An Analysis of Sustainable Livelihood Security, Crop and Livestock Diversification in Odisha

THESIS

SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE AWARD OF THE DEGREE OF

Master of Science (Agriculture)

in

Agricultural Economics

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Submittedby
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ID.No. 19412AGE014 **2021** **Enrolment No. 417394**

Dedicated to

My Beloved Parent
who sacrificed their today
for my tommorrow

काशी हिन्दू विश्वविद्यालय BANARAS HINDU UNIVERSITY
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To
The Registrar (Academic)
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Through: **The Head,** Department of Agricultural Economics
Institute of Agricultural Sciences,B.H.U., Varanasi.

Dear Sir,

I have great pleasure in forwarding the thesis entitled **"An Analysis of Sustainable Livelihood Security, Crop and Livestock Diversification in Odisha"** submitted by ***Ms. Truptimayee Jena*****, ID. No. 19412AGE014,** in partial fulfillment of the requirements for the degree of **Master of Science** in **Agricultural Economics**, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi and placing on record that he has completed the requisite residential requirements as contained in the statutes of the university.

I certify that the entire scheme of investigation presented herein was planned and carried out solely by the candidate under my guidance and supervision. The data presented in the thesis, to the best of my knowledge and belief, are genuine and original.

Thanking you.

Yours faithfully,

Forwarded by

(Virendra Kamalvanshi)
Supervisor

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By

Truptimayee Jena

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ACKNOWLEDGEMENT

"It is better to get wisdom than gold,

And to choose understanding rather than silver"

I am fortunate to offer flowers to ***Bharat Ratna Pt. Madan Mohan Malviyajee****, the founder of Banaras Hindu University which took me in a position to be called as man with real sense of humanity for his life time sacrifice and efforts in establishing such a great temple of learning engaged in humanizing the human being.*

I sincerely bow to omnipresence. It gives me immense pleasure to express my gratitude and regards to ***Dr. Virendra Kamalvanshi****, Associate Professor, Department of Agricultural Economics, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi and Chairman of my advisory committee, for his constant encouragement, valuable guidance, inspiring suggestions and above all meticulous counselling during the investigation and preparation of this manuscript.*

I am immensely thankful and indebted to ***Dr. P.S. Badal,*** *Professor and member of advisory committee, Department of Agricultural Economics, for his guidance and encouragement during research work. I would like to thank him immensely.*

I would like to express my gratitude from the core of my heart and fervent thanks to the esteemed members of my advisory committee, ***Dr. Kalyan Ghadei,*** *Professor Department of Extension Education, for their constructive and valuable suggestions and guidance during the whole course of investigation and preparation of this manuscript.*

I deem it my privilege in expressing my fidelity to ***Prof. Rakesh Singh,*** *HOD and* ***Dr. H.P. Singh,*** *Professor, Department of Agricultural Economics, Dr. P. K. Singh, Dr. O. P. Singh, Dr. Anoop M., Assistant Professor, Department of Agricultural Economics, for their diligent guidance, erudite suggestions, timely help, constructive criticisms, constant and continuous encouragement during the course of investigation.*

I am also thankful to the Non-teaching staff members ***Raj Kumar Ji, Ram Niwas Ji, Sudhir Ji, Sunil Ji*** *and****Jayant Ji*** *of Department of Agricultural Economics, for day by day help throughout my studies.*

This work would have been rather incomplete without the moral support and constant inspiration of my Father, ***Mr. Baya Jena*** *and Mother* ***Mrs. Mandakini Jena.*** *I express my indebtedness and most heartily devotion to them who set the foundation and were always with me during my ups and downs.*

I also express my warmest love and affection to my best friends ***Monikarani Pradhan, Vipul Keshari*** *and* ***Judhistir Bidika*** *for showering inbounding affection and*

everlasting encouragement. I thank them once again because I would have never achieved this level of education without their selfless sacrifices.

Without the help of seniors none can learn the lesson of life and cannot teach the same to loving juniors. So, my heartfelt and special thanks to my seniors ***Devegowda sir, Awadesh sir, Jeevan sir,Vaishanavi mam, Vikash sir, Anirban sir, Rakesh sir, Preeti mam, Anupam Jyoti mam and Rajan sir*** *for their kind guidance and co-operation.*

It is pleasure for me to offer thanks to my classmates ***Indrajeet, Sanjeev, Avinash, Pawana, Ajeeth, Ankit, Parmananda, Sharina, Nischita, Pavani Kalyani*** *and* ***Shravanti.***

The words are inadequate to express my feelings to my lovely juniors ***Aakash, Atul, Neha, Boudhik Chandini, Sadqua, Fatima, Saytam, Shivakant, Shriti, Shubham, Simran, Aashma, Nabin, Sipora, Dipankar, Jithin, Mohit and Harshita*** *for their immense love and affection which always inspired me to face the challenges.*

The graces of the God are always blessed to me and give me patience and power to overcome the difficulties which came in my accomplishment of this endeavour. I cannot dare to say thanks but only pray to bless me always.

Every beginning has an end to it but still I believe friends can scatter, friendship cannot. So the time spend in B.H.U. will always remain engraved in my mind and soul.

Last but not the least, I record my sincere thanks to all beloved and respected people who helped and could not find separate mentions. I still solicit their benediction to proceed at every step of respected destined life.

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ABSTRACT

The present study describes about “Sustainability” which means, a person's ability to provide themselves in a way that is long-term viable. The ability to withstand external shocks or stresses and recover from them by preserving or strengthening one's livelihood is often referred to as "sustainability". The present study was conducted in Odisha with the objective to estimate the status of sustainable livelihood security index , crop and livestock diversification and their relationship with sustainability. The present study is based on secondary data collected from various Governmental websites and other relevant sources. For the districts, time-series data (2015-19) & cross-sectional data on location, production, productivity of different crops or crop groups, ecological, economic, and social indicators, and the number of different livestock were gathered. Simpson index, Herfindahl index was used to analyse the extent of crop and livestock diversification. Multiple linear regression analysis was used to determine the relationship between sustainable livelihood security and crop and livestock diversification. This study uses three indices containing fourteen variables that made up this SLSI were the Ecological Security Index (ESI), Economic Efficiency Index (EEI), and Social Equity Index (SEI). It was discovered that sustainable livelihood security was highest in Odisha's Balasore district with index value 0.57 and lowest in Nuapada with index value 0.23. Overall crop diversification index was low in 21 districts and 9 districts were under moderate crop diversification index and no single district had high and very high status of crop diversification index. 23 districts had high livestock diversification indexes, only seven district, had a moderate level of diversification index, and no district had a low and very high level of diversification index. The SLSI approach aids in the establishment of inter-district goals for agricultural resource allocation and prioritises the activities and programmes important to each district for sustainable agricultural growth, which is why significance of SLSI is growing by the day.

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LIST OF ABBREVIATIONS

CEI	Composite Entropy Index
EEI	Economic Efficiency Index
ESI	Ecological Security Index
FAO	Food and Agriculture Organization
IDS	Institute of Development Studies
RLS	Rural Livelihood Security
SD	Sustainable Development
SEI	Social Equity Index
SID	Simpson Index of Diversification
SLA	Sustainable Livelihood Approach
SLI	Sustainable Livelihood Index
SLS	Sustainable Livelihood Security
SLSI	Sustainable Livelihood Security Index
UNDP	United Nations Development Programme
WTO	World Trade Organization

Chapter I

INTRODUCTION

The phrase "sustainable" refers to a person's ability to provide themselves in a way that is long-term viable. The ability to withstand external shocks or stresses and recover from them by preserving or strengthening one's livelihood is often referred to as "sustainability". Sustainable livelihood, according to **Chambers (1986)**, "a state of prosperity, as well as stockpiles and flows of food and cash, that ensures physical and social well-being and protects against poverty." Swaminathan (1991) defines SLS as a sustainable living option that is environmentally sound, economically feasible, and socially equitable. Swaminathan (1993) defined 14 primary dimensions of sustainable agriculture, which include social, economic, technological, political, and environmental factors. The definition of rural livelihood security (RLS) was proposed by **Chambers and Conway (1992),**it emphasises capability, equity, and long-term sustainability. The notion symbolises concern for both inter-generational and intra-generational fairness because it depicts the security or assurance of the people' means of subsistence not only now but also in the future.SLS is a phenomenon that involves both macro and micro levels of involvement. Stabilize population, reduce distress migration, prevent exploitation, and promote long-term sustainable resource management are some of the macro- level definitions for ensuring SLS. At the micro- and local levels, 'enough stocks and flows of food and currency to cover basic needs' and 'access to energy, revenue, and assets to mitigate shocks' are essential components of SLS**(McCracken and Pretty, 1988).**While it is feasible to address distressed migration by addressing regional economic disparities, resource depletion and social exploitation can only be addressed through equitable distribution, asset ownership, and access to natural and technological resources. In order for economic progress to continue, environmental protection must be maintained.SLS is more sustainable as a policy instrument than as a tactic aimed solely at addressing basic needs because it seeks to include the resources to address those needs. Ensuring SLS by allowing people to meet their own needs would result in less environmental strain, which ensures that more people will be able to meet their livelihood needs in the future **(Chambers, 1986).**

The Brundtland Commission and the United Nations Development Programme's first Human Development Report

Sustainable growth, according to the Brundtland Commission Report of 1987, is "development that meets current needs without jeopardising future generations' ability to meet their own needs." This report contains two key concepts: the concept of 'needs,' especially the basic needs of the world's poor, to which top priority should be given; and the concept of constraints imposed on the environment's ability to meet present and future needs by the state of technology and social organisation (World Commission on Environment and Development 1987).

Chambers and Conway (1992), as well as their forerunners

Robert Chambers of the Institute of Development Studies is widely credited with coining the term "sustainable livelihood" (IDS). The discussion paper he co-authored with Gordon Conway in 1992 is the most important source (Chambers and Conway, 1992). They provided a working description here-

A livelihood is sustainable if it can withstand and recover from stress and shocks, maintain or enhance its skills and properties, and provide future generations with sustainable livelihood prospects.; and if it contributes net benefits to other livelihoods at the local and global levels and in the short and long-term (Chambers and Conway, 1992).

Sustainable livelihood is viewed as a synthesis of the three existing principles of capacity, equity, and sustainability.

- Increasing capacity - in the face of change and unpredictability, people are adaptable, resilient, and able to take advantage of a variety of tools and opportunities;
- Enhancing equity - the poorer, including minorities and women, should have priority in terms of skills, assets, and access.
- Increasing social sustainability - by reducing external stress and shocks and offering safety lines, the poor's vulnerability can be reduced.

The White Paper of 1997

The overarching goal of UK international development policy, according to the November 1997 White Paper (DFID, 1997), was to eliminate poverty in poorer countries. One of three priority policy goals in the White Paper is to create sustainable livelihoods for vulnerable people, alongside human development and environmental preservation. Sustainable livelihoods were described in the White Paper as a policy goal rather than a concrete programme.

The Framework for Sustainable Rural Livelihoods (1998)

IDS published a Working Paper in June 1998 that provided an analytical context for sustainable rural livelihoods (Scoones,1998).The following propositions were proposed by **Saleth and Swaminathan (1993)**:

- Because of the complexity in terms of time and place, as well as in contrast to any scientifically defined norms or standards, the existence of SD must be viewed as relative rather than absolute.;

- As the sustainability requirements of households, resources, ecosystems, regions, nations, and, eventually, the planet itself are criterium, SD is a systematic and interconnected process.

- SD is a contextual process, as What is sustainable in one environment or place may not be so in another. As a result, there can't be a singular SLS solution that works everywhere., the planet itself are significantly interlinked.

Diversification of crops and animals, as well as increased total factor production, can all help to ensure a sustainable livelihood. Agricultural diversification has emerged as a critical component for achieving higher production growth, higher farm income, job creation, natural resource sustainability, and poverty alleviation. Crop diversification has enormous potential as an economic driver in the agricultural sector, and it may prove to be crucial in meeting the challenges that have arisen in the post-green revolution period. Farmers are under pressure to incorporate or substitute

new high-value crops in their cropping systems due to shrinking agricultural land and organisational holdings, as well as shifts in customer eating habits, as a result of the expansion of metropolitan regions and high population growth rates (Singh, 2011). Crop diversification is a strategy for increasing the utilisation of land, water, and other resources while also increasing the overall agricultural production of farm households. It provides farmers with feasible options for cultivating a variety of crops on their land. Crop diversification, which improves food supply by farming a range of crops in the same region, is an important part of guaranteeing food security. Livestock diversification is also vital for ensuring long-term livelihood stabilityA transition in livestock patterns from low- to high-productivity breeds is required, particularly in Odisha, where heavy rainfall, diurnal temperatures, and other factors have a significant impact. Livestock provides a major source of supplementary income and family nutrition to poor rural people in such circumstances. For developing countries like India, where agriculture provides a majority of families' livelihoods in both the farm and non-farm sectors, agriculture's sustainability cannot be addressed or specified in isolation from the issue of livelihoods. A sufficient stock and flow of food and cash with a person or a family to meet their basic needs is known as livelihood. India takes a comprehensive approach to achieving its 2030 Sustainable Development Goals (SDGs) by introducing a variety of programmes. The SDG Index Score for India varies from 42 to 69 for States and 57 to 68 for UTs. According to the survey, Kerala and Himachal Pradesh are the front runners among all states with a score of 69, while Chandigarh and Puducherry are the front runners among the UTs with scores of 68 and 65, respectively. The Economic survey references current Indian government programmes aimed at reaching the SDGs. Swachh Bharat Mission, BetiBachoBetiPadhao, Pradhan Mantri Awas Yojana, Smart Cities, Pradhan Mantri Jan Dhan Yojana, DeenDayal Upadhyay Gram Jyoti Yojana,Pradhan Mantri Ujjwala Yojana, Namami Ganga Mission are some of them.

NEED OF THE STUDY

Odisha, formerly Orissa, is a state in India's eastern region. It is the eighth-largest state in terms of territory and the eleventh-largest in terms of population. The

state is home to India's third-largest number of Scheduled Tribes. It is bordered on the north by West Bengal and Jharkhand, on the west by Chhattisgarh, and on the south by Andhra Pradesh. Odisha has a 485-kilometer coastline along the Bay of Bengal. The state of Odisha is divided into 30 districts. To simplify their administration, these 30 districts have been divided into three revenue divisions. North, Central, and South divisions exist, with headquarters in Sambalpur, Cuttack, and Berhampur, respectively. According to the census data from 2011,Odisha has a total population of 41,974,218 people, with 21,212,136 men (50.54 percent) and 20,762,082 women (49.46 percent), or 978 females per 1000 males, according to the 2011 Indian census. This is an improvement of 13.97 percent over the population in 2001. The population density is 270 people per square kilometre. According to the 2011 census, the literacy rate is 73 percent, with 82 percent of males and 64 percent of females being literate. The average annual rainfall in Odisha is about 1438 mm, with around 78 percent of that falling during the monsoon season.

In 2004–2005, the proportion of people living in poverty was 57.15 percent, nearly double the Indian average of 26.10 percent. The state's poverty rate has dropped by 24.6 percentage points since 2005. According to latest estimates, 32.6 percent of the population lives in poverty.

According to data from 1996 to 2001, the state's life expectancy was 61.64 years, which was higher than the national average of years. The state has a birth rate of 23.2 per 1,000 people per year, a death rate of 9.1 per 1,000 people per year, a 65 per 1000 live birth infant mortality rate, and a 358 per 1,000,000 live births maternal mortality rate. As of 2018, Odisha has a Human Development Index of 0.606.

It has large regional inequalities and lags behind in many aspects of human growth, including female literacy, school enrolment and retention, infant mortality, and low per capita health spending, among others. In terms of socioeconomic growth, some districts are lagging behind. These areas have poor food grain productivity, a higher rate of poverty, and low female literacy, among other issues. These have posed a threat to the state's ecological equilibrium, as well as the economic and social status of households in various districts.

Objectives

Keeping these problems in the mind these four objectives are selected for the study:

- To appraise the status of sustainable livelihood security (SLS)
- To evaluate the level of crop and livestock diversification
- To study the relationship between sustainable livelihood security (SLS) with crop and livestock diversification

Hypotheses

The study is based on following hypotheses –

1. There is variation in the status of sustainable livelihood security among all the districts of Odisha.
2. Level of crop diversification differs from district to district in the state of Odisha
3. There is fluctuation in livestock diversification.
4. More diversification in crop and livestock leads to better sustainability.

Plan of Study

Following the above brief introduction to the science, Chapter II presents a summary of the essential work done by previous researchers. The methodological specifics for achieving the study's objectives are discussed in Chapter III. Chapter IV contains an overview of the research field. The findings of the current analysis are presented in depth in Chapter V, with the aid of tables and figures. The entire thesis is outlined and concluded in the final chapter, which is accompanied by references.

Chapter II

REVIEW OF LITERATURE

This chapter provides a brief overview of recent research work that is important to the current study's theme. There are four parts in this chapter. Past research on sustainable livelihood indexes in various areas are covered in Section 2.1, while literature on crop and livestock diversification is covered in Section 2.2. Section 2.3 contains studies on diversification as a measure of long-term livelihood stability, while section 2.4 contains studies on food security. The analysis has been performed in chronological order of study publication in each part.

2.1 Review about the construction of sustainable livelihood security index

Bharti and Sen (1997) investigated Bihar's long-term livelihood stability. They concluded that in terms of overall performance of many districts in Bihar in terms of their Relative Sustainable Livelihood Security Index (SLSI), only about one-fourth of the 40 districts had SLSI of greater than 0.5, and about half of the total districts had SLSI of less than 0.4. As a result, most districts in south Bihar fared better in terms of agricultural sustainability than districts in north Bihar.

Caroline Ashley and Diana Carney (1999) conducted research on sustainable livelihoods in more than ten countries, including India, and recommended policies that would be appropriate for each region. They saw protection as a more appropriate term at the household level than sustainability, despite the fact that the basis of their livelihood emphasizes all four elements, namely environmentally, economically, institutionally, and socially.

Hatai et al. (2008) defined a method for calculating the Sustainable Livelihood Security Index (SLSI) and assessing the current state of agricultural sustainability. They also proposed some steps to help Orissa's agriculture become more sustainable. Ecological Security Index research (ESI),the Economic Efficiency Index research (EEI) and Social Equity Index research (SEI) revealed that the ecological and social equity aspects of all districts' agricultural systems differ

significantly from their economic aspects. Districts with higher SLSI scores were often referred to as advanced, and vice versa. As a result, SLSI has been discovered to represent a district's overall success in three dimensions of sustainability. The SLSI approach has also been linked to certain policy consequences.

Singh et al. (2009) provided an overview of current sustainability metrics and placed them in the context of the environmental, economic, and social aspects of sustainable development. At the district level in Gujarat, they developed the sustainable livelihood protection index (SLSI). Because of its simplicity and versatility, they observed that the SLSI is one of the most comprehensive but easy indices for assessing long-term livelihood preservation in rural settings. The SLSI not only outlined the overall development goals, but also the existence and types of policies that should be implemented in each study unit to improve livelihood protection. The SLSI supported consensus among different party groups, such as economists, environmentalists, and egalitarians, by balancing their mutual interests, and may provide guidelines for attaining sustainable development. It could be used as a teaching and policy tool to urge planners, managers, and development workers to think holistically.

Shaheen Akte (2012) investigated steps of livelihood protection in Bangladeshi urban settlements. Economic, food, health, education, and empowerment were chosen as protection areas, and indices were computed based on a number of components. The 3SLS and 2SLS models were used to calculate them. Based on the findings, he concluded that urban settlements in Bangladesh are unstable, regardless of where they are located. People in urban squatters tend to be almost similarly vulnerable, regardless of regional disparities in opportunities. This does not imply that the same intervention technique was used in all cases. The component indicators differed depending on where they were collected. He indicated that when designing programmes, access to assets/capital endowment should be considered. Livestock fisheries-based livelihoods may be promoted in areas where land/housing ponds are more available. Education-improving policies may be seen everywhere.

Vishnu et al. (2013)in Rajasthan, investigated the idea of Sustainable Livelihood Protection. The Sustainable Livelihood Security Index (SLSI) was developed using Swaminathan's definition for districts and selected farm households to examine the status of SLS using its three components, namely; Status of ecological security, economic efficiency, and social equity To represent the state as a whole, a sample of 80 farm households was drawn from the desert and non-desert areas of the state using a multistage stratified random sampling technique using the PPS method at village level to represent marginal (20), small (20), medium (20), and large (20) farmers. According to the findings, 12 districts have a high level of ecological protection, 19 districts have a moderate level of ecological security, and one district has a low level of ecological security. Eight districts were found to have a high economic status, 21 districts to have a moderate economic status, and only three districts to have a low status of economic efficiency. In terms of social equality, only two districts were found to have a very high status, eight districts to have a high status, sixteen districts to have a moderate status, and six districts to have a low status. There isn't a single district that has a really high SLS rating. Just nine districts out of 32 are found to have a high SLS status, 22 districts have a moderate SLS status, and only one district, Jaisalmer, has a low SLS status. Across Rajasthan's districts, there is a significant disparity in terms of social justice, ecological stability, and economic efficiency. In almost every aspect of SLS, the majority of the districts fall into the moderate category.

R. Buragohain et al. (2014)in Assam, investigated agricultural sustainability. Sustainable agriculture, according to them, combines three main objectives: environmental health, economic profitability, and social and economic equity. The study attempts to estimate agricultural sustainability for different districts of Assam with the aid of an index namely Sustainable Livelihood Security Index (SLSI). The three indices that made up this SLSI were the Ecological Security Index research (ESI), Economic Efficiency Index research (EEI), and Social Equity Index research (SEI). The study found significant differences in the agricultural systems of all Assam districts in terms of ecological, economic productivity, and social equity. Districts with an SLSI value of 0.40 or higher were classified as advanced, while those with a

value of 0.40 or lower were classified as backward. It was shown, 56 per cent of all districts of Assam had an index of SLSI above 0.5, while only one district Dhubri was found as having SLSI value less than 0.40.

R. Kamaruddin and S.Samsudin (2014) established a Sustainable Livelihood Index (SLI) in the district of Baling in the state of Kedah, Malaysia, to explore all aspects of rural poor households' livelihoods. The Sustainable Livelihood Approach (SLA) system was used to create this index. The data set yielded a total of 22 livelihood assets and outcomes indicators, which were divided into five categories: human, physical, natural, social, and financial assets, as well as two categories of livelihood outcomes: food security and health status. Then, for each household, an aggregate SLI was created by combining with equal weight all seven groups of livelihood assets and outcomes indices. In total, 73 percent of the households studied had a SLI of less than 0.5, with a mean of 0.47. The Sustainable Livelihood Index (SLI), which has been used as a measure of poverty, was found to shift in lockstep with total household income, according to the report. In the hardcore poor party, 90.91 percent of the households had a SLI of less than 0.5, meaning that households with a low income would also have a low SLI. While income and SLI were both pushed in the same direction, this study recommended that SLI be used instead of household income level alone to assess the capacity and preparedness of the rural poor.

K. Kareemulla et al. (2017) discussed agriculture's long-term viability in India. They stated that India's agricultural challenges stemmed from agroclimatic, environmental, social, and economic factors. The vibrancy of these dimensions contributes to the sustainability strength. A state-level analysis of sustainability was conducted for two time periods in order to better understand the regional and temporal dynamics of these dimensions. The human development index approach was used to calculate the sustainability index. The indices were calculated using data from two time periods, 2001 and 2011. The findings revealed that, in general, sustainability did not deteriorate over the reference period, despite the fact that some states gained and others lost in terms of change in sustainability levels.

A. Maurya, V. Kamalvanshi, C. Sen and P.S. Badal (2018) evaluated the status of SLS in Uttar Pradesh state of India. The study relied on secondary and cross-sectional data. The Ecological Security Index research (ESI), Economic Efficiency Index research (EEI), and Social Equity Index research (SEI) studies found that the ecological and social equity components of all districts' agricultural systems differ significantly from their economic aspects. Sustainable Livelihood Security (SLS) is a broad concept that encompasses current challenges and policy considerations related to sustainable development. The topic of SLS becomes even more significant for the farm industry in light of the changing social, economic, and climatic environment. Agricultural diversification is being considered as a possible SLS tactic. Districts with higher SLSI scores are typically referred to as advanced, and vice versa. As a result, SLSI has been discovered to reflect a district's total performance in three areas of sustainability. Twelve districts in the state have an index value of more than 0.5, while only five have an index value of less than 0.4, based on their overall performance in terms of their SLSI.

2.2 Review of crop diversification and livestock diversification measurement

Ergano et al. (2000) looked at the temporal shifts in the agrarian system of Haryana state. For the years 1970-71 to 1998-99, data on area under various crops such as cereals, pulses, oilseeds, commercial crops, vegetable crops, and fruits were collected. Crop diversification was measured using the Herfindahl index, Entropy index, and Composite Entropy index. Crop diversification indices were found to be higher in the early years of the study period for all crop classes, but declined as time went on. Cereals, commercial crops, vegetables, and fruits were discovered to be more diverse than pulses and oils.

Tyagi et al. (2000) looked at the existence and degree of crop diversification in various parts of Uttar Pradesh between 1989 and 1999. The Composite Entropy index was used as a measure of crop diversification, and it was discovered that U.P. Specialization of fine food grains, remunerative and high-income generating crops, primarily rice- wheat among food grains and sugarcane, fruits, and oilseed among non-food grains, dominated the agricultural economy.

Acharya (2003) at the national and state levels, examined the degree and type of crop diversification in Indian agriculture. For the years 1952-53 to 2001-02, data on area under major crops, state-by-state percentages of gross cropped area, crop value, and so on were gathered from various published sources. For assessing the extent of crop diversification in Indian agriculture, a national and state-level diversification index was created. According to the findings, the relative area under food grains has decreased while that under non-food grains has increased. Non-food crops such as oil seeds, vegetables, fruits, sugarcane, and cotton had replaced coarse cereals like jowar, bajra, ragi, and small millets as the arca under coarse cereals like jowar, bajra, ragi, and small millets. However, the region under major staple cereals such as rice, wheat, and even maize did not decrease in absolute terms.

Alagh et al. (2003) investigated the Indian agricultural economy's crop diversification patterns. The research was based on secondary data from 1960-1961 to 1995-1996. The crop sector's region and output patterns were also studied over time. The growth in given parameters was analysed using a semi-log regression growth rate against time. The findings revealed that crop production and output increased at a positive pace. The livestock and fisheries industries grew at a faster pace. From 1950-51 to 1979-80, the food grains and non-food grains sectors both grew by 2.46 percent.

Joshi et al. (2004) conducted a report on agricultural diversification in South Asia to better understand the trends and constraints that farmers face. The research was limited to two levels: macro and micro. Bangladesh, Bhutan, India, and the Maldives were among the seven countries represented at the macro stage. Nepal is a country in Nepal. Pakistan and Sri Lanka are both Muslim countries. More disaggregated analysis across various regions in India was attempted at the micro stage. The Simpson Index methodology was used to describe commodity diversification. The results of the study showed that agricultural sector in South Asia was steadily diversifying in favour of high value commodities. Diversification's effects on food security, job creation, and export earnings were also highlighted in the report.

Sharma (2005) conducted research in the Indian state of Himachal Pradesh on agricultural production and crop diversification. The research was focused on both primary and secondary sources of information. Primary data was obtained from 225 farm households using the personal interview method as part of a multistage sampling process. Averages, percentages, and compound growth rates were used to evaluate the results. The Herfindahl Index was used to compare shifts in the amount of land allocated to various crops over time. The findings revealed that agriculture in Himachal Pradesh has grown at a fairly rapid rate over the last three decades. From 9.99 lakh tonnes in 1974-75 to 14.11 lakh tonnes in 1999-2000, food grain production increased. In terms of area and fruit production, the horticultural sector has also seen significant growth.

Malik et al. (2006) based on information scanned from various published sources conducted a study in Haryana that analysed changes in cropping patterns and assessed the degree and nature of crop diversification in the state. To measure extent of crop diversification, he used the compound growth rate, Herfindahl, Entropy, Simpson Index of Diversity, and Crop Diversification indices. Between 1971 and 2004, the cropping pattern in this state changed dramatically. These indices showed a growing trend in crop diversification, with more land being diverted from food grains to oilseeds and cash crops.

Singh et al. (2006) mapped out the trend and methods of diversification in India's different states and crops. For the years 1990-91 and 2000-01, the Simpson index was calculated in various Indian states. In 1990-91, the diversification index ranged from 0.47 in West Bengal to 0.9 in Karnataka, and in 2000-01, it ranged from 0.40 in Orissa to 0.92 in Karnataka. In most cases, the increased diversification index indicated a move away from food crops in most of states. He also looked into the various infrastructural and technological factors that influence agricultural diversification in India's various states.

Marothia (2007) used time series analysis to investigate the movements and spread of crop diversification in Chhattisgarh's agro-climatic zones. The 1980s (pre-reform period) and 1990s (post-reform period) were used to conduct a decadal study

(post- reform period). To investigate improvements in crop diversification, averages and percentages were calculated. The status and prospects of crop diversification were investigated further by examining the perspectives of 357 farmers from 33 villages across three agro-climatic zones. The Simpson diversity index was used to investigate the pace and degree of crop diversification in Chhattisgarh. The study's findings revealed a gradual change from cereals to vegetables and food crops in the agro-climatic zones of the states in areas with reliable irrigation.

Jha et al. (2009) investigated the factors influencing agricultural diversification at three levels: nation (India), state (Haryana), and farms in Haryana's Kurukshetra district. The Simpson index was used to assess non-food crop diversification and concentration. Income, land distribution, irrigation intensity, institutional credit, road density, urbanisation, and market penetration are all possible factors. They conducted regression analysis and concluded that increased road density, urbanisation, and commercialization of agriculture promote each other, and that as a result of commercialization, farms in a region specialise in specific crops and crop groups based on the region's resources, infrastructure, and institutions.

Tingre et al. (2009) investigated the trend in crop diversification in Vidarbha's Amravati district. The research was focused on secondary data gathered over a 30-year period, from 1970-71 to 2000-2001. For two sub-periods, the diversification trend was estimated. The first cycle (Period I) ran from 1970-71 to 1985-86, and the second period (Period II) ran from 1986-87 to 2001-02. (Period II). Crop diversification and cropping intensity increased dramatically during the study period.

Acharya et al. (2011) used the Composite Entropy Index (CEI) and multiple linear regression to examine the type and degree of crop diversification in the Karnataka state over a 26-year period from 1982-83 to 2007-08. Except for oilseeds and vegetable crops, the CEI for different crop groups has shown that almost all crop groups have higher crop diversification index during the post-WTO (1995-96 to 2007-08) era than during the pre-WTO (1982-83 to 1994-95) period. Following the WTO, there has been a significant rise in the diversification of commercial crops such as cotton, tobacco, chillies, and sugarcane. A variety of infrastructure and technical

factors affect crop diversification. Crop diversification has an effect on development, according to the findings. Most of these parameters were found to influence the nature and extent of agricultural development and crop diversification, according to the study, so the creation of basic infrastructural facilities including sustained supply of irrigation water, markets, fertiliser availability, and proper roads and transportation is an essential pre-requisite for creating enabling conditions for fostering the process of agricultural development and crop diversification.

Pal et al. (2012) used a standardised Malda district data set to test various crop diversification steps. At the same time, it concentrated on the state of crop diversification in different blocks of Malda district, as well as a district-wise and state-wise status. Crop diversification was studied using the Herfindahl index and the Simpson index. Between 2001 and 2008, the study found that crop diversification was monotonizing, as evidenced by forward and backward moving crop diversification into a single class. Instead of high-value crops, peasants are also addicted to cereals.

Malik et al. (2012) conducted a report on crop diversification in a rural group in Pakistan's Peshawar valley. The primary goal was to look into crop diversification among the farmers in the study region. Farmers were able to transition from monocropping to multiple cropping due to the favourable environment, good irrigation system, public and private agricultural education, extension and marketing facilities, and recent technological advancements. Only a few farmers grew a single crop, while the majority grew three to seven crops. The majority of farm households grew cash and off-season crops in addition to cereal crops. Farmers' preferences for cash and off-season crops have increased, according to them, prompting the recent trend toward multiple cropping. Finally, they suggested that agriculture's profits be diversified further into value-added and industrial farm products in order to raise revenue. They also suggested that policies to increase farm income be implemented in the areas of rural infrastructure, education, and rural growth.

Utpal Kumar De and Kamal Bodosa (2014) studied to look at the spatiotemporal pattern of crop diversification in Assam over the last fifty years. Changes in land allocation for the production of different crops are pursued, as well as

the changing crop diversification index. In this case, the Herfindahl Index is used to understand diversification, and the locational quotient is used to determine regional crop concentration. The results show that crop specialisation has occurred in almost all districts, and particularly in the last phase of our study period. In response to changing water availability, weather patterns, access to credit, and risk, the hilly and backward districts saw more diversification, but toward lower value crops. It goes against the grain of crop diversification, which usually involves farmers focusing on high-value crops. Using the Random Effect Irrigation, chemical fertiliser, and growing irregular rainfall were found to play important roles in deciding inter-zonal variance in crop diversification using the GLS Robust Regression and Fixed Effect Model. However, crop diversity was hampered by the slow progress of irrigation, especially during off-monsoon seasons.

Sanjeev Kumar and Sakshi Gupta (2015) used the Simpson Index of Diversification (SID) and panel regression study to come acrossthe state-level trends and patterns of India's crop diversification from 1990 to 2011. Cropping patterns at the state level are shifting from food grains to high-value crops, according to the report, but the shift is not standardised across states and regions.SID statistics show that the agricultural economy in all countries has diversified, with some differences in food and non-food crops. Cropping rate, average annual rainfall, and gross irrigated area were discovered to be the most important factors influencing crop diversity. Farmers should be given more policy support in the form of higher cropping intensity, gross irrigated area, insurance coverage, agricultural research and education investment, and technological innovation, according to the report.

A. Maurya , V. Kamalvanshi, C. Sen and P.S. Badal (2018) examined crop and livestock diversification for all the district of Uttar Pradesh by using simpson index. Secondary and cross-sectional data were employed in this study. In 15 districts, the overall agricultural diversification index was very high, while 60 districts had a high crop diversification index. The relative area of wheat and rice crops was found to be particularly high. In the case of livestock, 70 districts were found to have a high degree of livestock diversity, only one district, Chitrakoot, had a moderate level of diversification, and no district had a low level of livestock diversification. Farmers

raised cows, buffaloes, sheep, goats, pigs, and poultry as their principal livestock. Because most of these parameters are found to influence the nature and extent of crop, establishing basic technological and infrastructural facilities such as a consistent supply of irrigation water, fertiliser availability, and proper roads and transportation is an essential prerequisite for fostering the process of agricultural development and crop diversification.

2.3 Reviewing diversification as a measure of sustainable livelihood security

Kumar et al. (2009) investigated goat farmers' coping strategies in the arid Rajasthan in the face of water shortage and shifting resource circumstances. The magnitude of linkages among different components of the farming system was quantified using an input-output model. The study was praised for its creativity in developing a farming system that allows for the sustainable production of grains for the family as well as feed and fodder for their small ruminants. Three farming systems have been identified: (I) rain-fed goat-based farming, (II) partially irrigated goat-based farming, and (III) rain-fed crop-based farming. Goat farmers have taken advantage of the potential synergy of linkages among various components of the farming system in response to changing resource and environmental conditions. Farmers' novel concept of leaving a portion of their land fallow during the lean season to graze their goats and sheep should be used as an opportunity to enable them to cultivate this fallow land as pasture with recommended legume and non-legume grasses. They speculated that this model could be repeated in other arid areas.

Soltani et al. (2012) conducted a study in rural Zagros, Iran, to discuss the two intertwined problems of rural poverty and forest depletion. A quantitative analysis based on the sustainable livelihood system methodology was used to classify household livelihood strategies, assess livelihood choices, and make recommendations for a watershed in the Zagros. The majority of households (64%) use a mixed strategy that includes forestry, animal husbandry, and subsistence agriculture, according to the survey. Households who depend heavily on forest extraction and livestock grazing (27%) are the poorest, whereas those who combine commercial crop cultivation with non-farm work (9%) earn more.

Vishnu et al. (2013) in all of Rajasthan's districts, investigated sustainable livelihood protection by crop and livestock diversification. The research was divided into two parts: the first was conducted at the district division level for a ten-year period from 2001 to 2010, and the second was conducted at the farm household level for a period 2012 to 2013. To represent the state as a whole, a sample of 80 farm households was drawn from the desert and non-desert areas of the state using a multistage stratified random sampling technique using the PPS method at village level to represent marginal (20), small (20), medium (20), and large (20) farmers. The relationship between SLS and crop and livestock diversification were investigated using multiple linear regression. In Ajmer, crop diversification was found to be positively and significantly linked to SLS. Bhilwara, Karauli, Jodhpur, Pali, Rajsamand, and Chittorgarh have positive and significant contributions, while Barmer and Banswara have negative and significant contributions. Crop diversification should be promoted in the districts of Ajmer, Bhilwara, Karauli, Jodhpur, Pali, Rajsamand, and Chittorgarh to improve the status of sustainable livelihood stability. The districts of Sawai, Madhopur and Pali should be prioritised for livestock rearing specialisation.

Maurya et al. (2018) studied crop and livestock diversification and it's impact on sustainable livelihood security in all the districts of Uttar Pradesh. At the district and division levels, multiple regression analysis was used to investigate the association between SLS and diversification. At the district level, the R^2 result value is very low, and the coefficient of crop and livestock diversification is minimal. Thirteen districts, including Allahabad, Bareilly, Faizabad, Jhansi, Meerut Moradabad, Varanasi, Azamgarh, Basti, Vindhyachal, Saharanpur, Chitrakoot, and Aligarh, have proven that crop and livestock diversification is responsible for more than half of their long-term livelihood security. Crop and livestock diversification provided less than 10%, or 0.02 percent, to sustainable livelihood stability in Gorakhpur division, suggesting their reliance on other variables such as services, non-farm and off-farm revenue, and so on. Seven of the 18 divisions are associated with or related to livestock diversification.

Chapter III

RESEARCH METHODOLOGY

This chapter is divided into three parts and is dedicated to the methodological specifics for achieving the study's objectives. The first segment is about deciding on a study field. The secondary sources and data collection are covered in the second section, while the conceptual methodology used to achieve the study's goals is covered in the third section:

3.1 The study area selection

Agriculture and related industries are the backbone of the Indian economy, as well as the economy of our state, Odisha. Agriculture and related practises provide a living for nearly 60% of the population. Growth in this sector is critical for ensuring food security as well as the overall socio-economic development of our state's farming community.

Odisha covers 1,55,707 square kilometres and is divided into ten agro climatic zones based on factors such as soil types, topography, rainfall, and cropping patterns. The State's total cultivated land area is 61.80 lakh ha, with 29.14 lakh ha (47%) being high land, 17.55 lakh ha (28%) being medium land, and 15.11 lakh ha (25%) being low land. In the Kharif season, about 65 percent of cultivated land is irrigated. The vast majority of farmers are small and marginal, with minimal capital. For this fragile farming culture, literacy is also a problem. The number of operational holdings in the state is 48.66 lakh, with an operational area of 46.19 lakh ha, according to the Agricultural Census-2015-16. Due to urbanisation and more land being put to non-agricultural use, the State's operational area decreased from 48.52 lakh ha in 2011-12 to 46.19 lakh ha in 2015-16. As a result, the average size of land holdings in the State has shrunk to 0.95 ha for all social classes. Odisha was chosen for the study because all 30 districts have significant differences in terms of location, population, agriculture, language, and other social, economic, and ecological factors. These have posed a threat to the state's ecological equilibrium, as well as the economic and social

status of households in various districts. Consistently rising inequality has become a major impediment to the state's successful production of sustainable agriculture.

3.2 Data sources

Secondary data was gathered for all of the state's districts from different government-published sources such as Directorate of Agriculture & Food Production Odisha, Directorate of Economics & Statistics, Directorate of Horticulture-Odisha, Bhubaneswar, District at a glance – 2019 (Odisha), Economic Survey Odisha 2018-19and other relevant sources. For the districts, time-series data (2015-19) & cross-sectional data on location, production, productivity of different crops or crop groups, ecological, economic, and social indicators, and the number of different livestock were gathered.

3.3 Framework for analysis

In order to achieve the study's various goals, the following analytical method was used for empirical research.

To achieve the first objective

The SLSI methodology is a generalisation of the relative approach that underpins the United Nations Development Programme's Human Development Index (UNDP, 1992). It's a cross-sectional metric for assessing the relative survival of a group of organisations. Swaminathan (1991) proposed the Sustainable Livelihood Security Index (SLSI) as an educational and policymaking method for evaluating the potential of sustainable development (SD).

Selection of variables for the sustainability of a livelihood

The evaluation of agricultural sustainability is a major issue in any research on sustainable agriculture. **Ashley et al.** mentioned protection as a more appropriate term at the household level than sustainability, despite the fact that the basis of their livelihood emphasizes all four elements, namely environmentally, economically,

institutionally, and socially. To empirically measure SLSI, a simple methodology was used, which involved selecting a collection of variables or indicators that could tell something more important and substantial about the ecological, fiscal, and equity aspects of agricultural sustainability. **R. Buragohain et al.** explained three indices that made up this SLSI were the Ecological Security Index (ESI), Economic Efficiency Index (EEI), and Social Equity Index (SEI). Despite the fact that many indices have been developed, they do not cover all aspects of sustainability. Furthermore, due to differences in biophysical and socioeconomic conditions, indicators established in one area could not be applicable to others. Fourteen variables, for example, have been chosen to represent the three dimensions of Sustainable Development of Agriculture.

a) Ecological security index,
b) Economic efficiency index and
c) Social equity index

At the district level, SLSI

Ecological security index comprised of variables such as the percentage of land covered by forest (%), cropping intensity (%), livestock density (per sq. km), population density (per sq. km), and annual rainfall (mm), among others. The efficient uses of human capital, as well as improvements in household overall quality of life, are critical for sustainable development. People will engage completely and contribute more to the economic development process if they are safe, trained, and qualified. The secret to breaking the slowdown in agricultural growth and productivity is human resources. As a result, the variable population density was chosen because of its ability to represent the magnitude of human pressure on overall ecological security. Forests are important for ecological balance and contribute significantly to the state's economy. Forest activities play an important role in the food security and survival of people who live near forests. Since forest occurrence and development are influenced by regional geophysical conditions, the critical minimum forest cover required for ecological protection varies by area. For example, FAO recommends essential minimum forest cover norms of 20%, 33.3 percent, and 66.6 percent for the plains,

plateau, and hills, and mountainous regions, respectively. Afforestation of wastelands and rejuvenation of degraded forests are being accelerated in order to achieve the 33 percent forest cover recommended in the National Forest Policy of 1988. As a result, the variable forest cover was chosen to ensure ecological safety. Cropping intensity is one of the indices used to determine the SDA degree. It calculates the amount of land used for cropping in a given year. More land has been brought under cultivation as a result of the growth of irrigation facilities, and farming communities can now grow several crops on the same land in the same year. Cropping intensity is a major contributor to assessing agricultural sustainability in the sense of ecological stability. The livestock sector contributes significantly to the socio-economic growth of a country by providing not only value-added products in agriculture and allied industries, but also employment, income, and nutritional protection to both urban and rural households. Thus, livestock density was chosen because of its ability to represent the level of animal pressure on the environment's overall resources. Rainfall is a very significant ecological element for crop production, that is, why it was taken into account.

Economic efficiency index includes total food grain yield (kg/ha), milk yield per animal (kg/day), irrigation strength (percentage), fertiliser intake (kg/ha), and per capita income (Rs.). The main foods are cereals and pulses, which are widely grown in Odisha. It accounts for roughly 84% of the total gross cropped area. Soil fertility, environment, irrigation, technology, and market performance all have an effect on food grain yield rates, either directly or indirectly. However, it has the potential to skew the assessment in favour of the districts' high-value cash crops. As a result, the variable yield rate of food grain was chosen to determine agricultural sustainability's economic performance. Food protection at the household level, according to FAO (1997), is the capacity of households to meet their daily food needs from their own production or from non-farm sources. Brown (1987) suggested critical minimum per capita grain availability of 180 kg/capita/annum, the variable per capita production of foodgrain has the potential to affect food security status. The proper application of fertiliser at the right time is critical to increasing agricultural productivity. It also preserves land productivity by supplying crops with the nutrients they need. As a result, variable fertiliser consumption is essential for agricultural sustainability. In the

phase of national growth, per capita income is extremely important. It also depicts the overall image of living standards, economic strength, and stability. As a result, the chosen variable per capita income has a strong capacity to reflect agricultural sustainability economic performance. Milk yield is another economic component that has a positive impact on the economy, so it was included in the economic efficiency index.

Social equity status uses Variables such as male literacy rate (percent), female literacy rate (percent), rural road connectivity (km.) and village electrification (no). Male and female literacy rates are both important in the growth of a country, but female literacy rates are especially important for women's empowerment and national development. It demonstrates the potential for women's social and economic inclusion, as well as population stabilisation. As a result, the chosen variables of male literacy rate and female literacy capture social equity for agricultural sustainability. The importance of 'rural road connectivity' in the rural infrastructure scenario cannot be overstated. The region's backwardness is exacerbated by poor road connectivity. Overall, it is an important move forward in addressing the critical issue of rural infrastructure that is needed for economic development. The state's village electrification situation remains a source of concern.

The lack of a stable electricity supply dampens the growth impulses in various economic sectors. It is a necessary condition of social equity in order to achieve long-term agricultural growth. Despite their differences and limitations, the selected

variables have a strong ability to reflect the picture of a district's agricultural systems' overall ecological, economic, and equity aspects. Directorate of Economics & Statistics provided secondary details and general information for the fourteen possible variables for all districts of Odisha (2019). Eq. (a) was applied to variables with positive consequences for SLS, and Eq. (a) was applied to all variables under each factor except for one variable (population density), which was applied to Eq. (b) because it has a negative impact on sustainable livelihood security. The numerators in equation (a) reflect the degree to which the k^{th} district better performed in the area with the i^{th} variable representing the j^{th} portion of its SLSI as compared to worst performance showing regions. The range, or difference between the maximum and minimum values of a given variable across districts, is the denominator, which is a simple statistical measure of total variation exhibited by that variable. In reality, the denominator acts as a scale or measuring rod by which each region's output for a given variable is assessed.

In which

i = variables (1, 2... n)

j = components (1, 2 &3)

k = districts (1, 2... K)

I_{ijk} = index value of i^{th} variable of j^{th} component of k^{th} district (i = 1, 2... n variables)

I_{jk} = index value of j^{th} component of k^{th} district (j = 1 to 3 components)

$SLSI_k$ = sustainable livelihood security index of k^{th} district (k = 1,2,.....30 district)

X_{ijk} = the value of the ith variable representing the j^{th} component of the k^{th} district)

To achieve the second objective

Crop diversification refers to a transition from regional dominance of a single crop to regional development of a variety of crops to meet the ever-increasing demand

for cereals, pulses, vegetables, fruits, oilseeds, fibre, fodder, grasses, and other foods. Its aim is to improve soil health and keep the agro-ecosystem in a state of dynamic equilibrium. Crop diversification aims to encourage technical advancements in sustainable agriculture by allowing farmers to choose from a variety of crop options for improved production and income. Livestock diversification is also a crucial component of achieving sustainable livelihood security. A shift in livestock patterns from low to high productivity breeds is needed, especially in Odisha, which is severely impacted by irregular rainfall, severe cyclones, extreme weather conditions, and other factors. Livestock provides a major source of supplementary income and family nutrition to poor rural people in such circumstances. There are many ways to measure crops diversification, and some of them include Herfindahl Index, Simpson Diversity Index, Ogive Index, Margalef Index, Shannon Index, Berger-Parker Index and Entropy Index.

Herfindahl index (H.I.) defined as the sum of squares of all n proportions is a measure of crop concentration. This measure is used to measure crop diversification on acreage proportion. The value of "H.I." varies from zero to one. It takes the value of one when there is complete specialization and approaches zero when the number of enterprises is more showing perfect diversification.

$$\textbf{H.I.} = \sum_{i=1}^{n} \boldsymbol{Pi}^2$$

Where, n = total number of crops

Pi = proportion of ith crop

The **Simpson Diversity Index** was created for districts using a formula-based approach.

$$\textbf{Dl}_j = 1 - \left(\sum_{i=1}^{N} \boldsymbol{Pi}^2 \right)$$

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/crop group/year/livestock) in their respective total

To achieve the third objective

The relationship between SLS and diversification at the district level was investigated using multiple regression analysis.

$$\mathbf{Y_t = a + b_1X_{1t}+b_2X_{2t}+U_t}$$

Where, Y_t = Sustainable Livelihood Security index,

X_1 = Livestock diversification index

X_2 = Crop diversification index

U = Disturbance term

a = Constant,

b_1 & b_2= Regression coefficient

t = time (1,2,...n years)

PROFILE OF THE STUDY AREA

Odisha's economy, like that of other emerging economies, has been undergoing structural changes that have shifted its focus away from agriculture and toward industry and services. In the last decade, the industry sector in Odisha has emerged as a major force of the state's economy. Since the 1990s, the state's industry-oriented policies have provided ideal conditions for investments and the entry of national and multinational companies into the country. Odisha is a preferred destination for investors due to its access to global markets, competent human capital, strong infrastructure, stable polity, and favourable business climate.

The contribution of the industrial sector to the Gross State Domestic Product (GSDP) and employment is important. With a slowly but steadily growing share of the State's GSDP over the years, the industry sector has emerged as one of the key drivers of the state's economy. According to the 2018-19 advance estimate, the industry sector's share of state GSDP is 29.25 percent, up from 28.81 percent in 2017-18.

Table 4.1: Odisha at a glance

S.No.	Details	Unit	Values
1.	Area	Sq.Km	1,55,707
2.	Districts	Nos.	18
	Sub-division	"	75
	Tehsil	"	317
	Municipalities	"	52
	N.A.Cs	"	62
	Police stations	"	617
	Development Blocks	"	314
	Gram Panchayat	"	6798
	Fire stations	"	318
	Inhabited Villages	"	47677

S.No.	Details	Unit	Values
3.	**Total Population asper Census 2011**	**000-No.s**	**41974**
	A) Male	"	21212
	B) Female	"	20762
	Projected population, 2020	"	47245
	A) Male	"	23805
	B) Female	"	23440
4.	Population Growth (2011 w.r.t. 2001)	%	14.0
5.	Density of Population (2011)	Total Persons per sq. Km	270
6.	**Rate of Literacy**	**Percentage**	**72.9**
	Male	"	81.6
	Female	"	64.0
7.	Total Electrified Villages	No.s	47677
8.	**Road length (2018-19)**	**000-K.M.**	
	1. National Highway	"	4848.06
	2. State Highway	"	4172.80
	3. District Roads	"	21621.77
	4. Total	"	30642.63
9.	**Land Utilization Pattern (2019-20)**	**000-Hectares**	
	1. Land put to non-agricultural use	"	1298
	2. Net sown area	"	5330
	3. Current fallow	"	850
	4. Other fallow	"	229
	5. Barren & uncultivable land	"	840
	6. Forest area	"	5813
	7. Misc. tree and groves	"	342
	8. Permanent pasture	"	494
	9. Culturable waste	"	375
10.	**Agriculture Production (2019-20)**	**000-MTs**	
	a) Food grains	"	16191.82
	b) Sugar Cane	"	1365.69
	c) Potato	"	261.39
	d) Oil seeds	"	518.61
	e) Jute	000-bales	44.92

S.No.	Details	Unit	Values
11.	**Education (2019-20)**		
	(a) Primary School	Nos.	33340
	(b) Upper Primary School	Nos.	21719
	(c) Secondary School	Nos.	10019
	(d) Degree Colleges	Nos.	904
	(e) Junior colleges	Nos.	2016
	(f) Medical Colleges	Nos	39
12.	Banking facilities (As on march 2020) Total Bank Branches	Nos.	5450
13.	**Communication facilities 2019-20**		
	a) Rural road length	In Kms	47295.00
	b) Inter college road	"	92683.13
	c) Intra college road	"	66608.59
	d) Forest road	"	7478.45
	e) Railway route	"	2653.00
	f) Post Offices (as on 01.04.2019)	Nos.	8215
14.	**Livestock Population (20th livestock census 2019)**	**Nos.**	**37646641**
	Poultry	"	19890538
	Cattle	"	9490016
	Buffalo	"	458324
	Sheep	"	1279149
	Goat	"	6393452
	Pig	"	135162
15.	**Health (31.10.20)**		
	a) District Headquarters hospital	No. s	39
	b) Sub divisional and other hospitals	"	111
	c) Community health centre	"	376
	d) Primary health centre	"	1275
	e) Health sub centre	"	6688
	f) Mobile health units	"	199
	g) Beds available	"	18387

(Source: Directorate of Agriculture & Food Production, Odisha & Directorate of Economics & Statistics)

4.1 Location

The present state of Odisha lies between the latitudes of 17.49'N and 22.34'N, and the longitudes of 81.27'E and 87.29'E. The state is bordered on the northeast by West Bengal, on the north by Jharkhand, on the south by Andhra Pradesh and Telangana, on the west by Chhattisgarh, and on the east by the Bay of Bengal.

4.2 Geology

Odisha, located on the eastern edge of peninsular India, accounting for about 73 percent of the total area. The Gondwana, which include the coal wealth, cover about 8% of the earth's surface. Aluminous/nickeliferous laterite and heavy minerals can be found in the Tertiary and Quaternary deposits that make up the majority of the area (in beach sand). Odisha's mountainous region accounts for roughly three-quarters of the state's total territory. Geographically, it is a member of the Indian Peninsula, which was once part of the Gondwanaland landmass.

4.3 Topography

The topography of Odisha is made up of rich plains along the coast and forested highlands in the interior. Odisha has been divided into five major morphological regions based on homogeneity, continuity, and physiographic characteristics: the Odisha Coastal Plain in the east, the Middle Mountainous and Highlands Area, the Central plateaus, the Western rolling uplands, and the major flood plains.

Coastal Plains, Central Table Land, Northern Plateau, and Eastern Ghats are the four physiographic zones that make up the state. North Western Plateau, North Central Plateau, North Eastern Coastal Plain, East and South Eastern Coastal Plain, North Eastern Ghat, Eastern Ghat High Land, South Eastern Ghat, Western Undulating Zone, Western Central Table Land, and Mid Central Table Land are the ten Agro climatic Zones.

Table 4.3: Physiography of Odisha

Items	Indicators	Statistics
Physiographic Zones (in nos.)	Physiographic Zones	4 Zones
		Northern Plateau
		Eastern Ghat
		Central Table Land
		Coastal Plain
Agro-climatic zones (In nos.)	Agro-climatic zones	10 Zones
		North Western Plateau
		North Central Plateau
		North Eastern Coastal Plain
		East and South Eastern Coastal Plain
		North Eastern Ghat
		Eastern Ghat High Land
		South Eastern Ghat
		Western Undulating Zone
		Western Central Table Land
		Mid Central Table Land

(Source: Odisha Profile – 2018)

Fig. 4.1: Map of Odisha

4.4 Soil type

Soil types in the state range from fertile alluvial deltaic soils in the coastal plains to mixed red and black soils in the Central Table Land, low fertility red and yellow soils in the Northern Plateau, and red, black, and brown forest soils in the Eastern Ghat area. Odisha's soils have been classified into eight classes.

Table 4.4: Soil types in Odisha

Items	INDICATORS	STATISTICS
Soil (In M Hectares)	Number of Taxonomically Broad Soil Groups	8
	Red loamy and red sandy soil	7.14 (45.54 %)
	Mixed red and Yellow Soil	5.50 (35.14 %)
	Black Soil	0.96 (6.20%)
	Laterite and lateritic soil	0.70 (4.52%)
	Deltaic alluvial Soil	0.67 (4.33 %)
	Coastal Saline and Alluvial Soil	0.25 (2.52 %)
	Brown Forest Soil	0.17 ((1.10 %)
	Mixed red and black Soil	0.16 ((0.65 %)

(Source: Odisha Profile – 2018)

4.5 Rivers

Odisha's rivers, although not perennial, support the state's basic needs. These rivers, which flow through Odisha and into the Bay of Bengal, are classified into four groups:

(i) Rivers with a source outside the state; (the Subarnarekha, the Brahmani and the Mahanadi).

(ii) Rivers that originate within the state (the Budhabalanga, the Baitarini, the Salandi, and the Rushikulya).

(iii) Rivers that originate in Odisha but flow through other states (the Bahuda, the Vansadhara, and the Nagavali).

(iv) Rivers that originate in Odisha but are tributaries to rivers that flow from other states (the Machhkund, the Sileru, the Kolab, and the Indravati).

Table 4.5: River basin in Odisha

River	Total Catchment Area (sq. kms)	Area inside Odisha (sq. kms)	Percentage to Geographical area of State	Length inside Odisha (kms)
Mahanadi	1,41,134	65,628	42.15	494
Brahmani	39,116	22,516	14.46	541
Baitarani	14,218	13,482	8.66	360
Budhabalanga	6,691	6,354	4.08	199
Subarnarekha	19,277	2,983	1.92	79
Rushikulya	8,963	8,963	5.76	175
Bahuda	1,118	890	0.57	78

(Source: Odisha Profile – 2018)

4.6 Climate

Odisha's weather is heavily affected by the sea due to its location on the coastal belt. The region's climate is tropical, resulting in extremely high temperatures in April and May. The weather in Odisha can be divided into three categories: summer, monsoon, and winter. The state also benefits from relatively brief periods of refreshing spring and mellow autumn. The sea, on the other hand, has a calming effect on the atmosphere of the coastal belt, while the hill tracts have a harsh climate.

4.7 Precipitation

Odisha receives 1482 mm of rain per year on average. The State receives approximately 78 percent of its rainfall between June and September, with the remaining 22 percent falling during the year.

Table 4.7: Climate of Odisha

Items	INDICATORS	STATISTICS
Precipitation & Climate	Type	Tropical
	Annual Normal Rain fall (in mm)	1451.2
	Actual Average Rain fall (mm)(2018)	1643.3
	Mean annual temperature (in centigrade)	26.89
	% of deviation	13.24
	Maximum temperature (Centigrade)	32.56
	Minimum temperature (Centigrade)	21.3

(Source: Directorate of Agriculture & Food Production, Odisha & Directorate of Economics & Statistics)

4.8 Setup of the Administration

Odisha is divided into 30 districts. To streamline their administration, these 30 districts have been divided into three revenue divisions. North, South, and Central divisions, with headquarters in Sambalpur, Berhampur, and Cuttack, respectively. The state is divided into 317 tehsils, 314 community development blocks, 6799 village panchayats, and 51313 villages. There are 47677 inhabited villages.

Table 4.8: Administration details in Odisha

Items	Indicators	Value
Population and administrative setup, As on 2018 (in Numbers)	Scheduled Tribe Communities	62
	Scheduled Caste Communities	93
	Particularly Vulnerable Tribal Group	13
	Total Districts	30
	Tribal Districts	13
	Subdivisions	58
	Tahsils	317
	Blocks	314
	Tribal Sub Plan Blocks	119
	Gram Panchayats	6,799
	Total Villages	51,313
	Inhabited villages	47,677
Urban Local Bodies (In nos.) as on 2018	Total Urban Local Bodies	114
	Municipal Corporation	5
	Municipalities	47
	Notified Area Council	62

(Source : Odisha Profile – 2018)

4.9 Demography

Odisha's population is 419,74,218 people, with 212,12,136 men and 207,62,082 women, accounting for 3.7 percent of India's total population according to census 2011. In this census, the State ranks 11th in terms of population size. In descending order of population, Uttar Pradesh, Maharashtra, Bihar, West Bengal, Andhra Pradesh (undivided), Tamilnadu, Madhya Pradesh, Rajasthan, Karnataka, and Gujarat have more people than Odisha. The state's population density is 270 people per square kilometre, compared to the national average of 382 people per square kilometre in 2011, an increase of 34 points since 2001.The State's sex ratio (females

per thousand males) is 979, which is higher than the national average of 943. However, Odisha's urban sex ratio, at 932, is lower than the rural sex ratio, which is 989. Literacy rate of Odisha is 72.87% , whereas male literacy rate is 81.59% and female literacy rate is 64.01%.

Table 4.9: Demography of Odisha

ITEMS	INDICATORS	AS PER 2011 CENSUS
Population (2011 Census) (In numbers)	Total of India's Population	4,19,74,218 3.47 (11th in Position)
	Male	2,12,12,136
	Female	2,07,62,082
	Rural	3,49,70,562
	Urban	70,03,656
	Other Population	20,332
	Child Population Total	52,73,194
	Male	27,16,497
	Female	25,56,697
	Rural	45,25,870
	Urban	7,47,324
	Population Density	270
	Rural	230
	Urban	2,090
	Scheduled Caste Population Total	71,88,463
	Scheduled Tribe Population Total	95,90,756
Projected Population, 2018	Total Population	4,60,19,138
	Male	2,32,02,951
	Female	2,28,16,187
Child Population (In numbers)	Total Population	52,14,078
	Male	26,96,972
	Female	25,17,106
Sex Ratio (2011 Census) (Number of females per '000 males)	Sex Ratio Total	979
Literacy Rate (%)	Total	72.87
	Male	81.59
	Female	64.01

(Source: Directorate of Agriculture & Food Production, Odisha & Directorate of Economics & Statistics)

4.10 Division and districts in Odisha

To make governance more effective, Odisha's 30 districts have been divided into three revenue divisions. Cuttack (Central Division), Sambalpur (Northern Division), and Berhampur (Southern Division) are the divisions with headquarters in Cuttack, Sambalpur, and Berhampur, respectively.

Table 4.10: Division & districts in Odisha

S.No.	Central Revenue Division (HQ: Cuttack)	Northern Revenue Division (HQ: Sambalpur)	Southern Revenue Division (HQ: Berhampur)
1.	Cuttack	Sambalpur	Ganjam
2.	Jagatsinghpur	Bargarh	Gajapati
3.	Kendrapara	Jharsuguda	Kandhamal
4.	Jajpur	Debagarh	Boudh
5.	Puri	Balangir	Kalahandi
6.	Khordha	Subarnapur	Nuapada
7.	Nayagarh	Dhenkanal	Koraput
8.	Balasore	Angul	Rayagada
9.	Bhadrak	Kendujhar	Nabarangpur
10.	Mayurbhanj	Sundargarh	Malkangiri

(Source: Odisha, Wikipedia)

4.11 Agriculture

Agriculture and allied industries remain critical to the Indian economy's long-term growth and development. Since Odisha is an agrarian state, agriculture is considered the lifeblood of the state's economy, as the majority of the population relies on it for a living. It employs and feeds more than 60% of the population, directly or indirectly, and is the state's single largest source of employment. Agriculture provides a lot of resources for development of industries . These resources are discussed below.

4.11.1 Land use pattern

Land is a fundamental requirement for the area's growth. The state of Odisha has a geographical area of 155 thousand square kilometres, accounting for 4.7% of the

country's total area, and a population share of 3.7 percent. In Odisha, there are approximately 375 thousand hectares of cultivable waste and approximately 824 thousand hectares of fallow land that are still available for productive use. This available land could be used for manufacturing. Table 4.11.1 shows the land use trend in detail.

Table 4.11.1: Odisha's Land use pattern

Items	INDICATORS	VALUE
LAND USE PATTERN As on 2017-18 (in '000 Ha.)	Total Geographical Area	15,571
	Recorded Forest Area	5,813
	Reporting Area For Land Use Statistics	15,467
	Forest area under Revenue Villages ,2016-17	1,897
	Total Area Not Available for cultivation	2,332
	Area under non-agricultural uses	1,298
	Barren & Un Culturable land	840
	Permanent pastures & other grazing lands	494
	Land under misc. tree crops & groves	342
	Culturable waste land	375
	Fallow Lands	824
	Current fallow	824
	Other fallow	229
	Net Area Sown	5,356
CROP PRODUCTION As on 2017-18	Gross Cropped Area	8,361
	Cropping Intensity (%)	156

(Source: Directorate of Agriculture & Food Production, Odisha & Directorate of Economics and Statistics, Odisha)

4.11.2 Area, production and yield of crop groups in Odisha

The main cropping season is Kharif, and rice is the most important crop, accounting for roughly two-thirds of the cropped area. Cropping is often limited to irrigated areas and areas with residual moisture throughout the rabi season. Pulses (arhar, moong, biri, kulthi), oilseeds (groundnut, sesamum, mustard, niger), fibres (jute, mesta, cotton), sugarcane, vegetables, and spices are also important crops grown in the state. During the Kharif season, rice dominates the cropped region, while during the Rabi season, pulses clearly dominate, occupying nearly half of the cropped area. Apart from oilseeds, fruits, and fibres, maize and ragi account for the majority of the crop. Sugarcane, spices, and minor millets are among the other crops. The total rice

production in the state was 65.51 lakh tonnes in 2017-18, with a paddy yield rate of 26.35 kg/ha.

Table 4.11.2: Area , production and yield of crop groups in Odisha

Items	AREA, 2017-18 ('000 Ha.)	PRODUCTION As on, 2017-18 (In 000 MT)	YIELD As on 2017-18 (Qtls, / Ha.)
Rice	3,766.39	6,551.37	17.39
Total Cereals	4167.81	7,406.87	17.77
Total Pulses	2,047.35	1,075.97	0.53
Total Food Grain (Cereals & Pulses)	6,215.16	8,482.84	13.65
Total Oilseeds	603.37	535.34	0.89
Total Fibres	160.17	525.68	137.80
Total Vegetables	651.52	9,067.65	735.65
Sugarcane (Cane)	27.00	298.06	118.80
Potato	25.09	1,996.26	34.49
Total Spices	161.62	847.97	0.57
Tobacco	0.31	0.18	17.39

(Source: Directorate of Agriculture & Food Production, Odisha & Directorate of Economics and Statistics, Odisha)

4.11.3 Fertiliser consumption in Odisha

Fertilizer use in the state has increased dramatically from 0.76 kg per hectare in 1961-62 to 68.67 kg per hectare during the years 2017-2018.

Table 4.11.3 Fertiliser consumption in Odisha

Items	INDICATORS	VALUE
FERTILISER CONSUMPTION As on 2017-18 in '000 MT	Nitrogen	325.05
	Phosphate	140.37
	Potassium	71.51
	Total Consumption	536.93
	Per Hectare consumption	68.67

(Source: Directorate of Agriculture & Food Production, Odisha & Directorate of Economics and Statistics, Odisha)

4.11.4 Horticultural Activity

Odisha's agro-climatic diversity allows for the cultivation of a wide range of horticultural crops, including perennial fruit crops, spices, a variety of root and tuber

crops, and a wide range of vegetables. Low temperatures in hilly areas at higher elevations provide optimal growing conditions for off-season vegetables. Lately, floriculture has also shown promising results. Vegetable productivity has been steadily increasing, even with regular fluctuations. In 2017-18, the state's vegetable area was projected to be 651.52 million ha, with a production of 9067.65 million tonnes.

Table 4.11.4: Horticultural production in Odisha

Items	**AREA (In '000 Ha.)**	**PRODUCTION**
Total Fruits (000 MT)	329.34	329.34
Major Fruits (000 MT)	,-	
Banana (000 MT)	24.50	466.58
Guava (000 MT)	14.27	104.07
Mango (000 MT)	199.41	813.94
Papaya (000 MT)	3.09	71.49
Pineapple (000 MT)	27.97	11.64
Pomegranate (000 MT)	0.96	0.91
Jackfruit (000 MT)	0.25	233.02
Litchi (000 MT)	12.41	20.39
Sapota (000 MT)	4.47	15.72
Total Flower (loose) ('000 MT)	3.36	24.91
Total Flower (Cut) (in lakh)	11.73	5,418.82
Total Plantation Crops (000 MT)	212.13	98.82
Cashew (000 MT)	150.72	90.83
Cocoanut (in lakh number)	50.91	3,424.70
Major Flower		
Marigold (' MT.)	2.62	23,594
Rose (lakh stems)	1.87	3,607
Gladioli (Spike)	1.60	1,576
Tuberose (MT)	0.51	1,314
Total Fruits (000 MT)	50.91	329.34

(Source: Directorate of Agriculture & Food Production, Odisha &
Directorate of Economics & Statistics, India
Directorate of Economics & Statistics, Odisha
Odisha Agriculture Census, 2010-11
Directorate of Horticulture, Odisha, Bhubaneswar
Economic Survey Odisha 2018-19)

4.11.5 Animal Husbandry

Livestock production and agriculture are intrinsically related, each being dependent on the other, and both crucial for overall food security. This sector apart from contributing to national economy in general and to agricultural economy in particular, also provides jobs generation opportunities, asset formation, coping mechanism against crop failure and social and financial security. Owing to favourable environment and topography, Animal Husbandry Sector have played prominent socio-economic role in Odisha. In Odisha, the livestock sector is highly livelihood intensive, with over 80% of rural households owning livestock of one species or another and earning supplemental income from them.

Table 4.11.5: Animal Husbandry in Odisha

Items	Indicators	Value
LIVESTOCK POPULATION, 2019 Census (In number)	Total Live Stock	2,07,32,498
	Rural	2,02,11,774
	Urban	5,20,724
	Total Poultry	1,98,90,538
	Rural	1,93,01,803
	Urban	5,88,735
	Total Cattle (Crossbreed)	13,05,773
	Male	3,19,719
	Female	9,86,054
	Total Cattle (Indigenous)	1,03,15,499
	Male	55,02,885
	Female	48,12,614
	Total Cattle (Crossbreed &Indigenous)	1,16,21,272
	Total Buffalo	7,26,306
	Male	3,35,255
	Female	3,91,051
	Total Bovine	1,23,47,578
	Sheep	15,81,129
	Goat	65,13,087
	Pigs	2,80,316

(Source: 2019 Livestock Census)

4.11.6 Irrigation Potential

Odisha has an 8.8-million-hectare gross ultimate irrigation capacity, while the country's total ultimate irrigation potential (UIP) is about 140 million hectares. As

compared to major and medium irrigation, minor irrigation has a higher share. Via minor irrigation, groundwater contributes more than 59 percent of the total ultimate capacity. The state government has made it a top priority to provide irrigation to at least 35 percent of the state's cultivable land. It has been estimated that 212 of the 314 blocks in the state have already received 35 percent irrigation facilities.

Table 4.11.6: Irrigation Potential in Odisha

Items	INDICATORS	VALUE
Irrigation Potential Created , 2018-19 (Area in '000 Ha)	Total(Kharif + Rabi)	5,917
	Kharif	4,047
	Rabi	1,869
	Major & Medium(Kharif+ Rabi)	2,078
	Kharif	1,426
	Rabi	652.45
	Mega (lift) (Kharif+ Rabi)	53.67
	Kharif	53.67
	Rabi	0.00
	Minor (LI point)(Kharif+ Rabi)	1,128.72
	Kharif	720.47
	Rabi	408.25
	Deep bore Well(Kharif+ Rabi)	510.48
	Kharif	384.46
	Rabi	126.02
	Total Minor (Lift)(Kharif+ Rabi)	1,639.21
	Kharif	1,104.93
	Rabi	534.28
	Minor (flow)(Kharif+ Rabi)	793.58
	Kharif	704.17
	Rabi	89.71
	Others(Kharif+ Rabi)	1,351.78
	Kharif	758.95
	Rabi	592.83
Irrigation Potential Utilised , 2018-19 (Area in '000 Ha)	Kharif+ Rabi	3,442.75
	Kharif	2,262.35
	Rabi	1,180.40

(Source: Directorate of Agriculture & Food Production, Odisha & Directorate of Economics & Statistics, Odisha Agriculture Census, 2010-11 Directorate of Horticulture, Odisha, Bhubaneswar)

Table 4.11.7: Disaster Management in Odisha

Items	INDICATORS	VALUE
DISASTER OCCURED in 2018-19	FLOODS/FLASH FLOODS/HEAVY RAIN	
	Number of Districts affected	6
	Number of Population affected	15,100
	Number of Human Casualty	3
	Relief Camps (2018-19)	
	Number of Districts	2
	Number of Relief Camps Opened	9
	Number of Beneficiary covered	3,816
	RAINFALL (2018-19)	
	Normal Rainfall (In MM)	1,144.3
	Actual	1,042.8
	Deviation	-8.90%
	Crop Loss due to Drought (Kharif-2018)	
	Number of Districts affected	4
	Number of Blocks affected	10
	Number of GPs Affected	100
	Number of Villages affected	505
	Number of ULB affected	2
	Number of Wards affected	3
	Area sustained crop-loss of 33% & above (in ha)	22,658.35
	Amount of Input Subsidy Released (in Rs.)	1,54,042,728
	FIRE ACCIDENT (2018-19)	
	Number of Accident occurred	4,923
	Number of Villages affected	3,935
	Number of Families affected	6855
	Approximate value of properties lost (in Rs.)	33,58,21,691
	Number of Persons died	92
	Number of Cattle died	195
	HEAT WAVE	
	Human lives lost in Sunstroke (2018)	52
	LIGHTNING 2018-19	
	Number of Human lives lost	398

(Source: Directorate of Agriculture & Food Production, Odisha &
Directorate of Economics & Statistics, Odisha
Agriculture Census,2010-11
Directorate of Horticulture, Odisha, Bhubaneswar)

Table 4.11.8: Economy of Odisha

Items	INDICATORS	ODISHA	INDIA
ECONOMY, 2018-19AE	Domestic Product & National/State Income		
	At Current prices		
	Gross Domestic Product/ Gross State Domestic Product (Rs. in crore)	3,78,991	1,51,92,588
	Growth Rate (%)	10.85	11.9
	Per Capita Net National Income/ Per Capita Net State Domestic Product (Rs. in crore)	75,223	1,03,007
	Growth Rate (%)	10.15	10.4
	At Constant (2011-12) prices		
	Gross Domestic Product/Gross State Domestic Product (Rs. in crore)	3,14,364	1,21,54,797
	Growth Rate (%)	7.94	7.1
	Per Capita Net National Income/Per Capita Net State Domestic Product (Rs. in crore)	61,678	81,805
	Growth Rate (%)	7.05	5.6
	Gross Value Added		
	At Current prices	100	100
	Primary (%)	27.27	19.41
	Secondary (%)	29.2	26.45
	Tertiary (%)	43.53	54.14
	At Constant (2011-12) Prices (%)	100	100
	Primary (%)	27.03	17.78
	Secondary (%)	30.09	27.94
	Tertiary (%)	42.88	54.28

(Source: Directorate of Agriculture & Food Production, Odisha &
Directorate of Economics & Statistics, Odisha
Agriculture Census, 2010-11
Directorate of Horticulture, Odisha, Bhubaneswar)

Chapter V

RESULTS AND DISCUSSION

This chapter discusses the study findings and interpretation, as well as the implications of those findings. Three parts make up this portion. Section 5.1 focuses on assessing the condition of Odisha's sustainable livelihood security status. Section 5.2 is concerned with determining the degree of crop and livestock diversification, while section 5.3 is concerned with estimating the interrelationship of sustainable livelihood security (SLS) with crop and livestock diversification. All of the above objectives have been examined at the district level.

Ecological security index comprised of variables such as the percentage of land covered by forest (%), cropping intensity (%), livestock density (per sq. km), population density (per sq. km), and annual rainfall (mm), among others. The efficient uses of human capital, as well as improvements in household overall quality of life, are critical for sustainable development. People will engage completely and contribute more to the economic development process if they are safe, trained, and qualified. The secret to breaking the slowdown in agricultural growth and productivity is human resources. As a result, the variable population density was chosen because of its ability to represent the magnitude of human pressure on overall ecological security. Forests are important for ecological balance and contribute significantly to the state's economy. Forest activities play an important role in the food security and survival of people who live near forests. Since forest occurrence and development are influenced by regional geophysical conditions, the critical minimum forest cover required for ecological protection varies by area. For example, FAO recommends essential minimum forest cover norms of 20%, 33.3 percent, and 66.6 percent for the plains, plateau, and hills, and mountainous regions, respectively. Afforestation of wastelands and rejuvenation of degraded forests are being accelerated in order to achieve the 33 percent forest cover recommended in the National Forest Policy of 1988. As a result, the variable forest cover was chosen to ensure ecological safety. Cropping intensity is one of the indices used to determine the SDA degree. It calculates the amount of land used for cropping in a given year. More land has been brought under cultivation as a

result of the growth of irrigation facilities, and farming communities can now grow several crops on the same land in the same year. Cropping intensity is a major contributor to assessing agricultural sustainability in the sense of ecological stability. The livestock sector contributes significantly to the socio-economic growth of a country by providing not only value-added products in agriculture and allied industries, but also employment, income, and nutritional protection to both urban and rural households. Thus, livestock density was chosen because of its ability to represent the level of animal pressure on the environment's overall resources. Rainfall is a very significant ecological element for crop production, that is, why it was taken into account.

Economic efficiency index includes total food grain yield (kg/ha), milk yield per animal (kg/day), irrigation strength (percentage), fertiliser intake (kg/ha), and per capita income (Rs.). The main foods are cereals and pulses, which are widely grown in Odisha . It accounts for roughly 84% of the total gross cropped area. Soil fertility, environment, irrigation, technology, and market performance all have an effect on food grain yield rates, either directly or indirectly. However, it has the potential to skew the assessment in favour of the districts' high-value cash crops. As a result, the variable yield rate of food grain was chosen to determine agricultural sustainability's economic performance. Food protection at the household level, according to FAO (1997), is the capacity of households to meet their daily food needs from their own production or from non-farm sources. Brown (1987) suggested critical minimum per capita grain availability of 180 kg/capita/annum, the variable per capita production of foodgrain has the potential to affect food security status. The proper application of fertiliser at the right time is critical to increasing agricultural productivity. It also preserves land productivity by supplying crops with the nutrients they need. As a result, variable fertiliser consumption is essential for agricultural sustainability. In the phase of national growth, per capita income is extremely important. It also depicts the overall image of living standards, economic strength, and stability. As a result, the chosen variable per capita income has a strong capacity to reflect agricultural sustainability economic performance. Milk yield is another economic component that

has a positive impact on the economy, so it was included in the economic efficiency index.

Social equity status uses Variables such as male literacy rate (percent), female literacy rate (percent), rural road connectivity (km.) and village electrification (no). Male and female literacy rates are both important in the growth of a country, but female literacy rates are especially important for women's empowerment and national development. It demonstrates the potential for women's social and economic inclusion, as well as population stabilisation. As a result, the chosen variables of male literacy rate and female literacy capture social equity for agricultural sustainability. The importance of 'rural road connectivity' in the rural infrastructure scenario cannot be overstated. The region's backwardness is exacerbated by poor road connectivity. Overall, it is an important move forward in addressing the critical issue of rural infrastructure that is needed for economic development. The state's village electrification situation remains a source of concern. The lack of a stable electricity supply dampens the growth impulses in various economic sectors. It is a necessary condition of social equity in order to achieve long-term agricultural growth. Despite their differences and limitations, the selected variables have a strong ability to reflect the picture of a district's agricultural systems' overall ecological, economic, and equity aspects. Directorate of Economics & Statistics provided secondary details and general information for the fourteen possible variables for all districts of Odisha (2019).

5.1 Evaluation of sustainable livelihood security status at district level

Affordable and long-term access to income and resources to meet basic needs is referred to as livelihood security (including adequate access to food, potable water, health facilities, educational opportunities, housing, time for community participation and social integration). Livelihoods can be made up of a variety of on-farm and off-farm activities that provide a variety of food and cash procurement strategies. At the district level, the state of sustainable livelihood security has been assessed. The index value ranges from 0 to 1.

From Table no. 5.1.1.1 to Table no. 5.1.4.2, the various relative indices of sustainability (ecological security index, economic efficiency index, social equity index, and sustainable livelihood security index) for Odisha are presented. All four indices have been divided into four groups, as follows: Low status index value (less than 0.25), moderate status index value (0.5), high status index value (0.5 to 0.75) and very high status index value (greater than 0.75). (index value more than 0.75). This is divided into four indices, which will be discussed further down.

5.1.1 Ecological security status

For society's well-being, ecological security is a necessary component of long-term livelihood security. We are all dependent on the environment because we are surrounded by it. The construction of an ecological security index was used to assess the relative ecological security status of different districts across the state. The relative values of the Ecological Security Index (ESI) for the year 2019 are shown in Table 5.1.1.1.

5.1.1.1 Ecological variables selected for agricultural sustainability in Odisha

Table 5.1.1.1 shows that Deogarh district has the most forest cover (46.26%) and has a sustainability index of 1, whereas Bhadrak district has 0.35 percent forest cover and has a sustainability index of 0. Cropping intensity values range from 100.48 percent in Jharsuguda (sustainability index is 0) to 143.75 percent in Jagatsinghpur (sustainability index is 1). The highest population density is in Khurda, at 800 people per square kilometre, but this has a negative impact on the sustainable livelihood index, so its sustainable livelihood index is zero, and the lowest is in Kandhamal, at 91 people per square kilometre (sustainability index is 1). The highest rainfall was 1722.7 mm in Malkangiri (sustainability index: 1), while the lowest rainfall was 854 mm in Bolangir (The index of sustainability is 0). In terms of livestock population density, the Balasore district had the highest value of 304 livestock per square kilometre (sustainability index of 1), while Gajapati had the lowest value of 75 livestock per square kilometre (sustainability index is 0).

Table 5.1.1.1: Ecological variables selected for agricultural sustainability in Odisha

S.No.	Districts	Population density (per sq. Km)	Livestock density (per sq. Km)	% of Forest cover area	Annual rainfall (mm)	Cropping intensity (%)
1.	**Angul**	200	109	29.57	965	133.105
2.	**Balasore**	610	304	4.77	1550.4	118.351
3.	**Baragarh**	254	98	4.93	983.9	137.226
4.	**Bhadrak**	601	265	0.35	1198.9	111.015
5.	**Bolangir**	251	114	11.48	854	115.276
6.	**Boudh**	142	123	17.08	1172.8	119.748
7.	**Cuttack**	667	217	9.01	1442.1	120.445
8.	**Deogarh**	106	106	46.26	1509.8	111.978
9.	**Dhenkanal**	268	143	17.4	1133.5	113.952
10.	**Gajapati**	134	75	18.71	1687.2	117.119
11.	**Ganjam**	430	127	9.25	1362.8	138.116
12.	**Jagatsinghpur**	682	264	4.54	1618.8	143.754
13.	**Jajpur**	630	244	6.11	1302.2	113.448
14.	**Jharsuguda**	274	94	15.43	1392.1	100.485
15.	**Kalahandi**	199	83	17.27	1425.4	119.739
16.	**Kandhamal**	91	85	41.39	1231.6	108.307
17.	**Kendrapara**	545	187	1.51	1504.3	116.108
18.	**Keonjhar**	217	156	20.42	1228.4	103.626
19.	**Khurda**	800	155	13.14	1530.1	111.633
20.	**Koraput**	157	97	15.2	1520.5	115.248
21.	**Malkangiri**	106	100	37.85	1722.7	101.978
22.	**Mayurbhanj**	242	220	10.06	1451.8	102.876
23.	**Nabarangpur**	231	112	22.58	1515.5	101.973
24.	**Nayagarh**	248	95	15.47	1219.7	131.603
25.	**Nuapada**	158	87	14.64	1011.3	107.015
26.	**Puri**	488	184	4.25	1510.9	128.167
27.	**Rayagada**	137	81	17.59	1381.6	104.933
28.	**Sambalpur**	157	87	26.14	1260.5	119.010
29.	**Subarnapur**	261	139	7.26	1116.1	137.618
30.	**Sundargarh**	216	132	21.92	1288.1	104.637

(Source: Publications of Directorate of Economics and Statistics, Odisha; Directorate of Economics and Statistics, Department of Agriculture, Govt. of India; 20th Livestock Census Report, 2019)

Table 5.1.1.2 : Individual indices to capture Ecological Security Index

S.No.	Districts	SLSI Population density	SLSI Livestock density	SLSI forest cover area	SLSI Annual rainfall	SLSI Cropping intensity
1	**Angul**	0.846	0.148	0.636	0.127	0.753
2	**Balasore**	0.267	1	0.096	0.801	0.412
3	**Baragarh**	0.770	0.101	0.099	0.149	0.849
4	**Bhadrak**	0.280	0.829	0	0.397	0.243
5	**Bolangir**	0.774	0.170	0.242	0	0.341
6	**Boudh**	0.928	0.209	0.364	0.366	0.445
7	**Cuttack**	0.187	0.620	0.188	0.676	0.461
8	**Deogarh**	0.978	0.135	1	0.754	0.265
9	**Dhenkanal**	0.750	0.296	0.371	0.321	0.311
10	**Gajapati**	0.939	0	0.399	0.959	0.384
11	**Ganjam**	0.521	0.227	0.193	0.585	0.869
12	**Jagatsinghpur**	0.166	0.825	0.091	0.880	1
13	**Jajpur**	0.239	0.737	0.125	0.515	0.299
14	**Jharsuguda**	0.741	0.083	0.328	0.619	0
15	**Kalahandi**	0.847	0.034	0.368	0.657	0.445
16	**Kandhamal**	1	0.043	0.893	0.434	0.180
17	**Kendrapara**	0.359	0.489	0.025	0.748	0.361
18	**Keonjhar**	0.822	0.353	0.437	0.430	0.072
19	**Khurda**	0	0.349	0.278	0.778	0.257
20	**Koraput**	0.906	0.096	0.323	0.767	0.341
21	**Malkangiri**	0.978	0.109	0.816	1	0.034
22	**Mayurbhanj**	0.787	0.633	0.211	0.688	0.055
23	**Nabarangpur**	0.802	0.161	0.484	0.761	0.034
24	**Nayagarh**	0.778	0.087	0.329	0.420	0.719
25	**Nuapada**	0.905	0.052	0.311	0.181	0.150
26	**Puri**	0.440	0.475	0.084	0.756	0.639
27	**Rayagada**	0.935	0.026	0.375	0.607	0.102
28	**Sambalpur**	0.906	0.052	0.561	0.467	0.428
29	**Subarnapur**	0.760	0.279	0.150	0.301	0.858
30	**Sundargarh**	0.823	0.248	0.469	0.499	0.095

(Source: Publications of Directorate of Economics and Statistics, Odisha; Directorate of Economics and Statistics, Department of Agriculture, Govt. of India; 20th Livestock Census Report, 2019)

5.1.2 Economic efficiency status

The economic efficiency index compares the relative economic efficiency of the state's various districts. The relative value of the Economic Efficiency Index (EEI) across the districts is shown in Table 5.1.2.2.

5.1.2.1 Economical variables selected for agricultural sustainability in Odisha

Table 5.1.2.1 shows that Subarnapur district has the highest food grain (cereals and pulses) yield in Odisha, with 3146 kg/ha (Sustainability index of 1), and Malkangiri has the lowest, with 1060 kg/ha (sustainability index is 0). Milk yield in Jagatsinghpur had a value of 4.384 kg/day (sustainability index 1), which was the lowest in the Nabarangpur district (1.227 kg /day) (sustainability index 0). Baragarh districts have 168.36% irrigation intensity (sustainability index 1), while Khurda has 101.35 % (sustainability index 0).Fertilizer consumption was highest in Nabarangpur with 151.03 kg/ha (sustainability index 1), and lowest in Kandhamal with 16.05 kg/ha (sustainability index 0). The highest per capita income was Rs. 92,211 in keonjhar district (sustainability index 1), while the lowest was Rs. 24,139 in Nabarangapur (sustainability index 0).

Table 5.1.2.1: Economical variables selected for agricultural sustainability in Odisha

S.No.	Districts	Consumption of fertilizer (kg/ha)	Milk yield (kg/day)	Irrigation intensity (%)	Per capita income (Rs)	Food grain yield (kg /ha)
1	**Angul**	25.45	2.182	104.322	63948	2824
2	**Balasore**	139.65	3.335	106.414	32714	2424
3	**Baragarh**	130.85	4.225	168.366	32764	1846
4	**Bhadrak**	100.14	2.465	102.634	29745	1638
5	**Bolangir**	58.7	1.578	108.163	34395	2422
6	**Boudh**	39.46	2.042	103.548	29776	1428
7	**Cuttack**	73.43	3.207	121.909	49536	2142
8	**Deogarh**	34.46	2.646	102.631	39213	1730
9	**Dhenkanal**	28.16	2.125	105.853	41451	1965
10	**Gajapati**	42.26	3.043	103.770	39687	1620
11	**Ganjam**	69.8	2.057	104.034	40334	1802
12	**Jagatsinghpur**	68.08	4.384	103.842	43946	1230
13	**Jajpur**	90.36	2.793	103.288	53277	1170
14	**Jharsuguda**	67.27	2.039	120.422	54148	1354
15	**Kalahandi**	62.63	2.535	143.72	32641	1676
16	**Kandhamal**	16.05	1.28	108.575	47185	1258
17	**Kendrapara**	34.27	2.81	121.324	28407	1855
18	**Keonjhar**	38.73	1.521	102.909	92211	1458
19	**Khurda**	76.22	2.706	101.357	56618	1522
20	**Koraput**	47.33	3.92	142.201	43715	1668
21	**Malkangiri**	60.27	3.097	106.036	27122	1060
22	**Mayurbhanj**	43.91	2.218	108.021	35742	2068
23	**Nabarangpur**	151.03	1.227	117.994	24139	2585
24	**Nayagarh**	44.48	1.903	102.808	26351	1532
25	**Nuapada**	34.15	2.513	109.699	32765	1265
26	**Puri**	88.28	3.679	114.530	31960	1624
27	**Rayagada**	69.25	2.425	109.312	37018	1536
28	**Sambalpur**	132.48	2.434	157.294	55656	1256
29	**Subarnapur**	49.05	3.461	160.567	29807	3146
30	**Sundargarh**	73.2	1.814	103.673	66881	1876

(Source: Publications of Directorate of Economics and Statistics, Odisha;
Directorate of Economics and Statistics,
Department of Agriculture , Govt. of India;
20th Livestock Census Report, 2019)

Table 5.1.2.2 : Individual indices to capture economical efficiency index

S.No.	Districts	SLSI Consumption of fertilizer	SLSI Milk yield	SLSI Irrigation intensity	SLSI Per capita income	SLSI Food grain yield
1	**Angul**	0.069	0.302	0.044	0.584	0.845
2	**Balasore**	0.915	0.667	0.075	0.125	0.653
3	**Baragarh**	0.850	0.949	1	0.126	0.376
4	**Bhadrak**	0.622	0.392	0.019	0.082	0.277
5	**Bolangir**	0.315	0.111	0.101	0.150	0.652
6	**Boudh**	0.173	0.258	0.032	0.082	0.176
7	**Cuttack**	0.425	0.627	0.306	0.373	0.518
8	**Deogarh**	0.136	0.449	0.019	0.221	0.321
9	**Dhenkanal**	0.089	0.284	0.067	0.254	0.433
10	**Gajapati**	0.194	0.575	0.036	0.228	0.268
11	**Ganjam**	0.398	0.262	0.039	0.237	0.355
12	**Jagatsinghpur**	0.385	1	0.037	0.290	0.081
13	**Jajpur**	0.550	0.496	0.028	0.428	0.052
14	**Jharsuguda**	0.379	0.257	0.284	0.440	0.140
15	**Kalahandi**	0.345	0.414	0.632	0.124	0.295
16	**Kandhamal**	0	0.016	0.107	0.338	0.094
17	**Kendrapara**	0.134	0.501	0.297	0.062	0.381
18	**Keonjhar**	0.168	0.093	0.023	1	0.190
19	**Khurda**	0.445	0.468	0	0.477	0.221
20	**Koraput**	0.231	0.853	0.609	0.287	0.291
21	**Malkangiri**	0.327	0.592	0.069	0.043	0
22	**Mayurbhanj**	0.206	0.313	0.099	0.170	0.483
23	**Nabarangpur**	1	0	0.248	0	0.731
24	**Nayagarh**	0.210	0.214	0.021	0.032	0.226
25	**Nuapada**	0.134	0.407	0.124	0.126	0.098
26	**Puri**	0.535	0.776	0.196	0.114	0.270
27	**Rayagada**	0.394	0.379	0.118	0.189	0.228
28	**Sambalpur**	0.862	0.382	0.834	0.462	0.093
29	**Subarnapur**	0.244	0.707	0.883	0.083	1
30	**Sundargarh**	0.423	0.185	0.034	0.627	0.391

(Source: Publications of Directorate of Economics and Statistics, Odisha; Directorate of Economics and Statistics, Department of Agriculture, Govt. of India; 20th Livestock Census Report, 2019)

5.1.3 Social Equity Status

Through the creation of a Social Security index, the relative social equity status of different districts in the state was investigated. The relative values of the Social Equity Index are shown in Table 5.1.3.2 (SEI).

5.1.3.1 Social variables selected for agricultural sustainability in Odisha

Table 5.1.3.1 shows that male literacy rates were highest in Jagatsinghpur with 92.4 percent (sustainability index 1), and lowest in Nabarangpur district, at 57.3 percent (sustainability index 0), whereas female literacy rates were highest in Khurda, at 81.6 percent (sustainability index 1), and lowest in Nabarangpur district, at 35.8 percent (sustainability index 0).The number of villages electrified was highest in Mayurbhanj district, with 3644 (sustainability index 1), and lowest in Jharsuguda, with 347 (sustainability index 0) . Mayurbhanj had the best rural road connectivity (sustainability index 1), while Deogarh had the worst (sustainability index 0).

Table 5.1.3.1: Social variables selected for agricultural sustainability in Odisha

S.No.	Districts	Male literacy (%)	Female literacy (%)	Village electrified (no.)	Rural road connectivity (km)
1	**Angul**	86	68.6	1652	1391.83
2	**Balasore**	87	72.3	2633	2131.95
3	**Baragarh**	83.7	65.4	1179	1718.49
4	**Bhadrak**	89.6	75.8	1242	1695.73
5	**Bolangir**	75.8	53.5	1751	1623.44
6	**Boudh**	83.3	59.8	1101	807.36
7	**Cuttack**	91.1	79.6	1852	1777.61
8	**Deogarh**	81.9	63	706	308.53
9	**Dhenkanal**	86.2	71	1081	1225.71
10	**Gajapati**	64.4	43.2	1382	685.46
11	**Ganjam**	81	61.1	2753	2989.39
12	**Jagatsinghpur**	92.4	80.6	1223	1225
13	**Jajpur**	86.8	73.3	1598	1627.43
14	**Jharsuguda**	86.6	70.7	347	323.41
15	**Kalahandi**	71.9	46.7	2047	1253.87
16	**Kandhamal**	76.9	51.9	2017	845.8
17	**Kendrapara**	91.5	79	1385	1245.29
18	**Keonjhar**	78.1	58.3	2059	1945.9
19	**Khurda**	91.8	81.6	1356	1188.89
20	**Koraput**	60.3	38.6	1383	1575.87
21	**Malkangiri**	59.1	38.3	898	780.38
22	**Mayurbhanj**	73.8	52.7	3644	3465.96
23	**Nabarangpur**	57.3	35.8	820	1904.6
24	**Nayagarh**	88.2	72	1534	648.71
25	**Nuapada**	70.3	44.8	656	702.93
26	**Puri**	90.8	78.3	1576	1694.93
27	**Rayagada**	61	39.2	2220	1670.32
28	**Sambalpur**	84.4	67.9	1229	1345.49
29	**Subarnapur**	84.4	64	856	741.42
30	**Sundargarh**	81	65.5	1713	1905.27

(Source: Publications of Directorate of Economics and Statistics, Odisha; Directorate of Economics and Statistics, Department of Agriculture, Govt. of India; 20th Livestock Census Report, 2019)

Table 5.1.3.2 : Individual indices to capture social efficiency index

S.No.	Districts	SLSI Male literacy rate	SLSI Female literacy rate	SLSI Village electrified	SLSI Rural road connectivity
1	**Angul**	0.817	0.716	0.395	0.343
2	**Balasore**	0.846	0.796	0.693	0.577
3	**Baragarh**	0.752	0.646	0.252	0.446
4	**Bhadrak**	0.920	0.873	0.271	0.439
5	**Bolangir**	0.527	0.386	0.425	0.416
6	**Boudh**	0.740	0.524	0.228	0.157
7	**Cuttack**	0.962	0.956	0.456	0.465
8	**Deogarh**	0.700	0.593	0.108	0
9	**Dhenkanal**	0.823	0.768	0.222	0.290
10	**Gajapati**	0.202	0.161	0.313	0.119
11	**Ganjam**	0.675	0.552	0.729	0.849
12	**Jagatsinghpur**	1	0.978	0.265	0.290
13	**Jajpur**	0.840	0.818	0.379	0.417
14	**Jharsuguda**	0.834	0.762	0	0.004
15	**Kalahandi**	0.415	0.237	0.515	0.299
16	**Kandhamal**	0.558	0.351	0.506	0.170
17	**Kendrapara**	0.974	0.943	0.314	0.296
18	**Keonjhar**	0.592	0.491	0.519	0.518
19	**Khurda**	0.982	1	0.306	0.278
20	**Koraput**	0.085	0.061	0.314	0.401
21	**Malkangiri**	0.051	0.054	0.167	0.149
22	**Mayurbhanj**	0.470	0.368	1	1
23	**Nabarangpur**	0	0	0.143	0.505
24	**Nayagarh**	0.880	0.790	0.360	0.107
25	**Nuapada**	0.370	0.196	0.093	0.124
26	**Puri**	0.954	0.927	0.372	0.439
27	**Rayagada**	0.105	0.074	0.568	0.431
28	**Sambalpur**	0.772	0.700	0.267	0.328
29	**Subarnapur**	0.772	0.615	0.154	0.137
30	**Sundargarh**	0.675	0.648	0.414	0.505

(Source: Publications of Directorate of Economics and Statistics, Odisha; Directorate of Economics and Statistics, Department of Agriculture, Govt. of India; 20th Livestock Census Report, 2019)

5.1.4 Sustainable Livelihood Security Status

The relative status of sustainable livelihood security across the state's districts has been examined using the composite index of sustainable livelihood security for all of the state's districts, as shown in table 5.1.4.1. The SLSI value ranged from 0.23to 0.57 in the tables. The tables also revealed that 6 districts have high status of sustainable livelihood security but no single district has a very high level of sustainable livelihood security. According to Hatai et al. the Economic Efficiency Index (EEI) and Social Equity Index (SEI) revealed that the ecological and social equity aspects of all districts' agricultural systems differ significantly from their economic aspects. Districts with higher SLSI scores were often referred to as advanced.

5.1.4.1 Overall ecological security index, economical efficiency index, social equity index and Sustainable Livelihood security status of Odisha

The overall ecological index value varies between 0.62 and 0.30. In terms of ecological security, Deogarh district came out on top, while Bolangir district came in last. In terms of the Economic Efficiency Index, Baragarh had the highest index value of 0.66, while Kandhamal had the lowest index value of 0.11. The district of Balasore was at the top of the social security index (index value 0.72), while the district of Malkangiri was at the bottom (index value 0.10). So, after averaging these indices, overall sustainable livelihood security was calculated, and it was discovered that sustainable livelihood security was highest in Odisha's Balasore district with index value 0.57 and lowest in Nuapada with index value 0.23.

Table 5.1.4.1: Overall ecological security index, economical efficiency index, social equity index and Sustainable Livelihood security status of Odisha

S.No.	Districts	ESI	RANK	EEI	RANK	SEI	RANK	SLSI	RANK
1	**Angul**	0.502	7	0.369	9	0.568	11	0.480	9
2	**Balasore**	0.515	5	0.487	4	0.728	1	0.577	1
3	**Baragarh**	0.393	24	0.660	1	0.524	16	0.526	4
4	**Bhadrak**	0.350	27	0.278	17	0.626	9	0.418	15
5	**Bolangir**	0.305	30	0.266	19	0.438	18	0.337	25
6	**Boudh**	0.462	16	0.144	28	0.412	20	0.340	23
7	**Cuttack**	0.426	19	0.450	6	0.710	2	0.529	2
8	**Deogarh**	0.626	1	0.229	24	0.350	24	0.402	17
9	**Dhenkanal**	0.410	21	0.225	25	0.526	15	0.387	19
10	**Gajapati**	0.536	4	0.260	21	0.199	27	0.332	27
11	**Ganjam**	0.479	10	0.258	22	0.701	4	0.480	8
12	**Jagatsinghpur**	0.592	2	0.359	11	0.633	7	0.528	3
13	**Jajpur**	0.383	25	0.311	14	0.614	10	0.436	12
14	**Jharsuguda**	0.354	26	0.300	15	0.400	21	0.351	22
15	**Kalahandi**	0.470	13	0.362	10	0.367	23	0.400	18
16	**Kandhamal**	0.510	6	0.111	30	0.396	22	0.339	24
17	**Kendrapara**	0.396	23	0.275	18	0.632	8	0.434	13
18	**Keonjhar**	0.423	20	0.295	16	0.530	14	0.416	16
19	**Khurda**	0.332	28	0.322	13	0.641	6	0.432	14
20	**Koraput**	0.486	8	0.454	5	0.215	26	0.385	20
21	**Malkangiri**	0.587	3	0.206	26	0.105	30	0.300	29
22	**Mayurbhanj**	0.475	12	0.254	23	0.709	3	0.479	10
23	**Nabarangpur**	0.448	17	0.395	7	0.162	29	0.335	26
24	**Nayagarh**	0.467	15	0.141	29	0.534	13	0.380	21
25	**Nuapada**	0.320	29	0.178	27	0.196	28	0.231	30
26	**Puri**	0.479	11	0.378	8	0.673	5	0.510	5
27	**Rayagada**	0.409	22	0.261	20	0.294	25	0.322	28
28	**Sambalpur**	0.483	9	0.527	3	0.517	17	0.509	6
29	**Subarnapur**	0.470	14	0.583	2	0.419	19	0.491	7
30	**Sundargarh**	0.427	18	0.332	12	0.560	12	0.440	11

Source: *Publications of Directorate of Economics and Statistics, Odisha; Directorate of Economics and Statistics, Department of Agriculture, Govt. of India; 20th Livestock Census Report, 2019)*

Table 5.1.4.2: Distribution of Districts under SLSI and its components indices in Odisha on the basis of index value

DISTRICTS				
STATUS	**ESI**	**EEI**	**SEI**	**SLSI**
Low		Boudh Deogarh Dhenkanal Kandhamal Malkangiri Nayagarh Nuapada	Gajapati Koraput Malkangiri Nabarangpur Nuapada	Nuapada
Total	**0**	**7**	**5**	**1**
Moderate	Baragarh Bhadrak Bolangir Boudh Cuttack Dhenkanal Ganjam Jajpur Jharsuguda Kalahandi Kendrapara Keonjhar Khurda Koraput Mayurbhanj Nabarangpur Nayagarh Nuapada Puri Rayagada Sambalpur Subarnapur Sundargarh	Anugul Balasore Bhadrak Bolangir Cuttack Gajapati Ganjam Jagatsinghpur Jajpur Jharsuguda Kalahandi Kendrapara Keonjhar Khurda Koraput Mayurbhanj Nabarangpur Puri Raygada Sundargarh	Bolangir Boudh Deogarh Jharsuguda Kalahandi Kandhamal Raygada Subarnapur	Anugul Bhadrak Bolangir Boudh Deogarh Dhenkanal Gajapati Ganjam Jajpur Jharsuguda Kalahandi Kandhamal Kendrapara Keonjhar Khurda Koraput Malkangiri Mayurbhanj Nabarangpur Nayagarh Rayagada Subarnapur Sundargarh
Total	**23**	**20**	**8**	**23**
High	Anugul Balasore Deogarh Gajpati Jagatsinghpur Kandhamal Malkangiri	Baragarh Sambalpur Subarnapur	Angul Balasore Baragarh Bhadrak Cuttack Dhenkanal Ganjam Jagatsinghpur Jajpur Kendrapara Keonjhar Khurda Mayurbhanj Nayagarh Puri Sambalpur Sundargarh	Balasore Baragarh Cuttack Jagatsinghpur Puri Sambalpur
Total	**7**	**3**	**17**	**6**
Very high				
Total	**0**	**0**	**0**	**0**

Source: *Publications of Directorate of Economics and Statistics, Odisha;*
Directorate of Economics and Statistics,
Department of Agriculture, Govt. of India;
20th Livestock Census Report, 2019)

5.1.4.2 Distribution of Districts under SLSI and its components indices in Odisha on the basis of index value

Out of 30 districts, 23 were found to have a moderate level of sustainable livelihood security. It was also discovered that one district had a low and no district had very high SLS status, while 6 districts had a high SLS status. Balasore (1 rank), Cuttack (2 rank), Jagatsinghpur (3 rank), and Bargarh (4 rank) performed better in the SLSI . Bolangir, Nabarangpur, Gajapati, Malkangiri, Nuapada, and Rayagada are the worst-performing districts in the SLSI.Nuapada has the lowest SLSI value due to the 2^{nd} lowest ESI value, 3^{rd} lowest SEI value and 4^{th} lowest EEI value. Malkangiriand Kandhamal also have low EEI and SEI values when compared to the ESI value. The SLSI has a narrower range than its component indices, indicating that district performance is inconsistent across the three aspects of sustainable livelihood security (ESI, EEI, and SEI). The table 5.1.4.1 shows all of the districts and their various statuses in terms of the Ecological Security Index (ESI), Economic Efficiency Index (EEI), Social Equity Index(SEI), and Sustainable Livelihood Security Index(SLSI) based on index value.

5.2 Extent of crop and livestock diversification

With the changing social, economic, and climatic environment, the issue of sustainable livelihood security for the agricultural sector becomes even more critical. Crop and livestock diversification is seen as a potential tool for ensuring sustainable livelihood security. Diversification could be used as a risk management strategy to help poor families reduce their vulnerability and manage risks by diversifying their farming activities.

Crop diversification and livestock rearing are the topics of this segment. As previously stated, the study was carried out at the district level. The index value varies from 0 to 1. Low level (index value less than 0.25), moderate level (index value 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) are the four categories of diversification indices. This section is divided into two sections, the first of which measures crop diversification and the second of which measures livestock diversification.

5.2.1 Crop diversification Index

Crop diversification indices have been constructed for districts. There are five crop groups viz, cereals, pulses, fruits & vegetables, sugars and oilseeds crop group. The diversification indices have been constructed for all the crop groups per year collectively from 2015 to 2019 .

On analyzing the Table 5.2.1, it is clear that out of 30 districts 20 districts have decreased crop diversification index value in 2018-19 as compared to 2015-16, 2016-17, 2017-18.This means there is less diversity in planting crops in these 20 districts during these four years. In the year 2015-16, 2016-17, 2017-18, 2018-19Jagatsinghpur district had highest crop diversification index value of (0.47, 0.43 , 0.42 , 0.47) and Sambalpur district had lowest crop diversification value of (0.02 , 0.03 , 0.01, 0.01) respectively . Overall crop diversification index was low in 21 districts and 9 districts were under moderate crop diversification index and no single district had high and very high status of crop diversification index.

5.2.2 Livestock diversification Index

Livestock diversification is also crucial for achieving sustainable livelihood security. A shift in livestock patterns from low-productive to high-productive breeds is required, particularly in Odisha, which is plagued by cyclones (especially in coastal Odisha), high rainfall, variation in temperature, and poor groundwater quality. Livestock provides a significant source of supplementary income and family nutrition to poor rural people in such situations. This section contains a presentation and discussion of this account. The value of livestock diversification ranged from 0.44 to 0.66 in the table. When it came to district level comparisons, 23 districts had high livestock diversification indexes, only seven district, Baleswar, Bhadrak, Dhenkanal, Jajpur, Kendrapara, Khordha, Puri, had a moderate level of diversification index, and no district had a low and very high level of diversification index. Farmers raised cows, buffaloes, sheep, goats, pigs, and poultry as their main livestock.

Table 5.2.1: Crop and livestock diversification index

S.No.	Districts	2015-16 Crop diversification index	2016-17 Crop diversification index	2017-18 Crop diversification index	2018-19 Crop diversification index	Overall Crop diversification index	Livestock diversification index
1	**Anugul**	0.226	0.256	0.232	0.233	0.24	0.53
2	**Balangir**	0.289	0.289	0.178	0.133	0.22	0.63
3	**Baleshwar**	0.078	0.064	0.039	0.013	0.05	0.45
4	**Bargarh**	0.197	0.254	0.218	0.115	0.20	0.61
5	**Bhadrak**	0.059	0.061	0.032	0.018	0.04	0.42
6	**Boudh**	0.117	0.236	0.139	0.083	0.14	0.66
7	**Cuttack**	0.369	0.394	0.330	0.321	0.35	0.51
8	**Deogarh**	0.043	0.201	0.139	0.077	0.12	0.51
9	**Dhenkanal**	0.188	0.174	0.211	0.091	0.17	0.49
10	**Gajapati**	0.207	0.251	0.261	0.183	0.23	0.56
11	**Ganjam**	0.341	0.396	0.354	0.298	0.35	0.65
12	**Jagatsinghapur**	0.479	0.431	0.422	0.473	0.45	0.52
13	**Jajapur**	0.349	0.372	0.296	0.291	0.33	0.44
14	**Jharsuguda**	0.029	0.052	0.064	0.013	0.04	0.53
15	**Kalahandi**	0.241	0.235	0.168	0.197	0.21	0.63
16	**Kandhamal**	0.178	0.165	0.207	0.152	0.18	0.59
17	**Kendrapara**	0.329	0.223	0.280	0.271	0.28	0.46
18	**Kendujhar**	0.048	0.081	0.057	0.027	0.05	0.54
19	**Khordha**	0.284	0.310	0.184	0.182	0.24	0.46
20	**Koraput**	0.235	0.177	0.219	0.239	0.22	0.61
21	**Malkangiri**	0.198	0.153	0.168	0.232	0.19	0.52
22	**Mayurbhanj**	0.027	0.044	0.026	0.011	0.03	0.54
23	**Nabarangpur**	0.134	0.203	0.099	0.120	0.14	0.55
24	**Nayagarh**	0.342	0.385	0.390	0.331	0.36	0.57
25	**Nuapada**	0.200	0.278	0.265	0.261	0.25	0.59
26	**Puri**	0.412	0.367	0.328	0.299	0.35	0.45
27	**Rayagada**	0.381	0.312	0.373	0.374	0.36	0.62
28	**Sambalpur**	0.026	0.039	0.015	0.026	0.03	0.56
29	**Sonepur**	0.097	0.056	0.022	0.042	0.05	0.63
30	**Sundargarh**	0.072	0.112	0.102	0.044	0.08	0.55

Source: *Publications of Directorate of Economics and Statistics, Odisha; Directorate of Economics and Statistics, Department of Agriculture, Govt. of India; 20th Livestock Census Report, 2019)*

5.3 Estimation of inter-relationship of Sustainable Livelihood Security with crop and livestock diversification

In general, crop or farming and livestock rearing are the two main sources of livelihood in rural areas. On-farm and off-farm income are required for sustainable livelihood security. Given the changing social, economic, and climatic environment, the issue of sustainable livelihood security for the farm sector has become even more intense. Crop and livestock diversification is seen as a potential tool for sustainable livelihood security. As a result, it's crucial to figure out how Sustainable Livelihood Security interacts with crop and livestock diversification.

5.3.1 Inter-relationship of Sustainable Livelihood Security with crop and livestock diversification at district level

The relationship between SLS and diversification at the district level was investigated using multiple regression analysis.

$$\mathbf{Y_t = a + b_1X_{1t}+b_2X_{2t}+U_t}$$

Where,

Y_t = Sustainable Livelihood Security index,

X_1 = Livestock diversification index

X_2 = Crop diversification index

U = Disturbance term

a = Constant,

b_1& b_2 = Regression coefficient

t = time (1,2,...n years)

At the district level, Table 5.3.1 shows the relationship between Sustainable Livelihood Security and crop and livestock diversification. In all cases (where dependent variable(Y) is taken as ecological security index, economic efficiency index, social security index, and sustainable livelihood security index one by one), the value of R^2 is very low at the district level. Because the values of independent

variables (X1- livestock diversification index, X2- crop diversification index) are nearly identical in all districts, the data has an econometric problem of homoscedasticity (very few variations in values of X1 and X2), resulting in a low R^2 value and coefficient of crop & livestock diversification is insignificant.

Table 5.3.1: Inter-relationship of Sustainable Livelihood Security with crop and livestock diversification at district level

Components	Intercept	b1	S.E. of b1	b2	S.E. of b2	R^2
Ecological Security Index	0.276985	0.282855	0.217233	0.099658	0.12132	0.082234
Economic Efficiency Index	0.425978	-0.03744	0.295234	-0.15996	0.164881	0.034448
Social Equity Index	0.768225	-0.64219	0.493317	0.314279	0.275506	0.097922
Sustainable Livelihood Security Index	0.490396	-0.13226	0.212053	0.084658	0.118426	0.031582

(Note: b1 – Coefficient of livestock diversification , b2 – Coefficient of crop diversification)

The coefficient of livestock diversification is positive implying that crop and livestock diversification will augment ecological security. But in the case of economic efficiency index if both crop and livestock are diversified at same time it might exceed the resource available to the farmer. So diversification at particular direction will augment or increase economic efficiency. Social equity and overall sustainable livelihood security exhibits identical relationship with crop and livestock diversification. Amita et al. had shown in her research that result value of R^2 is very low and coefficient of crop & livestock diversification is insignificant also the data had an econometric problem of homoscedasticity.

Chapter VI

SUMMARY AND CONCLUSION

Introduction

The phrase "sustainable" refers to a person's ability to provide themselves in a way that is long-term viable. The ability to withstand external shocks or stresses and recover from them by preserving or strengthening one's livelihood is often referred to as "sustainability". Sustainable livelihood, according to **Chambers (1986)**, "a state of prosperity, as well as stockpiles and flows of food and cash, that ensures physical and social well-being and protects against poverty." Swaminathan (1991) defines SLS as a sustainable living option that is environmentally sound, economically feasible, and socially equitable. Swaminathan (1993) defined 14 primary dimensions of sustainable agriculture, which include social, economic, technological, political, and environmental factors. The definition of rural livelihood security (RLS) was proposed by **Chambers and Conway (1992),** it emphasises capability, equity, and long-term sustainability. The notion symbolises concern for both inter-generational and intra-generational fairness because it depicts the security or assurance of the people' means of subsistence not only now but also in the future. SLS is a phenomenon that involves both macro and micro levels of involvement. Stabilize population, reduce distress migration, prevent exploitation, and promote long-term sustainable resource management are some of the macro- level definitions for ensuring SLS. At the micro- and local levels, 'enough stocks and flows of food and currency to cover basic needs' and 'access to energy, revenue, and assets to mitigate shocks' are essential components of SLS.

Need of the Study

Odisha, formerly Orissa, is a state in India's eastern region. It is the eighth-largest state in terms of territory and the eleventh-largest in terms of population. The state is home to India's third-largest number of Scheduled Tribes. It is bordered on the north by West Bengal and Jharkhand, on the west by Chhattisgarh, and on the south

by Andhra Pradesh. Odisha has a 485-kilometer coastline along the Bay of Bengal. The state of Odisha is divided into 30 districts. To simplify their administration, these 30 districts have been divided into three revenue divisions. North, Central, and South divisions exist, with headquarters in Sambalpur, Cuttack, and Berhampur, respectively. According to the census data from 2011, Odisha has a total population of 41,974,218 people, with 21,212,136 men (50.54 percent) and 20,762,082 women (49.46 percent), or 978 females per 1000 males, according to the 2011 Indian census. This is an improvement of 13.97 percent over the population in 2001. The population density is 270 people per square kilometre. According to the 2011 census, the literacy rate is 73 percent, with 82 percent of males and 64 percent of females being literate. The average annual rainfall in Odisha is about 1438 mm, with around 78 percent of that falling during the monsoon season.

In 2004–2005, the proportion of people living in poverty was 57.15 percent, nearly double the Indian average of 26.10 percent. The state's poverty rate has dropped by 24.6 percentage points since 2005. According to latest estimates, 32.6 percent of the population lives in poverty.

According to data from 1996 to 2001, the state's life expectancy was 61.64 years, which was higher than the national average of years. The state has a birth rate of 23.2 per 1,000 people per year, a death rate of 9.1 per 1,000 people per year, a 65 per 1000 live birth infant mortality rate, and a 358 per 1,000,000 live births maternal mortality rate. As of 2018, Odisha has a Human Development Index of 0.606.

It has large regional inequalities and lags behind in many aspects of human growth, including female literacy, school enrolment and retention, infant mortality, and low per capita health spending, among others. In terms of socioeconomic growth, some districts are lagging behind. These areas have poor food grain productivity, a higher rate of poverty, and low female literacy, among other issues. These have posed a threat to the state's ecological equilibrium, as well as the economic and social status of households in various districts.

Objectives

Keeping these problems in the mind these four objectives are selected for the study:

1) To appraise the status of sustainable livelihood security (SLS)

2) To evaluate the level of crop and livestock diversification

3) To study the relationship between sustainable livelihood security (SLS) with crop and livestock diversification.

Methodology

Secondary data was gathered for all of the state's districts from different government-published sources and other relevant sources. For the districts, time-series data (2015-19) & cross-sectional data on location, production, productivity of different crops or crop groups, ecological, economic, and social indicators, and the number of different livestock were gathered. To achieve the first objective the SLSI methodology is a generalisation of the relative approach that underpins the United Nations Development Programme's Human Development Index (UNDP, 1992). It's a cross-sectional metric for assessing the relative survival of a group of organisations. Swaminathan (1991) proposed the Sustainable Livelihood Security Index (SLSI) as an educational and policymaking method for evaluating the potential of sustainable development (SD).

The Study's Key Findings

(i) Deogarh district has the most forest cover of 46.26%, whereas Bhadrak district has the lowest 0.35% forest cover. Cropping intensity values range from 100.48% in Jharsuguda to 143.75% in Jagatsinghpur. The highest population density is in Khurda, at 800 people per square kilometre, and the lowest is in Kandhamal, at 91 people per square kilometre. The highest rainfall was 1722.7 mm in Malkangiri, while the lowest rainfall was 854 mm in Bolangir. In terms of livestock population density, the Balasore district had the highest value of 304 livestock per square kilometre, while Gajapati had the lowest value of 75 livestock per square kilometre. In terms of ecological security, Deogarh district came out on top, while Bolangir district came in last.

(ii) Subarnapur district has the highest food grain (cereals and pulses) yield in Odisha, with 3146 kg/ha and Malkangiri has the lowest, with 1060 kg/ha. Milk yield in Jagatsinghpur had highest value of 4.384 kg / day, which was the lowest in the Nabarangpur district (1.227 kg/day). Baragarh districts have 168.36% irrigation intensity, while Khurda has 101.35 %. Fertilizer consumption was highest in Nabarangpur with 151.03 kg/ha, and lowest in Kandhamal with 16.05 kg/ha. The highest per capita income was Rs. 92,211 in keonjhar district, while the lowest was Rs. 24,139 in Nabarangapur. In terms of the Economic Efficiency Index, Baragarh had the highest index value of 0.66, while Kandhamal had the lowest index value of 0.11.

(iii) Male literacy rates were highest in Jagatsinghpur with 92.4 percent, and lowest in Nabarangpur district, at 57.3 percent, whereas female literacy rates were highest in Khurda, at 81.6 percent, and lowest in Nabarangpur district, at 35.8 percent. The number of villages electrified was highest in Mayurbhanj district, with 3644, and lowest in Jharsuguda, with 347. Mayurbhanj had the best rural road connectivity, while Deogarh had the worst. The district of Balasore was at the top of the social security index (index value 0.72), while the district of Malkangiri was at the bottom (index value 0.10).

(iv) It was discovered that sustainable livelihood security was highest in Odisha's Balasore district with index value 0.57 and lowest in Nuapada with index value 0.23.

(v) Out of 30 districts 20 districts have decreased crop diversification index value in 2018-19 as compared to 2015-16, 2016-17, 2017-18.This means there is less diversity in planting crops in these 20 districts during these four years. In the year 2015-16, 2016-17, 2017-18, 2018-19 Jagatsinghpur district had highest crop diversification index value of (0.47, 0.43, 0.42, 0.47) and Sambalpur district had lowest crop diversification value of (0.02, 0.03, 0.01, 0.01) respectively. Overall crop diversification index was low in 21 districts and 9 districts were under moderate crop diversification index and no single district had high and very high status of crop diversification index.

(vi) 23 districts had high livestock diversification indexes, only seven district, Baleswar, Bhadrak, Dhenkanal, Jajpur, Kendrapara, Khordha, Puri, had a

moderate level of diversification index, and no district had a low and very high level of diversification index.

(vii) The SLSI approach aids in the establishment of inter-district goals for agricultural resource allocation and prioritises the activities and programmes important to each district for sustainable agricultural growth, which is why significance of SLSI is growing by the day.

(viii) The majority of districts have a moderate livelihood status, implying that the state of Odisha's overall sustainable livelihood is medium.

(ix) The crop diversification index in Odisha is low or medium, indicating that farmers in all districts have a high chance of crop failure due to lack of diversification techniques.

(x) The livestock diversification index is medium or high in all districts, indicating that cows, buffalo, sheep, poultry, goat and pigs are reared in most of the districts.

Implication of Policies

(i) In Bolangir district more focus should be given on ecological variables, in Kandhamal district more focus should be given on economic variables, in Malkangiri district social variables should be given more focus and in Nuapada district all three (ecological, economic and social) variables should be focused to enhance sustainable livelihood security status in the state.

(ii) Seven district, Baleswar, Bhadrak, Dhenkanal, Jajpur, Kendrapara, Khordha, Puri should be promoted for livestock diversification to improve the status of sustainable livelihood security.

(iii) In all districts crop diversification should be promoted to improve the status of sustainable livelihood security of area.

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