

**VULNERABILITY OF DAIRY FARMERS TO RISK AND
UNCERTAINTY IN COASTAL ODISHA AND
EFFECTIVENESS OF COPING STRATEGIES**



**THESIS SUBMITTED TO THE
ICAR - NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL
(DEEMED UNIVERSITY)**

**IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF**

**DOCTOR OF PHILOSOPHY
IN
AGRICULTURAL ECONOMICS**

BY

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M.V.Sc. (Veterinary Economics)

**DIVISION OF DAIRY ECONOMICS, STATISTICS & MANAGEMENT
ICAR - NATIONAL DAIRY RESEARCH INSTITUTE
(DEEMED UNIVERSITY)
KARNAL – 132001 (HARYANA) INDIA**

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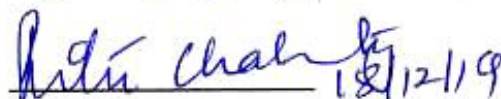
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This is to certify that the thesis entitled “**VULNERABILITY OF DAIRY FARMERS TO RISK AND UNCERTAINTY IN COASTAL ODISHA AND EFFECTIVENESS OF COPING STRATEGIES**” submitted by **Mr. SHIBASHISH BARAL** in partial fulfillment of the requirement for award of the degree of **DOCTOR OF PHILOSOPHY** in **AGRICULTURAL ECONOMICS** of the ICAR - National Dairy Research Institute (Deemed University), Karnal (Haryana), India, is a bonafide research work carried out by him under my supervision and guidance and no part of the thesis has been submitted for any other degree or diploma.

Date: June, 2019


(B.S. CHANDEL)
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Dedicated to
"Jejebabu"
for whom, I am
whatever I am today

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ABBREVIATIONS & SYNONYMS USED

Sl.No.	Abbreviations & Synonyms used	Full form
1	AH	Animal Husbandry
2	AI	Artificial Insemination
3	BQ	Black Quarter
4	CB	Crossbred
5	FCM	Fat Corrected Milk
6	FMD	Foot and Mouth Disease
7	GDP	Gross Domestic Product
8	Govt.	Government
9	ha	Hectare
10	HH	Household
11	HS	Haemorrhagic Septicemia
13	HYV	High Yielding Variety
14	MTs	Metric Tons
15	NDDB	National Dairy Development Board
16	PCA	Principal Component Analysis
17	Region-1	North Eastern Coastal Plains
18	Region-2	East & South Eastern Coastal Plains
19	SAU	Standard Animal Unit
20	SD	Standard Deviation
21	SDI	Simpson Diversification Index
22	SNF	Solid Not Fat
23	Surra	Trypanosomiasis
24	TE	Technical Efficiency

ABSTRACT

Risk is all pervasive in Indian agriculture and dairy sector is no exception to that. Odisha being a coastal state faces huge risk from climatic occurrences and underdeveloped production environment. Keeping this in view, the present study assessed risk, Vulnerability to risk and formulated risk efficient farm plans for coastal Odisha region. The primary data collected for the study pertains to the year 2015-16 collected from 400 households of the 4 districts of the coastal region of Odisha. The primary data were supplemented by the secondary data on cost of production, cost inputs and animal population of the region as required by the study. Risk and risk factors facing the dairy farmers were studied both at regional and farm level. The vulnerability of farmers was assessed by construction of a vulnerability index constructed as a function of exposure, sensitivity and adaptive capacity. Regression analysis was carried out in determining the factors affecting the farm level vulnerability. Farm enterprises diversification along with extent of adoption of livestock and crop insurance was assessed as strategies of risk diffusion. Finally risk efficient composite farm plans were formulated for the different categories of farm households by use of linear programming techniques and Minimisation of Total Absolute Deviation (MOTAD) model. Repeat breeding appears to be affecting the crossbred (CB) cows much more than the local cows. Among diseases, mastitis appears to be greatest contributor to household (HH) losses at about 40 per cent share while FMD and Blood protozoan diseases were found to be the second and third highest contributors. The natural calamity mortality of dairy animals was found to be very less in comparison to the diseases mortality at about 0.33 and 4.56 per cent, respectively. The regional economic loss to dairy and crop sector in coastal Odisha was found to be about Rs. 34,000 lakhs and Rs. 1,898 crores per annum, respectively. About 44 per cent of landless households were found to fall under highly vulnerable and very highly vulnerable category combinedly while the same in case of marginal farmers was found close to 50 per cent. The study found decrease in vulnerability with the increase in farm sizes. Regional location of households was found to be a factor affecting the degree of vulnerability of farmers, confirming different level of vulnerability between the two coastal region of Odisha. Animal husbandry diversification index was found to be highest in case of landless farmers at about 0.631 suggesting their greater dependence on livestock and diversifying for lowering the risk. The overall coverage of livestock mortality and crop damage by adoption of insurance coverages were found to be about 14 per cent and 20 per cent, respectively. In the composite risk efficient farm plans, increase in cropping intensity and increase in area of cash crops like groundnut and vegetable suggests them as crops of higher return with relatively lower risk association. Among dairy animals crossbred cows appeared to be more preferable than the local cows. The small animal holdings like goat and sheep increased in all farm plans in comparison to their present level of holdings suggesting them to be risk efficient farm activities with prospects of higher return.

तटीय ओडिशा में जोखिम और अनिश्चितता के लिए डेयरी किसानों की भेद्यता एवं उनसे सामना करने की रणनीतियों की प्रभावशीलता

सारांश

भारतीय कृषि में बहुत जोखिम है और डेयरी क्षेत्र इससे अछूता नहीं है। चूँकि ओडिशा एक तटीय राज्य है इसलिए यहाँ जलवायु बदलाव एवं अविकसित उत्पाद वातावरण का कृषि पर बहुत प्रभाव पाया जाता है। इन बातों को ध्यान में रखते हुए वर्तमान अध्ययन में तटीय ओडिशा में जोखिम का माप, जोखिम की चपेटता एवं इन जोखिमों का सामना करने की रणनीतियों का गठन किया गया है। इस अध्ययन के लिए प्राथमिक आंकड़े तटीय ओडिशा के चार जिलों के 400 घरों से सन् 2015-16 के लिए इकट्ठा किया गया। प्राथमिक आंकड़ों के साथ-साथ उत्पाद की लागत इंपुट लागत तथा पशुओं की आबादी पर द्वितीय आंकड़े भी इकट्ठा किए गए। किसानों की भेद्यता को भेद्यता सूची से मापा गया जोकि अनावरण, संवेदनशीलता एवं अनुकूली क्षमता पर निर्भर करता है। खेतों की भेद्यता के कारक निर्धारित करने के लिए प्रतिगमन विश्लेषण का इस्तेमाल किया गया। जोखिम प्रसार की रणनीतियों के तौर पर खेती विविधीकरण के साथ-साथ पशुओं के दत्तक ग्रहण एवं फसल बीमा को मापा गया। रैखिक प्रोग्रामिंग तकनीक एवं Minimization of Total Absolute deviation (MOTAD) मॉडल के माध्यम से विभिन्न वर्ग के किसानों के लिए जोखिम कुशल समग्र कृषि खोजना का गठन किया गया। दोहरे प्रजनन का प्रभाव देशी नस्ल की गायों के मुकाबले संकर गायों में ज्यादा पाया गया। समस्त रोगों में से थनैला रोग की वजह से किसानों को अधिकतम नुकसान होता है (40 प्रतिशत) जबकि मुंहपका - खुरपका रोग एवं रक्त प्रोटोजोवा रोग नुकसान करने में क्रमशः द्वितीय एवं तृतीय स्थान पर हैं। प्राकृतिक आपदा की वजह से डेयरी पशुओं की मृत्यु, रोग की वजह से होने वाली मृत्यु के मुकाबले कम है जोकि क्रमशः 0.33 और 4.56 प्रतिशत है। तटीय ओडिशा में डेयरी एवं फसलों से सालाना क्रमशः 34000 लाख रुपये एवं 1898 करोड़ रुपये का क्षेत्रीय आर्थिक नुकसान पाया गया। करीब 44 प्रतिशत भूमि रहित किसान अधिक और अत्याधिक भेद्यता वर्ग में पाये गए। जबकि 50 प्रतिशत सीमांत किसान इस वर्ग में पाये गए। खेतों के आकार के बढ़ने से भेद्यता में घटाव पाया गया। खेतों की अवस्थिति भी भेद्यता का एक महत्वपूर्ण कारक था। भूमि रहित किसानों के लिए पशुपालन विविधीकरण सूची सबसे अधिक (0.631) पाया गया जिससे उनका जोखिम कम करने के लिए पशुपालन एवं विविधीकरण के प्रति निर्भरता प्रमाणित होता है। बीमा द्वारा पशु मृत्यु एवं फसल बर्बादी की नुकसान भरपायी क्रमशः 14 प्रतिशत एवं 20 प्रतिशत पाया गया। समग्र जोखिम कुशल कृषि योजना के अनुसार सघंता में बढ़ोत्तरी एवं नकदी फसलें जैसे कि मूँगफली और सब्जियाँ के क्षेत्र में बढ़ोत्तरी करने से जोखिम में घटाव आएगा। देशी गायों के मुकाबले किसानों द्वारा संकर गायों का दत्तक ग्रहण, अत्याधिक आय एवं जोखिम कुशल योजनाओं के लिए आवश्यक है। सारे ही कृषि योजना में बकरी एवं भेड़ों की आबादी में बढ़ोत्तरी को जोखिम कुशल कृषि उद्यम पाया गया चूँकि इससे आय बढ़ोत्तरी की निश्चितता है।

Chapter 1

Introduction

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INTRODUCTION

1.1 Background

Risk is pervasive in Indian agriculture on account of various reasons. Dairy often works as a risk covering enterprise for agriculture as it can sustain farm income in the case of a harvest risk, utilising the by-products. In comparison to the land, livestock follows a more equitable distribution of assets over the farming population. A study shows that landless and marginal farm households, possessing less than one hectare of land, which comprised 83 per cent of the total households, hold more than 50 per cent of the country's cattle and buffalo population and more than 60 per cent of the small animals as against their share of 30 per cent in landholding (NSSO, 2013). At aggregate level the average area owned per household has decreased significantly from 0.725 ha in 2002-03 to 0.592 ha in 2012-13 and a decrease in total bovine population holding from 230 million in 2003 to 204 million in 2012. With the decrease in landholding the greater onus falls on livestock population for more equitable development of the rural households. But the decrease in absolute number of bovines brings in more productive and crossbred animals to match the production needs with more risk associated inherently to them. By itself, the livestock and dairy sector is also susceptible to risk (Bardhan et al., 2006). The various risks prevailing in dairy production are natural calamities, death of animal, disease occurrence, decrease in yield, market risks, etc. These are further exacerbated by price fluctuations, weak rural infrastructure, imperfect markets and lack of financial services and instruments in the form of credit and insurance (NCAP, 2012). Vulnerability to risk and uncertainty severely impacts the livelihood of millions of small and marginal farm families across the country having larger share in dairy production with increasingly lesser holding of land resources.

Milk is one of the largest agricultural commodity contributing to GNP, making dairy sector a very important productive activity in Indian agriculture alongwith rice. As per Central Statistical Organisation estimates, the value of output for paddy and milk were Rs. 1,70,400 crores and Rs. 3,74,268 crores in 2014-15, respectively at constant prices of 2011-12 (CSO, 2017). The contribution of livestock sector to India's GDP has been increasing constantly over the years with a share of 4.5 per cent of GDP in 2015-16 (NDDB, 2018). It generates a regular flow of income to the farmer's family throughout

the year. It is recognized as an important activity suitable for employment generation and value addition in the agricultural sector in the Indian economy in general and for rural families especially, small and marginal farmers and landless agricultural labourers, in particular. The country's estimated milk production for the year 2016-17 was 165.4 million tonnes (NDDB, 2018) which is close to 17 per cent of world's milk production. During the same year, India's per capita availability of milk was 355 gm/day (NDDB, 2018), which has been showing an increasing trend over the past years. The importance of dairy sector can be further stated by the sectoral contribution of agriculture and livestock sector in total GDP. In 2015-16, the share of agriculture and livestock sector was found to be about 17.5 per cent and 4.5 per cent in total GDP, respectively, with more than 50 per cent of the country's population still engaged in agriculture as primary occupation (NDDB, 2018). Also over the last three decades, it was observed that though the share of agriculture in total GDP has decreased consistently, the share of livestock sector within agricultural GDP has been increasing (Govt. of India, 2015). So, livestock sector and particularly the dairy has been assuming role of greater importance in ensuring equitable economic development of the rural masses. The equitable distribution of assets in livestock improving livelihood can only be ensured if the risk involved is lowered. The poor socio economic conditions of the livestock holders make them more vulnerable to risk in this activity. Thus, addressing the risk is an important issue to ensure sustained economic development of livestock holders.

1.2 Problem Statement

India's eastern part is largely untouched from the benefits of green revolution and represents underdeveloped production environment with high dependence on agriculture. Odisha being a major state of eastern India also bears the same situation. The share of agriculture in GSDP of Odisha is around 21.57 per cent in 2016-17 with employment dependence of above 60 per cent of the population. The milk production and the per capita availability of milk in this region are quite low compared to the all India average figures. For the year 2016-17, the per capita availability of milk is stated to be 128 gm per day in Odisha against the all India average of 355gm per day (NDDB, 2018). The low production may be attributed to the various risks and uncertainties faced by the dairy farmers in terms of animal diseases, price risk, death of animal, milk yield variability, prolonged dry period of animals, etc. In addition, India's eastern coast is more vulnerable to natural calamities like flood and cyclones than the western coast of India (Patwardhan

and Narayanan, 2003). Among eastern states, Odisha faces huge risks from these extreme climatic occurrences and droughts as well. The substantial nature of risk can be very well understood from a reported negative growth of 3.53 per cent in GSDP of Odisha in 2013-14 because of cyclone *Phailine* and floods (Govt. of Odisha, 2014). Apart from this, the state also lags behind on account of poverty alleviation, access to marketing, road connectivity, etc. adding further to risks. Because of this, agricultural production also fluctuates over time. The food grain production was reported to be 64.18 lakh tonnes in 2015-16 as compared to 105.27 lakh tonnes in 2014-15 and 83.60 lakh tonnes in 2013-14 with paddy still continuing to be the dominant food crop accounting for more than 90 per cent of total crops (Govt. of Odisha, 2017). The percentage share of irrigated area under principal crops in Odisha was reported to be 28.30 per cent as against all India figure of 44.90 per cent.

In view of the huge risks faced by farming community, not many studies have been undertaken in India pertaining to risk and uncertainties in dairy production and particularly in an underdeveloped production environment like Odisha. It is pertinent to mention that, though the per capita national average of milk availability has been showing an increasing trend consistently from 281 gm per day in 2010-11 to 355 gm per day in 2016-17, the increase in case of Odisha for the same period has been very low from 113gm per day to 128 gm per day (NDDB, 2018). Also during the last three reported years, the per capita availability has remained almost constant for Odisha at 124, 124 and 128 gm/day for the periods of 2014-15, 2015-16 and 2016-17, respectively. Odisha has 10 agro-climatic zones covering 30 districts in total, two of the agro-climatic zones are coastal and rest are non-coastal. The coastal Odisha with a geographical area of about 24 per cent of the state accounts for about 51 per cent of the state's total milk production and about 40 per cent of the state's total HYV paddy production. Coastal Odisha is also more susceptible to natural calamities like cyclone and flood than the rest of the state on account of its geographical location. The present study aims at quantifying various risks and uncertainties faced by the dairy sector and vulnerability of the farmers to it. The study works out alternative risk mitigation plans for a household in the coastal region.

1.3 Researchable Questions

The research issues that the study addresses are:

Introduction

- What are the risks and uncertainty factors faced by the dairy farmers in Odisha state?
- What is the extent of vulnerability across different farm holding types integrating crop and livestock production?
- Whether the various risk coping strategies adopted by farmers are effective in context?
- What could be the risk efficient farm plans to achieve optimum crop and livestock production with lower risk?

The purpose of the study is to generate research output to be helpful in course of policy formulation. The topics that came under discussion were identification and quantifications of important sources of risks faced by the dairy farm households along with assessing their degree of vulnerability and formulation of risk efficient farm plans. The findings of the study would be useful to dairy farmers operating under subsistence production environment and also the policy formulators working in the field. Hence, keeping in view of the potential usefulness of the research investigation, the present study entitled **“Vulnerability of Dairy Farmers to Risk and Uncertainty in Coastal Odisha and Effectiveness of Coping Strategies”** has been undertaken with the following objectives.

1.4 Objectives of the Study

In order to answer the above researchable questions, the specific objectives of the present study are:

1. To analyse risk and risk factors at regional and farm level.
2. To assess vulnerability of dairy farmers to risk and uncertainty and determine factors affecting it.
3. To find out the effectiveness of alternate risk mitigation strategies adopted by the farmers.
4. To develop the risk efficient farm plans.

1.5 Scope of the study

The main aim of the study was to assess the various risks and their quantification affecting the dairy farmers of coastal Odisha which represents an underdeveloped production environment prevalent in most parts of India. Not many studies have been hitherto undertaken in this field and the present study would be a step to fill the gap.

Apart from risk factors, the degree of household level vulnerability of dairy farmers across different farm groups would be reflection of the true picture prevalent on ground. This will be helpful for the policy makers as well as the producers to devise suitable risk mitigation strategies.

The study also finds out the important strategies of risk managements along with their relative effectiveness. The contribution of some of the factual risk mitigation strategies helps in assessing their usefulness. The farmers need a comprehensive farm plan involving all the enterprises of crop and livestock to counter the risks faced by them. In this regard, the formulation of risk efficient farm plans helps the farmers in reducing risk to achieve given level of profit to improve their performance along with reduction in level of vulnerability.

1.6 Limitations of the study

Though ample care has been taken in designing the study to fulfill the proposed objectives, a few limitations could not be ruled out which are given as below.

- Due to non-availability of records at farmer's end the reliability of the data totally depends on the memory of the respondents.
- While quantifying the risk of losses due to animal diseases, only the diseases of importance were selected rather than all the diseases to avoid dilution of focus.
- The study is subject to limitations of small sample size.

Organisation of the thesis

The present thesis has been systematically organized into six chapters. The first chapter deals with the introduction, statement of the problem, objectives and scope of the study along with its limitations. The review of literature has been presented in the second chapter. The third chapter deals with the presentation of research methodology which covers locale of the study, sampling design, data collection and statistical tools applied to analyze the data. The fourth chapter represents the profile of the study area which gives brief idea about agriculture and livestock situation in the study area. The findings of the study along with their discussion are presented in the fifth chapter. The sixth chapter is the summary and conclusions, which emerged from the result of the study. At the end bibliography and appendices have also been attached.

Chapter 2

Review of literature

REVIEW OF LITERATURE

Review of relevant studies conducted over time and space help researcher to comprehend their findings, including the empirical analytical frame employed in the endeavor. Hence, pertinent literature is reviewed in this section. The review of studies presented here consist of both conducted in India and abroad and has been classified into four categories, viz.,

- 2.1 Risk and risk factors on dairy farms.
- 2.2 Perception of risk and effective management strategies.
- 2.3 Vulnerability of dairy farmers.
- 2.3 Risk efficient crop and dairy plans.

2.1 Risk and risk factors on dairy farms

In this section, it was aimed to analyse the farmer's perception about the various sources of risk along with their relative importance and also quantification of various risks faced by the dairy farmers through the incidence of disease, reproductive problems, mortality due to disease and natural calamities, etc. Studies pertaining to all the above parameters have been reviewed in the following section.

Jha (1994) conducted a study in Haryana assessing the risks faced by the mixed farmers of the state. The risk was assessed through two approaches namely through an instability index and the probability of failure. Secondary data pertaining to various fields of dairy and crops were studied upon and the fluctuation in the revenue was assessed as risk. The instability index was calculated as a product of coefficient of variation around trend and the square root of the unexplained portion of the variation in the trend equation. The probability of failure was taken as the probability of the returns falling 10 per cent or more below the trend values.

Singh (1997) conducted a study on the data from the FMD out break in IVRI to estimate the risk of economic losses accruing from it. The overall risk of economic losses from morbidity and mortality were found out to be Rs. 15.44 and Rs. 4.58, respectively which were respectively 3.16 per cent and 0.94 per cent of the value of the animal. The

risk of economic losses from morbidity and mortality combined was found to be Rs. 20.02 which was about 4.10 per cent of the reported value of the animal.

Schmit et al. (2001) conducted a study measuring the financial risk exposure to the New York dairy producers from 1988 through 1997. Two procedures were followed in this aspect namely, decomposition of the variance and decomposition of the Gini measure of income dispersion. The decomposition of variance suggested variability in purchased feed quantities and milk production to be the major contributors to variability in return. Milk price variability was found to be of lesser importance. The decomposition of Gini measure of income dispersion showed milk revenues and purchased feed expenditures to be the most important contributors in the variability in return. Lowering feed costs and maintaining high and stable milk production appeared to be the most important approaches that the dairy producers could adapt to address the financial risks.

Bardhan et al. (2006) conducted a study in the Tarai belt of Uttarakhand with the objective of identifying sources of risk found relevant by the farmers, examining farmer's risk attitude, identifying factors that affect risk attitudes and evaluating the relevance of different risk management strategies. Farmer's attitude towards risk was measured using an attitudinal scale approach. Adverse effect on family health was considered as a major source of risk by the farmers. Regression analysis was carried out ascertaining relationship between socioeconomic factors and risk attitudes.

Chand and Raju (2008) conducted a study in Andhra Pradesh assessing the risk pertaining to volatility in farm production, prices and farm income. They captured the risk associated through an instability index in three major crops. Instability index was constructed for the area of cultivation, production, yield, farm harvest prices and gross returns for crops like paddy, groundnut and cotton. Instability index is a unit free measure and captures deviation from the underlying trend.

Flaten et al. (2008) conducted a study in Norway comparing the risk exposure in composite Salmon farming and agricultural enterprises. An implicit error component model was used to analyze the risk structure of yields, prices of farm products and economic returns at the farm level. The study indicated a higher farm level year to year variability in yields, prices and economic returns in Salmon farming than in agricultural enterprises. Stochastic dominance tests in the form of distribution of economic returns

from aquaculture and agricultural farms suggested Salmon farming as the most risk efficient alternative activity.

Ali (2011) conducted a study in the Gujranwala district of Punjab province of Pakistan to study the economic losses occurring in dairy animals due to delayed conception. The study was conducted on primary data collected through pre tested questionnaire from the dairy farm households of the region. The study mainly focussed on the small farm households with greater dependence on dairy enterprise. The risk of losses due to delayed conception was found to be quite high with the average per day loss due to delayed conception in heifers and the average per day loss were found to be Rs. 293 and 199 days, respectively. The risk of per day loss per heifer was found to be about Rs. 212. The average per day loss due to delayed conception in lactating animals and the average per day loss were found to be Rs. 455 and 214 days, respectively. The risk of per day loss per lactating animal was found to be about Rs. 261.

Berentsen et al. (2012) conducted a study comparing the relative risk exposure to the conventional and organic dairy farming in The Netherlands. Risk assessment was conducted with regard to gross margin and the underlying price and production factors. Farm accountancy database containing farm level panel data was used for the same, for the period 2001 to 2007. Factors with respect to price and production risks were identified by using a gross margin analysis scheme. The main price risk factors were found to be the milk price and the concentrate price. The main production risk variables were found to be milk yield per cow, roughage yield per hectare and veterinary costs per cow. For assessment of risk, an error component implicit detrending method was applied and the resulting detrended standard deviations were compared for the two types of farming systems.

Bangar et al. (2013) conducted a study in the village areas of Pune division of Maharashtra state to assess the risk of mortality rate in cattle. Overall morbidity and mortality rates in cattle were found to be 22.24 per cent and 4.42 per cent, respectively. Reproductive and digestive diseases were found to be the major causes of morbidity with 7.09 per cent and 5.14 per cent, respectively. Digestive and nutritional diseases were found to be the major causes of mortality at 1.43 per cent and 0.85 per cent, respectively.

Benni and Finger (2013) conducted a study analyzing the farm level panel data for Swiss dairy farmers between 1990 to 2009 investigating how agricultural policy

reforms and market liberalization has affected the gross revenue risk of Swiss dairy producers. Applying the variance decomposition method on the detrended data the effects of output prices and yield were studied on the revenue risks over three different time periods. A simulation model was used to evaluate the revenue risks in animal based support for roughage consuming cattle. Price was found to be the greatest contributor to revenue risk and yield risk was found to be increasing over the time.

Briner and Finger (2013) conducted a study on Swiss dairy farmers regarding the effect of price and production risks on optimal farm plans. Swiss dairy production is often restricted by the contracts between the farmers and the marketing agent, which are on monthly or yearly basis. The contracts are assumed to put restrictions on the flexibility of farmers to cope with fluctuations in milk price as well as fodder availability. Applying a bioeconomic whole farm model, the effect of price and weather risks as well as different risk management strategies on the gross margin and variability of gross margin in Swiss dairy production was evaluated in two different milk contract systems.

Kumar et al. (2013) undertook a study to analyse the risk of extra cost of management of anestrus buffaloes under field condition of India. They found out substantial risk of economic losses due to lowered production as well as extra cost of rearing the animal. The risk of approximate economic loss per animal per day due to anestrus condition was found to be Rs. 373.

Tiwari et al. (2013) conducted an analysis regarding risk of economic losses due to the impact of various infectious livestock diseases in India. They concluded that India alone loses about 4.45 billion US dollars (Rs. 20,000 crores) per year due to the uneconomic performance of the animals because of the adverse impact of diseases. They also concluded that foot and mouth disease and reproductive disorders are the two most harmful diseases prevalent in South Asia with significant risk of economic losses. The AICRP FMD project in 2005 had estimated an annual loss of Rs. 15,000 million per year in India due to FMD. According to them, Indian farmers also face a great deal of risk from mastitis with the annual economic losses estimated at Rs. 4,365 crores in 2001.

Ashfaq et al. (2014) conducted a study analysing effects of livestock diseases on dairy production and incomes in Faisalabad district of Punjab province of Pakistan. They found out the risk of morbidity in cows from the diseases namely mastitis,

haemoglobinuria and FMD were 5.8 per cent, 4.1 per cent and 18.43 per cent, respectively which is quite high. The risk of occurrence was also found to be higher in case of small farmers than the large farmers. The share of economic losses from the four diseases of mastitis, haemoglobinuria, FMD and tick infestation were found to be 9.01 per cent, 4.39 per cent, 70.25 per cent and 16.35 per cent, respectively. The risk of economic losses in case of cows was found to be Rs. 3659 per farm and Rs. 1873 per animal in case of mastitis, Rs. 4021 per farm and Rs 2059 per animal in case of haemoglobinuria, Rs. 25951 per farm and Rs. 13286 per animal in case of FMD, Rs. 8865 per farm and Rs. 4539 per animal in case of tick infestation. The total risk of losses out of the above four diseases were found to be Rs. 42497 and Rs. 21756 per farm and per animal, respectively.

Hossain et al. (2014) conducted a retrospective study on the risk of mortality of dairy cattle in the Central Cattle Breeding and Dairy Farm (CCBDF), Dhaka for the period 1992 to 2007. The overall mortality rate was found to be 5.6 per cent. The mortality rate of crossbred animals was found to be higher than the indigenous animals. The female cattle were found to die more (55.71 per cent) than the male cattle (44.29 per cent). The mortality rate was also found to be higher during rainy season (37.98 per cent) followed by winter (33.03 per cent) and summer (28.99 per cent).

Singh et al. (2014a) conducted a study estimating the economic losses due to haemorrhagic septicemia in cattle and buffaloes in India. The study took into consideration the various direct and indirect losses due to haemorrhagic septicemia in cattle and buffaloes. The total economic losses were calculated by using the following components, viz. loss from mortality, direct loss in milk yield, losses due to reproductive failures in affected bovines, loss in animal draught power, loss due to reduction in growth of calf, cost of treatment of affected animal and opportunity costs. It was found out that the risk of losses were distributed to be about 23 per cent and 77 per cent due to morbidity and mortality, respectively. The share of direct and indirect losses were found to be 80.3 per cent and 19.7 per cent of the total economic losses, respectively. The risk of total economic losses due to haemorrhagic septicemia was found to be Rs. 6816 and Rs. 10901 in case of cattle and buffaloes, respectively which is very substantial.

Singh et al. (2014b) conducted a study on 300 livestock owners of Purvanchal region of Uttar Pradesh and determined the morbidity, mortality and case fatality rate of

different livestock diseases using standard statistical procedures. The livestock were found to be at higher risk from the diseases namely haemorrhagic septicemia, foot and mouth disease, mastitis and trypanosomiasis. The overall risk of morbidity was found to be 15.5 per cent, 7.1 per cent and 5.3 per cent, respectively for mastitis, haemorrhagic septicemia and trypanosomiasis. The risk of losses due to mastitis per lactation in non-descript cow, crossbred cow and buffaloes were found to be Rs. 868, Rs. 1314 and Rs. 1272, respectively. The risk of losses due to trypanosomiasis was found to be Rs. 3328, Rs. 6193 and Rs. 9872 in case of non-descript cow, CB cow and buffaloes, respectively. Overall the study revealed risk of significant losses in large ruminants due to diseases.

2.2.1 Perception of risk and effective management strategies

Studies in this section involved the analysis of farmer's perception about the various strategies of risk mitigation along with their relative importance and also quantification of various activities of risk management adopted by the dairy farmers viz. diversification of farm enterprise and adoption of livestock insurance, etc. Studies pertaining to all the above aspects have been reviewed in the following section.

Boggess et al. (1985) conducted a study in North Florida and South Alabama regarding agricultural producer's perception of risk. A statistically random survey was conducted capturing the farmer's perception of various risks and risk management strategies. Summary statistics, chi square analyses and logistic regression techniques were used to analyse the data. Production risks were categorized as the most important category of crop risks followed by market risks and financial risks. Livestock risk was considered lesser than the crop risks.

Wilson et al. (1988) conducted a study on the dairy farmers of Arizona on their risk perception and management responses. Risk and variability associated with various production inputs like feed, labour, credit, etc were found to be of equal importance as the fluctuating milk prices and milk production of cows. Producers resort to various management tools like forward contracting of feed, etc to reduce these variabilities. The study also attempted to group individual dairy producers into risk related groups based on their various socioeconomic variables.

Bosch and Johnson (1990) conducted a study on evaluating the risk management strategies followed by dairy farms in the Virginia state of the USA. Simulation models for representative dairy farms were used to evaluate crop insurance

and hedging as risk management strategies. The variability and fluctuations in feed prices and crop yields were generally perceived as important sources of risk to dairy farms. It was found that the preferred strategies for higher levels of risk aversion were a combination of crop insurance and hedging.

Meuwissen et al. (2001) conducted a study on 612 livestock farmers in The Netherlands and studied the farmer's perception of risk and risk management. Analysis was conducted to associate these perceptions and management strategies with the different farm and farmer characteristics. Varimax rotated factor loadings were used for descriptive analysis and multiple regressions were used to study the relationships of the strategies with the characteristics. In general, the price and production risks were perceived as the important sources of risk. Insurance was found as an important strategy of risk mitigation. It was also found that the dairy farmers gave more importance to price risks while the mixed farmer gave more importance to the production risks.

Flaten et al. (2005) conducted a study in Norway exploring the organic and conventional dairy farmer's perception of risk sources and risk management strategies. This was conducted by examining the relationship between different farm and farmer characteristics, risk perception and mitigation strategies adopted. The study involved 363 conventional farm households and 162 organic farm households. Organic farmers were found to possess the least risk averse perceptions. Financial measures namely higher liquidity, decreased costs of production, disease prevention and insurance were perceived as important ways of handling risk.

Bardhan et al. (2006) in their study in the Tarai belt of Uttarakhand tried to analyse the relative importance of different risk management strategies followed by the dairy farmers. The farmer's response was captured on a structured questionnaire and the different forms of risk management options were assessed in a likert scale of 1 to 5, with 1 meaning least important and 5 meaning most important. The most important risk mitigation strategies were found to be applying strict and proper hygiene, ensuring production at lowest possible cost and buying of personal insurance. They also constructed a farmer's risk attitude score and found out the most important factors by means of regression analysis. The most important factors affecting the risk attitude were found to be herd size, off farm work and the number of dependant members.

Liyama et al. (2007) conducted a study on the most rural households in the semi-arid regions of sub-Saharan Africa to assess the adoption and effectiveness of Crop-livestock diversification patterns in dealing the livelihood risks arising out of rapid population growth and decrease in arable land for cropping. As intensive crop and livestock production was needed in dealing with the situation the study aimed at understanding the divergent patterns of intensification and their relation to the economic needs of the households. Principal Component Analysis was used to identify the effective crop and livestock diversification (CLD) patterns which reflect complementarities between crop and livestock types. An assessment of association was also made between CLD patterns and the economic returns. The most important out of the five identified CLD patterns was found to be the one in which households kept improved cattle and grew fruits.

Njavro et al. (2007) in their study in North west Croatia, analysed risk management strategies followed in dairy farms with specific focus on livestock insurance. The information related to farmer's risk perception, application and evaluation of risk management strategies along with governmental insurance premium subsidy was used in the study. Livestock insurance was found to be an effective strategy of risk management having positive effect on income stabilization, consequently leading to higher level of specialization, credit access and competitiveness. It was also found that demand for livestock insurance depends on farm structure, access to other risk management instruments as well as dairy farmer's risk management capacities.

Belhenniche et al. (2009) conducted a study on 80 Livestock farmers in Normandy which is one of the biggest dairy producing areas of France. The aim was to study farmer's perception regarding risk and risk management and establishing relationship between these strategies and dairy processing plants. Likert scales were used to capture data regarding risk perceptions and management and varimax rotated factor loadings along with multiple regressions were used as tools of study. Institutional risks and the price volatility pertaining to the input and outputs were found to be the major sources of risk.

Kumar et al. (2011) conducted a study in Tamil Nadu assessing the effectiveness of agricultural insurance schemes and crop diversification index as a measure of risk mitigation. The study employed farm level study across 600 households. They utilized Probit and Tobit models to analyze the factors affecting adoption of these

mitigation strategies. The crop insurance schemes like National Agricultural Insurance Scheme and Weather Based Crop Insurance Scheme were found to be of great importance among farmers.

Khan et al. (2014) conducted a study in Gorakhpur district of Uttar Pradesh to analyse risk perception and risk management strategies followed by the insured and non-insured dairy farmers. The study involved comparative data from insured and non-insured farmers numbering 120 each documenting the farmer's risk perception, risk management strategies and various socio economic characteristics. Climatic variability, epidemic livestock diseases, marketing constraints, feed cost variability, poor conception rate and delay in treatment or artificial insemination were found to be the most relevant sources of risk for the dairy farmers. Likewise vaccination of animals, having own agricultural land, having financial reserve, life insurance, livestock insurance and off farm employment were found to be the most relevant risk management strategies for the dairy farmers. The intensity and domination of risk and risk management tools adopted by dairy farmers was also reported to vary due to their personal perceptions of risk, socio economic status, institutional arrangements and farm type.

Maiti et al. (2014) conducted a study in coastal West Bengal and Odisha to assess the risks facing livestock rearers of that region due to climate change and various adaptation strategies adapted by them to cope up with the change. The climate induced risks faced by the livestock rearers has increased their vulnerability. Under this study 480 farm households rearing livestock were selected from 4 coastal districts of Odisha and West Bengal and the importance and effectiveness of about 17 adaptation strategies were checked through an exclusive climate change adaptation index. The most preferred adaptation strategies were found to be change in micro climate in cattle shed/grazing area/stall followed by frequently providing clean and fresh drinking water to the animals. The other strategies which found effective were, opting for livestock insurance, promotion of local breeds and increasing non-farm income, etc.

Megersa et al. (2014) conducted a study in Borana region of Ethiopia to assess the role of livestock diversification in countering the risk of household level food security under changing climatic conditions. The risk of food insecurity out of recurring droughts and huge cattle losses was found to be forcing the Bopana herders to shift from cattle pastoralism to multi species composite herding. The study examined the role of livestock diversification as a tool in combating the risk of household level food

insecurity using herder's perceptions, a modified household food security access scale (mHFIAS) and dietary diversity score. Livestock diversification was found to be a major factor affecting household food security. Households practising livestock diversification were found to have significantly lower months of food insecurity (2.3 vs 3.8), lower mHFIAS (5.5 vs 8.7) and a higher average offtake in terms of livestock sales (7.4 vs 4.0) than the non-diversified ones. Livestock diversification was also found to improve the quality of dietary intake of specific food groups and also the number of meals consumed per day on an average.

Dube et al. (2016) conducted a study using primary data collected from 60 farm households to study the farm level crop diversification using Entropy index. It was assumed that crop diversification is an effective risk mitigation strategy for smallholder farmers, and the study aimed at understanding the socioeconomic characteristics influencing crop diversification decisions using a censored Tobit model. The mean Entropy index value was found to be 0.88 suggesting a very high level of crop diversification among the farmers. In the study, crop diversification was found to be positively influenced by the gender of head of the household, production of cash crops and household level investment in basic farm equipments. On the other hand, the age of head of farm household, total farm size, access to agricultural markets and total area cultivated were found to have negatively influenced crop diversification. The study further recommended to increase the capacity of female headed households in farm decision making and promoting household investments in basic farm equipments as a measure to promote crop diversification.

Sharma and Choubey (2016) conducted a study on rural households of Sikkim to assess livelihood diversification as a risk mitigation strategy. On the primary data obtained from 300 rural households selected randomly an enquiry of diversification of livelihood and distribution of rural income was made by the application of Simpson's diversification index. The extent of diversification from Simpson's diversification index was found to be 0.55 and using Gini coefficient ratio the inequality in income distribution was assessed.

2.2.2 Vulnerability of dairy farmers

This section is aimed to analyse relative level of vulnerability of a farm household measured in terms of susceptibility to disturbances determined by exposures

to perturbations and the capacity to adapt. The relative level of vulnerability for different categories of farm households is further elaborated by the contribution of different factors towards it. All these are very important from the perspective of proper policy formulation in an underdeveloped production environment and studies pertaining to these, are reviewed in the following section.

Kelly and Adger (2000) conducted a study in the coastal Vietnam finding vulnerability of tropical storm impacts and other natural calamities at household and community level and drawing adaptive response to climate change. Suitable indicators were determined first and then normalized by the maxi-min technique of subtracting the minimum value from the actual value and then dividing by the range for each of the indicators. Proper weights were assigned to them for construction of the final index.

Luers et al. (2003) conducted a study in the Mexico to develop a method to quantify vulnerability applicable to the agricultural systems. Vulnerability was quantified as the expected value of the sensitivity of selected indicators to identified stressors divided by the state of the indicators of concern relative to a threshold of damage. Vulnerability was represented as an accounting of a minimum potential for a system's ability to adapt and respond to changes in circumstances. The method was followed by identification of outcome indicators of concern, identifying the stressors of concern, modelling of the relationship of the outcome indicators to the stressors, calibrating the stressor outcome model from the baseline data.

Swain and Swain (2011) conducted a study to assess the nature of vulnerability to agricultural drought in three blocks of Bolangir district of western Odisha. A composite drought vulnerability index was constructed (CDVI) by using indexing and vulnerability profile method. They utilised 19 key vulnerability indicating factors, of which six were bio-physical and 13 were socio economic in nature. The most influential biophysical factors were found to be rainfall variability, drought intensity and shortage of available water holding capacity of the soil, and the three most important socioeconomic factors were found to be poor crop insurance coverage, low irrigation development, and smaller forest area.

Kumar et al. (2012) conducted a study in the Tamil Nadu state of India constructing a farm level Climate Variability Vulnerability Index (CVVI). The study involved above 600 farm households. The CVVI was constructed as a function of

exposure, sensitivity and adaptive capacity. Procedure similar to the Human Development Index of UNDP was adopted in constructing the index. The indicator data was normalized depending on their functional relationship. Next to that weights were attached to the indicators using a Principal Component Analysis (PCA) before constructing the index. The farm households were categorized into 5 types viz. less vulnerable, moderately vulnerable, vulnerable, highly vulnerable and very highly vulnerable.

Deressa et al. (2008) conducted a study analysing the vulnerability of Ethiopian farmers based on the integrated vulnerability assessment approach using vulnerability indicators. Relatively least developed semi-arid and arid regions namely Afar and Somali were found to be highly vulnerable. Development of Irrigation network for regions with high irrigation potential was proposed to reduce the vulnerability. Apart from this, facility for early drought warning systems to help farmers better cope in times of drought and rearing of drought tolerant varieties of crops and species of livestock was proposed to reduce the vulnerability of Ethiopian farmers.

Piya et al. (2012) conducted a study analyzing the micro level vulnerability of rural Chepang community in Nepal utilizing the data collected from 221 Chepang households from four villages located in four different districts. In Nepal, the rural households are heavily dependant on the natural resources for livelihood and they have to frequently adjust to the vagaries of natural calamities. The study assumes vulnerability as a function of exposure, sensitivity and adaptive capacity and suitable indicators have been selected under the three broad fields. The indicator values were normalized by subtracting the observed value from the mean and dividing it by the standard deviation for each indicator. The household level index had been constructed after assigning proper weights to the indicators by principal component analysis. The study emphasizes the need to focus on micro level vulnerability study as the poorest section of society are often the most vulnerable ones and are missed out in macro level study. The study implies that exposure of a locality to long term changes in climate variables and occurrences of natural disasters were the most important components to determine the overall vulnerability of the locality. The study also has concluded that the poor households with low adaptive capacity were the most vulnerable irrespective of their location and should be the prime target of any policy intervention.

Can et al. (2013) conducted a study in the Giang province of Mekong delta of Vietnam which is often exposed to climatic variability and annual floods and thus, considered as one of the most vulnerable regions. A Livelihood Vulnerability Index (LVI) was constructed on the basis of household level data collected from 120 households from each village. Suitable indicators had been chosen under the five major components namely Human Capital, Natural Capital, Social Capital, Physical Capital and Financial Capital parameters and the subsequent sub components under them. The indicators were normalized by subtracting the values from the minimum value and dividing over the range for each indicator. The index for the subcomponents was constructed by simple average of the indicators while proper weights were assigned to the index of five major components to arrive at the overall Livelihood Vulnerability Index (LVI). The index was analysed for the better off and poor segments of the region and the poor segment of the region was found to be more vulnerable than the better off segment.

Maiti et al. (2015) conducted a study assessing the social vulnerability to climate change of the 29 eastern coastal districts across four eastern coastal states of India by using the 'Integrated vulnerability assessment approach' and the IPCC definition of vulnerability. Here also vulnerability has been assumed as a function of exposure, sensitivity and adaptive capacity and the suitable indicators under the three categories pertaining to socio economic and bio-physical parameters were selected. The study involved secondary data and macro level vulnerability assessment was carried on rather than household level study. The indicators were normalized by subtracting the value from the minimum value and dividing over the range for each indicator. Following this, the index has been computed by assigning proper weights to the indicators through Principal Component Analysis. The study found out the Pudukottai district of Tamil Nadu to be the most vulnerable while the East Godavari district of Andhra Pradesh was found out to be the least vulnerable. The net effect was also found to be negative for 10 districts including the Bhadrak district of Odisha which is indicative of an alarming situation.

2.2.3 Risk efficient crop and dairy plans

This section deals with the deterministic techniques of linear programming in terms of Minimisation of Total Absolute Deviation (MOTAD) model to suggest risk efficient farm plans in terms of reallocation of resources and better return to farmers in

view of the constraints. Linear programming technique can also be taken as a measure to counter the risks facing farm households quantified by the negative deviation from the mean value for different farming activities. Studies pertaining to these things have been reviewed in the following section.

Kennedy and Francisco (1974) conducted a study formulating farm production plans using both Hazell's MOTAD model as well as Focus Loss Constrained Programming (FLCP) technique. The three different formulations of MOTAD and FLCP used in their study found to perform equally well. They further stated that if the necessary time series data on gross margin were available, the MOTAD formulations were easy to run and had the flexibility in interpretation.

Boussard (1976) conducted a study comparing alternative models –portfolio selection approach, chance constrained programmes and game theory approach. He suggested that though quadratic programming was theoretically appealing was very much difficult to apply from practical point of view. He considered some linear approximation approach specially Hazell's MOTAD model to be much important for practical purposes though it appeared to lack theoretical support.

Watts et al. (1984) conducted a study comparing MOTAD and Target MOTAD risk income frontiers for a representative 400 acres farm in eastern Wyoming. They stated that if rational producers do not attach disutility to high income as to low income years, then the Target MOTAD model appears a more plausible approach for examining risk return trade-offs and is also more consistent with recent risk literature.

Romero and Rehman (1985) conducted a study assessing potential usefulness of the Multiple criteria Decision Making (MCDM) criteria and further covered the Goal programming and other related methodologies such as Multi objective programming (MOP), Compromise Programming, Multi Goal Programming and Generalised Goal Programming. They also focussed on methods of dealing with uncertainty and risk in farm planning models by demonstrating the incorporation of Game theory principle and MOTAD approach within MCDM framework.

Zimet and Sprean (1987) presented analysis of a typical crop and livestock farm in North Florida involving Target MOTAD model. The authors incorporated the potential competition and complementarities among crop and cattle enterprises in formulating the Target MOTAD model. The Target MOTD model was also found to be

more effective in comparison to MOTAD in dealing risk return trade offs across enterprises and formulation of the study.

Kang and Myoung (1988) conducted a study examining trade-off between risk-return in efficient farm planning with MOTAD and Target MOTAD approaches for an assured representative farm in South Western Oklahoma. Despite many assumptions and limitations in the analysis, the MOTAD approach by and large was found to offer some ideas about the possible efficient crop combinations at different risk return levels. Target MOTAD was found to be inflexible in the demonstration of the trade-off in this farm situation.

Novak et al. (1990) carried out a study applying Target MOTAD to assess the risk and returns of sustainable cotton crop rotations from old rotation experimental plots at Auburn University, Alabama, USA. Ten years of observations on deviations from target income were used to identify optimal sustainable rotation.

Parton and Cumming (1990) applied Target MOTAD model as an easy to use method of incorporating the downside risk aspects. They used it for farm decision making under financial pressure. The analysis of downside risk and introduction of a trade-off between financial and business risks were key features of the model. The study suggests that, the potential roles of new enterprises in farm plan can be easily tested by inclusion of generated prices and yields in the simulated years and by including establishment costs in the fixed financial obligations. The study further concludes that, Target-MOTAD technique offers a way of modelling the effects of fixed financial obligations in a volatile business environment.

Ortman (1992) conducted a study evaluating major mathematical programming technique used in farm planning and reported that quadratic programming (QP) is limited by availability of suitable algorithm. MOTAD was found to be computationally efficient and provided acceptable solutions compared with those derived using QP. Utility efficient programming appeared to have considerable potential of the safety first model and Target MOTAD seemed to be the most useful in that. Game theory models were found to form plans which were conservative.

Jha (1994) conducted a study in Haryana drawing a comparison of risk-return analysis with MOTAD and Target MOTAD. The MOTAD result was analysed as trade-off between risk which was defined as deviation from mean return and expected return.

But this approach was subjected to question as risk is not independent and is rather dependent on mean return. From farmer's point of view, the negative deviation from a fixed level of acceptable target was found to poses a threat. So the Target MOTAD model appeared to be theoretically more convincing for planning under risk. Also Target MOTAD model appeared to provide the details of short fall from target return under different years / situations for a particular enterprise combination.

Zia (1998) conducted a study trying to develop risk efficient resource allocation in agricultural systems of Pakistan. Farm plans were developed to ensure optimum utilisation of available farm resources for a given level of risk, leaving farmers to choose the most suitable to their production environment and attitude towards risk. The study aimed to reduce the decision space that risk programming models generate and there by making the decision making process easy for the farmers. It used compromise programming techniques together with risk planning methods for developing the best compromise farm plans which appear to be very useful in resource allocation and minimization of risk. Under the mean variance (E-V) efficiency criteria, it is assumed that the decision maker is risk averse with a quadratic utility function. In this analysis, linear approximation to MOTAD model was employed to develop a Compromise MOTAD.

Visagie et al. (2004) conducted a study to analyse farm planning decisions focusing on producer risk preferences. The study attempts to identify the optimal mix of crops and the number of animals the farm needs to manage the crop production risk for a range of risk levels. A mixed integer linear programming model in the form of MOTAD and target MOTAD was applied to model the decision environment for an integrated crop and livestock farm. The deviation of income from the expected value was used as a measure of risk.

Flaten and Lien (2005) Conducted a study applying a two stage stochastic utility efficient programming model with recourse applied to an organic dairy farm, and to illustrate how this model to be used in a stochastic dominance framework examining farm strategies and policies under various scenarios. This approach included both risk aversion in the decision maker's objective function as well as both embedded and non-embedded risk. The study did not find any important shifts in the resource use with increased risk aversion and the risk averse farmer was not found to be worse off than the

risk neutral farmer. Other factors such as production constraints and institutional constraints appeared more important for the farm plan than the degree of risk aversion.

Kehkha et al. (2005) conducted a study applying MOTAD Risk programming model in the Fars province of Iran exploring the effects of risks on the cropping pattern and farmer's income. Risk effects on resource shadow prices were also investigated in the study. The study established that the variability in the crops' gross margin or outcomes do have a significant effect on the cropping patterns. Diversification was also found to be an important tool in ensuring farm income certainty and a trade-off tool between risk and expected income.

Mesfin (2014) conducted a study on the small holder farmers of eastern high lands of Ethiopia to determine the crop mix and resource pattern under risk. The study involved primary data obtained from 175 households in eastern Ethiopia. MOTAD model was used to formulate various risk efficient plant utilizing optimum enterprise and resources combination. The most prominent sources of risks were identified to be drought, pests and diseases, poor market bargaining power, lack of disease resistant varieties, soil fertility decline and high input prices. The results of the MOTAD model suggested that farmers are risk averse and they are much oriented towards risk-minimization. Proper application of fertilizers or shifting to substitutes was found to reduce the effects of risk.

Kaseva et al. (2017) conducted a study analysing the optimal agroforestry enterprise mix under production risk in Mbooni west district of Kenya using linear programming and MOTAD models. As the most arid and semi-arid regions of Kenya had been experiencing deterioration in agricultural productivity translating into food insecurity and low levels of farm revenues, different agroforestry techniques have been disseminated to the farmers as a mitigation strategy. The study emphasized to take agricultural production risk into consideration for any policy intervention as agricultural production is a risky activity. First the influence of production risk on net returns of various agroforestry enterprises were determined and then the trade-off between the variability of net returns and expected returns to farm resources in the study area were determined. The MOTAD model results confirmed that farmers in the study area to be sensitive to production risk which influence their choice of farm enterprises and resource allocation. It was also found out that farmers' production decisions were not optimal but rational in the sense that they are risk minimizing.

2.5 Knowledge Gaps

The present study is designed to take necessary inputs from the studies already conducted in the proposed research area. It further envisages to address certain shortcomings in the previous studies. The study of risk and risk factors in previous studies have mainly been concentrated upon the agriculture and crop sectors with very little effort given to animal husbandry and dairy sector. The present study is proposed to keep its primary focus on dairy and animal husbandry sector. Previous studies of vulnerability have mainly been conducted in context to the climatic risks and variability. The dairy sector though acts as a risk covering agent for agriculture, is itself very much susceptible to risk and uncertainties. Here the vulnerability study of dairy farmers envisages a study taking into consideration the actual risk factors facing the dairy farmers rather than the broad climatic occurrences. The study also deals with finding out the factors affecting their level of vulnerability for necessary policy incorporations. Farm planning is incomplete without taking all the activities present including crop, animal husbandry, fishery, etc. In the present study, risk efficient composite farm plans are proposed to be formulated bringing all farm activities to one platform and allowing risk trade-off among them.

Chapter 3

Research Methodology

RESEARCH METHODOLOGY

The present chapter deals with the sampling design, data collection and analytical framework. The analytical framework describes the methodology that was adopted for the attainment of the research objectives. A detailed description of research methodology is cited in the succeeding sections.

- 3.1 Sampling Design
- 3.2 Data collection
- 3.3 Analytical Framework

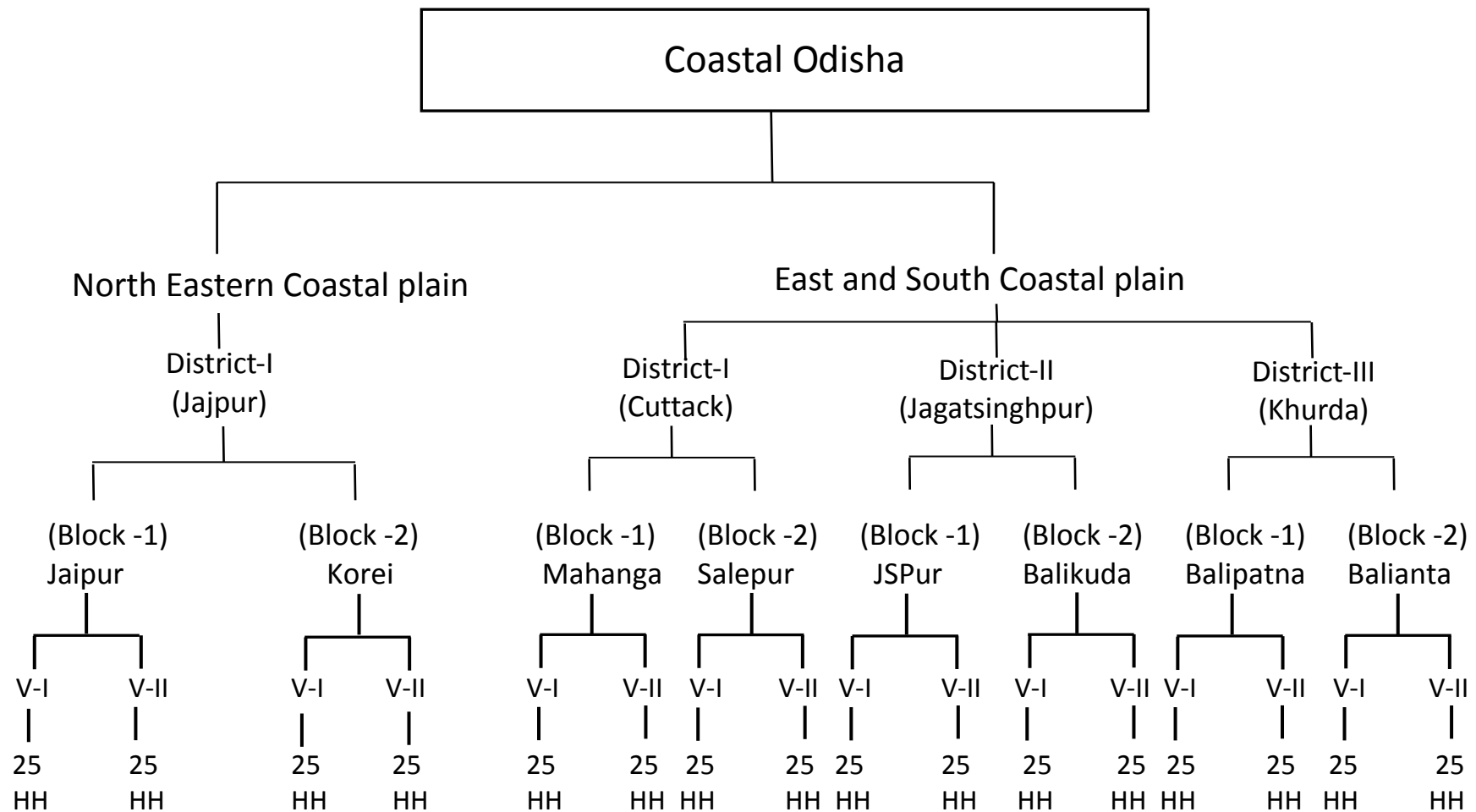
3.1 Sampling Design

Sampling design includes the steps followed in the selection of the sampling unit i.e. respondent households.

Coastal Odisha was selected purposively for the study. The justification for selection of this region is given in the problem statement. Coastal Odisha comprises of 2 agro-climatic zones namely North eastern coastal plain and East & south eastern coastal plain. The North eastern coastal plain has 3 districts in it namely Balasore, Bhadrak and Jajpur while the East and south eastern coastal plain has 7 districts in it namely Jagatsinghpur, Kendrapara, Cuttack, Khurda, Puri, Nayagarh and Ganjam. Total four districts were selected by proportional allocation from two agro-climatic zones i.e. Jajpur was selected from North eastern coastal plain and the districts from South eastern coastal plain were Cuttack, Jagatsinghpur and Khurda. From each district, two blocks were to be selected randomly taking eight blocks in total. Two villages were selected randomly from each block making it sixteen villages in total.

Before selection of households, a complete enumeration of households in each village was carried out having dairy enterprise with operational land holdings. The groups of households holding at least one milch animal were categorised on the basis of their operational holdings into marginal, small and medium categories by adopting cumulative square root method of stratification (Appendix). A category of landless household was also kept in the study. A sample comprising of 25 households was then allocated to each village having representation from all categories on proportionate basis and were selected randomly from the respective category.

Figure 3.1 – Sampling design for data collection



* V-I = Village 1, V-II = Village 2, HH = Household

Total Sample Size = 400 Households

3.2 Data collection

Primary household level data were captured through a detailed survey schedule prepared for the study. Data were collected on the various perceptions of risk and risk management, actual hazards faced, various management strategies adopted, land holding, livestock holding, farm and family income, cropping pattern, assets holding, family labour, agricultural and livestock input uses, prices of agricultural outputs etc., using pre-tested interview schedule from 400 dairy farm households spread across 2 coastal agro-climatic zones of Odisha. Information was also collected from veterinary doctors and from the offices of animal husbandry department of state about occurrence of diseases and implementation of livestock insurance scheme.

3.3 Analytical framework

The objective-wise analytical tool and technique used in the present study have been discussed in this section.

3.3.1 Analysis of risk and risk factors at regional and farm level

The analysis under this objective was divided into two parts capturing the risk factors in farmer's perception at household level and secondly quantifying the major risks faced by farmers. The amount of loss caused at regional level was proportionately upgraded based on the proportion of animal and type of household.

3.3.1.1 Factors of risk in farmer's perception

The perception of farmers on risk factors in dairy farming was collected using personal interview method on a pre structured schedule. For assessment of farmer's perception towards various sources of risk, the relevant sources of risk were identified first. The respondents were then asked to elucidate their perception towards different sources of risk in a Likert type scale of 1 to 5 with 1 representing non relevant and 5 representing very relevant for a particular factor. Likert's scale has been widely used in various studies due to its suitability in measuring an individual's perception and attitude as established in various studies like Chattopadhyaya (1963), Samanta (1977), Bhattacharya (1993), Wilson et al. (1993) and Meuwissen et al. (2001). The responses of the farmers were measured on a 5-point scale. Strong sense of irrelevance (Score-1) implied the relative unimportance nature of a particular source of risk. On the other hand, strong sense of relevance (Score-5) indicated relative high importance of a particular

source of risk. In between the two extremes somewhat irrelevant (score-2), Neutral (score-3) and somewhat relevant (score-4) were inserted as alternative responses.

Various sources of risks shortlisted in consultation with farmers were

1.-Price of milk	11.-Silent heat condition
2.-Animal Diseases	12.-Anoestrus condition
3.-Health situation of farm family	13.-Unavailability of credit
4.-Change in consumer preferences for milk and milk products	14.-Lack of extension support
5.-Change in interest rate of finance	15.-Distant location of AI centre or veterinary hospital
6.-Milk yield variability	16.-High cost of treatment / Medicines
7.-Ability to pay back loans	17.-Failure of vaccination
8.-Technical adoption (Adoption of CB animals)	18.-Disposal of unproductive animals
9.-Unavailability of green fodder in all seasons	19.-Cost of concentrates
10.-Poor conception rate due to AI	20.-Disposal of surplus milk

Average scores for the various sources of risk was taken across households along with their respective standard deviations to assess their relative importance. Factor analysis was applied to club the number of variables with $\lambda \geq 1$ to study the varimax rotated factor loadings for different sources of risk (Meuwissen et al., 2000) and grouping them into different categories based on their relative contribution. For factor analysis, it was assumed that the standard parametric statistical procedures are appropriate for ordinal variables in the form of Likert type scale (Wilson et al., 1993, Patrick and Musser, 1997).

3.3.1.2 Quantification of various risks faced by dairy farmers

The quantification of various sources of risks faced by the dairy farmers was carried out for four major sources as listed below. In each case an attempt was made to estimate the losses in value terms using methods discussed in the following sections.

- (a) Economic losses due to repeat breeding in dairy animals.
- (b) Economic losses due to disease incidence in dairy animals.

- (c) Economic losses from mortality of dairy animals due to natural calamities and diseases.
- (d) Economic losses from crop damage due to natural calamities and other reasons.

The detailed methodology for them is given as below.

3.3.1.2.1 Economic loss due to repeat breeding in dairy animals

Delayed conception is one of the most prominent causes of economic loss in dairy farming with repeat breeding. Generally, an animal is expected to get pregnant again within 2-3 months post parturition, failing which it is treated as a case of delayed conception. Repeat breeding is a condition where the animal fails to conceive after 3 attempts of service even though it exhibits normal oestrous cycle. It poses a very high risk of economic loss for dairy farming.

Under this study, only those animals were selected out of the total herd whose conception was delayed beyond the voluntary waiting period of 90 days and which failed to conceive after 3 services post parturition. For lactating animals under tropical humid conditions of India generally 90 days base line is considered as a standard period within which the animal normally should conceive. This is considered as a bench mark of reproductive index and is known as voluntary waiting period.

The second part of economic losses under the same was considered the delay in maturity of a heifer. The age of maturity is an important reproductive parameter for dairy animals. Many studies have reported the age of maturity of animals in Indian context. Kumar (2004) studied and reported the age of maturity for CB cows and buffaloes to be 20 months and 24 months respectively. The age of maturity for buffaloes is generally considered to be at par with the local cows. These values seem to be low with respect to tropical conditions and the present study did not involve any buffaloes as none of the sampled households reared them. So the age of maturity under present study has been taken as 24 months and 36 months for CB and Local cows respectively which seems quite practicable from coastal Odisha point of view.

The number of days delayed in heifers was counted from the age of maturity. The date of first service in heifers was noted first and also the time of conception. In case the heifer failed to conceive after 3 services, the extended period was taken as days delayed. In case of a lactating cow any delay beyond the voluntary waiting period of 90 days and 3 services were taken as the days delayed.

The economic losses were calculated per affected animal, per animal and per household.

The value of economic loss was calculated using the following components.

Total Loss (L_R) = Treatment Cost (T) + Extra Breeding Cost (B) + Value of Milk Production Loss (M) + Extra Feeding Cost (F) + Extra Labour Cost (L)

Treatment Cost (T): Treatment cost for heifers and lactating animals affected were captured as per the treatment provided to the affected animals by the farmers.

$$\text{Treatment Cost (T)} = \frac{\sum_{i=1}^r T_i}{r}$$

T_i = Treatment cost incurred on i^{th} animal,

r = Number of animals affected of repeat breeding.

Extra Breeding Cost (B): Extra breeding cost in heifers and lactating animals was captured as

$$\text{Extra Breeding Cost (B)} = \frac{\sum_{i=1}^r (S_{ni} * C_s)}{r}$$

S_{ni} = Number of services per conception in i^{th} animal affected of repeat breeding,

C_s = Cost of one service,

Value of Milk Production Loss (M): Loss of milk production is the most significant loss for a dairy farmer on account of extended period of conception out of repeat breeding condition. The milk production loss was calculated for the milch animals as follows.

Average milk yield (litres/day) per animal was worked out by the standard procedure of dividing the lactation yield of an animal by the average lactation length.

$$\text{Value of milk production loss (M)} = \frac{\sum_{i=1}^r (Y_{mi} * P_{mi} * D_{di})}{r}$$

where, Y_{mi} = Average milk yield (Litres/day) of i th animal affected of repeat breeding, which was estimated as Average milk yield of an animal (Litres/day) = $Y_m = \frac{\text{Peak yield} * 200}{305}$

P_{mi} = Unit milk price (Rs./Ltr.) of i th animal affected of repeat breeding,

D_{di} = Number of days delayed (Days) of i th animal affected of repeat breeding,

Extra Feeding Cost (F): Feeding cost often constitutes up to 65 per cent of the cost of rearing of animals. So the extra feeding cost arising out of delayed conception for repeat breeding is very important and is calculated as below.

$$\text{Extra Feeding Cost (F)} = \frac{\sum_{i=1}^r (D_{di} * F_{ci})}{r}$$

D_{di} = Number of days delayed (Days) of i th animal affected of repeat breeding,

F_{ci} = Per Day Feeding Cost of the i th animal affected of repeat breeding.

Extra Labour Cost (L): Labour cost is also an important portion of cost of animal rearing constituting upto one third of total cost (Baral and Bardhan 2016). The extra labour cost was calculated as below

$$\text{Extra Labour Cost (L)} = \frac{\sum_{i=1}^r (D_{di} * L_{ci})}{r}$$

L_{ci} = Per day incurred labour cost of i^{th} animal affected of repeat breeding,

The total economic loss accrued upon the affected animals due to repeat breeding when distributed over the whole animal population gives the risk of loss per animal and when distributed over total number of household, it gives the risk of loss per household.

3.3.1.2.2 Economic loss due to disease incidences in dairy animals

The risk of economic losses arising out of animal diseases is a very important threat to the dairy farmers. Diseases cast a very negative influence on the livestock production system setting off a cascading effect of low production, low income and subsistence livelihood (Singh et al. 2014). The consequences of diseases in animals are quite complex and very often go beyond the immediate loss of production. The various effects can be decreased productivity, loss of animal and incurred cost of treatment. The

various diseases affecting animals in a particular region may vary substantially. The losses accruing to various diseases occurring in dairy animals were studied through the primary data collected at farm household through structured schedule. The economic losses due to disease incidence were calculated in case of per affected per animal and per household.

The value of economic loss was calculated using the following components.

Total Loss (L_k) = Mortality Loss (MO) + Loss due to decreased milk yield (MY) + Treatment cost (TC)

The above expression gives loss value for the kth disease.

Mortality loss (MO): Mortality Loss was calculated for the diseases in which mortality is a high occurrence i.e. the blood protozoan diseases of Trypanosomiasis and Theileriosis. Mortality loss is calculated as per given below.

$$\text{Mortality loss (MO)} = \frac{\sum_{i=1}^n V_{ki}}{d_k}$$

N = no of animals died due to kth disease

V_{ki} = Market value of ith animal died due to kth disease,

d_k = Number of animals affected in the kth disease.

Loss due to decreased milk yield (MY): Loss due to reduction in milk yield = Value of direct reduction of milk yield

The loss due to decreased milk yield was calculated for the milch animals using the same method as described earlier in case of repeat breeding condition.

Treatment cost (TC): Treatment cost for heifers and lactating animals were captured as per the treatment provided to the affected animals for the diseases affecting it.

$$\text{Treatment Cost (TC)} = \frac{\sum_{i=1}^d T_{ki}}{d_k}$$

T_{ki} = Treatment cost incurred on ith animal for kth disease,

d_k = Number of animals affected in the kth disease.

The total economic loss accrued upon the affected animals for a particular disease when distributed over the whole animal population gives the risk of loss per animal for that particular disease and when distributed to total number of households gives the risk of losses per household from a particular disease. In order to estimate total economic losses from disease per affected animal, per animal and per household, the losses from all four diseases were summed up and divided by the total number of affected animal to the animal population and total number of household, respectively.

Finally the affected economic loss due to animal diseases may be calculated based on their probability of occurrence and can be calculated as below.

$$L_{pk} = L_k * p_k$$

Where, L_{pk} = Expected loss from k^{th} disease,

L_k = Reported loss in the k^{th} disease,

p_k = Probability of occurrence of k^{th} disease.

The information as probability of occurrence of particular disease was taken from farmers as well as veterinary doctors working in the area.

3.3.1.2.3 Economic loss from mortality of dairy animals due to natural calamities and disease incidence

Indian peninsula is prone to various forms of natural calamities occurring at frequent intervals. The various forms of calamities affecting are flood, cyclone, draught, etc. It is reported that India's eastern coast is more vulnerable than the western coast with respect to frequency of occurrence of extreme events like cyclones and depressions (Patwardhan and Narayanan, 2003). Coastal Odisha has frequently been affected by floods and cyclones which results in loss to agriculture and livestock sector.

The mortality rate of animals accruing due to natural calamities was calculated on the basis of the reported mortality in the last 5 years due to natural calamities. The value of the animals died has been estimated as per the current prices and the overall risk of loss was calculated as rupees per standard animal unit (SAU) per animal. An economic loss due to mortality was estimated by multiplying the average annual mortality rate with the average value of animal. The mortality rate was calculated as given below

$$\text{Annual Mortality Rate} = R(n) = \frac{M(n)}{T} * 100$$

where, $R(n)$ = Average annual Mortality Rate (per cent)

$M(n)$ = Avg. annual mortality of animals due to natural calamities (SAU)

T = Total standard animal unit in the study area

$$\text{Economic loss due to Mortality} = R(n) * V(n)$$

where $V(n)$ = average value of the animal died

Then average annual economic loss due to mortality was estimated per household

$$L(n) = \frac{M(n) * V(n)}{H}$$

where, H = Number of households in the concerned study.

The average annual economic losses were determined separately from natural calamity and due to diseases using the same procedure as discussed above.

3.3.1.2.4 Economic loss from crop damage due to natural calamities and other reasons

Per acre crop damage is given as

$$C(n) = \frac{D(n)}{A}$$

where, $C(n)$ = Crop damage from natural calamities (Rs./Acre/Annum)

$D(n)$ = Total annual crop damage from natural calamities (Rs./Annum),

A = Total area of cultivation (Acre/Annum).

Per household crop damage is given as

$$= C(n) * \text{average size of landholding per household}$$

3.3.1.2.5 Regional loss risk due to animal diseases and mortality

The per animal loss value due to repeat breeding, animal diseases and mortality was projected over the regional animal population to arrive at the regional loss risk.

Regional loss risk due to repeat breeding is obtained as

$$L_R = R_r * P$$

Where, L_R = Regional loss from repeat breeding (Rs./Annum)

R_r = Loss per animal due to repeat breeding (Rs./Animal)

P = Regional breedable population of animal

Regional loss risk due to animal diseases is obtained as

$$L_{Dk} = R_k * P$$

where, L_{Dk} = Regional loss from the k^{th} disease (Rs./Annum)

R_k = Loss per animal from k^{th} disease (Rs./Animal/Annum)

P = Regional population of animal

Loss for all the four animal disease is combinedly obtained as

$$(L_D) = \sum_{k=1}^4 R_k * P$$

Regional loss risk due to mortality of animals is obtained as

$$L_M = L(n/d) * P_S$$

where, L_M = Regional loss from mortality of animals (Rs./Annum)

$L(n/d)$ = Loss due to natural calamity or disease mortality of dairy animals (Rs./SAU)

P_S = Regional population of animals expressed in SAU

3.3.1.2.6 Regional loss risk due to crop damage

The per acre loss value due to crop damage was projected over the regional net sown area to arrive at the regional loss risk.

$$L_C = C(n/o) * A_S$$

where, L_C = Regional loss from crop damage (Rs./Annum)

$C(n/o)$ = Crop damage from natural calamities or other reasons (Rs./Acre/Annum)

A_S = Net sown area of the region

3.3.2 Vulnerability of dairy farmers to risk and uncertainty and factors affecting it

Vulnerability has been conceptualised in different ways across different disciplines and has been the focus of many research studies in recent times. It has been conceptualised in different ways in many previous studies ranging from (Liverman,

1990), (Cutter et al., 2009), (Nelson et al., 2010) and (Maiti et al., 2015) as is discussed in review of literature chapter.

3.3.2.1 Concept and Components of vulnerability

Vulnerability has three components Exposure, Sensitivity and Adaptive Capacity with “Exposure” defined as the direct dangers facing dairy enterprise, “Sensitivity” as the conditions that can ameliorate the hazard or trigger an impact and “Adaptive capacity” as the potential to implement adaption measures that will help avert potential impacts.

There are many approaches to study vulnerability, like econometric method, indicator method and index based method etc, but the index based method has been used in majority of the studies (Maiti et al., 2015). So the index based method was followed in the present study to formulate farm level vulnerability index for the dairy farmers of coastal Odisha.

Often research done at regional or national level data fail to capture the location specificity of smaller areas and even at the local level the most marginalised community must be the focus as they are the ones which are most vulnerable (Piya et al., 2012). So a farm level vulnerability index computation has been taken up as the subject of current research to assess the vulnerability of dairy farmers to risk and uncertainty based on primary farm level data. The vulnerability index can be expressed as a function of exposure, sensitivity and adaptive capacity with the expression of the model as given below.

Farm Level Vulnerability Index = f (Exposure, Sensitivity, Adaptive capacity)

The 1st two components together represent the potential impact and adaptive capacity is the extent to which these impacts can be averted. So the vulnerability (V) can be given as potential impact (I) less adaptive capacity (AC) (Kumar et al., 2012).

$$V = (I - AC)$$

Each of the component of vulnerability was measured through indicators as discussed below:

3.3.2.1.1 Exposure Indicators

This measure the extent of direct risk faced by the household which was approximated through, the five indicators as listed under

- 1 - Economic loss due to repeat breeding in last 1 year / SAU.
- 2 - Income loss due to disease incidence in last 1 year / SAU
- 3 - Value of dairy animals died due to natural calamities in last 5 years (Current Prices) / Present herd size SAU
- 4 - Value of Dairy animals died due to disease incidence in last 5 years (Current Prices) / Present herd size SAU
- 5 - Marketed surplus of milk produced

3.3.2.1.2 Sensitivity Indicators

These are the conditions that can ameliorate the hazard or trigger an impact of risk factors. The sensitivity of the farmers was approximated using following indicators.

- 1 - Crossbred (SAU) / Total (SAU)
- 2 - Intensity of poverty
- 3 - Livestock Income / Total Farm Income
- 4 - Amount of Veterinary Expenditure / Animal
- 5 - Milk Yield / SAU

3.3.2.1.3 Adaptive Capacity Indicators

This is the potential to implement adaption measures that will help avert potential impacts, of risk factors and it was approximated

1. - Per capita off farm income	8. - Membership in PACS
2.- Literacy level / Adult family member	9. - Proportion of irrigated land of total land holding
3. – Experience of agriculture	10. - Family Labour / Animal
4. - Farm's size / SAU	11. - Farm Diversification Index
5. - Membership in MCS	12. - AH Diversification Index
6. - Proportion of farm to HH income	13.- Total farm assets / area of farm
7.- % of crop area / livestock insured (Value)	

A detailed description of the indicators is given in Table No. 3.1

Table – 3.1. Indicators of vulnerability components

Determinants of Vulnerability	Vulnerability Indicator	Unit of Measurement & (Symbol)	Description of the Indicator	Apriori functional relationship
Exposure (Direct Danger)	Economic loss due to repeat breeding in last 1 year / SAU	Rs. / SAU (ELRB)	The loss accruing to an animal for repeat breeding condition. Total Loss is measured as Treatment Cost (T) + Extra Breeding Cost (B) + Value of Milk Production Loss (M) + Extra Feeding Cost (F) + Extra Labour Cost (L)	(+)
	Income loss due to disease incidence in last 1 year / SAU	Rs. / SAU (ELDS)	The loss accruing to an animal for any disease incidence. Total Loss is measured as Mortality Loss (Large Animal + Small Animals) + Loss due to milk yield + Treatment cost (Large Animal + Small Animals)	(+)
	Value of Dairy animals died due to natural calamities in last 5 years (Current Prices) / Present herd size SAU	Rs. / SAU (MNC)	The mortality of farm animals due to various natural calamities were considered for last 5 years to arrive at annual average. Values expressed in current prices.	(+)
	Value of Dairy animals died due to reasons other than natural calamities in last 5 years (Current Prices) / Present herd size SAU	Rs. / SAU (MDC)	The mortality of farm animals due to various disease conditions were considered for last 5 years to arrive at annual average. Values expressed in current prices.	(+)

	Marketed surplus of milk produced	Per cent (MSM)	The milk production and disposal of a farm household were expressed in terms of fat corrected milk. The marketed surplus expressed as per cent.	(+)
Sensitivity (Conditions ameliorating impact)	Crossbred SAU / Total SAU	Ratio (CBP)	The crossbred animal holding and the total animal holding of the farm household were expressed in standard animal unit (SAU). The ratio expressed in per cent.	(+)
	Intensity of poverty	Number (IPV)	The minimum income criteria of Rs. 32 / Head / Day was taken as the base of poverty line for rural areas. The intensity was calculated as $\{(Actual\ income - Minimum\ income) / Actual\ income\} * 100$	(+)
	Livestock Income / Total Farm Income	Ratio (LIFT)	The income from livestock and total farm income per annum were calculated and the ration of them was taken	(+)
	Amount of Vety. Exp / Animal	Rs. / SAU (VETE)	The total veterinary expenditure incurred on the farm animals per annum for a household was taken and was divided upon the total livestock holding of that household expressed in SAU	(+)
	Milk Yield / SAU	Ltr. Of FCM / SAU (MYS)	The total fat corrected milk production of a particular farm household was divided upon the total livestock holding expressed in SAU	(-)

Adaptive Capacity (Adoption measures averting impact)	Per capita off farm income	Rs. Per capita (POFI)	The annual income from off farm sources for a household was estimated and was expressed as per capita amount	(-)
	Literacy level / Adult family member	Schooling Years in number (LAF)	The literacy level of the adult family members were taken as the number of years of schooling. The total schooling years for all the family members was divided upon the number of adult family members	(-)
	Experience	Number of Years (EXP)	Number of years of experience in dairy farming for the head of the family	(-)
	Farm's size / SAU	Acres / SAU (FRMS)	The total farm size expressed in acres was expressed a ration up on the total livestock holding expressed in SAU	(-)
	Membership in MCS	Binary Variable (MCSM)	Given value "1" for membership and "0" otherwise	(-)
	Proportion of farm to HH income	Per cent (FHFI)	The income from farm for a household was expressed as ratio to the total household income	(-)
	% of livestock insured (Value)	Per cent (LINS)	The value of livestock insured in a farm household was expressed as a percent of the total value of livestock holding	(-)

	Membership in PACS	Binary Variable (MPAC)	Given value “1” for membership and “0” otherwise	(-)
	Proportion of irrigated land of total land holding	Per cent (IRRI)	The proportion of irrigated land to the total land holding of the household expressed in per cent	(-)
	Family Labour / Animal	Number / SAU (FAML)	The total family labour available for a family was expressed in terms of man hour equivalents and was expressed as a ratio upon the total livestock holding expressed in SAU	(-)
	Farm Diversification Index	Number (FRMD)	Herfindahl diversification index calculated for the crop enterprises for a farm spread over an year	(+)
	AH Diversification Index	Number (AHDI)	Herfindahl diversification index calculated for the present livestock holding in terms of SAU	(+)
	Total farm assets / area of farm	Rs. / Acre (ASST)	The value of total farm assets like tractors, power tiller, water pump, tanks etc. was expressed in terms of Rs. and was expressed as ration up on the total farm area in acres	(-)

3.3.2.2 Normalisation of different indicators

Calculated of vulnerability index as the different indicators shortlisted were in different scale and parameters, it makes them non additive in nature. So to bring them under comparable range they need to be normalised first (Feroze and Chauhan, 2010). For normalising the indicators though many methods have been tried in several studies, maximin method was used in the present study which has been used in several indian studies like (Hatai and Sen, 2008, Feroze and Chauhan, 2010 and Maity et al., 2015). This methodology was also used in UNDP's Human Development Index formulation. So normalisation was done by subtracting the minimum value from the observed value and dividing by range which is expressed as below.

$$X_{ij} = \frac{X_{ij} - \text{Min } X_i}{\text{Max } X_i - \text{Min } X_i}$$

where, X_{ij} is the value of the indicator j corresponding to the household.

3.3.2.3 Assigning weights through Principal Component Analysis

After normalization of the indicators the next step is to assign them proper weights for calculation of index. Many methods have been used in previous studies like expert judgement, arbitrary choice of equal weights and statistical methods such as principal component analysis and factor analysis (Kumar et al., 2012). But assigning all the indicators is taken as a subjective method and literature shows that indicators do not equally affect vulnerability (Hebb and Morsch, 2007). So Principal component analysis (PCA) was carried out to assign weights to different indicators like in case of (Piya et al., 2012, Maiti et. al., 2015).

Conceptually, PCA is a multivariate statistical technique for finding patterns in data of high dimension. Once the patterns hidden in data are identified, PCA helps to compress the data by reducing the number of dimension without much loss of information. In original data indicators may be correlated and PCA help to transform them into uncorrelated variables.

The steps followed for calculating the weights through PCA and construction of indices for each dimension of vulnerability was as follows:

Step- I : Compute $\hat{X} = X'_s X_s$

$$\begin{matrix} (k \times k) & (k \times n) & (n \times k) \end{matrix}$$

where, X_s ($n \times k$) is the normalized data matrix, X'_s ($n \times k$) is the transpose of normalized matrix and, n and K are the number of observations (districts) and number of indicators used.

- Step- II : Conversion of the array ($\dot{X}$) into symmetric matrix.
- Step –III : Eigen value decomposition of the symmetric matrix to get principal components.
- Step – IV : Selection of eigen vectors corresponding to the largest eigen value i.e., first principal components say ' W ($k \times 1$)' explaining the maximum variation.
- Step –V : Compute $\dot{Y} = X_s W$
($n \times 1$) ($n \times k$)($k \times 1$)
- Step-VI : Construction of final index by dividing the $\dot{Y}$ with sum of the first principal components.

The normalised indicators were multiplied as described above by the respective weights assigned to construct the indices separately for each component of vulnerability (exposure, sensitivity and adaptive capacity).

$$CI = \sum_{i=1}^k \left[\frac{X_{ij} - \text{Min } X_i}{\text{Max } X_i - \text{Min } X_i} \right] * b$$

where, 'b' is the value of assigned weights and CI = Component index.

Finally vulnerability index was calculated as

$$V = (E + S) - AC$$

Where, V = Vulnerability index,

E = Exposure index,

S = Sensitivity index,

AC = Adaptive capacity index.

3.3.2.4 Determining classes of vulnerability

The computed vulnerability index provided values for all the households distributed over a range depicting their relative positions. So it was necessary to classify these farm households into distinct classes based on their relative vulnerability. There are various methods available to determine stratum boundaries, cumulative square root of

frequency (CSRF) method allows greater efficiency for setting stratum boundaries (Singh and Mangat, 1996). CSRF methodology breaks down the population into intervals, which can be of equal or unequal width. The steps involved in its calculation are given below:

- a. Evaluate the data and determine the units that can be reviewed on an actual basis.
- b. Stratify the remaining data into ranges or classes. Number of classes and class interval are determined using the formulas given as below:

$$\text{No. of classes} = 2.5 \times (\text{number of samples})^{1/4}$$

$$\text{Class interval} = \frac{(\text{Largest figure} - \text{smallest figure})}{\text{No. of classes}}$$

- c. Determine the frequency for each range. This is the number of units within the range.
- d. Calculate the square root of the frequency.
- e. Calculated from the cumulative series of square root frequencies..

The cumulative square root frequency value of the last class is divided by the number of sample strata desired (can vary from 3 to 9) to get the cumulative square root value for each item.

Suppose, we desire to have 5 strata, then the upper limit of the first strata is determined using the formula as given below:

$$L_i = \left[\frac{Y_{i-1}}{\sqrt{f}} + (Y_i - Y_{i-1}) \left\{ \left(\frac{S_k}{L} \right) - S_{i-1} \right\} \right] \dots \dots \dots \text{Value 1}$$

Where, L_i = Upper limit of the i^{th} strata (In this case first strata)

L = Number of strata

Y_i = Upper limit of the class in which L_i lies

Y_{i-1} = Lower limit of the class in which L_i lies

S_k = Cumulative square root frequency value

$\sqrt{f}$ = Square root of the frequency of the i^{th} class in which L_i (S_k/L) lies

S_{i-1} = Cumulative square root frequency of the preceding class in which L_i (S_k/L) lies

$Y_i - Y_{i-1}$ = Width of the class in which in which L_i (S_k/L) lies

For the upper limit of second strata, the formula is:

$$L_i = \left[\frac{Y_{i-1}}{\sqrt{f}} + (Y_i - Y_{i-1}) \left\{ \left(\frac{S_k}{L} \right) \times 2 - S_{i-1} \right\} \right] \dots \text{Value 2}$$

ue 2

For the upper limit of third strata, the formula is:

$$L_i = \left[\frac{Y_{i-1}}{\sqrt{f}} + (Y_i - Y_{i-1}) \left\{ \left(\frac{S_k}{L} \right) \times 3 - S_{i-1} \right\} \right] \dots \text{Value 3}$$

ue 3

For the upper limit of fourth strata, the formula is:

$$L_i = \left[\frac{Y_{i-1}}{\sqrt{f}} + (Y_i - Y_{i-1}) \left\{ \left(\frac{S_k}{L} \right) \times 4 - S_{i-1} \right\} \right] \dots \text{Value 4}$$

ue 4

For the upper limit of fifth strata, the formula is:

$$L_i = \left[\frac{Y_{i-1}}{\sqrt{f}} + (Y_i - Y_{i-1}) \left\{ \left(\frac{S_k}{L} \right) \times 5 - S_{i-1} \right\} \right] \dots \text{Value 5}$$

ue 5

In this way, five strata were formed i.e., below value 1, between value 1 and value 2, between value 2 and value 3, between value 3 and value 4 above value 5 up to last value.

Distribution of vulnerability index values was suggestive of five classes of vulnerability viz., Less vulnerable, Moderately vulnerable, Vulnerable, Highly vulnerable and Very highly vulnerable. The above procedure was also followed to classify the farm households into distinct classes of five divisions for Exposure Index, Sensitivity Index and Adaptive Capacity Index.

3.3.2.5 Determining factors affecting vulnerability.

Regression analysis was carried out between household level vulnerability index and the household characteristics and the alternative mitigation strategies. Care was taken to exclude those variables which are already been taken in construction of the vulnerability index. Functionally, Vulnerability index (VI) = f (Household characteristics, Alternative mitigation strategies)

$$VI = a_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + b_6 x_6 + b_7 x_7$$

Where x_1 = Education Score of the HH (Average number of years of schooling of members)

x_2 = Distance from nearest market (Expressed in kms)

x_3 = Distance from nearest KVK (Expressed in kms)

x_4 = Percentage of irrigated land (Percentage of irrigated land in total land)

x_5 = Dependency ratio (Proportion of employed family members of total)

x_6 = Capital adequacy ratio (Proportion of loan amount to total annual farm capital)

x_7 = Region wise dummies (0 for region-1 and 1 for region-2)

3.3.3 Effectiveness of alternate risk mitigation strategies adopted by the farmers.

Risk mitigation can be both by risk reduction and risk diffusion (Jha, 1994). Present study was conducted to analyze for both. The detailed methodology is given as below.

3.3.3.1 Alternative strategies of risk reduction

The study of alternative strategies of risk reduction was done on the basis of primary data collected from farm households capturing the farmer's perception regarding various practices of risk management. It was carried out on the same line as the study for farm level risk analysis. For assessment of farmer's perception towards various practices of risk management, relevant practices of risk management were identified first. The respondents were then asked to elucidate their perception towards various risk management practices in a Likert type scale of 1 to 5 with 1 representing irrelevant and 5 representing very relevant for a particular factor. The responses of the farmers were measured on a 5-point scale. Strong sense of irrelevance (Score-1) implied the relative unimportance of a particular practice of risk management. On the other hand strong sense of relevance (Score-5) indicated relative high importance of a particular practice of risk management. In between the two extremes somewhat irrelevant (score-2), Neutral (score-3) and somewhat relevant (score-4) were inserted as alternative responses.

Various practices of risk mitigation considered under the study are

- 1 Production at lowest possible cost
- 2 Buying livestock or crop insurance

- 3 Buying personal insurance
- 4 Applying hygienic practices
- 5 Price contract for outputs
- 6 Price contract for inputs
- 7 Farm diversification
- 8 Off farm employment
- 9 Carrying adequate cash reserve
- 10 Vaccination of animals
- 11 Proper housing and sanitation

Average scores for the various practices of risk mitigation was taken across households along with their respective standard deviations to assess their relative importance. Factor analysis was applied to club the number of variables with $\lambda \geq 1$ to study the varimax rotated factor loadings for different risk mitigation practices (Meuwissen et al., 2000) and grouping them into different categories based on their relative contribution.

3.3.3.2 Alternative strategies of risk diffusion

The study of alternative strategies of risk diffusion was carried out mainly on the two aspects listed as below.

- (a) Enterprise diversification
- (b) Adoption of livestock insurance
- (c) Adoption of crop insurance

3.3.3.2.1 Enterprise diversification

A farm involves two types of risks. The first is non diversifiable as it is correlated with the farm portfolio referred to as systematic risk and the second component is not correlated with variations in the farm portfolio termed as non-systematic risk which can be eliminated by diversification of the farm (Jha, 1994).

There are quite few methods, which explain either concentration (i.e. specialization) or diversification of farm activities in a given time and space. Each method has some limitation and/or superiority over the others. Some of them are:

- 1) Herfindahl index (H.I)

- 2) Ogive index (O.I)
- 3) Entropy index (E.I)
- 4) Modified entropy index (M.E.I)
- 5) Simpson Diversification index (S.D.I)
- 1) **Herfindahl index (H.I):** It was for the first time used by Theil in 1967. Herfindahl index is the sum of square of the proportion of each farm activity in the total farm activity. With an increase in diversification, the sum of square of the proportion of activities decreases, so also the indices. The Herfindahl index takes a value one when there is complete specialization and approaches to zero as N gets large, i.e. if diversification is perfect. The major limitation of the index is that it cannot assume the theoretical minimum, i.e., zero for smaller values of N.
- 2) **Ogive index (O.I):** This index was first used by Tress (1938) to measure industrial diversity. It measures the deviations from benchmark given by equal proportion of each activity. e.g., if there are N activities, the norm used for measuring deviation is $1/N$. Like H.I, the Ogive index is also a measure of concentration.
- 3) **Entropy index (E.I):** The Entropy index is a direct measure of diversification having a logarithmic character. The Entropy index increases with an increase in diversification. The Entropy index approaches zero when the farm is specialized and there is perfect specialization, i.e., P_i equals one and takes a maximum value when there is perfect diversification. The upper limit of the Entropy Index is determined by the base chosen for taking logarithms and the number of crops. The upper value of the index can exceed one, when the number of total crops is higher than the value of the logarithm's base, and it is less than one when the number of crops is lower than the base of logarithm. The major limitation of the Entropy Index is that it does not give a standard scale for assessing the degree of diversification.
- 4) **Modified entropy index (M.E.I):** The Modified Entropy index is used to overcome the limitations of the Entropy index by using a variable base of logarithm instead of a fixed base of logarithm. The MEI is equal to $EI/\log N$. It is worth mentioning that the base of the logarithm is shifted to 'N' number of farm

activities. This index has a lower limit equal to zero when there is complete specialization or concentration and it assumes an upper limit of one in the case of perfect diversification i.e. it is bounded by zero and one. The Modified Entropy Index imparts uniformity and fixity to the scale used as a norm to examine the extent of diversification. The MEI however measures deviations from equal distribution among existing activities i.e. the number of crops only, and does not incorporate the number of activities in it. This index measures diversification given the number of farm activities and the index is not sensitive to change in the number of farm activities (Shiyani and Pandya 1998).

- 5) **Simpson Diversification index (S.D.I):** Considering our objective of assessing the extent of diversity in crop and livestock we used Simpson Index. The index provides a clear dispersion of commodities in a geographical region. The index ranges between 0 and 1. If there exists complete specialization, the index moves towards 0. The index is easy to compute and interpret. Simpson Diversity Index has been constructed for farm households on the basis of its popularity to analyze the extent of crop and animal husbandry diversification using following formula-

$$DI_j = 1 - \sum_{i=1}^n (P_i^2)$$

where,

DI_j = diversification index of j^{th} component { j = crop (area) and livestock (in no.) }

P_i = proportion of the i^{th} variable (crop/livestock) in their respective total.

The present study involved computation of Simpson diversification index as a measure of studying enterprise diversification.

3.3.3.2.2 Adoption of livestock insurance

Inspite of the best manage mental practices, some amount of risk are always inherent to the system. Insurance is an effective tool risk diffusion for those categories. Adoption of insurance is an alternative option in this regard. It has been dealt with the following measures for livestock and crop insurance.

Proportion of farmers insured is obtained as

$$P(I) = \frac{F(I)}{F}$$

Where, $P(I)$ = Proportion of farmers insured

$F(I)$ and F are Insured number of farmers and total number of farmers, respectively

Proportion of animals insured is obtained as

$$P(I) = \frac{A(I)}{A}$$

Where, $P(I)$ = Proportion of animals insured

$A(I)$ and A are number of animals insured and total number of animals in SAU, respectively

Proportion of loss recovered by insurance claim receipt is obtained as

$$\frac{\sum_{i=1}^n Cl_i}{\sum_{i=1}^n Am_i}$$

Where, Cl_i = Insurance claim amount received by i^{th} farmer (Rs.)

Am_i = Value of loss due to animal mortality for i^{th} farmer (Rs.)

n = Total number of farmers

3.3.3.2.3 Adoption of crop insurance

The effectiveness of crop insurance adoption as an alternative tool of risk mitigation is dealt with the following measures.

Proportion of farmers insured is obtained as

$$P(I) = \frac{F(I)}{F}$$

Where, $P(I)$ = Proportion of farmers insured

$F(I)$ and F are Insured number of farmers and total number of farmers, respectively

Proportion of crop insured is obtained as

$$P(I) = \frac{A(I)}{A}$$

Where, $A(I)$ and A are insured and total cropped area in acres respectively

Proportion of loss recovered by insurance claim receipt is obtained as

$$\frac{\sum_{i=1}^n Cl_i}{\sum_{i=1}^n Cd_i}$$

Where, Cl_i = Insurance claim amount received by i^{th} farmer (Rs.)

Cd_i = Value of crop loss for i^{th} farmer (Rs.)

n = Total number of farmers

3.3.4 Risk efficient crop and dairy plans

The formulation of risk efficient farm plan for a mixed farm can be considered as the selection of an appropriate set of crop and dairy activities for the farm and of the most suitable level at which each activity is to be conducted at minimum risk. The superiority of linear programming techniques over budgeting and gross margin analysis for farm planning purposes is an established fact. The study utilises linear programming techniques in formulation of farm plans. Recognizing the difficulty in working out the optimum plans for each of the selected farm households individually, the resource use data and input-output coefficients of selected respondents of similar groups were pooled and averaged to form synthetic farm plans for each category of farm. The farm plans were obtained for mixed farm holdings of marginal, small and medium farms of average holdings at 1.57, 3.28 and 5.22 acres respectively.

3.3.4.1 Optimum farm plan

Before we proceed to discussion of risk efficient farm plans, an optimum farm plan was worked out using simplex method of linear programming. In this maximum profit that can be attained within the framework of available resource constraint was estimated which was used as the maximum limit to parametrise in MOTAD model. The profit maximising linear programming problem (LPP) was formulated as shown below. The specification of this profit maximisation model can be given as below.

$$\text{Maximize } Z_i = \sum_{i=1}^n C_i X_i$$

Subject to:

$$\sum_{i=1}^n a_{ij} X_j \leq b_j, \text{ Where } j = 1, \dots, m$$

$$X_i \geq 0$$

Where, Z_i = Total return to fixed farm resources from farm activities

C_i = Return to fixed farm resources for ith activity

b_j = availability of jth resource

In short, maximization of total gross margin or return over variable cost is regarded as equivalent to maximisation of annual profit from the farm. Therefore, the above model maximizes returns to fixed farm resources to derive optimal plan which is combination of activity levels which is feasible in terms of constraints.

3.3.4.2 Risk efficient farm plan

A realistic farm plan should consider not only the return from an activity but also the contribution of individual activity to risk in farm portfolio. With this impression, risk efficient production plans were developed by using MOTAD (Minimisation of Total Absolute Deviation) model (Hazell, 1971). The MOTAD model measures risk as linear deviations from the mean value and may be presented as below.

MOTAD Model

$$\text{Minimize } Z_0 = \sum_{h=1}^S Y^-_h$$

Subject To -

$$\sum_{i=1}^n (a_{ij} * X_{ij}) \leq b_j, \text{ Where } j = 1 \dots \dots \dots m.$$

$$\sum_{i=1}^n (C_{hi} - g_i) * X_i + Y^-_h \geq 0, \text{ Where } h = 1 \dots \dots \dots S.$$

$$\sum_{i=1}^n (g_i * X_i) = \lambda, \text{ Where } \lambda = Z \text{-----} > 0$$

$$X_i \geq 0$$

where-

- Z_0 = Sum of the absolute value of the negative of the gross income of various enterprises from their mean values.
- Y^-_h = Absolute value of the negative total gross income deviation in the hth household from the average.
- C_{hi} = Gross margin of the ith activity in hth household.
- g_i = Mean value of the gross margin of the ith crop / dairy activity for the farm households.
- λ = Total profit to be parametrized over a range.
- b_j = Land, Labour and Capital which were further divided into availability of these resources in Kharif and Rabi seasons.
- X_{ij} = Crops, Dairy, Goatery, sheep, Fishery, were the major activity adopted by the animal farmers in the state.

In the above MOTAD model, risk is measured as linear deviation from the mean income across households as described in the second constraint. Implicitly due to plausible assumption of

risk aversion, risk is undesirable and hence is minimized in the objective function. The trade-off occurs between mean income and deviations from it. Further, risk-return frontier is developed by parametrically running the model with regard to mean income and minimizing deviation from the mean income (Jha, 1994).

3.3.4.2.1 Activities identified for the present farm plan

In order to determine risk efficient farm plans, only those activities which were acceptable to the farmers and were raised by the farmers of the study area in their existing production programme were considered. The different activities used in the present model real, disposal and artificial are discussed below.

The real activities also known as commercial or production activities constitute the principal alternatives of the planning framework. Each crop/crop varieties grown with distinctively different input-output coefficients were considered as separate activity in the model. Regarding animal husbandry and allied enterprise, different groups of animals were identified on functional basis. Milch animals, viz. indigenous animals and crossbred animals were represented separate activity. The small animal holdings i.e. goatery and sheeps were represented as separate activities. For practicality of inter enterprise comparison, 10 units of goats or sheeps were considered equivalent to one unit of dairy animal holding and the input-output data for them were computed on annual basis to make it comparable with crop activities. The fishery activity is calculated on per acre land per annum to make it compatible in comparison and the apiary is calculated on the basis of per box per annum. The disposal and artificial activities were generated by the computer, so these were not included in the model.

3.3.4.2.2 Identification of constraints or restrictions

One of the crucial components of the linear programming problem is the identification of resources and other limitations. The characteristics taken into consideration for classification of different resources included were productivity potential return rate, availability in various periods and the sources of availability, etc. Based on the basic principles of economic production, land, labour and capital were the three constraints incorporated in the model and are being described in the subsequent section.

Land : The size of the operational land holding is an important constraint to the maximisation of earnings. All the lands in the sample households were assumed to have

facilities of irrigation which is a feature of coastal area with high intensity of canal water irrigation. The cropping pattern of the study area were found to be following two crops per annum namely, kharif and rabi.

Labour : The labour constraint was considered on annual basis with the view of requirement for different enterprises and the availability of labour. The labour availability was worked out in total man-hours by considering family labour working force in the farm households as obtained in the survey. The availability of human labour was estimated in adult man equivalents unit using 1 man = 1.5 women = 2 children. Similarly, for all the enterprise activities, labour coefficients were calculated in terms of adult male units only.

Capital : The study involved capital restriction in terms of annual capital need for different enterprises and the availability of working capital for each category.

The linear programming technique with profit maximisation as its objective tends to take final plan towards specialization favouring relatively more profitable activities. However, it was felt that farmers were not in a position to expand the area under enterprises beyond a certain level due to several factors for instance, uncertainty in prices, lack of transportation, storage and processing facilities, timely unavailability of farm inputs, financial implications etc. Therefore, under such situations, the upper limit restrictions of area (0.25 ac) for fishery were imposed in the programming model.

The farmer often produces according to the household's consumption need (subsistence farming). However, in recent times with increased commercialisation of agriculture, the production of certain crop like kharif paddy and mung was considered necessary being a staple food in the area. Therefore, enterprise minima restriction was put for growing these crops.

The formulation of risk efficient farm plan using MOTAD model requires information on returns from different enterprise activities practised at farm household level. So the income for different enterprise activities as mentioned earlier has been computed for each household for the period of preceding year from the data collected during survey. Generally time series data is used for assessing mean value for activities spread over certain years, in this case the cross sectional household level data for one year has been used for the same. The average of this cross sectional data was used as a

proxy for the trend/average value and the deviation from the same was used as the measure of risk.

3.3.4.2.3 Estimation of input-output coefficients

The actual quantities of various inputs required for growing different crop (per acre), rearing of different animals and other enterprises (per unit) were used as input coefficients. Input coefficients were computed with respect to land, labour and working capital for all the mentioned enterprises. The output coefficients referred to return per unit of holding i.e. crops, animal and other enterprises. These were derived by multiplying the total output by its price and deducting the operating costs incurred on its production.

The activities and constraints used in the linear programming analysis can be summarised in the following equations –

Objective function:

$$\text{Maximize } \sum_{i=1}^6 C_i X_i + \sum_{k=1}^2 C_k D_k + C_s D_s + C_f D_f$$

Subject to following resource and non-resource constraints :

Land restriction :

$$\sum_{i=1}^6 a_i X_i + a_f D_f \leq A_j$$

Labour constraint :

$$\sum_{i=1}^6 l_i X_i + \sum_{k=1}^2 l_k D_k + l_s D_s + l_f D_f \leq L_m$$

Working capital constraint :

$$\sum_{i=1}^6 K_i X_i + \sum_{k=1}^2 K_k D_k + K_s D_s + K_f D_f + \leq C_m$$

Acreage Restriction

$$Y_i \leq X_i \leq Z_i$$

Linear deviation from mean constraint for (MOTAD) model :

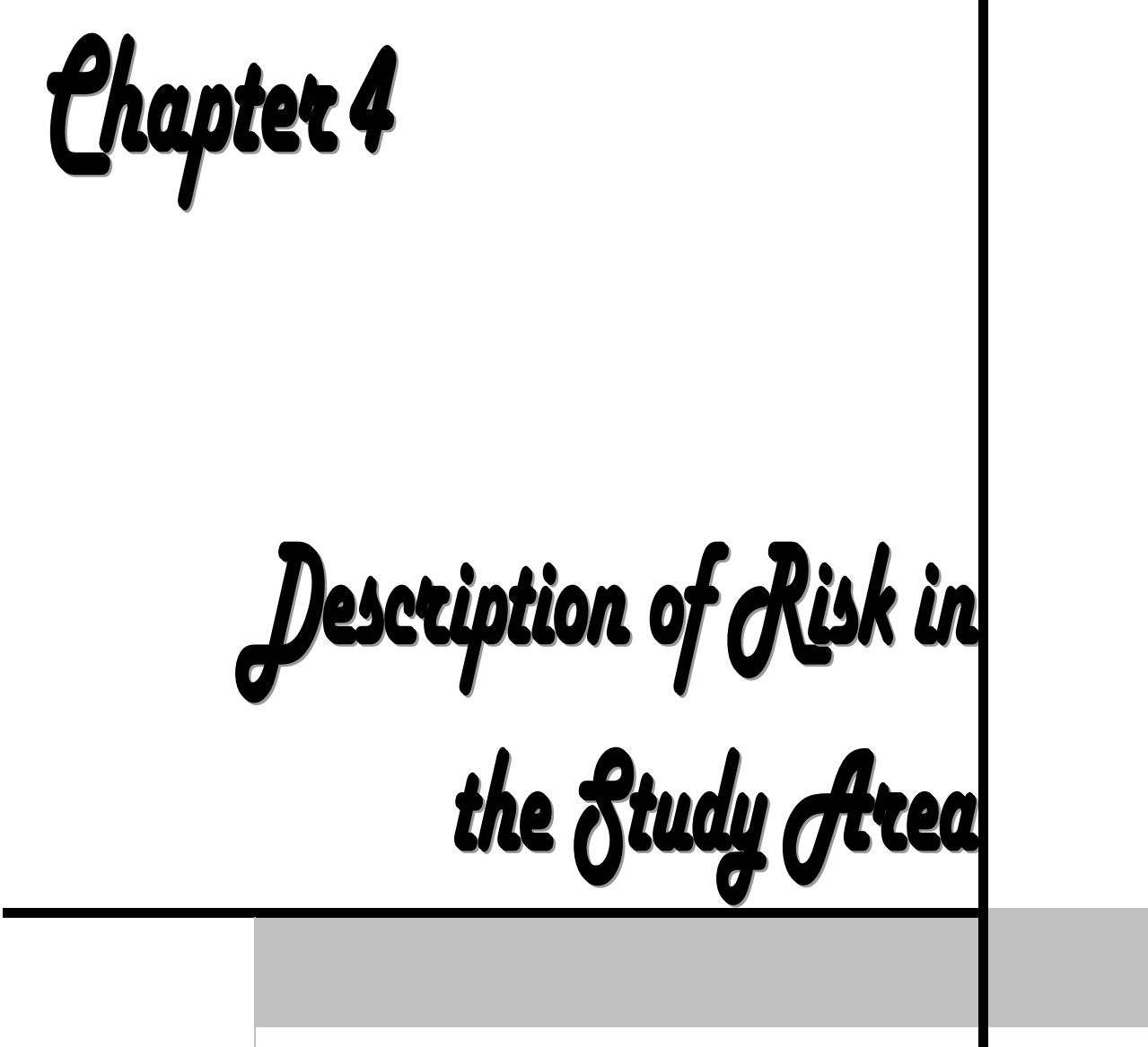
$$\sum_{i=1}^6 (C_i - g_i) X_i + \sum_{k=1}^2 (C_k - g_k) D_k + (C_s - g_s) D_s + (C_f - g_f) D_f + Y^-_h \geq 0$$

where,

- C_i = Net per acre revenue from one unit of crop activity,
- C_k = Net revenue per unit dairy activity,
- C_s = Net revenue per ten unit holding of small animals (goat and sheep),
- C_f = Net per acre revenue from one unit of fishery enterprise,
- X_i = Level of i th crop activity (acres), a decision variable,
- D_k = Level of k th dairy activity (numbers), a decision variable,
- D_s = Level of small animal activity (numbers), a decision variable,
- D_f = Level of fishery activity (acres), a decision variable,
- a_i = Area of land (acres) used by one unit of harvested crop activity,
- a_f = Area of land (acres) used by one unit of fishery holding,
- A_j = Total land available (acres) with j th category of households,
- l_i = Amount of labour used by one acre of i th crop activity,
- l_k = Amount of labour used by one unit of k th dairy activity,
- l_s = Amount of labour used by one unit of small animal activity,
- l_f = Amount of labour used by one acre of fishery activity,
- L_m = Amount of total labour available per annum in man days,
- K_i = Amount of working capital used by one unit of i th crop activity,
- K_k = Amount of working capital used by one unit of k th dairy activity,
- K_s = Amount of working capital used by one unit of small animal activity,
- K_f = Amount of working capital used by one unit of fishery activity,
- C_m = Total amount of working capital available per annum,
- Y_i = Minimum required acreage under i th crop activity,
- Z_i = Maximum possible acreage under i th crop activity,
- g_i = Mean value of gross margin of the i th crop activity,
- g_k = Mean value of gross margin of the k th dairy activity,
- g_s = Mean value of gross margin of the small animal activity,
- g_f = Mean value of gross margin of the fishery activity,
- Y^-_h = Absolute value of the negative total gross income deviation in the h th household from the mean return.

Chapter 4

Description of Risk in the Study Area

A decorative graphic consisting of a horizontal line, a vertical line, and a gray shaded rectangular area. The horizontal line is positioned below the chapter title and extends across the page. The vertical line is positioned to the right of the chapter title and extends from the top of the page to the bottom. A gray shaded rectangular area is located below the horizontal line and to the left of the vertical line.

DESCRIPTION OF RISK IN THE STUDY AREA

This chapter broadly outlines the geographical feature, agricultural profile and status of animal husbandry and dairy in the state of Odisha in general and a focus on coastal Odisha in particular.

4.1 General Background of Odisha

Odisha, the state formerly known as (Orissa) lies on the east coast of India between the latitude 17.78 N and 22.73 N and between longitudes 81.37 E and 87.53 E. The state is of historical importance with its territory forming a part of ancient Kalinga of Mahabharat fame. The famous Kalinga war was fought on its soil in 261 BC between emperor Ashoka and the people of Kalinga. The state has a very rich cultural heritage with its language Odia being accorded the status of a classical language in India.

With an area of 1,55,707 sq. kilometer, the state forms 4.87 per cent of total area of India and has a coastline of about 450 kilometer. The state has 30 districts, 58 subdivisions, 317 tehsils and 314 community development blocks. The number of urban local bodies and gram panchayats are 107 and 6,227, respectively with the number of villages at 51,349.

4.1.1 Demography

The state has a total population of 4.19 crore as per 2011 census ranking 11th population wise in the country with a population density of 270 per Sq. kilometer. As per the latest census, the urban population composition of the state was 16.31 per cent of total population with sex ratio at 978. The overall literacy rate of the state was 73.45 per cent with male literacy at 82.40 per cent and female literacy at 64.36 per cent. The poverty ratio of the state as per 2011-12 figure was 32.6 per cent.

4.2 Agriculture and Animal Husbandry Sector of Odisha

This section discusses the agriculture and livestock sector of the state. As both these activities are the major employments providing sources to the people of the state.

4.2.1 Agriculture Sector

Agriculture sector is the prime mover of state of economy of Odisha, driving its economy towards inclusive and sustainable development (Govt. of Odisha, 2015).

Description of risk in the study area

Though the share of agriculture in the Gross State Domestic Product (GSDP) of Odisha has shown a constant decrease over the years from more than 70 per cent in 1950s to about 15.4 per cent in 2014-15. More than 60 per cent population of the state still continues to derive their source of income from agriculture and allied sectors. The normal annual rainfall of the state is about 1,451.1 mm of which the South-West monsoon contributes about 80 per cent. In 2014-15 the total food grain production of the state was reported at 9,632 thousand metric tonnes out of which cereals and pulses comprised of 8,574 and 1,058 thousand metric tonnes, respectively (Odisha Agril. Statistics, 2014-15). The production of rice being the major cereal crop stood at 7,613 thousand metric tonnes. Total oil seed production was reported at 698 thousand metric tons and the total crop production was reported to be 10,144 thousand metric tons in 2014-15. A brief description of cropping pattern of various principal crops in Odisha is given in Table 4.1.

Table 4.1. Area, yield and production of principal crops in Odisha in the year (2016-17)

Type of Crops	Name	Area ('000Ha)	Yield (Quintal/Ha)	Production ('000MT)
Cereals	Rice	4180.22	18.21	7613.42
	Maize	279.61	27.85	778.66
	Ragi	165.8	8.67	143.74
	Wheat	12.76	17.46	22.28
Pulses	Mung	857.07	4.76	407.99
	Urad	598.14	4.55	271.97
	Arhar	138.88	8.96	124.44
Oilseeds	Groundnut	267.68	17.87	478.33
	Sesamum	212.85	4.03	85.85
	Mustard	145.36	4.24	61.63

Source – Directorate of agriculture and food production, Govt. of Odisha

4.2.2 Animal Husbandry Sector

This section of the study elaborates the livestock sector of the state. It has been discussed under three major headings namely livestock population, dairy production and fishery.

4.2.2.1 Livestock Population

The state has a very rich livestock population with the total bovine population reported at 12.34 million as per the latest livestock census in 2012. Out of this, total cattle and buffalo population constituted 11.62 million and 0.72 million respectively. The number of total cross bred and indigenous cattle was reported at 1.30 million and 10.31, respectively. The total goat, sheep and pig population was reported to be 6.51 million, 1.58 million and 0.28 million respectively. The total poultry population was reported to be 19.89 million.

4.2.2.2 Dairy Production

In contrast to the rich livestock population in the state, it has constantly lagged behind in dairy production. The reported milk production of the state in 2016-17 was about 2,003 thousand metric tonnes against the total milk production in India at 1,65,404 thousand metric tonnes during the same period constituting about 1.22 per cent of the total production (NDDB, 2018). The total milk production of the state has grown from 1,721 thousand metric tonnes in 2011-12 to 2,003 thousand metric tons in 2016-17 showing a meagre 2.11 per cent annual increase. The per capita availability of milk was reported at 128 gm per day during 2016-17 which has almost remained constant over the last three years. During 2013-14 the milk production from indigenous cattle, CB cattle and buffaloes was reported to be about 828 (45%), 758 (41%) and 272 (15%) thousand metric tonnes respectively (NDDB, 2016).

4.2.2.3 Fishery Sector

Odisha being a coastal state of India is richly endowed with production potential of inland, brackish water and maritime fishery resources. The state has a long coast line of about 480 kilometers with a continental shelf area of about 24,000 sq kilometers along the Bay of Bengal. The total fish production of the state during the year 2015-16 was 4.16 lakh metric tonnes with a value of export generation of about Rs. 2069 crores (Govt. of Odisha, 2017). The fresh water resources of the state are estimated to be about 6.82 lakh hectares, which comprises of 1.31 lakh hectares of tank or ponds, 2.0 lakh hectares of reservoirs, 1.80 lakh hectares of lakes, swamps and ponds & 1.71 lakh hectares of rivers and canals. During 2015-16 Odisha produced 521.28 thousand metric tonnes of fish of which 376.53 thousand metric tonnes came from inland sources and 144.75 thousand metric tonnes from marine sources. The inland fish production comprised of

Description of risk in the study area

336.22 thousand metric tonnes from fresh water and 40.31 thousand metric tonnes from brackish waters (Govt. of Odisha, 2017).

4.3 Animal Husbandry and Veterinary Infrastructure

Owing to its heavy dependence on animal husbandry sector the state has taken several steps to widen its veterinary infrastructure and service delivery system. The state has a network of 540 veterinary hospitals and dispensaries and 2,939 livestock aid centres (LAC) working at gram panchayat level. There are two establishments of Odisha Biological Products Institute functioning in the state to provide different vaccines needed for disease control programme in the state. Artificial Insemination (AI) is one of the key areas of dairy development in the state and is rendered through the network of 6,536 AI centres in the state out of which, 4416 are maintained by govt. agencies. To provide quality semen for the purpose of AI, an institute named Frozen Semen Bank (FSB) is operating in the state and has a stock of 39 jersey, 18 CB, 16 Red Sindhi and 12 Haryana donating breeding bulls (NDDB, 2016). Apart from infrastructure maintained by the Government, the co-operatives and other private participants are also maintaining their own AI centres to cater the need. The total such AI centres maintained in the state by (OMFED), (BAIF) and (JK) trust are reported to be 1440, 100 and 580, respectively. A brief outlay of veterinary and animal husbandry infrastructure in Odisha is given in Table 4.2.

Table. 4.2. Brief outlay of veterinary infrastructure in Odisha in 2015-16

Description		Numbers
Veterinary Institutions	Veterinary Hospitals	540
	Livestock aid centres	2939
Artificial insemination (AI) centres	Govt.	4416
	Non Govt.	2120
AI performed ('000)	All bovines	974
Vaccinations performed ('000)	FMD	2663
	HS	8282
	BQ	5297
Total cases treated ('000)	All animals	7658

Source – Directorate of AH & VS, Govt. of Odisha, National Dairy Development Board (NDDB)

4.4 Coastal Agro climatic Zones of the state

The state is delineated into 10 agro-climatic zones out of which two zones lie in coastal region. Rice is the major crop of the state. The state is divided into 10 distinct agro climatic zones. Though Odisha has 10 agro-climatic zones covering 30 districts in total, two of the agro-climatic zones are coastal and rest are non-coastal. The two coastal agro-climatic zones are namely North Eastern coastal plains and East & South Eastern coastal plains. Ten out of the total thirty districts of the state come under the two coastal agro-climatic zones. Three districts come under the North Eastern coastal plains namely Balasore, Bhadrak and Jajpur and rest 7 districts come under the South Eastern coastal plains namely Kendrapara, Cuttack, Jagatsinghpur, Khurda, Puri, Nayagarh and Ganjam. The coastal Odisha with a geographical area of about 24 per cent of the state accounts for about 51 per cent of the state's total milk production and about 40 per cent of the state's total HYV paddy production. Coastal Odisha is also more susceptible to natural calamities than the rest of the state. So the present study aims to bring out the various risk and uncertainties faced by the dairy sector and developing alternative risk mitigation plans for farm and dairy. The study focusses on coastal Odisha as it is the agricultural backbone of the state. A brief comparison between the coastal and non-coastal agro-climatic zones of the state is given below in Table 4.3.

Table. 4.3. Brief comparison between the coastal and non-coastal agro-climatic zones of Odisha.

Description	Coastal Agro-climatic Zones	Non-Coastal Agro-climatic Zones
Number of Districts	10	20
Amount of milk production ('000 MT)	876.86	841.14
Percentage of total milk production	51.03	48.97
Geographical Area (Sq. kilometer)	35,695.4	1,12,254.3
% of state geographical area	24.13	75.17
Production of HYV Paddy (Qntls)	2,94,46,546	4,93,26,104
% Production of HYV Paddy	37.39	62.61

Source – Economic Survey of Odisha 2016-17, Govt. of Odisha

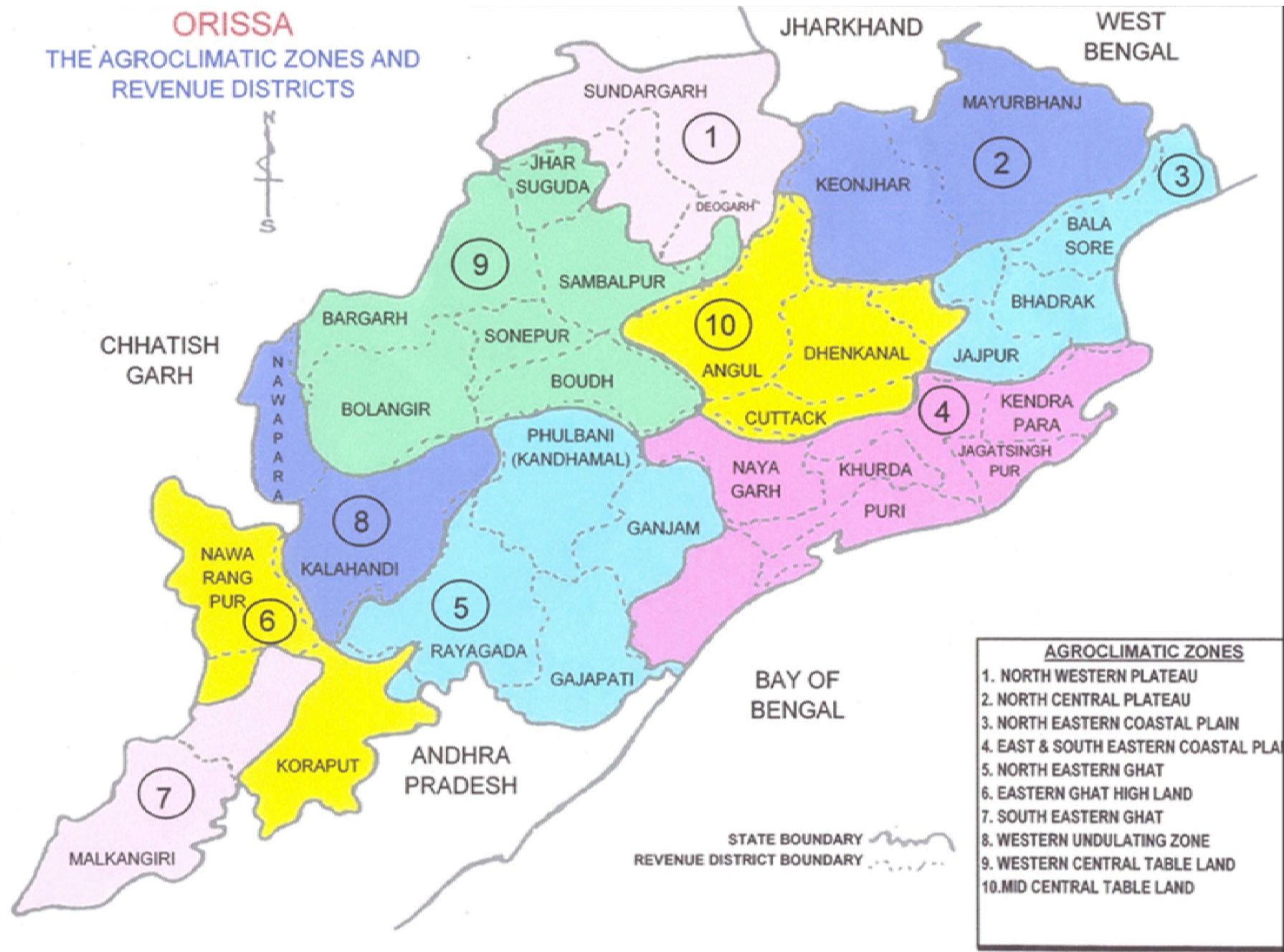
4.5 Risk Exposure and Production Environment Prevalent in the state

Odisha is inherently susceptible to various natural calamities owing to its geographical location. The following section elaborates the various risk factors and the production environment prevalent in that area.

4.5.1 Risk factors and Risk exposure to farmers

The risk factors and risk exposure to the farmers of the state happen due to many reasons including frequent occurrence of natural calamities, underdeveloped production environment, lack of infrastructure and resources, low productive animals, lack of feed and fodder, poor economic condition, subsistence level farming, etc. Though the agrarian economy of the state is considered its back bone with 15.4 per cent share in GSDP and providing employment and sustenance directly and indirectly to more than 60 per cent population of the state, it suffers from frequent natural shocks like cyclones, droughts and flash floods affecting its prospects. Because of its susceptibility to natural calamities, the food grain production generally fluctuates from year to year. The recurrent natural calamities have very adverse impact on the agrarian economy and the subsistence farmers in particular. The state is reported to have experienced about 952 small and big cyclones and 451 tornadoes from 1891 to 1970 (Govt. of Odisha, 2015). Between 1963 to 1999 Odisha experienced 13 major natural disasters which took a very toll of 22,228 human lives, affected 70,297 thousand people and made 34,21,000 people homeless. During 1971 cyclone, 9,658 people were killed and 49 lakh people were otherwise affected. The 1999 super cyclone ravaged the coastal districts of Odisha, and destroyed infrastructure to a great extent. In this, nearly 10,000 people and a large number of cattle lost their lives. The western and southern districts of Odisha suffered from recurrent droughts in 1999, 2000 and 2002.

During recent years, a severe cyclonic storm “Phailine” caused extensive damage in 19 of the 30 districts of Odisha. The subsequent floods after the cyclonic storm adversely affected about 132.35 lakh people in about 18, 374 villages of the state, in which about 5.41 lakh houses were also damaged (Govt. of Odisha, 2015). Total cropped area of about 11 lakh ha was affected in this with an estimated loss of about Rs. 2,300 crore. The substantial nature of risk can be very well understood from a reported negative growth of 3.53 per cent in GSDP of Odisha in 2013-14 because of cyclone Phailine and floods (Govt. of Odisha, 2014).



Agroclimatic Zones of Odisha

4.5.2 Low Productivity and Underdeveloped Production Environment

Odisha being on eastern coast of India has largely remained out of the benefits of green revolution and economic development that happened mostly in the western part of India. The average area of farm land holding is gradually decreasing in the state. As per the latest NSSO data, close to 75.39 per cent farm households of the state are marginal with average land holding of 0.57 ha with just 39.59 per cent in the total land holdings of the state (NDDB, 2016). The per capita availability of milk in the state is reported to be 124 gms per day in the year 2015-16 against the reported national average of 337 gm per day. The overall bovine milk yield per day was reported to be about 2.650 kg per day in the year 2013-14 which is quite low in comparison to other states. The average yield for indigenous cattle which comprises a large segment of the total bovine population of the state was reported to be about only 1.63 kg per day during the same period. The yield rate of major crops of Odisha are quite low in comparison to national average including rice which is the staple crop of the state at only 18.21 quintal/ha in 2013-14. The cropping intensity of the state is also reported to be only 158.4 per cent in 2010-11.

4.5.3 Limitations to Dairy Development in Odisha

There are many factors contributing to the impediments to dairy development in the state. Major composition of non-descript animals, feed and fodder scarcity, infrastructure inadequacy, low penetration of co-operative structure, poor marketing system, etc., are many of the reasons. In 2016, it was estimated that against a demand of 312 lakh metric tonnes of green fodder there was availability of only 161 lakh metric tonnes. Similarly in case of dry fodder, there was availability of only 106 lakh metric tonnes against a demand of 139 lakh metric tonnes. To cover the risks of small holder dairy enterprises, livestock insurance is a very good option which would cover the residual risks inherent to the system. But unfortunately the penetration of livestock insurance in the state has been very low which needs to be promoted with higher vigour. Due to inadequate financial inclusion of rural areas, the financing of dairy enterprises is still a major lacking area. Though the Co-operative structure in dairy was introduced in the state way back in 1980s with the establishment of OMFED, it has so far only 5,281 milk producer's co-operative societies (MPCS) with 2.72 lakh farmer members across the state. In 2016-17, The Orissa State Cooperative Milk Producers Federation (OMFED) procured about 3.90 lakh litres of milk and marketed about 4.32 lakh litres of milk per day (Govt. of Odisha, 2017) which is very low in comparison to the dairy production in the state.

Chapter 5

Results and Discussion

RESULTS AND DISCUSSION

This section presents the results of the analyses carried out in the study and related discussion of the results. The first section discusses the socio economic profile of the study area followed by the analysis of risk and risk factors at regional and farm level. The section 5.3 deals with the assessment of vulnerability of dairy farmers to risk and uncertainty and determination of factors affecting it. The last two sections explain the effectiveness of alternative risk mitigation strategies adopted by the farmers and the development of risk efficient farm plans, respectively.

5.1. Socioeconomic profile of respondent households in the study area

The study involved primary household level data from 16 villages of 4 districts of the coastal agro climatic zone in Odisha. Before proceeding to discuss the objective wise findings, it is very important to study the socioeconomic profile of the respondent households. Table 5.1 elicits the major parameters in this regard. The average age of household head of the north eastern coastal plains region (Region-1) and the east and south eastern coastal plains region (Region-2) was found to be 57.34 and 47.13 years respectively. The average age for the region-1 was found to be significantly higher than that of the region-2. Over all, the average age of household head across all the households was found to be around 49.68 years. The education level which has been captured through the number of years of formal schooling was found to be 9.84 and 8.48 years respectively for region-1 and region-2. The average years of schooling for members across all the households was found to be 8.82 years which refers to below matriculation. With regard to distribution of sample respondents across different caste categories, 12.85 per cent of respondents of region-2 belonged to scheduled caste in comparison to 6.05 per cent of respondents for region-1. The respondents belonging to OBC were 18.25 per cent and 13.64 per cent for region-2 and region-1, respectively. The composition of general caste respondents was found to be 80.31 per cent and 68.90 per cent for region-1 and 2 respectively. The overall caste composition across the households was found to be 11.15 per cent, 17.09 per cent and 71.75 per cent respectively for SC, OBC and General categories.

Table 5.1 - Profile of respondents belonging to different agro climatic zones

Sr. No.	Particulars	Region - 1	Region - 2	Overall
A.	Respondent Specific Characteristics			
1	Age [#] of Head (years)	57.34	47.13	49.68
2	Education*	9.84	8.48	8.82
3	Caste (% of total respondents)			
3.a	SC [#]	6.05	12.85	11.15
3.b	OBC [#]	13.64	18.25	17.09
3.c	General	80.31	68.90	71.75
4	Principal Occupation (In %)			
4.a	Agriculture + AH	37.99	35.61	36.20
4.b	Agriculture	21.73	15.39	16.97
4.c	Agriculture + Other	20.91	20.74	21.78
4.d	AH [#]	11.09	18.39	16.56
4.e	Govt. Service	3.27	3.35	3.33
4.f	Pensioner	5.01	6.52	6.14
B.	Household Specific Characteristics			
1	HH Size** (No.)	4.98	5.80	5.59
2	Households having Non Farm Activity (per cent)	88.64	86.30	86.88
3	Total HH Income (Rs.) [#]	103053	169240	119690
4	Dwelling Structure (per cent)			
5.a	Kacha	8.09	9.70	9.29
5.b	Semi Pucca [#]	16.64	45.17	38.03
5.c	Pucca [#]	75.27	45.13	52.66
C.	Farm Specific Characteristics			
1	Total Livestock (SAU)	3.96	3.43	3.56
2	FCM Sold [#] (per cent)	26.59	44.41	39.95
3	Land Total (Acre)	2.27	1.89	1.98
4	Irrigated land (per cent)	74.52	85.93	83.07
5	Households as Dairy Society members [#] (per cent)	11.25	71.45	56.40

*Education: Given as number of years of formal education; ** 4 children=3 adult women=2 adult men,

[#]Figures across the two agro-climatic regions are significantly different up to 5% level of probability

Six major sources of income of the household heads were observed in the study area, viz. agriculture + animal husbandry (AH), agriculture only, agriculture + other, AH only, government service and pensioner. Majority of the household heads were engaged in Agriculture + AH with 37.99 per cent and 35.61 per cent of the total for region-1 and region-2 respectively with no significant difference between them. Agriculture, was the main source of livelihood for by 21.73 per cent and 15.39 per cent of the respondents from region-1 and 2, respectively. Agriculture + other occupation was pursued by 20.91 per cent and 20.74 per cent of the respondents from region-1 and 2, respectively. Relatively lower proportion of respondents from both the regions were found to be engaged in the occupation of AH only with 11.09 per cent and 18.39 per cent from region-1 and 2, respectively with the value for region-2 being significantly higher than that of region-1. Very few respondents were found to have government service as their main occupation with the values of 3.27 per cent and 3.35 per cent for region-1 and 2, respectively. The number of pensioners was found to be little higher than that of the government service holders with 5.01 per cent and 6.52 per cent for region-1 and 2, respectively. Overall, across all households, 36.20 per cent of respondents had agriculture + AH as their principal occupation, followed by agriculture + other (21.78 %), agriculture only (16.97 %), AH (16.56 %), pension (6.11 %) and government service (3.33 %). The above results indicate animal husbandry and dairying was practised by about 53 per cent of households either with agriculture or alone. Thus it can be inferred that animal husbandry is considered as indispensable activity in the area for round the year sustainable income and livelihood security.

Average household size across was found to be 5.59 adult equivalents. However, the average household size for region-1 and 2 were 4.98 and 5.80 adult equivalents with no significant difference between them. The proportion of households having non farm income were 88.64 per cent and 86.30 per cent for region-1 and 2, respectively showing need for diversified sources of income to avoid farm risk. Overall, the proportion of households having non farm income across all the households was found to be 86.88 per cent. The average annual household income was found to be Rs. 1,03,053 and Rs. 1,69,240 for region-1 and 2, respectively indicating higher income status of households in the later region. Overall, the average household income across all families was found to be Rs. 1,19,690. The dwelling structure of the households were observed under three categories namely kacha, semi pucca and pucca houses. In region-1 the proportion of households dwelling in kacha, semi pucca and pucca houses was found to be 8.09, 16.64 and 75.27 per cent, respectively while for region-2 the same figures were found to be 9.7,

45.17 and 45.13 per cent respectively. The two regions were found to significantly differ from each other in case of semi pucca and pucca dwellings. Overall, across all the households the dwellings were found to be 9.29, 38.03 and 52.66 per cent, respectively for kacha, semi pucca and pucca types.

Average total livestock holding in terms of standard animal unit (SAU) was found to be 3.96 and 3.43 for region-1 and 2, respectively. The larger figure in case of region-1 is owing to the relatively higher number of local cows holdings there while in region-2 the proportion of cross bred cows was more. Average livestock holding was 3.56 SAUs. The proportions of the total fat corrected milk (FCM) sold in the market was be 26.59 and 44.41 per cent for region-1 and 2, respectively. Average proportion of FCM sold across all the households was found to be 39.95 per cent. The total land holding per household in acres was found to be 2.27 and 1.89 acres for region-1 and 2, respectively with overall average land holding of 1.98 acres. The percentage of irrigated area out of total land holding was found to be 74.52 per cent and 85.93 per cent for region-1 and 2 respectively, while across all the households it was 83.07 per cent showing high proportion of irrigated area in the region. The proportion of households having dairy society membership was found to be 71.45 per cent in case of region-2 while it was found to be only 11.25 per cent in case of region-1 which may be the possible reason for higher proportion of milk sold in the region-2. The overall proportion of households having dairy society membership was found to be 56.40 per cent. The above data of socio economic profile of the study shows that the sample selected is the representative sample of the area as it comprised of households of all category, size and income groups.

5.2 Analysis of risk and risk factors at regional and farm level

As discussed earlier, the study was conducted by capturing the risk perception of farm households at farm level as well as quantifying the various risks faced to farmers at regional level. They are being presented in the following sections.

5.2.1 Farm level risk analysis

This section analyses the perception of the farmers about different sources of risk at farm household level. As dairy production is often considered risky, the different sources of risk along with their relative importance is of prime importance to determine extent of risk. To get an insight into the farmer's perception of different sources of risk, a total 20 sources of risk were finalised after due deliberations with the stakeholders and the farmer's perception of their relative importance was captured in a likert type scale with 1 depicting non relevance and 5 depicting very high relevance.

Table 5.2 - Distribution of respondents according to their perception about relevance of different sources of risk.

Sources of Risk	Irrelevant	Somewhat Irrelevant	Neutral	Somewhat Relevant	Relevant	Average Score
1.Fluctuations in Price of Milk	43 (10.75)	25 (6.25)	28 (7.00)	145 (36.25)	159 (39.75)	3.88 (1.29)
2.Animal diseases	21 (5.25)	31 (7.75)	47 (11.75)	128 (32.00)	213 (53.25)	4.50 (1.14)
3.Health situation of farm family	48 (12.00)	56 (14.00)	129 (32.25)	103 (25.75)	64 (16.00)	3.20 (1.21)
4.Change in consumer preference	79 (19.75)	105 (26.25)	96 (24.00)	72 (18.00)	48 (12.00)	2.76 (1.28)
5.Change in interest rate of banks	96 (24.00)	48 (12.00)	104 (26.00)	79 (19.75)	73 (18.25)	2.96 (1.42)
6.Milk yield variability	20 (5.00)	31 (7.75)	92 (23.00)	113 (28.25)	144 (36.00)	3.82 (1.15)
7.Ability to pay back loans	89 (22.25)	55 (13.75)	83 (20.75)	84 (21.00)	89 (22.25)	3.07 (1.45)
8.Technology adoption (CB Animals)	19 (4.75)	17 (4.25)	84 (21.00)	108 (27.00)	172 (43.00)	3.99 (1.11)
9.Unavailability of green fodder round the year	48 (12.00)	60 (15.00)	32 (8.00)	123 (30.75)	137 (34.25)	3.60 (1.39)
10.Poor conception rate from to AI	45 (11.25)	20 (5.00)	136 (34.00)	60 (15.00)	139 (34.75)	3.58 (1.30)
11.Silent heat	59 (14.75)	41 (10.25)	72 (18.00)	144 (36.00)	84 (21.00)	3.38 (1.32)
12.Anoestrous	37 (9.25)	44 (11.00)	40 (10.00)	99 (24.75)	180 (45.00)	3.86 (1.33)
13.Timely unavailability of credit	49 (12.25)	115 (28.75)	44 (11.00)	89 (22.25)	103 (25.75)	3.21 (1.40)
14. Timely unavailability of extension support	87 (21.75)	49 (12.25)	96 (24.00)	76 (19.00)	92 (23.00)	3.09 (1.44)
15. Timely unavailability of AI or veterinary facility	59 (14.75)	129 (32.25)	85 (21.25)	47 (11.75)	80 (20.00)	2.90 (1.35)
16. Unpredictability of treatment cost	17 (4.25)	23 (5.75)	16 (4.00)	116 (29.00)	228 (57.00)	4.29 (1.06)
17. Failure of vaccination	57 (14.25)	71 (17.75)	64 (16.00)	121 (30.25)	87 (21.75)	3.28 (1.35)
18. Disposal of unproductive animals	63 (15.75)	76 (19.00)	48 (12.00)	80 (20.00)	133 (33.25)	3.35 (1.49)
19. Fluctuations in price of concentrates	49 (12.25)	63 (15.75)	40 (10.00)	100 (25.00)	148 (37.00)	3.59 (1.42)
20. Disposal of surplus milk	49 (12.25)	56 (14.00)	87 (21.75)	92 (23.00)	116 (29.00)	3.43 (1.35)

Figures in parentheses indicate percentage of respondents. Figures in parentheses for the last column indicate standard deviations.

Results and Discussion

The distribution of respondents according to their perception of relevance of different sources of risk and the average score for all the farmers for each source of risk is presented in Table 5.2. The standard deviation for each sources of risk shows that disparity exists to some extent among the respondents' perception of risks. The average score of all the sources of risk was found to be above the neutral score except the two sources viz. change in consumer preference for milk and milk products and change in interest rate of banks. The perceptions to all the sources of risks exceeding the neutral value of 3 were found to be significant at 1 and 5 % level of significance except for the risk of ability to pay back loans whose average value was found to be 3.07. For three more sources of risk, the average score was found to be less than the neutral score of three; viz. change in consumer preference of milk and milk products (2.76), distant location of AI centre / veterinary hospital (2.90) and change in interest rate of banks (2.96). The sources of risk perceived to be either somewhat relevant and relevant by a large population of farmers combined were high cost of treatment (86 % of the respondents), animal diseases (85 % of respondents), price of milk (76 % of the respondents), technology adoption or adoption of CB animals (70 % of the respondents), anoestrous condition (70 % of the respondents), milk yield variability (64 % of the respondents). This has been corroborated by the average scores estimated for these sources of risks viz. 4.29, 4.50, 3.88, 3.99, 3.86 and 3.82, respectively. The sources of risk considered to be relevant or somewhat relevant by a low combined proportion of farmers were change in consumer preference for milk and milk products (30 % of the respondents), distant location of AI centre or veterinary hospital (32 % of the respondents), change in interest rate of banks (38% of the respondents), lack of extension support (42 % of the respondents), health situation of farm family (42 % of the respondents), ability to pay back loans (43 % of the respondents). This is also reflected in the average score estimated for these sources of risks viz. 2.76, 2.90, 2.96, 3.09, 3.20 and 3.07, respectively. The factors such as lack of extension support and health situation of farm family which have been found to be of lesser importance is in sharp contrast to the earlier studies viz. (Bardhan et al., 2006) conducted in tarai region of Uttarakhand. This might be due to the relatively better facilities of animal health care and veterinary infrastructure in the coastal region of Odisha. Incidentally the top average scores obtained for the two sources of animal diseases (4.50) and high cost of treatment (4.29) as sources of risk are quite understandable. The disease incidence in animals comprising of pathogenic, parasitic and reproductive disorders are of great concern for the indian

farmers (Singh et al., 2014-2). In eastern India, the problem is further aggravated by diseases out of malnutrition also. The high costs of treatment owing mainly to the cost of medicine is also equally in sync with the findings as a major source of risk. The other sources viz. technology adoption / adoption of CB animals, price of milk, anoestrous condition and milk yield variability also got relatively high scores of 3.99, 3.88, 3.86 and 3.82, respectively. Though operation flood had been quite successful in India's eastern region owing to introduction of Jersey germplasm, in course of time farmers have started to face the consequences of uncontrolled cross breeding and increased disease susceptibility. Price of milk as source of concern is understandable as farmers often complain for the low price they are receiving for the milk and is consistent with the earlier studies (Bardhan et al., 2005) in this regard. Several problem in the pricing mechanisms of dairy cooperatives may also be assigned to this problem like, fixing of non-remunerative prices by the cooperatives in comparison to the cost of milk production, seasonal variability in price of milk and the practice of fixing the price of milk based on the criteria of fat and SNF content in the milk only (Bardhan et al., 2006). The risk of anoestrous condition in animals extending the intercalving period is a case concern as it substantially increases the farmer's losses (Ali, 2005). It burdens the poor farmer of feeding an animal with no clear prospects of return. The variability of milk yield can cause great stress to the economic prospects of dairying. With yield fluctuations and decrease in production, the farmer may face great difficulty in meeting the variable costs of production.

The data for twenty identified sources of risk across 400 households were further subjected to factor analysis to reduce the number of variables and club them into different groups based on their factor loadings, the results of which is presented in Table 5.3. The application of principal components analysis (PCA) resulted in construction of 5 principal components (factors) with eigenvalues greater than 1. The Bartlett's Sphericity test conducted to assess the applicability of PCA came out highly significant ($P < 0.01$) and this justified the use of PCA for dimension reduction in this case. These 5 category of factors together explained 67.57 percent of total original variability which can be regarded as satisfactory (Hair et al., 1995). The factors 1 to 5 depicted in Table 5.3 clubbed as different categories of risk can be best described as "Animal and farm health (factor-1)", "Financial situation (factor-2)", "Market factors (factor-3)", "Technology and infrastructure (factor-4)" and "Managerial factors (factor-5)".

Table No. 5.3 - Factor analysis and factor loadings for different sources of risk

Sources of Risk	Average (n=400)	SD	Most important factors				
			1	2	3	4	5
1.Fluctuations in Price of Milk	3.88	1.29	0.462	-0.479	0.717	0.306	-0.21
2.Animal diseases	4.50	1.14	-0.768	-0.079	0.067	0.139	0.578
3.Health situation of farm family	3.20	1.21	-0.698	0.024	0.342	0.474	0.326
4.Change in consumer preference	2.76	1.28	-0.291	-0.406	-0.623	0.257	-0.33
5.Change in interest rate of banks	2.96	1.42	-0.036	0.965	0.31	-0.014	0.088
6.Milk yield variability	3.82	1.15	-0.344	0.098	0.259	0.092	-0.719
7.Ability to pay back loans	3.07	1.45	0.354	0.534	0.621	0.291	-0.308
8.Technology adoption (CB Animals)	3.99	1.11	0.272	-0.008	0.255	-0.868	0.188
9.Unavailability of green fodder	3.60	1.25	-0.036	0.293	-0.078	0.583	0.754
10.Poor conception rate from to AI	3.58	1.30	0.784	0.092	-0.414	-0.336	0.198
11.Silent heat	3.38	1.32	-0.521	0.181	-0.356	0.164	-0.687
12.Anoestrous	3.86	1.33	0.718	-0.341	-0.013	-0.38	-0.294
13.Timely unavailability of credit	3.21	1.40	0.383	0.747	0.374	0.277	-0.212
14. Timely unavailability of extension support	3.09	1.44	-0.482	0.325	0.176	-0.556	-0.011
15. Timely unavailability of AI or veterinary facility	2.90	1.35	-0.146	0.108	0.181	-0.903	-0.04
16. Unpredictability of treatment cost	4.29	1.06	-0.322	-0.873	0.244	0.282	0.188
17. Failure of vaccination	3.28	1.35	0.614	0.236	0.309	-0.572	0.367
18. Disposal of unproductive animals	3.35	1.49	-0.449	0.546	-0.345	-0.458	-0.195
19. Fluctuations in price of concentrates	3.59	1.42	-0.079	0.931	-0.228	0.191	-0.12
20. Disposal of surplus milk	3.43	1.35	0.333	0.262	-0.665	-0.482	0.207

Factors 1 to 5 are named as, 1 – Animal and farm health, 2 – Financial situation, 3 – Market factors, 4 – Technology and infrastructure, 5 – Managerial factors; Loadings of ≥ 0.5 are depicted in bold

In factor-1 (animal and farm health), risks due to animal diseases, health situation of farm family, poor conception rate due to AI, silent heat and anoestrous conditions were loaded very high. This seems quite justifiable as very high average score was already obtained for sources of risk related to health and diseases. In factor-2 (financial situation), risks due to change in interest rate of banks, ability to payback loans, unavailability of credit, high cost of treatment, disposal of unproductive animals and cost of concentrates weigh more. The first three sources out of the above may well depict the difficulty associated with the obtaining of finance from banking institutions. In factor-3 (market factors) risks due to price of milk, change in consumer preference, ability to pay back loans and disposal of surplus milk weigh more. All these factors do seem to contribute to the segment of market risks which is very important from marketing point of view. In factor-4 (technology and infrastructure), risks due to technology adoption / adoption of CB animals, unavailability of green fodder, lack of extension support, distant location of veterinary facility and failure of vaccination weigh more. As already discussed, the adoption of CB animals has already been assigned higher average score as a risk component and it goes well along with lack of fodder and unavailability of extension support. In factor-5 (managerial factors) risks due to animal diseases, milk yield variability, unavailability of green fodder and silent heat condition appeared to weigh more.

5.2.2 Regional level risk analysis and quantification of risks

The quantification of various sources of risks faced by the dairy farmers were carried out for four common sources listed as below.

- (a) Economic losses due to repeat breeding.
- (b) Economic losses due to disease incidence.
- (c) Economic losses from mortality of dairy animals due to natural calamities.
- (d) Economic losses due to crop damage in farm households.

5.2.2.1 Economic losses due to repeat breeding

Delayed conception is a thing of great concern in dairy farming as it increases the inter-calving period and there by causes great economic loss. Out of the several causes responsible for delayed conception, repeat breeding is one of the major causes. Technically repeat breeding is the condition in which the animal in spite of showing

regular oestrous cycle (21 days) and regular attempts of service fails to conceive after three services. This study involved the computation of economic loss involved with the repeat breeding condition in dairy animals including local and crossbred animals. The losses contributing were calculated for various segments including treatment, breeding, extra feeding, extra labour and milk yield loss. The study also separately dealt the different categories of farm holdings viz. landless, marginal, small and medium categories apart from dealing with the overall scenario. The figures of losses pertaining to various segments are presented in Table 5.4.

Economic loss per dairy animal

Per dairy animal, the milk yield loss is found to contributing the greatest share at 50.91 per cent with the loss amount of Rs. 9,206. Milk yield loss was also found to hold the major share across all the farm holdings at 50.40, 51.30, 49.90 and 49.15 per cent for landless, marginal, small and medium category farmers, respectively. The corresponding loss amount for these farm holding were found to be Rs. 7,632, Rs. 9,704, Rs. 8,339 and Rs. 7,897, respectively. Next to milk yield loss the extra feeding costs appear to contribute the second largest share at 31.89 per cent across all the farm households with the loss amount at Rs. 5,767. The cost of extra feeding varies from 30.75 per cent for landless farmers to about 32.35 per cent for small category farmers. The amount of extra feeding cost varies from Rs. 4,657 in landless category to Rs. 5,406 in case of small category farmers. In spite of variation in amount in monetary terms across different categories of farm households, the per cent share remains almost same for all cases. This goes well along the many previous studies which have reported the cost of feeding contributing the major share in animal rearing as well (Baral and Bardhan, 2016). The comparatively larger amounts of feeding costs across the marginal and small category farmers may owe to the maintenance of high productive animals in these two categories. The extra labour cost was found to contribute the third largest share towards the total losses at 12.37 per cent and and Rs. 2238 across all the farm households. The labour cost across the different categories of farm households varies from Rs. 2203 in landless category to Rs. 2,287 in marginal category. The cost of labour appears to remain same across different households with the proportionate share varying from 12.09 per cent in marginal category to 14.55 per cent in case of landless category. The greater per cent share of labour cost for landless category may be due to absence of farming activities and devotion of more time towards animal husbandry.

Table 5.4 - Economic losses due to repeat breeding (Rs./Animal/Annum) across different farm categories in coastal Odisha

Per dairy animal across different farm holdings					
Heading	Landless	Marginal	Small	Medium	Overall
Treatment Cost	482 (3.18)	687 (3.63)	677 (4.05)	799 (4.97)	673 (3.72)
Breeding Cost	170 (1.12)	205 (1.08)	191 (1.15)	180 (1.12)	198 (1.10)
Extra feeding cost	4657 (30.75)	6035 (31.90)	5406 (32.35)	5085 (31.65)	5767 (31.89)
Extra labour cost	2203 (14.55)	2287 (12.09)	2099 (12.56)	2106 (13.10)	2238 (12.37)
Milk yield loss	7632 (50.40)	9704 (51.30)	8339 (49.90)	7897 (49.15)	9206 (50.91)
Number of days delayed*	80	92	84	84	89
Loss per affected animal	15144 (100)	18917 (100)	16713 (100)	16068 (100)	18082 (100)
Risk of loss per animal	4884	6479	6017	5945	6242
Loss per household	7865	12138	14448	15421	12366
Per Local Cow across different farm holdings					
Treatment Cost	120 (1.93)	210 (3.33)	235 (3.55)	268 (3.82)	209 (3.27)
Breeding Cost	67 (1.08)	85 (1.35)	65 (0.98)	78 (1.11)	79 (1.24)
Extra feeding cost	1632 (26.20)	1762 (27.96)	1998 (30.21)	2189 (31.23)	1814 (28.42)
Extra labour cost	1305 (20.95)	1066 (16.92)	1112 (16.81)	1152 (16.43)	1097 (17.19)
Milk yield loss	3104 (49.84)	3179 (50.44)	3204 (48.44)	3323 (47.44)	3184 (49.88)
Number of days delayed*	67	71	64	74	69
Loss per affected animal	6228	6302	6614	7010	6383
Risk of loss per animal	1308	1260	1389	1542	1300
Loss per household	1439	1412	1667	1851	1480
Per CB Cow across different farm holdings					
Treatment Cost	552 (3.27)	768 (3.64)	752 (4.08)	892 (5.05)	752 (3.74)
Breeding Cost	190 (1.13)	225 (1.07)	213 (1.16)	198 (1.12)	219 (1.09)
Extra feeding cost	5245 (31.08)	6765 (32.01)	5988 (32.48)	5591 (31.68)	6449 (32.09)
Extra labour cost	2378 (14.09)	2496 (11.84)	2268 (12.30)	2272 (12.87)	2434 (12.11)
Milk yield loss	8513 (50.44)	10819 (51.34)	9216 (49.99)	8696 (49.27)	10245 (50.97)
Number of days delayed*	82	96	87	86	93
Loss per affected animal	16878	21073	18437	17649	20099
Risk of loss per animal	6076	8218	7559	7413	7890
Loss per household	9114	13971	16630	17790	14241

Figures in parentheses denote the percentages of loss per affected animal, * Unit as days

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The substantial share of labour expenses goes well with the earlier finds as well assigning up to 30 per share for labour expenses in animal rearing (Dhaka et al., 1998). The treatment cost and breeding costs were found to be contributing a relatively lesser share to the total loss across all categories of farm households. Overall the treatment cost was found to be about Rs. 673 with 3.72 per cent share and the breeding cost at Rs. 198 with 1.10 per cent share. The treatment costs mainly involve the hormonal therapy often administered and the breeding cost involves the cost of AI. The total loss per affected animal was found to be Rs. 18,082 across all categories of farm households. The total losses per affected animal across different categories of farm households were found to be Rs. 15,144, Rs. 18,917, Rs. 16,713 and Rs. 16,068 for landless, marginal, small and medium categories, respectively. The comparatively low amount of loss in case of landless category may be due to the rearing of relatively lesser productive animals and more preference for local animals as perceived to involve lesser risk. The average number of days delayed in course of repeat breeding was found to be 89 days across all categories of farm holdings. Across different categories of farm holdings, the number of days delayed varies from 80 days in case of landless category to 92 days in case of marginal farm category. The highest delay in case of marginal farm category may owe to the more animal holding in this segment of farm households and relatively more productive animals. The risk of loss per animal basis distributed over the total animal holdings gave us the idea about the aggregate prevailing risk situation. The economic losses per animal across all categories of farm households was found to be Rs. 6,242 which was also found to vary from Rs. 4,884 in landless category to Rs. 6,479 in case of marginal farm category. Incidentally this is the amount which must be spent on per animal basis to counter the risk situation arising out of repeat breeding condition through insurance or any risk pooling strategy. The risk loss per household gave an idea about the potential economic loss facing the farm households based on their animal holding. The loss per household across all categories of farm holdings was found to be Rs. 12,366, which was also found to vary from Rs. 7,865 in case of landless category to Rs. 15,421 in case of medium farm category. The clear trend of increase in household level loss with increase in land holding is clearly justified by the higher animal holdings with increased land.

Economic loss in indigenous cows –

The repeat breeding condition is reported to be less in buffaloes in comparison to cattle and indigenous cows are reported to be less affected than the CB cows (Saraswat and Purohit, 2016). As buffaloes are mostly not reared in costal Odisha they did not constitute a part of sample animal population in this study. The study on risk of economic losses due to repeat breeding condition was further extended to the indigenous and CB cow population to see their segmental difference and to quantify the reported studies of differential occurrence. For indigenous cows the milk yield loss was also found to contribute the major share towards total loss at 49.88 per cent across all categories of farm households at Rs.3,184. The share of milk yield loss was found to be highest for medium category farm households at Rs. 3,323 in monetary terms and highest among marginal category farm households in per cent terms. As in case of indigenous animals the extra feeding costs was found to be contributing the second largest share in total losses at Rs. 1,814 and 28.42 per cent across all categories of farm households. The feeding costs vary from Rs. 1,632 in landless category to Rs. 2,189 in medium farm category with per cent share varying accordingly. The extra labour costs were found to be contributing about Rs. 1,097 and 17.19 per cent across all categories of farm households. For labour costs across all categories of farm households the least amount is reported in marginal farm category at Rs. 1,066 with the highest being Rs. 1,305 in landless category. The relatively higher labour cost amount in land less category may be due to the absence of crop activity and utilisation of more labour for AH activity. The treatment cost and breeding costs appear to contribute lesser amounts at Rs. 209 and Rs. 79 across all categories of farm households. Average number of days delayed was found to be 69 across all categories of farm households and highest in case of medium category at 74 days. The combined loss per affected animal was found to be Rs. 6,383 across all categories of farm households with highest and lowest amounts at Rs. 7,010 and Rs. 6,228 for medium and landless categories of farms respectively. This amount seems quite low in case of local animals in comparison to the figures for all the milch animals. The risk of loss distributed across all the indigenous animals and expressed in per animal basis was found to be Rs. 1,300 across all categories of farm households with highest at Rs. 1,542 and lowest at Rs. 1,260 for medium and marginal categories of farms respectively. This confirmed the relatively lower risk situation in case of indigenous cows. The risk of loss per household gave an idea regarding the aggregate loss faced by the farm households based on their aggregate animal holdings. The household level loss

for indigenous cows was found to be Rs. 1,480 across all categories of farm holdings which was found to be ranging from Rs. 1,412 in case of marginal farms to Rs. 1,851 in case of medium category farms.

Economic loss in crossbred cows –

As stated earlier the previous studies have reported the CB cows to be more susceptible to repeat breeding incidence than the indigenous cows (Saraswat and Purohit, 2016). In case of CB cows the number days delayed was found to be 93 across all the categories of farm households with 82, 96, 87 and 86 days respectively for landless, marginal, small and medium category households respectively. This shows the relatively longer incidence in case of the CB cows. The milk yield loss across all categories of farm households was found to be Rs. 10245 contributing about 50.97 per cent to the total loss. The amount across different categories of farm households was found to be highest in case of marginal farms at Rs. 10,819 and lowest at Rs. 8,513 for landless categories of farm households. The amount is much higher than the reported amount for the local cows. The relatively higher amount of milk yield loss in case of marginal farms may be due to the relatively higher proportions of CB animals reared by them with greater productivity. The extra feeding costs across all the households was found to be Rs. 6,449 with per cent share at 32.09. The same was again found to be highest for marginal farms and lowest for landless farm households at Rs. 6765 and Rs. 5,245 respectively. In terms of percent share the small farm households appear to have the greatest share at 32.48 per cent. The labour cost was found to be contributing the third largest share towards the total losses as in the previous cases. Overall the labour cost was found to be contributing about Rs. 2,434 with 12.11 per cent share. The labour cost for different categories of farm households was found to be highest in case of marginal farm households and lowest for small farm households at Rs. 2,496 and Rs. 2,268 respectively. In terms of per cent share, the highest share was found to be among landless farm households while the lowest share was found to be among marginal farm households at 1,409 per cent and 11.84 per cent respectively. But in spite of having relatively lower amount for extra labour cost at Rs. 2,378 the per cent share was found to be highest at 14.09 per cent. This may be attributed to the comparatively larger focus on AH activities due to absence of cropping. The treatment costs and breeding costs were found to be Rs. 752 and Rs. 219 across all categories of farm households respectively which is found to be much higher than in the case of local animals. The higher cost of treatment in case of CB animals may

well be attributed to their higher productivity. The cost of treatment was found to be highest in case of medium farms at Rs. 892 and lowest in case of landless farms at Rs. 552 respectively. The incurred cost of treatment in case of landless farms may be attributed to their relatively poor economic conditions and lesser inclination to spend on animal health. An increase spending on treatment may be advised for this category of farmers which may help to address the situation. The breeding cost was found to be highest in the marginal farms at Rs. 225 and lowest in the landless farms at Rs. 190. The per cent share for breeding costs was found to be almost same for different farm categories without much change, suggesting uniform cost for AI available at government veterinary hospitals. The combined loss per affected CB animal across all the farm types was found to be Rs. 20,099 which is quite substantial from the farmers in eastern part of India. Across different farm types the loss per affected animal was found to be highest in case of marginal farms at Rs. 21,073 and lowest in case of landless farms at Rs. 16,878. This seems to go in accordance with the reported number of days delayed for the respective classes at 82 and 96 which is also lowest and highest respectively. The risk of loss distributed across all the CB animals was found to be Rs. 4,497 per CB animal across all the categories of households. The risk of loss per CB animal was found to be highest in case of marginal farms at Rs. 8,218 and lowest for landless farms at Rs. 6,076 landless farms. The aggregate household level loss across all farm categories was found to be 14,241 with highest and lowest values observed in case of medium and land less farm categories at Rs. 17,790 and Rs. 9,114 respectively.

Over all the risk of loss due to repeat breeding condition was found to be quite high across all categories of farm households. The risk of loss facing the CB animals was found to be much higher than that facing the indigenous animals. Across all segments the milk yield loss was found to contribute the largest share followed by the extra feeding costs and extra labour costs. The treatment costs across all segments were found to be quite low which might be out of the ignorance of the farmers regarding the option of treatment as recourse. Increased spending in treatment could lead to early solution of the problem and is quite advisable.

5.2.2.2 Economic losses due to disease incidence

Diseases pose a serious threat to the dairy farming with the potential of causing significant losses. Diseases like mastitis, HS and surra cause great economic losses in the eastern part of India (Singh et al., 2014). The occurrence of diseases in animals is often

overlapping and multiple in nature. So it was decided to include the most important and clearly defined diseases in the region rather than going for all the diseases at once and the present study was undertaken to evaluate the economic losses caused by various diseases in the dairy animals and to assess the exposure of risk associated with it. The salient findings pertaining to the above study are presented in Table 5.5. As in case of repeat breeding, the loss due to disease incidence in dairy animals was also separately presented for indigenous and crossbred animals in Table 5.6 and 5.7 respectively.

Out of the primary household data collected the five most important diseases causing potential losses to the dairy farming were found to be mastitis, trypanosomiasis, theileriosis, FMD and ketosis. As these five diseases were found to be contributing close to 75 per cent of the total losses, it was decided to focus on these five. Haemorrhagic septicaemia though considered as an important disease affecting animal population is mostly known to affect buffaloes. As buffaloes are very rarely reared in eastern Odisha, they did not comprise part of the sample animal population under the present study and hence HS did not figure out as an important disease in the present study. Trypanosomiasis and theileriosis being blood parasitic diseases of many similarities were clubbed together for convenience. The losses pertaining to milk yield and treatment was calculated for all the diseases with mortality loss being calculated for trypanosomiasis and theileriosis as observed.

Per dairy animal –

Mastitis was found to be the most important disease contributing close to 39 per cent of total disease risk per household. For mastitis the overall loss per affected animal was found to be Rs. 4,980 out of which the milk yield loss and treatment cost comprised Rs. 3,856 and Rs. 1,144 respectively. The loss per mastitis affected animals was found to vary across different farm categories in a great way with the lowest and highest values reported as Rs. 3,902 and Rs. 5,181 for landless and marginal farm categories respectively. The risk of loss expressed on per animal basis was also found to be in the same pattern with the highest and lowest values for marginal and landless farm categories at Rs. 1,619 and Rs. 1,112, respectively. The overall household level loss due to mastitis was found to be Rs. 3,094 with values increasing from Rs. 1,812 in case of landless farms to Rs. 3,857 in case of medium farms. The increase in household level loss with increase in land holding is clearly understood due to higher animal holding in large farm households. At household level, mastitis was found to be contributing about

41 per cent of the total disease loss in case of landless farms which decreases to about 37 per cent in case of medium farms. This may indicate higher incidence of mastitis in small farm households due to the less hygienic conditions prevailing there.

Table 5.5 - Economic losses due to disease incidence in dairy animals

All dairy animals combined (Rs./Animal/Annum)					
Disease	Landless	Marginal	Small	Medium	Overall
Mastitis					
Milk yield loss	3060	4058	3577	3282	3856
Treatment cost	842	1123	1220	1256	1124
Loss per affected animal	3902	5181	4796	4538	4980
Loss per animal	1112	1619	1583	1509	1567
Loss per household	1822 (40.83)	3008 (39.19)	3781 (39.07)	3857 (37.03)	3094 (39.12)
Surra (Trypanosomiasis) & Theileriosis					
Milk yield loss	1978	2591	2557	2441	2530
Treatment cost	1031	1527	1422	1853	1481
Mortality loss	1233	2554	1693	1767	2253
Loss per affected animal	4243	6673	5671	6060	6264
Loss per animal	647	1018	879	970	960
Loss per household	919 (20.59)	1867 (24.32)	2030 (20.98)	2508 (24.08)	1848 (23.36)
FMD (Foot and Mouth Disease)					
Milk yield loss	3389	4439	4459	4167	4348
Treatment cost	157	285	266	263	271
Loss per affected animal	3546	4725	4725	4430	4619
Loss per animal	807	1146	1181	1074	1123
Loss per household	1151 (25.78)	1872 (24.39)	2477 (25.59)	2410 (23.14)	1951 (24.66)
Ketosis					
Milk yield loss	1261	1741	1899	1751	1733
Treatment cost	919	1221	1227	1481	1209
Loss per affected animal	2180	2963	3126	3233	2942
Loss per animal	338	489	571	614	497
Loss per household	572 (12.81)	929 (12.10)	1391 (14.37)	1641 (15.76)	1016 (12.85)
Total loss per animal	2904	4271	4214	4167	4147
Total loss per household	4464	7675	9679	10417	7909

Figures in parentheses indicate percentage share of the loss due to particular disease in total loss. Loss per household expressed as (Rs. / Annum)

Results and Discussion

The blood protozoan diseases of Trypanosomiasis and Theileriosis were combinedly found to be the second most important disease with close to 23 per cent contribution towards total disease risk per household at Rs. 1,848. The loss per affected animal for these two diseases was found to be the highest among all the diseases at Rs. 6,264 across all the farm categories. Overall across all farm types the milk yield loss stood at Rs. 2,530, the treatment cost at Rs. 1,481 and mortality loss at Rs. 2,253 for the blood protozoan diseases. The important nature of the blood protozoan diseases can also be found from the reported mortality losses contributing highly to the total losses in that disease. The cost of treatment was also found to be the highest for blood protozoan diseases among all the diseases. The risk of loss per animal was found to vary from Rs. 1,031 in landless farms to Rs. 1,853 in medium farms. The share of per household risk towards the overall disease risk for blood protozoan diseases was found to be the highest in case of marginal farm categories at 24.32 per cent followed by the medium farms at 24.08 per cent suggesting high rate of occurrence in these segments.

The foot and mouth disease (FMD) was found to be the third most important in terms of contribution of total disease risk per household at 24.66 per cent and Rs. 1,951 across all farm categories. Overall the loss per affected animal was found to be Rs. 4,619 with milk yield loss and treatment cost share at Rs. 4,348 and Rs. 271, respectively. The milk yield loss in case of FMD was found to be the highest among all diseases re-emphasising the potential losses facing it. The average treatment costs for FMD was also found to be the lowest among all diseases confirming the limited scope of treatment available after the onset of the disease and the importance of vaccination towards prevention of the disease. Across different farm households the milk yield loss and the treatment cost were found to be highest in case of small farms at Rs. 4,459 and Rs. 285 in case of marginal farms. The risk of loss per animal was found to be the highest in case of small farms at Rs. 1,181, followed by Rs. 1,146 in case of the marginal farms. The higher per animal loss in case of small farms may be due to the relative larger herd size in that category which might lead to infection among several animals in case of an occurrence. The per cent contribution at household level towards total losses was found to be the highest in case of landless farms at 25.78 per cent suggesting high occurrence in that segment.

Ketosis was found to be the fourth most important disease in terms of contribution towards total risk of loss from diseases at 12.85 per cent and Rs. 1,016 across all farm categories at household level. Ketosis is a disease of high importance as it involves body energy metabolism and mainly occurs in the high yielding animals at production stage. The loss per affected animal was found to be Rs. 2,942 across all farm categories with the share of milk yield loss and treatment cost at Rs. 1,733 and Rs. 1,209 respectively. The loss per affected animal in case of Ketosis was found to be highest in case of medium farms at Rs. 3,233 followed by the small farms at Rs. 3,126. Risk of loss per animal was also found to be the highest in case of medium farms at Rs. 614 followed by Rs. 571 in case of small farms. At household level also, ketosis was found to be contributing about 15.76 per cent share in case of medium farm categories towards total loss from diseases suggesting greater occurrence and presence of relatively high yielding animals in case of large land holding farm categories.

The total risk of loss for all the diseases combined was found to be Rs. 4,147 per animal across all the farm categories. The value was found to be highest in case of marginal farm categories at Rs. 4,271 and lowest in case of landless farm categories at Rs. 2,904. This measure can be treated as the quantified risk value assignable for the occurrence of above mentioned diseases. The relatively higher risk value in case of marginal farm households may be treated as a thing of concern as dairy is an important part of livelihood for this segment of farms with relatively higher dependency on livestock. As diseases pose substantial risk for dairy farming in India, it is high time that initiation must be taken to formulate insurance products to cater to the risks of animal disease. This quantification may be a source of reference for steps in that direction. The total loss at household level, was found to show a clear pattern of increase with increase in the landholding. This may go well with the fact of increased herd size in case of farms of higher land holding.

Per local cow –

The indigenous animals are generally perceived to be more resistant towards diseases than their crossbred counterparts. To have better insight into the pattern of losses facing the dairy animals due to diseases, separation has been made between the indigenous and crossbred cows. The economic losses in indigenous dairy animals due to diseases have been presented in Table 5.6.

Table 5.6 - Economic losses due to disease incidence in local dairy animals.

Local dairy animals (Rs./Animal/Annum)					
Disease	Landless	Marginal	Small	Medium	Overall
Mastitis					
Milk yield loss	849	912	944	946	915
Treatment cost	289	347	428	424	361
Loss per affected animal	1138	1260	1372	1370	1276
Loss per animal	205	252	288	301	257
Loss per household	225 (27.26)	282 (25.92)	346 (25.64)	362 (26.28)	293 (25.95)
Surra (Trypanosomiasis) & Theileriosis					
Milk yield loss	759	861	1005	1032	887
Treatment cost	356	474	506	625	477
Mortality loss	592	795	606	604	735
Loss per affected animal	1707	2131	2117	2261	2099
Loss per animal	171	213	233	226	214
Loss per household	188 (22.72)	239 (21.92)	279 (20.72)	271 (19.71)	244 (21.59)
FMD (Foot and Mouth Disease)					
Milk yield loss	1204	1595	1852	1894	1624
Treatment cost	68	96	100	96	95
Loss per affected animal	1272	1691	1953	1990	1719
Loss per animal	318	423	488	498	430
Loss per household	350 (42.32)	473 (43.48)	586 (43.43)	597 (43.39)	490 (43.40)
Ketosis					
Milk yield loss	501	566	725	728	598
Treatment cost	222	371	423	490	374
Loss per affected animal	723	937	1148	1219	971
Loss per animal	58	84	115	122	89
Loss per household	64 (7.70)	94 (8.67)	138 (10.22)	146 (10.63)	102 (9.06)
Total loss per animal	751	972	1124	1147	990
Total loss per household	827	1089	1349	1376	1129

Figures in parentheses indicate percentage share of the loss due to particular disease in total loss.
Loss per household expressed as (Rs. / Annum)

The disease FMD was found to be the greatest contributor to household losses with close to 43 per cent share across all farm categories. The treatment cost was found to be the least in case of FMD at Rs. 95 across all farm categories. This underlines the limited scope of treatment available in case of FMD and vaccination as the preferred mode of prevention. The loss figures at animal level and household level clearly depict a distinct upward trend with increase in the land holding. This is suggestive of the fact that more productive indigenous animals are held by the better land holding households. The overall household loss due to FMD was found to be Rs. 490 with the values ranging from Rs. 350 in land less category to Rs. 597 in medium farm households.

Mastitis was found to be the second highest loss contributor at close to 26 per cent across all farm categories for overall household loss. Mastitis is generally perceived to be more prevalent in high yielding animals and indigenous cows being low yielders may be well understood to be at lower risk.

The blood protozoan diseases of Trypanosomiasis and Theileriosis were combinedly found to be the third highest contributors at 21.59 per cent towards household level loss across all categories of farm holdings. Indigenous cows are relatively resistant to blood protozoan diseases and this is evident from the lower incidence rate evident from the gap between per animal loss and loss per affected animal.

Ketosis was found to be the least important of the four diseases in case of indigenous animals with close to 9 per cent share in household loss across all the farm categories. Like mastitis ketosis is also a disease mainly affecting the high yielding animals so the indigenous animals are at a lesser risk from it. The loss per animal and per household across all farm categories was found to be Rs. 89 and Rs. 102 respectively.

Overall the total loss due to diseases per indigenous animal across all the farm categories was found to be Rs. 990. The loss per animal was also found to be showing a distinct pattern of increase with increase in land holding, with lowest value of Rs. 751 in landless farms and highest value of Rs. 1,147 in case of medium farms. This is clearly suggestive of the fact that, more productive animals are maintained in case of larger landholding farm categories.

Per crossbred cow –

From disease point of view, the crossbred animals are at a greater risk disposal than the indigenous animals. The economic losses in indigenous dairy animals due to diseases have been presented in Table 5.7.

Table 5.7 - Economic losses due to disease incidence in crossbred dairy animals

Crossbred dairy animals (Rs./Animal/Annum)					
Disease	Landless	Marginal	Small	Medium	Overall
Mastitis					
Milk yield loss	3475	4658	4075	3715	4415
Treatment cost	945	1271	1369	1410	1269
Loss per affected animal	4420	5928	5444	5124	5684
Loss per animal	1415	2075	2014	1896	2003
Loss per household	2122 (40.00)	3527 (38.63)	4431 (38.41)	4550 (36.76)	3628 (38.54)
Surra (Trypanosomiasis) & Theileriosis					
Milk yield loss	2249	2931	2891	2702	2859
Treatment cost	1182	1734	1619	2080	1682
Mortality loss	1376	2899	1927	1982	2556
Loss per affected animal	4807	7563	6438	6764	7097
Loss per animal	721	1286	1094	1218	1202
Loss per household	1081 (20.39)	2186 (23.94)	2408 (20.87)	2922 (23.60)	2169 (23.05)
FMD (Foot and Mouth Disease)					
Milk yield loss	4216	5427	5328	4957	5292
Treatment cost	191	351	321	320	331
Loss per affected animal	4407	5778	5649	5277	5624
Loss per animal	970	1387	1412	1266	1353
Loss per household	1454 (27.42)	2358 (25.82)	3107 (26.93)	3040 (24.55)	2455 (26.08)
Ketosis					
Milk yield loss	1374	1927	2085	1906	1912
Treatment cost	1022	1356	1355	1632	1340
Loss per affected animal	2396	3282	3440	3538	3252
Loss per animal	431	624	722	778	633
Loss per household	647 (12.19)	1060 (11.61)	1589 (13.78)	1868 (15.09)	1160 (12.33)
Total loss per animal	3536	5371	5243	5158	5192
Total loss per household	5304	9131	11536	12380	9412

Figures in parentheses indicate percentage share of the loss due to particular disease in total loss.
Loss per household expressed as (Rs. / Annum)

Mastitis appears to be the greatest contributor to losses among the dairy animals with 38.54 per cent share in household level loss across all farm categories. The milk yield loss also appears to be the largest component in case of mastitis at Rs. 4,415 across all the farm categories. The milk yield loss in mastitis was found to be highest in marginal farms at Rs. 4,658 and lowest in landless farms at Rs. 3,475. The treatment cost shows a distinct pattern of increase with landholdings. The higher reported treatment costs in case of medium farms may be the reason for relatively lesser loss per affected animal at Rs. 5,124. This may suggest better spending and care in case of large landholding class households resulting in lesser loss amount in comparison to others.

FMD appears to be the second highest contributor towards disease losses after mastitis in crossbred cows with overall loss contribution at household level at 26.08 per cent. The milk yield loss in case of FMD appears to be highest among all the four diseases at Rs. 5,292 across all the farm types. The treatment cost though appears to be the least among all in case of FMD confirming the little scope after onset of the disease and vaccination as the preferred mode of prevention.

The blood protozoan diseases of Trypanosomiasis and Theileriosis together appeared to be contributing the third highest share of household level loss at 23.05 per cent across all category of farm holdings. But the loss per affected animal is found to be the highest in this case at Rs. 7,097 across all category of farm holdings. This is substantiated by the high treatment cost and mortality loss involved in case of blood protozoan infection.

The fourth highest contributing disease in the household loss was found to be Ketosis at about 12.33 per cent contribution for the same. Ketosis is generally a metabolic disease involving the high yielding animals. So the milk yield loss is quite substantial at Rs. 1,912 across all category of farm households. The treatment cost appears to be second highest after blood protozoan diseases at Rs. 1340 across all category of farm households.

Overall, the total loss per animal was found to be Rs. 5,192 across all categories of farm holdings, with the highest and lowest per animal losses reported to be at Rs. 5,371 and Rs. 3,536 in case of marginal and landless households. Though there is no distinct pattern, the total per animal loss was found to be decreasing with increased land

holding from marginal to medium category farm households. The household level loss for the CB animals distinctly shows a pattern of increase with the landholding in accordance with the higher animal holdings in large farm households.

Economic loss due to disease incidence based on probability of occurrence

The occurrence of diseases are based on certain probabilities which are area specific. The estimated loss when multiplied by these probabilities of occurrence, gives a more realistic assessment of impact of diseases. In this regard, the economic losses based on the probability of occurrence of different diseases in coastal Odisha has been presented in Table 5.8. For better analysis, the values are presented separately for indigenous and crossbred cows as well.

For all dairy cows, the average duration of disease incidence was found to be the highest in case of FMD at about 42 days followed by Mastitis and blood protozoan diseases at 37 and 24 days, respectively. The probability of occurrence was found to be the highest in case of mastitis at 33.25 per cent followed by FMD and Ketosis at 27.09 and 18.75 per cent, respectively. The higher incidence of mastitis may be due to presence of more high yielding crossbred animals which are generally prone to this. Apart from this, the incidence rate of FMD is also found to be quite high as coastal Odisha is often considered as an endemic zone for FMD causing substantial loss to the dairy sector. The probable loss per household due to mastitis appears to be the highest at Rs. 1,029/HH/Annum underlining the importance of this disease. Apart from this, blood protozoan diseases and FMD also appear to be posing significant threat at loss values of Rs. 314 and Rs. 528, respectively.

In case of the indigenous dairy cows, the average duration of diseases appear to be of same importance as in case of all cows combined, though the duration is lesser for all diseases. The probability of occurrence though differs considerably here with FMD assuming the greatest importance followed by Mastitis at 27.25 per cent and 21.36 per cent, respectively. The probable household loss appears to be highest in case of FMD for case of indigenous cows at Rs. 133/HH/Annum. Indigenous cows are generally considered more resistant to diseases in comparison to their CB counterparts and this is well reflected in their case.

Table 5.8 – Risk of Economic losses due to disease incidence in dairy animals based on probability of occurrence.

Diseases	Average duration of disease (Days)	Annual Probability of occurrence (Per cent)	Probable loss per animal (Rs./Annum)	Probable loss per HH (Rs./Annum)
All cows				
Mastitis	37	33.25	521	1029
Trypanosomiasis & Theileriosis	24	16.98	163	314
FMD (Foot & Mouth Disease)	42	27.09	304	528
Ketosis	17	18.75	93	191
Local cows				
Mastitis	20	21.36	55	63
Trypanosomiasis & Theileriosis	19	11.19	24	27
FMD (Foot & Mouth Disease)	35	27.25	117	133
Ketosis	12	10.40	9	11
CB Cows				
Mastitis	41	37.21	745	1350
Trypanosomiasis & Theileriosis	26	18.91	227	410
FMD (Foot & Mouth Disease)	48	27.03	366	664
Ketosis	19	21.53	136	250

In case of crossbred cows mastitis appears to pose the greatest threat at average duration of disease at 41 days and probable household level loss at Rs.1,350/HH/Annum. The probability of mastitis occurrence is also found to be the highest in case of crossbred cows at 37.21 per cent which underlines their susceptibility in comparison to indigenous cows due to their higher productivity. FMD appears to be of second highest importance in crossbred cows at a probable loss of Rs. 664/HH/Annum. Odisha is considered as an endemic zone for FMD and occurrences are well known to cause substantial economic loss. So specific vaccination drives targeting the high yielding dairy animals may be the need of the hour to counter the situation. The blood protozoan diseases of

Trypanosomiasis and Theileriosis appear to be the third highest contributor to household level loss at Rs. 410/HH/Annum. Vaccination for Theileriosis is already available in market but has not been acceptable to farmers due to their higher prices. So government may consider to launch Theileria vaccination at affordable rates to increase its level of penetration among high yielding dairy cows.

5.2.2.3 Economic losses due to mortality of dairy animals in Coastal Odisha

Mortality of dairy animals is one of the major sources of risk facing the dairy farmers. This is very important and may cause substantial economic loss to the farmer. The mortality loss of the dairy animals calculated based on the incidence of natural calamities and diseases has been presented in Table 5.9.

Mortality of dairy animals due to natural calamities

Out of the various risks facing dairy production, the risk out of natural calamities is one of the most important one. It is reported that India's eastern coast is more vulnerable to natural calamities like flood and cyclones than the western coast of India (Patwardhan and Narayanan, 2003). Odisha in particular faces substantial risk from the frequent occurrence of these dangers and even its economy reported a negative growth of 3.53 per cent in GSDP in 2013–14 because of cyclone Phailine and floods (Govt. of Odisha, 2014). As livestock mortality is often perceived as a consequence of any natural calamity substantially affecting the dairy farming, the present study was undertaken to assess the risk of dairy animal mortality due to natural calamities. Across all farm categories, the mortality rate due to natural calamities was found to be the highest in case of Landless class at 0.53 per cent and lowest at 0.25 per cent in case of medium class. The mortality rates were found to show a decreasing trend across all the farm categories with increase in the land holding of the households. This may suggest the better coping capacity to the calamities with increase in economic condition of the farm households. The overall mortality rate due to natural calamities across all categories of farm households was found to be 0.33 per cent which do not appear to be high in comparison to the mortality rate due to diseases. The lower mortality rates in natural calamities may owe to the steps taken by the state govt. in the last one and half decades after the occurrence of a super cyclone in 1999 which caused great loss to life and property with human casualty estimated at close to 10,000. Concrete shelters for flood and cyclones have been made in almost all panchayats which helps to cope with the extreme situation in an effective way.

Table 5.9 – Economic losses due to mortality of dairy animals in Coastal Odisha

Farm size category	Economic loss due to mortality of dairy animals in coastal Odisha					
	Mortality losses due to natural calamities		Mortality losses due to diseases		Total mortality losses due to natural calamities and diseases	
	Economic loss (Rs./SAU/Annum)	Household economic loss (Rs./HH/Annum)	Economic loss (Rs./SAU/Annum)	Household economic loss (Rs./HH/Annum)	Economic loss (Rs./SAU/Annum)	Household economic loss (Rs./HH/Annum)
Landless	47 (0.53)	123	603 (5.70)	1568	651 (6.23)	1691
Marginal	38 (0.32)	106	621 (4.45)	1750	658 (4.77)	1856
Small	45 (0.27)	154	620 (4.52)	2109	666 (4.79)	2263
Medium	65 (0.25)	233	603 (4.33)	2171	668 (4.58)	2403
Overall	41 (0.33)	122	618 (4.56)	1820	659 (4.89)	1942

Figures in the parentheses indicate mortality rate of dairy animals expressed in (Per cent/Annum)

The dairy animal mortality expressed in terms of Rs./SAU/Annum gives an idea about the risk of loss facing each unit of animal holding. In contrast to the higher mortality rates observed in case of landless farms due to natural calamities, the risk of dairy animal mortality was found to be relatively low for that farm category at Rs. 47.4/SAU/Annum in contrast to the highest overall value observed in case of medium farm category at Rs. 64.6/SAU/Annum. The relatively higher observed risk value in case of the medium farm categories in spite of a relatively lower mortality rates may be due to more productive and animals of higher value holding in that segment. The increasing trend in risk of dairy animal mortality as observed across all categories of farm households may suggest an increase in productive animal holding and animals of higher value with increase in land holding. The household economic loss expressed in terms of Rs./HH/Annum gives an idea about the loss estimates at household level. The household loss was found to be the highest in case of medium farms at Rs. 232.6 and lowest at Rs. 106.0 in case of marginal farms. The increasing trend of household level loss with increase in land holding may owe to the higher animal holding with increase in land holding. The overall household level loss due to natural calamities across all farm categories was found to be Rs. 121.6.

Mortality of dairy animals due to diseases

The economic loss facing the dairy farm households due to various important diseases has already been discussed in the previous sections, but the mortality of animals occurring due to diseases is still a very important risk factor having substantial economic implications. In view of the above things the present study was undertaken to assess the risk of dairy animal mortality due to disease incidence. The mortality rate was found to be the highest in case of landless farm category at 5.70 per cent and lowest in case of medium farm category at 4.33 per cent. The overall mortality rate was found to be 4.56 per cent with similar rates across all the farm types except the landless category. This may suggest more or less uniform pattern of dairy animal mortality across all the farm types except the landless households where the higher mortality may be assigned to poor rearing conditions.

The risk of dairy animal mortality due to diseases spread across the total dairy animal population and expressed in Rs./Annum/SAU may give an idea regarding the risk of loss facing each unit of animal holding. The result for the same was found to remain

more or less uniform over all the types of farm holdings. The overall loss value involving all the farm categories was found to be Rs. 618.3/SAU/Annum. The uniform risk value across different farm types may be indicative of the spread of uniform risk which would need a common method of address without much differentiation. The household level economic loss is an indication of the aggregate losses faced by the respective categories of farm households, with the values showing a clear pattern of increase with increase in land holding. The overall household level losses was found to be Rs. 1820.3/HH/Annum across all farm types.

Overall mortality of dairy animals due to natural calamities and diseases

The overall mortality loss of dairy animals is the losses due to natural calamities and diseases combined together. The overall mortality rate was found to be 4.89 per cent per annum with highest and lowest values observed in landless farms and medium farms at 6.23 per cent and 4.58 per cent. The mortality rates clearly found to be assuming a decreasing trend with increase in the land holding. But in contrast, the mortality loss spread across all the animals and expressed in terms of Rs./SAU/Annum was found to assume an increasing trend with the increase in landholding. This may be due to holding of more productive and animals of higher economic value by the larger farm households. The overall economic loss expressed per SAU may be taken as the value of mortality risks faced by each unit of dairy holding. This value may be was found to be Rs. 659.2 across all farm types and may be taken as an indicative figure for formulation of sustainable premium rates for dairy animal insurance to counter the mortality risks. The household economic loss was found to be Rs. 1941.9/HH/Annum across all categories of farm types showing a clearly upward trend with the increase in land holding.

5.2.2.4 Economic loss due to crop damage in Coastal Odisha

In an underdeveloped production environment like Odisha, agriculture sector assumes a great importance with a high degree of dependency. As discussed earlier, Odisha faces a great amount of risks due to occurrence of various natural calamities including flood and cyclones and they cause substantial damage to the crop sector. Causes other than natural calamities are also responsible for crop damage. The economic loss due to crop damage in costal Odisha has been presented in Table 5.10.

Table 5.10 – Economic losses due to crop damage in Coastal Odisha

Category	Economic loss due to crop damage in coastal Odisha					
	Crop losses due to natural calamities		Crop losses due to reasons other than natural calamities		Total crop losses due to natural calamities and other reasons	
	Loss per acre (Rs./Acre/Annum)	Loss per household (Rs./HH/Annum)	Loss per acre (Rs./Acre/Annum)	Loss per household (Rs./HH/Annum)	Total loss per acre (Rs./Acre/Annum)	Total loss per household (Rs./HH/Annum)
Landless	-	-	-	-	-	-
Marginal	3956	6211	527	827	4483	7038
Small	4491	14752	758	2490	5249	17241
Medium	4497	23494	945	4939	5442	28433
Overall	4090	8726	593	1349	4682	10075

Crop damage due to natural calamities

The crop damage due to natural calamities expressed on per acre basis was found to range from Rs. 3,956/Acre/Annum in marginal farm category to Rs. 4,497/Acre/Annum in medium farm category. The overall loss per acre was found to be Rs. 4,090/Acre/Annum across all farm categories. This indicates a progressive loss per unit of land with increase in farm size. This may be due to better productive land holdings with larger farm sizes. The overall loss per household appears to be Rs. 8,726/HH/Annum across all farm categories. On expected lines the household loss appears to be increasing with landholding with the value for medium category farmers at Rs. 23,494/HH/Annum.

Crop damage due to reasons other than natural calamities

It appears that the magnitude of crop damage is much more due to natural calamities than other reasons. The per acre loss amount in case of different farm types ranges from Rs. 527/Acre/Annum in case of marginal farms to Rs. 945/Acre/Annum in case of medium farms. The higher loss amount in case of greater land holding class farms may be due to rearing of more cash crops in their case. The household level loss appears to be Rs. 1349/HH/Annum across all farm types with an increasing trend along size of farm holding.

Total crop damage due to natural calamities and other reasons

This is the combined loss amount arising due to natural calamities and other reasons. The total loss per acre ranges from Rs. 4,483/Acre/Annum in case of marginal farms to Rs. 5,442/Acre/Annum in case of medium farms with the overall amount at Rs. 4,682/Acre/Annum across all category of farms. The overall household loss is Rs. 10,075/HH/Annum across all category of farm holdings.

5.2.2.5 Regional losses in Coastal Odisha due to diseases and mortality

The economic loss due to repeat breeding, diseases and mortality on per animal basis has been calculated and discussed in the previous chapters. For a state like Odisha with high dependency on agriculture these losses have a substantial effect on the regional economy. So the regional loss projection for coastal Odisha was obtained by extending to the animal population of the region and has been presented in Table. 5.11.

Table.5.11 - Economic Losses Due to Various Risk Factors in Coastal Odisha Region (Rs. In Lakhs / Annum)

Factors of Economic Losses		Local cows	CB Cows	All Cows
Due to Repeat Breeding		2,921.10 (32.45)	6,078.45 (67.54)	8,999.55 (100)
Due to Diseases				
Production Diseases	Mastitis	359.62 (3.67)	1,419.83 (14.48)	1,779.45 (18.15)
	Ketosis	60.64 (0.62)	892.80 (9.11)	953.44 (9.73)
	Total	420.25 (4.29)	2,312.63 (23.59)	2,732.88 (27.87)
Non Production Diseases	Blood Protozoan Disease	556.28 (5.68)	1,454.71 (14.84)	2010.99 (20.51)
	FMD	2,721.98 (27.76)	2,340.58 (23.87)	5,062.56 (51.63)
	Total	3,278.25 (33.43)	3,795.29 (38.71)	7,073.54 (72.14)
Sub Total Due to Diseases		3,698.51 (37.72)	6,107.92 (62.28)	9,806.43 (100)
Due to Mortality				
Natural Calamity		230.12 (1.49)	730.35 (4.72)	960.47 (6.21)
Diseases		3,478.82 (22.48)	11,041.03 (71.33)	14,519.85 (93.8)
Sub Total Due to Mortality		3,708.94 (23.96)	11,771.38 (76.05)	15,480.32 (100)

Figures in the parentheses indicate per cent of gross sub total value for all Cows

Regional loss due to repeat breeding

The estimation was made separately for local cows and CB cows which was found to be about Rs. 2,921 lakhs and Rs. 6,078 lakhs, respectively per annum. CB cows being more productive in comparison bear higher losses than local cows on expected lines. For all cows the combined, loss value comes out to be around Rs. 8,999 lakhs per annum which is quite high for an underdeveloped region with high dependency on livestock economy.

Regional loss due to diseases

The disease loss comprising of four major diseases as discussed earlier was extended to the regional animal population. Economic losses due to the production diseases was found to be about Rs. 2,733 lakhs per annum while that of non production disease stood at Rs. 7,074 lakhs per annum. Mastitis was found to be causing highest losses among production diseases at Rs. 1,779 lakhs while FMD was found to be causing highest losses at Rs. 5,062 lakhs per annum among the non production diseases. The loss value in case CB cows was found to be higher than the local cows in all diseases except FMD, where it stood about Rs. 2,722 lakhs and Rs. 2,341 lakhs for local and CB cows respectively per annum. The total loss due to diseases was found to be about Rs. 9,806 lakhs per annum.

Regional loss due to mortality

It has been found earlier that mortality rate of livestock due to natural calamities was much lesser in comparison to the mortality due to diseases. For coastal region of Odisha the loss from livestock mortality due to natural calamity and diseases was found to be about Rs. 960 lakhs and Rs. 14,519 lakhs respectively per annum. The substantial nature of mortality loss due to diseases clearly states the need for better animal health care practices which is very essential for sustainability of livestock economy.

5.2.2.6 Economic losses due to crop damage in Coastal Odisha region

Odisha being an agricultural state has major dependency on agriculture practice. The losses per acre and household has been presented in the previous sections of study. The regional loss projection for coastal Odisha has been obtained by extending it to the net sown area of the region and is presented in Table. 5.12.

Results and Discussion

The crop loss was estimated for natural calamity and non natural calamity reasons. As found earlier and in contrast to livestock sector, the loss due to natural calamity was found to be much higher than losses due to non natural calamities. Crop loss value from natural calamity and reasons other than natural calamities were found to be Rs. 1,657 crores and Rs. 240 crores, respectively per annum. The total loss value stood at Rs. 1,898 crores per annum which is quite substantial for a state like Odisha. Proper policy measures for compensation of this loss through institutional and insurance support is very much essential and need of the hour.

Table 5.12 - Economic losses due to crop loss in coastal Odisha region

Description of Crop Losses	Loss Value (Crores of Rs. / Annum)	Proportion of total in Per cent
Due to Natural Calamity	1,657.79	87.34
Due to reasons other than Natural Calamities	240.36	12.66
Total	1,898.145	100

5.2.3 Salient findings on risk and risk factors

In analysis of the farmer's perception about different sources of risk at farm household level, the factors which were found to be most relevant were high cost of treatment, animal diseases, price of milk, technology adoption, anoestrus condition and milk yield variability with average score estimates at 4.29, 4.50, 3.88, 3.99, 3.86 and 3.82, respectively. Similarly the sources of risk found to be less relevant were change in consumer preferences, distant location of AI centre or Veterinary hospital, change in interest rate of banks, lack of extension support, health situation of farm family and ability to pay back loans with average score values at 2.76, 2.90, 2.96, 3.09, 3.20 and 3.07, respectively. The factor analysis of the different sources of risk through Principal Component Analysis resulted in them being clubbed into five different factors which together explained about 67.57 per cent of total variability. The five clubbed factors were named as "Animal and farm health", "Financial situation", "Market factors", "Technology and infrastructure" and "Manage mental factors" owing to the corresponding sources of risk loading on them.

The loss per affected animal due to repeat breeding was found to be Rs. 18,082 with average number of days delayed at 89. Milk yield loss was found to have the largest share in repeat breeding condition at about 51 per cent followed by extra feeding cost and extra labour cost at about 32 per cent and 12 per cent, respectively. CB cows are found to be more affected by repeat breeding condition than their local counterparts with average number of days delayed at 93 and 69 days, respectively. The loss per affected CB cow due to repeat breeding was also found to be substantially higher than the local cows with values at Rs. 20,099 and Rs. 6,383, respectively. Over all repeat breeding was found to be significantly causing losses with per farm household loss at Rs. 12,366. Across all categories of farm households the cost of treatment contributing to the losses was found to be quite low at only 3.72 per cent of the aggregate loss which is suggestive of lack of knowledge on treatment option available for repeat breeding and the need of more institutional support in this regard.

The four most important diseases responsible for causing economic losses were found to be Mastitis, blood protozoan diseases, FMD and Ketosis. Mastitis alone was found to be the highest contributor to losses at about 39.12 per cent of household loss due to diseases. FMD was found to be the second highest contributor at 24.66 per cent followed by Blood protozoan diseases and Ketosis at 23.36 and 12.85 per cent respectively. Loss per animal due to various diseases was found to be Rs. 4,147 and that for household at Rs. 7,909. Wide differences were found between the household loss from local cows and CB cows at Rs. 1,129 and Rs. 9,412 respectively. This finds justification in the high productivities of CB animals with more need of treatment facility for them. In case of local cows FMD has maximum share in household loss at 43.40 per cent while for CB cows it was found to be Mastitis at 38.54 per cent contribution to household loss. More penetration of FMD vaccination with possible vaccination for blood protozoan diseases is the need of the hour. Among all diseases FMD was found to be affecting for highest durations at 42 days followed by Mastitis at 37 days. Annual probability of occurrence was found to be highest for Mastitis at 33.25 per cent with probable household loss at Rs. 1,029 which is highest among all four diseases.

The household mortality loss of livestock due to natural calamities was found to be Rs. 122 in comparison to the mortality loss due to diseases at Rs. 1,820. Mortality due to natural calamities was found to be only 0.33 per cent while it was observed to be 4.56 per cent for diseases. The lesser mortality rate from natural calamities goes contrary to the earlier notion for a disaster prone state like Odisha and is a result of the growing

disaster preparedness and construction of cyclone shelters. Over all household loss due to mortality was found to be Rs. 1,942 per annum with mortality rate of 4.89 per cent. Crop loss was found to be more due to natural calamities than other reasons which is in contrast to the findings of livestock mortality. Per acre crop loss from all reasons was found to be Rs. 4682/annum while per household it was observed to be Rs. 10,075/annum.

In livestock sector regional losses from non production diseases was found to be substantially higher at Rs. 7,073 lakh per annum in comparison to losses from production diseases at Rs. 2,732 lakh per annum. Among all diseases FMD was found to cause greatest loss at Rs. 5,062 lakh per annum. Regional losses due to repeat breeding was found to be substantially high at Rs. 8,999 lakh per annum which is comparable to the combined loss caused by the diseases considered here. This reiterates the potential loss due to repeat breeding and the need of institutional support in dealing it. The regional livestock mortality loss was found to be Rs. 15,480 lakhs per annum which is substantial for an agrarian state like Odisha. The regional losses due to crop damage from natural calamities was found to be much higher at 87.34 per cent than due to other reasons at only 12.66 per cent. Over all the crop damage loss per annum was found to be about Rs. 1,898 crores/annum.

5.3 Vulnerability of dairy farmers to risk and factors affecting it.

Indian farming community owing to its subsistence nature has always been vulnerable to risks and uncertainties. As discussed earlier in one of the several studies, vulnerability is defined as the susceptibility of a system to disturbances determined by exposure to perturbations and the capacity to adapt (Nelson et al., 2010). Indian subcontinent and particularly the coastal India is exposed to many forms of natural hazards which makes this area in a way more vulnerable and susceptible. As stated earlier, India's eastern coast is more vulnerable than the western coast with respect to frequency of occurrence of extreme events like cyclones and depressions (Maiti et al., 2015). So this makes coastal Odisha one of the most vulnerable regions of India owing to the frequent occurrences of extreme events like floods, depressions, cyclones and inundation which puts great stress on its agrarian economy. So, the present study was under taken to assess the household level vulnerability prevailing among the dairy farmers of coastal Odisha which might be of help for micro level policy implications. Out of the many methods of assessing vulnerability, the index based method was chosen

to be used in the present study owing to its simple nature of application and interpretation. The vulnerability index has been defined as a function of exposure, sensitivity and adaptive capacity which are discussed one by one in the following sections.

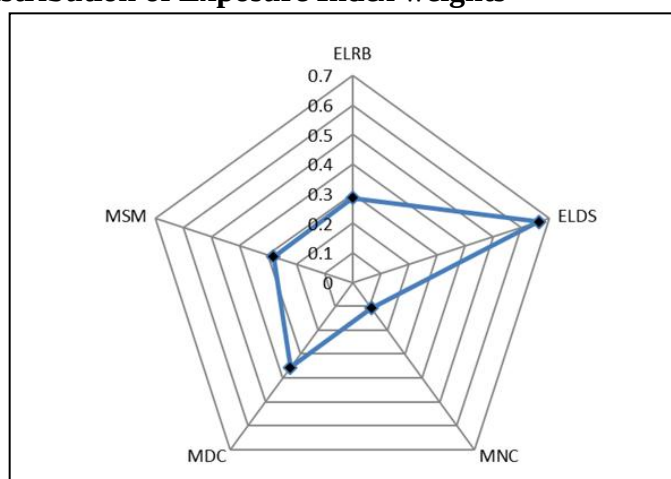
5.3.1 Farm level exposure index

Exposure is defined as the direct danger facing the dairy enterprises and as stated earlier, five different indicators listed as earlier were used to compute the exposure index. The indicators after being carefully computed for each household were subjected to principal component analysis to assign them proper weights. The indicators for computation of exposure component of vulnerability index along with their respective weights are given in Table 5.13. Out of the five indicators, “ELDS” appears to have the maximum weight at 0.6615, followed by “MDC”, “ELRB” and “MSM” at 0.3559, 0.2858 and 0.2810, respectively. This shows that, the losses happening due to various animal diseases is an important risk factor in dairy farm enterprises. This substantiates the earlier discussion in previous chapter where the losses happening due to various animal diseases was quantified and was found to be of substantial risk. Apart from this, mortality of animals due to various animal diseases is also a factor of significant risk. With the livestock insurance penetration still at a very low rate, the mortality of animals due to various livestock diseases poses as an important factor of risk exposure causing high degree of direct economic loss.

Table 5.13 - Exposure index indicators and assigned weights

Sl. No.	Exposure Indicators	Exposure Indicators (symbols)	Weights Assigned
1	Economic loss due to repeat breeding and heat detection in last 1 year / SAU	ELRB	0.285816
2	Economic loss due to disease incidence in last 1 year / SAU	ELDS	0.661558
3	Value of dairy animals died due to natural calamities in last 5 years (Current prices) / SAU	MNC	0.107411
4	Value of dairy animals died due to disease incidence in last 5 years (Current prices) / SAU	MDC	0.355942
5	Marketed surplus of milk produced	MSM	0.281072

Graph. 5.1 Distribution of Exposure Index weights



The distribution of the computed weights for various indicators of exposure index is presented in a graphical manner for better comprehension. The respective weights were multiplied with the indicators and summed to obtain the exposure index of each of the households. Cumulative square root of frequency (CSRf) method was utilised to classify the farm households into distinct classes based on their relative exposure. Total five distinct classes were drawn and the distribution of farm households over these classes has been presented in Table 5.14.

Table 5.14 - Distribution of farmers under different classes of exposure

Class of Exposure	Number of Farmers	Percentage
Less Exposed (0.005 – 0.146)	148	37.00
Moderately Exposed (0.147 – 0.358)	90	22.50
Exposed (0.359 – 0.628)	29	7.25
Highly Exposed (0.629 – 0.893)	99	24.75
Very Highly Exposed (0.894 – 1.145)	34	8.50
Total	400	100

The relative distribution of households over the five classes of exposure depicts the highest number of households falling under less exposed category while, the second largest number of households fall under highly exposed category. To draw further inferences it was required to divide the total households on the basis of farm size and relative exposure category which is presented in Table 5.15.

Table 5.15 - Frequency distribution of farm size and exposure index wise categories

Exposure Index							
Farm Type	Parameters	Less Exposed	Moderately Exposed	Exposed	Highly Exposed	Very Highly Exposed	Grand Total
Landless	Frequency	13	4	3	8	4	32
	Row percent	40.63	12.50	9.38	25.00	12.50	
	Column percent	8.78	4.44	10.34	8.08	11.76	
Marginal	Frequency	82	63	20	87	24	276
	Row percent	29.71	22.83	7.25	31.52	8.70	
	Column percent	55.41	70.00	68.97	87.88	70.59	
Small	Frequency	46	18	2	4	6	76
	Row percent	60.53	23.68	2.63	5.26	7.89	
	Column percent	31.08	20.00	6.90	4.04	17.65	
Medium	Frequency	7	5	4	0	0	16
	Row percent	43.75	31.25	25.00	0.00	0.00	
	Column percent	4.73	5.56	13.79	0.00	0.00	
Grand Total	Frequency	148	90	29	99	34	400
Chi Square Value = 0.673, (P Value) < 0.0001							

The results show that, among the landless category of households, 40.63 per cent of households fall under less exposed class while 25.00 and 12.50 per cent fall under highly exposed and very highly exposed class, respectively. Among marginal farm households, 31.52 per cent and 8.70 percent fall under highly exposed and very highly exposed category, while no households of medium farm category were found to fall under highly exposed or very highly exposed class. Though there is no distinct pattern, but the trend is quite suggestive that the severity of exposure component of vulnerability decreases with the increase of farm size. Further chi square test was performed to check if there is any difference among the farm size categories with respect to the degree of exposure which came out to be highly significant. This implies that there is significant difference among different farm size categories with respect to their distribution over relative risk exposure classes.

5.3.2 Farm level sensitivity index

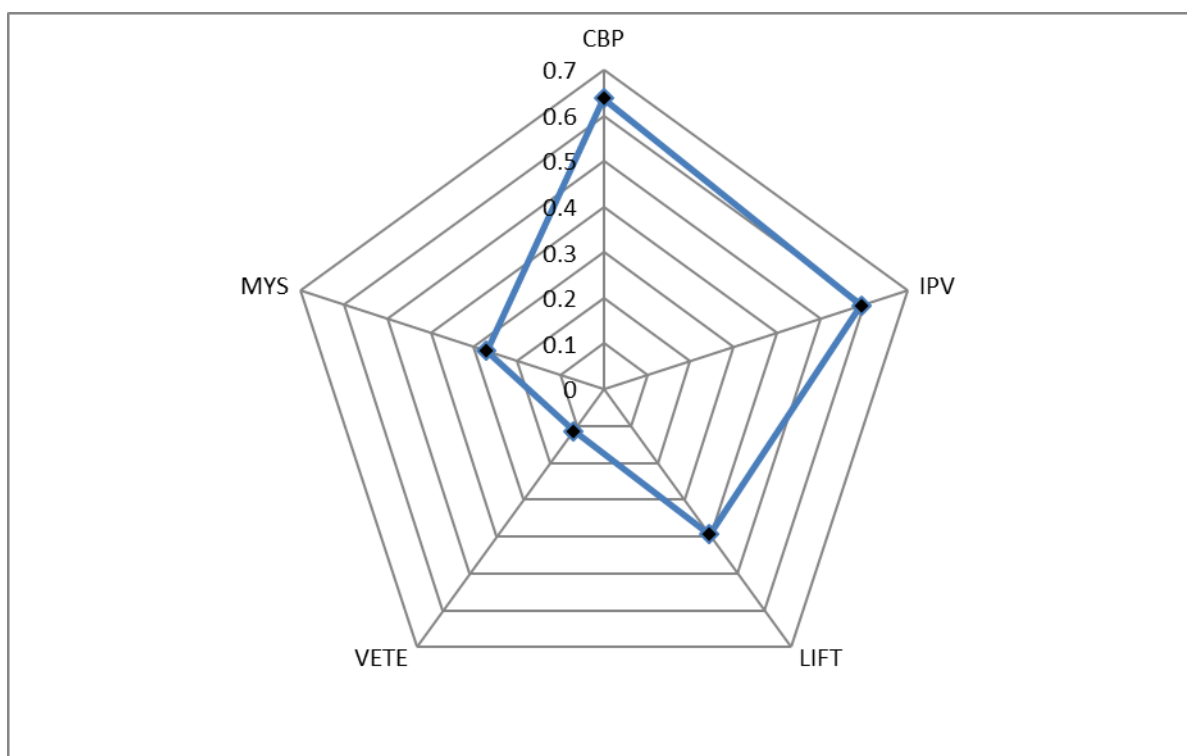
As discussed earlier, vulnerability under the present study has been expressed as a function of exposure, sensitivity and adaptive capacity. “Sensitivity” is defined as the conditions that can ameliorate the hazard or trigger an impact and it adds directly to the extent of vulnerability. As discussed earlier, five different indicators mentioned previously were used to capture the farm level sensitivity index. The indicators after being computed for each households were subjected to principal component analysis to assign them proper weights. The indicators used for calculation of sensitivity component of vulnerability index along with their respective weights is given in table 5.16. Out of the five indicators, “CBP” appears to be of very high weightage at 0.6377 followed by “IPV” and “LIFT” at values 0.5940 and 0.3930, respectively. This is clearly indicative of the fact that technological adoption in form of having cross bred animals makes farmers more sensitive to risk. This may be well evident from the higher losses reported in case of repeat breeding conditions for cross bred animals than the local animals. Apart from that, cross bred animals being more susceptible to diseases than the local animals can be one major factor attributing higher risks. Intensity of poverty assuming substantial importance in risk enhancement is very well understood from an underdeveloped production environment point of view. Poverty is one of the greatest hindrances causing deprivation at each stage of life. Generally, gross income from livestock is increased significantly with rearing of more cross bred animals. This is because of the associated

increased productivity in case of cross bred animals. So the proportion of livestock income in total farm income is well understood to be a factor of sensitivity to risk.

Table 5.16 - Sensitivity index indicators and assigned weights

Sl. No.	Sensitivity Indicators	Sensitivity Indicators (symbols)	Weights
1	Crossbred SAU / Total SAU	CBP	0.637792
2	Intensity of poverty	IPV	0.594049
3	Livestock Income / Total farm income	LIFT	0.393033
4	Amt. of veterinary Expense / Animal	VETE	0.11354
5	Milk yield / SAU	MYS	0.270112

Graph. 5.2 - Distribution of Sensitivity Index weights



The distribution of the computed weights for various indicators of sensitivity index is presented in a graphical manner for better comprehension. The respective weights were multiplied with the indicators and summed to obtain the sensitivity index of each of the households. Cumulative square root of frequency (CSRf) method was utilised to classify the farm households into distinct classes based on their relative sensitivity. Total five distinct classes were drawn and the distribution of farm households over these classes has been presented in Table 5.17.

Table 5.17 - Distribution of farmers under different classes of sensitivity

Class of Sensitivity	Number of Farmers	Percentage
Less Sensitive (0.559 – 0.683)	80	20.00
Moderately Sensitive (0.684 – 1.074)	40	10.00
Sensitive (1.075 – 1.296)	34	8.50
Highly Sensitive (1.297 – 1.495)	137	34.25
Very Highly Sensitive (1.496 – 1.724)	109	27.25
Total	400	100

The relative distribution of households over the five classes of sensitivity depicts the highest number of households falling under highly sensitive category while, the second largest number of households fall under very highly sensitive category. This is suggestive of quite high rate of sensitivity occurrence among the farm households. To draw further inferences it was required to divide the total households on the basis of farm size and relative sensitive category which is presented in Table 5.18.

Table 5.18 - Frequency distribution of farm size and sensitivity index wise categories

Sensitivity Index							
Farm Type	Parameters	Less Sensitive	Moderately Sensitive	Sensitive	Highly Sensitive	Very Highly Sensitive	Grand Total
Landless	Frequency	0	5	5	13	9	32
	Row percent	0.00	15.63	15.63	40.63	28.13	
	Column percent	0.00	12.50	14.71	9.49	8.26	
Marginal	Frequency	74	29	19	85	69	276
	Row percent	26.81	10.51	6.88	30.80	25.00	
	Column percent	92.50	72.50	55.88	62.04	63.30	
Small	Frequency	6	2	4	33	31	76
	Row percent	7.89	2.63	5.26	43.42	40.79	
	Column percent	7.50	5.00	11.76	24.09	28.44	
Medium	Frequency	0	4	6	6	0	16
	Row percent	0.00	25.00	37.50	37.50	0.00	
	Column percent	0.00	10.00	17.65	4.38	0.00	
Grand Total	Frequency	80	40	34	137	109	400
Chi Square Value = 0.259, (P Value) < 0.0001							

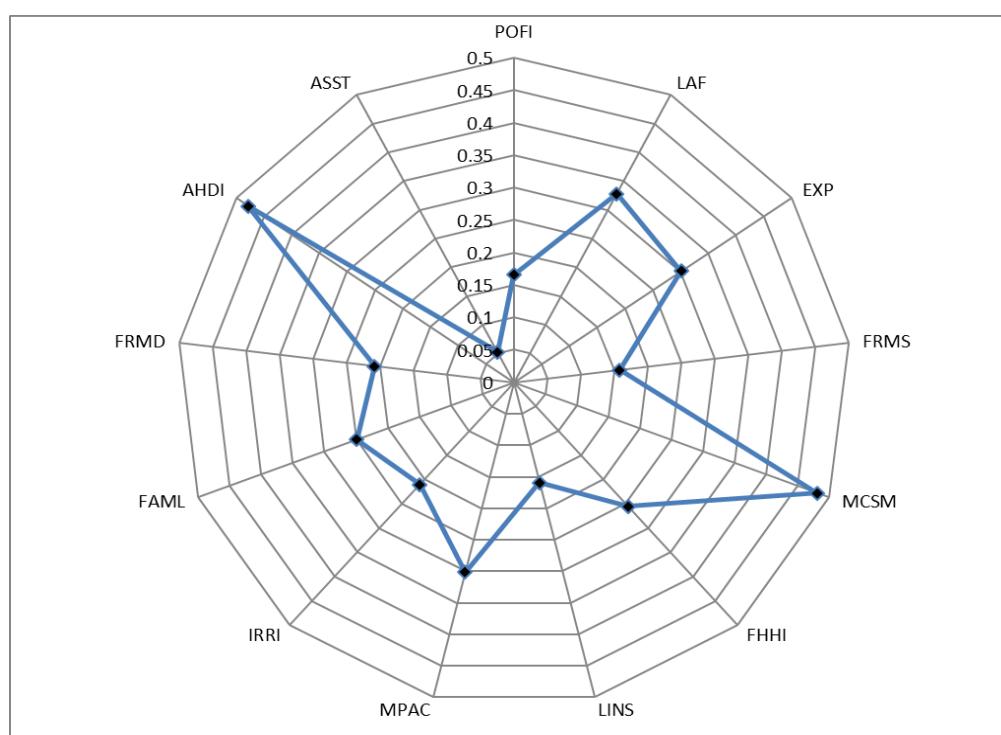
The findings show that, close to 70 per cent of all landless farm households fall under the highly sensitive and very highly sensitive category combinedly, while the combined figures for the same bracket for marginal and medium farm households are close to 56 per cent and 38 per cent, respectively. This is clearly indicative of a pattern which shows that the sensitivity of farm households decreases with the increase in farm sizes. Further chi square test was performed to check if there is any difference among the farm size categories with respect to the degree of sensitivity which came out to be highly significant. This implies that there is significant difference among different farm size categories with respect to their distribution over relative risk sensitive classes.

5.3.3 Farm level adaptive capacity index

The “Adaptive Capacity” is the capacity to adapt measures to avert potential impacts of risk. This segment of vulnerability actually helps to mitigate the incidence of adverse conditions and hence deducted from the sum of exposure and sensitivity index. Thirteen different indicators were used to capture the farm level adaptive capacity index. The indicators after being computed for each households were subjected to principal component analysis to assign them proper weights. The indicators used for calculation of adaptive capacity component of vulnerability index along with their respective weights is given in Table 5.19. The five most important components are found to be “MCSM”, “AHDI”, “LAF”, “MPAC” and “EXP” with their respective weights of 0.4810, 0.4782, 0.3279, 0.3012 and 0.3011, respectively. This is suggestive of the fact that membership in Milk Co-operative Society is one of the most effective risk adaptive measures. In an environment where price of milk is perceived to be of great risk, the membership in MCS is an important adaptive measure which guarantees price stability. The animal husbandry diversification is also found to be a quite important risk adoption measure. Though cross bred animals are important for enhancement of income from livestock, holding their increased proportion may well add to the concentration of risk. So livestock diversification by holding both small and large animals including cross bred and local cows is a better approach for risk mitigation. The third important factor of adaptive capacity i.e. literacy level proves the importance of education as a means of overcoming adverse conditions. The importance of membership in PACS and experience in dairy farming are well understood to be contributing highly towards adaptive capacity. Like membership in MCS, membership in PACS also addresses the risk of capital availability which is very important in an under developed production environment.

Table 5.19 - Adaptive capacity index indicators and assigned weights

Sl. No.	Adaptive Capacity Indicators	Adaptive Capacity Indicators (symbols)	Weights
1	Per capita off farm income	POFI	0.16574
2	Literacy level / Adult family member	LAF	0.327925
3	Experience	EXP	0.301162
4	Farm size / SAU	FRMS	0.158148
5	Membership in MCS	MCSM	0.481043
6	Proportion of farm to HH income	FHHI	0.255496
7	% of livestock insured	LINS	0.159561
8	Membership in PACS	MPAC	0.301198
9	Proportion of irrigated land of total land holding	IRRI	0.210368
10	Family labour / Animal	FAML	0.248498
11	Farm diversification index	FRMD	0.207937
12	AH diversification index	AHDI	0.478213
13	Total Farm assets / Area of farm	ASST	0.052427

Graph. 5.3 - Distribution of Adaptive Capacity Index weights

The distribution of the computed weights for various indicators of adaptive capacity index is presented in a graphical manner for better comprehension. The respective weights were multiplied with the indicators and summed to obtain the adaptive capacity index of each of the households. Cumulative square root of frequency (CSRF) method as described earlier was utilised to classify the farm households into distinct classes based on their relative adaptive capacity. Total five distinct classes were drawn and the distribution of farm households over these classes has been presented in table 5.20.

Table 5.20 - Distribution of farmers under different classes of adaptive capacity

Class of Adaptive Capacity	Number of Farmers	Percentage
Less Adaptive (0.828 – 1.175)	87	21.75
Moderately Adaptive (1.176 – 1.475)	40	10.00
Adaptive (1.476 – 1.835)	161	40.25
Highly Adaptive (1.836 – 2.169)	92	23.00
Very Highly Adaptive (2.170 – 2.548)	20	5.00
Total	400	100

The relative distribution of households over the five classes of adaptive capacity depicts the highest number of households falling under the middle category while, the second largest number of households fall under highly adaptive category. Quite a large segment of total farm households comprising about 22 per cent were found to fall under less adaptive category while only 5 per cent of the total farm households were found to be very highly adaptive. This is suggestive of a medium rate of adaptive capacity occurrence among the farm households. To draw further inferences it was required to divide the total households on the basis of farm size and relative adaptive capacity category which is presented in Table 5.21.

Table 5.21 - Frequency distribution of farm size and adaptive capacity index wise categories

Adaptive Capacity Index							
Farm Type	Parameters	Less Adaptive	Moderately Adaptive	Adaptive	Highly Adaptive	Very Highly Adaptive	Grand Total
Landless	Frequency	5	5	18	4	0	32
	Row percent	15.63	15.63	56.25	12.50	0.00	
	Column percent	5.75	12.50	11.18	4.35	0.00	
Marginal	Frequency	76	30	119	47	4	276
	Row percent	27.54	10.87	43.12	17.03	1.45	
	Column percent	87.36	75.00	73.91	51.09	20.00	
Small	Frequency	6	5	16	37	12	76
	Row percent	7.89	6.58	21.05	48.68	15.79	
	Column percent	6.90	12.50	9.94	40.22	60.00	
Medium	Frequency	0	0	8	4	4	16
	Row percent	0.00	0.00	50.00	25.00	25.00	
	Column percent	0.00	0.00	4.97	4.35	20.00	
Grand Total	Frequency	87	40	161	92	20	400
Chi Square Value = 0.024, (P Value) < 0.0001							

The findings show that close to 32 per cent of landless farmers fall under the less adaptive and moderately adaptive class combinedly, while the figure for the same bracket in case of marginal, small and medium class are 39 per cent, 15 per cent and 0 per cent, respectively. On the other hand, the figures for highly adaptive and very highly adaptive class combinedly rises from land less category at about 13 per cent to about 50 percent in case of medium category. This is clearly indicative of a pattern which shows that the adaptive capacity of farm households increases with the increase in farm sizes. Further chi square test was performed to check if there is any difference among the farm size categories with respect to the degree of adaptive capacity which came out to be highly significant. This implies that there is significant difference among different farm size categories with respect to their distribution over relative adaptive category classes.

5.3.4 Farm level vulnerability index

The central focus of the present study has been to find out the relative degree of vulnerability facing the different farm households of the coastal Odisha region. Under various studies, vulnerability has been defined in different ways but the overall description can be susceptibility of a system to disturbances determined by exposure to perturbations and the capacity to adapt (Nelson et al., 2010). Under the present study vulnerability is defined as a function of exposure, sensitivity and adaptive capacity and these three components have been calculated and studied elaborately. Study further mandates the computation of farm level vulnerability index utilising the above three components for each household the result of which is presented in this section. Cumulative square root of frequency (CSRF) method as described earlier was utilised to classify the farm households into distinct classes based on their relative vulnerability index. Total five distinct classes were drawn and the distribution of farm households over these classes has been presented in Table 5.22.

Table 5.22 - Distribution of farmers under different classes of vulnerability

Class of Vulnerability	Number of Farmers	Percentage
Less Vulnerable (-1.325 to -0.844)	14	3.50
Moderately Vulnerable (-0.843 to -0.287)	79	19.75
Vulnerable (-0.286 to 0.079)	137	34.25
Highly Vulnerable (0.080 to 0.506)	110	27.50
Very Highly Vulnerable (0.507 to 0.956)	60	15.00
Total	400	100

Table 5.23 - Frequency distribution of farm size and vulnerability index wise categories

Vulnerability Index							
Farm Type	Parameters	Less Vulnerable	Moderately Vulnerable	Vulnerable	Highly Vulnerable	Very Highly Vulnerable	Grand Total
Landless	Frequency	0	4	14	9	5	32
	Row percent	0.00	12.50	43.75	28.13	15.63	
	Column percent	0.00	5.06	10.22	8.18	8.33	
Marginal	Frequency	7	42	87	92	48	276
	Row percent	2.54	15.22	31.52	33.33	17.39	
	Column percent	50.00	53.16	63.50	83.64	80.00	
Small	Frequency	5	27	28	9	7	76
	Row percent	6.58	35.53	36.84	11.84	9.21	
	Column percent	35.71	34.18	20.44	8.18	11.67	
Medium	Frequency	2	6	8	0	0	16
	Row percent	12.50	37.50	50.00	0.00	0.00	
	Column percent	14.29	7.59	5.84	0.00	0.00	
Grand Total	Frequency	14	79	137	110	60	400
Chi Square Value = 0.882, (P Value) < 0.0001							

From the findings, it is clear that about 43 per cent of total farm households fall under the category of highly vulnerable and very highly vulnerable combinedly while about 23 percent fall under less vulnerable and moderately vulnerable category combinedly. This is clearly suggestive of the fact that the relative occurrence of vulnerability in case of dairy farmers of coastal Odisha is quite high. To have a further glimpse of relative vulnerability over different sizes of farm holding the findings are presented in Table 5.23.

The findings clearly show that, about 44 per cent of landless households fall under highly vulnerable and very highly vulnerable category combinedly while the figure for the same bracket in case of marginal farmers is close to 50 per cent. But the figures for the same bracket decreases to about 21 per cent and zero per cent in case of small and medium farms, respectively. This shows a clear trend suggestive of the decrease in vulnerability with the increase in farm sizes, which has already been stated in several other studies (Piya et al., 2012) and (Can et al., 2013). As relatively high proportion of marginal farm households fall under the higher vulnerability segment, the policy focus should shift towards lower land holding farms to help them for better coping up mechanism.

5.3.5 Factors affecting Farm level vulnerability index

The results of the multiple regression analysis carried out to identify the factors affecting farm level vulnerability index has been presented in Table 5.24.

Table 5.24 – Factors affecting household level vulnerability index

Sl. No.	Variables	β -Vaues	Standard Error	t - Values
1	Intercept	0.325***	0.106	3.062
2	Distance from nearest market	-0.003	0.004	-0.726
3	Distance from nearest KVK	0.005***	0.001	3.273
4	Percentage of irrigated land	-0.039**	0.016	-2.416
5	Dependency ratio	-0.272**	0.132	-2.062
6	Capital adequacy ratio	-0.123*	0.063	-1.943
7	Region wise dummies (Region1=0, Region2=1)	-0.439***	0.054	-8.196
	R ² Value	0.470		
	F - Value	13.490***		

Significant at ***1, **5 and *10 percent level of probability

Overall, the factors significantly affecting the household level vulnerability index were found to be Distance from nearest KVK ($P<0.01$), Percentage of irrigated land ($P<0.05$), Dependency ratio ($P<0.05$), Capital adequacy ratio ($P<0.1$) and the Region wise location of the households ($P<0.01$). The sign and magnitude of the regression coefficient provides implication about their extent and direction of influence on the vulnerability index. Distance from nearest market was not found to have any significant effect on the vulnerability index. This implies that with increase in distance from nearest KVK, the level of vulnerability of a household also increases. This may highlight the need for enhancement of extension support to the farm households and strengthening of extension network. The decrease in vulnerability with increase in the proportion of irrigated land, may well suggest the need for enhancing irrigation facilities. With better irrigation facilities and increased productivity of land, the level of vulnerability of households is well expected to come down. The dependency ratio is suggestive of decrease in level of vulnerability with increase in number of employed persons in a household. With creation of employment opportunities and increased economic affluence, the level of vulnerability is well expected to come down. The capital adequacy ratio which may be taken as an indicator of credit availability shows negative relationship with vulnerability index. This may indicate that with better scope of credit the households with sound economic conditions become lesser vulnerable. The region wise indicators clearly indicate the households in region-1 (North eastern coastal plains) to be more vulnerable in comparison to the households present in region-2 (East and south eastern coastal plains). Out of the two agro climatic regions of coastal Odisha, region-2 is better placed in terms of irrigation facilities due to the presence of more number of rivers in that region in comparison to region-1. So, this difference in the level of land productivity may be a factor for the region-1 being more vulnerable than region-2. As already stated in several studies, developing irrigation facilities should be taken as a definite measure in reducing vulnerability in an agrarian society (Piya et al., 2012). So adequate policy decisions to enhance irrigation facilities equally in both the regions of coastal Odisha, may be a step towards correcting their differential vulnerability.

5.3.6 Salient findings on the vulnerability

The main exposure indicators having high weights on the exposure index were found to be “ELDS”, “MDC” and “ELRB” at values 0.6615, 0.3559 and 0.2858, respectively. This is suggestive of the fact that, losses due to disease incidence, repeat breeding and death of animals are the greatest contributors to exposure index. The

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frequency distribution of farmers under different classes of exposure index shows that number of farm households fall under less exposed category followed by the highly exposed category at 37.00 per cent and 24.74 per cent, respectively. The frequency distribution of farm size and exposure index wise categories shows that the combined number of landless farm category households falling under highly exposed and very highly exposed category is about 38 per cent. The proportion of households for the same bracket in case of marginal farm category appears to be about 40 per cent. But the figure decreases subsequently in case of small and medium farms to about 13 per cent and 0 per cent, respectively. This may be suggestive of the fact that, the severity of the exposure component decreases with increase in land holding. This is further strengthened by the result of chi square test, which confirms that there is significant difference among different farm size categories with respect to their distribution over relative risk exposure classes.

In construction of the sensitivity index, the indicators which appear to be highly influencing are “CBP”, “IPV” and “LIFT” with weights at 0.6377, 0.5940 and 0.3930 respectively. This is suggestive of the fact that, crossbred animal holding and income risks are the major contributors in sensitivity. The frequency distribution of farmers under different classes of sensitivity shows that about 61 per cent of households fall under highly sensitive and very highly sensitive category while about 30 per cent of farm house holds fall under less sensitive and moderately sensitive category. The distribution of farm size and exposure index wise categories shows that, about 69 per cent of landless farm house holds fall under highly sensitive and very highly sensitive category. About 56 per cent households of marginal farms fall under the same bracket, while the proportion for small and medium farm categories is about 8 per cent and 0 per cent, respectively. This is again suggestive of the fact that, the sensitivity of farm households decreases with increase in farm size.

The indicators highly affecting the adaptive capacity of farm households were found to be, “MCSM”, “AHDI” and “LAF” at values 0.4810, 0.4782 and 0.3279, respectively. This means that membership of milk cooperative society, animal husbandry diversification index and literacy of farm household mostly influence adaptive capacity. The distribution of farmers under different classes of adaptive capacity shows that, 28 per cent of all households fall under highly adaptive and very highly adaptive category. The frequency distribution of farm size and adaptive capacity index wise categories shows that, only 0 per cent and 1.45 per cent of landless and marginal farmers fall under

very highly adaptive category respectively, while about 16 per cent and 25 per cent small and medium farmers fall under very highly adaptive category respectively. This also suggests that, adaptive capacity greatly increases with the increase in land holding of the household.

The distribution of farmers under different classes of vulnerability shows that, about 15 per cent and 28 per cent of the farmers fall under very highly vulnerable and highly vulnerable class. The frequency distribution of farm size and vulnerability index wise categories shows that, about 23 per cent of landless and marginal farmers fall under very highly vulnerable category combinedly, while only 9 percent of small and medium farmers fall under very highly vulnerable category. This clearly suggests that, vulnerability of households decreases with increase in farm size.

The factors that highly affect vulnerability were found to be, distance from nearest KVK ($P<0.01$), per centage of irrigated land ($P<0.05$) and dependency ratio ($P<0.05$). The region wise location of households also appears to be significantly affecting the level of vulnerability ($P<0.01$). The percentage of irrigated land being significantly affecting the vulnerability also indicates the need of increasing irrigation facility to address the situation.

5.4 Effectiveness of alternate risk mitigation strategies adopted by the farmers.

As discussed earlier risk mitigation can be by both risk reduction and risk diffusion. The present study was undertaken to analyse for both. The risk reduction part was captured through the farmer's perception regarding different risk management strategies and the risk diffusion part dealt with quantification of actual enterprise diversification and adoption of livestock insurance as risk mitigation strategies. The findings are presented in the following sections.

5.4.1 Alternative strategies of risk reduction

This study involved the perception of different strategies of risk management and their effectiveness by the farmer at farm household level. As dairy production is often considered risky, the different strategies of risk management along with their relative importance are of prime importance to understand. To get an insight into the farmer's perception of different strategies of risk management, a total 11 activities of risk mitigation were finalised after due deliberations and the farmer's perception of their relative importance was captured in a likert type scale with 1 depicting non relevance and 5 depicting very high relevance.

Table 5.25 – Distribution of respondents according to their perception of relevance of different risk management strategies

Strategies of Risk Management	Irrelevant	Somewhat Irrelevant	Neutral	Somewhat Relevant	Relevant	Average Score
1.Production at lowest possible cost	43 (10.75)	26 (6.50)	29 (7.25)	133 (33.25)	169 (33.25)	3.89* (1.30)
2.Buying livestock insurance	42 (10.50)	61 (15.25)	41 (10.25)	109 (27.25)	147 (36.75)	3.64* (1.39)
3.Buying personal insurance	89 (22.25)	47 (11.75)	97 (24.25)	77 (19.25)	90 (22.50)	3.08 (1.45)
4.Applying strict hygienic rules	15 (3.75)	26 (6.50)	17 (4.25)	121 (30.25)	221 (55.25)	4.27* (1.05)
5.Price contract for outputs	49 (12.25)	118 (29.50)	42 (10.50)	87 (21.75)	104 (26.00)	3.19** (1.41)
6.Price contract for inputs	71 (17.75)	115 (28.75)	24 (6.00)	89 (22.25)	101 (25.25)	3.08 (1.49)
7.Diversification of enterprises	21 (5.25)	15 (3.75)	81 (20.25)	104 (26.00)	179 (44.75)	4.01* (1.12)
8.Off farm employment	59 (14.75)	41 (10.25)	77 (19.25)	138 (34.50)	85 (21.25)	3.37** (1.32)
9.Carrying adequate cash reserves	37 (9.25)	51 (12.75)	41 (10.25)	86 (21.5)	185 (46.25)	3.83* (1.36)
10.Vaccination of the animals	17 (4.25)	23 (5.75)	15 (3.75)	119 (29.75)	226 (56.50)	4.28* (1.05)
11.Proper housing and sanitation	59 (14.75)	41 (10.25)	71 (17.75)	83 (20.75)	146 (36.5)	3.54** (1.44)

Figures in parentheses indicate percentage of respondents. Figures in parentheses for the column of average score indicate standard deviations. Significantly different from the neutral score at *1% and **5 per cent level of probability.

The distribution of respondents according to their perception of relevance of different strategies of risk management and the average score for all the farmers for each such activity is presented in Table 5.25. The standard deviation for each strategies of risk management was observed to be greater than one. It indicates presence of disparity to some extent among the respondents' perception of different risk management strategies. The average score of all the strategies of risk management was found to be above the neutral score. The average scores to all the strategies of risk management exceeding the neutral value of 3 were found to be significant at 1 and 5 per cent level of probability except for the two strategies viz. buying personal insurance and price contracts for inputs with average score value at 3.08 each. This suggests that farmers are indifferent towards these two risk management strategies but do not consider them irrelevant. The strategy of price contract not assuming much importance by the farmers may be owed to the relatively lesser penetration of cooperatives in major parts of the state and the milk price offered by the milk societies not being remunerative enough. This may highlight the much stressed demand of going for area specific cost of milk production approach to determine the price of milk rather than following the uniform biaxial approach using fat and SNF only. The strategies of risk management considered either somewhat relevant or relevant by a large population of farmers were found to be vaccination of the animals (87 per cent of the respondents), applying strict hygienic rules (86 per cent of the respondents), diversification of the enterprises (71 per cent of the respondents), carrying adequate cash reserves (68 per cent of the respondents), production at lowest possible cost (67 per cent of respondents) and buying livestock insurance (64 per cent of the respondents). This has been supplemented by the high average score for the above mentioned strategies at 4.28, 4.27, 4.01, 3.83, 3.89 and 3.64, respectively. The findings for buying of livestock insurance as a management strategy goes against the general perception of farmer's lack of awareness about the benefits of insurance cover. This is also in sharp contrast to the findings of earlier studies viz. (Bardhan et al., 2006) where livestock insurance as a risk mitigation strategy was found to be insignificant. It has been more than a decade since the launch of pilot livestock insurance scheme in India covering 200 districts and the benefits there of has started to percolate to the grass root level enhancing awareness. The findings regarding carrying adequate cash reserves as an effective risk management strategy is also found to be in contrast to the general perception that the subsistence nature of Indian farmers disallows them to carry adequate cash reserves to counter risk. The near equal importance assigned for the vaccination of

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animals and applying strict hygienic rules goes in sync with each other as both are concerned with the good health of the dairy animals and are very important in farm management.

The data for the eleven identified strategies of risk management across 400 households were further subjected to factor analysis to reduce the number of variables and club them into different groups based on their factor loadings, the results of the same is presented in Table 5.26. The application of principal components analysis (PCA) resulted in construction of 4 principal components (factors) with eigenvalues greater than 1. The Bartlett's Sphericity test conducted to assess the applicability of PCA came out highly significant ($P < 0.01$) and this justified the use of PCA for dimension reduction in this case. These 4 factors together explained 62.53 percent of total original variability which can be regarded as satisfactory (Hair et al., 1995). The factors 1 to 4 depicted in Table 5.24 clubbed as different categories of risk can be best described as "Prices and costs (factor-1)", "Health and sanitation (factor-2)", "Insurance and solvency (factor-3)" and "Production management (factor-4)". In factor-1 (prices and costs) the risk management strategies viz. production at lowest possible cost, price contract for outputs, price contract for inputs and diversification of enterprises load very high. Very high average scores have already been obtained for the strategies of production at lowest possible cost and diversification of enterprises. So the loadings for factor-1 seems quite justifiable on this ground. In factor-2 (health and sanitation) the strategies of applying strict hygienic rules, off farm employment, vaccination of the animals and proper housing and sanitation load very high. The first, third and fourth strategies out of the above may well depict the importance of hygiene and health for optimum management of dairy animals. In factor-3 (insurance and solvency) the strategies of buying livestock insurance, buying personal insurance, diversification of enterprises, off farm employment and carrying adequate cash reserve load very high. Livestock insurance as an important strategy of risk management has already come up with high average score. The solvency requirement along with financial security cover may well be understood as important factors for risk mitigation and this is well reflected in factor-3. In factor-4 (production management) the strategies of production at lowest possible cost, buying personal insurance, price contract for outputs, carrying adequate cash reserves and proper housing and sanitation load very high. Effective production management is a must for any dairy enterprise involving a number of other factors for risk redressal. The components of factor-4 go well with this as strategies of production management.

Table 5.26 - Factor analysis and factor loadings for different risk management strategies

Sources of Risk	Average (n=400)	SD	Most important factors			
			1	2	3	4
1.Production at lowest possible cost	3.89	1.30	-0.651	-0.423	-0.076	-0.855
2.Buying livestock insurance	3.64	1.39	-0.461	0.191	-0.918	-0.094
3.Buying personal insurance	3.08	1.45	0.388	-0.055	0.725	0.863
4.Applying strict hygienic rules	4.27	1.05	-0.009	0.914	0.721	0.475
5.Price contract for outputs	3.19	1.41	0.591	0.076	0.045	0.874
6.Price contract for inputs	3.08	1.49	-0.581	0.123	-0.499	-0.142
7.Diversification of enterprises	4.01	1.12	0.615	-0.206	0.704	0.199
8.Off farm employment	3.37	1.32	0.394	0.671	0.689	0.121
9.Carrying adequate cash reserves	3.83	1.36	0.171	-0.493	0.767	-0.532
10.Vaccination of the animals	4.28	1.05	-0.048	0.565	-0.354	-0.361
11.Proper housing and sanitation	3.54	1.44	0.193	0.508	0.335	0.738

Factors 1 to 4 are named as, 1 – Prices and Costs, 2 – Health and sanitation, 3 – Insurance & Solvency, 4 – Production Management; Loadings of ≥ 0.5 are depicted in bold

5.4.2 Alternative strategies of risk diffusion

The study of alternative strategies of risk diffusion was carried out mainly on the three aspects as listed below.

- (a) Enterprise diversification.
- (b) Adoption of livestock insurance.
- (c) Adoption of crop insurance.

5.4.2.1 Enterprise diversification

As discussed earlier the non systematic risk which is not correlated with the variations in the farm portfolio can be eliminated by the diversification of the farm enterprises. Dairy as an enterprise involves both the activities of animal husbandry and cropping. Diversification in both the enterprises is very essential towards risk diffusion and to facilitate this, the study pertaining to diversification of animal husbandry and cropping has been presented separately in Table 5.27 and is explained in subsequent paragraphs. Under Simpson Diversification Index (SDI) the value of 1 indicates complete diversification and the value of 0 indicates complete specialisation. For better interpretation of the results, the index values may be classified into different categories viz. low level (index value less than 0.25), moderate level (index value from 0.25 to 0.5), high level (index value more than 0.5 to 0.75) and very high level (index value more than 0.75). The above classification has been followed in several studies including (Agarwal, 2013) studying farm level diversification and assessing its effectiveness.

Animal Husbandry diversification

The landless farm households were observed to have high level of diversification at value 0.631. The higher level of diversification observed among the land less category may owe to their more diverse species composition of livestock including local cows, CB cows, sheep, goat and swine, etc. The rearing of small animals like sheep and goat is generally considered as a social taboo and generally opted for by the households of lower economic affluence. The second highest level of diversification was found in case of marginal farm households falling under moderate category which may suggest a decrease in AH diversification with increase in farm size. The overall diversification across all the households was found to be 0.446 which comes under moderate category.

Table 5.27 - Animal Husbandry and Crop Diversification Indices at farm household level in Coastal Odisha.

Farm Category	Farm household level	
	Animal Husbandry diversification index	Crop diversification index
Landless	0.631	-
Marginal	0.435	0.531
Small	0.409	0.549
Medium	0.435	0.525
Overall	0.446	0.534

Crop diversification

The Simpson Diversification Index (SDI) values for crop diversification seems to fall under high category for all types of farm households. The values of crop diversification index for different farm categories were found to be 0.531, 0.549 and 0.525 for marginal, small and medium category of farm households, respectively. The overall crop diversification including all types of farm households was found to be 0.534 which also falls under high range. Overall, the observed diversification across different farm categories appear to be quite same with no significant difference among them.

5.4.2.2 Adoption of livestock insurance

In spite of applying the best managerial practices in dairy farming, some amount of risk will always remain inherent to the system. This may very well depict the risky nature of the enterprise and livestock insurance may well be considered as one of the best options to counter those risks. In India and particularly in Odisha, the livestock insurance cover available for the dairy animals mostly covers the risk of death of the animal within the period of insurance. Though previously the dairy farmers were not considered to be aware much about the benefit of livestock insurance, with the progress of the pilot livestock insurance scheme across the country and National Livestock Mission (NLM) recently has helped the benefit to percolate to grass root level and thereby increasing awareness. The present study focusses on the quantification of the extent of adoption and the benefit received due to livestock insurance among the dairy farmers of the study area. For better comprehension the findings of the study has been presented in following two sections.

Extent of adoption of livestock insurance and benefit received

Table 5.28 presents the findings pertaining to the extent of adoption of livestock insurance and benefit received among the farmers. In terms of proportion of farmers opting for livestock insurance, the landless households appear to be quite behind than other types of farm households. The insurance adoption rate for landless farmers was found to be about 23.33 per cent against 40.31 per cent in medium farms which is also the highest among all farm types. Overall the insurance adoption tends to increase from landless farms to marginal farms and after a brief drop for small farms again increases for the medium farms. This may help us to suggest the increase in insurance adoption rate with the increase in farm size. The percentage of animals insured against the adoption rate of livestock insurance seems to be in sharp contrast. The percentage of animals insured seems to be quite consistent and is found to be the highest among the medium farms at 67.62 per cent. The percentage of animals insured shows a clear increasing trend with the increase in land holding with the corresponding figure at 53.63 per cent for land less class to 67.62 per cent in case of medium class. The overall percentage of animals insured across all farm types was found to be 58.92 per cent. This may suggest that farmers are specific in choosing insurance coverage for the animals and they may be opting coverage for only the high productive animals at more disposal of risk. With overall finding of 32.18 per cent farmers opting for livestock insurance and about 58.92 per cent of animal holdings getting insured in them, it may roughly be suggested that about 19 per cent of all milch animals are entitled to insurance coverage which is product of the above two figures. This may well suggest the need to extend the insurance coverage to a lot more dairy cattle population which is hitherto has been left uncovered. The study determines the amount of benefit received by the farmers in terms of claims from insurance in the event of mortality. It has been analysed in terms of proportion of mortality loss recovered through claims from livestock insurance separately to the farmers who opted for insurance and the rest. There seems to be a clear increasing trend in the benefit received by the insured farmers with the increase in land holdings. Overall benefit received per insured farmers increases from Rs. 488 in case of landless farmers to Rs. 1186 in case of medium farmers with the average amount of Rs. 809 across all types of farm households. The recovery of mortality loss through insurance was to the extent of 38.66 per cent among farmers opted for insurance. The same was very less i.e. 14.17 per cent on an average farm size category. One of the

reasons for low coverage may be lower valuation of animals to lessen the burden of insurance premium on the farmer. But proper valuation of animals at par with its market value is very much essential to ensure adequate compensation to the farmer in case of a mishap. Like in the case of insured farmers, the average insurance benefit received per farmer also shows a clear increasing trend with increase in land holding. The average benefit received per farmer across all types of farm holdings was found to be Rs. 275 per annum which may seem quite abysmal in comparison to the various losses faced by the dairy farmers including those due to disease incidence and calamities.

Table 5.28 - Extent of adoption of Livestock Insurance as a risk mitigation strategy and benefit received.

Farm Category	Proportions		Amount	
	Opting for livestock insurance (Per cent of HH)	Livestock insured by farmer opting for insurance (Per cent of animals)	Claims received by the farmers opting for livestock insurance (Rs/Annum/HH)	Claims received per farmer (Rs/Annum)
Landless	23.33	53.36	488	121
Marginal	33.57	57.61	762	270
Small	28.39	64.34	1038	310
Medium	40.31	67.62	1186	499
Overall	32.18	58.92	809	275

Source : Based on data collected from farmers for last 5 years

Extent of loss coverage and risk mitigation

Table 5.29 presents the findings pertaining to the amount of loss incurred by the farmers due to dairy cattle mortality and the benefit amount received in that regard. The findings are presented in two categories i.e. the benefit of livestock insurance received by the farmers who actually opted for it and the benefit received by farmers on an average comprising the whole population irrespective of opting for insurance coverage. The reported mortality loss of dairy animals was observed to follow a clearly increasing trend with increase in land holding with values ranging from Rs. 1,821 per Annum in landless class to Rs. 2,644 per annum in the medium class of farms. The overall mortality loss across all category of farm holdings was found to be Rs. 2,094 per Annum. The

proportion of loss recovered in case of insured farmers clearly shows an increasing trend with increase in land holding, with the values ranging from 26.82 per cent in landless farms to 44.86 per cent in case of medium farms. The overall loss recovered in case of insured farmers was found to be 38.66 per cent. The lower proportion of loss coverage may be owed to the reasons of lower insurance adoption among farmers and also insuring the animals for lower values to help lower the insurance premium burden on the farmers. The average proportion of losses covered per farmer comprising both insured and non-insured class was found to be quite low in comparison with the values ranging from an abysmal 7.14 per cent in landless farmers to about 20.76 per cent in medium farmers. Though the proportion of loss coverage appears to be increasing with increase in land holding the overall loss covered stands at a mere 14.17 per cent across all categories of farms.

Table 5.29 - Extent of loss coverage by adoption of Livestock Insurance as a risk mitigation strategy.

Farm Category	Farmers opting livestock insurance			Overall farmers		
	Mortality losses (a) (Rs/Annum)	Claims received from livestock insurance (b) (Rs/Annum)	Loss recovered (Per cent) (b/a*100)	Mortality losses per farmer (c) (Rs/Annum)	Claims received per farmer (d) (Rs/Annum)	Loss recovered (Per cent) (d/c*100)
Landless	1821	488	26.82	1691	121	7.14
Marginal	2014	762	37.84	1856	270	14.57
Small	2382	1038	43.56	2263	310	13.70
Medium	2644	1186	44.86	2403	499	20.76
Overall	2094	809	38.66	1942	275	14.17

Source : Based on data collected from farmers for last 5 years

This finding is clearly suggestive of the need to extend the insurance coverage further to larger number of livestock population and introduction of more inclusive insurance products covering the losses due to diseases and permanent disability of the animal. Livestock disease insurance is a need of the time and encouraging results have been found by its successful implementation in countries like USA, Australia, Canada and EU (Koontz et al., 2006). Apart from this other innovative approaches like

introduction of index based livestock insurance can be mulled over which involves careful layering of risk pools and allows the community to select their extent of coverage based on the perceived risk exposure (Mahul and Skees, 2007). Govt. of India may consider launching of pilot schemes to check out the feasibility in Indian context.

5.4.2.3 Adoption of crop insurance

Agriculture is subjected to the vagaries of nature and crop damage often results out of the factors which are beyond the control of the farmer. To counter these situations of loss, crop insurance is one of the most effective tools of management. In Indian agriculture, crop insurance has already come a long way since the launch and inception of National Agricultural Insurance Scheme (NAIS) in the year 1999 to the recent launch of Pradhan Mantri Fasal Bima Yojna (PMFBY). In view of the above things it was important to know the extent and magnitude of crop damage faced by the farmers in the present study area and the extent of loss mitigation possible by the adoption of crop insurance. For better comprehension the findings of the study has been presented in following two sections.

Extent of adoption of crop insurance and benefit received

Table 5.30 presents the findings pertaining to the extent of adoption of crop insurance and benefit received among the farmers. In terms of proportion of farmers opting for crop insurance, the marginal households appear to be quite behind the other types of farm households. The insurance adoption rate for marginal farmers was found to be about 73.57 per cent while it was about 79.39 per cent and 88.30 per cent in case of small and medium farmers. The overall crop insurance adoption among all types of farmers was found to be 75.41 per cent. The adoption of crop insurance has been mainly made possible by the presence of credit institutions like PACS, RRBs and commercial banks, which make mandatory crop insurance provisions along with agricultural loan advances. The proportion of crop area insured by the farmers appears to be following an opposite trend compared to the proportion of farmers opting for crop insurance. The proportion of crop area insured decreases from 61.24 per cent in case of marginal farmers to 53.44 per cent in case of medium farmers with the over all proportion at 59.51 per cent. So with about 75 per cent farmers opting for crop insurance and about 60 percent of cropped area getting insured, it can be said that about 45 per cent of all cropped area is getting insured in coastal Odisha which needs to be improved further to

strengthen the objective of risk mitigation. The study also involved in determining the amount of benefit received by the farmers. The findings are presented in two categories i.e. the benefit of crop insurance received by the farmers who actually opted for it and the benefit received by farmers on an average comprising the whole population irrespective of opting for insurance coverage. The amount of benefit received by the insured farmers was found to be Rs. 2331 per annum across all category of farmers, while the same figure for overall farmers was found to be Rs. 1801 per annum.

Table 5.30 - Extent of adoption of Crop Insurance as a risk mitigation strategy and benefit received.

Farm Category	Proportions		Amounts	
	Opting for crop insurance (Per cent of HH)	Crop area insured by the farmers opting for crop insurance (Per cent of land)	Claims received by the farmers opting for crop insurance (Rs./Annum)	Claims received per farmer (Rs./Annum)
Landless	-	-	-	-
Marginal	73.57	61.24	1691	1244
Small	79.39	54.52	3831	3042
Medium	88.30	53.44	6242	5512
Overall	75.41	59.51	2331	1801

Source : Based on data collected from farmers for last 5 years

Extent of loss coverage and risk mitigation

Table 5.31 presents the findings pertaining to the amount of loss incurred by the farmers due to crop damage and the benefit amount received in that regard. The findings are presented in two categories i.e. the benefit of crop insurance received by the farmers who actually opted for it and the benefit received by farmers on an average comprising the whole population irrespective of opting for insurance coverage. The reported benefit received in comparison to the crop loss gives the proportion of loss covered in each case. The proportion of loss covered was found to be quite same in all category of farmers from 24.57 per cent in case of marginal farmers to 25.32 per cent in case of medium farmers with the overall proportion at 24.90 per cent. The proportion of loss recovered in

case of all farmers was also found to be more or less same without much difference across different farm types with a figure of 20.30 per cent overall recovery of losses.

This study is clearly suggestive of the need to extend the insurance coverage further to larger proportion of crop area and introduction of more inclusive insurance products. The crop insurance coverage also needs to be extended to various other crops mainly cash crops which are not being covered presently.

Table 5.31 - Extent of loss coverage by adoption of Crop Insurance as a risk mitigation strategy.

Farm Category	Farmers opting crop insurance			Overall farmers		
	Crop losses (a) (Rs./Annum)	Claims received from crop insurance (b) (Rs./Annum)	Loss recovered (Per cent) (b/a*100)	Crop losses per farmer (c) (Rs./Annum)	Claims received per farmer (d) (Rs./Annum)	Loss recovered (Per cent) (d/c*100)
Landless	-	-	-	-	-	-
Marginal	6883	1691	24.57	6211	1244	20.03
Small	15146	3831	25.30	14752	3042	20.62
Medium	24649	6242	25.32	23494	5512	23.46
Overall	9362	2331	24.90	8726	1801	20.30

Source : Based on data collected from farmers for last 5 years

5.4.3 Salient findings on risk mitigation strategies

Of all the eleven strategies of risk management tabulated to capture the farmers' perception of importance about them, scored more than the neutral average score of 3. This confirms their relative importance and as effective strategies of risk management. The strategies which got the highest average scores were found to be vaccination of the animals, applying strict hygienic rules, diversification of enterprises, production at lowest possible cost and carrying adequate cash reserves at average score values at 4.28, 4.27, 4.01, 3.89 and 3.83 respectively. The comparatively high score for livestock insurance depicts awareness about this with progress of time. The PCA analysis resulted

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in construction of 4 components with eigen values greater than 1 and they together found to be explaining about 62.53 per cent of variability in the original data which can be taken as satisfactory. The four factors were named as 1-Prices and costs, 2-Health and sanitation, 3-Insurance and solvency and 4-Production management.

The animal husbandry diversification value was found to be the highest in case of landless households at 0.631. The relatively higher value in case of landless farmers may be due to their larger dependence on the animal husbandry and rearing of more number of species. Over all the animal husbandry diversification was found to be decreasing with increase in farm size and the overall diversification across all farm categories was found to be about 0.446. The crop diversification was found to be more or less same across all the farm categories with an overall value of 0.534 which may be considered as falling under high range.

The extent of adoption of livestock insurance was found to be highest in case of medium farmers at about 40 per cent of farmers opting for livestock insurance, while the figure was found to be lowest for landless category of farmers at about 23 per cent. The adoption of livestock insurance was found to be progressing with the increase in farm size. Overall it was found that about 32 per cent of farmers are opting for insurance with about 59 per cent of their animals getting insured. This suggests that about 19 per cent of all insurable milch animals of the region are entitled to livestock insurance coverage. The amount of claim received per insured farmer was found to be about Rs. 809 while the claim amount received per overall farmer was found to be about Rs. 275. In terms of coverage of mortality loss through insurance claim benefit, it was found that 39 per cent of overall mortality losses were covered through insurance claims. The overall coverage of mortality loss of animals by insurance claims were found to be about 14 per cent. The overall crop insurance adoption among all types of farmers was found to be about 75.41 per cent. The proportion of crop area insured by the farmers opting for crop insurance was found to be about 59 per cent. The average claim received by the farmers opting for crop insurance was found to be about Rs. 2,331 that for overall farmers was found to be about Rs. 1,801. For extent of crop loss coverage by adoption of crop insurance, it was found that about 25 per cent of all crop losses are getting covered by claim received in case of the farmers opting for crop insurance. For overall farmers the loss coverage was found to be about 20 per cent of the estimated crop loss.

5.5 Risk Efficient Farm Plans.

Farm production decisions are often driven by the simple principle of available resources and the returns obtained from them. In a risk neutral situation, farmer would always optimise the returns from various enterprises to maximise profit. Though this may not be the ideal situation happening in field, still this can be the first step in formulating risk efficient farm plans by knowing the highest level of profit that can be obtained if there is no risk.

5.5.1 Risk neutral farm plan

The risk neutral farm plan broadly assumes that farmers maximize aggregate return subject to resource and non-resource constraints without taking into account the variability of return involved in the respective enterprises. Animal husbandry along with cropping activities form the backbone of agriculture in the study area. Odisha being a coastal state, fishery was also found to have presence in the regular farming activities of the region. So the composite farm plan involved all the activities of cropping, dairying and animal husbandry along with fishery. Apart from landless farm households, marginal, small and medium households are the three major land holding classes of the region. So composite farm plans were developed for all the three classes of farm households involving the available resources and constraints.

5.5.2 Farming activities under the present study

The farm plan took into consideration all the farming activities including cropping, animal husbandry and allied activities like fishery. Six different cropping activities prevailing in the region were taken into consideration. Paddy being the main crop of the region is grown both in Kharif and Rabi seasons. The crops of Rabi season are Mung, Urad and Ground nut apart from Rabi Paddy. The animal husbandry activities comprised of local and crossbred cows along with small ruminants of goat and sheep. Fishery was also represented as allied activity.

5.5.3 Formulation of risk efficient farm plans – Application of MOTAD

The objective of the present study is to evolve efficient enterprise mix which would ensure certain level of return with risk attached to it. The maximisation farm plan resulted in highest possible return irrespective of the risk in farm enterprises. However, due to uncertainty in prices, yield, etc. in different situations, farm returns are subjected to uncertainty. So a realistic farm plan requires incorporation of risk component into it.

The MOTAD (Minimisation of Total Absolute Deviation) involves negative deviations from mean value return as a risk component which is incorporated in the formulation of risk efficient farm plans. This meets the dual objective of minimisation of risk and attainment of the expected level of return (Jha, 1994). The utility function of the farmers was kept in mind while deriving a set of optimal plans on three categories of synthetic farms namely marginal, small and medium.

5.5.4 Risk content and enterprise pattern in farm plans

The available resources were allocated under conditions of risk amongst different activities of crop, animal husbandry and fishery for the three size groups of farms taken in study and the results are presented in Tables 5.32, 5.33 and 5.34 for marginal, small and medium farms, respectively. The process of resource allocation with risk minimisation resulted in five risk efficient farm plans parametrised over a range of target returns. Each of the plans represented a different combination of enterprise mix for values of return and risk. The Plan-1 of every farm was formulated for a target return of the same value as the existing return, while Plan-5 had the highest return.

5.5.4.1 Risk Efficient Farm Plan for marginal farms

Five risk efficient farm plans were formulated for the marginal farm households with increasing levels of target return from Rs. 49,356 to Rs. 84,165. The first plan which targeted for same level of return as the existing farm plan appeared to have a Coefficient of Variation (CV) value of 5.18 per cent. The CV value taken as a measure of risk content of the plan provides an idea about the per cent of variation in the expected return. The cropping intensity though increased to about 195 per cent than the existing intensity of 129 per cent. The cropping pattern appears to be shifting more in favour of crops like Mung and cash crops like ground nut whose proportions of cultivated area increases to about 41 per cent and 8 per cent from their existing level of about 19 per cent and 2.5 per cent, respectively. This is suggestive of better return prospects from these crops with relatively lesser risk content. The animal husbandry activities seem to have lesser representation and resource allocation with holding of two local cows only with no cross bred cows and small ruminants. The fisheries sector which had presence in the existing farm plan appears to be missing in Plan-1 and also in all successive plans. The cropping intensity appears to be following a fluctuating trend in the successive plans of higher return.

Table.5.32 - Risk Efficient Farm Plans for Marginal Farm Households under Mixed Farming System (NSA = 1.57 acres)

Particular Enterprises	Unit	Existing Plan	Risk efficient plans				
			Plan-1	Plan-2	Plan-3	Plan-4	Plan-5
Cropping Activities							
Kharif Paddy	Acre	1.01 (50.00)	1.10 (35.95)	1.10 (44.72)	1.10 (35.6)	1.10 (35.04)	1.10 (35.15)
Rabi Paddy	Acre	0.25 (12.38)	-	-	-	-	-
Mung	Acre	0.39 (19.31)	1.25 (40.85)	0.97 (39.44)	1.57 (50.81)	0.90 (28.67)	0.63 (20.13)
Urad	Acre	0.12 (5.95)	0.08 (2.62)	-	-	0.31 (9.88)	-
Ground nut	Acre	0.05 (2.48)	0.24 (7.85)	-	-	0.36 (11.47)	0.93 (29.72)
Vegetables	Acre	0.20 (9.91)	0.39 (12.75)	0.39 (15.86)	0.42 (13.6)	0.47 (14.97)	0.47 (15.02)
Total Cropped Area	Acre	2.02 (100)	3.06 (100)	2.46 (100)	3.09 (100)	3.14 (100)	3.13 (100)
Cropping Intensity	%	128.6	194.9	156.6	196.8	200	199.3
Animal Husbandry & Allied Activities							
Local Cow	No.	1.1	2	0	0	0	0
CB Cow	No.	0.6	0	1	1	1	1
Goat and Sheep	No.	1	0	1	2	3	3
Fisheries	No.	0.04	0	0	0	0	0
Expected Return	Rs.	49,356	49,356	58,354	67,425	76,388	84,165
CV	%		5.18	4.94	4.43	6.42	11.83

Figures in the parentheses indicate per cent of Total Cropped Area

After reaching 195 per cent in Plan-1, it again falls to about 157 per cent in Plan-2 and then rises to the maximum possible returns. Plan -2 with least cropping intensity of about 157 per cent has maximum share of cropping under mung and vegetables at about 39 and 16 per cent, respectively. This denotes the importance of vegetable cropping as a crop of higher return with lesser risk. The least CV value is noted in Plan-3 at 4.43 per cent among all plans which increases substantially to 11.83 per cent in case of Plan-5. Plan-3 with an expected return of Rs. 67,425 appeared to be the least risk content plan proving a stable alternative for the risk averse farmers. Among crops, Mung appeared to be following an increasing trend to about 1.57 acre in Plan-3 which then gradually decreased in subsequent plans to 0.63 acre in Plan-5. In contrast Ground nut which appeared to be completely missing in both Plan-2 and Plan-3 increased steadily to 0.93 acre in Plan-5. This is suggestive of the role of groundnut cultivation for higher expected returns. Over all a right combination of the crops namely Mung, Groundnut and Vegetables appeared to be key for higher return with lower risk.

In case of animal husbandry and allied activities, the local cows appeared to have a prominent presence in Plan-1 at 2 units but it was absent in all subsequent risk efficient farm plans. Though the holding of local cows initially increased from the existing level of 1.1 units to a double value in Plan-1, it got omitted in all subsequent farm plans. This may be due to the lower return prospects from local cows than the crossbred counterparts. Crossbred cows, which was missing initially in Plan-1 are found in all subsequent plans till Plan-5. The preference to crossbred cows for increased levels of expected return can mainly be attributed to the prospects of higher return from them. Small ruminants like goat and sheep appeared to have an increasing presence in all higher levels on expected return. Though the holding of small ruminants was initially absent in Plan-1, it increased constantly to three units in Plan-3. Small ruminants thus appear to provide considerable returns with comparatively lesser risk content than the other animal husbandry activities. The disappearance of fishery enterprise in all plans is quite surprising. Odisha being a coastal state has substantial inland water resources with potential for development of inland fishery. But the sector appears to have supporting activity and run at subsistence level and hence does not add much to the returns of the farmer.

5.5.4.2 Risk Efficient Farm Plan for Small Farms

On similar line five risk efficient farm plans were formulated for the small farms of the study area with different levels of expected returns ranging from Rs. 99,209 to Rs.

1,33,087. The Plan-1 having the same level of expected return as the existing farm plan provided an alternative resource allocation simultaneously with risk minimisation. The cropping intensity of Plan-1 increased to about 177 per cent from the existing level of about 132 per cent, which was suggestive of better resource allocation potential. Kharif paddy being the principal cereal crop of the region is maintained at a constant level of about 2.29 acres though its share in the overall cropped area slightly decreases from that of Plan-1 to be maintained at a more or less constant level. The Rabi paddy appeared to be missing in all the formulated farm plans which may be due to its lesser return prospects with comparatively higher risk content. Mung being the principal rabi crop of the region appeared to have increased presence in all subsequent plans of higher return. This underlines the importance of Mung as a crop of stable return with relatively lesser risk content. Urad is the second pulses crop which is planted in the region in rabi season appeared to be present substantially for all levels of increased return in contrast to marginal farm plans, where it was mostly absent. The area under urad cultivation though appeared to increase initially to about 1.59 acres in Plan-3 decreased constantly in all subsequent farm plans to about 0.13 acre in Plan-5. This shows paddy to be a medium risk efficient crop which is generally not favourable for increased levels of expected return. Groundnut in contrast to urad follows a constantly increasing trend in terms of cropped area for all the higher levels of expected return. The cropped area of groundnut increased consistently from 0.06 acres in Plan-1 to 1.64 acres in Plan-5. This highlights the importance of groundnut as a risk efficient cash crop. The area under vegetables also showed an increasing trend from 0.70 acres in existing plan to 0.98 acres in Plan-5. Vegetable as a kharif crop alongside kharif rice acts as a source of financial support for the farm family. Being a cash crop, higher return is expected from it and its enhanced presence in the final plan is positive sign in farm planning. It also denoted the higher possible return from vegetable in comparison to its risk content. Overall cropping intensity increased from about 132 per cent in existent plan to the maximum possible limit in the plan of highest expected return.

In case of animal husbandry and allied activities local cows had considerable presence in the existing farm plan at about 2 unit holdings. But the presence of local cows appeared to be missing in all subsequent levels of farm planning. Though this is quite surprising, it might be attributed to the lesser return expected from them. The crossbred cows in contrast appeared to have a consistent presence in all the plans for different levels of expected return.

Table.5.33 - Risk Efficient Farm Plans for Small farm Households under mixed farming System (NSA = 3.28 acres)

Particular Enterprises	Unit	Existing Plan	Risk efficient plans				
			Plan-1	Plan-2	Plan-3	Plan-4	Plan-5
Cropping Activities							
Kharif Paddy	Acre	2.10 (48.62)	2.29 (39.56)	2.29 (35.95)	2.29 (35.56)	2.29 (34.97)	2.29 (34.97)
Rabi Paddy	Acre	0.43 (9.96)	-	-	-	-	-
Mung	Acre	0.91 (21.07)	1.20 (20.73)	1.67 (26.22)	1.45 (22.52)	1.13 (17.26)	1.51 (23.06)
Urad	Acre	0.09 (2.09)	1.42 (24.53)	1.59 (24.97)	1.52 (23.61)	1.17 (17.87)	0.13 (1.99)
Ground nut	Acre	0.09 (2.09)	0.06 (1.04)	-	0.31 (4.82)	0.98 (14.97)	1.64 (25.04)
Vegetables	Acre	0.70 (16.21)	0.82 (14.17)	0.82 (12.88)	0.87 (13.51)	0.98 (14.97)	0.98 (14.97)
Total Cropped Area	Acre	4.32 (100)	5.79 (100)	6.37 (100)	6.44 (100)	6.55 (100)	6.55 (100)
Cropping Intensity	%	131.7	176.5	194.2	196.3	199.6	199.6
Animal Husbandry & Allied Activities							
Local Cow	No.	2.1	0	0	0	0	0
CB Cow	No.	1.01	1	1	1	1	1
Goat and Sheep	No.	2	2	3	4	3	3
Fisheries	No.	0.07	0	0.02	0	0	0
Expected Return	Rs.	99,209	99,209	1,07,158	1,15,096	1,24,096	1,33,087
CV			4.95	4.41	4.63	8.12	12.04

Figures in the parentheses indicate per cent of Total Cropped Area

This denotes the higher expected return from the crossbred animals with lesser risk associated to them in comparison. The small ruminants appear to have an increased and uniform presence across all the different levels of farm plan, in comparison to their presence in the existing plan. The small ruminants represent high return enterprise with comparatively lesser risk association. Unlike marginal farm plans where the fishery enterprise was completely absent for all the farm plans, it appeared at a small quantum of about 0.02 acres in Plan-2 for the small farms. The absence of fishery enterprise in all subsequent plans for small households depicts the need for promoting that sector with govt. assistance to make it financially more profitable and viable. The CV for the plans initially dropped to 4.41 per cent in Plan-2 from a level of 4.95 in Plan-1 suggesting a scope of better resource allocation in the existing plan. As the CV increased substantially for subsequent plans to about 12.04 per cent in Plan-5 it depicted higher risk association with increased farm returns, providing scope for risk averse farmers to choose any plan of suitable risk and enterprise combination for them.

5.5.4.3 Risk Efficient Farm Plan for medium Farms

The plans for medium farm was formulated parametrising the returns from its existing return of Rs. 1,44,116 to Rs. 1,92,511, which depicts the highest return with optimum resource allocation. Kharif paddy appeared to have a constant presence across all the levels of farm plans, though its per cent share in total cropped area went on decreasing consistently from about 53 per cent in existing plan to about 35 per cent in Plan-5. Rabi paddy appeared to be missing in all subsequent levels of farm planning as in the case of marginal and small farms. This again depicted the lower return prospects from that crop in comparison to high input cost and risk content. Surprisingly Mung which had increasing crop area in the plans of higher expected return in case of small farms, appeared to follow a decreasing trend from 2.95 acres in Plan-1 to about 2.08 acres in Plan-5. Similar trend was observed in case of urad also, where the cropped area decreased consistently from 1.83 acres to about 0.02 acres in Plan-5. This underlines the importance of mung and urad as crops of medium risk with lesser return prospects. Groundnut as a cash crop showed a consistently increased presence in all the plans of higher expected return from 0.04 acres in Plan-1 to about 3.12 acres in Plan-5 which are about 0.42 per cent and 30 per cent of the total cropped area. This underlined the importance of groundnut as a cash crop helpful in increasing the income level of the farmers with comparatively less risk.

Table.5.34 - Risk Efficient Farm Plans for Medium farm Households under Mixed Farming System (NSA = 5.22 Acres)

Particular Enterprises	Unit	Existing Plan	Risk efficient plans				
			Plan-1	Plan-2	Plan-3	Plan-4	Plan-5
Cropping Activities							
Kharif Paddy	Acre	3.50 (52.56)	3.65 (38.15)	3.65 (41.86)	3.65 (35.17)	3.65 (35.2)	3.65 (34.97)
Rabi Paddy	Acre	0.75 (11.27)	-	-	-	-	-
Mung	Acre	1.35 (20.28)	2.95 (30.83)	2.8 (32.12)	2.08 (20.04)	2.08 (20.06)	2.08 (19.93)
Urad	Acre	0.20 (3.01)	1.83 (19.13)	0.91 (10.44)	1.97 (18.98)	1.09 (10.52)	0.02 (0.2)
Ground nut	Acre	0.15 (2.26)	0.04 (0.42)	0.23 (2.64)	1.17 (11.28)	2.04 (19.68)	3.12 (29.89)
Vegetables	Acre	0.71 (10.67)	1.10 (11.5)	1.13 (12.96)	1.51 (14.55)	1.51 (14.57)	1.57 (15.04)
Total Cropped Area	Acre	6.66 (100)	9.57 (100)	8.72 (100)	10.38 (100)	10.37 (100)	10.44 (100)
Cropping Intensity	%	127.5	183.3	167.0	198.8	198.6	200.0
Animal Husbandry & Allied Activities							
Local Cow	No.	2.9	0	2	0	0	0
CB Cow	No.	1.5	1	1	1	1	1
Goat and Sheep	No.	3	4	5	2	2	1
Fisheries	No.	0.09	0	0.07	0	0	0
Expected Return	Rs.	1,44,116	1,44,116	1,55,836	1,67,033	1,79,033	1,92,511
CV	%		4.41	4.26	6.49	10.21	14.11

Figures in the parentheses indicate per cent of Total Cropped Area

For animal husbandry enterprises, like the plans for marginal farms, the local cows were present only in case of Plan-2 which appeared to be the plan of least risk content at a CV value of about 4.26 per cent. This may be suggestive of the fact that the local cows are risk efficient without better prospect of return from them. In all the plans of higher expected return, the cross bred cows found a lesser presence than their existing level at about 1 unit for every plan. Though the crossbred cows present better prospect in terms of return in comparison to the local cows, their presence in lesser magnitude was quite surprising. This may be due to their lesser risk efficiency in comparison to the crops of higher return. The small ruminant holdings though increased to its highest quantum of about 5 units in Plan-2, decreased subsequently for all subsequent plans. In line with crossbred cows, the prospect of return from small ruminants like goat and sheep may not be as risk efficient as their crop counterparts. The fishery enterprise appeared in Plan-2 only as in case of small farm plans and was absent in all subsequent farm plans. The risk content of the farm plans appeared to be the lowest in case of Plan-2 at a CV value of 4.26 per cent, suggesting it to be the suitable plan for risk averse farmers expecting a medium range of return. The CV increased substantially to about 14 per cent in Plan-5 depicting the prospect of higher return in that plan with substantial risk content also which may be suitable to a risk seeking farmer.

5.5.5 Salient findings of Risk Efficient Plans

In all the risk efficient plans for different farm sizes, the cropping intensity appeared to be increasing from the existing level to the highest possible level in Plan-5. The area under kharif paddy remained more or less constant throughout all the plans, with rabi paddy getting completely ousted in the risk efficient plans. This underlines the fact that paddy being the staple and major cereal crop of the region has lesser per unit returns. The proportionate area under mung cultivation shows an increasing trend for all the plans of small households, while for marginal and medium farms it falls for subsequent plans after an initial rise of first two plans. The same case is also applicable to urad also, which is suggestive of the fact that both the crops are of medium prospect in terms of their risk content and return. In contrast groundnut appears to having an increasing trend in all higher levels of expected return in the plans for all the farm types. Same trend is observed in case of vegetables which is suggestive of the higher prospects of risk and return from both the crops. For animal husbandry and allied enterprises, the local cows obviously lag behind in comparison to their crossbred counterparts in

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returns/unit. Local cows only appear in the least risk content plans for marginal and medium farms only. This might be due to the lesser return prospect from them inspite of their lower risk content. The crossbred animals though have presence across all the levels of the farm plans, remain almost constant and do not rise further in plans of higher return. This is suggestive of the better risk efficiency of the cash crop enterprises in comparison to the dairy holdings. The small ruminants present a better prospect in their presence across all the higher levels of farm plans among all the animal husbandry enterprises. This may underline the importance of goatery as a risk efficient enterprise with prospects of higher return. The CV value for plans of existing level of return appears to be slightly high in comparison to the plans of next higher returns across all farm types. This may be suggestive of scope of better resource allocation with minimum risk in higher returns.

Chapter 6

Summary and Conclusions

SUMMARY AND CONCLUSIONS

Being largely untouched from the benefits of green revolution, India's eastern part represents underdeveloped production environment with high dependence on agriculture. Odisha being a major state of eastern India also bears the same situation. The share of agriculture in GSDP of Odisha is around 21.57 per cent in 2016-17 with employment dependence of above 60 per cent of the population (Govt. of Odisha, 2017). The milk production and the per capita availability of milk in this region are quite low compared to the all India average figures. For the year 2016-17, the per capita availability of milk is stated to be 128 gm per day in Odisha against the all India average of 355gm per day (NDDB, 2018). It is pertinent to mention that, the increase in per capita availability in case of Odisha for the same period has been very low from 113gm per day to 128 gm per day (NDDB, 2018).

Odisha has 10 agro-climatic zones covering 30 districts in total, two of the agro-climatic zones are coastal and rest are non-coastal. The coastal Odisha with a geographical area of about 24 per cent of the state accounts for about 51 per cent of the state's total milk production and about 40 per cent of the state's total HYV paddy production. Coastal Odisha being on eastern coast of India is also more susceptible to natural calamities like cyclone and flood than the rest of the state on account of its geographical location (Patwardhan and Narayanan, 2003). Not many studies have been undertaken in India pertaining to risk and uncertainties, particularly in an underdeveloped production environment like Odisha. In this regard the present study was comprehended with the title **'Vulnerability of Dairy Farmers to Risk and Uncertainty in Coastal Odisha and Effectiveness of Coping Strategies.'** The study aimed at quantifying various risks and uncertainties faced by the dairy farmers and vulnerability to it. The study worked out alternative risk mitigation plans for a household in the coastal region with the following specific objectives.

1. To analyze risk and risk factors at regional and farm level.
2. To assess vulnerability of dairy farmers to risk and uncertainty and determine factors affecting it.
3. To find out the effectiveness of alternative risk mitigation strategies adopted by the farmers.
4. To develop risk efficient farm plans.

Summary and Conclusions

The study was undertaken in two Coastal zones Odisha both at farm and regional level involving primary and secondary data. Primary data were collected using pre-tested interview schedule from 400 dairy farm households in four districts spread across two coastal agro-climatic zones of Odisha using multistage simple random sampling. Information was also collected from veterinary doctors and from offices of animal husbandry department of the state about occurrence of diseases and implementation of livestock insurance scheme. The collected data were analysed to assess and quantify the various risk factors faced by the farm households. Losses were calculated due to repeat breeding, disease incidence and mortality of dairy animals both at household and regional level. Crop losses due to natural calamities and other reasons were also calculated at farm household and regional level. Farm enterprise diversification and adoption of crop and livestock insurance were analysed as different strategies of risk mitigation. Farmers' perception about different sources of risk and different strategies of risk management was studied to assess their relative importance. Farm level vulnerability index was calculated for the farm households and factors affecting vulnerability was calculated using regression technique. Risk efficient composite farm plans were worked out using MOTAD model.

The main findings of the study are summarized as follows :

In analysis of the farmers' perception about different sources of risk at farm household level, the factors which were found to be most relevant were the animal diseases, price of milk, technology adoption, anoestrus condition and milk yield variability. Similarly, the sources of risk found to be less relevant were change in consumer preferences, distant location of AI centre or Veterinary hospital, change in interest rate of banks, lack of extension support, health situation of farm family and ability to repay loans. Based on Principal Component Analysis (PCA), these were clubbed into five categories of factors which together explained about 67.57 per cent of total variability and these were 'Animal and farm health', 'Financial situation', 'Market factors', 'Technology and infrastructure' and 'Management factors' owing to the corresponding sources of risk loading on them.

Economic Losses :

The loss per affected animal due to repeat breeding was found to be Rs. 18,082 with 89 average number of days delayed in production. Milk yield loss was found to



Small Ruminant Rearing in the Study Area



Typical Livestock Shed

have the largest share (51 per cent) in repeat breeding losses followed by extra feeding cost (32 per cent) and extra labour cost (12 per cent). CB cows are found to be more affected by repeat breeding condition than their local counterparts with average number of days delayed were 93 and 69 days, respectively resulting into economic losses of Rs. 20,099 and Rs. 6,383, respectively. The loss due to repeat breeding was estimated to be Rs. 12,366 per farm household. Across all categories of farm households the cost of treatment contributing to the losses was found to be quite low at 3.72 per cent of the aggregate loss which is suggestive of lack of knowledge on treatment option available for repeat breeding and the need of more institutional support in this regard.

The four most important diseases responsible for causing economic losses were found to be Mastitis, blood protozoan diseases, FMD and Ketosis. Mastitis alone was found to be the highest contributor to losses at about 39.12 per cent of household loss due to diseases. FMD was found to be the second highest contributor at 24.66 per cent followed by Blood protozoan diseases and Ketosis accounting for 23.36 and 12.85 per cent of the total losses due to diseases, respectively. Loss per animal due to various diseases was found to be Rs. 4,147 and that for household at Rs. 7,909. Wide differences were found between the household loss from diseases in local cows and CB cows at Rs. 1,129 and Rs. 9,412, respectively. This finds justification in the high productivities of CB animals with more need of treatment facility for them. In case of local cows, FMD has maximum share in household loss at 43.40 per cent while for CB cows it was found to be Mastitis at 38.54 per cent share in household loss. More penetration of FMD vaccination with possible vaccination for blood protozoan diseases is the need of the hour. Among all diseases, FMD was found to be affecting an animal for highest durations at 42 days followed by Mastitis at 37 days. Annual probability of occurrence was found to be highest for Mastitis at 33.25 per cent resulting into expected household loss at Rs. 1,029 which is highest among all four diseases.

The household loss of livestock mortality due to natural calamities was found to be Rs. 122 in comparison to the mortality loss due to diseases at Rs. 1,820. Mortality due to natural calamities was found to be only 0.33 per cent while it was observed to be 4.56 per cent for diseases. The lesser mortality rate from natural calamities goes contrary to the earlier notion for a disaster prone state like Odisha and is a result of the growing disaster preparedness and construction of cyclone shelters. Average loss due to livestock mortality comes around Rs. 1,942 per annum per household with a mortality rate of 4.89

Summary and Conclusions

per cent. Crop loss was found to be more due to natural calamities than other reasons which is in contrast to the livestock mortality. Per acre crop loss from all reasons was found to be Rs. 4,682 per annum while per household, it was observed to be Rs. 10,075 per annum.

In livestock sector, the regional losses from non production diseases was found to be substantially higher at Rs. 7,073 lakh per annum in comparison to losses from production diseases at Rs. 2,732 lakh per annum. Among all diseases FMD was found to cause the highest loss at Rs. 5,062 lakh per annum. Regional losses due to repeat breeding was found to be substantially high at Rs. 8,999 lakh per annum which is comparable to the combined loss caused by the diseases considered here. This reiterates the potential loss due to repeat breeding and the need of institutional support in dealing with it. The regional livestock mortality loss was found to be Rs. 15,480 lakh per annum which is substantial for an agrarian state like Odisha. The regional losses due to crop damage from natural calamities was found to be much higher at 87.34 per cent than due to other reasons at only 12.66 per cent. Over all the crop damage loss per annum was found to be about Rs. 1,898 crore.

Vulnerability :

The distribution of farmers under different classes of vulnerability showed that, about 15 per cent and 28 per cent of the farmers fall under very highly vulnerable and highly vulnerable class. The frequency distribution of farm size and vulnerability index wise categories showed that, about 23 per cent of landless and marginal farmers together fall under very highly vulnerable category, while only 9 per cent of small and medium farmers fall under very highly vulnerable category. This clearly suggests that, vulnerability of households decreased with increase in farm size. Vulnerability was considered to be positive functions of exposure and sensitivity and negative of adaptability. These components were analysed separately to estimate overall vulnerability index.

Losses due to disease incidence, repeat breeding and death of animals were the greatest contributors to exposure index. The frequency distribution of farmers under different classes of exposure index showed that 37 per cent of farm households fall under less exposed category and 24.74 per cent under high exposure category. The frequency distribution of farm size as per exposure index showed that the combined number of



Harvest Yard and Dry Fodder Storage



Dairy Farm House Hold

landless farm category households falling under highly exposed and very highly exposed category was about 38 per cent. The proportion of households for the same bracket in case of marginal farm category appeared to be about 40 per cent. But the figure decreased subsequently in case of small and medium farms. This may be suggestive of the fact that, the severity of the exposure component decreases with increase in land holding. This is further strengthened by the result of chi square test, which confirms that there is significant difference among different farm size categories with respect to their distribution over relative risk exposure classes.

In sensitivity, crossbred animal holding and income risks are the major contributors. The frequency distribution of farmers under different classes of sensitivity showed that about 61 per cent of households fall under highly sensitive and very highly sensitive category while about 30 per cent of farm house holds fall under less sensitive and moderately sensitive category. The distribution of farm size and exposure index wise categories showed that, about 69 per cent of landless farm house holds fall under highly exposed and very highly exposed category. About 56 per cent households of marginal farms fall under the same bracket, while the proportion for small and medium farm categories decreases subsequently. This is again suggestive of the fact that, the sensitivity of farm households decreased with increase in farm size.

The adaptive capacity of a farmer is considered ability to cope with risk. It was found that, membership of milk cooperative society, animal husbandry diversification index and literacy of farm household mostly influence adaptive capacity. The distribution of farmers under different classes of adaptive capacity showed that, 28 per cent of all households fall under highly adaptive and very highly adaptive category. The frequency distribution of farm size and adaptive capacity index wise categories showed that, no landless and 1.45 per cent of marginal farmers fall under very highly adaptive category, respectively, while about 16 per cent and 25 per cent small and medium farmers fall under very highly adaptive category, respectively. This also suggests that, adaptive capacity greatly increased with the increase in land holding of the household.

The factors that reduced vulnerability were found to be, percentage of irrigated land ($P < 0.05$), dependency ratio ($P < 0.05$) and capital adequacy ratio. The location of household in a region also appears to be significantly affecting the level of vulnerability ($P < 0.01$). Distance from KVK has positive effect on vulnerability. It is apprehended that

percentage of irrigated land improves adaptive capacity of the household and hence help in reducing vulnerability.

Risk Management Strategies and their Effectiveness:

Of all the eleven strategies of risk management tabulated to capture the farmers' perception of importance about them, scored more than the neutral average score of 3. This confirms their relative importance and as effective strategies of risk management. The strategies which got the highest average scores were found to be vaccination of the animals, applying strict hygienic rules, diversification of enterprises, production at lowest possible cost and carrying adequate cash reserves at average score. The comparatively high score for livestock insurance depicts awareness about this with progress of time. The PCA analysis resulted in construction of four components with eigen values greater than 1 and they together found to be explaining about 62.53 per cent of variability. These were prices and costs, health and sanitation, insurance and solvency and production management.

The animal husbandry diversification value was found to be the highest in case of landless households at 0.631. The relatively higher value in case of landless farmers may be due to their larger dependence on the animal husbandry and rearing of more number of species. Over all the animal husbandry diversification was found to be decreasing with increase in farm size and the average diversification across all farm categories was found to be about 0.446. The crop diversification was found to be more or less same across all the farm categories with an average value of 0.534 which was highest on small farm categories.

The extent of adoption of livestock insurance was found to be highest in case of medium farmers at about 40 per cent of farmers opting for livestock insurance, while the figure was found to be lowest for landless category of farmers at about 23 per cent. The adoption of livestock insurance was found to be progressing with the increase in farm size. Overall, about 32 per cent of farmers were opting for insurance with about 59 per cent of their animals getting insured. This suggests that about 19 per cent of all insurable milch animals of the region are entitled to livestock insurance coverage. The amount of claim received per household was Rs. 809 among insurance adopted household while the claim amount received decreased to about Rs. 275 when households not insuring their animals were also included. In terms of coverage of mortality loss through insurance



Survey Visuals at Household and Institutions

claim benefit, it was found that 39 per cent of overall mortality losses were recovered through insurance claims among the households adopting insurance. The overall coverage of mortality loss of animals by insurance claims reduced to 14 per cent when the households not insuring their animals were included. The overall crop insurance adoption among all types of farmers was found to be about 75.41 per cent. The proportion of crop area insured by the farmers opting for crop insurance was found to be about 59 per cent. The average claim received by the farmers opting for crop insurance was found to be about Rs. 2,331 that for overall farmers was found to be about Rs. 1,801. For extent of crop loss coverage by adoption of crop insurance, it was found that about 25 per cent of all crop losses are getting covered by claim received in case of the farmers opting for crop insurance. For overall farmers, the loss coverage was found to be about 20 per cent of the estimated crop loss.

Risk Efficient Plans :

In all the risk efficient plans for different farm sizes, the cropping intensity increased from the existing level. Rabi paddy was found to be less profitable than kharif paddy and it was ousted in all the risk efficient plans. This underlines the fact that paddy being the staple and major cereal crop of the region has lesser per unit returns. The proportionate area under *Mung* cultivation showed an increasing trend for all the plans of small households, while for marginal and medium farms it falls for subsequent plans after an initial rise of first two plans. The same was the case for *Urad* also, which is suggestive of the fact that both the crops are of medium prospect in terms of their risk content and return. In contrast groundnut appeared to having an increasing trend in all higher levels of expected return in the plans for all the farm types. Same trend is observed in case of vegetables which is suggestive of the higher prospects of return with lesser increase in risk from both the crops.

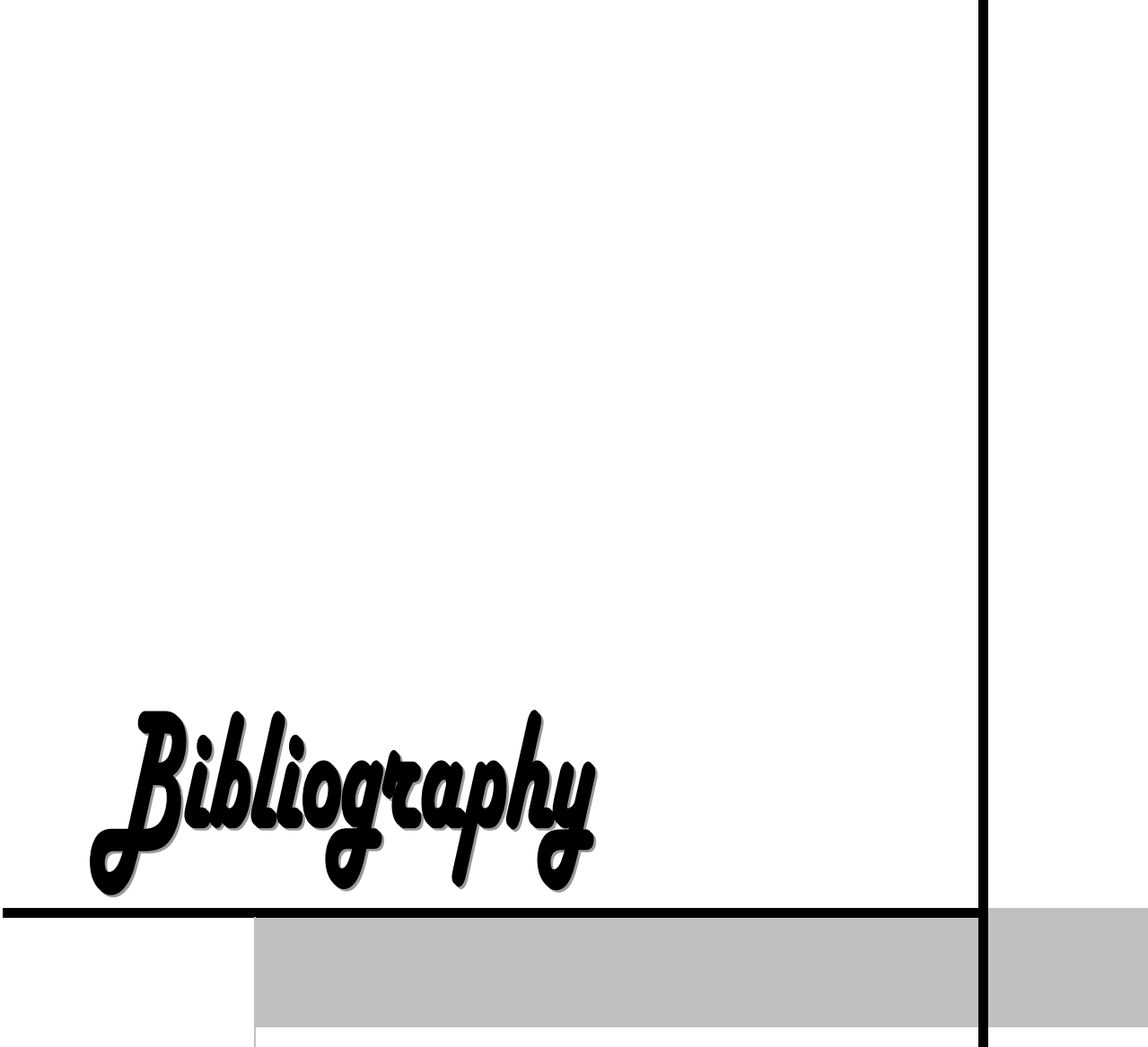
For animal husbandry and allied enterprises, the local cows obviously lagged behind in comparison to their crossbred counterparts in returns. Local cows only appeared in the least risk content plans for marginal and medium farms only. This might be due to the lesser return prospect from them inspite of their lower risk content. The crossbred animals though have presence across all the levels of the farm plans, remain almost constant and do not rise further in plans of higher return. The level of small ruminant activities increased with rise of income with minimisation of risk across all the higher levels of farm plan. This states the importance of goatery as a risk efficient

enterprise with prospects of higher return. The CV value of first plan suggest the amount of risk that can be minimised with existing level of expected returns. The alternative plans exhibit different levels of expected returns and minimum risk associated with it. A farmer may adopt one depending on his preference for risk and available resources.

Conclusions and Policy Implications :

- ❖ The repeat breeding is one of the highest loss causing factor for dairy animals. Improved facilities for treatment of repeat breeding along with better facilities for AI will help in reducing this risk. Similarly, among diseases mastitis and FMD were found to be causing heavy economic losses to the farmers. The addressing of vaccination programme more emphatically and increasing awareness among farmers through training will prove to be more benefiting in curtailing disease risk in animal husbandry.
- ❖ Losses due to mortality of dairy animals and crop damage were found to be high and widespread causing substantial losses to the farm households. Extending livestock and crop insurance among farmers with more vigour can be helpful in recovering these losses to the farming community.
- ❖ Natural calamities and animal diseases were found to be the greatest loss causing factors to crop and dairy sector. With increasing occurrences of cyclones and floods weather indexed crop insurance should be promoted as an alternative mechanism for loss redressal. Similarly dairy cattle disease insurance can be another alternative to address the losses due to diseases.
- ❖ The North Eastern Coastal plain area of Odisha was found to be more vulnerable than the East and South Eastern plains with lack of irrigation facility among other infrastructural facilities supporting agriculture. There emphasis is required to develop irrigation facilities, market structures, roads, etc which will improve adaptive capacity of the farmers in the former areas or zone of the state.
- ❖ The identification of less risk enterprises and crops like pulses (Mung and Urad), cash crops like groundnut and vegetables and better management of small ruminants and fishery and their inclusion in production system will help farmers to overcome risk. The farmers may be guided through field extension officers of agriculture department to adopt risk efficient plans which promise higher returns with lesser risk.

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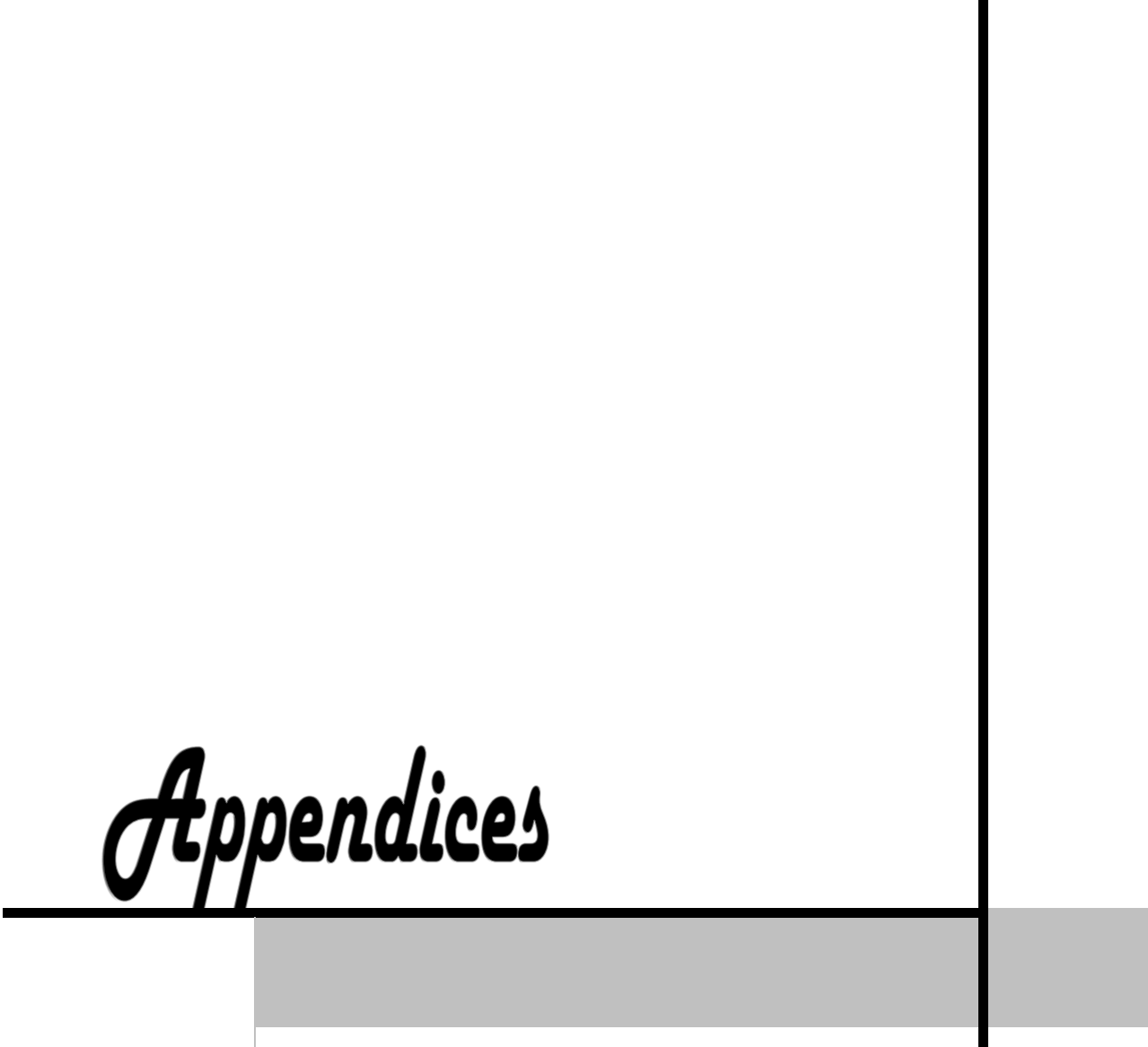
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Appendices

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APPENDIX

Table - Distribution of Farm Size Categories

Farm Size Category	Range of Land Holding (Acres)	No. of Households	Average farm landholding (Acres)
Landless	Less than 0.005	32	-
Marginal	0.005 to 2.47	276	1.57
Small	2.47 to 4.94	76	3.28
Medium	4.94 to 24.7	16	5.22
Overall		400	2.08

NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL (HARYANA)
(Dairy Economics Statistics & Management Division)

**“Vulnerability of Dairy Farmers to Risk and Uncertainty in Coastal Odisha and
Effectiveness of Coping Strategies”**

VILLAGE SCHEDULE : For Common Village Information

	name		name
1. District		3. Location	
2. Block		4. Village	

[1] availability of some facilities			
item no.	item		distance from village (Km)
1.	road connectivity (<i>kaccha- 1, pucca- 2</i>)		
2.	name of nearest town/city		
3.	dairy cooperative society		
4.	milk collection centre		
4.1	co-operative		
4.2	private sector		
5.	KVK/extension institution		
6.	artificial insemination centre		
7.	semen collection centre		
8.	panchayati breeding bull		
9.	veterinary hospital/ dispensary		
10.	stockmen centre		
11.	markets for purchase of cattle feed		
12.	market for sale and purchase of livestock products		

[2] milk composition		
items	average fat (%)	average snf (%)
Local cow milk		
CB cow milk		
Buffalo milk		

[3] prices and fluctuations			
items	unit code	current prices/wages (Rs.)	Previous Year prices/wages (Rs.)
1. dry fodder			
1.1			
1.2			
1.3			
2. green fodder			
2.1			
2.2			
2.3			
3. compound concentrates (<i>Mention Brands</i>)			
3.1			
3.2			
4. labour wages			
4.1. men			
4.2. women			
4.3. child			
5. permanent labour			
5.1 cash			
5.2 kind			
6. salvage value of adult animals			
6.1. crossbred cow			
6.2. local cow			
6.3. buffalo			
7. dung*			
% of dung			
used as			
7.1. manure			
7.2. dung cakes			

[4] any outbreak of disease of livestock during the past 5 years	
particulars	cattle, buffalo, goat
1. number of animals affected (also specify name of the disease)	
2. number of prophylactic vaccinations made for	FMD / BQ / HS / Others
3. number of animals died (specify name of the disease)	

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(Dairy Economics Statistics & Management Division)

“Vulnerability of Dairy Farmers to Risk and Uncertainty in Coastal Odisha and Effectiveness of Coping Strategies”

VILLAGE SCHEDULE : FOR COMPLETE ENUMERATION & SELECTION

	name		name
1. District		3. Location	
2. Block		4. Village	

[illegible]

“Vulnerability of Dairy Farmers to Risk and Uncertainty in Coastal Odisha and Effectiveness of Coping Strategies”

[1] Descriptive identification of sample household			
1. District		6.Name of head of household	
2. Block			
3. Village		7.MCS Membership	Yes(1) / No(0)
4. BPL status	Yes(1) / No(0)	8.Social Group	General (1), OBC(2), SC(3), ST(4)
5. PACS	Yes(1) / No(0)	9. House Type	Kacha(1), Semipucca(2), Pucca(3)

[2] Details of the family members											
Sl. No	Gender	Age	Education	Occupation	Income	Sl. No	Gender	Age	Education	Occupation	Income

Education – No. of years of schooling, Occupation – Primary, Income – In Rs./Annum

[3] Land inventory and cropping pattern										
Land as on date of survey		Specific Unit			irrigated			unirrigated		
owned										
leased-in										
leased-out										
total operated										
Cropping pattern in survey season										
Crop Name										
Irrigated area										
Unirrigated area										

[4] Farming activities other than crop & livestock (Fishery, Poultry, Apiculture etc.)				
Name of enterprise	Holding in units	Annual Input Cost (Rs)	Annual Production (Qty)	Value of production (Rs)

[5] Sale & Purchase of animals during last 5 years											
Sl.	Animal	Sale/Pur	Year	Amount	Cause	Sl.	Animal	Sale/Pur	Year	Amount	Cause

[6] Cropping pattern during last one year							
crops	Area and Production in season						
	rabi		kharif		summer		crop insurance
	Area (Unit)	Production (Qty)	Area (Unit)	Production (Qty)	Area (Unit)	Production (Qty)	Name, Area, Season, Premium
1. cereals							
1.1 Paddy							
1.2							
1.3							
2. cash crops							
2.1							
2.2							
2.3							
2.4							
3.fodder crops*							
3.1							
3.2							
4. vegetables							
4.1							
4.2							
5. pulses							
5.1							
5.2							
6. perennial plantation							
6.1							
6.2							
7 others							
7.1							
7.2							

* If the crop is used for feeding the animals, report it as fodder crop

[7] Loans taken for Dairy and Crop enterprise						
Sl No	Name of Source	Amount	Purpose	Period	Outstanding	Interest Rate

[8] Machinery, tools and equipments					
items	number	year of purchase	purchase cost (Rs.)	present value (Rs.)	annual repairs (Rs.)
tractor					
Power tiller					
Water pump					
Tubewell					
Plough					
chaff cutter					
milk cans					
feeding trough					
water tank					
bullock cart					
tractor trolley					
others (specify)					

[9] Civil structure used in dairy and agri. enterprise						housing system: loose(1)/close (2)			
items	no.	type (code)	location (code)	floor area		year of construction	construction cost (Rs.)	present value (Rs.)	annual repair (Rs.)
				unit	area				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1. animal shed									
2. store for agri inputs & products									
3. store for storage of feed and fodder									
4. manger									
5. open space									
6. others (specify)									
Type Code - Kacha(1), Semipucca(2), Pucca(3) ; Location Code- in House(1), Outside(2)									

[10] Details of small livestock holding of the household				
Description	No.	Market Value (Rs.)	Treatment Cost (Rs./Last 1 year)	Annual Gross Income (Rs./Last 1 year)
Sheep				
Goat				
Pig				
Poultry				
Others:				

[11] Details of Bovine Population in the Household

[illegible]

Codes for Species & Breed -: L (Local cow), C (Crossbred cow), B (Buffalo);

[Sex – Adult/Heifer/Calf(A/H/C) – Species & Breed – Calving order – Last Calved Months(nM) – Pregnant or not with duration(months) – Present milk/peak yield]

[12] feed and fodder fed per animal on the day of visit

[illegible]

[13] composition of home made concentrate

ingredient	quantity used (kg) per kg concentrate	ingredient price (Rs./kg)
1.grains (names)		
2.oil cakes (names)		
3.brans (names)		
4.chunnies (names)		
5.animal protein supplements (names)		
6.others (specify)		

[14] Loss of farm resources during last 5 years & Insurance Coverage	
	Measurable Variables
Loss of farm resources due to natural calamities (last 5 yrs.)	Occurrence of any natural calamity in last 5 yrs (Yes-1, No-0)
	No. of time & Description-
	Crop Loss in Rs. (Present Value) -
	Death of <u>Large animal</u> due to calamity (Yes-1, No-0)
	No. of Animals & Description -
	Value of Animals in Rs. (Present Value) -
	Death of <u>Small animal</u> due to calamity (Yes-1, No-0)
	No. of Animals & Description -
	Value of Animals in Rs. (Present Value) -
Loss of farm resources due to reason other than natural calamities (last 5 yrs.)	Occurrence of crop loss in last 5 yrs (Yes-1, No-0)
	No. of time & Description -
	Crop Loss in Rs. (Present Value) -
	Death of <u>Large animal</u> due to other than calamity (Yes-1, No-0)
	No. & Description -
	Value of Animals in Rs. (Present Value) -
	Death of <u>Small animal</u> due to other than calamity (Yes-1, No-0)
	No. & Description -
	Value of Animals in Rs. (Present Value) -
Insurance Coverage (last 5 yrs.)	Presence of insurance coverage (Livestock / Crop)
	Benefit of Insurance Received-

[15] Labour use pattern						
Type of labour	no. of workers	average no. of days labour hired	total hours worked per person per day	distribution of total hours work		
				AH activities	agri. operations	other (household etc.)
family						
hired casual		in month:				
hired permanent labour		in year:				

[16] Disposal of milk & Milk Products									
milk disposal	Local Cow			CB Cow			Buffalo		
	agency name	qty (lit.)	prices (Rs./lit)	agency name	qty (lit.)	prices (Rs./lit)	agency name	qty (lit.)	prices (Rs./lit)
on the day of visit									
production and disposal of milk products									
	Milk Product Name	Production (Kg)	Disposal of Milk Product						
			Agency		Qty(kg)				
In Last 15 days									

[17] Defined set of statements for risk attitude scale (Mark the corresponding box against each statement)						
Sl. No	Sources of risk	Strong Disagreement (1)	Disagreement (2)	Undecided/Neutral (3)	Agreement (4)	Strong agreement (5)
1	I never insure my animals					
2	I am the first producer in my village to adopt new technology					
3	I never have enough resources in hand that can be easily converted to cash to repay all my debts					
4	I never enter into future contract in marketing livestock and livestock products					
5	I do not have adequate life insurance					
6	I never spread the milk production from the animals throughout the year					
7	Off farm income is not important for the financial survival of my family					
8	In case of emergency, I donot have sufficient back up labour to carry on the production					
9	I use very specialized machines for my production practices					
10	I prefer investing in crossbred animals					
11	I never enter into any contract with input suppliers					
12	I am not a low cost producer					
13	I never vaccinate my animals					
14	I never call a veterinarian to my livestock production					
15	I do not invest in farm operation to create opportunities for farm expansion					
16	I do not participate in training relevant to my livestock business					
17	My animals are kept in free ranging system upto some extent					
18	I donot produce highest possible quality even if it means higher cost					
19	There is nobody else in family who has a greater interest in animal husbandry					
20	I never consult a veterinarian or scientist before taking major decisions in livestock production.					
21	My animals are often sick					
22	Productivity of my animals are very low					
23	I never use HYV fodder seed					
24	I never go for AI with high quality semen					
25	I do not grow fodder crops in between paddy and rice					

[18] Defined set of statements for risk management strategies scaling (Mark the corresponding box against each statement)						
Sl. No.	Risk management strategies	Irrelevant (1)	Somewhat irrelevant (2)	Neutral (3)	Somewhat relevant (4)	Relevant (5)
1	Producing at lowest possible cost					
2	Buying livestock insurance					
3	Buying personal insurance					
4	Applying strict hygiene rules					
5	Price contract for outputs					
6	Price contract for inputs					
7	Diversification					
8	Off-farm employment					
9	Carrying adequate cash reserve					
10	Vaccination of animals					
11	Proper housing & sanitation					

[19] Defined set of statements for risk perception scaling (Mark the corresponding box against each statement)						
Sl. No	Sources of risk	Irrelevant (1)	Somewhat irrelevant (2)	Neutral (3)	Somewhat relevant (4)	Relevant (5)
1	Price of milk					
2	Animal Disease					
3	Health situation of farm family					
4	Change in consumer preference for milk and milk products					
5	Change in interest rate of banks					
6	Milk yield variability					
7	Ability to pay back loans					
8	Technology adoption (CB Animals)					
9	Unavailability of green fodder in all seasons					
10	Poor conception rate due to AI					
11	Silent heat					
12	Anoestrous					
13	Unavailability of credit					
14	Lack of extension support					
15	Distant location of AI centre or Vety. Hospital					
16	High cost of treatment / medicines					
17	Failure of vaccination					
18	Disposal of unproductive animals					
19	Cost of concentrates					
20	Disposal of surplus milk					