

**ECONOMICS OF IRRIGATED CROPPING SEQUENCES IN
RAHURI DISTRICT OF MAHARASHTRA**

by

Waghmare Pradnyasheel Sadashiv
(Reg. No. 019/209)

A Thesis submitted to the

**MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI- 413 722, DIST- AHMEDNAGAR,
MAHARASHTRA, INDIA**

In partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL ECONOMICS



DEPARTMENT OF AGRICULTURAL ECONOMICS

**POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI- 413 722, DIST- AHMEDNAGAR
MAHARASHTRA STATE, INDIA**

2021

**ECONOMICS OF IRRIGATED CROPPING SEQUENCES IN
NANDED DISTRICT OF MAHARASHTRA**

by

Waghmare Pradnyasheel Sadashiv
(Reg. No. 019/209)

A Thesis submitted to the
**MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI- 413 722, DIST- AHMEDNAGAR,
MAHARASHTRA, INDIA**

In partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL ECONOMICS

APPROVED BY

Dr. M.S. Jadhav
(Chairman and Research Guide)

Dr. D.B. Yadav
(Committee Member)

Dr. V.G. Pokharkar
(Committee Member)

Dr. M.R. Patil
(Committee Member)

**DEPARTMENT OF
AGRICULTURAL ECONOMICS**

POST GRADUATE INSTITUTE

**MAHATMA PHULE KRISHI VIDYAPEETH,
RAHURI- 413 722, DIST- AHMEDNAGAR
MAHARASHTRA STATE (INDIA)**

2021

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
thereof has not been submitted
by me or other person to any
other University or Institute
for a Degree or
Diploma

Place : MPKV, Rahuri

(Waghmare P.S.)

Date : / /2021

Dr. M.S. Jadhav

Assistant Professor,
Department of Agricultural Economics,
RCSM College of Agriculture,
Kolhapur – 416 004,
Maharashtra State, INDIA.

CERTIFICATE

This is to certify that the thesis entitled, “**ECONOMICS OF IRRIGATED CROPPING SEQUENCES IN NANDED DISTRICT OF MAHARASHTRA**” submitted to the Faculty of Agricultural, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) in the partial fulfilment of the requirement for the award of the degree of **MASTER OF SCIENCE** in **AGRICULTURAL ECONOMICS**, embodies the results of a piece of *bona fide* research work carried out by **Mr. WAGHMARE PRADNYASHEEL SADASHIV** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledge

Place : MPKV, Rahuri
Date : / /2021

(Dr. M.S. Jadhav)
Research Guide

Dr. D.B. Yadav
Head,
Department of Agricultural Economics
Mahatma Phule Krishi Vidyapeeth,
Rahuri – 413 722, Dist. Ahmednagar,
Maharashtra, INDIA.

CERTIFICATE

This is to certify that the thesis entitled, **“ECONOMICS OF IRRIGATED CROPPING SEQUENCES IN NANDED DISTRICT OF MAHARASHTRA”** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahmednagar (M.S.) in partial fulfilment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ECONOMICS**, embodies the result of a piece of bonafide research work carried out by **Mr. WAGHMARE PRADNYASHEEL SADASHIV** under the guidance and supervision of **Dr. M.S. JADHAV**, Assistant Professor, Department of Agricultural Economics, RSCM College of Agriculture, Kolhapur and that no part of the thesis has been submitted for any other degree or diploma.

Place : MPKV, Rahuri

Date : / /2021

(D.B. YADAV)

Dr. P.N. Rasal

Associate Dean,

Post Graduate Institute,

Mahatma Phule Krishi Vidyapeeth,

Rahuri – 413 722 Dist. Ahmednagar,

Maharashtra, INDIA.

CERTIFICATE

This is to certify that the thesis entitled, **“ECONOMICS OF IRRIGATED CROPPING SEQUENCES IN NANDED DISTRICT OF MAHARASHTRA”** submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (M.S.) in partial fulfilment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ECONOMICS**, embodies the results of a piece of bonafide research work carried out by **Mr. WAGHMARE PRADNYASHEEL SADASHIV** under the guidance and supervision of **Dr. M.S. JADHAV**, Assistant Professor, Department of Agricultural Economics, RCSM College of Agriculture, Kolhapur and that no part of the thesis has been submitted for any other degree or diploma.

Place : Rahuri

Date : / /2021

(P.N. RASAL)

ACKNOWLEDGEMENT

I avail this opportunity to acknowledge all those who helped and guided me during the course of my research work.

Before giving way to my feelings, I cordially want to salute that supreme cosmic consciousness from which everything originates in the beginning and to which everything goes to end. Though formal and dead words cannot carry the fragrance of emotions with them, still they are the only available way of expressing emotions in such formal acknowledgement.

*On the path of search for knowledge, one needs complementary guidance and this task was performed by my research guide **Dr. M.S. Jadhav**, Assistant Professor, Department of Agricultural Economics, RCSM College of Agriculture, Kolhapur. I express my sincere gratitude and indebtedness for his inspiring guidance, keen interest, constructive criticism, constant encouragement and immense sympathy during the preparation of this manuscript and PG life.*

*I am deeply indebted to **Dr. P.G. Patil**, honourable vice chancellor, **Dr. A.L. Pharande**, Ex Dean, Faculty of Agriculture, MPKV, Rahuri and **Dr. P.N. Rasal**, Associate Dean, PGI, MPKV, Rahuri, for providing necessary facilities, useful suggestions and constant encouragement at all the time.*

*I extend my heartfelt thanks to the members of my Advisory Committee **Dr. D.B. Yadav**, Head, Department of Agricultural Economics, **Dr. V.G. Pokharkar**, Associate Professor, Department of Agricultural Economics and **Dr. M.R. Patil**, Associate Professor, Department of Statistics, MPKV, Rahuri for their constructive criticism, valuable guidance and critical evaluation of this manuscript.*

*With deepest sense of gratitude, I wish to express my heartiest and profound thanks towards **Dr. R.B. Hile**, Associate Professor and **Dr. G.G. Joshi**, Associate Professor, Department of Agricultural Economics, MPKV, Rahuri, who guided me, and their helpful comments, suggestions and co-operation helped me in completion of the present study.*

*I am under deep obligation for constant inspiration and constant criticism from **Dr. A.V. Gavali**, **Dr. R.R. Nirgude**, **Dr. D.J. Sanap**, **Dr. J.T. Dorge**, **Dr. B.H. Kamble**, **Dr. A.J. Amale**, **Dr. S.B. Sapkal**, and for their co-operation in timely completion of my post graduate research work.*

My research work would not have been superfine and super finished without the assistance and co-operation extended by the staff members of Agricultural Economics department. I wish to convey my heartfelt thanks to my department colleagues Prashant, Rahul, Pradip, Poonam, and all my seniors whose excellent company and co-operation helped me in carrying out my study with joy and happiness.

*There are no words to express my feelings of adoration, love, respect and obligation to my beloved parents, who moulded me to what I am. My dearest mother **Mrs. Suvarnamala Waghmare** and my beloved father **Mr. Sadashiv Waghmare**, I am so lucky to have caring and supporting brothers **Anil Waghmare and Pravin Waghmare** who stood as pillar behind me and helped me to make my future bright. Thanks, are also extended to all other family members and relatives for their encouragement and affection during my higher studies.*

I wish to convey my heartfelt thanks to my best friends Yuvraj, Rushikesh, Krishna, Sushant, Vinod, Ravi and Laxman for their moral support and encouragement.

I acknowledge the guidance and advice extruded by my seniors especially, Mr. Sachin Waghmare and Mr. Datta Bhosle who directly or indirectly gave encouragement and humorous company all the way.

I would be failing my duties if I do not record deep sense of appreciation for the whole-hearted co-operation and assistance provided for completing this work by Farmers of Naigaon and Kandhar tahsils of Nanded district. Last but not least my warm acknowledgment to farmers, soldiers, scientists and great social workers, who have devoted their life for the country.

Finally, I would like to thank one and all, who helped me directly or indirectly during this investigation.

Place : M.P.K.V., Rahuri

Date : / / 2021

(Waghmare P.S.)

CONTENTS

Chapter No.	Title	Page No.
	CANDIDATE'S DECLARATION	III
	CERTIFICATE OF RESEARCH GUIDE	IV
	CERTIFICATE OF HEAD OF DEPARTMENT	V
	CERTIFICATE OF ASSOCIATE DEAN	VI
	ACKNOWLEDGEMENT	VII
	CONTENTS	IX
	LIST OF TABLES	XII
	LIST OF FIGURES AND PLATES	XIII
	ABBREVIATIONS	XIV
	ABSTRACT	XV
1	INTRODUCTION	1
	1.1 General Information	3
	1.2 Objectives	3
	1.3 Hypothesis	4
	1.4 Scope and Utility of Study Area	4
	1.5 Limitation	4
2	REVIEW OF LITERATURE	5
	2.1 Identification of Cropping Sequence	5
	2.2 Resource Use Structure	6
	2.3 Cost of Production, Gross and Net Return	7
	2.4 Employment Potentiality	9
	2.5 Constraints in Adopting Cropping Sequence	10
3	METHODOLOGY AND SOCIO-ECONOMIC FEATURES OF STUDY AREA	11
A.	METHODOLOGY	11
	3.1 Data Requirement	11
	a) Structure of sample farm	11
	b) Physical quantities of input and output	11
	c) Production cost and value of output	11

	3.2	Source of Data	12
	3.3	Sampling Design	12
	3.3.1	Selection of tehsils	12
	3.3.2	Selection of villages	12
	3.3.3	Selection of sample farmers	12
	3.4	Collection of Data	13
	3.4.1	Primary data	13
	3.5	Method of Data Analysis	13
	3.5.1	Estimation of input requirement	13
	3.5.2	Estimation of costs and returns	13
	3.5.3	Output-input relationships	13
	3.6	Concepts and Their Meanings	13
	3.6.1	Cost concepts used	13
	3.7	Functional Analysis	16
	3.7.1	Estimation of Cobb-Douglas production function	16
	3.7.2	Estimation of marginal value product	17
	3.8	Economic Analysis	17
	3.8.1	Employment function	18
	3.8.2	Income function	18
	3.8.3	Expenditure function	18
	3.9	Problems in Adoption of Major Cropping Sequences	19
B.	BACKGROUND INFORMATION OF STUDY AREA		19
	3.10	Physical Features of the Nanded District	20
	3.10.1	Geography and location	20
	3.10.2	Topography and soil	20
	3.10.3	Climate and rainfall	20
	3.10.4	Land utilisation pattern	20
	3.10.5	Cropping pattern	21
4	RESULT AND DISCUSSION		23
	4.1	General Information of Sample Household	23
	4.1.1	Size of the family and its composition	23
	4.1.2	Educational status	24

	4.1.3	Capital assets	24
	4.1.4	Land use pattern of sample farmers	27
	4.1.5	Cropping pattern of sample farmers	28
	4.2	Identification Different Cropping Sequences	30
	4.3	Resource Use Structure of Major Cropping Sequence	31
	4.3.1	Human labour	31
	4.3.2	Bullock labour	32
	4.3.3	Machine labour	32
	4.3.4	Seed	33
	4.3.5	Manures and fertilizers	33
	4.3.6	Irrigation and plant protection charges	33
	4.4	Cost and Return of from Major Cropping Sequence	36
	4.4.1	Functional analysis	37
	4.4.2	Resource use efficiency	38
	4.5	Employment, Income and Expenditure Pattern	40
	4.5.1	Employment pattern	40
	4.5.2	Average annual employment of farm families	40
	4.5.3	Employment function	41
	4.5.4	Average annual income of farm families	42
	4.5.5	Income function	43
	4.5.6	Average annual expenditure of farm families	45
	4.5.7	Expenditure function	46
	4.6	Problems in Adoption of Major Cropping Sequences	47
	4.6.1	Ranking of problems	48
5	SUMMARY AND CONCLUSIONS		50
	5.1	Summary	51
	5.2	Conclusions	54
	5.3	Policy Implications	55
6	LITERATURE CITED		56
7	APPENDICES		60
8	VITAE		73

LIST OF TABLES

Sr. No.	Title	Page No.
3.1	Distribution of selected farmers	12
3.2	Land utilization pattern of the Nanded district and selected tehsils (2019-20)	21
3.3	Cropping pattern of Nanded district and selected tehsils (2019-20)	21
4.1	Average size of family and its composition of sample household	24
4.2	Educational status of the sample farmer	24
4.3	Capital assets of the sample farmers	25
4.4	Livestock of selected sample farmers	26
4.5	Land use pattern of sample farmers	27
4.6	Cropping pattern of sample farmers	29
4.7	Existing cropping sequences observed on the farm of sample farmers	31
4.8	Resource use level of major cropping sequence	32
4.9	Cost of cultivation of major cropping sequences	34
4.10	Cost and return of major cropping sequences	36
4.11	Results of Cobb-Douglas production function	37
4.12	Resource use efficiency of major cropping sequences	39
4.13	Average annual employment of farm families	40
4.14	Regression analysis of employment function	42
4.15	Average annual income of farm families	43
4.16	Regression analysis of income function	44
4.17	Average annual expenditure of farm families	45
4.18	Regression analysis of expenditure function	46
4.19	Problems in adoption of cropping sequences	47
4.20	Per cent position and garret value for problems in adoption of major cropping sequences	48
4.21	Garret score and rank for problems in adoption of major cropping sequences	49

LIST OF FIGURES

Fig. No.	Description	Between Pages
1	Map of Nanded district	20-21
2	Family size and its composition	24-25
3	Educational status of sample families	24-25
4	Cost and return of major cropping sequences	36-37
5	B:C ratio of major cropping sequences	36-37
6	Average annual employment of farm families	40-41
7	Average annual income of farm families	44-45
8	Average annual expenditure of farm families	46-47

LIST OF PLATES

Plate. No.	Description	Between Pages
1	Data collection	12-13
2	Cropping sequence I (Soybean-chickpea-S.groundnut)	32-33
3	Cropping sequence II (cotton-onion-S.groundnut)	32-33
4	Cropping sequence III (Soybean-R.sorghum)	32-33

ABBREVIATIONS

/	- Per
Agril.	- Agriculture
e.g.	- Exempli gratia (For example)
Econ.	- Economics
<i>et al.</i>	- et alia (others)
etc.	- Etcetera
Fig.	- Figure
ha.	- Hectare
Lit.	- Literature
No.	- Number
i.e.	- That is
J.	- Journal
kg.	- Kilogram
Q	- Quintal
Qty.	- Quantity
Res.	- Research
₹	- Rupees
Univ.	- University
<i>Viz.</i>	- Videlicet (namely)
Vol.	- Volume
@	- At the rate
N	- Nitrogen
P	- Phosphorus
K	- Potash
%	- Per cent
hrs.	- Hours
FYM	- Farm yard manure

ABSTRACT

ECONOMICS OF IRRIGATED CROPPING SEQUENCES IN NANDED DISTRICT OF MAHARASHTRA

by

Mr. Waghmare Pradnyasheel Sadashiv

A candidate for the Degree

of

MASTER OF SCIENCE (AGRICULTURE)

In

AGRICULTURAL ECONOMICS

Mahatma Phule Krishi Vidyapeeth,

Rahuri - 413 722

2021

Research Guide : **Dr. M. S. Jadhav**

Department : **Agricultural Economics**

The study “Economics of irrigated cropping sequences in Nanded district of Maharashtra” was conducted in six villages of Naigaon and Kandhar tehsils of Nanded district. The objectives of the study were to identify the different cropping sequences, to estimate resource use structure of major cropping sequences. Besides to estimate the employment, income and expenditure pattern of sample farmers adopting major cropping sequences were studied. The constraints in adoption of major cropping sequences in Nanded district were also examined.

The study was based on primary data of 90 cultivators for the year 2020-21 spread over the six randomly selected villages of two tehsils. From each selected village, 15 cultivators, five from each size group *viz.*, small, medium and large were randomly selected. Thus, total sample consisted of 30 each of small, medium and large size groups. Out of existing 17 cropping sequences three major cropping sequences *viz.*, Soybean-chickpea-summer groundnut cropping sequence (CS I) is the dominant cropping sequence which is adopted by 37 farmers (41.11 per cent) followed by Cotton-summer groundnut (CS II) which is adopted by 29 farmers (32.22%) and Soybean-*Rabi* sorghum (CS III) is adopted by 25 farmers (27.78%), were selected for the present study. The average per hectare utilization of resources *viz.*, total human labour, N and K were more used in cropping sequence II than other two cropping sequences. Per hectare labour utilization indicated that the utilization of human labour was maximum in cropping sequence II. Per hectare utilization of bullock power, machine power and manure were high in cropping sequence I.

The average per hectare cost of cultivation was highest in cropping sequence I (₹206733.31) followed by cropping sequence II (₹164822.05) and cropping sequence III (₹111982.54). Cost A for cropping sequences I, II and III was ₹118424.39, ₹90887.01 and ₹63259.45, whereas cost B was ₹186448.19, ₹148094.38 and ₹101676.24 respectively. The total hired human labour cost was the highest in cropping sequence II

(₹37872.32) followed by I (₹31333.50) and III (₹18945.44). Total cost on seed, fertilizers, manure, plant protection and irrigation was more for cropping sequence I followed by cropping sequence II and III. Per quintal cost was the highest in cropping sequence II i.e. ₹5233.56 followed by cropping sequence I (₹4548.26) and III (₹3344.15). B:C ratio at cost C was more in case of cropping sequence II i.e. 1.59, followed by cropping sequence I (1.40) and cropping sequence III (1.34).

Results of Cobb-Douglas production function showed that, human labour (X_1) was significant for cropping sequence I, machine power and K were significant for cropping sequence II and machine power and manure were significant for cropping sequence III. Total employment in cropping sequence I, II and III was 392.15 days, 383.64 days and 340.04 days respectively. Of the total employment generated in cropping sequence III, 58.34 per cent was generated from crop production and 21.95 per cent was generated from livestock activities. In all the three cropping sequences, the share of crop production in total employment was highest. Five independent variables *viz.* number of earners (X_1), number of animals (X_2), area under vegetables (X_3), area under cash crops (X_4) and GIA (X_5) were selected in regression analysis of employment function. Results of estimated employment function shows that, selected five independent variables included in employment function have jointly explained 90, 76 and 84 per cent variation for cropping sequence I, II and III.

Total income generated was ₹394650.95, ₹378080.77 and ₹297337.16 in cropping sequence I, II and III respectively. In all the three cropping sequences, the share of crop production was highest followed by livestock activities. Total five independent variables have jointly explained 82 per cent, 93 per cent and 87 per cent variation in the regression analysis of income function of cropping sequence I, II and III, respectively.

Total average expenditure in cropping sequence I was ₹271361.38 followed by cropping sequence II ₹238424.74 and cropping sequence III ₹202018.18. The share of crop production in total expenditure in cropping sequence I, II and III was 48.84 per cent, 44.30 per cent and 38.89 per cent, respectively. The regression analysis of expenditure function shows that, selected five independent variables have jointly explained 84 per cent, 93 per cent and 89 per cent variation in the expenditure in cropping sequence I, II and III, respectively.

Unavailability of labour in peak period, high cost of fertilizers, high wages of labour, high cost of seed, lack of availability of quality seed, insufficient institutional credit, etc. were the major problems faced by farmers in adopting major cropping sequences.

1. INTRODUCTION

In the Indian economy, the agricultural sector holds a prominent position. Agriculture still provides a living for 54.6 per cent of India's population. Furthermore, the agriculture sector contributes 16.10 per cent of GDP and generates significant export revenues (\$38.5 billion, i.e. 12.6 per cent of total export earnings in 2018-19) (source <https://www.indiastat.com>) Contribution of agriculture to national GDP has decreased through time, but the fraction of the people depending on agriculture has not decreased accordingly. On the other hand, the number of people who rely on agriculture is growing in absolute terms. As a result, the average size of a holding has been steadily decreasing, resulting in increasing land fragmentation and unemployment. As land is the most limiting issue, reliance on it has reached a breaking point. As the scope to cultivate new land is limited, major increase in agricultural production can only be achieved through reducing cost or increasing productivity of factors of production like land, labour and capital.

However, many developing countries, such as India, have been unable to advance their agricultural sector due to a variety of physical, natural, economic, social, political, and human problems. It is becoming increasingly apparent that land is limited, and its intensive usage is essential. This is especially true in nations like India, where population pressure is increasing all the time. Rainfed agriculture accounts for 70 per cent of Indian agriculture. In other words, only about a third part of the entire cultivable area is irrigated. The state of Maharashtra, on the other hand, barely has a 13 percent irrigated area. With the expansion of irrigated land and the availability of shorter-duration cultivars of many crops, the potential for boosting cropping intensity through cropping sequence is growing. Farmers want to grow those crops which can be cultivated with little risk and yields a high profit. Farmers, on the other hand, want their family members to have full-time jobs on their farms throughout the year.

Previous research and experience have shown that mono or solo cropping, such as sugarcane, may not provide appropriate employment for family members while yielding good profits for the farmer. Other crop sequences, on the other hand, may not yield large profits for farmers but may provide adequate work for family members. Increased productivity per unit area is one technique to boost agriculture production on the tiny or marginal unit of farming. This can be accomplished by developing more efficient crop varieties and improving management practices such as fertilizer application, weed and pest control, irrigation application, and so on.

Cropping sequence is described as the planting of two or more crops in the same year on the same piece of land (Reddy and Reddy, 2000). Double, triple, and quadruple cropping involve two, three, and four crops, respectively, depending on the number of crops planted in a year. In addition to these technologies, ratoon cropping and relay cropping are also popular. Ratoon cropping or ratooning is the process of raising a crop with regrowth coming out of the root or stalks after the crop has been harvested. Cropping sequence has a long history. Agricultural scientists used to try to become familiar with old techniques. New cropping sequence concepts have gradually emerged, and there has now been considerable accumulation of important scientific information based on growth analytical work on various crop sequential growth of crops.

From the perspective of both the individual farmer and the nation as a whole, the cropping sequence is critical. In case of a single farmer, it is a matter of determining the sequence of crops to be grown on a limited area over the course of a year with the available labour, money and management resources. From a national perspective, the issue is the 'plan priorities' of changing cropping patterns. As a result, the cropping sequence addresses fundamental challenges at both the micro and macro levels. At the micro level, maximization of farm profit with available resources, and at the macro level, the most efficient utilization of the nation's productive resources from the important objectives of appropriate cropping sequences in intensive agriculture. The importance of cropping sequences in the farm economy cannot be overstated. An attempt to achieve optimal resource use toward the most productive cropping sequence would become a guideline for prescribing the direction in which resource and cropping sequence shifts should occur in a given location. Such a move in area to a highly profitable cropping sequence and the most efficient use of resources would not only boost farmers economic positions, but would also have a significant impact on the state's economy.

The farmer's challenge is thus choosing of crops to be cultivated in various seasons that will fit into the sequence to form an optimal cropping sequence in the farm business. Many farmers now have more options for crop rotations, such as monoculture, double cropping, triple cropping, or even four crops per year, thanks to technological advancements in several areas. Subsistence farming is gradually being phased out. From traditional farming, in which a farmer grows only the crops he needs for his personal consumption, to commercialized farming, in which only the crops with the best comparative advantages are framed. Farmers are attempting to adopt profitable cropping

sequences in this technological environment. Farmers will employ a profitable cropping sequence if new technology is available.

There are a number of factors that contribute to this, including resource structure, managerial capacity, risk-bearing ability, infrastructure such as credit facilities, irrigation, marketing facilities, and remunerative prices. Efforts are therefore needed to examine cost-effective cropping sequences in the context of existing resource structures and increasing resource availability.

The role of the production economist, in this approach, is to supply new knowledge to cultivars on a conditional basis in order to improve resource use efficiency and maximize profit. As a result of this circumstance, it was decided to conduct a research on economics of irrigated cropping sequence systems in Nanded area in order to meet the objectives.

1.1 The Problem

From the perspective of individual farmer, the subject of comparative economics of cropping sequence is crucial. It will indicate the best mix of various resources such as labour, fertilizer, working capital, and so on in the production of the produce on his farm. The cropping sequences of the sample farmers are compared in this study.

The goal of determining the most profitable cropping sequence and optimum resource use would become a guideline for prescribing the direction in which the shift of resources and cropping sequence should occur in the selected area. Such a shift of area to the highly profitable cropping sequence and the optimum level of resource use would not only strengthen the farmers' economic position, but it would also improve the environment. This research aims to investigate the adoption of various cropping sequences in the context of the existing resource structure, with the goal of generating high farm revenue and employment for the farmer. In view, the objectives have been framed for the study as below:

1.2 Objectives

1. To identify the different cropping sequences.
2. To study the resource use structure of major cropping sequences.
3. To study the employment, income and expenditure pattern of sample farmers adopting major cropping sequences.
4. To study the constraints in adoption of major cropping sequences.

1.3 Hypothesis

The hypotheses of the study are as under.

1. Null H_0 # Profit does not vary with cropping sequence.
Alt. H_1 # Profit vary with cropping sequence.
2. Null H_0 # Resource use, employment and income does not vary with cropping sequences.
Alt. H_1 # Resource use, employment and income vary with cropping sequences.

1.4 Scope and Utility of the Study Area

The current research is focused on a specific location, namely, Nanded district of Maharashtra. Farmers may be able to follow a vast variety of cropping sequences. The current study examines important cropping sequences, with an economic analysis that will serve as a guideline for individuals who use or willing to use these cropping sequences. Besides, the finding of study may be relevant in other areas where a comparable agro-ecological condition exists.

The primary goal of this research is to determine the most appropriate and economic cropping sequence, which will aid in raising productivity, improving farmer conditions, and, ultimately, improving people's economic position. The findings will be extremely useful in formulating production-oriented policies.

1.5 Limitation of the Study

The data for this study was mostly gathered through interviews using schedules. As a result, the obtained data is based on recall memory bias because the farmers did not keep any records about cultivation expenses, input application, or returns, particularly for subsidiary firms. Cross-checks at the time of data collection, however, were made to reduce them. Because the data was gathered from farmers in the Nanded district of Maharashtra who used different cropping sequences, generalization of the findings to other places should be done with caution. The proposed model analyzed optimal solutions from an economist's perspective, using current input and product prices, rather than taking into account ecology and the environment.

2. REVIEW OF LITERATURE

This chapter aims to represent some review of the past research works that are related to the present study. Number of researchers had done study regarding the cropping sequences. While carrying out systematic research, it is necessary to have knowledge of the previous research works carried out by other researchers. It gives an insight in respect of manner in which the problems have been tackled, the nature of results obtained and the conclusions derived. The review of past literature, therefore, forms an integral part of any systematic research work. Therefore, the literature closely related to the present study was reviewed in this chapter. The literature is grouped into following categories.

- 2.1 Identification of different cropping sequences
- 2.2 Resource use structure
- 2.3 Cost of production, gross and net return
- 2.4 Employment potentiality
- 2.5 Constraints in adoption of cropping sequences

2.1 Identification of Cropping Sequence

Yaduvanshi *et al.* (2014) studied bio-chemical amelioration effects on physico-chemical dynamics of sodic soils under rice-wheat cropping system. The results revealed that, inclusion of *Sesbania aculeata* as green manure either before or after rice-wheat cropping sequence is equally better to improve the soil physical dynamics and crop productivity of B class sodic soils in Indo-Gangetic region of UP.

Srivastava *et al.* (2015) studied the field experiment which was conducted during three consecutive years of 2011 to 2013 at Central Potato Research Station, Shilong to evaluate the economic feasibility of potato based cropping system under rainfed condition of eastern Himalayan region. There were seven cropping systems replicated thrice under randomized block design. Among the cropping systems, potato-cabbage recorded significantly the highest potato tuber equivalent yield, production efficiency, economic efficiency, maximum net monetary return, benefit cost ratio and energy productivity. Hence, it concluded that, potato-cabbage cropping sequence was stable and most profitable cropping sequence in that region.

Talathi and Mahadkar (2015) observed that, groundnut-rice is a very popular cropping sequence adopted by the farmers in Konkan region of Maharashtra due to favorable climatic conditions. The study was conducted to evaluate the effect of different organic manures in groundnut-rice cropping system.

Tiwari *et al.* (2017) studied rice based cropping system in Central Plain of India. The study revealed that, rice-potato-Japanese mint and rice-potato-onion cropping sequences were economically viable and more productive.

Kaur *et al.* (2018) studied that, in field experiment conducted at Regional Station, Bathinda during 2010-13 to evaluate various crop sequences under variable irrigation regimes, among various sequences barley-cotton crop sequence gave significant highest cotton equivalent yield which was at par with mustard-cluster bean and mustard-cotton crop sequence.

Dixit *et al.* (2019) studied that monocropping cultivation of jatropha crop was not proven economical viable. Study revealed that, cultivation of jatropha at 3m apart and inter-cultivation of sweet basil-matricaria cropping sequence was highly economical.

Kumar *et al.* (2020) studied that, cultivation of summer moongbean as a sequence crop with rice-wheat and rice-maize system under assured irrigation increases cropping intensity and system productivity.

From the above reviews it can be concluded that, farmers can adopt different cropping sequences which will fit into the cropping pattern of the region. There are different cropping sequences for different regions over different time period.

2.2 Resource Use Structure

Hiremath *et al.* (2011) studied energy use efficiency of various cropping sequences in Northern Transition Zone of Karnataka. Results revealed that, the land use efficiency was recorded highest in groundnut-sunflower and groundnut-sorghum cropping sequences. However, potato-chickpea recorded moderate land use efficiency.

Bhaskar *et al.* (2013) studied economic appraisal of rice based cropping sequence. The study revealed that, rice-potato system was sustainable, productive and more resource use efficient followed by rice-mustard and rice-pea cropping sequence.

Gullani *et al.* (2013) observed positive effect of organic farming on productivity, B:C ratio of soybean and sedimentation value of wheat flour in soybean-wheat cropping sequence.

Mishra *et al.* (2013) evaluated different rice based cropping sequences in Eastern Plateau and Hill zone of India. The study reveals that, rice-groundnut-greengram sequence was found to be the most efficient of user N while rice-groundnut-fallow used P and K more efficiently than the other cropping sequences.

Yadav *et al.* (2013) observed that the highest effect of inorganic nutrient, organic manure and bio-fertilizer on rice-potato-onion cropping sequence.

Kumara *et al.* (2014) studied effect of long term manures and fertilizers application on carbon sequestration. The results suggest that, under pearl millet-wheat cropping sequence, recommended dose of fertilizer and FYM maintain the soil quality parameter which ultimately helps in increasing carbon sequestration rate.

Mali *et al.* (2015) studied long term effect of fertilization and manuring on productivity and quality of soil under sorghum-wheat cropping sequence. The results revealed that, application of 50per cent N + 50per cent RDF through FYM recorded highest sorghum and wheat grain yield.

Avasthe *et al.* (2016) studied field experiment which was conducted at Research Farm, ICAR Sikkim Centre, Tadong with five maize based cropping sequences to identify the resource efficient cropping systems under resource scare, rainfed conditions of Sikkim Himalaya. Among the intensified cropping sequences, maize-urdbean-buckwheat system was most resource efficient cropping sequence compared to other cropping systems.

Ghorai *et al.* (2016) studied the productivity and resource use efficiency of jute based cropping systems. Results revealed that, land use efficiency was highest in jute-rice-mustard-mungbean (94.5%) cropping sequence followed by jute-rice-baby corn-veg. jute (93.2%)

Hussain *et al.* (2019) studied field experiments which were carried out at Mountain Livestock Research Institute (MLRI), Manasbal, Sher-e-Kashmir University of Agricultural sciences and Technology Kashmir, India to study the direct and residual effect of different rates of organic and chemical sources of nutrients on fodder sorghum-fodder oat cropping sequence during *kharif* 2008, 2009 and *rabi* 2008-09, 2009-10. Application of FYM @ 25 tonnes recorded higher green fodder yield of sorghum than rest of treatments.

To conclude, the above reviews indicated that, the resources such as land, manure, fertilizers and bio-fertilizers, plant protection, etc. were the major determinants in adoption of major cropping sequences but it was varied across the region, locality and time period.

2.3 Cost of Production, Gross and Net Return

Hiremath *et al.* (2011) studied energy use efficiency of various cropping sequences in Northern Transition Zone of Karnataka. The results revealed that, among different cropping sequences, potato-sunflower and potato-chickpea recorded significantly higher groundnut equivalent yield, production efficiency and net return.

Bhaskar *et al.* (2013) studied economic appraisal of rice based cropping sequence in major soil series of upper Assam. There were four different rice based cropping sequences. Results showed that, among different cropping sequences, highest return was obtained from rice-potato cropping sequence (₹103097/ha) in *Aeric Fluvacuents* followed by rice-pea cropping sequence (₹95108/ha).

Mishra *et al.* (2013) evaluated different rice based cropping sequences in Eastern Plateau and Hill zone of India. Study shows that, among different cropping sequences evaluated, rice-frenchbean-greengram produced highest equivalent yield (17.31 tonnes/ha/year), net return (₹39899/ha) and B:C ratio (2.25). However rice-radish-greengram cropping sequence recorded highest production efficiency (61.54 kg/ha/day).

Singh *et al.* (2014) studied profitability of high value crops with organic N source under rice based cropping sequence. There were seven different rice based cropping sequences. The study revealed that, among all the seven cropping sequences, rice-potato-onion gave highest rice grain yield (35.57t/ha), profitability (₹738/ha/day) and net return (₹268656/ha).

Saren *et al.* (2015) studied SRI in rice-groundnut cropping sequence under island ecosystem. Study concluded that, early planting of rice in second fortnight of June with the spacing of 20cm x 20cm recorded higher rice grain yield (4678kg/ha), productivity (26.8kg/ha/day) and profitability (₹62882/ha) compared with wider spacing.

Srivastava *et al.* (2015) studied profitability of potato based cropping system in Eastern Himalayan Region. There were seven cropping systems replicated thrice under randomized block design. Among the cropping systems, potato-cabbage recorded significantly the highest potato tuber equivalent yield (51.6t/ha), production efficiency, economic efficiency, net return, B:C ratio (3.5) and energy productivity.

Avasthe *et al.* (2016) studied three year fixed plot field experiment which was conducted at Research Farm, ICAR Sikkim Centre, Tadong with five maize based cropping sequences to identify the resource efficient cropping systems under resource scare, rainfed conditions of Sikkim Himalaya. Among the intensified cropping sequences, maize-urdbean-buckwheat system recorded significantly higher values of system productivity, relative system production efficiency, net return, B:C ratio compared to other cropping systems.

Tripathi *et al.* (2017) studied improving sustainability of rice-wheat system through intensification. The results revealed that, rice-wheat-greengram cropping sequence recorded maximum equivalent wheat yield (15.21t/ha), total return (₹182551/ha) and B:C ratio (1.37).

Kumar *et al.* (2019) studied crop diversification in Eastern Himalayas. A field study was carried at farmers field by KVK, Longleng, Nagaland during 2013-15 to assess the most productive and profitable rice based cropping system. Results revealed that rice yield ranges from 1.75-1.86/ha under different cropping sequences. Significantly higher system rice equivalent yield (SREY) was recorded with rice-cabbage (30.6t/ha) compared to other sequences.

To summarize, the above reviews indicated that, by adopting various cropping sequences fitted to particular region, farmers got relatively per hectare higher grain yield, profitability, production efficiency, net return and benefit-cost ratio.

2.4 Employment Potentiality

Sharma and Kumar (2009) suggested that among the different crop sequences, the most cost effective cropping sequence was rice-gobisarson-greengram, which had generated maximum employment.

Sah *et al.* (2010) observed that paddy-chilli and paddy-sunflower cropping sequences were suggested for saline soils whereas, for non-saline soils, paddy-potato and paddy-greenpea sequences were suggested. Sunflower incorporation in the existing paddy based cropping sequences increased the land utilization up to a maximum of 26.32 per cent in case of marginal farmers and 36.44 per cent in case of small farmers. They suggested land use may generate an enhanced employment option from 142 to 205 and 176 to 197 man-days $ha^{-1}year^{-1}$ for the marginal and small farmers, respectively, and increase their per capita income irrespective of their class.

Chitale *et al.* (2011) found that the rice-potato-cowpea cropping sequence was most employment generating cropping sequence with better economic return. In this sequence, maximum number of persons employed which was 554 man-days in a year and therefore it's efficiency in terms of employment generation was highest i.e. 152.30 per cent compared with other sequences.

Singh *et al.* (2012) concluded that the employment generation efficiency much higher in cropping system involving menthol mint and vegetable crops, the maximum employment was generated in maize-cauliflower-onion-menthol mint+okra cropping system.

Yadav *et al.* (2014) studied rice based cropping sequences. The results revealed that, employment generation from rice-potato-onion (469 man days/ha/year) was more than from other cropping sequences.

Avasthe *et al.* (2016) concluded that, employment generation (285 man-days/ha) was more from maize-urdbean-buckwheat cropping sequence than other cropping sequences.

To summarize, the above reviews indicated that, by growing more than two crops in a year, farmers can get more employment (man days) than by adopting monocropping.

2.5 Constraints in Adoption of Cropping Sequences

Grover *et al.* (2001) studied constraints analysis of mungbean production in cereal based cropping system in Punjab. The results revealed that, two third mungbean growers suffered from Mungbean yellow mosaic virus (MYMV). Yield loss due to insect/pest infestation was another major problem in mungbean cultivation.

Ramasamy (2004) studied constraints to growth in Indian agriculture. He reported major constraints *viz.*, technical constraints, resource constraints and capital constraints. In technical constraints modern varieties, the high yielding varieties were not spread equal area over India and unbalanced use of agrochemicals, also high mechanization and rained bias. In resource constrains land use for agriculture is decreases, increase in demand of water, etc.

Jat (2010) reported that, labour management was the most important constraint which was ranked first amongst all. It was due to migration of labour from study area (Indore, MP) to industrial area. He reported institutional infrastructure as the second constraint which consist of problems in credit creation, problems in marketing etc.

Choudhari (2012) reported the production portfolio of sample farmers, a mix of pulses, cereals, vegetables, oilseeds, cash crops etc. Results concluded that, the most important constraints were observed to be economic cause followed by natural cause, social cause, technological cause, etc.

Singh *et al.* (2012) studied the eight villages of two blocks of Burhanpur district of Madhya Pradesh during the year 2009-10. The study reveals that lack of education and lack of knowledge were the major constraints. Problem of non-availability of credit at proper time was also another constraint.

To summarize, the above reviews indicated that, there were number of constraints such as insect/pest infestation, technical problems, infrastructural problems, non-availability of credit at proper time, natural problems, etc. These were the major hindrance in adoption of different cropping sequences.

3. METHODOLOGY AND SOCIO-ECONOMIC FEATURES OF STUDY AREA

A. Methodology

The goal of any scientific research is to reach helpful conclusions based on the objectives. It is critical for the investigator to use acceptable methodologies and procedures in order to get the conclusions. With this in mind, the purpose of this chapter is to discuss the techniques used to achieve the study's objectives. It covers the sample selection procedure, data collection method, type of data gathered, data sources, and analytical procedures utilized to provide results that meet the objectives of the study.

3.1 Data Requirement

The examination of resource use structure, costs and returns structure, resource productivities, and resource use efficiency of various cropping sequences for crop production activity in the region is part of the project. On the following points, thorough information was necessary.

- a. Sample farm structure
- b. Quantities of various inputs used and farm output
- c. Production cost and output value

a. Structure of sample farms

Farm level data on land use pattern, cropping pattern, investment in different capital assets, and composition of sample households were necessary in order to understand the structural organization and background information of the sample farms.

b. Physical quantities of input and output

Physical inputs such as human labour (both hired and family), bullock labour (owned and hired), seed, manure, chemical fertilizers, plant protection measures, as well as physical output composed of main and by-products of crops.

c. Production costs and value of output

The data on different aspects such as wages of hired human and bullock labour, irrigation costs, seed, manures, chemical fertilizers, pesticides, fungicides, repairs of equipment or machinery, and livestock care by the chosen sample households. In addition, prices of animal products and agricultural harvest prices were required for calculating the value of crop output.

3.2 Sources of Data

Both forms of data, primary and secondary, were required for the completion of this study. Data at the macro level were gathered from government records in agriculture, animal husbandry, cooperatives and so on. For the year 2020-21, the micro level statistics were collected through personal interviews with 90 randomly selected sample families.

3.3 Sampling Design

The current study used a three-stage stratified random sample strategy, with tahsils as the primary sampling unit, villages as the secondary sampling unit and farm households as the final sampling unit.

3.3.1 Tahsil selection

The tahsil was the primary sampling unit. Two tehsils, Naigaon and Kandhar, from Nanded district were purposefully selected for this study based on the highest irrigated area.

3.3.2 Selection of villages

The village, the secondary unit of sample, was selected randomly from each tahsil by listing them in ascending order of cropped area, with Ikalimore, Kothala and Salegaon from Naigaon Tahsil and Kautha, Telur and Shirur from Kandhar Tahsil of Nanded district.

3.3.3 Selection of sample farmers

The farmer was the tertiary and final unit of sample. The list of farmers with cropped land was obtained from village revenue records and divided into three size groups based on operational holdings, with holding sizes of less than 1.00 ha, 1.01 ha to 2.00 ha and more than 2.01 ha designated as small, medium, and large size groups, respectively. Then, randomly thirty cultivators were chosen from each size group. As a result, the overall sample size was 90 farms.

Table 3.1. Distribution of selected farmers

Sr. No.	Tahsils	Villages	Size groups			Overall
			Small	Medium	Large	
1	Naigaon	Ikalimore	5	5	5	15
		Kothala	5	5	5	15
		Salegaon	5	5	5	15
2	Kandhar	Kautha	5	5	5	15
		Telur	5	5	5	15
		Shirur	5	5	5	15
Total			30	30	30	90

3.4 Data Collection

3.4.1 Primary data

For the year 2020-21, data was gathered by a survey method. The specific information was gathered mostly through personal interviews with sample farms. The information was gathered using a specially developed schedule that included information on the cost of cultivation and employment, as well as the revenue and spending of farmers. Appendix-I contains the details of the data collection schedule.

3.5 Method of Data Analysis

The information gathered from sample families was organized as per sample categories. The data was then analyzed further to determine sample means for various aspects of crop production activities. For this study, two tools were used: a simple tabular method and production function analysis. Multiple regression analysis was used to investigate the relative contribution of specific variables on total family income, labour employment and expenditure.

3.5.1 Estimation of input requirement

A tabular approach of analysis with basic averages was used to estimate the input requirements for crop production operations. On a per-hectare basis, the input needs for each crop were determined independently. Human labour (hired + family), bullock labour, seeds, manures and fertilizers, plant protection chemicals, irrigation and other inputs were needed for the crop enterprise. For each of the sample categories, the input requirements were estimated.

3.5.2 Estimation of costs and returns

The data collected was analyzed to determine the cost of production and returns for each crop separately. To determine the amount of profitability, a cross sectional (i.e. size group wise) comparison of crop cost and returns, as well as the cropping sequence as a whole, was done independently.

3.5.3 Relationship between input and output

The ratio of gross income to total cost is known as the benefit-cost ratio. This ratio is derived by dividing gross income by total production costs for each crop and for the entire cropping sequence.

3.6 Concepts and Their Meaning

3.6.1 Cost concepts

The primary data collected at the farm level was processed, assembled, for various crops using standard cost concepts

Cost 'A'

It is also called as paid out cost, this cost approximates the expenditure incurred by the farmer in cash and kind in the cultivation of crop and includes the following items.

1. Hired human labour
2. Seed
3. Manure
4. Fertilizers
5. Plant protection measures
6. Machinery charges
7. Owned and hired bullock labour
8. Land revenue and other cesses
9. Interest on working capital
10. Depreciation on implements and machinery
11. Repairs of machinery and Irrigation charges

Cost 'B'

Cost 'B' = Cost 'A'+ Rental value of owned land +Interest on fixed capital

Cost 'C'

Cost 'C'= Cost 'B' + imputed value of family labour.

Thus, the cost 'C' represents the total cost of cultivation.

Cost concepts such as Cost 'A,' Cost 'B,' and Cost 'C' have been used to calculate per hectare costs and returns for crops of various sizes.

1. Human labour

Both hired and family labour were included. The majority of the labour force employed in agricultural cultivation is drawn from the growers' own family. However, the cultivators must occasionally hire hired labour for specific activities. It includes the labour necessary to complete various operations. Ploughing, harrowing, weeding, planting, earthing up, manuring, fertilizer application, plant protection, irrigation, harvesting, winnowing and other related activities (includes actual labour required for organization of inputs, watching, etc.).The cost of human labour is made up of

- a. Actual wages paid to hired labour, as well as those paid to labour hired on a contract for the entire year or a portion of it for various operations.
- b. The estimated value of family members' labour for various operations.
- c. Wages paid to agricultural servants related to various enterprises.

The earnings of male and female family members were computed using the wage rate in force at the time of casual labour for various operations. However, the following formula was employed to convert female labour into man-days.

$$\text{Man days} = \text{Female labour days} \times 0.75$$

2. Bullock labour

In the event of hired bullock labour, the current bullock labour rates for a specific operation in the area were taken into account. Costs for owned bullock labour were calculated based on the charges given to the hired bullock pair, which included the labour required for operations such as ploughing, harrowing, manuring and input organization.

3. Machine power

The prevailing rate of hired machine labour (i.e. tractor, threshing machine) or specific operations in the village were taken into account in the case of hired machine labour. Charges for hired machine labour were accounted for using the charges paid to the hired machine as a base.

4. Seed

The cost of seed purchased was calculated based on the amount paid by the growers. The cost of owning seed was calculated using current rates in the village.

5. Manure

The rate at which manure produced on one's own farm was appraised was the same as that used in the village. The price paid by cultivators was used to account for the expense of purchased manure. A load cartload of manure was equal to four quintals, with a current price of ₹150 per quintal.

6. Fertilizers

To assess the real expenditure on nitrogen, phosphorus and potash, urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP) fertilizers were utilized and the quantity of nitrogen, phosphorous and potash was computed.

7. Pesticides and insecticides

Insecticides and pesticides were charged at the amounts that the cultivators actually paid.

8. Irrigation charges

Irrigation was mostly accomplished through wells, bore wells and canals. The cost of electricity for the electric motor that drew irrigation water was proportional to the area under irrigated crops. Then the information on number of irrigation applied for individual

crop, horse power of the electric motor, canal charges were worked out as the charges paid by the cultivators for irrigation the crop.

$$\text{Irrigation charges} = \frac{\left(\begin{array}{l} \text{Depreciation} \\ \text{on irrigation} \\ \text{structure} \end{array} + \begin{array}{l} \text{Interest on} \\ \text{on fixed} \\ \text{capital} \end{array} \right) \times \text{Plot} + \left(\begin{array}{l} \text{Irrigation} \\ \text{hours} \end{array} \times \begin{array}{l} \text{per hour machine} \\ \text{maintenance} \\ \text{cost} \end{array} \right)}{\text{Irrigated gross cropped area}}$$

9. Tax, cess and land revenue

Land revenue, additional land revenue and cess by the Zillah Parishad, taxes on account of the Employment Guarantee Scheme and educational taxes, which were actually paid by the cultivator, are all included in this cost item.

10. Repairs and depreciation on equipment and machinery

Depreciation is the loss of an asset's value due to normal wear and tear. Only proportionate charges for the crop on a hectare basis were taken, with a standard rate of 10 per cent applied to the present worth of farm tools and machinery at the start of the year.

11. Interest on fixed capital

Interest was imposed at a rate of 10 per cent on present values of fixed assets (excluding land, animals, and traditional ancient wells) such as agricultural buildings, implements, equipment, machinery, bore wells and irrigation structures.

12. Interest on working capital

Working capital interest was charged at a rate of 6 per cent per year for the entire harvest season.

13. Rental value of land

Land rental value is equal to one-sixth of gross produce value (main + by-produce) minus total land revenue paid.

3.7 Functional Analysis

3.7.1 Estimation of Cobb-Douglas Production Function

For estimation of resource use productivity, Cobb-Douglas production function was used which is as follows

$$Y = aX_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} X_6^{b_6} X_7^{b_7} e^u$$

Where,

$$Y = \text{Output of main produce (q/ha)}$$

X_1	= Human labour (man days/ha)
X_2	= Bullock labour (pair days/ha)
X_3	= Machinery (hr/ha)
X_4	= Manures (q/ha)
X_5	= N (kg/ha)
X_6	= P (kg/ha)
X_7	= K (kg/ha)
A	= Constant/ intercept
b_i	= Regression coefficient of respective resource variable
e^u	= Error term

3.7.2 Estimation of Marginal Value Product

The marginal value product (MVPs) of individual resources were estimated and compared with the marginal cost (MC). The MVP of individual resources were estimated by using following formula,

$$MVP = b_i \frac{\bar{Y}}{\bar{X}_i} P_y$$

Where,

MVP	= Marginal value product
b_i	= Production elasticity corresponding to the i^{th} input
Y	= Geometric mean of output
X	= Geometric mean of i^{th} input
P_y	= Price per unit of output

If the ratio of MVP/MC is more than one, then the particular resource has been underutilized and if the ratio of MVP/MC is less than one, then that particular resource has been over utilized.

Concept of Income in Crop Production

Gross Income: Value of main produce and by-produce at the time of harvest of crop

Farm Business Income=Gross income -Cost A

Family Labour Income=Gross income -Cost B

Net Income=Gross income -Cost C

Farm investment Income=Net Income + rental value of land+ Interest on fixed capital

3.8 Economic Analysis

Multiple linear regression analysis was used to estimate the employment, expenditure and income function in order to determine the parameters that influence these

economic indicators in the context of the sample family. For this aim, data at the household level, regardless of size groups was used.

3.8.1 Estimation of Employment Function

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + eu$$

Where,

- Y = Annual total family employment (man-days)
- a = Intercept
- X₁ = Number of Earners (Number per family.)
- X₂ = Number of Milch animal (Number per family.)
- X₃ = Area under Vegetable
- X₄ = Area under cash crops
- X₅ = GIA (Gross Irrigated Area) in hectare
- bi's = Regression coefficient
- eu = Error term

3.8.2 Estimation of Income Function

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + eu$$

Where,

- Y = Annual total family Income
- a = Intercept
- X₁ = Number of Earners (Number per family.)
- X₂ = Number of Milch animal (Number per family.)
- X₃ = Area under Vegetables
- X₄ = Area under cash crops
- X₅ = GIA (Gross Irrigated Area) in hectare
- bi's = Regression coefficient
- eu = Error term

3.8.3 Estimation of Expenditure Function

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + eu$$

Where,

- Y = Annual total family expenditure
- a = Intercept
- X₁ = Number of Earners (Number per family.)
- X₂ = Number of Milch animal (Number per family.)
- X₃ = Area under Vegetables

- X_4 = Area under cash crops
 X_5 =GIA (Gross Irrigated Area) in hectare
 b_i 's = Regression coefficient
 e_u = Error term

3.9 Problems in Adoption of Major Cropping Sequences

In the quantification of constraints expressed by the farmers, Garretts ranking method was used. The orders of merit given by the respondents were converted into rank by using the formula. To find out the most significant factor which influences the respondent, Garretts ranking technique was used. As per this method, respondents have been asked to assign the ran for all the factors and the outcomes of such ranking have been converted into score value with the help of the following formula,

$$\text{Per cent Position} = 100(R_{ij} - 0.5)/N_j$$

Where,

R_{ij} = Rank given for the i^{th} variable by j^{th} respondent

N_j = No. of variables ranked by j^{th} respondents

B. Background Information of Study Area

Agriculture is backbone of Indian economy. Approximately 60 per cent of the Indian population relied on agriculture for its livelihood. Agriculture accounts for roughly 15.96 per cent of national GDP, while it accounts for about 9.9 per cent of the country's total exports. Agricultural output is highly influenced by climatic and geographical factors such as temperature, rainfall, soil type, and so on. In addition to these elements, economic considerations such as transportation and irrigation infrastructure, as well as the availability of sufficient and timely credit at lower rates, influence the crops farmed and the farm economy. It is vital to familiarize with the background information of research area (e.g., agro-climatic conditions and infrastructure).

This chapter focuses on broad facts on the research area, such as physical features and agricultural patterns, such as land usage, cropping patterns, and so on, as farmers carry out their farm activities while taking into account the region's environmental and socioeconomic conditions. The information about the research area and sample growers aids in a better understanding of the rationale behind the findings. In view, following general information of the study area is briefly discussed in this chapter.

3.10 Physical Features of Nanded District

3.10.1 Geography and Location

Nanded is located between 18.15 and 19.55 degrees North latitude and 77.70 and 78.15 degrees East longitude. Nanded district is bordered on the north by Hingoli and Yavatmal districts, on the north-west by Parbhani district, and on the south by Latur district. Its borders are also connected to Telangana state on the east and south-east sides, and it has a border connection with Karnataka state on the south. The river basins of the Godavari, Manjara, and Manyad have covered a large portion of the district. Nanded district covers a total area of 10,528 square km and is divided into thirteen municipalities and thirteen Nagar Parishads. There are 1603 villages and 1309 Gram Panchayats.

3.10.2 Topography and Soil

Most of the area in the district has covered with deep black cotton soil. However, in some parts of the district, red soil also occurs.

3.10.3 Climate and Rainfall

As the Nanded district comes under assured rainfall zone, the average annual rainfall of the district is 956 mm. On an average, the district has moderate climate. The area has three distinct seasons: monsoon/rainy, winter and summer. The rainy season begins in mid-June and continues until the end of September and October. Winter begins in December and lasts until the middle of February. Summer, on the other hand, begins in March and lasts until the middle of June. The intensity of rainfall is not uniform throughout the district. It is particularly heavy in the Eastern region, and it is gradually diminishing in the Western region. From the middle of June until the end of September, the area receives most of its rain from the South West monsoon.

3.10.4 Land Utilization Pattern

Table 3.2 shows the land utilization pattern of Nanded district. Total geographical area of Nanded district is 1044354 ha. Whereas, total geographical area of Naigaon and Kandhar tahsils is 60206 ha and 83011 ha respectively. Net sown area of Nanded, Naigaon and Kandhar is 791684 ha, 46643 ha and 68152 ha respectively. Gross cropped area of Nanded district is 1067825 ha whereas, for Naigaon tahsil it is 70244 ha and for Kandhar tahsil it is 89204 ha.

Table 3.2 Land utilization pattern of the Nanded district and selected tahsils (2019-20) (ha)

Sr. No.	Particulars	Naigaon	Kandhar	Nanded
1.	Total geographical area	60206 (100.00)	83011 (100.00)	1044354 (100.00)
2.	Area under forest	836 (01.38)	6345 (07.64)	105250 (10.08)
3.	Area not available for cultivation	7183 (11.93)	0000 (00.00)	42824.62 (04.10)
4.	Cultivation waste	183 (00.30)	102 (00.12)	9456.41 (00.91)
5.	Total Fallow land	3443 (05.72)	1491 (01.80)	70750 (06.77)
6.	Net sown area	46643 (77.47)	68152 (82.10)	791684 (75.81)
7.	Area sown more than once	23601 (15.82)	21052 (25.36)	276141 (23.79)
8.	Gross cropped area	70244	89204	1067825
9.	Total cultivable area	50269	69471	871588

(Figure in the parentheses indicate the percentage to total geographical area)

Source: Socio -economic Review and District Statistical Abstract of Nanded district (2019-20)

3.10.5 Cropping Pattern

Table 3.3 states information about the cropping pattern of Nanded district and the selected (Naigaon and Kandhar) tahsils for the year 2019-20.

Table 3.3 Cropping pattern of Nanded district and selected tahsils (2019-20) (ha)

Sr. No.	Crop	Naigaon	Kandhar	Nanded
I.	Cereals			
1.	Wheat	4966	16800	79782
2.	Sorghum	5829	8594	82291
3.	Maize	2490	3877	52525
4.	Pearl millet	2574	7179	112326
	Total cereals	10795	25394	162994
II.	Pulses	26190	16699	331085
III.	Oil seeds			
5.	Soybean	3230	4549	82588
6.	Groundnut	385	302	7549
	Total oil seeds	3615	4851	90511
IV.	Sugarcane	7621	14752	70911
V.	Onion	6299	12730	109814
VI.	Cotton	11092	16771	107740
VII.	Fodder crops	4730	8123	37833
VIII.	Total fruits and vegetable	7546	16540	126810

Source : Socio-Economic Review and District Statistical Abstract of Nanded district (2019-20).

From Table 3.3 it is concluded that, in Naigaon tahsil, sorghum was the major crop followed by wheat. Whereas, in Kandhar tahsil, wheat was the major crop followed by sorghum. Area under total cereals in Nanded district was 162994 ha. Whereas, it was 10795 ha in Naigaon tahsil and 25394 ha in Kandhar tahsil. Area under pulses in Nanded, Naigaon and Kandhar was 331085 ha, 26190 ha, 16699 ha respectively. Soybean was the major oilseed crop grown in Nanded, Naigaon and Kandhar followed by groundnut. Cotton was the important cash crop in the district. Area under cotton in Nanded was 107740 ha. Whereas, in Naigaon and Kandhar was 11092 ha and 16771 ha respectively. Besides these conventional crops, there was some area under fruits and vegetables. Area under fruits and vegetables in Nanded, Naigaon and Kandhar tahsils was 126810 ha, 7546 ha and 16540 ha respectively.

4. RESULT AND DISCUSSION

The outcomes of the research are presented and interpreted in this chapter. The study focuses on resource structure, costs and returns, as well as resource utilization productivity of main cropping sequences. The employment, income, and expenditure pattern of a group of farmers who use significant cropping sequences are also investigated. The primary data pertains to 90 Maharashtra sample houses for the 2020-21 fiscal year, while secondary data was statistically analyzed and the results are provided. In general, this chapter discusses and provides objective wise findings of study under the following broad headings.

- 4.1 General information about sample households
- 4.2 To identify the major cropping sequences
- 4.3 To study resource use structure of major cropping sequences
- 4.4 Cost and return of major cropping sequences
- 4.5 To study the employment, income expenditure pattern of sample farmers
- 4.6 To study the constraints in adoption major cropping sequences

4.1 General Information about Sample Households

As previously stated, 90 households were chosen from six villages, which were divided into three groups based on the size of their landholdings: small, medium and large. These groups were developed in order to investigate their qualities in greater depth. In this section, we'll look at some of the most crucial components of sample farm structure and organization in the chosen area. For the year 2020-21, the aspects studied are family size and composition, land use pattern, cropping pattern, income and employment creation, and capital investment.

Many farmers are not very attentive of cropping sequence and do not calculate precise profitability even when they try to go for enterprise with higher returns.

4.1.1 Size of family and its composition

The information on the size of family and its composition according to different size of classes of sample household is given in Table 4.1.

From Table 4.1, it is concluded that the average family size for small, medium and large group was 4.60, 4.73 and 4.80 members respectively. At overall level, average family size was 4.71 persons. The average family composition of males, females and children was 24.33, 23.78 and 51.89 percent, respectively.

Table 4.1 Average size of family and its composition of sample household (No./Farm)

Sr. No.	Particulars	Size Group			Overall
		Small	Medium	Large	
1.	Male	1.07	1.17	1.20	1.15
		(23.26)	(24.74)	(25.00)	(24.33)
2.	Female	1.10	1.13	1.13	1.12
		(23.91)	(23.89)	(23.54)	(23.78)
3.	Children	2.43	2.43	2.47	2.44
		(52.83)	(51.37)	(51.46)	(51.89)
4.	Total	4.60 (100.00)	4.73 (100.00)	4.80 (100.00)	4.71 (100.00)

(Figures in the parentheses indicate percentage to the total)

4.1.2 Educational status

The educational status of the sample farm families is given in the Table 4.2.

Table 4.2 Educational status of the sample farmer (No./Farm)

Sr. No.	Particulars	Size group			Overall
		Small	Medium	Large	
1.	Upto Primary	0.63	0.50	0.40	0.50
		(13.70)	(10.57)	(08.33)	(15.80)
2.	Upto Secondary	1.67	1.60	1.70	1.62
		(36.30)	(33.83)	(35.42)	(13.63)
3.	Upto Higher Secondary	1.10	1.37	1.37	1.17
		(23.91)	(28.96)	(28.54)	(22.94)
4.	Upto degree	0.40	0.57	0.80	0.55
		(08.70)	(12.05)	(16.67)	(32.25)
5.	Illiterate	0.90	0.70	0.57	0.72
		(19.57)	(14.80)	(11.88)	(15.36)
6.	Total	4.60 (100.00)	4.73 (100.00)	4.80 (100.00)	4.71 (100.00)

(Figures in the parentheses indicate percentage to the total)

From the above Table 4.2, it can be concluded that, 19.57, 14.80 and 11.88 percent members were illiterate from small, medium and large cultivators. At overall level 15.36 members from the cultivar's family were illiterate. Also 36.30, 33.83 and 35.42 percent from the cultivator's family were studied up to secondary level from small, medium and large group respectively. 23.91, 28.96 and 28.54 were up to higher secondary, whereas up to degree level, there was 8.70 percent from small group, 12.05 percent from medium group and 16.67 percent from large group.

4.1.3 Capital assets

The value of capital assets on different items such as building, implements and livestock are presented in Table 4.3. Land is the major factor of production which dominates the total assets held by the cultivator. The percentage of land to the total assets

accounted for 79.84, 88.45 and 90.32 per cent in small, medium and large size groups, respectively.

Table 4.3 Capital assets of the sample farmers (₹/Farm)

Sr. No.	Particulars	Size Group			
		Small	Medium	Large	Overall
1.	Land	1937500	4200000	7558333.3	4565277.78
		(79.84)	(88.45)	(90.32)	(86.21)
2.	Household and cattle shed	332533.34	399666.67	550933.34	427711.117
		(13.70)	(08.42)	(06.58)	(09.57)
3.	Irrigation structure	110733.33	106716.67	130482.66	115977.553
		(04.56)	(02.25)	(01.56)	(02.79)
4.	Bullock drawn implements	12843.33	13591.67	14356.67	13597.2222
		(00.53)	(00.29)	(00.17)	(00.33)
5.	Tractor and its implements	30000	24333.33	109300	54544.4433
		(01.24)	(00.51)	(10.31)	(01.02)
6.	Hand tools and implements	3132.33	3930.59	4791.30	3951.40667
		(00.13)	(00.08)	(00.06)	(00.08)
7.	Total assets including land	2426742.33	4748238.93	8368197.30	5181059.52
		(100.00)	(100.00)	(100.00)	(100.00)
8.	Total assets excluding land	480374.00	577779.67	844827.30	634326.99
		(19.80)	(12.17)	(10.10)	(14.02)

(Figures in the parentheses indicate percentage to the total)

Investment in farm assets is presented in Table 4.3. It can be observed that, at overall level, per farm investment on land was 86.21 per cent, houses and cattle shed was 09.57 per cent, irrigation structure 2.79 per cent, bullock drawn implements 0.33 per cent, tractor and its implements 1.02 per cent and hand tools and implements was 0.13 per cent. The total assets excluding land were 19.80 per cent.

The total value of investment in farm assets excluding land was worked out for small, medium and large size group was ₹480374.00, ₹577779.67 and ₹844827.30 respectively. In small farmers, per farm investment on irrigation structure was 4.56 per cent and bullock drawn implements 0.53 per cent.

In medium farmers, per farm investment on irrigation structure was 2.25 per cent, bullock drawn implements 0.29 per cent, tractor and its implements 0.51 per cent. Large farmers, per farm investment on irrigation structure were 1.56 per cent, bullock drawn implements 0.17 per cent, tractor and its implements 10.31 per cent.

From the above Table it is also concluded that, the major contribution in farm assets was of land followed by the houses and cattle shed. Large size group farmers have invested more in tractor and its implements compared to small and medium size group farmers.

Table 4.4 Livestock of selected sample farmers

(No./Farm)

Sr. No.	Particulars	Size Groups							
		Small		Medium		Large		Overall	
		Number	Value	Number	Value	Number	Value	Number	Value
1.	Bullock pair	0.30	24166.67	0.53	41700.00	0.70	58566.67	0.51	41477.78
			(32.19)		(45.05)		(43.33)		(41.09)
2.	Cow	0.60	19666.67	0.50	17433.33	0.60	21333.33	0.57	19477.78
			(26.19)		(18.83)		(15.78)		(19.30)
3.	Cow calf	0.17	1266.67	0.17	1400.00	0.30	3333.33	0.21	2000.00
			(01.69)		(01.51)		(02.47)		(01.98)
4.	Buffalo	0.43	20866.67	0.63	28800.00	0.93	46900.00	0.67	32188.89
			(27.79)		(31.11)		(34.70)		(31.89)
5.	Buffalo calf	0.07	666.67	0.20	2033.33	0.23	2133.33	0.17	1611.11
			(00.89)		(02.20)		(01.58)		(01.60)
6.	Goat/Sheep	1.40	8116.67	0.13	933.33	0.50	2883.33	0.68	3977.78
			(10.81)		(01.01)		(02.14)		(03.94)
7.	Poultry	0.67	333.33	0.67	266.67	0.00	0.00	0.44	200.00
			(00.44)		(00.29)		(00.00)		(00.20)
	Total	3.63	75083.33	2.83	92566.67	3.27	135150	3.24	100933.33
			(100.00)		(100.00)		(100.00)		(100.00)

(Figures in the parentheses indicate percentage to the total)

Livestock plays an important role in Income of farmers. The information regarding Livestock position of selected farmers presented in Table 4.4 showed that, at the overall level, per farm value of bullock pair was ₹41477.78, cow was ₹19477.78 and buffalo was ₹32188.89 which accounted for 41.09 per cent, 19.30 per cent and 31.89 per cent, respectively.

In small group, per farm value of bullock pair, cow, buffalo and goat were ₹24166.67, ₹19666.67, ₹20866.67 and ₹8116.67 which accounted for 32.19 per cent, 26.19 per cent, 27.79 per cent and 10.81 per cent of total value, respectively.

In medium group, per farm value of bullock pair, cow, buffalo and goat were ₹41700, ₹17433.33, ₹28800.00 and ₹933.33 which accounted 45.05 per cent, 18.83 per cent, 31.11 per cent and 01.01 per cent of total value, respectively.

In large group, per farm value of bullock pair, cow, buffalo and goat were ₹58566.67, ₹21333.33, ₹46900 and ₹2883.33 which accounted 43.33 per cent, 15.78 per cent and 34.70 per cent and 02.14 per cent of total value, respectively.

It is concluded from above Table 4.4 that medium group farmers have invested more in bullock pair (45.05%). The small farmers invested more in buffalo followed by cow and goat and sheep. At overall level, the major contribution in livestock was of bullock pair, followed by buffalo and cow.

4.1.4 Land use pattern of sample farmers

The information related to the land utilization of the selected holdings is given in Table 4.5.

Table 4.5 Land use pattern of sample farmers (ha)

Sr. No.	Particulars	Size Groups			
		Small	Medium	Large	Overall
1	Total land holding	0.78	1.68	2.94	1.80
		(100.00)	(100.00)	(100.00)	(100.00)
2	Permanent fallow	0.02	0.02	0.04	0.03
		(02.57)	(01.19)	(01.36)	(01.71)
3	Operational holding	0.76	1.66	2.90	1.77
		(96.15)	(98.81)	(98.64)	(97.87)
4	Current fallow	0.01	0.01	0.04	0.02
		(01.28)	(00.60)	(01.36)	(01.11)
5	Net cropped Area	0.75	1.65	2.86	1.75
		(94.87)	(98.21)	(97.28)	(97.41)
6	Gross cropped area	1.60	2.97	4.80	3.12
7	Cropping intensity (%)	216.22	180.00	167.83	178.14

(Figures in the parentheses indicate percentage to the total)

The total holdings in respect of small, medium and large size of farms were worked out to 0.78, 1.68 and 2.94 hectares, respectively and at overall level it was 1.80 hectares. The proportion of net cropping area was worked out 97.41 per cent of total holding at the overall level. The proportion of net cropping area was maximum in case of medium size group of holding (98.21%) while it was low in case of small size group of holding (94.87%). The gross cropped area was 1.60, 2.97 and 4.80 hectare in small, medium and large group respectively. The cropping intensity in small, medium and large group was 216.22, 180.00 and 167.83, respectively and 178.14 percent at overall level.

4.1.5 Cropping pattern of sample farmers

Cropping pattern is another vital factor influencing the level of expenses on farm and the returns from farm business. It is also an indicator of economic condition of selected farm families.

The information of average cropping pattern of sample cultivators in two tehsils (Naigaon and Kandhar) of Nanded district is presented in Table 4.6. At the overall level, the share of chickpea was found to be highest i.e. 23.62 per cent followed by soybean which is 20.88 per cent. Share of some other crops were cotton (12.84 %), Summer groundnut (8.17 %), wheat (7.05 %) and *Rabi* sorghum (6.13 %).

In case of small farmers, area under chickpea was the highest i.e. 23.76 per cent followed by soybean, cotton, groundnut and *rabi* sorghum which was 21.25 per cent, 12.50 per cent, 11.87 percent and 7.50 per cent, respectively. Area under vegetables was five per cent, which was highest among three groups. 43.12 per cent of total area was under *kharif* crops.

In medium group, area under soybean was 21.21 per cent followed by cotton (11.45%), green gram (6.06%), black gram (5.39%) and pigeon pea (2.36%) among *kharif* crops. Chick pea (22.90%), wheat (7.40%) and *rabi* sorghum (5.05%) were major *rabi* crops. Among *summer* crops, share of groundnut was the highest i.e. 7.41 per cent. Area under vegetables was 3.36 per cent.

In large group, share of soybean was found to be highest i.e. 22.08 per cent followed by chickpea (21.67%), cotton (14.58%), wheat (8.75%), etc. Vegetables were grown on 2.92 per cent area.

From the table 4.6, it is concluded that, soybean was grown on larger area among *kharif* crops followed by cotton, green gram, black gram and pigeon pea. Among *rabi* crops, area under chickpea was the highest followed by *rabi* sorghum and wheat.

Groundnut was the major summer crop. The share of area under vegetables was decreased from small group to large group and at overall it was 3.78 per cent.

Table 4.6 Cropping pattern of sample farmers (ha)

Sr. No.	Particulars	Size group			
		Small	Medium	Large	Overall
1.	Kharif crops				
	Cotton	0.20	0.34	0.70	0.41
		(12.50)	(11.45)	(14.58)	(12.84)
	Soybean	0.34	0.64	1.06	0.67
		(21.25)	(21.21)	(22.08)	(20.88)
	Green gram	0.06	0.18	0.22	0.15
		(03.75)	(06.06)	(04.58)	(04.86)
	Black gram	0.04	0.16	0.20	0.13
		(02.50)	(05.39)	(04.17)	(04.06)
	Sorghum	0.02	0.05	0.10	0.06
		(01.25)	(01.68)	(02.08)	(01.67)
	Pigeon pea	0.03	0.07	0.09	0.06
(01.88)		(02.36)	(01.88)	(02.04)	
Other	0.00	0.06	0.08	0.04	
	(00.00)	(02.02)	(01.67)	(01.23)	
Sub total	0.69	1.50	2.45	1.54	
	(43.12)	(50.17)	(51.03)	(47.58)	
2.	Rabi crops				
	Wheat	0.08	0.22	0.42	0.24
		(05.00)	(07.40)	(08.75)	(07.05)
	Safflower	0.01	0.06	0.12	0.06
		(00.63)	(02.02)	(02.50)	(01.72)
	R. Sorghum	0.12	0.15	0.28	0.18
		(07.50)	(05.05)	(05.83)	(06.13)
	Gram	0.38	0.68	1.04	0.72
(23.76)		(22.90)	(21.67)	(23.62)	
Sub total	0.59	1.11	1.86	1.20	
	(36.88)	(37.37)	(38.75)	(38.52)	
3.	Summer crops				
	Groundnut	0.19	0.22	0.30	0.23
		(11.87)	(07.41)	(06.25)	(08.17)
	Sesamum	0.01	0.01	0.03	0.02
		(00.63)	(00.34)	(00.62)	(00.53)
	S. Sorghum	0.04	0.04	0.02	0.03
(02.50)		(01.35)	(00.42)	(01.42)	
Sub total	0.24	0.27	0.35	0.27	
	(15.00)	(09.10)	(07.30)	(10.12)	
4.	Vegetables	0.8	0.10	0.14	0.35
		(05.00)	(03.36)	(02.92)	(03.78)
	Gross cropped area	1.60	2.97	4.80	3.12
		(100.00)	(100.00)	(100.00)	(100.00)

(Figures in the parentheses indicate percentage to the total)

4.2 Identification of Different Cropping Sequences

It is observed from the Table 4.7 that, cropping sequences found in the Nanded district were Soybean-chickpea- summer groundnut, Cotton- summer groundnut, Soybean-*Rabi* sorghum, Cotton-sesamum, Black gram- *Rabi* Sorghum-Soybean, Sorghum-Wheat-summer Groundnut, Soybean- *Rabi* Sorghum-Chilli, Green gram-Safflower-cucumber, Cotton-Tomato, Soybean-Wheat-Sesamum, Sorghum-Safflower, Turmeric- summer Groundnut, etc.

In case of small farmers, soybean-chickpea- summer groundnut cropping sequence was the dominant cropping sequence which was adopted by 9 farmers followed by cotton-summer groundnut and soybean-*Rabi* sorghum which were adopted by 8 farmers each.

In case of medium group farmers soybean-chickpea-summer groundnut was widely adopted cropping sequence i.e. by 11 farmers. After that cotton-summer groundnut and soybean-*Rabi* sorghum were major cropping sequences which were adopted by 10 and 8 farmers respectively. Soybean-*Rabi* Sorghum-Chilli was also found to be major cropping sequence which was adopted by 7 farmers.

In case of large group farmers, Soybean-Chickpea- summer Groundnut was the dominant cropping sequence which was adopted by 16 farmers followed by cotton-groundnut which was adopted by 10 farmers. Soybean-*Rabi* sorghum and Cotton-wheat were also found to be adopted by large number of farmers i.e. 8 and 7, respectively.

At the overall, Soybean-Chickpea- summer Groundnut was the dominant cropping sequence which was adopted by 37 farmers followed by cotton- summer groundnut adopted by 29 farmers and Soybean- *Rabi* sorghum adopted by 25 farmers.

For further calculation and analysis we selected three major cropping sequences viz. Soybean-Chickpea- summer Groundnut, cotton- summer groundnut and Soybean-*Rabi* sorghum as CS I, CS II and CS III respectively. These cropping sequences were selected on the basis of percentage to the total number of sample cultivar i.e. 90 in number. This selected cropping sequences I (Soybean-Chickpea- summer Groundnut) was adopted by 37 i.e. 41.11 per cent farmers, cropping sequence II (cotton- summer groundnut) was adopted by 29 i.e. 32.22 per cent farmers and cropping sequence III (Soybean- *Rabi* sorghum) was adopted by 24 i.e. 27.78 percent farmers.

Table 4.7 Existing cropping sequences observed on the farm of sample farmers

Sr. No.	Cropping sequences	Size			Total (90)	Percentage (%)
		Small	Medium	Large		
1.	Soybean-Chickpea- summer Groundnut	9	12	16	37	41.11
2.	Cotton-Sesamum	3	5	6	14	15.56
3.	Sorghum-Safflower	4	4	2	10	11.11
4.	Soybean-Wheat-Sesamum	5	6	4	15	16.67
5.	Black gram- <i>Rabi</i> Sorghum-Soybean	2	4	5	11	12.22
6.	Cotton-Wheat	4	5	7	16	17.78
7.	Black gram-Chickpea- summer Sorghum	4	4	2	10	11.11
8.	Soybean- <i>Rabi</i> Sorghum-Chilli	5	7	4	16	17.78
9.	Cotton-summer Groundnut	8	11	10	29	32.22
10.	Green gram- <i>Rabi</i> Sorghum-Brinjal	6	3	3	12	13.33
11.	Red gram-Brinjal	2	4	0	6	06.67
12.	Sorghum-Wheat-Summer Groundnut	5	6	3	14	15.56
13.	Cotton-Sugarcane	0	2	4	6	06.67
14.	Green gram-Safflower-cucumber	4	3	1	8	08.89
15.	Sorghum-Chickpea	4	5	3	12	13.33
16.	Turmeric-Summer Groundnut	0	3	5	8	08.89
17.	Soybean- <i>Rabi</i> Sorghum	8	9	8	25	27.78
18.	Cotton-Tomato	4	2	1	7	07.78

4.3 Resource Use Structure of Major Cropping Sequence

The information on per hectare utilization of different inputs for major cropping sequences in Nanded district of Maharashtra is presented in Table 4.8.

4.3.1 Human labour

It is observed from the Table 4.8 that, in cropping sequence I, the use of total human labour was 104.45 man-days per hectare comprising 33.15 male man-days and 71.29 female man days. In cropping sequence II, the use of total human labour was 126.24 man days per hectare, comprising 32.95 male man days and 93.29 female man days. In case of cropping sequence III, the use of total human labour was 63.15 man days of which

27.29 were male man days and 35.86 were female man days. The per hectare labor utilization indicated that the utilization of human labour was maximum in cropping sequence II followed by cropping sequence I and cropping sequence III.

4.3.2 Bullock labour

It is observed from the Table 4.8 that, the use of bullock labour for cropping sequence I was 12.81 pair days and for cropping sequence II, it was 7.05 pair days. Whereas, in cropping sequence III, the use of bullock labour was 7.56 pair days. The per hectare resource use structure indicate that, the utilization of bullock labour was maximum in cropping sequence I (12.81 pair days) followed by cropping sequence III (7.56 pair days) and cropping sequence II (7.05 pair days).

Table 4.8 Resource use level of major cropping sequence (per ha)

Sr. No.	Particular	Unit	Cropping sequences		
			I	II	III
1.	Total human labour		104.45	126.24	63.15
	Male	Man days	33.15	32.95	27.29
	Female	Man days	71.29	93.29	35.86
2.	Bullock Power	Pair days	12.81	7.05	07.56
3.	Machine power	Hr	15.71	2.94	10.80
4.	Manures	q	08.50	08.04	06.82
5.	Seed	kg	275.02	101.50	85.02
6.	Fertilizers				
	N	kg	100.51	145.78	130.00
	P	kg	175.93	110.95	114.89
	K	kg	30.10	60.20	40.00
7.	Irrigation charges	₹	8996.83	4947.80	3384.55
8.	Plant protection charges	₹	8763.48	7520.96	3999.07

4.3.3 Machine power

Table 4.8 reveals that, in cropping sequence I, per hectare utilization of machine power was observed to be 15.71 hr and 2.94 hr. in case cropping sequence II. In case of cropping sequence III, the per hectare utilization of machine power was 10.80 hr. In cropping sequence I (15.71 hr) per hectare utilization of machine power was more than cropping sequence III (10.80 hr) and cropping sequence II (2.94). The machine power i.e.

use of tractors was mostly for the operation of carrying and spreading of FYM, ploughing and harrowing.

4.3.4 Seed

Table 4.8 reveals that, in cropping sequence I, on an average, utilization of seed material was 275.02 kg per hectare which was much higher than the other two cropping sequences i. e. II and III which was 101.50 and 85.02 kg per hectare, respectively.

High seed rate in case of cropping sequence I is because, this cropping sequence comprise soybean as *kharif* crop, chickpea as *rabi* crop and groundnut as summer crop which have high seed rate as compared to crops in cropping sequences II and III.

4.3.5 Manures and fertilizers

Table 4.8 reveals that, in case of cropping sequence I, the use of manure was 8.50 q/ha, in cropping sequence II, it was 8.04 q/ha and for cropping sequence III, it was 6.82 q/ha. Manure was found more in case of cropping sequence I than cropping sequences II and cropping sequence III. In case of cropping sequence I, the per hectare use of chemical fertilizers i.e. Nitrogenous, Phosphorus and Potash was 100.51, 175.93 and 30.10 kg per ha, respectively. In case of cropping sequence II, per hectare use of chemical fertilizers i.e. Nitrogenous, Phosphorus and Potash was 145.78, 110.95 and 60.20 kg per ha, respectively. In case of cropping sequence III, per hectare use of chemical fertilizers i.e. Nitrogenous, Phosphorous and Potash was 130, 114.89 and 40 kg per ha respectively. The farmers adopting cropping sequence I had used more Phosphorous fertilizers than cropping sequence II and III. The use of Nitrogenous fertilizer was high in cropping sequence II, whereas the use of Potash fertilizers was highest in cropping sequence II.

4.3.6 Irrigation and plant protection charges

Table 4.8 reveals that, per hectare irrigation charges were observed more in cropping sequence I (₹8996.83 per ha) than those of cropping sequence II(₹4947.80 per ha) and cropping sequence III(₹3384.55). Plant protection charges were also observed more in cropping sequence I (₹8763.48 per ha) than those of cropping sequence II (₹7520.96 per ha) and cropping sequence III (₹3999.07 per ha).

Table 4.9 Cost of cultivation of major cropping sequences

(per ha)

Sr. No.	Cost items	Cropping sequences					
		Soybean-chickpea-groundnut		Cotton-S.groundnut		Soybean-R.sorghum	
		Qty	Value(₹)	Qty	Value(₹)	Qty	Value(₹)
I 1.	Hired human labour (Man days)						
	a) Male	33.15	9945.00	32.95	9885.32	27.29	8187.44
	b) Female	71.29	21388.50	93.29	27987	35.86	10758
	Total hired human labour	104.45	31333.50	126.24	37872.32	63.15	18945.44
2.	Bullock labour (Pair days)	12.81	6405	07.05	3525.82	7.56	3781.31
3.	Machine power(Hrs.)	15.71	7855.65	2.94	1471.71	10.80	5400
4.	Manure (q)	8.50	1275.00	8.04	1206.00	6.82	1023.53
5.	Seed (Kg)	275.02	25502.04	101.50	12738.46	85.02	7902.11
6.	Fertilizers (Kg)						
	N	100.51	1447.34	145.78	2099.23	130	1872
	P	175.93	8796.50	110.95	5547.50	114.89	5744.50
	K	30.10	852.73	60.20	1705.47	40	1133.20
7.	Irrigation charges (₹)		8996.83		4947.80		3384.55
8.	Plant protection charges(₹)		8763.48		7520.96		3999.07
9.	Incidental charges (₹)		2635.30		2088.88		1667.84
10.	Repairs (₹)		800.30		924.51		459.59

Table 4.9 contd..

Sr. No.	Cost items	Cropping sequences					
		Soybean-chickpea-groundnut		Cotton-S.groundnut		Soybean-R.sorghum	
		Qty	Value(₹)	Qty	Value(₹)	Qty	Value(₹)
	Working capital		104563.67		81648.66		55318.72
11.	Interest on working capital @ 6 % per annum		6273.82		4898.92		3319.12
12.	Depre. on farm implements		7284.07		4139.65		4417.47
13.	Land revenue and taxes (₹)		302.83		199.78		204.14
	Cost A		118424.39		90887.01		63259.45
14.	Rental value of land (₹)		48249.85		43735.94		24988.48
15.	Int. on fixed capital @ 10 per cent per annum		19773.95		13471.43		13428.31
	Cost B		186448.19		148094.38		101676.24
16.	Family labour (Man days)						
	a) Male	29.48	8843.12	23.54	7061.67	19.63	5889.82
	b) Female	38.14	11442.00	32.22	9666.00	14.72	4416.48
	Cost C		206733.31		164822.05		111982.54
17.	Production (q)	64.05		50.37		45.20	
II	Gross Income (₹)		291316.10		263614.30		151155.70
	Per quintal cost (₹)		4548.26		5233.56		3344.15

4.4 Costs and Returns of Major Cropping Sequences

Table 4.10 reveals the information about cost, return, gross income and B:C ratio of the sample farmers adopting major cropping sequences. From the Table 4.10 it is concluded that per hectare gross return obtained from cropping sequence I was highest i.e. ₹291316.10 followed by cropping sequence II (₹263614.30) and cropping sequence III (₹151155.70). Cost A, Cost B and Cost C of the cropping sequences I was ₹118424.39, ₹186448.19 and ₹206733.31 respectively. For cropping sequence II, the Cost A, Cost B and Cost C were ₹90887.01, ₹148094.38 and ₹164822.05 respectively. Whereas the Cost A, Cost B and Cost C of the cropping sequence III was ₹63259.45, ₹101676.24 and ₹111982.54 respectively.

Table 4.10 Cost and return of major cropping sequences (per ha)

Sr. No.	Particular	Unit	Cropping sequences		
			I	II	III
1.	Total cost				
	Cost A	₹	118424.39	90887.01	63259.45
	Cost B	₹	186448.19	148094.38	101676.24
	Cost C	₹	206733.31	164822.05	111982.54
2.	Profit at				
	Cost A	₹	172891.71	172727.29	87896.25
	Cost B	₹	104867.91	115519.92	49479.46
	Cost C	₹	84582.79	98791.38	39173.16
3.	Production	q	64.05	50.37	45.20
4.	Gross income	₹	291316.10	263614.30	151155.70
5.	B:C ratio				
	Cost A		2.45	2.90	2.38
	Cost B		1.56	1.78	1.48
	Cost C		1.40	1.59	1.34

The profit at cost C was the highest in cropping sequence II which was ₹98791.38 followed by cropping sequence I (₹84582.79) and cropping sequence III (₹39173.16). Total production was highest in cropping sequence I which was 64.05 q/ha whereas in cropping sequence II and III, the total production was 50.37 q/ha and 45.20 q/ha respectively.

B:C ratio for cost A was the highest in cropping sequence II i.e. 2.90 followed by cropping sequence I (2.45) and cropping sequence III (2.38). B:C ratio for cost B was also highest in cropping sequence II which is 1.78 followed by cropping sequence I and cropping sequence III which was 1.56 and 1.48 respectively.

B:C ratio at cost C was the highest in cropping sequence II i.e. 1.59, whereas in cropping sequence I it was 1.40 and in cropping sequence III it was 1.34. From overall discussion it can be concluded that, the cropping sequence II was more profitable (on the basis of B:C ratio) than other two cropping sequences.

4.4.1 Functional analysis

To study the resource use productivity, Cobb-Douglas production function was used. Seven independent variables were considered *viz.* human labour (X_1), bullock labour (X_2), machine power (X_3), manure (X_4), N (X_5), P (X_6) and K (X_7).

Table 4.11 Results of Cobb-Douglas production function

Sr. No.	Particular	Unit	Cropping sequence		
			I	II	III
1.	Sample size		37	29	25
2.	Intercept		1.28 (0.21)	1.53 (0.26)	7.62 (4.78)
3.	Human labour (X_1)	days	0.12*** (0.04)	-0.01 (0.06)	-1.14 (4.94)
4.	Bullock labour (X_2)	days	0.02 (0.07)	-0.13 (0.08)	-0.57 (21.66)
5.	Machine power (X_3)	hrs.	-0.02 (0.04)	0.95*** (0.29)	1.53*** (0.48)
6.	Manure (X_4)	q	-0.04* (0.02)	-0.61*** (0.18)	0.34** (0.14)
7.	N (X_5)	kg	-0.03 (0.08)	-0.05 (0.10)	-0.05 (0.43)
8.	P (X_6)	kg	0.003 (0.08)	-0.30*** (0.09)	0.19 (0.32)
9.	K (X_7)	kg	0.01 (0.02)	0.18* (0.09)	-0.03 (0.03)
10.	R^2		0.81	0.76	0.86

(Figures in the parentheses are standard errors of respective regression coefficients)

(*, ** and *** indicates significance at 10, 5 and 1 per cent level)

4.4.1.1 Cropping sequence I

From Table 4.11 it is concluded that, in case of cropping sequence I, the value of R^2 was 0.81 which indicates that the seven independent variables have jointly explained 81 per cent variation in the output. Among these seven independent variables, coefficient of human labour (X_1) was highly significant at 1 per cent level indicating that 1 per cent increase in human labour will increase the yield by 0.12 per cent. Manure was significant at 10 per cent level. Machine power (X_3) and N (X_5) had negative impact on dependent variable i.e. yield. Bullock labour (X_2), P (X_6) and K (X_7) had positive relation with yield but non-significant.

4.4.1.2 Cropping sequence II

Table 4.11 reveals that, the value of R^2 in case of cropping sequence II was 0.76 which indicates that the seven independent variables have jointly explained 76 per cent variation in the output. The coefficient of machine power (X_3), manure (X_4) and P (X_6) were found to be highly significant 1 per cent level, whereas K (X_7) was significant at 10

level of significance indicating that, if machine power and K increased by 1 per cent, will increase the yield by 0.95 and 0.18 per cent. Human labour (X_1), Bullock labour (X_2), manure (X_4), N (X_5) and P (X_6) had negative relationship with the output.

4.4.1.3 Cropping sequence III

Table 4.11 reveals that, the value of R^2 for cropping sequence III was 0.86 indicating that, the selected seven independent variables have jointly explained 86 per cent variation in the output. Coefficient of machine power(X_3) was found to be highly significant at 1 percent level and manure(X_4) was found to be significant at 5 per cent level indicating that, increase in 1 percent of machine power and manure will increase the yield by 1.53 per cent and 0.34 per cent respectively. P (X_6) was found to be positive but non-significant, whereas human labour (X_1), bullock labour(X_2), N(X_5) and K (X_7) were found to be negative.

4.4.2 Resource use efficiency

Efficiency of resources which were used by the selected sample farmers adopting major cropping sequences was examined with the help of MVP/MC ratio and presented in the Table 4.12.

4.4.2.1 Cropping sequence I

Table 4.12 reveals that, the ratio of marginal value product to the factor cost (MVP/MC) was greater than unity in case of human labor (X_1), bullock labor (X_2) and K (X_7) which indicates underutilization of these resources. It means that there is need to increase these resources in order to increase the output. MVP/MC was less than unity in case of machine (X_3), manure (X_4), N (X_5) and P (X_6) which indicates that there was the over utilization of these resources. It means that, there is no need to increase these resources in order to increase the output.

4.4.2.2 Cropping sequence II

From Table 4.12 it is revealed that, the marginal value product to the factor cost ratio was greater than unity in case of machine (X_3) and K (X_7) indicating the under utilization of these resources. It means that, in order to increase the output, there is need to increase these resources. Whereas, the ratio of MVP/MC is less than unity in case of human labour (X_1), bullock labour (X_2), manure (X_4), N (X_5) and P (X_6). This indicates that, there was excess utilization of these resources which means, there is no need to increase these resources for increasing the output.

Table 4.12 Resource use efficiency of major cropping sequences

Sr. No.	Particulars	Units	Bi	GM	GM of Y	Unit price	MP	MVP	MC	MVP/MC
A. Cropping sequence I										
1.	Human labor	Mandays	0.118	43.25	26.44	14102.35	0.072	1017.99	300	3.39
2.	Bullock labor	Days	0.025	6.381	26.44	14102.35	0.103	1460.18	500	2.92
3.	Machine	Hrs.	-0.023	9.029	26.44	14102.35	-0.06	-957.88	500	-1.92
4.	Manure	q	-0.037	4.6188	26.44	14102.35	-0.20	-2943.68	150	-19.62
5.	N	Kg	-0.028	35.814	26.44	14102.35	-0.02	-294.50	14.40	-20.45
6.	P	Kg	0.003	60.916	26.44	14102.35	0.0012	17.83	50	0.35
7.	K	Kg	0.0105	10.483	26.44	14102.35	0.026	373.06	28.33	13.17
B. Cropping sequence II										
1.	Human labor	Mandays	-0.01	54.5232	27.43	10699.99	-0.006	-64.20	300	-0.21
2.	Bullock labor	Days	-0.13	9.88	27.43	10699.99	-0.37	-2958.99	500	-5.92
3.	Machine	Hrs.	0.95	7.96	27.43	10699.99	3.27	34988.97	500	69.98
4.	Manure	q	-0.60	5.84	27.43	10699.99	-2.85	-30494.97	150	-203.30
5.	N	Kg	-0.05	82.24	27.43	10699.99	-0.01	-106.99	14.40	-7.43
6.	P	Kg	-0.29	54.69	27.43	10699.99	-0.15	-1604.99	50	-32.10
7.	K	Kg	0.18	34.34	27.43	10699.99	0.14	1497.00	28.33	52.84
C. Cropping sequence III										
1.	Human labor	Mandays	-1.14	47.63	47.23	7400.40	-1.13	-8365.61	300	-27.89
2.	Bullock labor	Days	-0.57	21.84	47.23	7400.40	-1.23	-9122.11	500	-18.24
3.	Machine	Hrs.	1.53	37.24	47.23	7400.40	1.94	14360.02	500	28.72
4.	Manure	q	0.34	17.33	47.23	7400.40	0.93	6857.31	150	45.72
5.	N	Kg	-0.05	129.14	47.23	7400.40	-0.02	-135.33	14.40	-9.40
6.	P	Kg	0.19	114.80	47.23	7400.40	0.08	578.48	50	11.56
7.	K	Kg	-0.03	12.95	47.23	7400.40	-0.11	-809.70	28.33	-28.58

4.4.2.3 Cropping sequence III

From Table 4.12 it is revealed that, the ratio of marginal value product to factor cost was greater than unity in case of machine (X_3), manure (X_4) and P (X_6) indicating that there was under-utilization of these resources. It means that, there is need to increase these resources in order to increase the yield. The MVP/MC ratio was less than unity for human labour (X_1), bullock labour (X_2), N (X_5) and K (X_7) indicating that there was excess utilization of these resources. It means that, in order to increase the yield, there is no need to increase these resources.

4.5 Employment, Income and Expenditure Pattern

4.5.1 Employment pattern

The main activity of the farmer is to cultivate land and grow crops in such a way as to efficient use of labour to secure the maximum income. However, owing to limitation of land holding and irrigation, all family members do not find adequate employment in crop production activity throughout the year. They are therefore, required to find employment in alternative activities in order to earn additional income. The details of source wise average annual employment pattern of per farm of earner (male and female workers) in different cropping sequences are presented in Table 4.13.

4.5.2 Average annual employment of farm families

Table 4.13 Average annual employment of farm families (days)

Sr. No.	Particular	Cropping sequence		
		I	II	III
1.	Crop production	270.32 (68.93)	262.25 (68.35)	198.36 (58.34)
2.	Livestock	72.14 (18.40)	61.36 (15.99)	74.69 (21.95)
3.	Wages	20.84 (05.31)	27.88 (07.28)	43.14 (12.69)
4.	Service/Business	28.85 (07.36)	32.15 (08.38)	23.85 (07.02)
5.	Total employment	392.15 (100.00)	383.64 (100.00)	340.04 (100.00)

(Figures in the parentheses indicate percentage to the total employment)

From the above Table 4.13 it can be concluded that, the employment generation through cropping sequence I was highest i.e. 392.15 days followed by cropping sequence II (383.64 days) and cropping sequence III (340.04 days). Among each cropping sequence, the employment generated through crop production was highest i.e. from cropping

sequences I, II and III it was 270.32, 262.25 and 198.36 days respectively. Also, there were other forms of employment such as from livestock, wages, service/business. The employment generated through livestock activities was highest in cropping sequence III i.e. 74.69 days (21.95%) followed by cropping sequence I 72.14 days (18.40%) and cropping sequence II 61.36 days (15.99%). From wages also, employment generation was highest in cropping sequence III (12.69%) followed by cropping sequence II (07.28%) and cropping sequence I (05.31%).

From the foregoing discussion, it is concluded that the crop production activity was the major source of employment in all three cropping sequences. However, wages and livestock were other sources of employment.

4.5.3 Employment function

In order to establish the functional relationship between total family employment and the factors like numbers of earners in family (X_1), numbers of animals (X_2), area under vegetables (X_3), area under cash crop (X_4), gross irrigated area (X_5), the multiple linear regression model was used and the result are presented in the Table 4.14.

4.5.3.1 Cropping sequence I

It can be revealed from the Table 4.14 that the five independent variables have jointly explained the 90 per cent of total variation in cropping sequence I. Coefficients of no. of animals (X_2) and gross irrigated area (X_5) were found to be highly significant at 1 per cent level of significance which indicates that, if number of animal is increased by 1 unit, the total employment will increase by 10.45 days. Also, if gross irrigated area is increased by 1 ha, the total employment will increase by 32.95 days. Area under cash crops (X_4) was significant at 5 per cent level which indicates that, if area under cash crops is increased by 1 ha, the total employment will increase by 20.49 days. Also area under vegetables (X_3) was significant at 10 per cent level. Area under vegetables had negative impact on gross family employment. While, impact of number of earners (X_1) on gross family employment was found to be positive but it was non-significant.

4.5.3.2 Cropping sequence II

The Table 4.14 reveals that the five independent variables have jointly explained by 76 per cent of total variation in cropping sequence II. Coefficients of number of animals (X_2) and area under cash crops (X_4) were found to be highly significant at 1 per cent level of significance indicating that, if livestock unit is increased by 1 unit, the total employment will increase by 5.67 days and if we increase area under cash crops by 1 ha, the total employment will be increase by 66.69 days. Number of earners (X_1) and area under

vegetables (X_3) were significant at 5 per cent level indicating that if we increase 1 person in the family, the total employment will increase by 4.26 days and if we increase 1 ha area under vegetables, the total employment will increase by 32.47 days. Gross irrigated area (X_5) was found to be positive but non-significant.

Table 4.14 Regression analysis of employment function

Sr. No.	Particulars	Cropping sequence		
		I	II	III
1.	Sample size	37	29	25
2.	Constant	204.53 (11.55)	167.17 (9.65)	228.90 (11.38)
3.	No. of Earners(X_1)	1.48 (2.27)	4.26** (1.93)	-0.48 (2.94)
4.	No. of Animals(X_2)	10.45*** (2.08)	5.67*** (1.11)	0.82 (1.84)
5.	Area under vegetables(X_3)	-31.47* (17.54)	32.47** (13.60)	11.66 (17.10)
6.	Area under cash crops(X_4)	20.49** (9.66)	66.69*** (10.14)	41.59** (17.01)
7.	GIA(X_5)	32.95*** (6.87)	4.11 (12.56)	22.44 (17.74)
8.	R^2	0.90	0.76	0.84

(Figures in the parentheses are standard errors of respective regression coefficients)

(* , ** and *** indicates significance at 10, 5 and 1 per cent level)

4.5.3.3 Cropping sequence III

The Table 4.14 reveals that, the five independent variables have jointly explained by 84 percent of total variation in cropping sequence II. Area under cash crops (X_4) was found to be significant at 5 percent indicating that increase in area under cash crops by 1 ha, total employment will increase by 41.59 days. Number of animals (X_2), area under vegetables (X_3) and gross irrigated area (X_5) were found to be positive but non-significant. Also number of earners (X_1) in the family had negative impact on gross family employment.

4.5.4 Average annual income of farm families

Farm income refers to the total annual earnings of the family from sale of agricultural produce after meeting family requirements. In this study, the household farm income was estimated based on the sales of crop produce and livestock products. The average annual income from different cropping sequences is presented in Table 4.15.

From Table 4.15 it is revealed that, the income from crop production was ₹254633.33 from cropping sequence I, ₹223740 from cropping sequence II and

₹147326.67 from cropping sequence III. Also there were other sources of family income like livestock activity, service/business and wages. Income generated through livestock activities was highest in cropping sequence II (₹87653.84) which was approximately 23 per cent to the total family income followed by cropping sequence III (₹84589.64) and cropping sequence I (₹82256.30). Also, income from the wages was highest from cropping sequence III (₹20548.75) followed by cropping sequence I (₹17503) and cropping sequence II (₹15200.05). From the table it can be concluded that, the major share of total family income was from crop production activity. In terms of percentage 64.52 percent of total income was generated from crop production in cropping sequence I followed by cropping sequence II (59.18%) and cropping sequence III (49.55%). 28.45 percent income was generated from livestock activities in cropping sequence III followed by cropping sequence II (23.18%) and cropping sequence I (20.84%). The share of service/business was 15.09 per cent, 13.62 per cent and 10.20 percent from cropping sequences III, II and I, respectively.

Table 4.15 Average annual income of farm families (₹/Family)

Sr. No.	Particular	Cropping sequence		
		I	II	III
1.	Crop production	254633.33 (64.52)	223740.00 (59.18)	147326.67 (49.55)
2.	Livestock	82256.30 (20.84)	87653.84 (23.18)	84589.64 (28.45)
3.	Wages	17503.00 (4.44)	15200.05 (4.02)	20548.75 (6.91)
4.	Service/Business	40258.32 (10.20)	51486.88 (13.62)	44872.10 (15.09)
5.	Total income	394650.95 (100.00)	378080.77 (100.00)	297337.16 (100.00)

(Figures in the parentheses indicate percentage to the total income)

4.5.5 Income function

In order to establish the functional relationship between total family income and the independent factors like number of earners in family (X_1), numbers of animals (X_2), area under vegetables (X_3), area under cash crop (X_4) and gross irrigated area (X_5), the multiple linear regression model was used and the result are presented in the Table 4.16.

4.5.5.1 Cropping sequence I

It can be revealed from the Table 4.16 that the five independent variables have jointly explained the 82 per cent of total variation in cropping sequence I. Coefficients of

gross irrigated area (X_5) was found to be highly significant at 1 per cent level indicating that, if gross irrigated area is increased by 1 ha the total income will increase by ₹88184.51. Also area under cash crops(X_4) was found to be significant at 10 per cent level. Number of earners (X_1) and area under vegetables(X_3) were found to be negative and had negative impact on gross family income whereas number of animals (X_2) had positive relation but non-significant.

4.5.5.2 Cropping sequence II

It can be revealed from the Table 4.16 that, the five independent variables have jointly explained the 93 per cent of total variation in cropping sequence II. Area under cash crops (X_4) was found to be highly significant at 1 per cent level indicating that, if the area under cash crops is increased by 1 ha, the total family income will be increased by ₹82935.06. All the other independent variables *viz.*, number of earners (X_1), number of animals (X_2), area under vegetables (X_3) and gross irrigated area (X_5) had positive impact but are non-significant.

Table 4.16 Regression analysis of income function

Sr. No.	Particulars	Cropping sequence		
		I	II	III
	Sample size	37	29	25
1.	Constant	230215.8 (34819.06)	201849.5 (17041.45)	161748.4 (23245.37)
2.	No. of Earners(X_1)	-10384.4 (6849.48)	5544.665 (3412.9)	2435.92 (6000.23)
3.	No. of Animals(X_2)	8711.121 (6285.24)	1671.015 (1962.88)	1186.807 (3758.57)
4.	Area under vegetables(X_3)	-48969.1 (52858.53)	26877.58 (24011.28)	62935.81* (34951.9)
5.	Area under cash crops(X_4)	53258.63* (29106.49)	82935.06*** (17895.69)	54896.76 (34746.44)
6.	GIA(X_5)	88184.51*** (20701.48)	25643.45 (22171.52)	79595.16** (36242.67)
7.	R^2	0.82	0.93	0.87

(Figures in the parentheses are standard errors of respective regression coefficients)

(*, ** and *** indicates significance at 10, 5 and 1 percent level)

4.5.5.3 Cropping sequence III

It can be revealed from the Table 4.16 that the five independent variables have jointly explained the 87 per cent of total variation in cropping sequence III. Gross

irrigated area (X_5) was significant at 5 per cent level and area under vegetables (X_3) was found to be significant at 10 per cent level. Other independent variables like number of animals (X_2), number of earners (X_1) and area under cash crops (X_4) had positive relation with gross family income.

4.5.6 Average annual expenditure of farm families

The details of the expenditure incurred by the sample families on different items of expenditure such as crop production, expenditure on livestock, family consumption, business expenditure, land development and other are given in Table 4.17.

Table 4.17 Average annual expenditure of farm families (₹/Family)

Sr. No.	Particular	Cropping sequence		
		I	II	III
1.	Crop production	132536.82 (48.84)	105642.33 (44.30)	78561.18 (38.89)
2.	Livestock activity	32200.63 (11.87)	34862.47 (14.63)	35229.57 (17.43)
3.	Family expenditure			
	Food consumption	48756.85 (17.97)	44645.33 (18.72)	42110.12 (20.85)
	Education	14846.74 (05.48)	14748.25 (06.18)	12245.66 (06.06)
	Health	12552.64 (04.62)	11758.66 (04.93)	10288.41 (05.09)
	Other	10256.33 (03.78)	8953.69 (03.77)	9566.84 (04.75)
4.	Business expenditure	11781.92 (04.34)	10248.78 (04.30)	8452.22 (04.18)
5.	Land development	8429.45 (03.10)	7562.23 (03.17)	5564.18 (02.75)
6.	Total expenditure	271361.38 (100.00)	238421.74 (100.00)	202018.18 (100.00)

(Figures in the parentheses indicate percentage to the total expenditure)

From Table 4.17 it is revealed that, expenditure on crop production was highest. In cropping sequence I, it was ₹132536.82, in cropping sequence II, it was ₹105642.33 and in cropping sequence III, it was ₹78561.18. For livestock activity, the expenditure was highest in cropping sequence III (₹35229.57) followed by cropping sequence II (₹34862.47) and cropping sequence I (₹32200.63). In case of family expenditure, the maximum expenditure was on food consumption followed by education and health. Business expenditure was highest in cropping sequence I (₹11781) followed by cropping sequence II (₹10248.78) and cropping sequence III (₹8452.22). Land development expenditure was also highest in cropping sequence I (₹8429.45).

Overall, the percentage share of expenditure for crop production was highest i.e. 48.84, 44.30 and 38.89 per cent for cropping sequences I, II and III respectively. The total

expenditure was highest in cropping sequence I (₹271361.38) followed by cropping sequence II (₹238421.74) and cropping sequence III (₹202018.18).

4.5.7 Expenditure function

In order to establish the functional relationship between total family expenditure and the factors like numbers of earners in family (X_1), numbers of animals (X_2), area under vegetables (X_3), area under cash crop (X_4), gross irrigated area (X_5), the multiple linear regression model was used and the result are presented in the Table 4.18.

4.5.7.1 Cropping sequence I

It can be revealed from the Table 4.18 that the five independent variables have jointly explained the 84 per cent of total variation in cropping sequence I. Coefficients of area under cash crops (X_4) and gross irrigated area (X_5) were found to be highly significant at 1 per cent level indicating that, if area under cash crops increased by 1 ha, total expenditure will increase by ₹55259.34 and if gross irrigated area is increased by the 1 ha, total expenditure will increase by ₹69334.34. Number of earners (X_1) and area under vegetables (X_3) had negative impact on total expenditure. Number of animals (X_2) shows positive impact on dependent variable i.e. gross family expenditure but was non-significant.

Table 4.18 Regression analysis of expenditure function

Sr. No.	Particulars	Cropping sequence		
		I	II	III
	Sample size	37	29	25
1.	Constant	61636.46 (23785.4)	76115.2 (10357.62)	59910.43 (15683.56)
2.	No. of Earners(X_1)	-715.191 (4678.98)	709.5327 (2074.33)	1993.035 (4048.34)
3.	No. of Animals(X_2)	4472.497 (4293.54)	1955.777 (1193.02)	1185.868 (2535.90)
4.	Area under vegetables(X_3)	-91649.2 (36108.42)	13613.75 (14593.81)	27176.08 (23581.92)
5.	Area under cash crops(X_4)	55259.34*** (19883.06)	48823.8*** (10876.82)	62901.98** (23443.3)
6.	GIA(X_5)	69334.34*** (14141.48)	16039.05 (13475.63)	40126.86 (24452.8)
7.	R²	0.84	0.93	0.89

(Figures in the parentheses are standard errors of respective regression coefficients)

(* , ** and *** indicates significance at 10, 5 and 1 per cent level)

4.5.7.2 Cropping sequence II

It can be revealed from the Table 4.18 that the five independent variables have jointly explained the 93 per cent of total variation in cropping sequence II. Coefficient of area under cash crops (X_4) was found to be highly significant at 1 per cent level indicating

that, if area under cash crops is increased by 1 ha, total expenditure will increase by ₹48823.80. All other independent variables like number of earners (X_1), number of livestock (X_2), area under vegetables (X_3) and gross irrigated area (X_5) had positive impact on total family expenditure but non-significant.

4.5.7.3 Cropping sequence III

It can be revealed from the Table 4.18 that, the five independent variables have jointly explained the 89 per cent of total variation in cropping sequence III. Area under cash crops (X_4) was found to be significant at 5 per cent level indicating that, increase in area under cash crops by 1 ha, the total expenditure will increase by ₹62901.98. All other independent variables like number of earners (X_1), number of animals (X_2), area under vegetables (X_3) and gross irrigated area (X_5) showed positive relation with dependent variable i.e. total family expenditure.

4.6 Problems in Adoption of Major Cropping Sequences

At the time of survey, questions were asked to the sample farmers to understand the problems faced by them in adoption of major cropping sequences.

The information related to problems in adoption of major cropping sequences is presented in Table 4.19. Out of 90 respondents, unavailability of labour in peak period ranked as first by 48 respondents. Similarly high cost of fertilizers ranked by 43 respondents, high wages of labour as first rank by 40 respondents, etc.

Table 4.19 Problems in adoption of cropping sequences

Sr. No.	Problems	Rank given by the respondent							
		I	II	III	IV	V	VI	VII	VIII
1.	High wages of labour	10	9	40	9	6	4	5	7
2.	High cost of seed	9	16	7	37	8	5	3	5
3.	High cost of fertilizers	21	43	10	8	3	2	0	3
4.	Unavailability of labour in peak period	48	12	9	8	6	3	2	2
5.	Insufficient institutional credit	0	3	7	8	9	32	19	12
6.	Lack of availability of quality seed	1	4	10	15	35	8	12	5
7.	Lack of technical knowledge	1	2	6	2	8	18	29	24
8.	Other	0	1	1	3	15	18	20	32

Garret value is calculated by using Garret raking conversion table. In this table, per cent position is given along with Garret score. The nearest value of per cent position is seen from the table and garret score is given to that per cent position.

Table 4.20 Per cent position and garret value for problems in adoption of major cropping sequences

Sr. No.	$100 (R_{ij}-0.5)/N_j$	Per Cent Position	Garret Value
1.	$100*(1-0.5)/7$	6.25	80
2.	$100*(2-0.5)/7$	18.75	68
3.	$100*(3-0.5)/7$	31.25	59
4.	$100*(4-0.5)/7$	43.75	53
5.	$100*(5-0.5)/7$	56.25	47
6.	$100*(6-0.5)/7$	68.75	40
7.	$100*(7-0.5)/7$	81.25	32
8.	$100*(8-0.5)/8$	93.75	21

4.6.1 Ranking of problems

The Garret scores calculated based on the ranks given by the respondents are presented in Table 4.21. It is observed from the table that, the major problem found was unavailability of labour in peak period which was the problem of 67.99 per cent of respondents which was ranked first, followed by high cost of seed which was faced by 65.58 per cent farmers. After that, 55.53 per cent farmer faced the problem of high wages of labour which was third major problem faced by the farmers. The fourth major problem was of high cost of seed which was faced by 55.10 per cent farmers. Lack of availability of quality seed was ranked at 5, which was faced by 46.57 per cent farmers. Sixth major problem was insufficient institutional credit, which was faced by 40.04 per cent farmer. After that, seventh major problem was about lack of technical knowledge which was faced by 35.60 per cent farmers.

Table 4.21 Garret score and rank for problems in adoption of major cropping sequences

Sr. No	Problems	Garret Score									per cent	Rank
		I	II	III	IV	V	VI	VII	VIII	Total		
1.	High wages of labour	800	612	2360	477	282	160	160	147	4998	55.53	3
2.	High cost of seed	720	1088	413	1961	376	200	96	105	4959	55.10	4
3.	High cost of fertilizer	1680	2924	590	424	141	80	0	63	5902	65.58	2
4.	Unavailability of labour in peak period	3840	816	531	424	282	120	64	42	6119	67.99	1
5.	Insufficient institutional credit	0	204	413	424	423	1280	608	252	3604	40.04	6
6.	Lack of availability of quality seed	80	272	590	795	1645	320	384	105	4191	46.57	5
7.	Lack of technical knowledge	80	136	354	106	376	720	928	504	3204	35.60	7
8.	Other	0	68	59	159	705	720	640	672	3023	33.59	8

5. SUMMARY AND CONCLUSION

The problem of providing food for an ever growing human population in the developing world is a challenge to human beings. India is not exception to this. The increase in population in India during last forty years shows that the per capita food production has been increased significantly. Thus, there is a need for intensifying the efforts through appropriate for increasing the production. The net area under irrigation and gross area irrigated have been increased considerably since independence. With the increase in the area under irrigation and availability of short duration varieties of different crops, it has become possible to increase the productivity per unit time and area by taking more than one crop on the same piece of land and within the period of an agricultural year. This practice of taking more than one crops on the same piece of land in a year is called cropping sequence. Cropping sequence is followed in irrigated area by availability of irrigation in un-irrigated condition by using moisture retentive practices. Such cropping sequences enable the farmers not only to increase food production but also to increase the farm income and employment. The author, therefore, undertook a study on the “Economics of irrigated cropping sequences in Nanded district of Maharashtra” has been up with the following specific objectives:

- a. To identify the different cropping sequences.
- b. To study the resource use structure of major cropping sequences.
- c. To study the employment, income and expenditure pattern of sample farmers adopting major cropping sequences.
- d. To study the constraints in adoption of major cropping sequences.

Naigaon and Kandhar tehsils from Nanded district were selected purposively for this study. Three villages *viz.* Kothala, Ikalimore and Salegaon from Naigaon tahsil, three villages *viz.* Kautha, Telur and Shirur from Kandhar tahsil were randomly selected. Fifteen cultivators from each village were selected randomly. For the purpose of analysis cultivators selected from these villages were grouped into three categories on the basis of their operational holding *viz.* small group farmers (up to 1.00 ha), medium group farmers(1.01 to 2.00 ha) and large group farmers (2.01 and above ha). Thus, total sample of ninety were selected randomly for the present study comprising 30 small, 30 medium and 30 large farmers.

5.1 Summary

1. At overall level, average family size was 4.71 persons. Average family size for small, medium and large group was 4.60, 4.73 and 4.80 persons, respectively.
2. Average illiteracy was 15.36 per cent at overall level, whereas for small, medium and large size group, it was 19.57 per cent, 14.80 per cent and 11.88 per cent respectively.
3. The average investment in farm implements was ₹2426742.33 for small group farmers, ₹4748238.93 for medium group farmers and ₹8368197.30 for large group farmers. At overall level the average per farm investment in farm implements was ₹5181059.52.
4. Total land holding for small farmers was 0.78 ha, whereas for medium group farmers it was 1.68 ha and for large group farmers it was 2.94 ha. At overall level, total land holding was 1.80 ha. Net cropping area for small, medium and large size group was 0.75, 1.65 and 2.86 ha respectively. Overall net cropping area was 1.75 ha. The overall cropping intensity was 178.14 per cent. Cropping intensity for small, medium and large size group was 216.22, 180.00 and 167.83 per cent respectively.
5. The cropping of sample farmers was dominated by soybean, cotton, chickpea, groundnut, wheat, etc. Soybean was major *kharif* crop (20.88 %) followed by cotton (12.84%). Among *Rabi* crops, chickpea was major crop (23.62 %) followed by wheat (7.05%). Groundnut was major crop among summer crops, which was 8.17 per cent.
6. Among existing 17 cropping sequences, three cropping sequences were major *viz.*, Soybean-chickpeas-summer groundnut, Cotton-summer groundnut and soybean-*Rabi* sorghum. Soybean-chickpeas-summer groundnut was dominant cropping sequence which was adopted by 37 (41.11%) farmers followed by Cotton-summer groundnut adopted by 29 (32.22%) and soybean-*Rabi* sorghum adopted by 25 (27.78%) farmers. These sequences were selected on the basis of percentage to the total number of farmers.
7. Per hectare resource utilization of total human labour was highest in cropping sequence II i.e. 126.24 man days followed by cropping sequence I (104.45 man days) and III (63.15 man days). Utilization of bullock labor, machine power, manure and seed were high in cropping sequence I than other two cropping

sequences. Irrigation and plant protection charges were also highest in cropping sequence I than other two sequences. Lowest utilization of resources were in cropping sequence III.

8. Per hectare cost of cultivation was highest in cropping sequence I (₹206733.31) whereas in cropping sequence II, it was ₹164822.05 and in cropping sequence III, ₹111982.54. The gross income was highest in cropping sequence I (₹291316.10) followed by cropping sequence II (₹263614.30) and cropping sequence III (₹151155.70). But the B:C ratio at cost C of cropping sequence II was highest (1.59) than cropping sequence I (1.40) and cropping sequence III (1.34).
9. In case of resource use productivities in adoption of cropping sequences, it was observed that all the seven variables *viz.*, human labour (X_1), bullock labour (X_2), machine power (X_3), manure (X_4), N (X_5), P (X_6) and K (X_7) have jointly explained 81 per cent, 76 per cent and 86 per cent variation in the output of cropping sequences I, II and III respectively.
10. Total employment generated for cropping sequences I, II and III was 392.15 days, 383.64 days and 340.04 days respectively. In cropping sequence I, 68.93 per cent of the total employment was generated from crop production activity, whereas from livestock activity, the employment generated was 18.40 per cent. 68.35 per cent employment was generated from crop production activity in cropping sequence II followed by livestock which was 15.99 per cent. In cropping sequence III, 58.34 per cent of total employment was generated from crop production followed by livestock activities (21.95 %).
11. Independent variables included in the functional analysis of employment function were, no. of earners (X_1), no. of animals (X_2), area under vegetables (X_3), area under cash crops (X_4) and gross irrigated area (X_5). These five variables have jointly explained 90 per cent, 76 per cent and 84 per cent variation in cropping sequences I, II and III respectively. No. of animals and GIA were significant at 1 per cent level and area under cash crops was significant at 5 per cent in cropping sequence I. In cropping sequence II no. of animals and area under cash crops were significant at 1 per cent level and no. of earners was significant at 5 level of significant. Area under cash crops was significant at 5 per cent level in cropping sequence III.
12. Annual income generated from cropping sequence I was highest i.e. ₹394650.95 followed by cropping sequence II (₹378080.77) and cropping sequence III

- (₹297337.16). The share of income from crop production was highest in all three cropping sequences i.e. 64.52 per cent, 59.18 per cent and 49.55 per cent resp. Income from livestock in cropping sequence I, II and III was 20.84 per cent, 23.18 per cent and 28.45 per cent resp.
13. Independent variables included in the functional analysis of income function were, no. of earners (X_1), no. of animals (X_2), area under vegetables (X_3), area under cash crops (X_4) and gross irrigated area (X_5). These five variables have jointly explained 82 per cent, 93 per cent and 87 per cent variation for cropping sequences I, II and III resp. GIA was significant at 1 per cent in cropping sequence I whereas area under cash crops was significant at 10 per cent level. Area under cash crops was significant at 1 per cent level in cropping sequence II. In cropping sequence III, GIA was significant at 5 per cent and area under vegetables was significant at 10 per cent level of significance.
 14. Annual per farm expenditure was highest in cropping sequence I (₹271361.38) followed by cropping sequence II (₹238421.74) and cropping sequence III (₹202018.18). Of the total expenditure, major share was of crop production followed by food consumption and livestock activity. Expenditure on crop production for cropping sequence I, II and III was 48.84 per cent, 44.30 per cent and 38.89 per cent, respectively.
 15. Independent variables included in the functional analysis of expenditure function were, no. of earners (X_1), no. of animals (X_2), area under vegetables (X_3), area under cash crops (X_4) and gross irrigated area (X_5). These five variables have jointly explained 84 per cent, 93 per cent and 89 per cent variation for cropping sequences I, II and III resp. Area under cash crops and GIA were significant at 1 per cent level of significance in cropping sequence I. In cropping sequence II, area under cash crops was significant at 1 per cent level. In cropping sequence III, area under cash crops was significant at 5 per cent level of significance.
 16. Adoption of major cropping sequences faces number of problems such as unavailability of labour in peak period, high cost of fertilizers, high wage rates, high cost of seed material, lack of availability of quality seed, lack of institutional credit, etc.

5.2 Conclusions

1. In Nanded district, among 17 cropping sequences observed, Soybean-chickpea-summer groundnut, Cotton-summer groundnut and Soybean-*Rabi* sorghum were found to be major cropping sequences.
2. The average per hectare resource use structure was highest in cropping sequence I except total human labor, N and K which was highest in cropping sequence II.
3. The average cost of cultivation was highest in cropping sequence I (₹206733.31) followed by cropping sequence II (₹164822.05) and cropping sequence III (₹111982.54). Total gross income for cropping sequence I, II and III was ₹291316.10, ₹263614.30 and ₹151155.70 resp. Benefit cost ratio of cropping sequence I, II and III was 1.40, 1.59 and 1.34 resp. Cropping sequence II (B:C ratio 1.59) was beneficial on the basis of B:C ratio.
4. The results of estimated Cobb-Douglas production function shows that, in cropping sequence I, human labour was found to be significant indicating that, there is need to utilize more human labour in order to increase the output. In cropping sequence II machine power and K were positively significant. It means that, more utilization of these resources is needed in order to get higher output. Similarly, in cropping sequence III, machine power and manure were significant.
5. The average per farm annual employment in cropping sequence I, II and III was 392.15 days, 383.64 days and 340.04 days resp. Employment was highest in cropping sequence I. In all the three cropping sequences, the share of crop production was maximum.
6. Regression analysis of employment function shows that, in cropping sequence I, no. of animals, area under cash crops and GIA were significant indicating that, there is scope for increasing these variables. In cropping sequence II no. of earners, no. of animals, area under vegetables and area under cash crops had significant effect on employment. Area under cash crops was significant in cropping sequence III.
7. The average per farm annual income was highest in cropping sequence I (₹394650.95) followed by cropping sequence II (₹378080.77) and cropping sequence III (₹297337.16). Major share of income in all the cropping sequences was from crop production followed by livestock activities.
8. Functional analysis of income function shows that, GIA and area under cash crops were significant in cropping sequence I. In cropping sequence II, area under cash

crop was found to be significant indicating that, there is scope for increasing this resource. Area under vegetable and GIA were significant in cropping sequence III.

9. In cropping sequence I, total per farm average annual expenditure was ₹271361.38 which was more than other cropping sequences. In cropping sequences II and III, total expenditure was ₹238421.74 and ₹202018.18 resp.
10. Regression analysis of expenditure function shows that, area under cash crops and GIA was significant in cropping sequence I. Whereas, in cropping sequence II and III area under cash crops was significant.
11. Unavailability of labor in peak period, high cost of fertilizers, high wages of labour, high cost of seed, lack of availability of quality seeds, etc. were some of the major problems faced by farmers.

5.3 Policy Implications

1. The cropping sequence II i.e. Cotton-summer groundnut (B:C ratio 1.59) was beneficial on the basis of benefit cost ratio than Soybean-chickpea-summer groundnut (B:C ratio 1.40) and Soybean-*rabi* sorghum (B:C ratio 1.34). This cropping sequence also generates good amount of employment. Hence this cropping sequence (Cotton-summer groundnut) may suggested to adopt by the farmers to get the maximum income from crop production in Nanded district of Maharashtra.

6. LITERATURE CITED

Anonymous, 2018.<https://www.indiastat.com>

- Avasthe, R.K., Babu, S., Singh, R., Yadav, G.S. and Rajkhowa, D.J. 2016. Intensification of maize based cropping sequence in rainfed ecosystem of Sikkim Himalayas for improving system productivity, profitability, employment generation and energy use efficiency under organic management condition. *Indian Journal of Agricultural Sciences*,**86**(6).
- Bhaskar, B.P., Dharam Singh, Baruah, U., Dipak Sarkar and Vadivelu, S. 2013. Economic appraisal of rice based cropping sequences in major soil series of upper Asom. *Indian Journal of Agricultural Sciences*,**83**(3).
- Chitale, S., Sarawgi, S.K., Tiwari, A. and Urkurkar, J.S. 2011. Assessment of productivity and profitability of different rice (*Oryza sativa*) based cropping systems in Chhattisgarh plains. *Indian Journal of Agronomy*,**56**(4): 305-310.
- Choudhari, J. 2012. An economic study on diversification of agriculture in Mhow block of Indore district in Madhya Pradesh. *M.Sc. (Agri) Thesis, The Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior*.
- Dixit, H., Singh, Y.P., Mishra, V.K. and Gupta, R.K. 2019. Jatropha (*Jatropha curcas*) based intercropping systems: An alternate land use for rehabilitation of degraded sodic lands. *Indian Journal of Agricultural Sciences*,**89**(1).
- Ghorai, A.K., Kumar, M., Mitra, S., Majumdar, B., Naik, M.R. and Kundu, D.K. 2016. Productivity and resource use efficiency of different jute based cropping systems under nutrient and crop residue management practices. *Journal of Agri. Search*,**3**(2): 76-81.
- Grover, D.K., Weinberger, K., Shnmugasudurama, S. and Singh, G. 2003. Constraints analysis of mungbean production in Punjab. *Journal Research, Punjab Agricultural University*,**42**(2):228-236.
- Gullani, P., Sharma, S.K., Sirothia, P. and Joshi, O.P. 2013. Feasibility of organic farming system under soybean-wheat cropping sequence in Malwa region of western Madhya Pradesh,**11**(2):62-69.

- Hiremath, S.M., Ganajaxi Ganajaxi, Halikatti, S.I. and Chittapur, B.M. 2011. Productivity, profitability and energy use efficiency of different cropping sequences in Northern Transition Zone of Karnataka. *Indian Journal of Agricultural Sciences*,**81**(10).
- Hussain, A., Raja, W., Sheikh, T.A., Ansar-ul-Haq, Allam, I. and Teli, N.A. 2019. Direct and residual effect of organic and chemical sources of nutrients on fodder sorghum-fodder oat cropping sequence. *Indian Journal of Agricultural Research*,**53**(1):108-111.
- Jat, Ram Niwas 2010. Economic viability of different cropping pattern prevailing in Dewas district of Madhya Pradesh. *M. Sc. (Ag.) Thesis, The Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior*.
- Kaur, A., Sekhon, K.S., Thanam, S., Sidhu, A.S. and Buttar, G.S. 2018. Evaluation of mustard and barley based cropping sequences under variable irrigation supplies. *Indian Journal of Agricultural Sciences*,**88**(7).
- Kumar, M., Kumar, R., Rangnamei, K.L., Das, A., Meena, K.L. and Rajkhowa, D.J. 2019. Crop diversification for enhancing the productivity for food and nutritional security under the Eastern Himalayas. *Indian Journal of Agricultural Sciences*,**89**(7).
- Kumar, R., Singh, A., Nath, C.P., Tripathi, C.M., Prahraj, C.S., Singh, N.P. and Shantanu Kumar Dubey. 2020. Summer Mungbean for doubling farmer's income and livelihood security. *Indian Farming*,**70**(3).
- Kumara, B.H., Antil, R.S. and Dev, R. 2014. Impact of long term manures and fertilizers application on carbon sequestration and its efficiency under pearl millet-wheat cropping sequence. *International Journal of Farm Sciences*,**4**(1):21-26.
- Mali, D.V., Kharches, V.K., Jadhao, S.D., Katkar, R.N., Konde, N.M., Jadhao, S.M. and Sonune, B.A. 2015. Effect of long term fertilization and manuring on soil quality and productivity under sorghum-wheat sequence in inceptisol. *Indian Journal of Agricultural Sciences*,**85**(5).
- Mishra, M.M., Mohanty, M., Gulati, J.M.L. and Nanda, S.S. 2013. Evaluation of various rice based crop sequences for enhanced productivity, profitability and energy efficiency in Eastern Plateau and Hills Zone of India. *Indian Journal of Agricultural Sciences*, **83**(12).

- Ramasamy, C. 2004. Constraints to growth in Indian agriculture. Need technology Resource Management and Trade strategies. *Indian Journal of Agricultural Economics*, **59**(1): 1-34.
- Reddy, T.Y. and Reddy, G.H.S. 2000. Principles of Agronomy
- Sah, K.D., Sarkari, D., Seal, A. and Singh, D.S. 2010. Micro-level planning for optimum land use in coastal area of West Bengal-A case study. *Agropedology*, **20**(1):19-29.
- Saren, B.K., Damodaran, V., Ravisankar, N., Bommayasamy, N. and Subramani, T. 2015. Evaluation of System of Rice Intensification (SRI) in rice-groundnut system under Island Ecosystem. *Indian Journal of Agricultural Sciences*, **85**(11).
- Sharma, B.C. and Kumar, A. 2009. Performance of rice (*Oryza sativa* L.)-based multiple crop sequences under sub-tropical irrigated conditions of Jammu. *Green Farming*, **2**(11): 751-753.
- Singh, M., Singh, A., Singh, S. and Ram, M. 2012. Evaluation of alternate menthol mint (2 M2 *Enthearvensil*) based intensive cropping systems for indo-gangetic plains of north India. *Archives of Agronomy and Soil Science*, **58**(4):411–421.
- Singh, Y., Singh, K., Babu, S., Yadav, S.K. and Yadav, M.K. 2014. Profitability of high value crops with organic Nitrogen sources under rice based cropping sequence. *Indian Journal of Agricultural Sciences*, **84**(3).
- Srivastava, A.K., Yadav, S.K., Bag, T.K., Yogesh Kumar and Sushil Kumar. 2015. Productivity, profitability and resource use efficiency of potato (*Solanum tuberosum*) based cropping systems in Eastern Himalayan Region. *Indian Journal of Agricultural Sciences*, **85**(7).
- Talathi, M.S. and Mahadkar, U.S. 2015. Evaluation of organic manure for sustaining productivity in groundnut-rice cropping system. *International Journal of Farm Sciences*, **5**(4):51-55.
- Tiwari, J.K., Singh, R.K., Singh, A.K. and Singh, R.K. 2017. Rice-potato based cropping sequences in relation to production potential and economic returns under irrigated ecosystems of Central Plains. *Indian Journal of Agricultural Sciences*, **87**(10).
- Tripathi, S.C., Subhash Chander and Raj Pal Meena. 2017. Improving sustainability of rice-wheat system through intensification. *Indian Farming*, **67**(4).

- Yadav, S.K., Babu, S., Singh, Y., Yadav, M.K., Yadav, G.S., Pal, S., Singh, R. and Singh, K. 2013. Effect of organic nutrient sources on yield, nutrient uptake and soil biological properties of rice (*Oryza sativa*) based cropping sequence. *Indian Journal of Agronomy*,**58**(3):271-276.
- Yadav, S.K.,Yadav, M.K.,Subhash Babu, Yogeshwar Singh and Kalyan Singh. 2014. Profitability of high value crops with organic nitrogen sources under Rice (*Oryza sativa*) based cropping sequence. *Indian Journal of Agricultural Sciences*,**84**(3).
- Yaduvanshi, N.P.S., Singh, R., Singh, K.N., Kumar, S., Mishra, V.K., Singh, Y.P. and Sharma, D.K. 2014. Bio-Chemical amelioration effects on physico-chemical dynamics of sodic soils under rice-wheat cropping system. *Indian Journal of Agricultural Sciences*,**84**(3).

4. Buildings

Sr. No.	Building type	Size	Building year	Present value (₹)	Repairing charges (₹)	Remaining life (years)
1	House					
2	Farm house					
3	Cattle shed					
4	Store house					
5	Shop					
6	Other					

5. Irrigation structure

Sr. No.	Type	Digging/ Purchasing Year	Present value (₹)	Irrigation capacity (ha)	Remaining life (years)	Repairing Charges (₹)
1	Well					
2	Bore-well					
3	Pipe line					
4	Electric motor (hp)					
5	Diesel engine					
6	Drip/sprinkler system					
7	Other					

6. Farm implements and machineries

Sr. No.	Particulars	Number	Purchase Year	Purchase Cost (₹)	Repairing charges (₹)	Remaining life
A	Implements					
1	Wooden					
2	Plough					
3	Iron plough					
4	Harrow					
5	Seed drill					
6	Hoes					
7	Other					
B	Machineries					
1	Tractor					
2	Trolley					
3	Rotavator					
4	Plough					
5	Harrow					
C	Bullock cart					
D	Spade					
E	Sickle					
F	Axe					
G	Other					

7. Livestock

Sr. No.	Type	Number	Age (years)	Present value (₹)
1	Bullock			
2	Cow			
A	Local			
	Milch			
	Dry			
B	Crossbreed			
	Milch			
	Dry			
C	Calves			
3	Buffalo			
A	Milch			
	Dry			
B	Calves			
C	Goats			
4	Poultry			
5	Other			

8. Cropping pattern (2020-21)

Sr. No.	Season	Crop	Area (ha)	
			Irrigated	Rainfed
1.	<i>Kharif</i>	1		
		2		
		3		
		4		
		5		
		6		
2.	Rabi	1		
		2		
		3		
		4		
		5		
		6		
3.	Summer	1		
		2		
		3		
		4		
		5		
		6		
4.	Annual	1		
		2		
		3		
		4		
5.	Fruit crops	1		
		2		
		3		
		4		
6.	Vegetables	1		
		2		
		3		
		4		

10. Annual family employment of farm family.

Sr. No.	Particulars	Employment
1	Crop production	
2	Livestock activity	
3	Wage earnings	
4	Service / business	
	Total employment	

11. Annual income of farm families

Sr. No.	Particulars	Income (₹)
1	Crop production	
2	Livestock activity	
3	Wage earnings	
4	Service / business	
	Total employment	

12. Annual expenditure of farm families

Sr. No.	Particulars	Expenditure (₹)
1	Crop production	
2	Livestock activity	
3	Family expenditure	
	(a) food consumption	
	(b) education	
	(c) health	
	(d) other	
4	Business expenditure	
5	Land development	
	Total expenditure	

13. Constraints in adoption of major cropping sequence

Sr. No.	Constraints	Yes	No
1	High wages of labour		
2	High cost of seed		
3	High cost of fertilizers		
4	Unavailability of labor in peak period		
5	Insufficient institutional credit		
6	Lack of availability of quality seed		
7	Lack of technical knowledge		
8	Other		

Appendix-II Cost of cultivation (2020-21)

1. Cost of cultivation of soybean (per ha.)

Sr. No	Cost items	Qt	Value(₹)
1	Hired human labour		
	a. male	11.75	3525.53
	b. female	19.67	5901.02
2	Bullock labour	3.69	1845.94
3	Machine power (hr)	3.42	1710.00
4	Seed(kg)	75.02	7502.04
5	Manures(q)	6.80	1020.00
6	Fertilizers(kg)		
	N	50	720.00
	P	74.89	3744.50
	K	0.00	0000
7	Irrigation charges		1265.31
8	Plant protection charges		1493.87
9	Incidental charges		280.82
10	Repairs		199.18
11	Working capital		29208.21
12	Int. on working capital		1752.49
13	Depre.on farm implements		2386.90
14	Land revenue and taxes		168.28
15	Cost 'A'		33515.88
16	Rental value of land		14158.25
17	Interest on fixed capital		6546.91
18	Cost 'B'		54221.07
19	Family labour		
	a. Male	7.10	2130.61
	b. Female	9.71	2913.00
20	Cost 'C'		59264.68
21	Output (q)	21.48	85959.18
22	Per quintal cost		4001.82

2. Cost of cultivation of cotton**(per ha)**

Sr. No	Cost items	Qt	Value(₹)
1	Hired human labour		
	a. male	14.76	4428.00
	b. female	49.48	14845.50
2	Bullock labour	8.74	4370.00
3	Machine power (hr)	1.53	765.23
4	Seed(kg)	1.49	2738.46
5	Manures(q)	7.25	1087.50
6	Fertilizers(kg)		
	N	120.41	1733.90
	P	60.20	3010.00
	K	60.20	1705.47
7	Irrigation charges		1775.89
8	Plant protection charges		3558.97
9	Incidental charges		411.28
10	Repairs		396.41
11	Working capital		40826.61
12	Int. on working capital		2449.60
13	Depre.on farm implements		1986.79
14	Land revenue and taxes		175.89
15	Cost 'A'		45438.89
16	Rental value of land		21169.74
17	Interest on fixed capital		6367.06
18	Cost 'B'		72975.69
19	Family labour		
	a. Male	12.05	3615.08
	b. Female	14.51	4353.00
20	Cost 'C'		80943.77
21	Output (q)	24.26	128073.8
22	Per quintal cost		5236.05

3. Cost of cultivation of chickpea**(per ha)**

Sr. No	Cost items	Qt	Value(₹)
1	Hired human labour		
	a. male	7.78	2334.05
	b. female	11.86	3558.00
2	Bullock labour	2.42	1210.34
3	Machine power (hr)	2.82	1410.00
4	Seed(kg)	100	8000
5	Manures(q)	5.88	882.00
6	Fertilizers(kg)		
	N	25.05	360.72
	P	50.10	2505.05
	K	30.10	852.73
7	Irrigation charges		1865.97
8	Plant protection charges		3185.56
9	Incidental charges		384.74
10	Repairs		274.22
11	Working capital		26823.38
12	Int. on working capital		1609.40
13	Depre.on farm implements		2366.97
14	Land revenue and taxes		81.85
15	Cost 'A'		30881.60
16	Rental value of land		13942.20
17	Interest on fixed capital		5729.05
18	Cost 'B'		50552.85
19	Family labour		
	a. Male	7.16	2148.00
	b. Female	9.08	2724.75
20	Cost 'C'		55425.60
21	Output (q)	19.12	84144.33
22	Per quintal cost		4400.85

4. Cost of cultivation of Summer groundnut

(per ha)

Sr. No	Cost items	Qt	Value(₹)
1	Hired human labour		
	a. male	10.61	3183.03
	b. female	43.98	13194.00
2	Bullock labour	4.68	2340.53
3	Machine power (hr)	1.47	735.29
4	Seed(kg)	100	10000
5	Manures(q)	6.01	901.5
6	Fertilizers(kg)		
	N	25.46	366.62
	P	50.92	2546.00
	K	0.00	0.00
7	Irrigation charges		5865.55
8	Plant protection charges		4084.03
9	Incidental charges		469.75
10	Repairs		326.89
11	Working capital		44013.17
12	Int. on working capital		2640.79
13	Depre.on farm implements		2530.18
14	Land revenue and taxes		152.69
15	Cost 'A'		49336.83
16	Rental value of land		20049.41
17	Interest on fixed capital		7498.47
18	Cost 'B'		76884.71
19	Family labour		
	a. Male	11.21	3363.02
	b. Female	10.77	3323.25
20	Cost 'C'		83570.98
21	Output (q)	23.44	121212.60
22	Per quintal cost		51714.18

5. Cost of cultivation of *Rabi*. sorghum

(per ha)

Sr. no	Cost items	Qt	Value(₹)
1	Hired human labour		
	a. male	10.69	3207.42
	b. female	19.40	5820.00
2	Bullock labour	4.80	2400.00
3	Machine power (hr)	2.29	1145.07
4	Seed(kg)	10	400
5	Manures(q)	4.11	616.50
6	Fertilizers(kg)		
	N	80	1152.00
	P	40	2000
	K	40	1133.20
7	Irrigation charges		2165.14
8	Plant protection charges		1935.78
9	Incidental charges		372.47
10	Repairs		185.32
11	Working capital		22532.90
12	Int. on working capital		1351.97
13	Depre.on farm implements		2311.77
14	Land revenue and taxes		138.99
15	Cost 'A'		26335.63
16	Rental value of land		12355.66
17	Interest on fixed capital		6897.45
18	Cost 'B'		45588.74
19	Family labour		
	a. Male	8.65	2595.00
	b. Female	15.27	4583.25
20	Cost 'C'		52766.99
21	Output (q)	25.41	74967.89
22	Per quintal cost		2950.33

8. VITAE

MR. WAGHMARE PRADNYASHEEL SADASHIV

MASTER OF SCIENCE (AGRICULTURE)

IN

AGRICULTURAL ECONOMICS

2021

Title of thesis		:	Economics of irrigated cropping sequences in Nanded district of Maharashtra.
Major field		:	Agricultural Economics
Biographical information			
Personal	Date of Birth	:	5 th June, 1996
	Place of Birth		Aurala
	Father's Name	:	Mr. Sadashiv Mahadu Waghmare
	Mother's Name	:	Mrs. Suvarnamala Sadashiv Waghmare
Educational	Bachelor Degree	:	College of Agriculture, Parbhani
	Class	:	First class
	Name of University	:	Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani.
Address		:	At. Aurala. Post Salegaon, Tq. Naigaon Dist. Nanded PIN Code 431 809.
	e-mail id	:	pswaghmare5696@gmail.com
	Contact number	:	9689336932

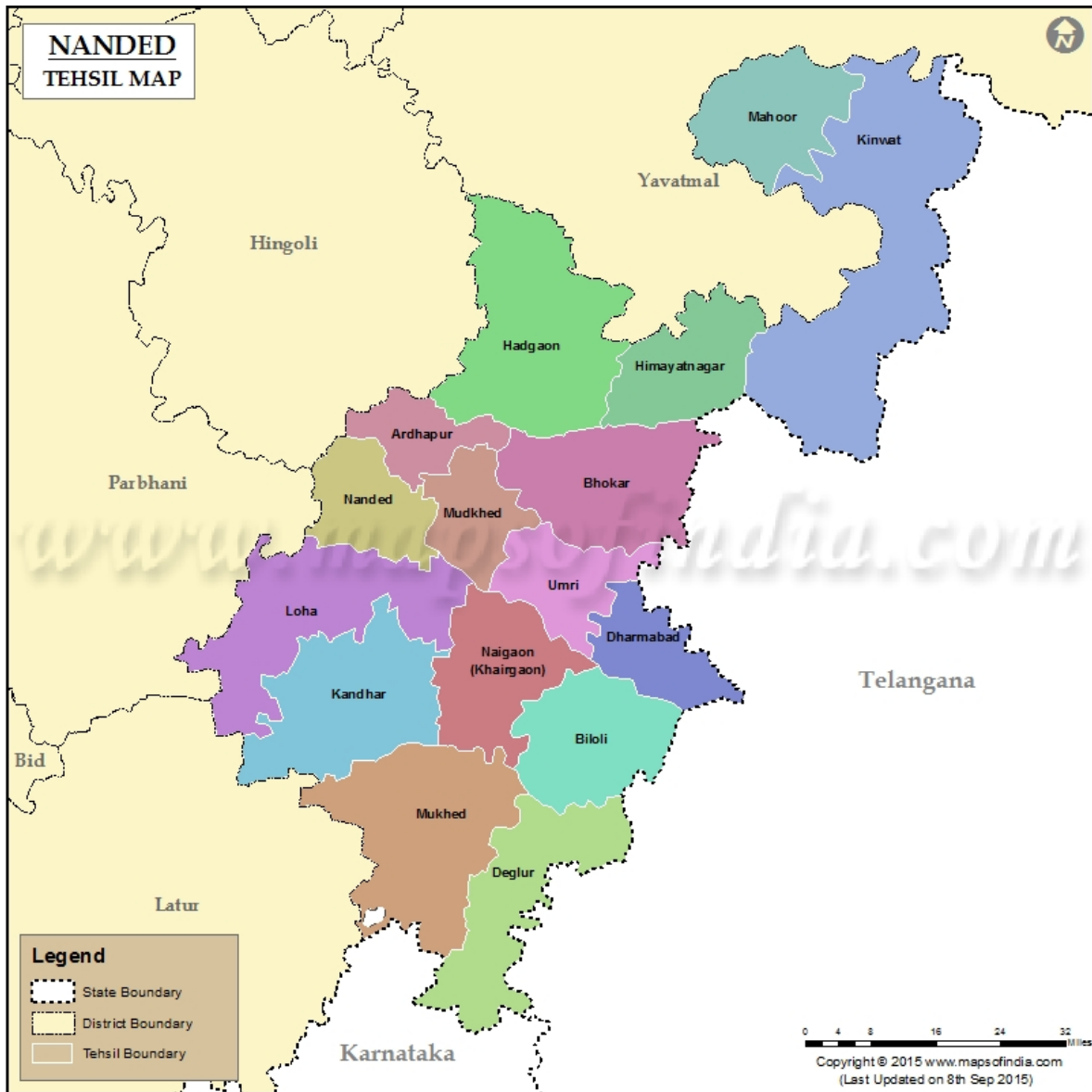


Fig. 1. Map of Nanded district

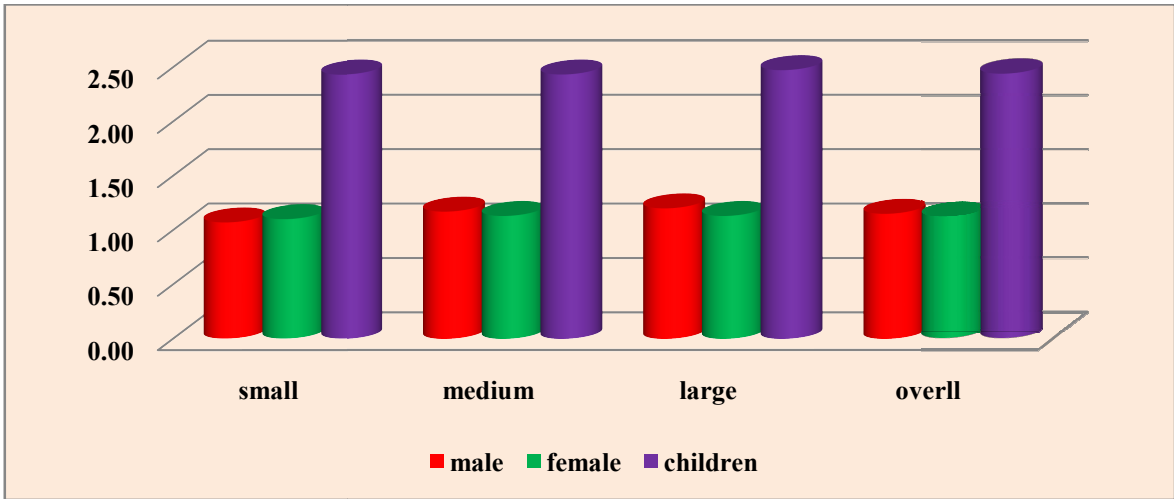


Fig.2. Size and composition of family

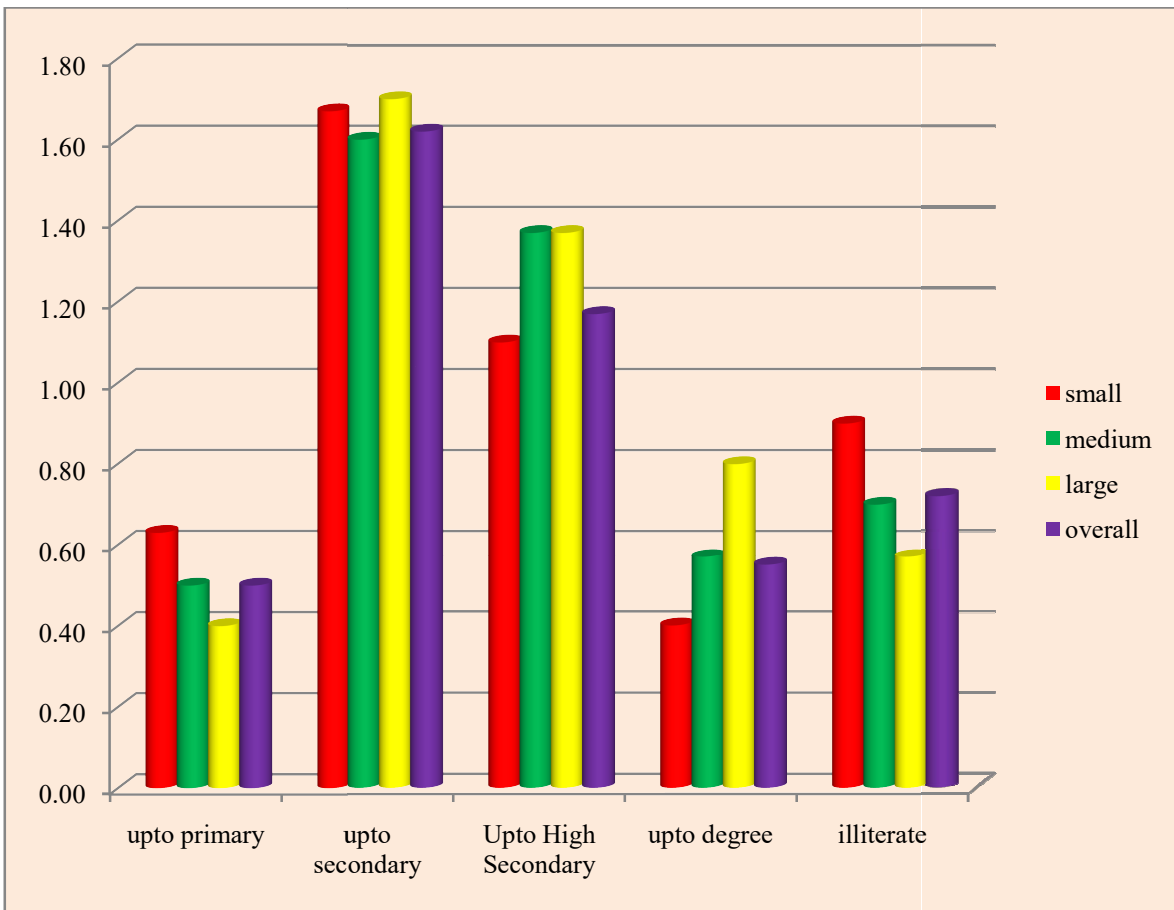


Fig 3. Educational status of sample families

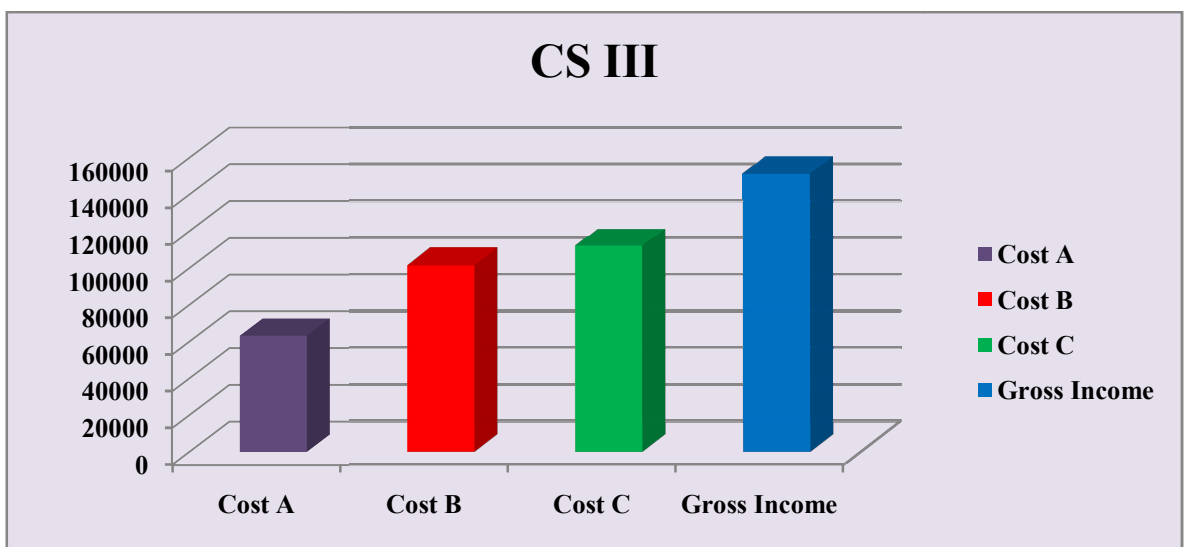
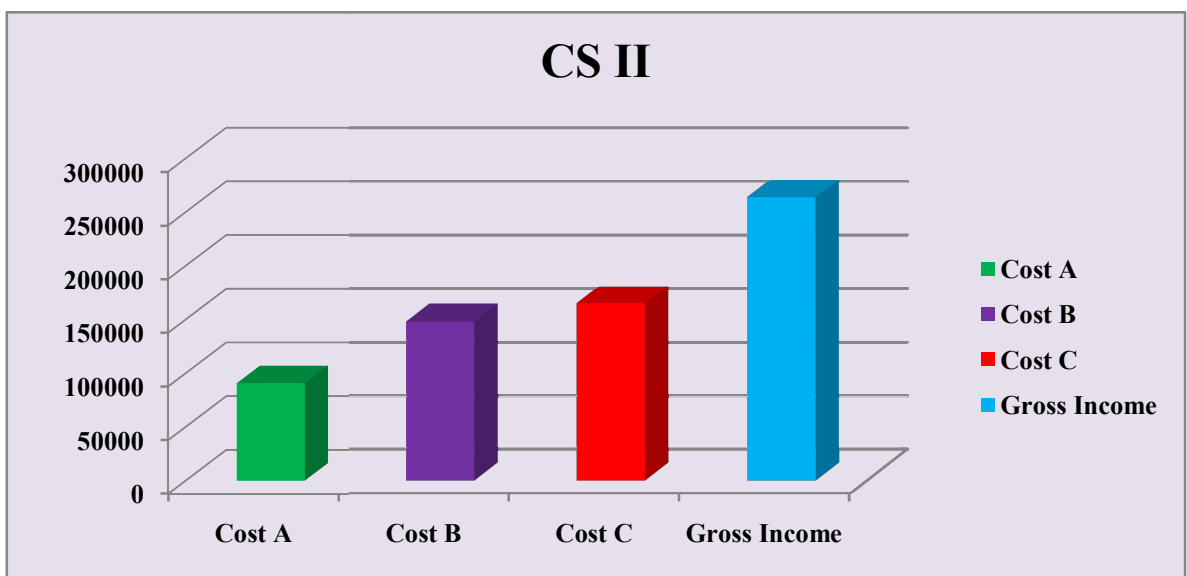
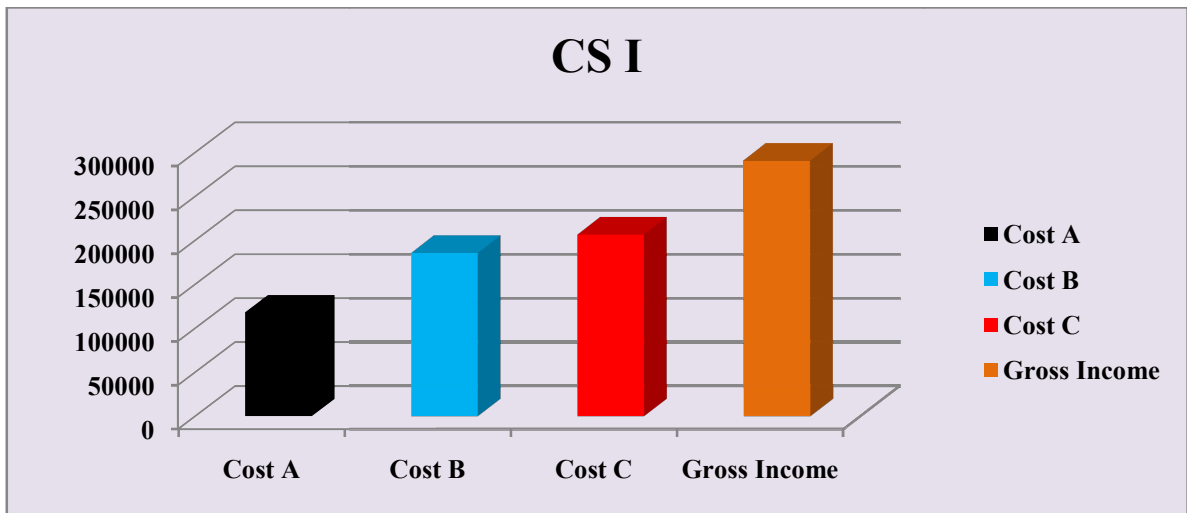


Fig. 4. Cost and return of major cropping sequences (₹)

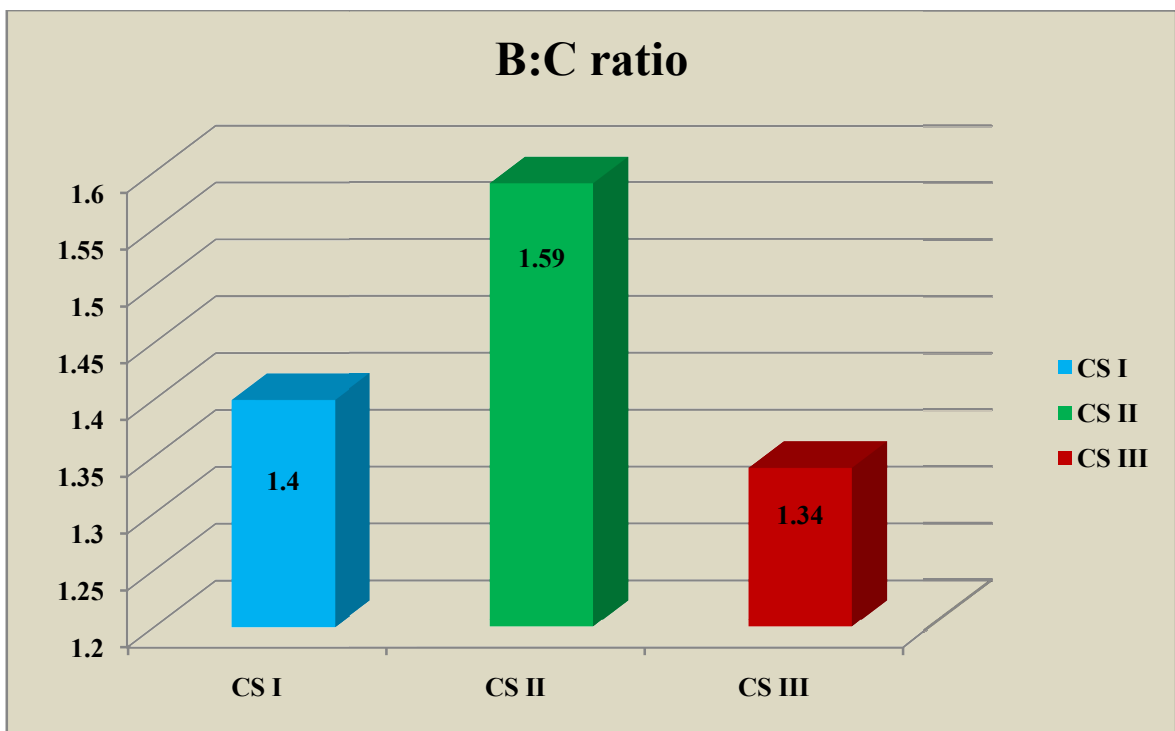


Fig. 5. B:C ratio of major cropping sequences

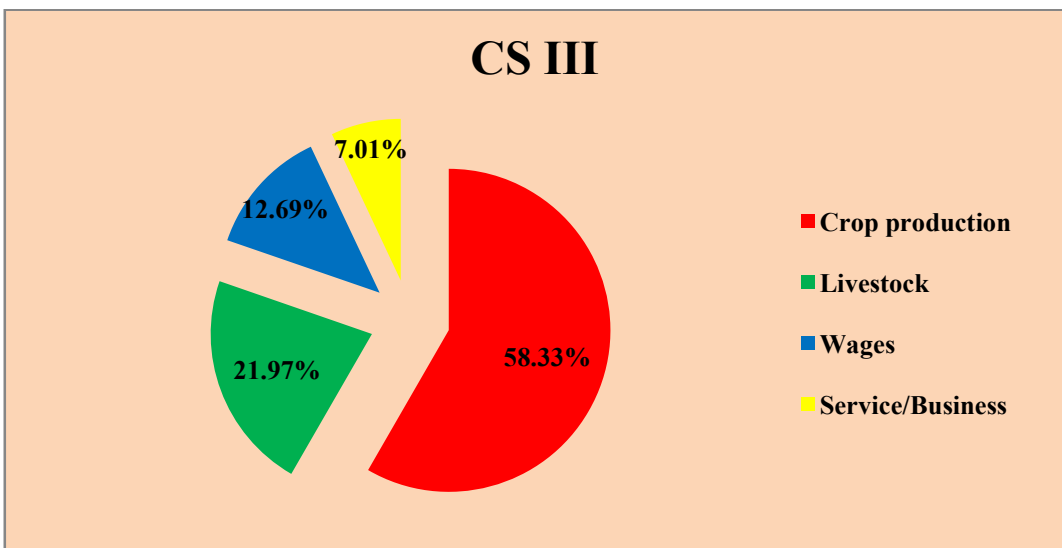
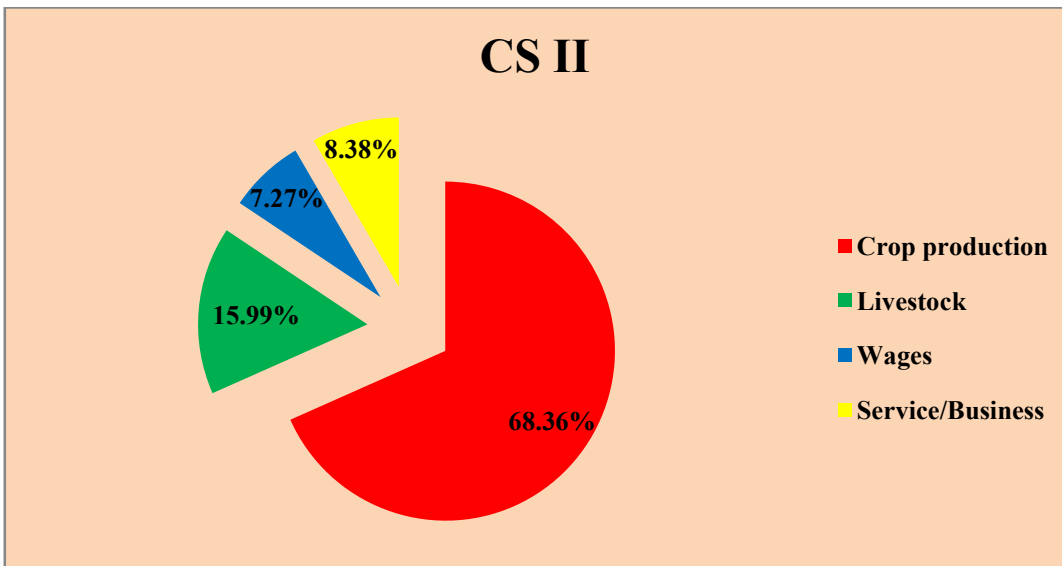
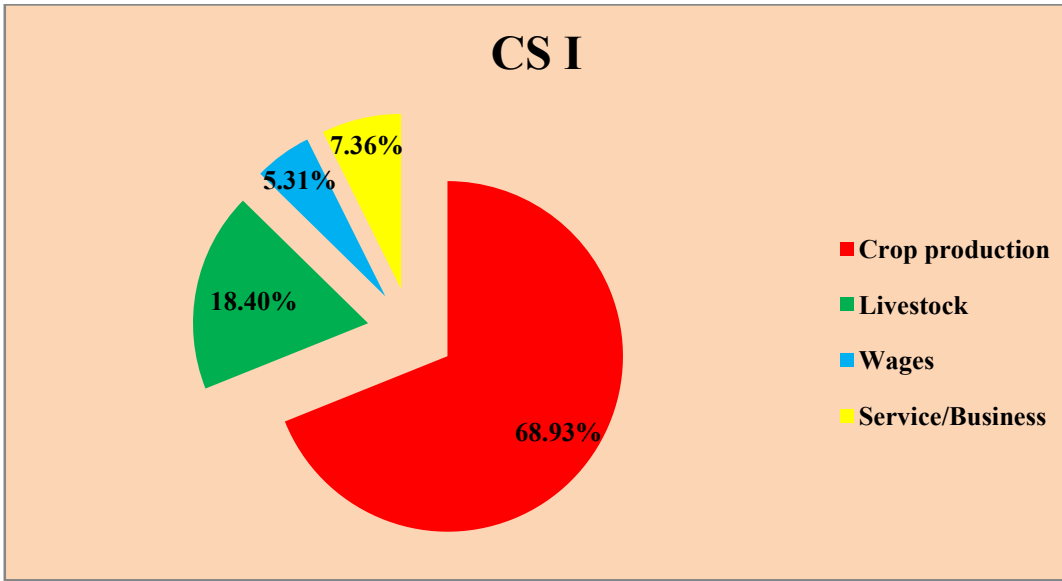


Fig. 7. Average annual employment of farm families

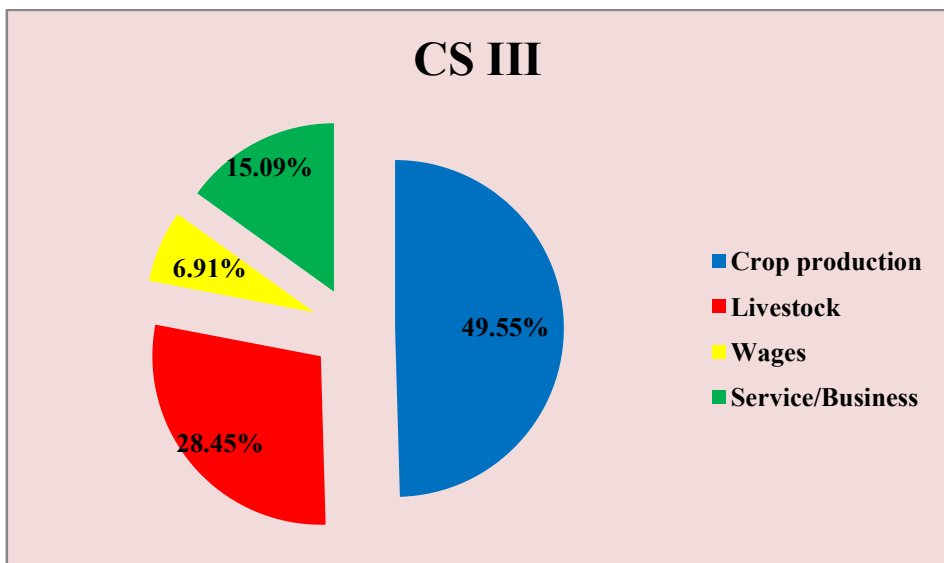
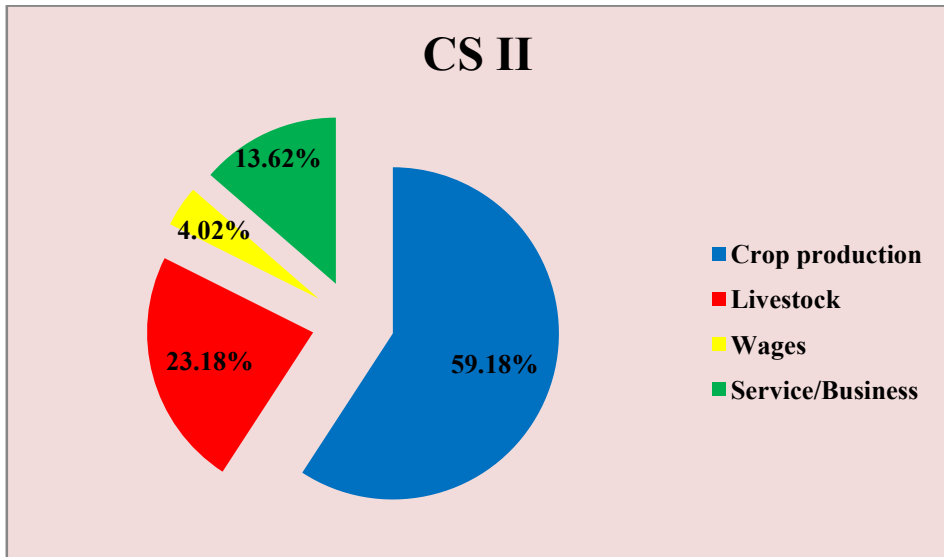
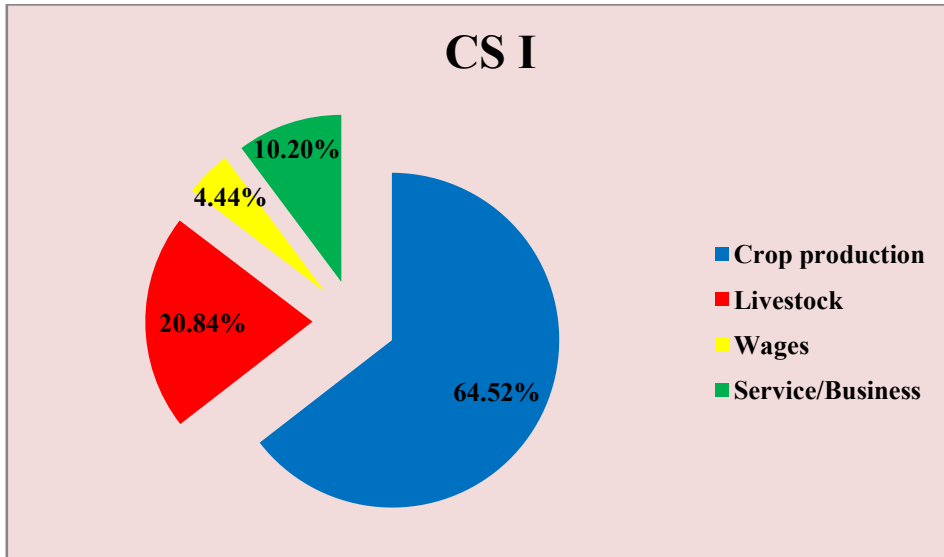


Fig. 8. Average annual income of farm families

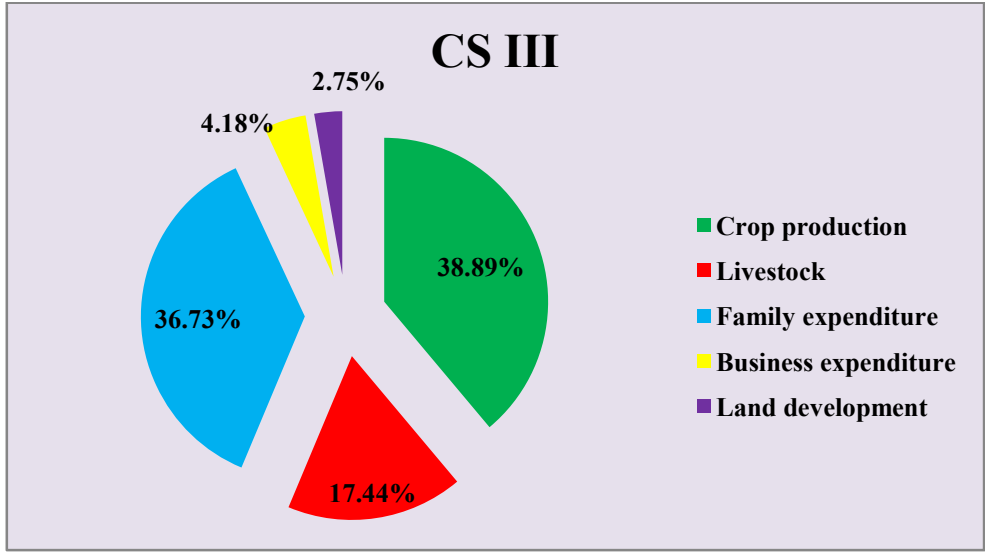
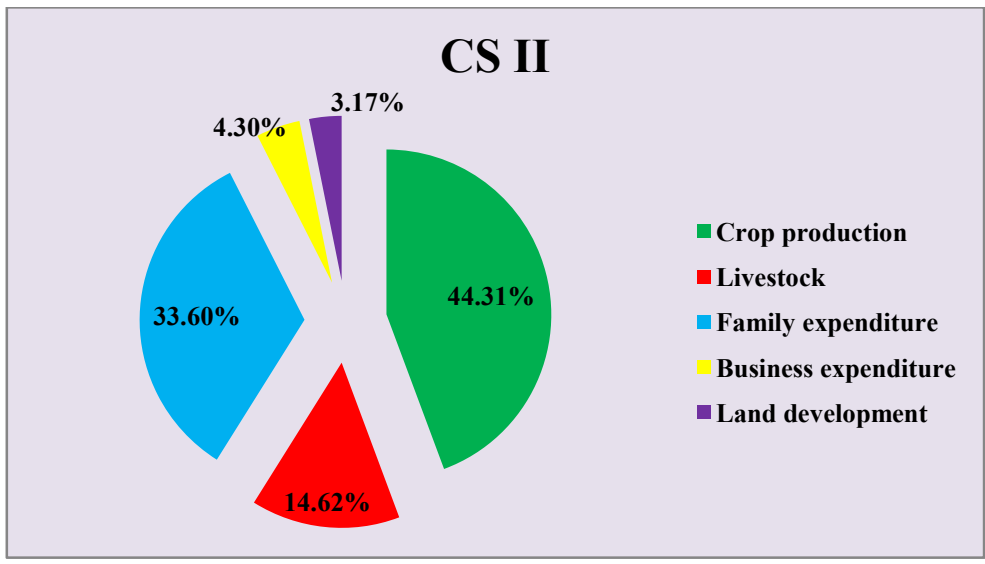
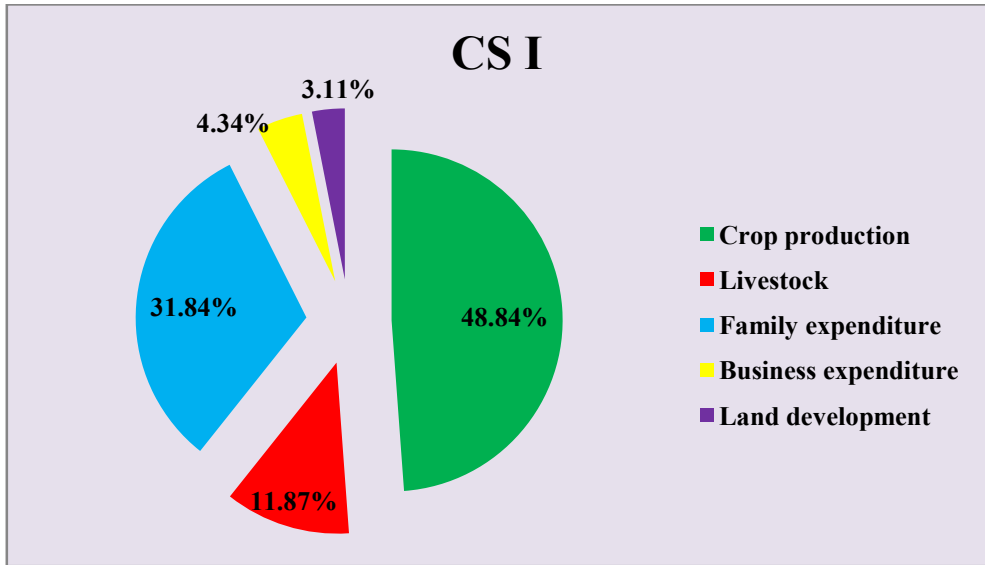


Fig. 9. Average annual expenditure of farm families



Plate 1. Data collection



Plate 2.Cropping sequence I - Soybean-chickpea-Summer groundnut



Plate 3. Cropping sequence II – Cotton-summer groundnut



Plate 4. Cropping sequence III – Soybean-*Rabi* sorghum