CHAPTER ONE
INTRODUCTION

1.1 Background of the Study
India has experienced an unprecedented growth in agricultural production in general and foodgrain production in particular over the past five decades after the advent of Green Revolution. From a very deplorable condition in the early sixties, India has not only become self-reliant in food grain production but has acquired resilience to a great extent to tide over the adverse circumstances (Anant, 2002; Patnaik, 2001).

In spite of these impressive achievements, the Indian agriculture sector is faced with certain problems. Too much emphasis on foodgrains in terms of technological confinement coupled with subsidies and price support by the government has led to a comparatively higher growth in the area allocation under foodgrain production at the cost of other crops. The resultant increase in foodgrain production has sometimes posed the problem of surplus supply and the maintenance of excess buffer stock. In some prominent crop growing areas production of foodgrains, especially rice is no longer viable due to high real cost in terms of resources that go into the production process. Yet the farmers find it lucrative (in certain pockets of the country) due to government incentives and support that accompanies it. According to the approach paper to India's Tenth Five Year Plan, "The policy approach to agriculture has been to secure increased production through subsidies in inputs such as power, water and fertilizer, and by increasing the minimum support price rather than through building new capital assets in irrigation, power and rural infrastructure. This strategy has run into serious difficulties. Deteriorating state finances have meant that subsidies have 'crowded out' public agricultural investments in roads and irrigation and
expenditure on technological upgrading. Apart from the inability to create new assets, the lack of resources has eroded expenditure on maintenance of canals and roads... Excessive use of subsidized fertilizers has created an imbalance between N, P and K, whereas excess use of water has produced waterlogging in many areas" (Government of India, 2001: p.26). Vyas (2004) and Anant (2002) also held that indiscriminate use of subsidies, particularly input subsidies has crowded out the resources for public investment in infrastructure development.

Moreover, a large-scale regional disparity is still in existence with respect to agricultural development in India. It is often alleged that the new agricultural strategy has been confined to only a handful of northwestern states like Punjab, Haryana, Uttar Pradesh etc. and many other states especially those of northeastern part of India lagged far behind to reap the benefits. Despite richness in natural endowment, the northeastern region is one of the most backward areas of the country where agriculture is very risky and productivity is relatively low (Barah, 2004).

One of the major challenges concerning the farm sector of India is to reverse the deceleration in agricultural growth. The two major sources of growth in agriculture, viz., area expansion and productivity growth, which served well in the past, are now plagued with some limitations. While the scope of area expansion is limited by inelastic supply of land, it is argued that any significant technological breakthrough cannot be expected in the near future and hence, one has to depend on the exploitation of the potential of the existing technology (Government of India, 2006). Therefore, a third alternative which may prove to be very useful in this context, at least in the short run, is to move towards diversification, particularly into high value crops (Mandal, 2011).
The dominance of wheat-paddy system has led to serious economic, social and ecological problems such as deceleration in productivity growth, drop in agricultural employment, overexploitation of ground water resources and decline in soil fertility, especially in the Green Revolution areas of the country. In Punjab soil has deteriorated because of excessive use of chemical fertilizers and growing the same crops over and over again (Sidhu and Dhillon, 1997). According to Sidhu and Sidhu (1988) Punjab’s over dependence on rice and wheat has led to some serious ecological and production related marketing problems. Moreover, the gradual changes in the consumption pattern within the country as well as abroad are a clear indication that the policy focus needs to be reoriented towards diversifying the cropping pattern to meet the emerging market needs. Diversification of agriculture in favour of more competitive and high value quality products assumes greater importance in the context of opening up of the economy and its competitiveness, particularly in the farm sector.

The lesson for Assam from the experience of the Green Revolution areas of India is not to concentrate only on one or two crops but to go for a diversified cropping pattern to avoid adverse environmental consequences apart from reaping other benefits such as stability of yields, reduced risk of crop failure, increased productivity, increased agro-returns, enhanced employment and so on. It should be noted that there is a special need of diversification of crops in Assam. Winter or ‘Sali’ paddy that has traditionally occupied a major share\(^1\) in the total cropped area is very much prone to frequent floods, which is a major source of instability of agricultural production in the state. Hence, diversification into not only crops

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\(^1\) Although the share of paddy in the total cropped area has declined over the years, the shares of total paddy and winter paddy in the total cropped area in 2006-07 were found to be as high as 66 per cent and 46 per cent respectively.
but also seasons may provide a boost to agricultural production and its stability to a great extent\(^2\) (Mandal, 2011).

Diversification within the crop-growing sector is, thus, required for developing the agriculture sector and making agriculture a remunerative profession for the farmers of Assam. Moreover, frequent floods causing a great havoc to crops, lives and property have regularly haunted the plain areas of the state. Crop diversification can be used as one of the means to cope with the agro-economic problems of flood prone areas. Again, the agro-economic conditions and cropping pattern in the flood free areas are different from those of the flood prone areas. The nature of crop diversification, therefore, is likely to be different in these two areas. Research on development of crop varieties and their use, which are more resistant to the adverse agro-economic and geographical conditions of both the regions, assume added importance in this context.

1.2 Significance of the Study

Flood is a recurring phenomenon in Assam which causes extensive damage to its crop growing sector every year and, thus, is a major source of instability of agricultural production in the state. However, an appropriate combination of crops may be instrumental in minimizing the damage to crop growing sector caused by the vagaries of flood. It has been observed, especially since the deployment of Shallow Tube Well (STW) based irrigation system in the late nineties that to avoid crop losses due to frequent floods many farmers in the state have adopted a risk averse strategy as a result of which there has been a decline in the acreage share of kharif foodgrains and an increase in the same of rabi foodgrains and vegetables. Whether such a strategy is spread over the state

\(^2\) About half the farmers in the state cultivate and harvest their field only once a year (Government of Assam, 2003).
or only in a few pockets requires an examination. The present study seeks to address this issue. While a number of important studies on various dimensions of agriculture of Assam have become available by now, studies on the nature of cropping pattern and extent of crop diversification in the state in general and in the flood prone and flood free areas in particular are hard to come by. The proposed study is induced by the necessity to fill this gap to some extent. Moreover, the proposed study has important policy implications as well. One of the objectives of the study is to recommend suitable policy measures for inducing patterns of crop diversification to attain economic and environmental sustainability of agriculture in the state.

1.3 Objectives and Research Questions

1.3.1 Objectives

The study has been taken up with the following objectives.

a) To investigate the existing cropping pattern in different agro-economic and environmental conditions of Assam.

b) To find out the changes in cropping pattern over the years, if any, and study the nature, trends and patterns of crop diversification in different agro-climatic conditions.

c) To identify the agro-economic, institutional and infrastructure related factors behind the observed patterns of crop diversification.

d) To investigate the impact of crop diversification on income generation in the farms.

e) Based on the findings of the study to recommend suitable policy measures for inducing/encouraging cropping pattern with higher productivity.
1.3.2 Research Questions

Besides the above objectives the following research questions will be specifically pursued in the course of the proposed study.

a) Has crop diversification been adopted as a strategy for coping with uncertainties and limits imposed by flood?

b) What policy measures need to be adopted to enhance the ability of the farmers in flood prone areas in coping with the limits imposed by flood?

1.4 Data Source and Analytical Framework

1.4.1 Data Source

The present study has been based on both secondary and primary sources of data. Data pertaining to different aspects of agricultural situations of the state have been collected from various sources of Government of Assam such as Directorate of Agriculture, Directorate of Economics and Statistics, Irrigation Department, Water Resource Department. These secondary sources of data provided information regarding the status of agriculture in the state in terms of cropping pattern, land utilization pattern, production and productivity of various crops and growth of area under different crops in various agro-climatic conditions. They also provided an insight of flood prone and flood free areas, the extent of damage and other background materials related to agriculture. Analysis of these data gave a broad picture of agriculture in the state. However this was not sufficient to represent the farmers' choices, responses and strategies. To capture these dimensions a field survey has been conducted to collect primary data.

1.4.2 Sample Design for Primary Data Collection

Primary data has been collected with the help of the technique of multistage sampling. In the first stage four non-contiguous districts have been selected...
purposively from different parts of the plains in Assam. Thus four districts namely Dhubri, Morigaon, Dibrugarh and Cachar have been selected, which fall in four different agro-climatic zones of Lower Brahmaputra Valley, Central Brahmaputra Valley, Upper Brahmaputra Valley and Barak Valley. In the second stage three Agricultural Development Officer’s (ADO) circle have been selected from each district in such a way that one is chronically flood prone, one is occasionally flood prone and one is flood free. This choice in relation to flood proneness has been made after consultation with officials of district Agriculture Offices and other informed sources. In the third stage from each ADO circle two villages have been selected purposively such that they fulfill the criterion of flood proneness mentioned above. Finally 10 per cent of the farm (cultivator) households have been selected at random from each village. This way a sample of 360 farm (cultivator) households from 24 villages have been selected at random as ultimate sample units for detailed observation.

1.4.3 Analytical Methodology
The data on area under different crops for the study period across different districts have been collected from secondary sources as mentioned in 1.4.1. The district level data have then been aggregated according to agro-climatic conditions to investigate the existing cropping pattern as well as changes therein over time across different agro-climatic zones. Moreover, to investigate the variations in the extent of crop diversification among the agro-climatic zones the proportion of area under different crops have been summarized into a measure of crop diversification. On the other hand, for a more rigorous analysis crop diversification across the sample farms has been calculated on the basis of area
and value share of individual crops in the crop portfolio\(^3\). The analytical details of crop diversification measurement have been discussed in the rest of this section.

There are several measures of crop diversification, which have been used in the empirical studies (Chand, 1995; Shiyani and Pandya, 1998; Gupta and Tewari, 1985). They are Herfindahl Index, Ogive Index, Entropy Index, Modified Entropy Index, Composite Entropy Index etc.

**Herfindahl Index**

Herfindahl Index is computed as sum of the squares of acreage or value share of each crop in the total crop portfolio.

Let \( H.I. = \sum_{i=1}^{N} P_i^2 \) \(^1\)

Where,

- \( P_i = \text{acreage/value share of the } i^{th} \text{ crop in total crop portfolio} \)
- \( A_i = \text{area/value under } i^{th} \text{ crop} \)
- \( \sum_{i=1}^{N} A_i = \text{total cropped area/total value of output and} \)
- \( N = \text{number of crops grown} \)

Then,

\[ H.I. = \sum_{i=1}^{N} P_i^2 \quad (1.1) \]

With increase in diversification, the Herfindahl Index decreases. It takes value one when there is complete specialization and zero when there is perfect diversification. Since H.I. measures concentration rather than diversification, sometimes \((1 - H.I.)\) is used to measure the extent of diversification.

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\(^3\) Here total crop portfolio implies total cropped area or total value of output from cultivation
The H.I. is bounded by zero and one. It attains the minimum value when all crops have equal acreage share of \( \frac{1}{N} \). This minimum approaches zero when \( N \) increases infinitely. A major limitation with H.I. is that its lower bound \( \frac{1}{N} \) never becomes zero but approaches zero as \( N \) becomes larger and larger. Thus it cannot attain the theoretical minimum, i.e., zero for larger values of \( N \). Because of this as the sample size gets large it may cause score of the index to change rapidly especially when the number of crops considered in its computation is very small (Anosike and Coughenour, 1990).

**Ogive Index (O.I.)**

The Ogive Index is computed by the following formula.

\[
O.I. = \sum_{i=1}^{N} \left( P_i - \left( \frac{1}{N} \right) \right)^2 + \left( \frac{1}{N} \right) \quad (1.2)
\]

Where, \( N \) and \( P_i \) have the connotations mentioned earlier. Like the H.I. the O.I. is a measure of concentration. The value of O.I. decreases with increase in diversification and vice versa. The major limitation of the index is that the upper bound tends to zero in case of perfect concentration. Thus, the index tends to zero in cases of perfect concentration as well as perfect diversification.

**Entropy Index (E.I.)**

The Entropy Index is specified as follows.

\[
E.I. = \sum_{i=1}^{N} P_i \log \left( \frac{1}{P_i} \right)
\]

\[
E.I. = -\sum P_i \log P_i \quad (1.3)
\]
The E.I. is a weighted sum of acreage or value shares, the weights being logarithm of the inverse of such shares. It gives less weight to crops with larger shares whereas the reverse is done in case of H.I.

Hackbart and Anderson (1975, 1978) have shown that the entropy index satisfies certain properties that make it unique. These properties may be mentioned as follows.

a) Continuity: Entropy index of diversification depends on the number of economic sectors or activities, \( n \) and the proportions in these sectors \( P_1, P_2, \ldots, P_n \). The measure is continuous in the arguments \( P_1, P_2, \ldots, P_n \) so that it may be expressed as \( E.I.(P_1, P_2, \ldots, P_n) \).

b) Symmetry: E.I. is functionally symmetrical in \( P_1, P_2, \ldots, P_n \). That is, it depends on the proportions and not on their order.

c) Extremal Property: E.I. attains the maximum value when \( P_1 = P_2 = \ldots = P_n = \frac{1}{n} \). Thus equal proportion among the sectors or activities concerned gives maximum diversification.

d) Additivity: Suppose one of the sectors, say the \( n^{th} \), is divided into two sub sectors, with relative shares \( q_1 \) and \( q_2 \) respectively so that \( q_1 + q_2 = P_n \). Then the new measure of diversity will be the original measure plus the conditional diversity within the \( n^{th} \) sector. That is, symbolically

\[
E.I.(P_1, P_2, \ldots, P_{n-1}, q_1, q_2) = E.I.(P_1, P_2, \ldots, P_{n}) + P_{n} E.I.(q_1/P_n, q_2/P_n)
\]

The E.I. increases with the increase in diversification and it approaches zero when there is perfect concentration. It attains the maximum value when each crop has equal share in crop portfolio, i.e., \( P_i = \frac{1}{N} \) (where, \( i = 1, 2, 3, \ldots, N \)).
upper bound of the index is given by \( \log(N) \). However, the upper limit of E.I. is determined by the base of logarithm and the number of crops taken into account. The upper bound of the index can exceed one when the number of crops is higher than the value of logarithm's base, it will be equal to one when number of crops and value of logarithm's base are equal and it can be less than one otherwise. Thus, the major limitation of E.I. is that it does not give standard scale for measuring the degree of diversification (Shiyani and Pandya, 1998).

Since the upper limit of E.I. is \( \log(N) \), which depends on number of crops \( N \), it cannot be used to compare the degree of diversification in different locations where different number of crops are grown (Palanisami et al., 2010). Thus despite satisfying the above mentioned properties the usefulness of E.I. gets limited in making comparisons when different number of crops are grown across regions and time periods, and by different households.

**Modified Entropy Index (M.E.I.)**

The limitations of the Entropy Index have been sought to be overcome, at least to some extent by Modified Entropy Index. In M.E.I. the base of the logarithm is taken as variable instead of a fixed base. It is computed as follows.

\[
M.E.I. = \sum_{i=1}^{N} P_i \cdot \log_N \left( \frac{1}{P_i} \right)
\]

\[
M.E.I. = -\sum_{i=1}^{N} P_i \cdot \log_N P_i \quad (1.4)
\]

Here the base of the logarithm is taken to be \( N \), i.e., number of crops. This index has a lower limit equal to zero when there is complete concentration and it assumes upper limit of one when there is complete diversification. It provides for
uniformity and fixity to the scale used as norm to measure the degree of diversification (Shiyani and Pandya, 1998).

When there is perfect equality among the crops in terms of share in crop portfolio, i.e., \( P_i = \frac{1}{N} \) the M.E.I. gives the highest level of diversification equal to one, irrespective of the number of crops grown. Thus like E.I. the usefulness of M.E.I. gets limited in making comparisons when different numbers of crops are grown across regions and time periods, and by different households. This is a serious limitation of modified entropy index.

**Composite Entropy Index (C.E.I.)**

The C.E.I. is computed as follows.

\[
C.E.I. = - \sum_{i=1}^{N} P_i \log N P_i [1 - \left( \frac{1}{N} \right)]
\]

Or, \( C.E.I. = M.E.I. \left[ 1 - \left( \frac{1}{N} \right) \right] \) \hspace{1cm} (1.5)

Thus, C.E.I. is nothing but adjusted M.E.I., the adjustment factor being \( 1 - \left( \frac{1}{N} \right) \).

The C.E.I. has all the desirable properties of M.E.I. It has an added advantage in that it can be used to compare diversification across situations or cross-sectional units having different and larger number of crops since it gives due weight to the number of crops. The C.E.I. increases with rise in diversification and vice versa. It ranges between zero and one.

It is to be noted that the maximum level of diversification is achieved, irrespective of the diversification measure used, when there is equal distribution of total cropped area/gross value of output under different crops taken into account. A combination of many crops, with one crop dominating area/value share would
result in a lower value of crop diversification index. The value of the index will be higher when total cropped area/gross value output is distributed more equally among a larger number of crops.

Table 1.1 illustrates the maximum limit on the level of crop diversification given by different diversification measures. It can be easily verified from Table 1.1 that when there is equal distribution of total cropped area/gross value of output among different crops the levels of diversification measured by H.I. and E.I. increase with increase in the number of crops grown whereas M.E.I. remains constant. Thus M.E.I. is insensitive to the number of crops taken. This is a serious limitation of M.E.I. Moreover, a suitable diversification measure should give due weight to both area share and number of crops taken into account. This limitation of M.E.I. is sought to be overcome by Composite Entropy Index (C.E.I.).

Table 1.1: Levels of Diversification under Equal Acreage/Value Shares

<table>
<thead>
<tr>
<th>No. of Crops Grown (N)</th>
<th>Area/Value Share (P_i)</th>
<th>Diversification Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>H.I.</td>
</tr>
<tr>
<td>2</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>4</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>5</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>10</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>20</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>100</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Thus from the above discussion it is clear that each of the measures of crop diversification has its own merits and limitations. In the present study the Composite Entropy Index has been used considering its superiority over other measures of diversification cited above.
The examination and analysis of the spatio-temporal variations in the cropping pattern and crop diversification across Assam has been done on the basis of acreage figures of different field crops collected from secondary sources. The preliminary explanation of the variations in cropping pattern and crop diversification across the sample farm households has been done along with the relevant background factors such as availability of irrigation, tenancy arrangements, flood-proneness etc. for which descriptive statistics have been used. This has further been substantiated for more intensive analysis of the primary data for which suitable econometric modeling such as linear and non-linear regression models have been used. In order to investigate the impact of flood proneness, along with other relevant factors, on the extent of crop diversification non-linear methods of logistic regression and tobit regression have been used. To examine the impact of crop diversification on income generation and its mutual interdependence with marketing a linear regression model and a simultaneous equations model have been respectively formulated and estimated by ordinary least square method and two stage least square method.

1.5 Limitations of the Study

One of the determinants of cropping pattern changes over time is changes in the relative costs and prices of different crops. However, the role of these factors could not be incorporated in the study because of non-availability of consistent and comparable time series data on input and output price variables for the study period. Though an analysis with cross section sample data is fairly detailed in other respects such data is not amenable for capturing the effect of change in relative price movements.
1.6 Structure of the Dissertation

The thesis is comprised of eight chapters. This introductory chapter is followed by Chapter Two, which covers theoretical issues and empirical debates related to cropping pattern and crop diversification. Chapter Three contextualizes cropping pattern in the agricultural profile of Assam. Chapter Four explores the nature of changes in the cropping pattern and crop diversification that have taken place over a period of time across different ago-climatic zones. A brief background of the field study areas, the sample and a preliminary analysis of field level inputs have been sketched in Chapter Five. This is followed by Chapter Six where an intensive analysis of the inputs from field investigation has been done using econometric tools and case study format. Chapter Seven is concerned with investigation of the contribution of crop diversification to income generation in the farms. The concluding chapter presents a recapitulation of the principal findings, abstractions of broad inferences emerging from the study and a discussion of its policy implications.