2$ and $X_3$ on $Y$.

$$H_0: \beta_4 = 0$$

$$\hat{\beta}_4 = 2.14$$

The confidence interval is defined as

$$\hat{\beta}_4 - t_{a/2}se(\hat{\beta}_4) \leq \beta_4 \leq \hat{\beta}_4 + t_{a/2}se(\hat{\beta}_4)$$

$$\alpha = 5\%$$

In this case, the confidence interval is

$$2.1424 - 1.96(0.5133) \leq \beta_4 \leq 2.1424 + 1.96(0.5133)$$

$$2.1424 - 1.006 \leq \beta_4 \leq 2.1424 + 1.006$$

$$1.1363 \leq \beta_4 \leq 3.1485$$

The hypothesized value of $\beta_4 = 0$ does not fall in the confidence interval defined above. Hence, one can reject the null hypothesis $\beta_4 = 0$ with 95% of confidence. In other words the possibility of rejecting a true null hypothesis is 5 out of 100 samples. However the actual confidence level approximates to 100% as the ‘p’ value of the estimate is very small (table
of regression coefficients). Now, one can adopt the alternative hypothesis $H_1$:

$$H_1 : \beta_4 \neq 0$$

In this analysis, the coefficient $\beta_3$ has a positive sign which implies that $\beta_3 > 0$

**Fig. 4.7 Impact of Crop Mixing Percentage on productivity in the Long-run**

<table>
<thead>
<tr>
<th>Productivity</th>
<th>Without Soil Erosion</th>
<th>With soil Erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMP</td>
<td>339</td>
<td>2.14</td>
</tr>
<tr>
<td></td>
<td>235</td>
<td>2.14</td>
</tr>
</tbody>
</table>

$\tan \alpha = 64.95$ *The diagram is only a representative tool. The angle need not represent the exact value of $\tan \alpha$

**Source:** Drawn based on the regression results

### 4.26 Overall Significance of the Model

The overall significance of the model can be checked using the ‘F’ statistic. It is proved that the ratio of explained sum of squares (due to
regression) and the Residual sum of squares (due to residuals) gives the F value and the ‘F’ value follows the ‘F’ distribution with 4 df in the numerator and 355 df in the denominator. The model is significant, if the computed value of ‘F’ exceeds the critical value as obtained from the ‘F’ table. Alternatively, one can observe the \( \rho \) value in respect of the model. A very small ‘p’ value explicitly states that the model is statistically significant.

The null hypotheses are

\[
H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0
\]

\[
H_1 : \text{Not all slope coefficients are simultaneously equal to zero.}
\]

In our analysis, the ‘F’ value is 45.28. The critical value obtained from the ‘F’ table with 4 (numerator) and 355 (denominator) df. at 1% significant level is 3.32. The computed ‘F’ value far exceeds the critical value. Hence one can reject the null hypothesis that all the coefficients are simultaneously zero. In the same way, we adopt the alternative hypothesis that the coefficients are not simultaneously zero and they are highly significant.

The regression model presented in this chapter leads us to the conclusion that organic fertiliser application and crop mixing percentage have positive impact on productivity in the long-run whereas adversities cumulate from the application of the chemical fertilisers and soil erosion.
The positive impact of Crop Mixing Percentage on productivity in the long-run demands mono-cropping of pepper. However, farmers in the survey area were of the opinion that moderate shade giving plants within the plantation promotes production for a long period of time. However, production per acre will be greater if such plants are absent. This is a phenomenon in the short-run. The life span of such plantations will be short compared to those plantations in which shade trees are maintained at very moderate rates (Local communication).
Works Cited


Kerala Agricultural University, Package of Practices Recommendations Crops -2007, Mannuthy, Trissur.

