

**Impact of Drought on Rural Households: A Study of Three Districts
of the Marathwada Region of Maharashtra**

*A Thesis Submitted to the University of Hyderabad in Partial Fulfillment of
the Requirements for the Award of the Degree of*

DOCTOR OF PHILOSOPHY

IN ECONOMICS

By

BHAGAT NITIN DATTUJI

(Registration No. 15SEPH17)



SCHOOL OF ECONOMICS

UNIVERSITY OF HYDERABAD

HYDERABAD-500046, INDIA

NOVEMBER, 2022

**Impact of Drought on Rural Households: A Study of Three Districts
of the Marathwada Region of Maharashtra**

*A Thesis Submitted to the University of Hyderabad in Partial Fulfillment of
the Requirements for the Award of the Degree of*

DOCTOR OF PHILOSOPHY

IN ECONOMICS

By

BHAGAT NITIN DATTUJI

(Registration No. 15SEPH17)

Under the supervision of

Prof. Bopanna Nagarjuna



**SCHOOL OF ECONOMICS
UNIVERSITY OF HYDERABAD
HYDERABAD-500046, INDIA
NOVEMBER, 2022**





**SCHOOL OF ECONOMICS
UNIVERSITY OF HYDERABAD**

DECLARATION

This is Bhagat Nitin Dattuji, hereby declare that this thesis entitled, “**Impact of Drought on Rural Households- A Study of Three Districts of Marathwada Region of Maharashtra**” was submitted to the University of Hyderabad in the fulfilment of the requirement for the award of a degree of Doctor of Philosophy (PhD) in the School of Economics, which is original research work has been done by me under the supervision of Prof. B. Nagarjuna. The thesis has not been submitted to any other university or institution to award any degree. I hereby agree that my thesis can be deposited in Shodhganga/INFLIBET.

A plagiarism statistics report is enclosed which is checked by the University of Hyderabad.

Date:

Name: **Bhagat Nitin Dattuji**

Place: **Hyderabad**

Signature of the Scholar

(Reg. no. 15SEPH17)



**School of Economics,
University of Hyderabad**

CERTIFICATE

This is to certify that the thesis entitled **“Impact of drought on Rural Households- A Study of Three Districts of Marathwada Region of Maharashtra”** was submitted by Mr Bhagat Nitin Dattuji bearing registration number 15SEPH17 in the partial fulfilment of the requirements of the award of Doctor of Philosophy in the School of Economics, which is a bonafide work completed by him under my guidance and supervision. This thesis is free from plagiarism, and it has not been submitted previously to any other institution or university for the award of any degree. The researcher has fulfilled the UGC regulations of Publication and conference presentations before submitting the thesis, which is mentioned below.

A. Publication: 1) Bhagat Nitin Dattuji and prof. B. Nagarjuna (2022): “Impact of the 2015 Drought on Rural Livelihood – A Case Study of Masurdi Village in Latur District of Maharashtra, India” in, International **Journal of Science and Research (IJSR)**, **Volume 11, Issue 3, March 2022, pp. 1317-1327, ISSN: 2319-7064, peer-reviewed journal, DOI: 10.21275/SR22326212841**

B. presentations in Conferences: 1) Presentations titled: “Impact of Drought on Rural Livelihood A Case Study of Masurdi Village in the Marathwada Region of Maharashtra”. In, the 3rd International Conference on Climate Change, organised by the International Society of Environmental, Relationship and Sustainability (ISERS), which is held between 1st to 3rd June 2022, in Bali, Indonesia (Hybrid Event).

2) Presentations titled: “Effect of drought on Rural Farm Households- A Study of two Villages of Beed District of Maharashtra state, India”. In, the 7th Go Green Summit, organised by the International Society of Environmental, Relationship and Sustainability (ISERS), which is held between 14th to 15th October 2021, in Manila, Philippines (virtual).

3) Presentations titled: “Rainfall trends Analysis of Beed districts of Maharashtra, India”. In, the 2nd International Conference on Climate Change, organised by the International Society of Environmental, Relationship and Sustainability (ISERS), which is held between 26th to 27th May 2021, in Kuala Lumpur, Malesia (virtual).

In addition, the student has passed the following courses towards the fulfilment of coursework requirements for a PhD degree in economics.

Course code	Title of the course	Credits	Pass/Fail
EC-801	Research Methodology	4	Pass
EC-823	Institution, Behavioural Economics and Development	4	Pass
EC-824	Applied Environmental and Resources	4	Pass
Total Credits	-	12	Pass

Signatures of supervisor and dean:

Prof. B. Nagarjuna

Supervisor

School of Economics,
University of Hyderabad

Prof. R. Ramamurthy

Dean

School of Economics,
University of Hyderabad

ACKNOWLEDGEMENTS

Receiving a doctoral degree that is a proud moment in one's life, here I am heartily satisfied to accept such a distinguished degree from a prestigious institution. Undoubtedly, I would be the first candidate in my family to be awarded a doctorate degree. It has been a life-changing and thought-provoking experience for me to pursue this degree, and I could not have done it without the help, love, support, direction, cooperation, guidance and encouragement which I have ever had from so many people. First and foremost, I would like to express my sincere gratitude to my guide and mentor Prof. Bopanna Nagarjuna for his valuable guidance and immense support in the completion of my thesis work. He gave a lot of his invaluable time to help me at different stages until I finished my thesis. He always motivated, encouraged and inspired me to learn new things and come up with new ideas. I am truly grateful to him for my academic and professional progress thus so far. I felt extremely fortunate to do research under his guidance and supervision. He is much more to me than a guide. I do not have words to express my gratitude and sincere thanks to him. I never forget his assistance throughout my life. I would like to pay my gratitude and thanks to doctoral research committee members Prof. Phanindra Goyari and Dr Lima Kumba Walling for giving me suggestions and insights whenever required during the research work.

My special thanks to Prof. G. Sridevi and Dr B. Nageswara Rao who helped me a lot as the coordinators of the work-in-progress seminars, particularly during the seminar time. I wish to acknowledge the Dean of the School of Economics, Prof. Ramana Murthy and former Dean of the School of Economics Prof. Naresh Kumar, for providing me with an essential atmosphere to carry out my research work. I express my heartfelt gratitude to my M. Phil supervisor Prof. Sunil S. Narwade, Head of the Department of Economics, Dr Babasaheb Ambedkar Marathwada University, Aurangabad to encourage me to take admission to the University of Hyderabad.

I am indebted to all faculty members of the school of economics for their help and contribution to my learning process. I am thankful to Prof. R. V. Ramamurthy, Prof. R. Vijay, Dr Parjna Mishra and Dr Krishna Reddy who supported me a lot during the coursework. I would also like to thank the non-teaching staff of the school of Economics Mr Adi Narayana Venna, Mr Srinivasa, Mr Venkatesh, Mr Madhu, Mr Tarun Miss Vishkha and others for their constant support whenever needed. I thank the librarian and the staff of Indira Gandhi Memorial Library, University of Hyderabad who have continuously supported me in my PhD work. I am grateful

to Dr Devesh Nigam, Controller of Examinations, University of Hyderabad for his considerable concern and support in all academic activities.

I have great pleasure in acknowledging my dear seniors Dr Raju Chelle, Dr Madhukar Siddharam, Mr Prashant Bagade, Mr Prashant Donta, Mr Matta Shrinivas, Mr Subhash Chandra, Miss Mamata Waikar, Dr Jitender Kumar, Dr T.K. Venkatachalapathy, Dr Bhaskar Yellami, Mr Krisna Swami, Dr Satyanarayana Turangi, Mr Bhimsen, Dr Shiva Krishna Golla, Dr Ramjee Chintagada, Mr Vijay Belkhede, Mr Debnath, Mr Mahendra Belkhedkar, Mr Kiran Dake, Dr P. Moon (JNU), Mr Sachin Nisraghandh, Dr Ashok Uke (BAMU) and others who supported and encouraged me during my research work. I am thankful to my classmates Dr T. Kaladar, Dr Y.N. Raju, Dr Raju Guntukula, Mr Ramakant and others who helped me during my early days on campus. I special thanks my close friend Mr Dhananjay Kumar who helped me in several ways and he was always ready to discuss on research-oriented issues in the hostel room, department's computer lab, library and student canteen on the campus. I would like to thank my junior close friends Mr Rushabh Dongade, Mr Swapnil Wagamarae, Mr Mithun, Mr Vir Pratap Gautam, Mr Pabitra, Mr Ruzu Thai Bramha, Mr Nandisha, Mr Amol Kambale, Mr Viraj Bansode, Mr Mukesh Kumar, Mr Kailash Bhandari, and others for sharing their experiences in the mess hall about universities class and classrooms, discussion on various emerging issues all over the world and I also appreciate their dedication about their study.

This PhD study would not have been possible without the cooperation and support extended by those who helped me in the field study. I want to thank all rural households, village Sarpanch and key informants who played the role of torch bearer while I was conducting my field study. I acknowledge the indispensable contributions made by the villagers of my study site, especially the Bansode brothers, Tayade sir, Hinge sir (Osmanabad), Fulchand More Kaka (Taka, Latur), Prakash Ingale (Aurangabad), Prakash Ujagre (Beed), Shahoo Kale (Majalgaon), Shahebrao Jagtap Police Patil (Takalgaon), Survase Kaka Fauji (Patoda), Gaikwad Kaka (Tandelwadi), Mr Amol Janrav, and Pravin Photo Studio (Washi); they provided their support and cooperation during the fieldwork.

Last but not least, words fail to express the enduring affection, love and blessing of my lovely father, mother, sisters and brothers, and uncles for taking an interest in my higher education and keeping faith in me and my capacity to complete the undertaken task. I am grateful to my father Dattuji Bhagat, mother Anuradha Bhagat, maternal uncle Balashaheb Ingole, and my sister Mrs Paranali Bhagat, for their unstinted support, encouragement and affection. Love to

my adorable niece Akashara and nephew Aryan, for being patient, adjusting, and compromising with her/his little heart's desire to be by my side always. Finally, with immense pleasure and gratitude, I place on record my appreciation to all persons who were helpful to me in completing this work. I owe my sincere thanks to many personalities who helped me in one way or another in finishing this work. I record my heartfelt gratefulness to all who helped me directly or indirectly to complete this research work. Ultimately, I would like to add that I am alone responsible for the errors and omissions in the study, and none other may be blamed for it.

Bhagat Nitin Dattuji

CONTENTS

DEDICATION.....	iii
DECLARATION	iv
CERTIFICATE	v
ACKNOWLEDGEMENTS.....	vii
CONTENTS.....	x
List of Tables	xv
List of Figures	xxii
LIST of ABBREVIATIONS.....	xxv
Chapter 1: Introduction	1
1.1 Background	1
1.2 Motivation/significance of the study	2
1.3 Research questions	3
1.4 Objectives of the study	4
1.5 Research hypothesis	4
1.6 Drought definitions	5
1.7 Classification of Drought	5
1.8 Theoretical framework of the study	6
1.9 Data sources and research methodology	9
1.9.1: Location map of the study area	10
1.9.2 Area of study	11
1.9.3 Primary data collection, Sample selection method.....	11
1.9.4 Secondary data sources.....	14
1.9.5 Rainfall deviations.....	15
1.9.6. Multiple regression model	15
1.9.7 Binary logit regression model.....	15
1.10 Limitations of the study	16

1.11 Organization of the study	17
Chapter 2: Profile of the Study Area.....	18
2.1 Brief introduction of the Maharashtra state.....	18
2.2 Brief geographical information of Marathwada region.....	21
2.3. Brief introduction of three districts in the study area.....	29
2.3.1 Geographical position and physical features of Beed district	29
2.3.2 Rivers.....	30
2.3.3 Climate and rainfall	30
2.3.4 Crop and vegetables.....	30
2.4.1 Geographical position and physical features of Osmanabad district.....	35
2.4.2 Rivers.....	37
2.4.3 Climate and rainfall	38
2.4.4 Crop and vegetables.....	41
2.4.5 Types of soil	41
2.5.1 Geographical position and physical features of Latur district.....	42
2.5.2 Rivers.....	43
2.5.3. Climate and rainfall	44
2.5.4 Crops and vegetables	44
2.5.5 Types of soil	49
2.6 Conclusion.....	50
Chapter 3: Review of literature	51
3.1 Brief introduction	51
3.2 Rainfall trends and variability	51
3.3 Drought, agriculture and rural livelihoods	59
3.4 Drought and economy	66
3.5 Drought and vulnerability	67
3.6 Drought and food security, poverty and children's education	69

3.7 Drought: perceptions, coping, adaptation and mitigation strategies	70
3.8 Conclusion.....	82
Chapter 4: Temporal rainfall Trend analysis and variability of three drought-prone (Beed, Osmanabad, and Latur) districts and the history of rainfall (drought) of Marathwada region of Maharashtra	84
4.1 Introduction	84
4.2 Brief overview of the studies	85
4.3 Data and methodology	85
4.3.1 Mann-Kendall test for rainfall trend analysis	86
4.3.2 The magnitude of the trend.....	87
4.3.3 Rainfall variability test: Coefficient of variations (CV).....	88
4.3.4 Rainfall Anomaly Index (RAI).....	89
4.3.5 Rainfall deviation	89
4.3.6 Reasons for using few statistical tools in this chapter (the Rainfall Anomaly Index, deviations and parametric and non-parametric tests)	89
4.4 Results and discussion.....	90
4.4.1 Rainfall variability pattern of Beed district	103
4.4.2 Rainfall variability pattern of Osmanabad district	104
4.4.3 Rainfall variability pattern of Latur district.....	106
4.5. History of Marathwada drought (rainfall).....	116
4. 6 Conclusion.....	134
Chapter 5: Socio-economics conditions in the drought prone-areas among rural households in irrigated and rain-fed villages – (An Empirical investigation from primary as well as secondary data)	137
5.1 Introduction	137
5.2 Socio-economic profile of the sample households.....	140
5.3 Impact of drought on various factors (social, economic and environment) and describes the few governments drought mitigation measures and programmes in the drought	169

5.4 Impact of drought on total foodgrain production in the study area using multiple regression model	194
5.5 Information of the cattle camps, drinking water takers position in the drought years, and describes the block wise crop annewari/paisewari over the tree districts	197
5.6 Conclusion.....	207
Chapter 6: Determinates of farm household's choice of coping and adaptation strategies to cope with drought from three districts of Marathwada region of Maharashtra.....	210
6.1 Introduction	210
6.2 Overview of the study	211
6.3 Concept of coping and adaptation strategies.....	211
6.4 Statistical analysis	212
6.4.1 Binary logit regression model.....	213
6.5 Results and discussion.....	214
6.6 Role of socio-economics and demographic characteristics in adaptation decisions....	227
6.6.1. Household size.....	228
6.6.2 Age of the farm households heads.....	229
6.6.3 Family types	229
6.6.4 Land size.....	230
6.6.5. Credit access or loan/debt get from national and private banks	230
6.6.6. SHGs access	231
6.6.7 Education	231
6.6.8 Farming experience	231
6.6.9 Livestock ownership.....	232
6.6.10 Annual income.....	232
6.7 Conclusion.....	233
Chapter 7: Summary, conclusion and policy implications.....	235
7.1 Introduction	235
7.2 Chapter-wise findings	236

7. 3 Policy measures and suggestions	246
6.4 Directions for the upcoming research	247
6.5 Final remark.....	248
Bibliography	249
Appendix A. Questionnaire.....	
Published paper.....	
Conference certificates.....	
Plagiarsam report.....	

List of Tables

Table 1. 1: Multi-stage sample selection method	13
Table 2. 1: Shows a broad picture of Maharashtra's administrative setups	19
Table 2. 2: Highlights Maharashtra's total working population, including males and females	19
Table 2. 3: According to the population census 2011, district-wise information of the total households, total population, total male and female and sex ratio of Aurangabad division of Maharashtra (in thousands, 000).....	22
Table 2.4: According to the census 2011, area and density of each district in the Marathwada region	23
Table 2.5: As per population census 2011, every district-wise literacy rate of the Marathwada region	24
Table 2.6: As per population census 2011, total scheduled caste and scheduled tribe population and their total percentage of total state population and their literacy rate over Marathwada region	25
Table 2. 7: As per census livestock 2012, every district wise-information of livestock over the Marathwada region of Maharashtra (in thousands, 000)	27
Table 2.8: Every district wise-information from primary and secondary education sources over the Marathwada region of Maharashtra (in thousands, 000)	28
Table 2. 9: Demographic information of Beed district and Maharashtra	31
Table 2.10: Demographic features of two sample villages of the Beed district	33
Table 2. 11: Demographic Information of Osmanabad district and Maharashtra	36
Table 2.12: Demographic features of two sample villages of Osmanabad district	38
Table 2. 13: Annual rainfall of Osmanabad district 2018.....	39
Table 2. 14: Average annual rainfall among all blocks of Osmanabad district since 2014-15 to 2018-19	40
Table 2. 15: Average annual rainfall of Latur district from 1991 to 2018.....	44
Table 2.16: Demographic features of Latur district from (population census 2011 and 2001)	45
Table 2.17: Demographic information of Latur district and Maharashtra	46
Table 2. 18: Demographic features of two sample villages of Latur district.....	48
Table 4. 1: Classification of Rainfall Anomaly Index	90
Table 4. 2: Range of annual RAI of Beed district over the period from 1901 to 2018	91
Table 4. 3: Dry and rainy years in Beed district over the period from 1901 to 2018	93

Table 4.4: Range of annual RAI of Osmanabad district over the period from 1901 to 2018..	94
Table 4. 5: Dry and rainy years in Osmanabad district over the period from 1901 to 2018 ...	97
Table 4.6: Range of annual RAI of Latur district over the period from 1901 to 2018	97
Table 4.7: Dry and rainy years in the Latur district over the period from 1901 to 2018.....	100
Table 4.8: Statistical summary of monthly, seasonal and annual rainfall of Beed district during from 1901 to 2018.....	102
Table 4.9: Statistical summary of monthly, seasonal and annual rainfall of Omarabad district during from 1901 to 2018	103
Table 4.10: Statistical summaries of monthly, seasonal and annual rainfall of Latur district during from 1901 to 2018	105
Table 4.11: Mann-Kendall test results and magnitude of trend of the Beed district rainfall (Sen's slope estimators) from 1901 to 2018	112
Table 4.12: Mann-Kendall test trend results and Sen's slope (magnitude of trend line) of Osmanabad district.....	113
Table 4.13: Mann-Kendall trend test results and Sen's slope (magnitude of trend line) of Latur district from 1901 to 2018.....	114
Table 4.14: Classifications of rainfall deviations (IMD)	117
Table 4.15: South-west monsoon rainfall percentage departure from normal all over India from 1901 to 2017	122
Table 4. 16: Annual rainfall data all over the Marathwada Region of Maharashtra from 1871 to 2016	125
Table 4.17: Annual rainfall deviation from normal all over India from (1901 to 2016)	130
Table 5.1: Selected district, block, and villages information in the study area	140
Table 5. 2: Characteristics of irrigated and rain-fed villages in both normal and drought years	140
Table 5. 3: Total sample households' percentages of irrigated and the rain-fed villages.....	143
Table 5.4: Each district and each village-wise percentage of the total sample Households..	144
Table 5. 5: Each village sample household's percentages according to total village households	145
Table 5.6: Religion status according to irrigated and rain-fed villages' areas.....	145
Table 5.7: Religion status according to landholding size from irrigated and rain-fed village's areas	146
Table 5.8: Religion status according to social groups from irrigated and rain-fed villages' areas	146

Table 5.9: Rural household's classification of irrigated and rain-fed villages according to social groups.....	147
Table 5.10: Family types position in the irrigated and rain-fed village in the study area	148
Table 5.11: Percentages classification of family type according to landholding size	148
Table 5. 12: Percentages classification of family type according to social groups	149
Table 5.13: Types of the houses of sample households in the irrigated and rain-fed village	150
Table 5.14: Classification of houses by landholding size	151
Table 5.15: Classification of houses within social groups.....	152
Table 5.16: Toilet facility available among farmers' households in the both ecosystem.....	152
Table 5. 17: Toilet facility available among farmers' households according to landholding size	153
Table 5. 18: Social group-wise toilet facility available in sample households	154
Table 5. 19: Percentage of the households that used toilets in the drought period in both ecosystem.....	155
Table 5. 20: Various drinking water sources of households used in the drought period from the two different ecosystems (irrigated and rain-fed villages)	155
Table 5. 21: Classifications of drinking water sources according to landholding from the two different ecosystems (irrigated and rain-fed villages)	157
Table 5.22: Social groups-wise classification of drinking water sources from the two different ecosystems (irrigated and rain-fed).....	157
Table 5.23: Primary sources of cooking in the irrigated and rain-fed villages.....	158
Table 5. 24: Classifications of social groups according to primary cooking sources.....	159
Table 5.25: Main lighting sources of households in the different ecosystem.....	160
Table 5.26: Male and female heads out of the total households in the study area.....	160
Table 5.27: Male and female percentage of the total households' members in the study area	161
Table 5.28: Age-wise distribution of rural farm household heads in irrigated and rain-fed villages	162
Table 5.29: Marital status of households' heads in both irrigated and rain-fed regions.....	163
Table 5.30: Marital status of the household heads according to landholding size in irrigated and rain-fed regions	163
Table 5.31: The marital status of the household heads according to landholding size in irrigated and rain-fed villages areas	164

Table 5.32: Education level status of households heads among the irrigated and rain-fed villages	164
Table 5.33: Education level status of households heads among marginal, small, medium, and large farmers in the irrigated and rain-fed villages	165
Table 5.34: Occupational status of farm household heads in irrigated and rain-fed villages	166
Table 5.35: Classification of household cultivators by landholding size	167
Table 5.36: Distribution of landholding size according to social groups from irrigated and rain-fed villages areas.....	168
Table 5.37: Income level distribution among rural households in the normal year from the irrigated and rain-fed areas	169
Table 5.38: Income level distribution among rural households in the drought year from the irrigated and rain-fed areas	170
Table 5.39: Descriptive statistics of normal and drought years' income (continuous variable)	171
Table 5.40: Distribution of income level according to landholding size in the normal year.	171
Table 5.41: Category wise and income groups wise analysis of rural households in the normal year from the irrigated and rain-fed areas.....	172
Table 5.42: Income distribution of rural households according to landholdings size in the drought year from irrigated and rain-fed areas	173
Table 5.43: Category-wise income distribution of rural households from irrigated and rain-fed areas in the drought year	173
Table 5.44: Condition of households who fetches water from long distances during the drought period in the both ecosystems	174
Table 5.45: Households fetching water condition from long distances in the drought period in both kinds of villages according to Landholding size	175
Table 5.46: Social group-wise households fetching water condition from long distances in the drought period in both kinds of ecosystems by social groups	175
Table 5.47: Household fetching water from long distances in the drought period in (km)...	176
Table 5.48: Classification among household respondents who is fetched water from long distances in the drought period	177
Table 5.49: Livestock status among farm households in irrigated and rain-fed villages	178
Table 5.50: Livestock status by landholding size among farm households in irrigated and rain-fed villages	178

Table 5.51: Livestock status among farm households by social groups in irrigated and rain-fed villages	179
Table 5.52: Fodder situations among farm households in irrigated and rain-fed villages during the drought	179
Table 5.53: Agriculture input subsidy (drought relief) availed by farm households in irrigated and rain-fed villages during the drought	180
Table 5.54: Agriculture input subsidy (drought relief) availed by farm households according to landholding size in irrigated and rain-fed villages during the drought	180
Table 5.55: Agriculture input subsidy (drought relief) availed by farm households according to social groups in irrigated and rain-fed villages during the drought	181
Table 5.56: Crop insurance status among the rural household during the drought	182
Table 5. 57: Crop insurance status among the rural household during the drought according to landholding size	182
Table 5.58: Social groups-wise crop insurance status among the rural household during the drought	183
Table 5.59: The loan or debt position of farm households that have obtained from major banks during drought.....	183
Table 5.60: Landholding size -wise loan or debt situation of the sample farm households ..	184
Table 5.61: Social groups-wise loan or debt situation of farm households	185
Table 5.62: Drought effect on school going children in the both ecosystems	185
Table 5.63: Drought impact on school going children by landholding size	186
Table 5.64: Social groups-wise impact of drought on school going children	187
Table 5.65: Migration status among rural household's respondents during drought in the irrigated and rain-fed villages	187
Table 5.66: Migration status according to landholding size among rural households' respondents during drought in the irrigated and rain-fed villages	188
Table 5.67: Migration status according to social groups among rural household's respondents during drought in the irrigated and rain-fed villages	189
Table 5.68: Impact of drought on health in the both ecosystem of the study area	189
Table 5.69: Work done under the Jalyukt Shivar programme in the irrigated and rain-fed village	190
Table 5.70: Households members participation in drought period in SHGs from the both ecosystems	190
Table 5.71: Below poverty line status according to irrigated and rain-fed areas	191

Table 5.72: Beed district multiple regression model results, (model-1).....	194
Table 5.73: Osmanabad district multiple regression model results, (Model-2).....	195
Table 5.74: Latur district multiple regression model results, (Model. 3)	196
Table 5.75: Taluka wise cattle (fodder) camps in the Beed district. Maharashtra, 2015- 2016	198
Table 5.76: Cattle camps in Beed District of Maharashtra until 1 April 2018 -2019.....	198
Table 5.77: Annewari/ paisewari of Kharif crops (yield production) of Beed district in 2016- 17.....	199
Table 5.78: Annewari/paisewari of Kharif crops (yield production) of Beed district in 2017-18	200
Table 5.79: Annewari/ paisewari of Kharif crops (yield production) of Beed district in 2018- 19.....	200
Table 5.80: Kharif annewari of Osmanabad District, in the drought year 2018-19	201
Table 5.81: Position of water tankers provided by the government in the drought year 2018-19.	202
Table 5.82: Status of the private well requisition in the drought period 2018-19	202
Table 5.83: Total livestock in Osmanabad district in 2018	203
Table 5.84: Cattle camps in Osmanabad district until 31/05/2016.....	203
Table 5.85: Cattle camps in Osmanabad district until 07/06/2019.....	204
Table 5. 86: Kharif crops annewari of the Latur district in 2016-17 (including major crops soybean, jwari, tur, moong, ulid)	204
Table 5.87: Kharif crops Annewari of the district in 2017-18 (Including major crops soybean, jwari, tur, moong, ulid)	205
Table 5.88: Kharif crops annewari of the Latur district in the year 2018-19	205
Table 5.89: Water tanker status of Latur district during the years 2015-16 and 2018-19	206
Table 5.90: Total pubic water tankers in Aurangabad division of Maharashtra (2018-19)...	206
Table 6 1: Descriptive statistics of explanatory variables and dependent variables.....	217
Table 6.2: Definition of exoplanetary variables used in this model	219
Table 6 3: Farmers major coping and adaptation strategies adopted by farm households against drought.....	220
Table 6.4: Binary logit model results for coping and adaptation strategies.....	221
Table 6 1: Descriptive statistics of explanatory variables and dependent variables.....	217
Table 6.2: Definition of exoplanetary variables used in this model	219

Table 6 3: Farmers major coping and adaptation strategies adopted by farm households against drought.....	220
Table 6.4: Binary logit model results for coping and adaptation strategies.....	221

List of Figures

Figure 1.1: Various impacts of drought.	7
Figure 1.2: Period of drought happenings and Connection among different types of droughts	8
Figure 1.3: Schematic presentation of drought impact categories and examples of related drought impacts.....	9
Figure 1.4: Shows the sample selection units step-by-step.....	13
Figure 2.1: Highlights Maharashtra's total working population, including males and females.....	21
Figure 2.2: District wise information of the total households, total population, total males and females of the Aurangabad division of Maharashtra (in thousands, 000)	23
Figure 2.3: Area and density of each district in the Marathwada region, according to the population census of 2011	24
Figure 2.4: Every district wise literacy rate of the Marathwada region as population census 2011.....	25
Figure 2.5: The total scheduled caste and scheduled tribe population and their total percentage of the total state population and literacy rate over the Marathwada region (as per population census 2011).....	26
Figure 2.6: As per census livestock 2012, every district wise-information of livestock over the Marathwada region of Maharashtra (in thousands, 000)	28
Figure 2.7: Population information as per census 2011 of Beed and Maharashtra	32
Figure 2.8: Demographic information according to population census 2011, district of Osmanabad and Maharashtra.....	37
Figure 2.9: Annual Rainfall of Osmanabad district, 2018	40
Figure 2.10: Population particulars Latur district according to census of 2011 and 2001	46
Figure 2.11: Demographic information of Latur district and Maharashtra as per census 2011	48
Figure 4.1: Ranges of annual RAI of Beed district over the period from 1901 to 2018.....	101
Figure 4.2: Ranges of annual RAI of Osmanabad district over the period from 1901 to 2018	101
Figure 4.3: Ranges of annual RAI of Latur district over the period from 1901 to 2018	102
Figure 4.4: Temporal variations and trends in seasonal and annual rainfall of Beed District for the period 1901 to 2018	106

Figure 4.5: Temporal variations and trends in seasonal and annual rainfall of Osmanabad District for the period 1901 to 2018.....	108
Figure 4.6: Temporal variations and trends in seasonal and annual rainfall of Latur District for the period 1901 to 2018	110
Figure 4.7: Mann- Kendall test p-values over Beed district from 1901 to 2018	113
Figure 4.8: Mann- Kendall test p-values over Beed district from 1901 to 2018	114
Figure 4.9: Mann- Kendall test p-values of Latur district from 1901 to 2018.....	116
Figure 4.10: Marathwada region south west monsoon data from 1871 to 2016 obtained from Indian Institute of tropical Metrology (IITM)	121
Figure 4.11: South-west monsoon rainfall percentage departure from normal all over India from 1901 to 2017	125
Figure 4.12: Annual rainfall deviation from normal all over Marathwada Region of Maharashtra from 1871 to 2016.....	130
Figure 4. 13: Annual rainfall deviation from normal all over India during the period 1901 to 2016.....	134
Figure 5. 1:.....	139
Figure 5.2: Percentage of two different ecosystems irrigated and Rain-fed (areas).....	143
Figure 5.3: Selected village-wise percentages among the sample households of the study area	144
Figure 5.4: Classifications of social groups among irrigated and rain-fed villages.....	148
Figure 5.5: Classifications of social groups according to family type.....	150
Figure 5.6: Types of the houses of the sample households in the irrigated and rain-fed village	151
Figure 5.7: Toilet facilities available in both ecosystem	153
Figure 5.8: Toilet facility available among rural households in irrigated and rain-fed areas	154
Figure 5.9: Using toilets in the drought in the both ecosystem	155
Figure 5.10: Different drinking water sources of households in the drought period from the two different ecosystems (irrigated and rain-fed villages)	156
Figure 5.11: Primary sources of cooking in the irrigated and rain-fed village	159
Figure 5.12: Main lighting sources of households.....	160
Figure 5.13: Male and female households head out of the total households	161
Figure 5.14: Male and female percentages of the total households' members in the study area	162

Figure 5.15: Age-wise distribution among all sample household heads in the study area ...	163
Figure 5.16: Education level status of households heads among the irrigated and rain-fed villages	165
Figure 5.17: Percentages of household cultivators by landholding size	168
Figure 5.18: Households income distribution during normal and drought years in the irrigated and rain-fed areas	171
Figure 5.19: Households fetching water from long distances in the drought period in both kinds of villages.....	175
Figure 5.20: Households fetching water from long distances in the drought period in (km)	177
Figure 5.21: The loan or debt position of farm households that have obtained from major banks during drought.....	184
Figure 5.22: Drought impact on the school going children in the different ecosystem.....	186
Figure 5.23: Migration status among rural households' respondents during drought in the irrigated and rain-fed villages	188
Figure 5.24: Health problem faced by households' respondents during the drought	190
Figure 5.25: Households members Self Help Groups participation in the drought.....	191
Figure 5.26: Farmers perceptions of various environment impact of drought in the study area	192
Figure 5. 27: Various impacts of drought perception at different scales in the study area by farmers.....	193
Figure 6.1: Coping and adaptation strategies adopted by farm households to cope with drought	214
Figure 6.2: Drought adaptation strategies of the sample farm households, both irrigated and rain-fed villages (long-term strategies)	215
Figure 6.3: Coping strategies of drought adopted by village households, both irrigated and rain-fed (short-run coping strategies)	216

LIST of ABBREVIATIONS

ACZ	Agro-Climatic Zone
AEZ	Agro-Ecological Zones
AMS	American Metrological Society
APD	Adjusting Planting Dates
APL	Above Poverty Line
AUC	Area Under Cultivation
BLR	Binary Logistic Regression
BPL	Below Poverty Line
CBI	Central Bank of India
CSO	Central Statistical Organization
CV	Coefficient of Variations
CVI	Climate Vulnerability Index
DCCBs	District Co-operative Central Banks
DES	Directorate of Economics and Statistics
DRO	District Revenue Office
DSER	District Socio-Economics Review
ESM	Economic Survey of Maharashtra
FAO	Food and Agriculture Organization
FPS	Fair Prices Shops
GCA	Gross Cropped Area
GDP	Gross Domestic Product
GHGs	Green House Gases
GIS	Geographical Information System
GOs	Government Organizations
GOI	Government of India
GOM	Government of Maharashtra
GVA	Gross Value Added
HSC	Higher Secondary School Certificate
HYVs	High Yielding Varieties
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics

IITM	Indian Institute of Tropical Methodology
IMD	Indian Metrological Department
IPCC	Intergovernmental Panel on Climate Change
ITA	Innovative Trend Analysis
IWP	Indian Water Portal
LDCs	Least Developed Countries
LVI	Livelihood Vulnerability Index
MGNREGS	Mahatma Gandhi National Rural Employment Guarantee Schemes
MKT	Mann Kendall Test
MLM	Maximum Livelihood Method
MOSPI	Ministry of Statistics and Programme Implementation
MSSM	Multi-Stage Sampling Method
NDRF	National Disaster Response Fund
NGOs	Non-Government Organizations
NREGA	National Rural Employment Guarantee Act
NSSO	National Sample Survey Office
OBCs	Other Backwards classes
OCs	Open Castes
OLM	Ordinary Least Square Method
RAI	Rainfall Anomaly Index
PDS	Public Distribution System
PNB	Punjab National Bank
PVC	Polyvinyl Chloride Pipes
SBI	State Bank of India
SCs	Scheduled Castes
SDRF	State Disaster Response Fund
SHGs	Self Help Groups
SD	Standard Deviation
SMKT	Sequential Mann-Kendall Test
SRSM	Simple Random Sampling Method

SPI	Standard Precipitation Index
SSC	Secondary School Certificate
SSE	Sen's Slope Estimator
STs	Scheduled Tribes
WALMI	Water and Land Management Institute
WMO	World Metrological Organization

Chapter 1

Introduction

1.1 Background

In recent years, changing climate has impacted natural and human systems in all geographical regions and across oceans. Current climate-related extremes are such as heatwaves, droughts, floods, cyclones, and wildfires. These extreme impacts have revealed that some ecosystems and human systems are highly vulnerable to ongoing climatic variability (IPCC., 2014). Natural calamities have become more common and severe in recent decades due to global warming; it has increased the frequency and intensity of drought episodes (Ari et al., 2021). During the 21st century, human and animal mortality, migration, economic losses, environmental and social effects have widespread in Asia, Africa, America, Europe, and Oceania due to drought. Recurrent droughts continue to cause misery, eroding livelihood, and harming the natural ecosystem in Africa and Asia. Furthermore, it also induces disease, hunger, and famines due to bad quality of water and lack of food (Sharma, 2004). Among all natural hazards, drought has a significant threat to the farm community in various arid and semi-arid regions. It is also one of the most complicated natural disasters, along with increased frequency, vast geographic coverage, and long duration. In the developing world, agriculture is the primary source of rural livelihood, which is highly dependent on rainfall (Keshavarz et al., 2017; Khetwani & Singh, 2020). Around 28 % geographical area of India is vulnerable to severe and moderate drought (Katalakute et al., 2016). India has experienced drought after once every three years in the past several decades. It is one of the most vulnerable and prone to drought countries in the globe with increased drought intensity in the recent few years (Udmale et al., 2014). An existing feature of the Indian scenario is that generally low level of income and quality of life, and there is a wide range of socio-economic circumstances, levels of development, and poverty across regions (Nadkarni, 1985). About 54.6% of the population works in agriculture and allied industries, which makes up the foundation of the Indian economy. For the fiscal year 2019-20, it contributes about (17.8 %) of the country's Gross Value Added (GVA) at current prices (Department of Agriculture, Annual Report, 2018; Annual Report, 2020-21). Indian agriculture mainly depends on rainfall, which contributes around (70 to 90 %) of the average annual rainfall from the southwest monsoon (Kumar and et al., 2013). The monsoon continues to be a gamble in Indian agriculture, with more than 50 % country's cultivated area has lacking irrigation (Venkateswarlu et al., 2014). The drought of 2009 had a significant impact on agricultural crops like sugarcane and oilseeds. The production of sugarcane and oilseeds decreased by 12% and 5%, respectively (Shreekanth S., 2010).

In addition, agriculture also plays an essential role in the state economy. A large portion of the state's population depends on agriculture. The contribution of this sector in the total Gross State Value Added (GAD) is around (12.02 %) for the year 2016-17 ([Economic Survey of Maharashtra, 2017-18](#)). Maharashtra is the wealthiest state in the country, which accounts for roughly (15 %) of India's GDP ([Udmale et al., 2015](#)). The state government has declared the drought over 14708 villages out of 43722 villages in 2015-16. It means that around (34 %) of the state area was covered by drought. The whole Marathwada region has been severely affected by drought. ([Mukherjee S., 2015](#)). The region's natural and socio-economic resources were negatively affected by a series of drought episodes from 2012 to 2016 ([Khetwani & Singh, 2020](#)). Again, the state government announced drought over 181 blocks in 2018-19 ([Ghadyalpatil A., 2018](#)); and ultimately declared drought in 151 blocks across 26 districts ([Jain B., 2018](#)).

1.2 Motivation/significance of the study

There are very few studies available on drought impact related to agriculture, socio-economics, and environmental concerns. After reviewing the extensive literature, the study has found some gaps in the existing literature. There is no study at the farm households level using cross-section data in the area as well as comparison with the irrigated and rain-fed village over the Marathwada region and across Maharashtra. The study's primary purpose is to focus on the farm sector, particularly on farm households in irrigated and rain-fed villages (small, marginal, medium, and large farm households) in the Marathwada region of Maharashtra. Out of five regions of Maharashtra, the Marathwada is considered as one of the state's backward regions in terms of socio-economics development, industrialization, job creation, and low irrigation. Marathwada region is one most severely drought-affected areas of Maharashtra due to its various geological, ecological, and climatic features. Drought causes significant reductions in agricultural output, increased farmer suicides cases, out-migration, drinking water scarcity, famine, malnutrition, poverty, poor health and education, fodder scarcity, unemployment, hopelessness, sense of loss, indebtedness, sanitization, etc. Most of the region's population is engaged in agriculture and allied activities for their livelihood, and agriculture is largely dependent on rainfall ([Dhaktode N., 2020](#); [Udmale et al., 2014](#); [Mahajan & Dodamani, 2016](#); [Joshi, 2019](#)). Drought has caused many problems, particularly in rural areas like as loss of livestock income, depletion of surface water, threatened wildlife, employment on-farm, non-farm sector, school-going children, food, and hydropower-production also ([Sivakumar & Kerbhat, 2004](#); [Udmale et al. 2015](#); [Udmale et al. 2014](#); [Nadkarni M., 1985](#); [Biradar & Sridhar,](#)

2009). Many people were migrated from rural to urban areas to seek employment (Nagarguna et al., 2010; Ezra and Keroze, 2001). The low and unsuitable agriculture production in the drought-prone areas has been the major cause of regional imbalances (Kolte & Jaiswal, 1981). A major part of Maharashtra is known to be drought-prone. Marathwada has a prolonged history of drought. The major effect of drought is on rural life, mostly on poor people, small and middle farmers, and agriculture labour (Borkar and Nadakani, 1975). Maharashtra's both in Vidarbha and Marathwada region are famous for farmer suicide cases, agrarian distress, economic backwardness and drought prone-ness. Therefore, there is a need to conduct this kind of study in that area. Drought has induced various socio-economic and environmental problems in these regions. Marathwada faced several severe drought years during the period from 1871 to 2016. Some of the worst drought years were such as 1871, 1876, 1877, 1885, 1888, 1899, 1905, 1907, 1912, 1918, 1920, 1921, 1925, 1929, 1936, 1937, 1939, 1971, 1972, 1984, 1985, 1986, 1994, 1997, 2012, 2014, 2015 (see in chapter 4).

Many studies have observed that Maharashtra's Marathwada region is highly severe to drought-prone but there is no study available at micro level or at the household level. The study tries to fill the gap in the existing literature. The present study based on households as well as local level. Further, the study has selected three severe drought-prone districts from the region and selected six villages from these districts, three are irrigated and three are rain-fed, and tries to make comparison between them. The study also attempts to identify various issues at local level which has caused by drought. Furthermore, it is also tries to find out impact of the drought on the food grain production at the district level and particular coping and adaptation strategies which have been adopted by households to cope with drought during the drought at the households' levels in the study area. Moreover, the study analyses long-term rainfall data to identify drought years and its intensity in the study region.

1.3 Research questions

- 1) What are the temporal rainfall trends and seasonal variability in rainfall over the three drought-prone districts of Maharashtra's Marathwada region from 1901 to 2018?
- 2) Does the drought negatively influence on rural farm households? And what problems do they face during the drought, such as (drinking water, education, credit, insurance, livestock fodder, out-migration and crop production, etc.)?
- 3) How do they cope with severe drought conditions? What are the coping and adaptation strategies they have adopted in the drought period, and what are the choices of determinates?

- 4) Do the marginal and small and medium land holding households face more severe problems than large size landholding households?
- 5) Does the drought decrease more agriculture crop production compared to rain-fed villages?
- 6) Do the government's drought relief and mitigation programmes mitigate the drought impact in the drought?
- 7) Is the drought forced to migrate the people from rural to urban areas?
- 8) Do severe drought like-conditions harm the rural economy?
- 9) Does the drought reduce livestock and pasture in the study area?

1.4 Objectives of the study

- 1) To understand the history of drought (rainfall) over the Marathwada region and analyse the temporal rainfall trends and variability of the three districts of Beed, Osmanabad, and Latur districts of Maharashtra.
- 2) To study the socio-economic conditions among rural farm households in irrigated and rain-fed villages in the drought prone-areas (study area).
 - i) To study the impact of drought on marginal, small, medium and large farmers as well as different social groups.
 - ii) To study the severe impact of drought on native drinking water supply and which are the water sources available during the drought.
- 3) To examine the determinates of farm households' choice of coping and adaptation strategies to cope with drought from three districts of the Marathwada region of Maharashtra.

1.5 Research hypothesis

- 1) Drought influences negatively on rural households.
- 2) Few droughts mitigation measures (crop insurance and subsidy) and drought relief programmes (cattle camp, and food security) have positive effects on households in drought-prone study areas.
- 3) Positive and negative rainfall trends have been observed in the long-term data series over the study region.
- 4) Farmers choices of determinates to adapt coping and adaptations strategies to drought have found statistically significant relationship between them in the study area.

1.6 Drought definitions

Drought defines into two categories conceptual as well as operational. The conceptual definitions are like dictionary types, mostly describing the boundaries of drought; that kind of interpretation is only helpful for furthering our explanation of the phenomenon. The operational definitions describe the specific features and thresholds of the phenomenon. It also illustrates the drought events' onset, continuation, termination, and severity (Wilhite and Glantz, 1985; Wilhite, 2000). There are various ways in which drought varies from other natural calamities (such as floods, tropical cyclones, tsunamis and earthquakes). First, it can be challenging to pinpoint the beginning and termination of a drought since its impacts frequently develop slowly over a long period of time and might remain for years after the event has passed. As a result, drought is commonly described as a creeping phenomenon (Wilhite, 2000; Tannehill, 1949).

- i) **According to American Heritage Dictionary (1976)** it states that drought as, “a long period with no rain, particularly during the crop growing season.”
- ii) **The World Meteorological Organization (1986)**, drought is defined as, “a sustained extended deficiency in precipitation (rainfall).”
- iii) **According to the UN Secretariat General (1994)**, “drought denotes a naturally occurring phenomenon that occurs when precipitation is significantly recorded below-average levels compared to the normal level. It has generated considerable hydrological imbalances that negatively affect land resource production practices”.
- iv) **United Nations' Food and Agriculture Organization (FAO, 1983)**, “a drought disaster is defined as "the proportion of the year when a crop loss due to a lack of moisture”.
- v) **The encyclopaedia of climate and weather (Schneider,1996)** it describes, “an extended period of deficit rainfall relative to the statistical multi-year for a region throughout a season, a year, or several years”.
- vi) **Drought, according to Palmer (1965)**, “a considerable divergence from an area's usual hydrologic condition” (Mishra and Singh, 2010; Wilhite and Glantz, 1985; Wilhite, 2000).

1.7 Classification of Drought

National Commission on Agriculture (NCA) has classified drought into three categories: agriculture, metrological, and hydrological (Bokil, 2000). The National Drought Mitigation entre (NDMC) has been sorted drought into four groups, which are metrological, agriculture,

hydrological, and socio-economic; these are mentioned below (Mishra and Singh, 2010; NDMC, 2000; Wilhite and Glantz, 1985).

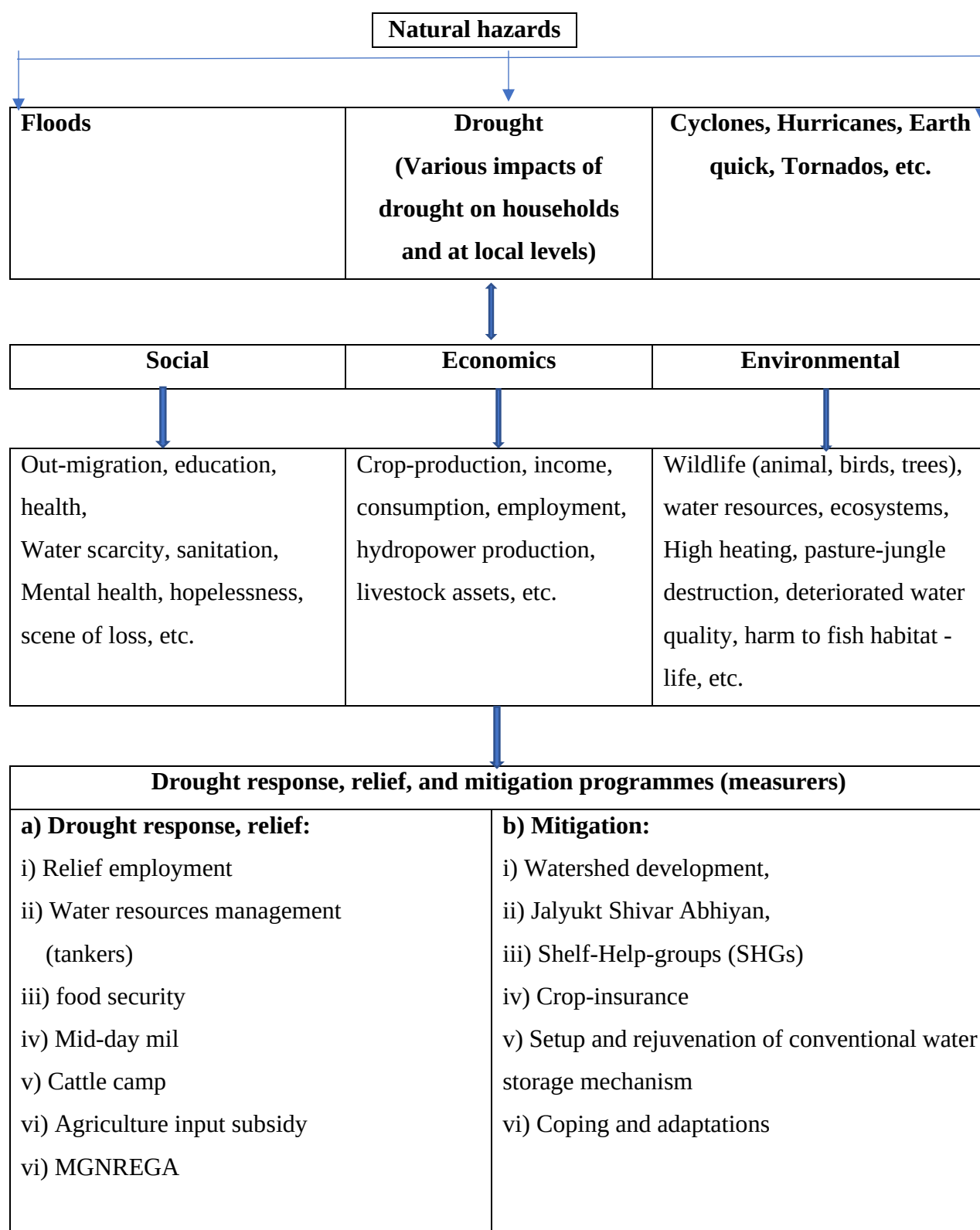
- i) **Meteorological drought:** “a lack of precipitation over a region for a while or the rainfall is decreased more than 0.25 % from the normal value of the area” (Mishra and Singh, 2010; Bokil, 2000).
- ii) **Agriculture drought:** “when soil moisture and rainfall are insufficient to support healthy crop growth during the crop growing season” (Mishra, 2010; Bokil, 2000).
- iii) **Hydrological drought:** “when surface and sub-water resources are drying up, and the prolonged meteorological drought converts into a hydrological drought” (Mishra, 2010; Bokil, 2000).
- iv) **Socio-economic drought:** “The drought occurs when the demand for an economic good exceeds supply due to a weather-related shortfall in the water supply” (Mishra & Singh, 2010).

The present study is based on agriculture drought and tries to identify its impacts on rural livelihood, particularly in the study area. Therefore, the study framed three main and two sub-objectives to determine the impacts of agriculture droughts, mainly on agriculture crops and related activities of rural farm households.

1.8 Theoretical framework of the study

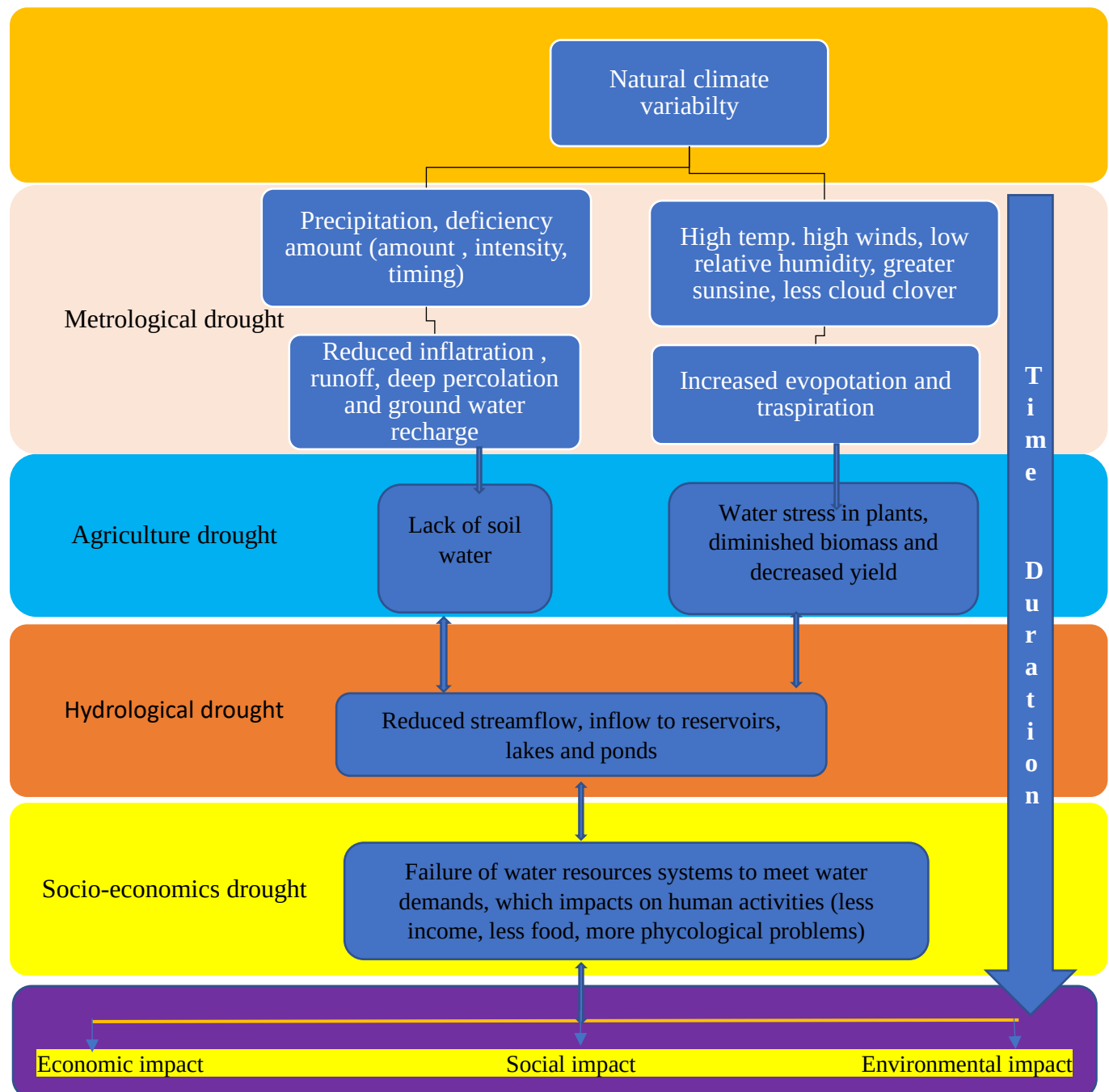
This is a micro-study at the villages and household level. The study wants to investigate the drought impact (economic, social, and environmental) on rural households in the irrigated and rainfed villages and the government’s policies to mitigate the drought impact from the three districts (Beed, Osmanabad, and Latur) Marathwada region in Maharashtra. This study’s theoretical framework is developed studying wide literature on drought and; it has been used in several studies to examine impact of drought on rural life and its effects on social, economic, environmental and biological factors in the study areas (Keshavarz and Karami, 2012; Wilhite, 2000; Ayugi et al., 2022). Figure 1.1 shows a schematic illustration of the theoretical foundation of our investigation.

Figure 1.1: Various impacts of drought



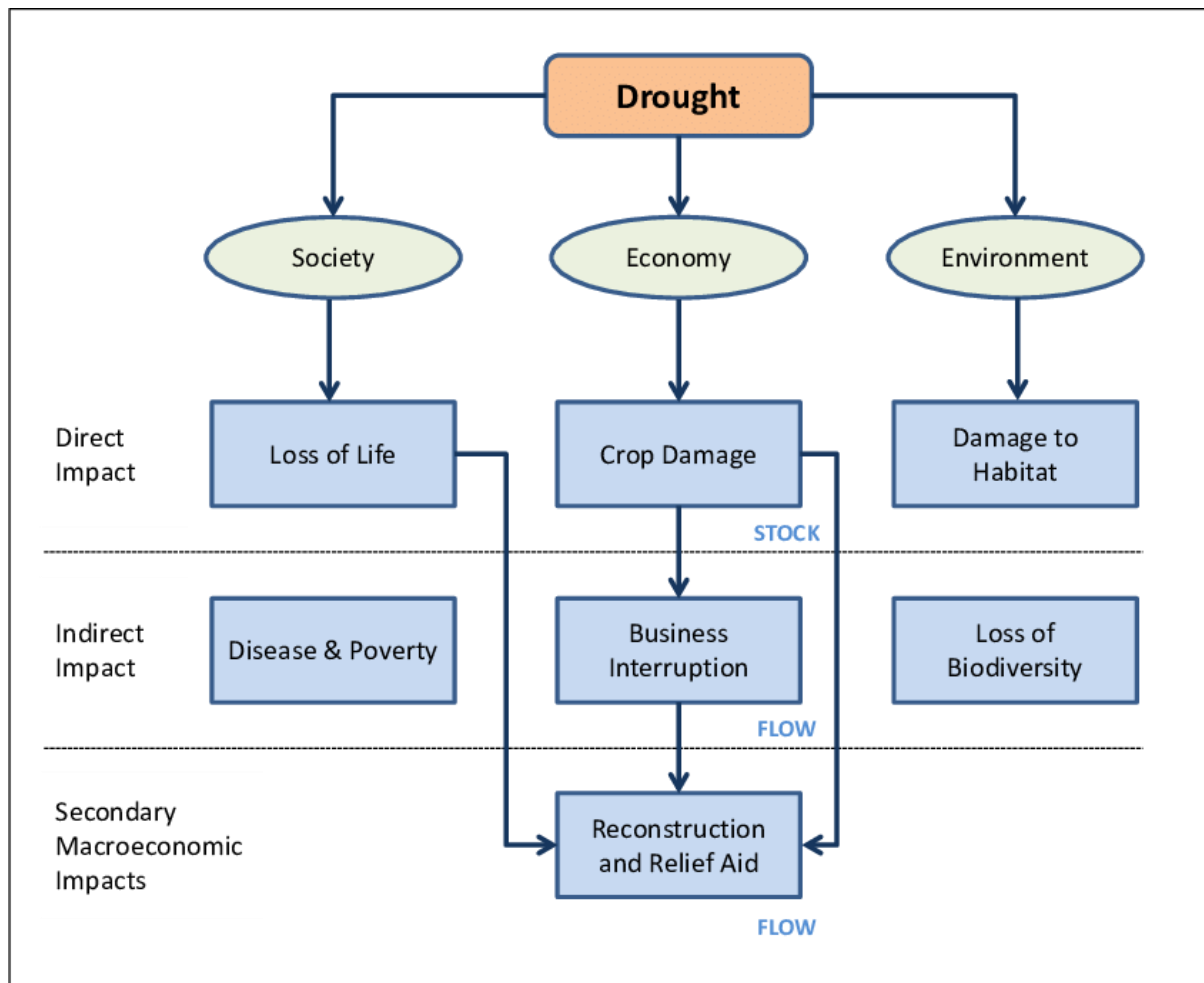
(Authors' own diagram using several studies)

Figure 1.2: Period of drought happenings and Connection among different types of droughts



(Source: National Drought Mitigation Centre, University of Nebraska-Lincoln, USA, 2000)

Figure 1.3: Examples of related drought impacts and Schematic presentation of drought impact groups

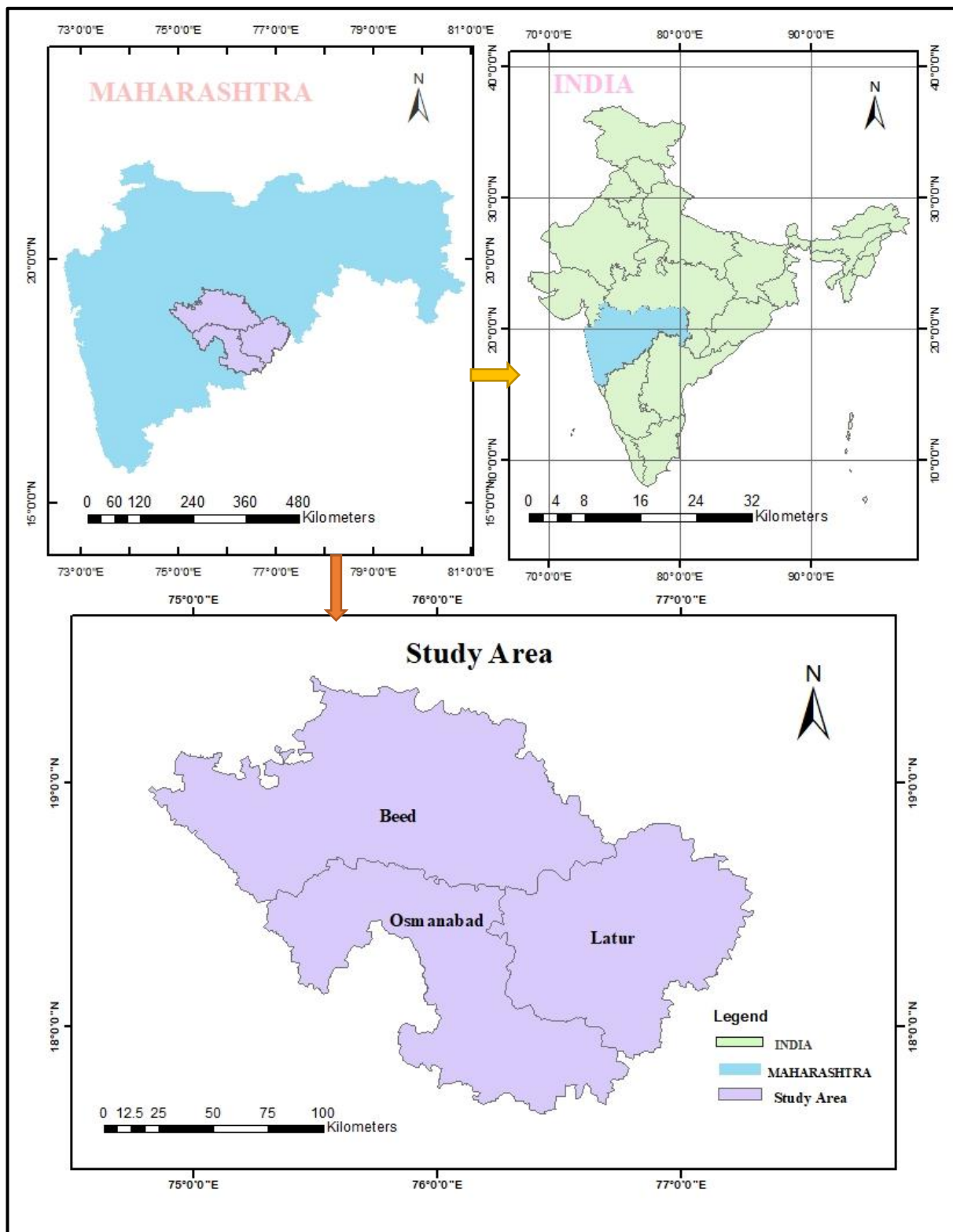


(Source: Jenkins, 2011)

1.9 Data sources and research methodology

The study is based on cross section as well as secondary data sources. For the collection of cross section data both quantitative and quantitative, mixed methods have been used. The primary data collected through structured questionnaire using multistage sampling method, focused groups discussion at the household and key informant interview at local levels (village, block and District). The secondary data has been collected through various government offices at local levels and many online websites of governments such as district, state and nation levels. Figures, charts, descriptive statistics, rainfall deviations, rainfall anomaly index multiple and binary regression analysis etc. tools and techniques are applied for primary and secondary data analysis. The result has been calculated using SPSS, EViews, Stata, Arc GIS and Excel statistical packages.

1.9.1: Location map of the study area



(Source: using Arc GIS)

1.9.2 Area of study

Bombay state was separated into two states: Maharashtra and Gujarat, On 1st May 1960. According to census 2011, Among all the states in India, Maharashtra has the second-largest population and is ranked third in terms of area. It is located on the western side of the country. For the academic intention, the state has been divided into six revenue divisions (viz. Konkan, Pune, Nashik, Aurangabad, Amravati, and Nagpur) and 36 districts ([Economic Survey of Maharashtra, 2017-18](#)). Geographically it has five regions which are namely, Vidarbha, Marathwada, Konkan, Paschim Maharashtra, and Khandesh. The meteorological department of India, the state has been separated into four sub-divisions such as Konkan & Goa, Madhya Maharashtra, Marathwada, and Vidarbha (<https://www.imdpune.gov.in>). On 1 November 1956, the region was transferred from Hyderabad to Bombay state. Aurangabad is known as the capital of Marathwada. The entire area of the region has 64590 km square and the total population of the region according to census 2011 is 1, 87, 31, and 872. A total of eight districts are in the region, namely Aurangabad, Jalana, Beed, Osmanabad, Nanded, Latur, Parbhani, and Hingoly. Three districts from the Marathwada region have been selected for the study, namely Beed, Osmanabad, and Latur (detailed information has given in chapter 2).

1.9.3 Primary data collection, sample selection method

i) Questionnaire

In the numerous studies, the structured questionnaire has been employed ([Udmale et al. 2014](#), [Habiba et al. 2012](#), [Manadhar et al. 2011](#), [Ashraf & Routray 2013](#), and [Keshavarz et al. 2013](#)) for the survey/primary data collection at the individual and household level. In this study, the structured questionnaire has been prepared for the collection of cross-section data, which has been divided into six parts: general information of the households and household heads, classification of landholding size, impacts of drought on economic, social, environmental factors, local government's role to mitigate drought impact, households coping and adaptation practices to mitigate the drought impact and various drought impacts scales. Both the open-ended and close-ended questions were included in the questionnaire. Before conducting the field survey, the pilot study has been done in the Masurdi village of Latur district of Maharashtra, where it has collected 100 households level data (information). After that the study has formed a structured questionnaire and selected study area. The pilot survey helped to prepare a questionnaire and selection of the study area. Additionally, it is assisted to avoid

unnecessary and irrelevant questions that have been associated with personal level of the households.

ii) Key informant interviews

The personal level interview has been taken for the village selection, such as village Sarpanch, Gram Sevak, Talathi, Mandal officer in both Tehsil and block level, the Taluka agricultural officer and Resident deputy collector at the district level. The researcher also discussed and collected the information from the editor of the local newspapers: Lokmat, Dainik Sakal, Maharashtra Times, Punya Nagari, etc. Further, we communicated with the local journalist who has been covered local news at the village level in the drought period of 2015-16 and 2018-19. After the complete discussion with the above authorities, the village has been selected for the study (this oral kind of interview has been conducted from the key informant only for village selection).

iii) Sample selection method

Several studies have used multi-stage sampling techniques for the collection of household survey data ([Udmale et al. 2012](#), [Habiba et al. .2014](#), [Alemayehu and Bewket, 2017](#)). Here, Beed, Osmanabad, and Latur districts have been selected from the Marathwada region for the case study, where there were severe drought conditions have reported in 2015 and 2018. Due to that, the highest number of water tankers were developed during the drought by local and state governments in 2015-16 ([Central Water Commission, 2015-16](#)). The study is used a multi-stage sampling method for primary data collections. In the first stage, the three districts (Beed, Latur, and Osmanabad) have been selected purposively from the Marathwada region of Maharashtra based on low rainfall, migration of people, drinking water scarcity and reduction in livestock assets and decreased in agriculture production compared to normal year. These three districts fall under Balaghat range and also lay in the Godavari and sub-river basins of Godavari (Manjara, Sindphana, and Terana tributary of Manjara). Villages come under the Bhalagat range which have mostly fallen in rain-fed areas and some villages are situated in the bank of Godavari and sub river basin which are mostly irrigated. In the second stage, two blocks/talukas have been selected purposively from each district based on one block is developed and highly irrigated. The second block comparatively is non-developed, low irrigated and the large area come under the Balaghat range . In the third stage, also the villages have been selected purposively from each block. Village is selected as a penultimate unit. The three irrigated villages have been selected from the Godavari, and sub-river basins based on the village are situated on the river's bank. The dam is near the village, and the canal facility is

available, and the village is highly irrigated and has extensive cultivation of sugarcane and cotton areas. The above three villages were selected from developed blocks.

On the other hand, the remaining three villages have been selected from non-developed blocks based on the villages are situated on Balaghat rang (hilly area). The village agriculture totally depends on rainfall, and there are very limited sources available for irrigation. Ultimately, six villages have been selected for the study (three are irrigated, and three are rain-fed villages). Finally, the farm households have been selected randomly from the six villages in the fourth stage. The total sample is 290. (the detailed information of the villages has given in chapter 2, and more information on sample selection method has been mentioned in the following table 1.1 as well as in chapter 5).

Figure 1.4: Shows the sample selection units step-by-step

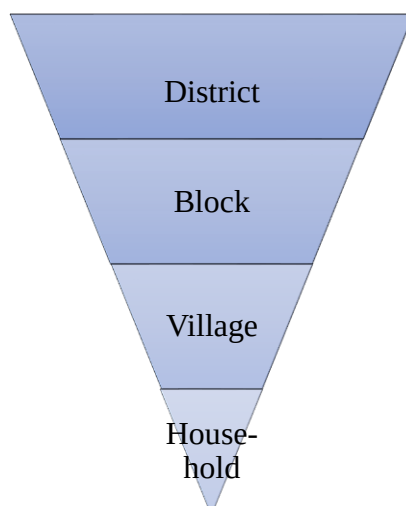


Table 1. 1: Multi-stage sample selection method

Stages of sample selection	I- stage	II -stage	III- stage	IV- stage	-
Sample selection Methods	Purposive	Purposive	Purposive	Randomly	-
Units	Districts	Blocks	Villages	Households	(%)
	Beed	Manjalgaon (developed)	Lukhegaon (highly irrigated)	46	(15.86)
		Patoda (non-developed)	Karanjwan (totally rain-fed)	51	(17.59)
	Osmanabad	Osmanabad (developed)	Bhandarwadi (highly irrigated)	53	(18.28)

		Washi (non-developed)	Jawalka (totally rain-fed)	50	(17.24)
	Latur	Latur (developed)	Takalgaon (highly irrigated)	50	(17.24)
		Ausa (non-developed)	Yellorewadi (totally rain-fed)	40	(13.79)
Total	Three	Six	Six	290	(100)

(Source: filed survey, 2018-19)

1.9.4 Secondary data sources

The secondary data has been conducted from a number of departments, including the agriculture and irrigation departments at the block level, Tehsil, Panchayat (block development office), district, and divisional levels. Furthermore, district-level data has been received from various departments at district levels such as the Collector Office, Zilla Parishad, District Ground Water Bord, agriculture, and irrigation departments. Crop production data has obtained from Government of Maharashtra, Department of Agriculture, (<http://krishi.maharashtra.gov.in>). The monthly rainfall time-series data is obtained from the website of the Indian Water Portal (<https://www.indiawaterportal.org/metdata>) during the period from 1901 to 2002. This monthly time series is used in several studies to analyse the rainfall trend (Shree & Kumar, 2018; Duhan & Pandey, 2013; Chandniha et al., 2017). The remaining time series data have been gathered from the Department of Krishi Government of Maharashtra (maharain.gov.in) from 2003 to 2018 over 37 rainfall stations of Beed, Osmanabad, and Latur districts. The study used both parametric and non-parametric tests to examine the trend and seasonal variation in the time series data. These days, The Mann-Kendal (MK) test is broadly applied to determine the monotonic trend in the rainfall and temperature time series data or hydro-metrological data. The test result is not affected by outliers (Rahman et al., 2017; Patra et al., 2012; Duhan & Pandey, 2013; Subash & Sikka, 2014; Ingle et al., 2018; Yang et al., 2020; Bryan et al., 2009; Asfaw et al., 2018). Furthermore, the magnitude of change in the data series is determined using the Sen's slope estimator (Sen, 1968). Overall, the statistical analysis of three district rainfall data has been prepared using an excel sheet and XLSTAT software.

1.9.5 Rainfall deviations

To find out the drought and normal years the rainfall deviations has computed. The following formula is utilized to calculate the rainfall deviation as per drought manual, 2016.

$$\text{RF dev} = \{(\text{RFi} - \text{RFn}) / \text{RFn}\} * 100$$

Where,

RFi = Actual rainfall (mm) over a corresponding time period,

RFn = For the same time period, normal rainfall (mm), (minimum 30 years averages).

1.9.6. Multiple regression model

This study evaluates the impact of climatic variables on the three districts' total food grain output for a period of 19 years, from 2000 to 2018. A multiple regression model has been employed to find out association in between above-mentioned variables. The climate variables are used in the study such as annual rainfall, maximum temperature, and minimum temperature. Climate variables are taken into account as explanatory variables. The outcome variable is the production of food grains. Many studies used a multiple regression model (ordinary least square technique) to evaluate the impact of climate change on agriculture crop production and productivity (Guntukula, 2020; Parthasarathy et al., 1988; Kelkar et al., 2020; Sarker et al., 2014). The following regression equation is used as a multiple linear regression model.

$$y_i = b_1 + b_2 \text{rainf}_t + b_3 \text{maxtemp}_t + b_4 \text{mintemp}_t + u_t \dots \dots \dots (1)$$

y_i = total foodgrain production ("00" tonnes), rainf_t = annual rainfall (mm), maxtemp_t = average maximum temperature(°C), mintemp_t = average minimum temperature (°C), u_t = error term.

1.9.7 Binary logit regression model

A binary logistic model specification is implemented to model respondents' drought coping and adaptation practices. In order to dummy response variables are binary options (Marie et al., 2020). Logistic model specification according to (Green, 2011):

$$\log\left(\frac{P_i}{1-P_i}\right) = \log(P_i) = \beta_0 + \beta_i X_i \dots \dots \dots (1)$$

Where, P_i is the probability of adopting specific adaptation strategies from the given set dummy dependent variable, X_i is the explanatory or independent variables. Therefore, the β_i parameter

shows the log odds for the dependent or outcomes variable. The probability of odds is defined as P_i = the farm household adopt and, $(1 - P_i)$ = not adopt (Zha and Gupta, 2021; Jin et al., 2016). The log odd defines as:

$$\frac{P_i}{1 - P_i} = \exp(\beta_0 + \beta_i X_i) \dots \dots \dots (2)$$

(More information on this topic is given in chapter 6)

1.10 Limitations of the study

Every research work has its own set of constraints and limitations. It is important to recognize that the current study has a specific set of limitations.

- i) The first limitation of the study is that it is mainly based on cross-section data, which has been collected from six villages of the three districts of irrigated and rain-fed areas (ecosystems) of the Marathwada region of Maharashtra. Moreover, the total sample size is only 290.
- ii) The survey data has covered only farm sector households; non-farm sector households have not been included in the study. Furthermore, the study covered only the rural farm sector; it is not focused on the urban, industrial, and service sectors.
- iii) For the identification of drought years, the study only used the Drought Anomaly Index and rainfall deviation. The RAI was calculated over the three districts, and rainfall deviation was calculated only for the Marathwada region and across India only for southwest monsoon rainfall and annual rainfall time series data.
- iii) Another limitation of the study is that it used a few climatic variables such as rainfall and temperature to analyse the drought impact on foodgrain production. The crop production data has been conducted from the agriculture department of Maharashtra from 2000 to 2019 for 19 years only. For the climatic variables data collection few online sources have been used such as the Indian water portal, Indian Institute of Topical Metrology (IITM), and Open Government Data (OGD) Platform India.
- iv) Another limitation of the study is that it uses only monthly rainfall time series data to detect the rainfall trends. Only the non-parametric Mann-Kendall test and Sen's slope estimators have been used to identify the significance of the rainfall trends. The study used only means,

standard deviations, maximum and minimum values, and coefficient of variations in the descriptive statistics for data visualization.

v) The study examined only long-term (adaptation strategies) and short-term (coping strategies), which farmers have practised in the drought. Furthermore, merely the binary logistic regression model has applied to determine the association in between socio-economic variables and coping and adaptation practices of the farmers.

1.11 Organization of the study

The present study is organized into seven chapters to the convenience of research analysis. The 1st chapter describes the study's introduction/background and motivation; the contents are also included in this chapter: research questions, objectives, hypothesis, theoretical framework, classification of drought, drought definition, data sources and methodology, and the limitations of the study. The 2nd chapter deals with a short description of the study area, demographic and geographical information of Beed, Osmanabad, and Latur districts, and the village demographic features. The 3rd chapter compiles literature review on various issues of drought. Chapter 4th highlights temporal rainfall trend analysis and variability of three districts of Beed, Osmanabad, and Latur district of Maharashtra. The 5th chapter describes the socio-economic profile of the sample farm households (socio-economics conditions in the drought prone-areas among rural households in irrigated and rain-fed villages - an empirical investigation from primary data). It illustrates the housing condition of farm households, their income in the drought period, drinking water facilities, education level, village characteristics, latrine facilities, cooking sources, lighting facilities, etc. Furthermore, this chapter use multiple regression analysis to examined relationship between total food grain production of three districts and climatic variables and also provides information on cattle camps and crop annewari/paisewari data for three years from 2016 to 2018. Chapter 6th analyses determinates of farm households' choice of coping and adaptation strategies to cope with drought from three districts, and finally, chapter 7th deals with conclusion and policy measures.

Chapter 2

Profile of the Study Area

2.1 Brief introduction of the Maharashtra state

Maharashtra is one of India's most developed and industrial states, and Mumbai is the nation's commercial capital. The state's geographical position is 15.45 to 22.0 North latitude (degrees) and 72.45 to 80.45 East longitude (degrees). According to the population census of 2011, Maharashtra has a total of 11.24 crore population. It is the second-highest population position among all states of India. The state has 5, 83,61,397 are men and 5, 40,11,575 are women out of the total people. As per the economic survey of Maharashtra 2020-21, the total scheduled caste and scheduled tribe population is 1,3 275, 898 and 10, 507, 000, respectively. The total literacy rate is 82.30, and the Sex ratio (females per thousand males) is 929. The density of population is 365 per sq. kilometre, and the total rural and urban population is 5,08, 2,513 core and 6, 15, 45, 441 core, respectively ([Socio-economics Review, 2201-22; Handbook of Basic Statistics of Maharashtra 2018](#)).

Its total geographical area is 3.08 lakh sq. kilometres, which is the third-highest among the all-state. It is situated in India's western and central parts. Furthermore, it has a 720 km huge coastline of the Indian Ocean. Sahyadri as well as Satpuda mountain ranges have been protected naturally to the state. The state boundaries have bounded by five states, such as Madhya Pradesh is on the north, Gujrat is situated to the north-west, and Chhattisgarh is located in the east. Furthermore, in the south-east where the Telangana is situated and lastly the state of Goa is fall in south-west. Moreover, art and crafts have a long and varied history in the state, it has flourishing under numerous rulers, including the Marathas, Mughals, and British. The Ajanta and Ellora caves and the Warli murals are excellent examples of the arty tradition ([State Enviroment Report, 2015](#)).

Maharashtra state has been divided into five geographical regions, such as Vidarbha, Konkan, Marathwada, Khandesh, and west Maharashtra. For administerial purpose, the state has been segmented into six administrative divisions, namely, Amaravati, Aurangabad, Pune, Nagpur, Nashik, and Konkan. It has total of 36 districts. Furthermore, it has 33 Zillah Parishads, 355 Tehsils, 349 Panchayat Simitis, a total number of villages is 43,6,65, out of that, 40,959 inhabited and 2706 uninhabited, 22 municipal corporations, 222 municipals councils, 3 Nagar panchayats, seven cantonment boards (see table 2.1).

Table 2.1: Shows a broad picture of Maharashtra's administrative setups

	Units	1960-61	1970-71	1980-81	1990-91	2000-01	2020-11	2020-21
Sr. No	Following Panchayats local bodies' works related to the development of rural areas							
1	Total districts	26	26	36	30	35	35	36
2	Total zilla parishad	25	25	25	29	33	33	34
3	Total tehsils	229	232	232	300	353	355	358
4	Total panchayat samitis	295	296	296	298	321	351	351
	Total gram panchayats	21,636	22,300	24,281	25,827	27,735	27,913	27,832
5	Total villages	38837	38661	41833	43025	43722	43664	44198
	Following urban local bodies' works related to the development of the urban areas							
i)	Municipal corporation	3	4	5	11	15	23	27
ii)	Municipality	220	221	220	228	229	226	241
iii)	Contentment boards	5	7	7	7	7	7	7
iv)	Census town	38	57	57	90	127	279	N.A.

(Source: Economic Survey of Maharashtra 2021-22, <https://mahades.maharashtra.gov.in>, <https://censusindia.gov.in/2011>)

Table 1 shows the broad picture of administrative setups of Maharashtra state from 1960-61 to 2020-21. In 2020-21, Maharashtra has 36 districts. Furthermore, it has 34 Zilla Parshad, 351 panchayat samitis, and 27832 gram panchayats that have existed, now. These organizations are work-related to the development of rural areas. On the other hand, 27 municipal corporations, seven contentment bords, and 241 municipal councils have existed. These organization mainly works with related to the development of urban areas.

Table 2.2: Highlights Maharashtra's total working population, including males and females

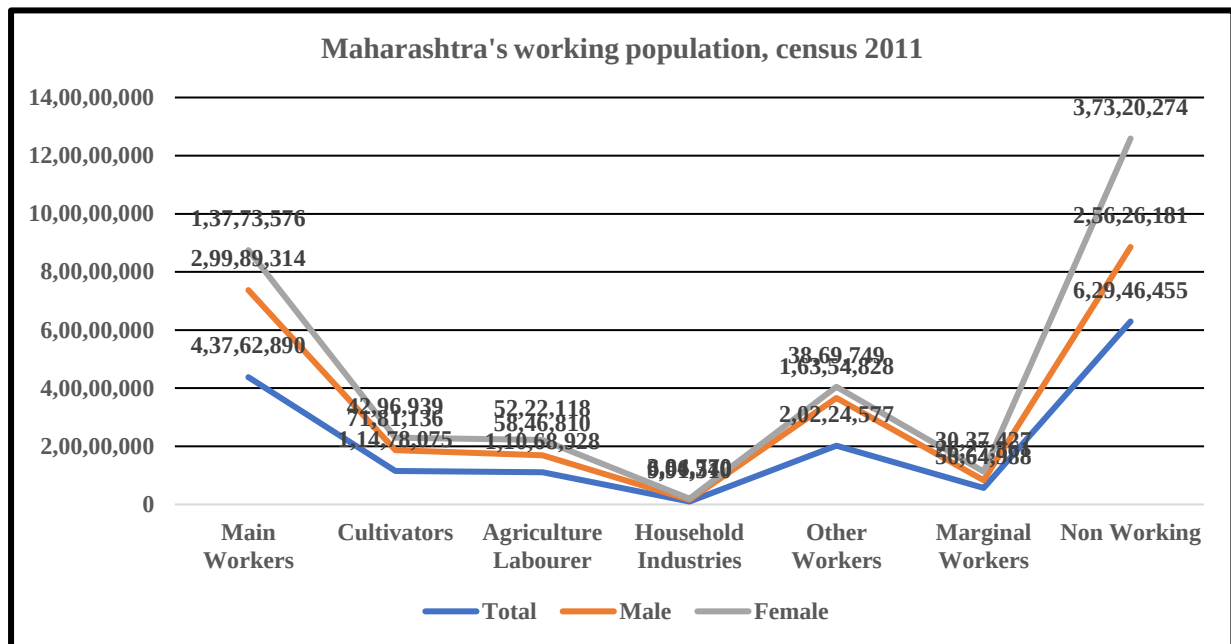
Maharashtra working population	Total	Male	Female
Main workers	437,62,890	299,89,314	137,73,576
Cultivators	114,78,075	71,81,136	42,96,939
Agriculture labourer	110,68,928	58,46,810	52,22,118

Household industries	9,91,310	6,06,540	3,84,770
Other workers	202,24,577	163,54,828	38,69,749
Marginal workers	56,64,988	26,27,561	30,37,427
Non working	629,46,455	256,26,181	373,20,274

(Source: censusindia.co.in/states/maharashtra)

Information about the entire working population in Maharashtra state is provided in Table 2.2, which also includes data on the main workers, cultivators, agricultural labourers, household industries, other workers, marginal workers, and the non-working population. The total main workers were (437,62,890), of which 299,89,314 (68.53 %) were males and 137,73,576 (31.47 %) were females. Furthermore, the total cultivators were 114,78,075 of which, 71,81,136 (62.56 %) were males and 42,96,939 (37.44 %) were females. Moreover, total agriculture labour were 110,68,928, of which 58,46,810 were male (52.82 %) and 52,22,118 (47.18 %) were female. Then, out of total 56,64,988 marginal workers, 26,27,561 (46.38 %) were male and 30,37,427 (53.62 %) were female. Lastly, out of total 629,46,455 non working persons 256,26,181 (40.71 %) were male and 373,20,274 (59.29 %) were female. It is observed that the male working population is more than females workers in all types of workers and only in the case of the non-working population where the females more than males.

Figure 2.1: Highlights Maharashtra's total working population, including males and females



(Source: censusindia.co.in/states/maharashtra)

2.2 Brief geographical information of Marathwada region

Officially, the Aurangabad division has known as the Marathwada region. The physical position of the region is 17°35 to 20°41 North latitude and 74°40 to 78°16 East longitude. The division has the maximum eight districts in the state compared to other regions. The regions' district names are Nanded, Parbhani, Hingoli, Latur, Osmanabad, Beed, Jalna, and Aurangabad. The Marathwada meteorological sub-division has existed in Maharashtra's centre and south-eastern regions. This area is part of the tropical semi-arid zone, which has recently made headlines because of farmer suffering and suicides in the extreme drought years of 2014–15 (Kulkarni et al., 2020). The total geographical space of the region is 64,590 square kilometres, which is 21% of the state areas. Marathwada is a geographic and climatic area of the Deccan plateau, which is largely covered by deep black cotton soil. This area is divided into three primary geographical zones based on its height fluctuations (ranges). The Ajanta Mountain ranges and Balaghat hills are well-known as the northern and southern uplands of the region. In contrast, the Godavari and Manjara river basins lied in the centre region. The region is positioned in the rain shadow of Sahyadri mountain ranges, which makes vulnerable to rainfall fluctuations (Kulkarni et al., 2020). Maharashtra has a total of 519 rainfall stations, out of which Marathwada has 92. Furthermore, the total district-wise station is like Nanded has

20, Beed has 14, Latur has 13, Parbhani has 11, Aurangabad has 11, Osmanabad has 10, Jalana has 7, and Hingoli has 6, respectively (imdpune.gov.in).

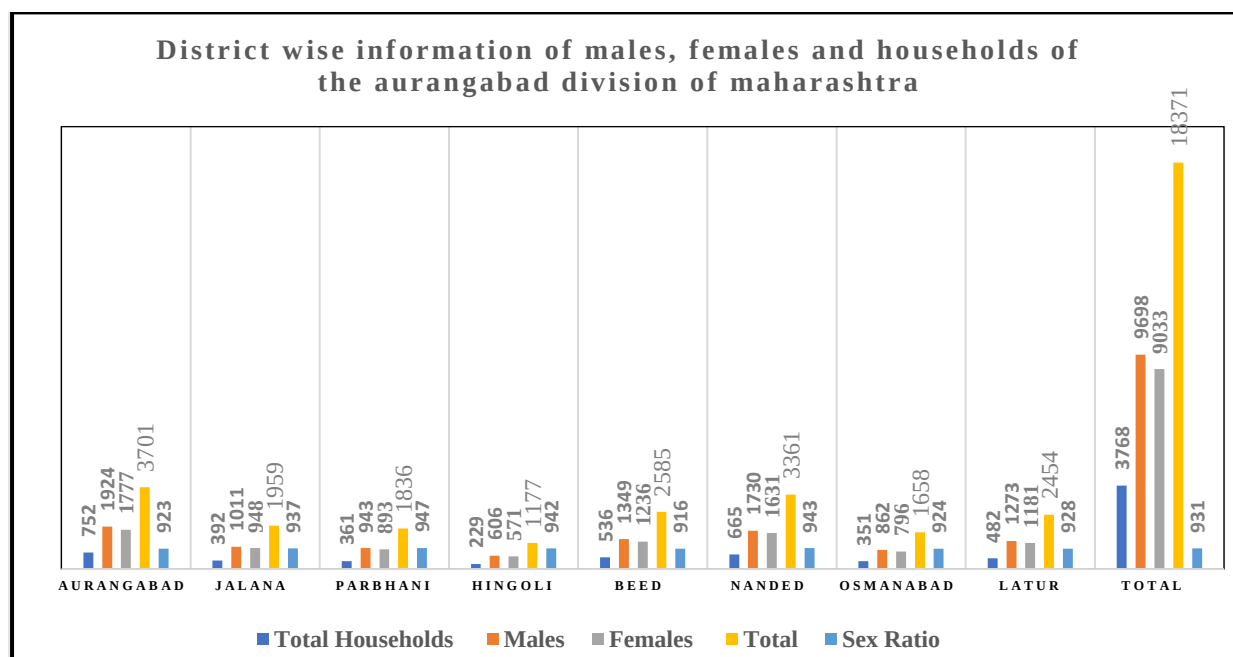
Table 2.3: According to the population census 2011, district-wise information of the total households, total population, total male and female and sex ratio of Aurangabad division of Maharashtra (in thousands, 000)

District names	Total Households	Male	Female	Total	Sex Ratio
Aurangabad	752	1924	1777	3701	923
Jalana	392	1011	948	1959	937
Parbhani	361	943	893	1836	947
Hingoli	229	606	571	1177	942
Beed	536	1349	1236	2585	916
Nanded	665	1730	1631	3361	943
Osmanabad	351	862	796	1658	924
Latur	482	1273	1181	2454	928
Total	3768	9698	9033	18371	931

(Source: Handbook of basic statistics of Maharashtra, 2018) Note: Marathwada region and Aurangabad division are the same)

Table 2.3 illustrates the district-wise information households of males and females of the Aurangabad division of Maharashtra. It shows that total 3768 households have existed in the Aurangabad division, and their total people were 18371, of which 9698 were males, and 9033 were females. In comparison to per thousand males, the division sex ratio is 931 (all figures are considered in thousands, 000).

Figure 2.2: District wise information of the total households, total population, total males and females of the Aurangabad division of Maharashtra (in thousands, 000)



(Source: Handbook of basic statistics of Maharashtra, 2018)

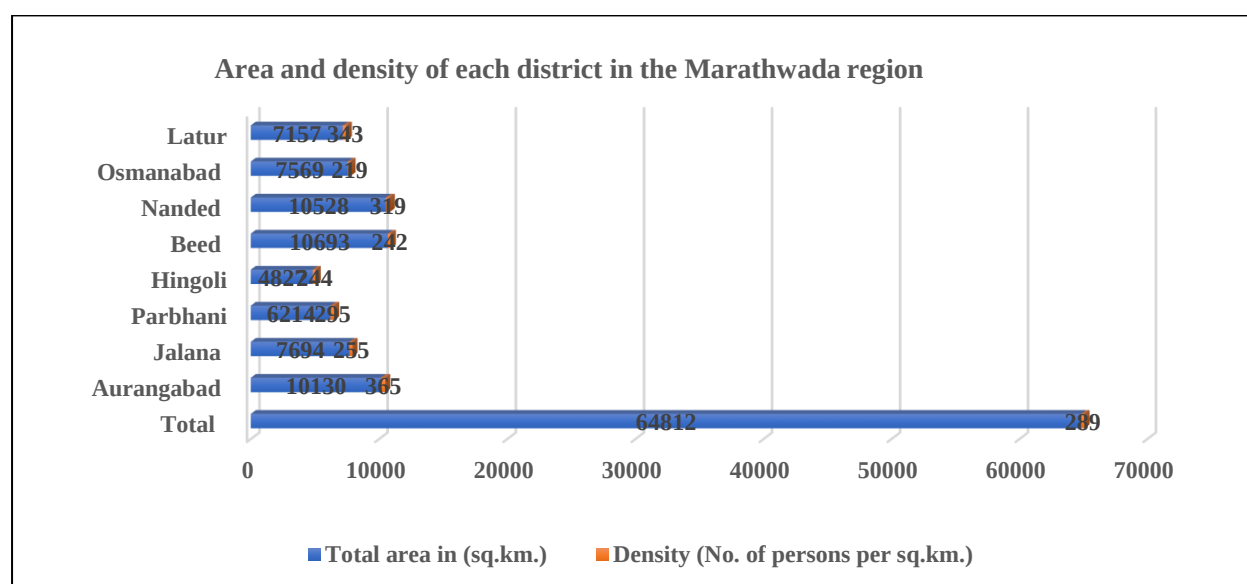
Table 2.4: According to the census 2011, area and density of each district in the Marathwada region

District names	Total area in (sq.km.)	Density (No. of persons per sq.km.)
Aurangabad	10130	365
Jalana	7694	255
Parbhani	6214	295
Hingoli	4827	244
Beed	10693	242
Nanded	10528	319
Osmanabad	7569	219
Latur	7157	343
Total	64812	289

(Source: Handbook of basic statistics of Maharashtra, 2018)

The above table 2.4 highlighted the area and density of the Marathwada region of Maharashtra. Out of eight districts, Aurangabad district density was high compared to other seven districts, whereas Osmanabad's density has been reported low, which was 219. The region density was 289.

Figure 2.3: Area and density of each district in the Marathwada region, according to the population census of 2011



(Source: Handbook of basic statistics of Maharashtra, 2018)

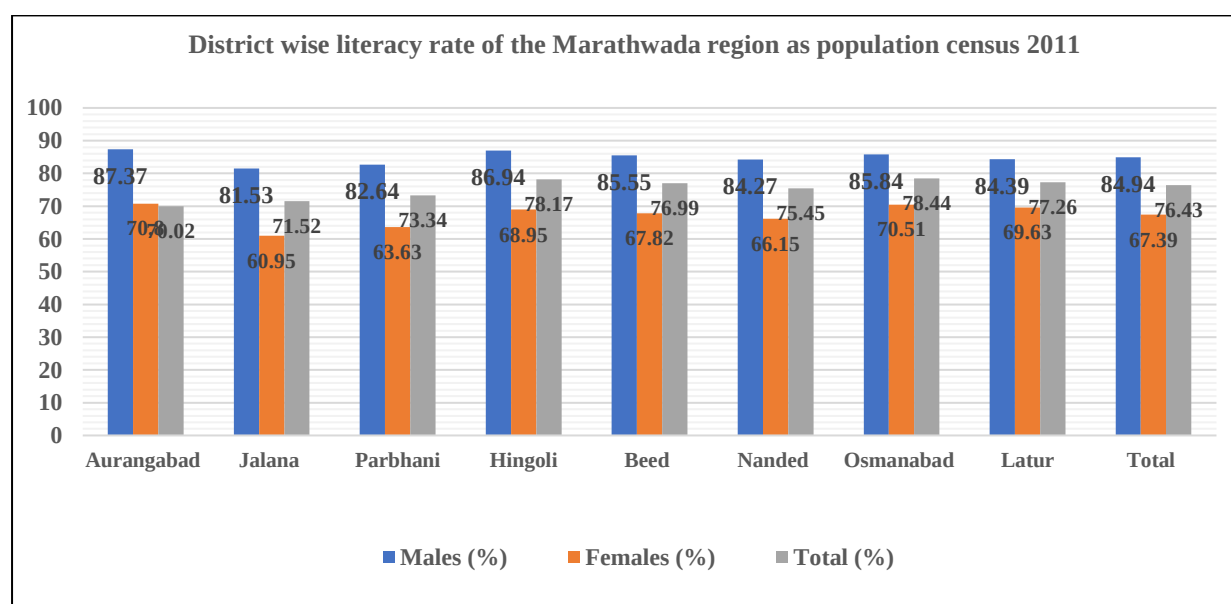
Table 2.5: As per population census 2011, every district wise literacy rate of the Marathwada region

District names	Males (%)	Females (%)	Total (%)
Aurangabad	87.37	70.8	70.02
Jalana	81.53	60.95	71.52
Parbhani	82.64	63.63	73.34
Hingoli	86.94	68.95	78.17
Beed	85.55	67.82	76.99
Nanded	84.27	66.15	75.45
Osmanabad	85.84	70.51	78.44
Latur	84.39	69.63	77.26
Total	84.94	67.39	76.43

(Source: Handbook of basic statistics of Maharashtra, 2018)

The above table 2.5 data was collected from the Handbook of basic statistics of Maharashtra, 2018 (as per the census of 2011). It describes district-wise male, female and total literacy of every district as well region. It is found that the Aurangabad district male literacy ratio was 87.37 % which was higher among the all-district compared to both the males and females ratios. The Jalana district literacy ratio reported low among the female category, which was 60.95 %.

Figure 2.4: Every district wise literacy rate of the Marathwada region as population census 2011



(Source: Handbook of basic statistics of Maharashtra, 2018)

Table 2.6: As per population census 2011, total scheduled caste (SCs) and scheduled tribe (STs) population and their share of total state population and their literacy rate over Marathwada region

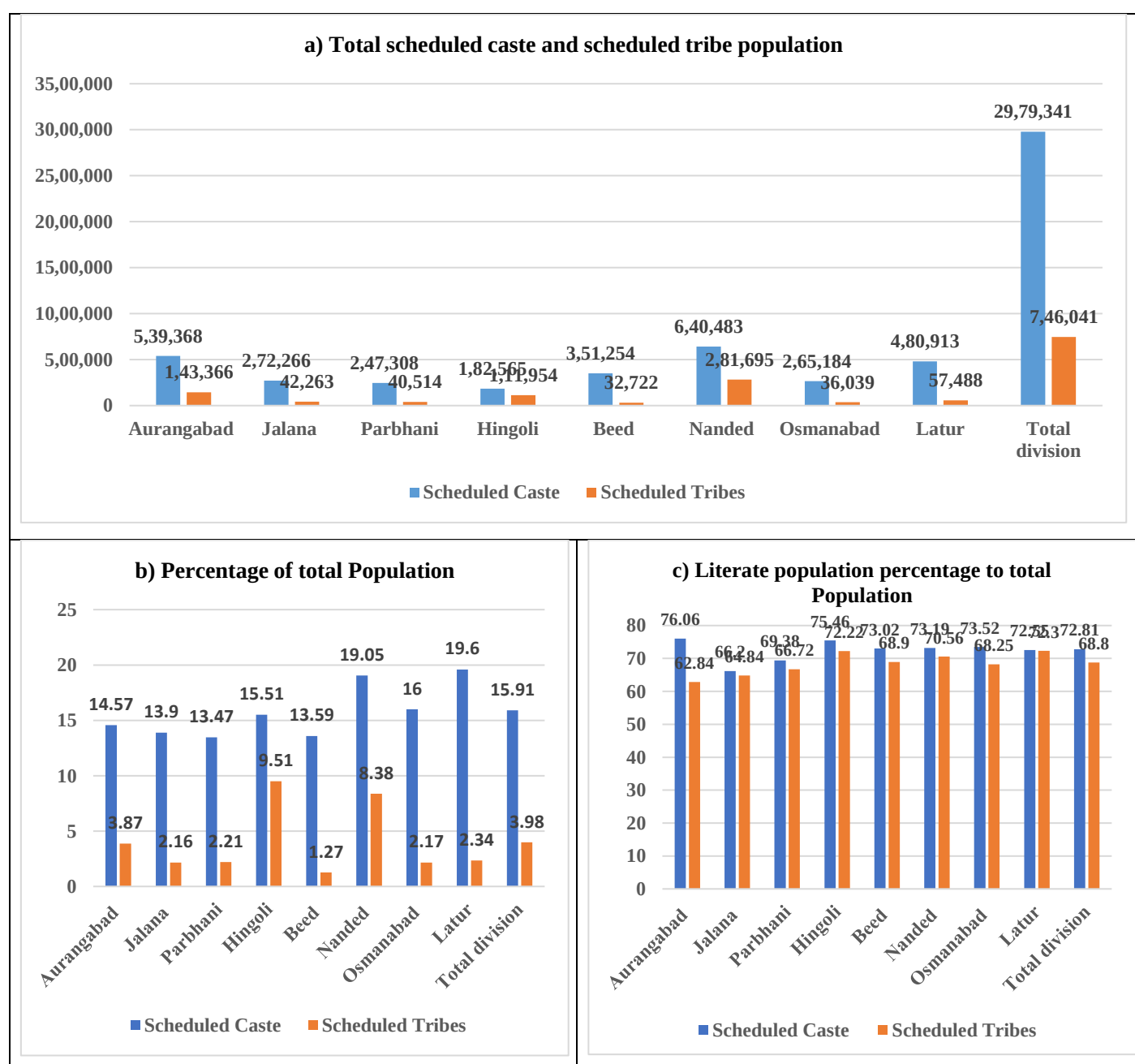
District names	Scheduled Caste	Scheduled Tribes	Percentage of total Population		Literate population percentage to total Population	
			S.Cs.	S.Ts.	S.Cs.	S.Ts.
Aurangabad	5,39,368	1,43,366	14.57	3.87	76.06	62.84
Jalana	2,72,266	42,263	13.90	2.16	66.20	64.84
Parbhani	2,47,308	40,514	13.47	2.21	69.38	66.72
Hingoli	1,82,565	1,11,954	15.51	9.51	75.46	72.22
Beed	3,51,254	32,722	13.59	1.27	73.02	68.90
Nanded	6,40,483	2,81,695	19.05	8.38	73.19	70.56
Osmanabad	2,65,184	36,039	16.00	2.17	73.52	68.25
Latur	4,80,913	57,488	19.60	2.34	72.55	72.30
Total	29,79,341	7,46,041	15.91	3.98	72.81	68.80

(Source: Handbook of basic statistics of Maharashtra, 2018)

Table 2.6 shows the total SCs and STs population and their total proportion to total state populace and literacy rate over the Marathwada region (as per the census report, 2011). It is reported that the highest proportion of SCs populace reported in Latur and Nanded districts, which were (19.60 %) and (19.05 %), respectively. In contrast, the lowest percentages were reported in Parbhani and Jalana districts, which were (13.47 %), and (13.59 %), respectively.

The highest percentages of STs populations were reported in Hingoli (9.51 %) and Nanded (8.38%) districts. Furthermore, the lowest percentages of the population were reported in Beed (1.27 %) and (2.16 %) Jalana districts. The highest literacy rate among all districts of the Marathwada region for the SCs was recorded in Aurangabad district (76.06 %), and the lowest recorded in Jalana district, which was (66.20 %). Furthermore, the STs highest literacy rate was reported in Latur district, which was (72.30 %), whereas the lowest was in the Aurangabad district (62.84 %).

Figure 2.5: The total SCs and STs population and their total percentage of the total state population and literacy rate over the Marathwada region (as per population census, 2011)



(Source: Handbook of basic statistics of Maharashtra, 2018)

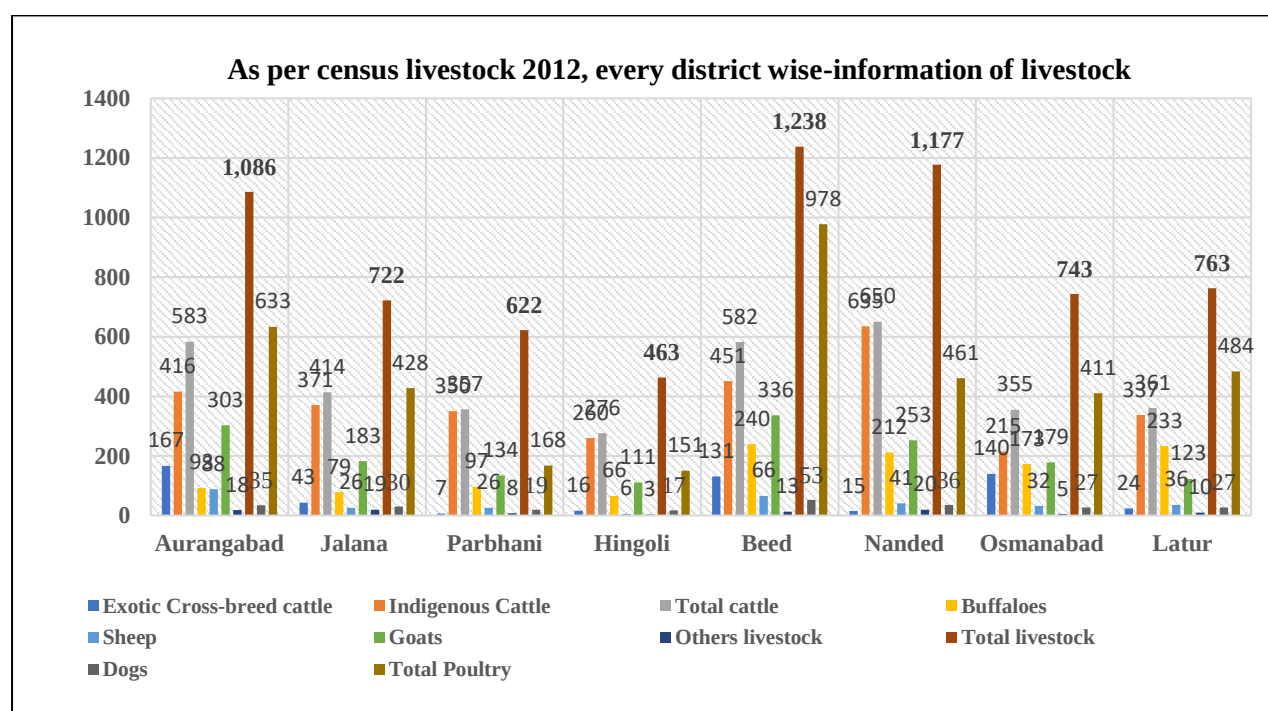
Table 2. 7: As per census livestock 2012, every district wise-information of livestock over the Marathwada region of Maharashtra (in thousands, 000)

District names	Exotic Cross-breed cattle	Indigenous Cattle	Total Cattle	Buffaloes	Sheep	Goats	Others livestock	Total livestock	Dogs	Total Poultry
Aurangabad	167	416	583	93	88	303	18	1,086	35	633
Jalana	43	371	414	79	26	183	19	722	30	428
Parbhani	7	350	357	97	26	134	8	622	19	168
Hingoli	16	260	276	66	6	111	3	463	17	151
Beed	131	451	582	240	66	336	13	1,238	53	978
Nanded	15	635	650	212	41	253	20	1,177	36	461
Osmanabad	140	215	355	173	32	179	5	743	27	411
Latur	24	337	361	233	36	123	10	763	27	484
Total division	543	3,035	3,578	1,193	321	1,622	96	6,814	244	3714

(Source: Handbook of basic statistics of Maharashtra, 2018)

Table 2.7 shows the livestock information as per the census 2012 over the Marathwada region of Maharashtra (in Thousands, 000). Out of the total (6814) livestock, 1238 (18.17 %) were reported in the Beed district, which was the highest among the eight districts. Followed by 1177 (17.27 %) were recorded in the Nanded district, which has the second-highest, while the lowest was recorded in Prabhani and Osmanabad districts, 622 (9.12 %), 743 (10.90 %), respectively. The highest number of goats were reported in Beed, Aurangabad, and Nanded districts. Furthermore, the highest number of Buffaloes were reported in Beed and Latur districts. Moreover, the total highest cattle were reported in Nanded, Beed, and Aurangabad districts, respectively.

Figure 2.6: As per census livestock 2012, every district wise-information of livestock over the Marathwada region of Maharashtra (in thousands, 000)



(Source: Handbook of basic statistics of Maharashtra, 2018)

Table 2.8: Every district wise-information from primary and secondary education sources over the Marathwada region of Maharashtra (in thousands, 000)

Districts	Primary Education			Secondary Education (Including Higher Secondary)		
	Organisations	Students	Teachers	Organisations	Students	Teachers
Aurangabad	3,267	6,89,102	22,580	1,109	2, 70,234	8,345
Jalana	1,916	3,14,868	10,503	487	1,28,258	3,270
Parbhani	1,529	3,00,043	10,272	611	1,17,145	3,941
Hingoli	1,038	1,78,516	6,211	277	70,084	2,041
Beed	2,937	7,19,520	17,716	760	1,81,779	6,097
Nanded	2,953	5,10,277	17,007	823	1,90,080	6,282
Osmanabad	1,361	2,11,851	8,580	493	87,476	3,050
Latur	1,936	3,92,519	14,414	755	1,69,768	5,731
Total division	16,937	33,16,696	107,283	5,315	12,14,824	38,757

(Source: Handbook of basic statistics of Maharashtra, 2018)

Table 2.8 describes the district wise-information from primary and secondary education sources over the Marathwada division of Maharashtra (in thousands, 000). In the case of primary education institutions, most of the institutions exist in Aurangabad district, followed

by Nanded, Beed, Latur, Jalana, Parbhani Osmanabad and Hingoli. It is also demonstrated that most primary institutions exist in the Aurangabad district, followed by Nanded, Beed, Latur, Jalana, Parbhani, Osmanabad, and Hingoli sequentially. Furthermore, in the case of secondary education institutions, including upper secondary, most have existed in Aurangabad, Nanded, Beed, Latur, Parbhani, Osmanabad, Jalana and Hingoli, respectively. The majority of registered pupils in elementary education have been found in Beed, Aurangabad, Nanded, Latur, Jalana, Parbhani, Osmanabad, and Hingoli, respectively.

2.3. Brief introduction of three districts in the study area

2.3.1 Geographical position and physical features of Beed district

The district takes its name from the town of Beed, which was previously known as Bhir, and it has two theories for its origin. Sarvananas emperors ruled over the Beed in the 2nd century A.D. The king Sarvanana's had discovered their first coins which found at Aurangabad and in Vidarbha. The Vakatakas, Rashtrakutas, Chalukyas, and Yadavs, all Hindu kings were come after the Satvahans. Pulakesi was a great king and the second ruler of the Chalukyas empire who's reigned over North and South Maharashtra for a considerable time. Including Beed, Nizam, and Mughal rule spread over the country in the 16th century. Then, the Marathas had a significant loss in the Battle of Panipat at Panipat in 1761. Even massive loss in the battle, the Maratha empire governed over the district until 1817.

At the western middle side of the Aurangabad division, on the bank of Bindusara river and in the Balaghat rang where the Beed district is placed. The geographical position of the district is 18 28', 19 27' North latitude and 74 54', 76 57' East longitude. The total area of the Beed district is 10,693 km², which is 3.47 % of Maharashtra. Out of the total area of the district, 158.31 km² belong to urban and 10,534.69 km² belong to rural. Total 11 blocks/taluks have existed in the district, namely Beed, Georai, Manjlgaon, Ambejogai, Ashti, Patoda, Shirur Kasar, Dharur, Kaij, Wadwani, and Parli. The district has been divided into six revenue departments for administrative purposes, namely, Beed, Georai, Ashti, Manjlgaon, Ambejigai, and Prali. ([District Socio-economics Review, 2017](#); [District Census Handbook Beed, 2011](#)). According to population census 2011, the district has 2,585,049 population out of that 1,349,106 are males, and 1,235,943 are females. Rural population is 2,070,751 and the urban population is 514,298. The total number of villages is 1,368, the number of households is 534,278. Furthermore, as per the census 2011, the district literacy rate is 76.99 %. Out of that, male literacy is 85.55 %, and female literacy is 67.82 %. The scheduled caste population is

13.59 %, and the Scheduled tribe is 1.27 %. In the agriculture and allied sectors total number of cultivators is 606,280, and the number of agriculture laborers is 373,566 ([District Census Handbook Beed, 2011](#)).

2.3.2 Rivers

The Godavari is the important river in the district, and it passes through the boundary of the north blocks of Majalgaon and Georai. Manjara, Sindphana, Bindusara, and Waan are also important rivers in the district. Manjara and Sindphana are major tributary of the Godavari. In addition to, Talwar, Kambadi, Ruti, Mehekari, are small rivers in the district, which are completely dried up after the month of March in the summer season. Beed district soil is black and rocky; out of blocks of Beed district, Georai and Manjgaon blocks, soil is black and productive because there is a flow of the Godavari River as well as Sindphana river flow going through Manjalgaon block. This land is fertile and useful for agriculture ([District Socio-economics Review, 2021](#)).

2.3.3 Climate and rainfall

There are three main seasons in the Beed district such as monsoon, summer and winter. The district's climate is hot during the summer and usually dry throughout the year. The only exception of the southwest monsoon season which is stated from June until the end of September when whether is dry and cold. The temperature has been started increased from February to May during the summer season. Whether is occasionally observed cold during the winter season. Several times the district has faced severe drought problems due to the low rainfall. Generally, rainfall is started from middle of the June and it stays until the September. Sometimes the rainfall falls in the month of October.

2.3.4 Crop and vegetables

There are two main agriculture seasons first one is Kharif, and the second one is Rabi. In the Kharif season, they cultivate sorghum, cotton, pearl millet, green gram, red gram, soybean, groundnut, etc. In the Rabi season, there are sorghum, wheat, green chickpea and sunflower, etc. are cultivated. Sugarcane and cotton cash crops cultivate yearly when there is adequate rainfall, whereas some farmers are cultivated cotton without inadequate rainfall in the rain-fed areas.

Table 2.9: Demographic information of Beed district and Maharashtra

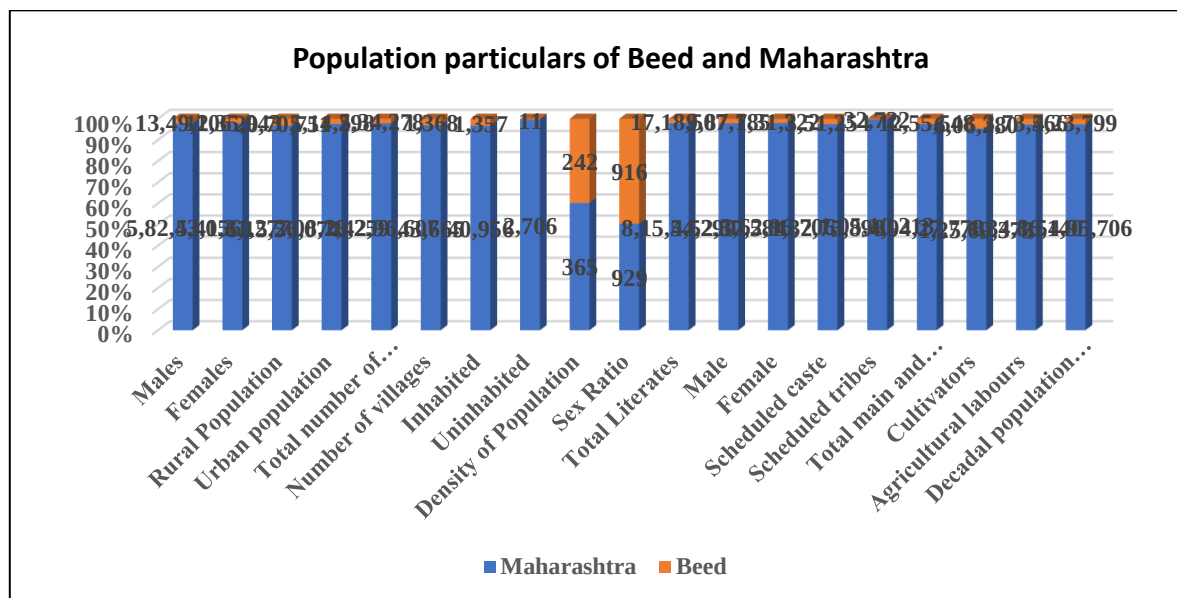
Demographic particulars			
Sr. No.	Population census, 2011	Maharashtra	Beed
1	Total population	112, 374, 333	25,85,049
2	Males	58,243,056	1,349,106
3	Females	54,131,277	1,235,943
8	Rural population	61,556,074	2,070,751
9	Urban population	20,818,259	514,298
4	Total number of households	24,296,607	534,278
5	Number of villages	43,665	1,368
6	Inhabited	40,956	1,357
7	Uninhabited	2,706	11
10	Area	30,77,13	10693.00
11	Density of population	365	242
12	Sex ratio	929	916
13	Total literates	81,554,290 (82.34 %)	1,718,507 (76.99 %)
14	Male	45,257,584 (88.38 %)	987,185 (85.55 %)
15	Female	36,296,706 (75.87 %)	731,322 (67.82 %)
16	Scheduled caste	13,275,898 (11.81 %)	351,254 (13.59 %)
17	Scheduled tribes	10,510,213 (9.35 %)	32,722 (1.27 %)
18	Total main and marginal workers	49,427,778 (43.99 %)	1,255,548 (48.57 %)
19	Cultivators	12,569,373 (25.43 %)	606,280 (48.29 %)
20	Agricultural labours	13,486,140 (27.28 %)	373,566 (29.75 %)
21	Decadal population growth (2001 to 2011)	15,495,706 (15.99 %)	423,799 (19.61 %)

(Sources: district census handbook of Beed, 2011)

The above table 2.9 shows the demographic information of Beed district and Maharashtra state. It describes that out of the total population of 1,255,548 (48.57 %), of the marginal and main workers of the district, male workers are 727,819 (53.95 %), and female workers were 527,729 (42.70 %). Total cultivators were 606280 (48.29%), male was 339,833 (46.69 %) and females were 266447 (50.49 %). District sex ratio was (916) and state ratio was (929); it was low

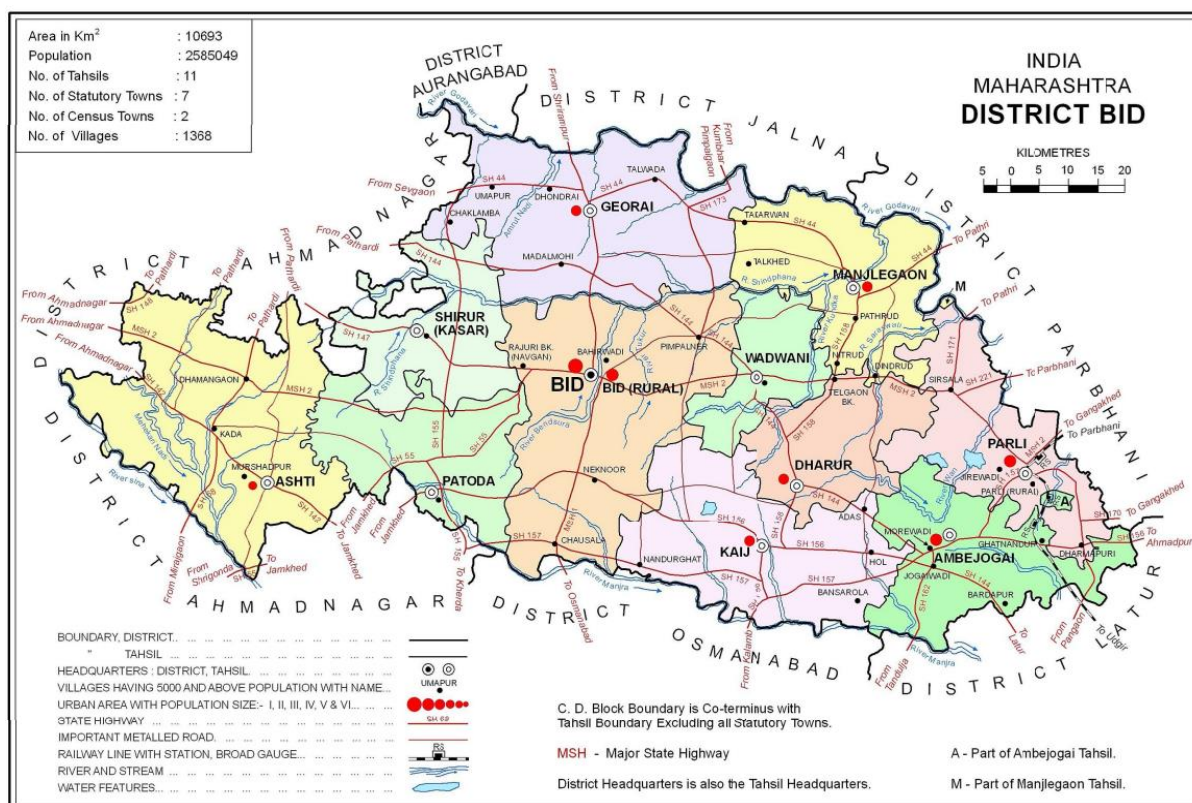
compared to state ratio. Across the state literacy rate was (82.34 %) and the district literacy rate was (76.99). Density was low compared to the state, which is 242.

Figure 2.7: Population information as per census 2011 of Beed and Maharashtra



(Sources: district census handbook of Beed, 2011)

2.1: Map of the Beed district



(Sources: district census handbook of Beed, 2011)

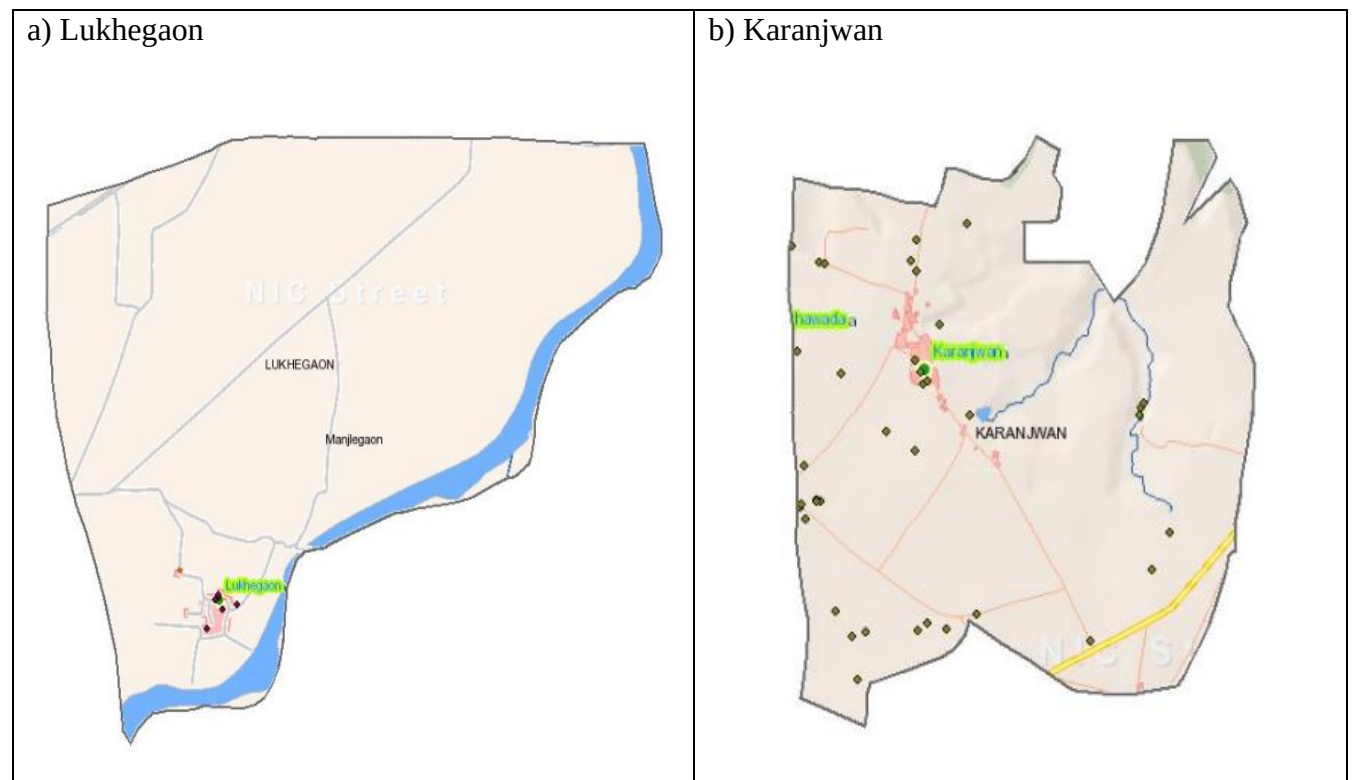
Table 2.10: Demographic features of two sample villages of the Beed district

(Ecosystem)	Lukhegaon (irrigated village)	Karanjwan (rain-fed village)
Distance from taluka or district	Lukhegaon distance is 6 K.M. from Manjalgaon block in the way of northeast (situated on Sindphana river)	Karanjwan distance is 7 K. M. from Patoda taluka at east direction and 25 K. M. at the west direction from Beed district (located in Balaghat range)
Total area	Total area 372.65 hectare	Total area 856.88 hectare
Total Irrigation	Highly irrigated	Irrigated 00 hectare (N. A.)
Total forest	Forest 00.	Forest/hill 88.49 hectare
Literacy rate	Total literacy rate (65.6%)	Total literacy rate (63.4 %)
Total population	Lukhegaon total population is 773 (Male 393, female 380)	Total population 1194 (Male 614, female 553)
Total working population	The total working population is 396	The total working population is 698
School Level	Primary school, up to 4 th class (Marathi and Urdu)	Secondary level up to 7 th Class (Marathi)
Total households	Total households are 181	Total households 253

(Source: District Census Handbook of Beed, 2011) (Note: N. A. = Not Available)

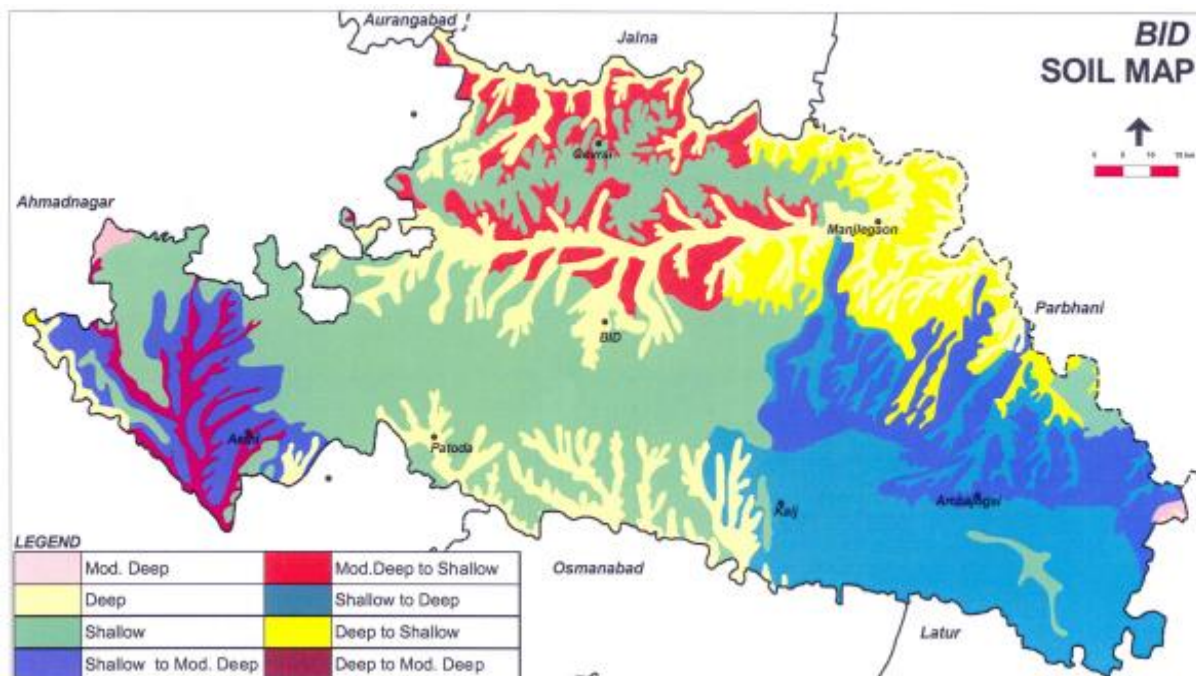
Table 2.10 shows the demographic information of two sample villages of Beed district. The Lukhegaon is the irrigated village and Karanjwan is the rain-fed village. Total area of Lukhegaon village is 372.65 hectare and total area of Karanjwan is 856.88 hectare. As per population census 2011 the irrigated village total literacy rate was (65.6 %) and rain-fed village literacy rate was (63.40 %). Furthermore, Lukhegaon total population was 773 (Male 393, female 380) and while, Karanjwan total population was 1194 (Male 614, female 553). The Lukhegaon village has primary school which medium of teaching is Marathi and Urdu. The Karanjwan has medium higher secondary school which teaches in Marathi medium. Moreover, the total number of households in Lukhegaon is 181 and in Karanjwan is 253.

2.2: Two sample villages map of the Beed district



(Source: grammanchitra.gov.in)

2.3: Soil map of the Beed district

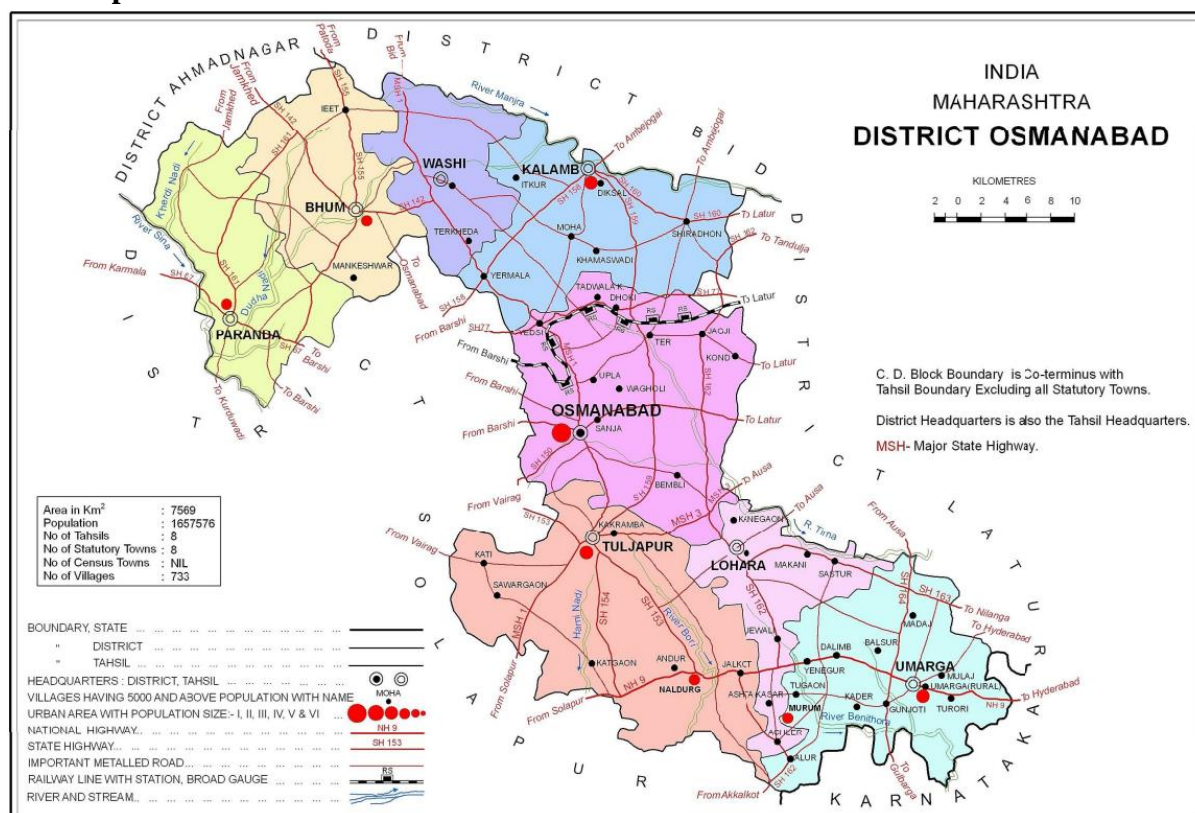


(Source: Agriculture Contingency Plan, District Beed, CRIDA, 2012)

2.4.1 Geographical position and physical features of Osmanabad district

The Osmanabad district was formerly known as “Dharashiv”. At the beginning of the 20th century, the king of Hyderabad State, Nizam Osman Ali, renamed the district name from his name. The district was prosperous, glorious during the age of the Satavahanas. Currently, the district headquarter is in Osmanabad city. The district falls in the Balaghat pathar in the Marathwada region of Maharashtra. It has eight blocks viz Paranda, Bhum, Tuljapur, Washi, Kalamb, Osmanabad, Lohara and Umarga. The district has been administratively divided into four revenue blocks viz Bhum, Kalamb, Umarga and Osmanabad. The entire area of the district is 7569 km^2 which of that, 129.0 km^2 is an urban and 7439.99 km^2 is belongs to rural. The district's geographical position is 7.35 to 8.40 degrees north latitude and 75.6 to 76.40 degrees east. The following district boundaries have bounded the district. Solapur is in the southwest; Ahmednagar is in the northwest; Beed is in the north; Latur is in the east; and Bidar & Gulbarga is in south Karnataka ([District Socio-Economic Review of Osmanabad, 2017](#); [District Census Handbook of Osmanabad, 2011](#)).

2.4: Map of the Osmanabad district



(Source: District Census Handbook of Osmanabad, 2011)

Table 2.11: Demographic Information of Osmanabad district and Maharashtra

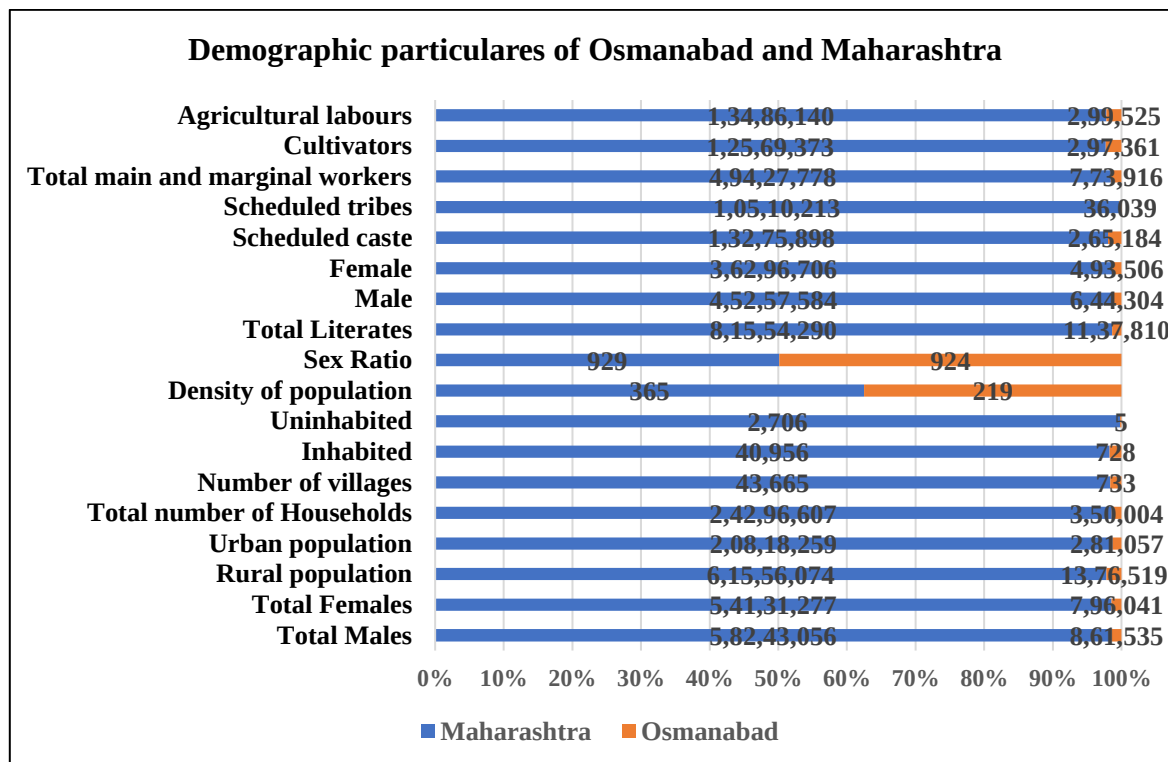
Demographic particulars			
Sr. No.	Population census, 2011	Maharashtra	Osmanabad
1	Total population	112, 374, 333	16,57,576
2	Males	58,243,056	861,535
3	Females	54,131,277	796,041
8	Rural population	61,556,074	13,76,519
9	Urban population	20,818,259	281,057
4	Total number of households	24,296,607	350,004
5	Number of villages	43,665	733
6	Inhabited	40,956	728
7	Uninhabited	2,706	5
10	Area	30,77,13	7569.00
11	Density of population	365	219
12	Sex ratio	929	924
13	Total literates	81,554,290 (82.34 %)	1,137,810 (78.44 %)
14	Male	45,257,584 (88.38 %)	644,304 (85.84 %)
15	Female	36,296,706 (75.87 %)	493,506 (70.51 %)
16	Scheduled caste	13,275,898 (11.81 %)	265,184 (16.00)
17	Scheduled tribes	10,510,213 (9.35 %)	36,039 (2.17 %)
18	Total main and marginal workers	49,427,778 (43.99 %)	773,916 (46.69 %)
19	Cultivators	12,569,373 (25.43 %)	297,361 (38.42 %)
20	Agricultural labours	13,486,140 (27.28 %)	299,525 (38.70 %)
21	Decadal population growth (2001 to 2011)	15,495,706 (15.99 %)	170,990 (11.50 %)

(Source: District Census Handbook of Osmanabad, 2011)

According to the population census, 2011, the district's total population is 16,57,576, which was 1.35 % of the total Maharashtra population; out of that, the males were 86,535, and females were 796,04. A total number of villages are 733 out of that inhabited are 728, only five are uninhabited. The district's total area is 7569.00, which is 2.45 % of Maharashtra. Total Cultivators were 297,361, which was 17.93 % of the total district population, and 0.23 % of

Maharashtra cultivators. Agriculture laborers were 299, 525, which was 18.00 % of the district population, 2.22 % of Maharashtra's agriculture laborers.

Figure 2.8: Demographic information according to population census 2011, district of Osmanabad and Maharashtra



(Source: District Census Handbook of Osmanabad, 2011)

The above figure 2.8 gives the information according to the population census, 2011. It shows the differences between Osmanabad and Maharashtra populations regarding some factors like males, Females, Rural Population, Urban population, Total number of Households, Number of villages, number of households etc.

2.4.2 Rivers

There are no significant river flows in the Osmanabad district in the summer season. All rivers are dried up. Terna, Manjara, Sina, Bori, Benitura, and Banganga are the main rivers in the district. Terna is the tributary of Manjara, and the Manjara is a branch of the Godavari River. The Terna streams from west to east through Kalamb, Osmanabad, Omega blocks. Bori is the main tributary river of Sina; its flows in Tuljapur taluka then enters into the Solapur district and joins to Sina River. Sina runs in the western boundaries of Paranda block, which flows from north to south in Paranda, where is a big dam on the Sina River. It is a tributary of the Bhima River.

2.4.3 Climate and rainfall

There are three main seasons in the district, typically Monsoon, winter, and summer. The weather of the district is usually dry. Monsoon is began from June to September, which is the primary rainy season of the district. Winter starts from October until January, summer is started from February and ended in May ([District-Socio-economic Review, 2017](#)). The rainfall of the district is mainly dependent on southwest monsoon, which is essential for Kharif seasons. The district reservoirs and groundwater bodies depend on southwest monsoon rainfall.

Table 2.12: Demographic features of two sample villages of Osmanabad district

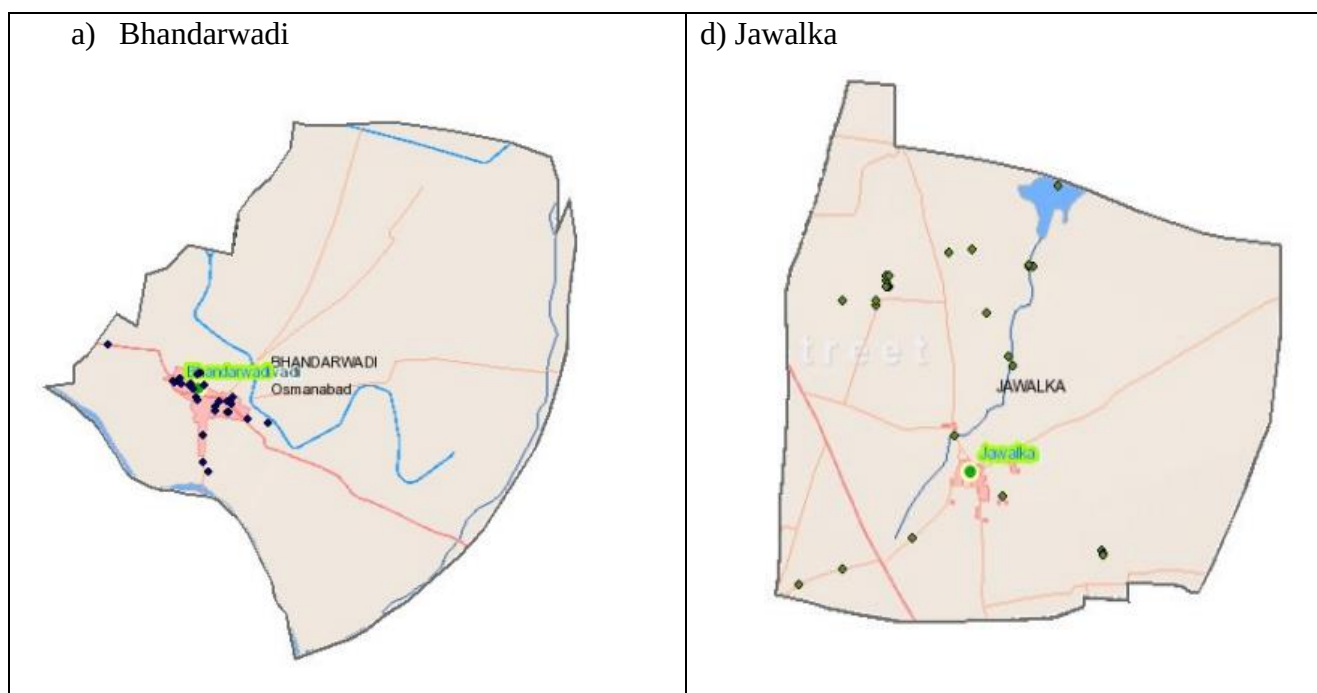
(Ecosystem)	Bhandarwadi (Irrigated village)	Jawalka (Rain-fed village)
Distance from taluka or district	It is situated 19 kilometres east of the district headquarters of Osmanabad	Jawalka village is situated in Washi Tehsil, and it is 6 kilometres away from the Washi.
Total area	745.67	702.32
Total Irrigation	Highly irrigated	Mostly rain-fed
Total forest	-	-
Literacy rate	1315 (68.5 %)	525 (72.10 %)
Total population	1919	728
Total males	987 (51.4 %)	390 (53.57 %)
Total females	932 (48.6 %)	338 (46.33 %)
Scheduled caste	363 (18.9 %)	82 (11.30 %)
Scheduled tribes	29 (1.5 %)	10 (1.4 %)
Total working population	1065 (55.5 %)	430 (59.10 %)
School Level	Primary to higher secondary up to 12 th	Primary level up to 4 th
Total households	446	184

(Source: District Census Handbook of Osmanabad, 2011)

Table 2.12 shows the demographic information of two sample villages of Osmanabad district. The Bhandarwadi village is irrigated village which is situated 19 kilometres east of the district headquarters of Osmanabad. The Jawalka is rain-fed village which is situated in Washi Tehsil, 6 kilometres away from the Washi block. Total geographic area of the Bhandarwadi is 745.67 hectare, while, Jawalka has 702.32 hectare. Furthermore, according to population census, 2011 the irrigated village total population was 1919 and rain-fed village total population was 728. Moreover, total households in Bhandarwadi village are 446, while Jawalka has 184 total households.

The education has available in Bhandarwadi village up to 12th class, whereas in Jawalka which is up to Primary level. Jawalka has recorded more literacy rate than Bhandarwadi villa

2.5: Two sample villages map of the Osmanabad district



(Source: grammanchitra.gov.in)

Table 2.13: Annual rainfall of Osmanabad district 2018

Sr. No.	Blocks/Talukas	Annual Averages of rainfall (mm)	Rainfall until 31/10/2018 (mm)	Total annual percentage of rainfall
1	Umerga	799.00	697.40	87.28
2	Washi	715.60	447.02	62.47
3	Tuljapur	837.40	520.26	62.13
4	Lohara	799.00	471.35	58.99
5	Kalamb	715.60	410.51	57.37
6	Osmanabad	751.70	426.53	56.74
7	Bhum	905.90	392.40	43.32
8	Paranda	615.50	242.80	39.45
Total average rainfall		767.46	451.03	58.77

(Source: Department of Revenue, Collector office of Osmanabad, 2019)

Table 2.13 shows the taluka-wise annual rainfall and south-west monsoon rainfall of Osmanabad district in 2018. The total average annual rainfall was 767.46 (mm), and the south-west rainfall was 451.03 (mm). Among all talukas of the district, Paranda taluka had deficient rainfall in 2018.

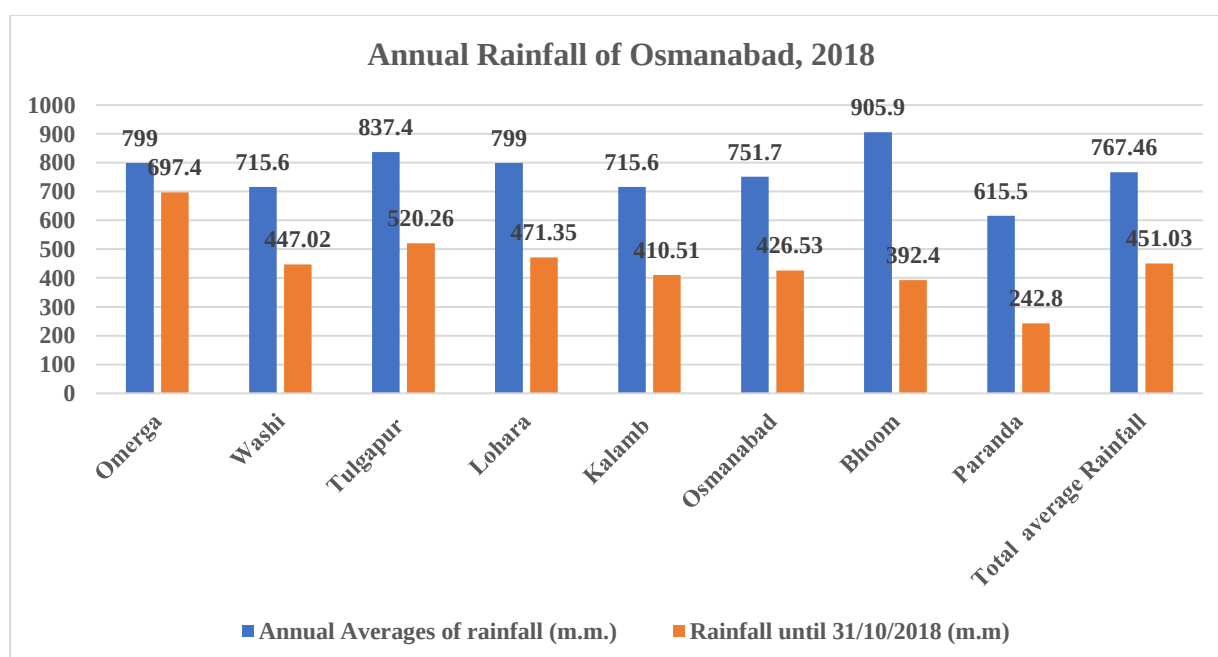
Table 2.14: Average annual rainfall among all blocks of Osmanabad district since 2014-15 to 2018-19

Sr. No.	Blocks	2014-15	2015-16	2016-17	2017-18	2018-19
1	Osmanabad	398.5	396.4	835.3	1007.2	427.0
2	Tuljapur	503.8	392.2	843.8	881.9	519.7
3	Umerga	449.4	425.2	1142.2	890.6	697.4
4	Lohara	444.0	438.4	851.9	781.7	471.0
5	Kalamb	344.4	336.2	723.8	693.8	410
6	Bhum	439.0	322.8	821.6	917.2	392.4
7	Washi	542.7	362.8	809.3	811.4	446.6
8	Paranda	437.7	331.8	677.2	801.6	242.8
Total Rainfall		3559.8	3005.8	6705.1	6785.4	3606.9
Average Rainfall		444.9	375.7	838.1	848.2	450.9
Percentage		58.00	49.00	109.20	110.50	58.70

(Source: Department of Revenue, Collector office of Osmanabad, 2019)

Table 2.14 describes the average annual rainfall among all Blocks of Osmanabad district from 2014-15 to 2018-19. It was recorded that tremendous deficit in rainfall in the years 2014-15, 2015-16, and 2018-19. In 2014 average annual rainfall was received only 444.9 (mm), then in 2015, it was recorded 375.7(mm), and in 2018 it was received 450.9 (mm). There were three severe drought years from 2014 to 2018.

Figure 2.9: Annual Rainfall of Osmanabad district, 2018



(Source: Department of Revenue. Collector office of Osmanabad, 2019)

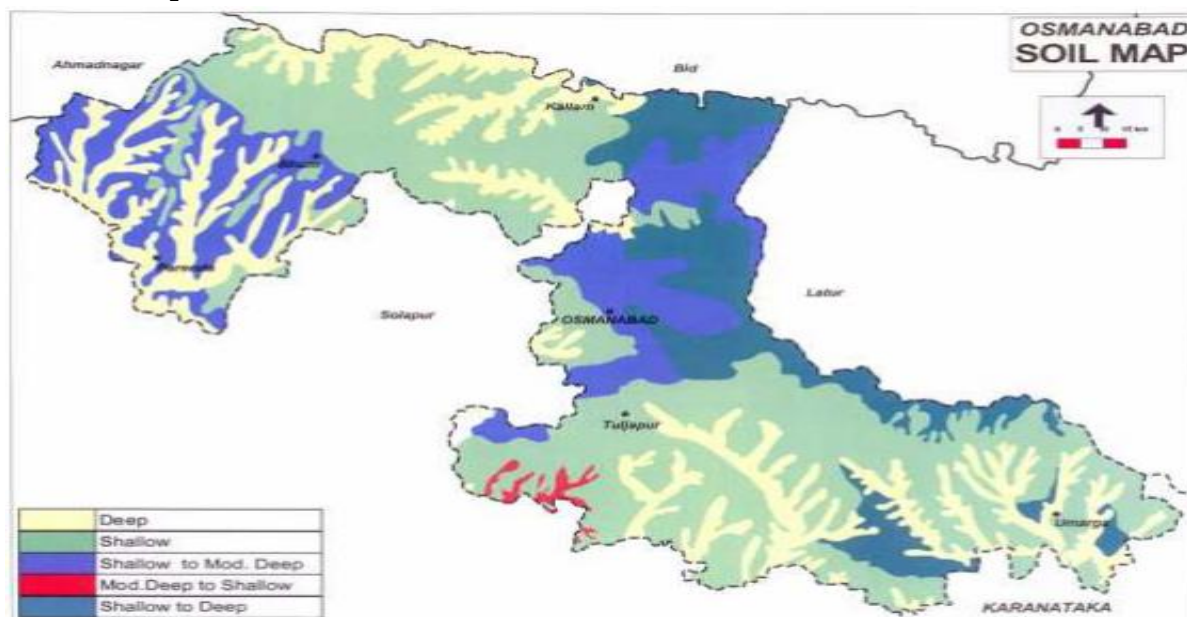
2.4.4 Crop and vegetables

There are two main crops season in Osmanabad district, likely Kharif and Rabi. In the Kharif season, farmers usually cultivate sorghum, pearl millet, soybean, black gram, green gram, and pigeon pea. Tur (pulses) is the major legume crop in the Kharif season of the district, out of the total legume hectare area cultivation which has covered (20.90 %) of the area. Jawar, wheat, and chickpeas are the main crops in the rabi season of the district. In oilseeds, they cultivate sunflower, groundnut, soyabean, safflower, linseed etc. Cotton and sugarcane are the primary cash crops of the districts. Fruits and vegetables are both horticulture crops that the farmers have also cultivated. in the fruit category, they cultivate mango, grapes, orange, lemon, guava and watermelon. In the vegetable category, they cultivate ladyfinger, potato, cauliflower, sweet gourd, onion. They also cultivate cabbage, cluster beans, curry leaves, coriander leaves, fenugreek leaves, spinach, bitter gourd, capsicum, carrot, radish, green chili, brinjal, drumstick, etc. Minimum hectare cultivation has observed of fruits and vegetables in the district ([District Socio-economic Review 2021](#)).

2.4.5 Types of soil

The soil of the district is divided into two parts. In the first part, there is a heavy deep, black, and fertile land which is mostly found in Osmanabad, Kalamb, and Umerga blocks. In the second part, a medium shallow and light soil is mostly found in other districts blocks. Therefore, farmers cultivate many kinds of crops in Kharif and Rabi seasons. In the second part, soil, which is also useful for Rabi crops ([District-Socio-economic Review, 2017](#)).

2.6: Soil Map of Osmanabad District



(Source: Agriculture Contingency Plan, District Osmanabad, CRIDA, 2012)

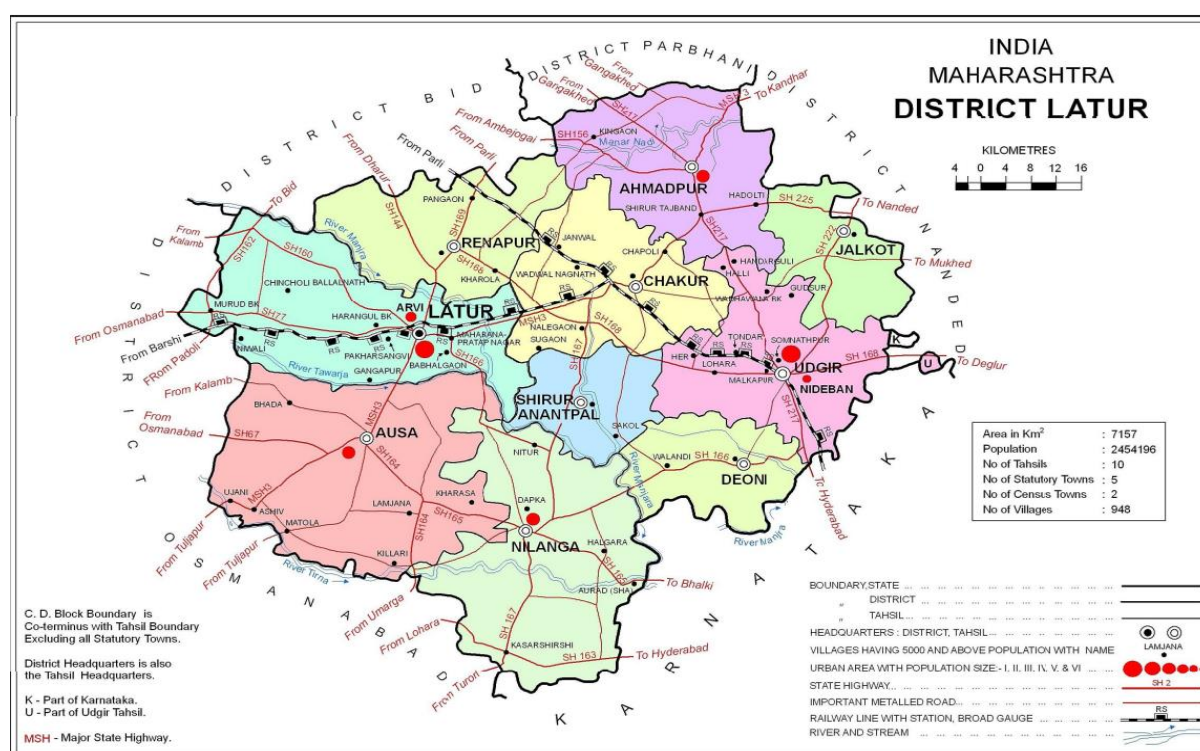
2.5.1 Geographical position and physical features of Latur district

Latur is a district place, which is the part of Aurangabad division of Maharashtra. It has a long and illustrious history. It was the native residence of the Rashtrakutas king 'Latta'. Almogavars was the first king (lord) of Lattaalura (Latur), who developed that place. Those Rashtrakutas who came in power after the Badami's Chalukyas in 753 A.D. They identified as Lattaalura residents (Latur). It appears that Rashtrakutas were native to that place ([District Socio-Economic Review of Latur, 2017](#); [District Census Handbook, Latur, 2011](#)). In 1853, the district was provisionally handed to the British regime. After that, in the year 1860 when it was gone back to the State of Hyderabad, with its centre established at Naldurga. It had been known as the Naldurga district at that time. In 1904, the district was discontinued.

Furthermore, a newly district headquarters established with the name of Osmanabad. It had most of the area that came under the Nizam's estate in the Marathwada region. It was called "Sarf-e-Khas." ([District Census Handbook of Latur, 2011](#)). The Sarf-e-Khas merged into the Bombay state after the military action had taken by the government of India in 1947. Besides, Maharashtra separated from the Bombay state on 1 May 1960 (former which was the part of Bombay state, including Gujrat). On the border between Maharashtra and Karnataka the district is existed. Earlier the district was part of Osmanabad district. It was separated on 15 August 1982 from Osmanabad district. It locates in the basin of Manjra and Tawarja Rivers. Recently, it has 10 Blocks, seven towns, and 928 villages, including 20 isolated villages. Latur has trade importance due to the transportation facilities; there is a wheel type circle like cycle which has

called market place ‘Ganj Golai’ (District Socio-Economic Review of Latur, 2017; District Census Handbook of Latur, 2011). The geographical position of the district is 18.5 to 18.7 degrees north latitude and 73.25 to 77.25 degrees East latitude. The district has 7157km² total area. It is about 2.32 % of Maharashtra and 11.04 % of the Aurangabad division. The entire area of the district comes under the Balaghat Plateau. It is approximately 440 to 636 meters above the level of the sea. Nanded is on the northwest, to the north is Parbhani, to the northwest is Beed, and Osmanabad is on the western and southern sides. The Bidar district is on the eastern side of the Latur district (District Socio-Economic Review of Latur district, 2016).

2.7 Map of the Latur District



(Source: District Census Handbook of Latur, 2011)

2.5.2 Rivers

The district's primary river is Manjara. Its origin is from the Balaghat plateau in the Beed district of Patoda block near the Sautada village. It flows from the north boundary of the Osmanabad district. After that, its flow has gone from the middle part of the Latur district, then it enters into the Karnataka State. Terna, Rena, Tawarga, are its tributaries. Moreover, Manyad, Lendi, and Gharni rivers are in the district.

2.5.3. Climate and rainfall

There are three main seasons in the district in a year, such as monsoon, winter, and summer. The monsoon starts in the middle of June and until the ending of October. Then, winter begins from November until the ending of February, and summer starts from March and until the middle of June. Latur district is situated on the Deccan plateau, where the rainfall mainly depends on the west-north monsoon. In the rainy season, the climate is humid; in the chill season climate may be cold and dry, and in the summer, the weather may be hot and dry.

2.5.4 Crops and vegetables

The district economy mainly depends on agriculture and related activities. According to population census 2011, out of the total working population, about 85 % are farmers and agriculture labourer. Rabi and Kharif are two main crops season in Latur district. Here soyabean is the core crop. In the 2021, the soyabean crop total net area cultivation is 45,99,76 which is 69.24 % of the total net area cultivation. Jawar, bajara, wheat rice and maize etc. are the principal foodgrain crops in the district. Cotton and sugarcane are the primary cash crops of the districts. Fruits and vegetables are both horticulture crops that the farmers have also cultivated. In the fruit category, they cultivate mango, grapes, orange, lemon, guava and watermelon. In the vegetable category, they cultivate ladyfinger, potato, cauliflower, sweet gourd, onion. They also cultivate cabbage, cluster beans, curry leaves, coriander leaves, fenugreek leaves, spinach, bitter gourd, capsicum, carrot, radish, green chili, brinjal, drumstick etc. Fruits and vegetables production have reported very less hectare in the districts ([District Socio-Economic Review of Latur, 2021](#)).

Table 2.15: Average annual rainfall of Latur district from 1991 to 2018

Sr. No.	Year	Average Rainfall	Actual rainfall	Deviation
1	1991	738.39	492.22	-33.34
2	1992	738.39	585.86	-20.66
3	1993	738.39	679.1	-8.03
4	1994	738.39	459.5	-37.77
5	1995	738.39	798.73	8.17
6	1996	738.39	966.35	30.87
7	1997	738.39	566.21	-23.32
8	1998	738.39	1152	56.02
9	1999	738.39	788	6.72
10	2000	738.39	851.1	15.26

11	2001	738.39	729.7	-1.18
12	2002	738.39	612.5	-17.05
13	2003	738.39	748.1	1.32
14	2004	738.39	757.2	2.55
15	2005	738.39	1007.5	36.45
16	2006	738.39	806.7	9.25
17	2007	738.39	837.5	13.42
18	2008	738.39	709.6	-3.90
19	2009	738.39	526.4	-28.71
20	2010	738.39	1010.4	36.84
21	2011	738.39	721.55	-2.28
22	2012	738.39	761.88	3.18
23	2013	738.39	847.48	14.77
24	2014	738.39	446.7	-39.50
25	2015	738.39	413.48	-44.00
26	2016	738.39	1110.92	50.45
27	2017	738.39	772.84	4.67
28	2018	738.39	515.22	-30.22

(Source: Latur district collector office, Latur, 2019)

The Latur district's yearly rainfall is depicted in table 2.15 from 1991 to 2018. It illustrates the various variabilities in the rainfall of the district. In 1991, 1992, 1994, 1997, 2009, 2014, 2015, and 2018 there was a significant deficit in rainfall, and in 1996, 1998, 2005, 2010, and 2016, there was an excess in the rainfall. The 2016 was an excess rainfall year among all the years when there was 1110.92 (mm) rainfall recorded, and 2015 was a significant deficit in the rainfall where there was 413.48 (mm) rainfall recorded.

Table 2.16: Demographic features of Latur district from (population census 2011 and 2001)

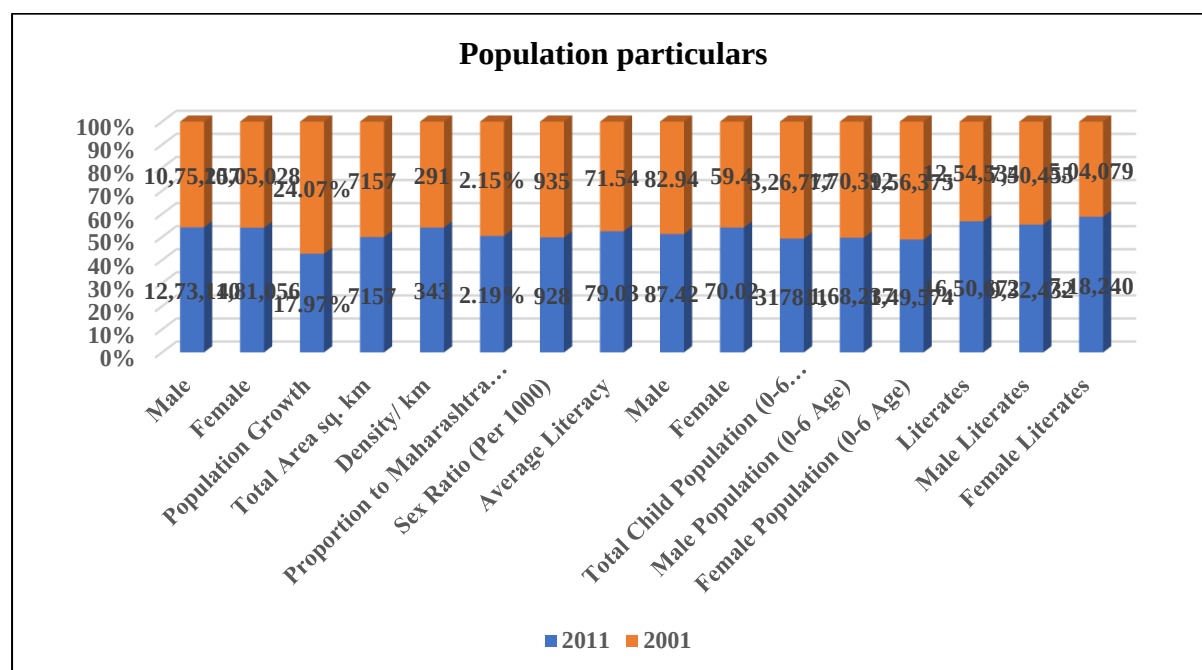
Population Particular	2011	2001
Total population	24, 54,196	20,80,285
Male	12,73,140	10,75,257
Female	11,81,056	10,05,028
Population growth	17.97 %	24.07 %
Total area sq. km	7157	7157
Density/ km	343	291
Proportion to Maharashtra population	2.19 %	2.15%
Sex ratio (per 1000)	928	935
Average literacy	79.03	71.54
Male	87.42	82.94

Female	70.02	59.40
Total child population (0-6 Age)	317811	3,26,777
Male population (0-6 Age)	1,68,237	1,70,392
Female population (0-6 Age)	1,49,574	1,56,375
Literates	16,50,672	12,54,534
Male literates	9,32,432	7,50,455
Female literates	7,18,240	5,04,079

(Source: District census handbook of Latur, 2011)

The above table 2.16 shows the population particulars of the Latur district from two population censuses (2011 and 2001). It depicts the differences between both population censuses among various factors. In accordance with the population statistics, 2001, the whole population is 20,80,285, but according to census population 2011, it is 24,54,196. It means that it is increased by 15.24 percent in the first decade of the twenty-first century. Moreover, Maharashtra's total population growth in this decade is 17.79.

Figure 2.10: Population particulars Latur district according to census of 2011 and 2001



(Source: District census handbook of Latur, 2011)

Table 2.17: Demographic information of Latur district and Maharashtra

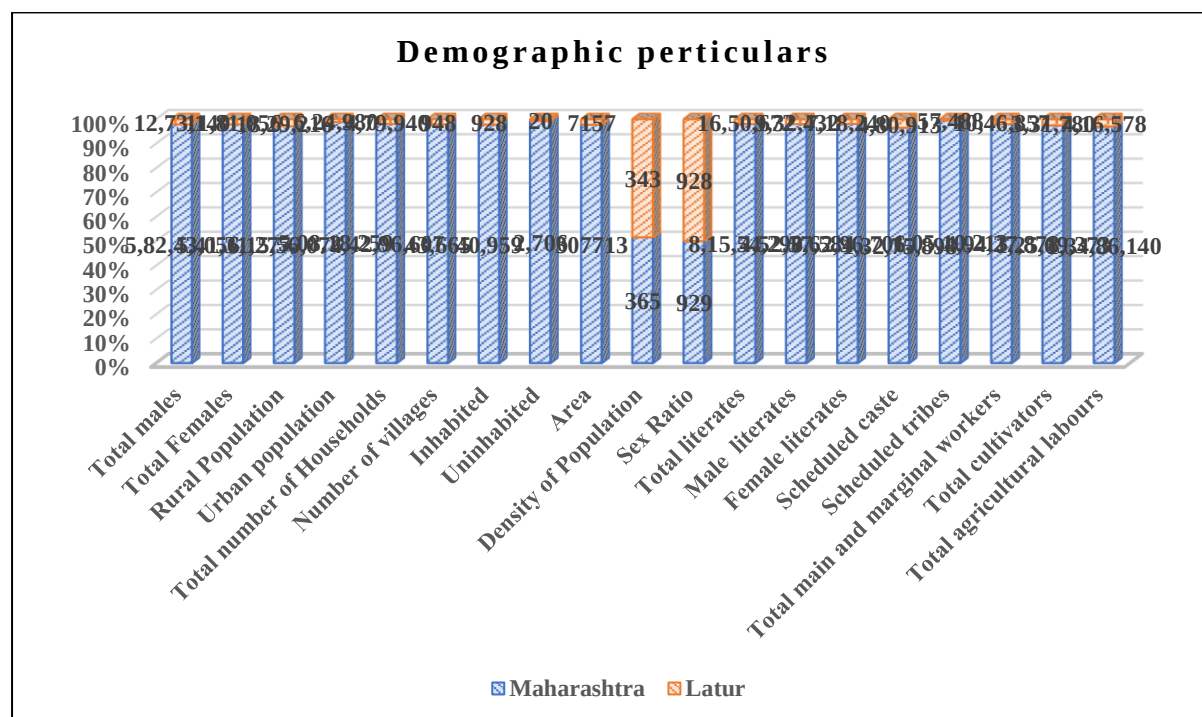
Demographic particulars			
Sr. No.	Population census, 2011	Maharashtra	Latur
1	Total population	112,374,333	2,454,196
2	Males	58,243,056	1,273,140
3	Females	54,131,277	1,181,056
8	Rural population	61,556,074	1,829,216

9	Urban population	50,818,259	624,980
4	Total number of households	24,296,607	479,940
5	Number of villages	43,665	948
6	Inhabited	40,959	928
7	Uninhabited	2,706	20
10	Area	307713	7157
11	Density of population	365	343
12	Sex Ratio	929	928
13	Total literates	81,554,290 (82.34 %)	1,650,672 (77.26 %)
14	Male	45,257,584 (88.38 %)	932,432 (84.39 %)
15	Female	36,296,706 (75.87 %)	718,240 (69.63 %)
16	Scheduled caste	13,275,898 (11.81 %)	480,913 (19.60 %)
17	Scheduled tribes	10,510,213 (9.35 %)	57,488 (2.34 %)
18	Total main and marginal workers	49,427,878 (43.99 %)	1,046,857 (42.66 %)
19	Cultivators	12,569,373 (25.43 %)	331,780 (31.69 %)
20	Agricultural labours	13,486,140 (27.28 %)	416,578 (39.79 %)
21	Decadal population growth	15,495,706 (15.99 %)	373,911 (17.97 %)

(Source: District census handbook of Latur, 2011)

The table 2.17 shows the demographic information of Latur districts and Maharashtra state as per the population census 2011. It has noted that the 10 years growth of the district population is more than state, which is (17.97 %). The district's SCs population percentage is more than state which is (19.60 %), whereas the STs population percentage is less than the state which is (2.34 %). Density of the district population is lower compared to state which is 343 and sex ratio is lower than the state, which is 928. The districts total cultivators and agriculture labours percentage is higher than the state. However, the district literacy ratio has recorded lower than the state, which is (77.26 %).

Figure 2.11: Demographic information of Latur district and Maharashtra as per census 2011



(Source: District census handbook of Latur, 2011)

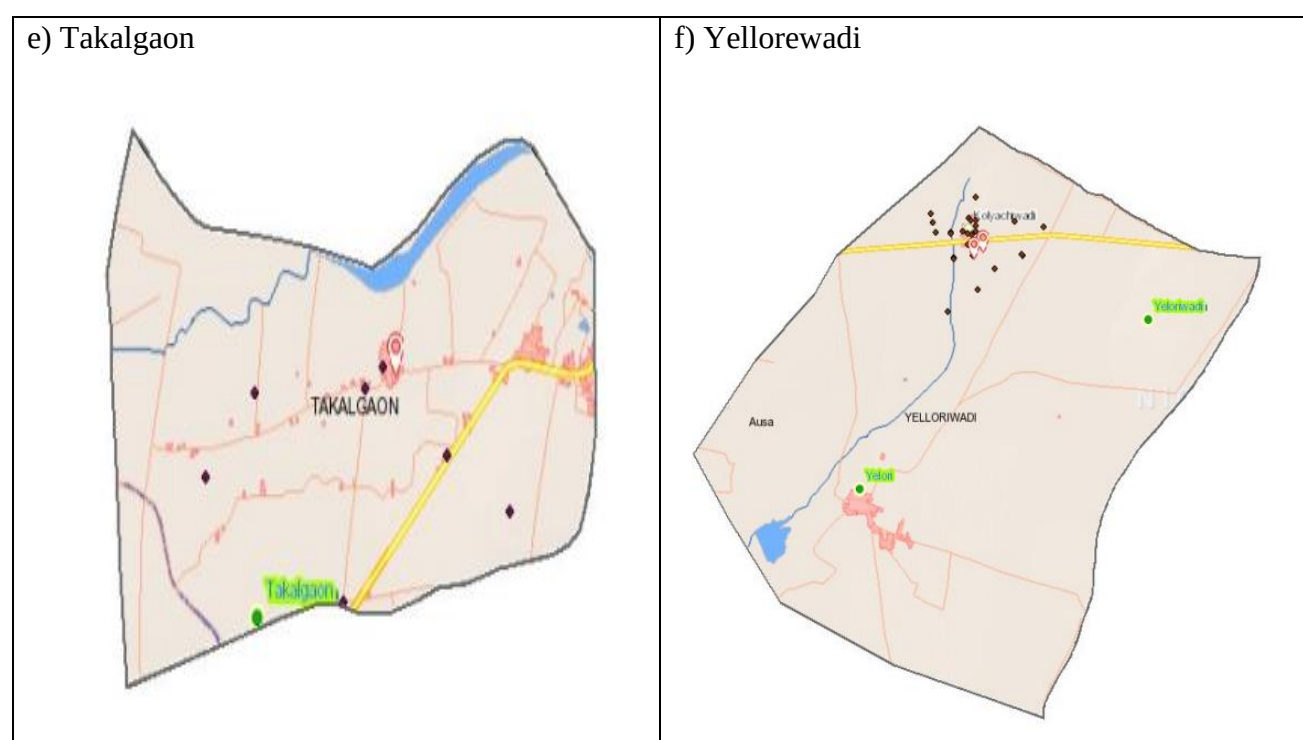
Table 2.18: Demographic features of two sample villages of Latur district

(Ecosystem)	Takalgaon (Irrigated village)	Yellorewadi (Rain-fed village)
Distance from taluka or district	Takalgaon village distance is 38 kilometres from the Latur block/district	It is 9 kilometres away from the sub-district headquarters, Ausa, and 35 kilometres from the district headquarters, Latur.
Total area	440.29	348.60
Total irrigation	Highly irrigated	Totally Rain-fed
Total forest	-	-
Literacy rate	683 (65.5 %)	408 (63.65 %)
Total population	1043	641
Total males	547 (51.77 %)	349 (54.44 %)
Total females	496 (49.33 %)	292 (45.56 %)
Scheduled caste	62 (5.95 %)	22 (3.43 %)
Scheduled tribes	-	619 (96.53 %)
Total working population	559 (53.60 %)	330 (51.48 %)
School level	Primary up to 4 th	Primary up to 4 th
Total households	227	131

(Source: District census handbook of Latur, 2011)

Table 2.18 shows that demographic features of two sample households of Latur district. The Taklagaon village is irrigated village which is situated 38 kilometres far from the district headquarters of Latur. The Yellorewadi is rain-fed village which is 9 kilometres away from the sub-district headquarters of Ausa block and 35 kilometres from the district headquarters Latur. Total geographic area of the Takalgaon has 440.29 hectare, while, Yellorewadi has 348.60 hectare. Furthermore, according to population census, 2011 the irrigated village total population was 1043 and rain-fed village total population was 641. Moreover, total households in Bhandarwadi is 227, while Jawalka has 131 total households. The education has available in both villages up to 4th class. Literacy rate in the Takalgaon village was (65.5 %) and Yellorewadi literacy rate was (63.65 %).

2.8: Two sample villages map of the Latur district



(Source: grammanchitra.gov.in)

2.5.5 Types of soil

The district's soil can be broadly categorized into three groups: shallow, medium, and deep soil, which is derived from trap rock. The shallow soil, which is colour in ranges from light to dark brown, texture ranges from loamy to clay loam, and structure as granular to sub-angular blocky, is mainly found in the district's north-eastern side.

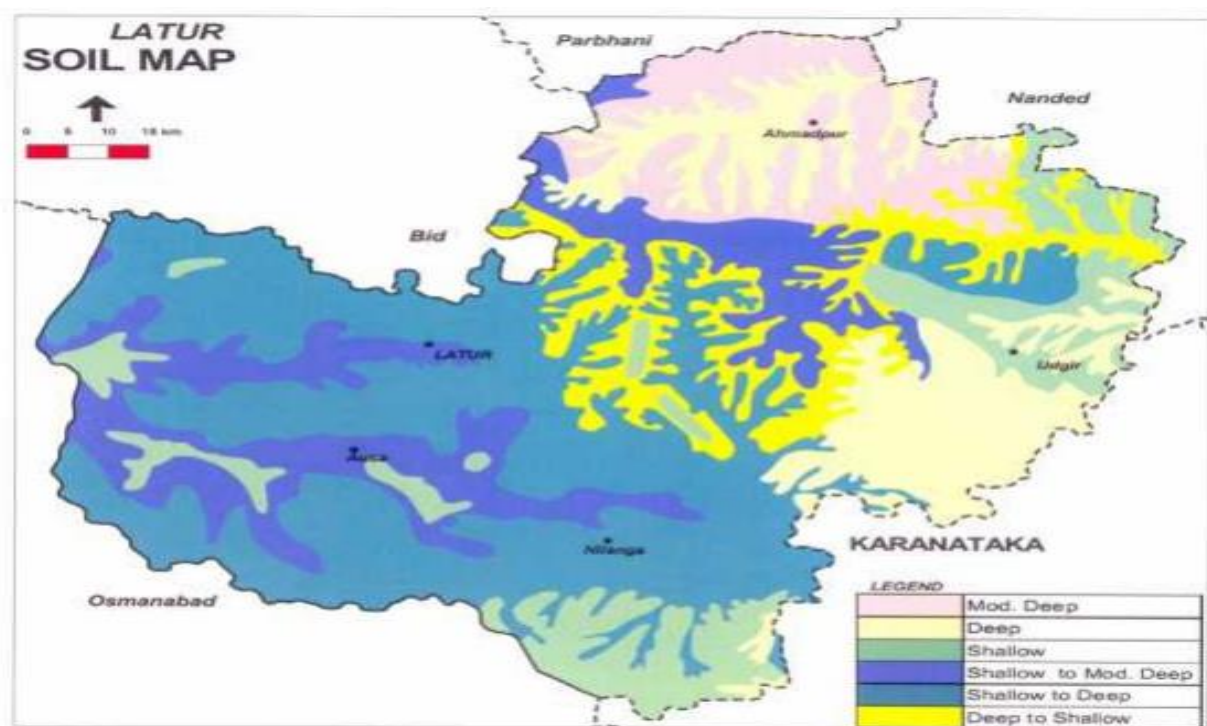
ii) Medium soil

Medium kinds of soil patches lie in the central and the northern part of the district and Nilanga block. The soil is dark brown to dark grey-brown, which is clay loam to clayey in texture and sub-angular rocky to rocky in texture.

iii) Deep soil

Deep soil is generally found in the southern part of the district and both the basin of Terna and Manjra Rivers. It has a clay-like texture and colours from very black to dark grey-brown.

2.9 Soil map of Latur district



(Source: Agriculture Contingency Plan, District Latur, CRIDA, 2012)

2.6 Conclusion

The above description explains the geographical positions of three districts, including their administrative set ups, locations maps, climate, soil, rivers, crops, and demographic features. Furthermore, it is described block and village characteristics, geographical information in the study area. It has been indicated district, villages and soil types maps, which helps to easily identify study area locations.

Chapter 3

Review of literature

3.1 Brief introduction

This chapter has made an attempt to review the existing literature on the subject at various levels including global, national, state and local to achieve the above goals as mentioned in the earlier chapter of the study. The chapter has been divided literature review into six parts such as 1) Rainfall trends and variability, 2) Drought, agriculture and rural livelihoods, 3) Drought and Economy, 4) Drought and vulnerability, 5) Drought and food security, poverty and children education 6) Drought and perceptions, coping, adaptation and mitigation strategies,

3.2 Rainfall trends and variability

Many studies used slope-based and rank-based methods to detect statistical trends in climatic variables. Rank-based techniques are Mann Kendell, Spearman's rank correlation techniques applied to identify the trends over the time series data. On the other hand, the simple linear regression method (OLS) and Sen's slope estimator have been used to recognize the trends. Using time series data, most of the study shows increasing and decreasing trends ([Yadav et al., 2021](#)). Climate change poses significant problems to agricultural systems, particularly in drought-prone areas of the world, where poverty is prevalent, irrigation facilities are scarce, and productivity is poor ([Panda, 2016](#)).

[Chandniha et al., \(2017\)](#) examined the spatio-temporal rainfall variability using monthly time series data in Jharkhand state for 18 metrological stations from 1901 to 2011. MK test and autocorrelation were employed to observe possible trends over the study reason. Over long-run data, the Theil and Sen's slope were used to determine the magnitude of change. Over the study period, the slope test showed a decreasing trend for annual, winter, and monsoon seasons. The “post-monsoon” rainfall recorded the highest variability, and the annual rainfall data series recorded the lowest for 111 years.

[Goyal, \(2014\)](#) evaluated the long-run rainfall trends over the 21 stations of Assam state during the period from 1091 to 2002. MK test is applied to detect a statistically substantial trend. It has shown that there was no significant change or trend found in the annual rainfall series. It has revealed that yearly rainfall observed strong association with the rainy season among all season.

Shree & Kumar, (2018) examined seasonal and annual precipitation trends of the Ranchi district in the Jharkhand state for 113 years. The study revealed a statistically insignificant increasing trends recorded in post and pre -monsoon rainfall and insignificant decreasing trends for winter, south-west monsoon, and annual precipitation from 1901 to 2014. A statistically significant declining trend indicated only for south-west monsoon rainfall at a 5% significant level.

Chatterjee et al., (2016) analysed geographical and special monotonic trends in the monthly time series rainfall data from 18 weather stations of the West Bengal, India, for 102 years (1901-2002). The study employed a few tests, before applying the non-parametric MK test on time series data. First, to detect inhomogeneity in the time series, the RHtestsV4 software package was used. Furthermore, the cumulative deviation test was applied to check the data's homogeneity at a 5% significance level. Out of the 18 stations, 11 stations showed a decreasing trend, and the remaining stations found an increasing trend. At 95% and above confidence level only five stations observed a significant negative trend.

A study by **(Khavse et al., 2015)** studied rainfall and temperature trends using monthly rainfall and average monthly maximum temperature time series over the Labhandi station of Raipur district, Chhattisgarh, India, from (1971 to 2013). The study reported that the monthly average temperature observed upward significant trends for August, November, and December at the level of significance of 5 %. Only the yearly rainfall series found a significant growing trend at a 5 % level.

A statistical study on long-term trends in the rainfall time series from 1901 to 2002 (102 years) of Madhya Pradesh's forty five districts, which has been investigated by **(Duhan & Pandey, 2013)**. The study applied the non-parametric MK test and Sen's estimator of slope to identify trends and magnitude of change over a period. It is also observed seasonal and inter-annual variability for all districts. In the summer season, a significant increasing trend recorded for eight stations. Simultaneously, a significant downward trend was found in the monsoon season in the Balgat and Dindori stations. The annual precipitation trend found an important declining in Balaghat, Dindori, and Shahdol districts.

A block-level analysis of precipitation trends has been studied by **(Ingle et al., 2018)**. Their study examined seasonality and precipitation trends over 25 blocks from the North Maharashtra region, India, from 1901 to 2016. The precipitation trend analysis found decreasing

precipitation trend over all blocks in both Dhule Jalgaon and Nandurbar District in 1901 to 2000 for all seasons, Furthermore, Akkalkuwa block of Nandurbar district has reported positive significant trend in monsoon rainfall from 1987 to 2016 and negative significant rainfall trends have found in Bodwad, jammer and Muktainagar blocks of Jalgaon district in the monsoon rainfall from 1987 to 2016. Nearby 17 blocks of the region have contributed less rainfall over the last 30 years (1987-2016) in the south-west monsoon season.

Patra et al., (2012). analysed temporal rainfall variations in the annual, monthly, seasonal and long-term data of Odisha state, India from 1871 to 2006. The study was used both distribution and distribution tests to recognize rainfall trends and variability. The analysis observed a statistically insignificant decreasing trend in annual and monsoon rainfall series over a long time. However, post-monsoon season has found rising trend. The study evaluated that in the contribution of overall annual rainfall, 78.80 % of rainfall received during the monsoon season, which had most crucial to agriculture, hydro-power development and reservoir operation over the state.

Bouklikha et al., (2020) examined long-term (1970-2016) spatial and temporal rainfall trends by applying an innovative trend analysis technique (ITA) over 17 stations which is situated in the Tafna watershed in the northwest of Algeria. The (ITA) approach was classified into three parts, such as Low, Medium, and high, which would be helpful for upcoming studies on floods (high) and droughts (low). The study found that monthly precipitation observed decreasing trends in all stations over February, March, April, and May. Similar circumstances were recorded in the maximum stations for June and July 82 % and for December around 58 %. A decreasing trend was recorded over the winter and spring seasons. Around 58% of the stations in the study's centre region identified a declining trend in rainfall. In contrast, it affects the minimum and maximum values during the summer and autumn which indicated an upward trend.

Latif et al., (2017) studied south Asian summer-rainy precipitations trends using three observed data sets to examine monthly and seasonal changes from 1951 to 2015 in Pakistan. The study used the ordinary least square method to detect rainfall trends, and the MK test has employed to investigate the statistical significance of trends. Also, measure the impact of trends, the Z-test was used. The analysis's findings indicated that considerable upward trends in Pakistan during the middle of the rainy season and downward trends in the central-north Indian region. Additionally, seasonal precipitation trends were identified as irregular behaviour across

the northern part of the Indo-Pak territory and strong rising trends were observed over the CMRC. In contrast, the seasonal inter-annual time scale observed strong downward trends in the CNI region. The June month recorded a significant positive rainfall trend over the CMRC, while July, August recorded crucial months in rainfall contribution.

Phuong et al., (2022) used Sen's ITA technique to identify the partial and overall trends in yearly rainfall accounts for the period of 2011 to 2020 in Vietnam. The study also calculated Standard Precipitation Index (SPI), which lowest value that observed a potential change and the highest intensity in the metrological drought for the 3 and 12 months in the study area. In yearly rainfall data having high dominancy, the results of the temporal trend analysis showed a decline and neutrality. The calculated ITA estimators mainly modify between the values of -10 and -14 annually. Moreover, significant decreasing rainfall trends were identified with the lower value of sub-groups, which shows possible increases in drought intensity over the study area.

Nair & Mirajkar, (2021) investigated the temporal variations of rainfall trends over 11 districts in the two divisions of the climate extreme Vidarbha region of Maharashtra state. The study used three monthly time series data sets, such as observed historic data from 1951 to 2013, simulated data sets, and future data from 2020 to 2095, to detect rainfall trends and calculate the correlation of coefficients to check the relationship between two data sets over the region. The analysis results found that the historical rainfall data set did not observe significant trends over 63 years. The monthly and annual data series have also detected no significant trend over the region. Besides that, the future rainfall data series was investigated as a negative significant trend.

Gupta et al., (2021) examined the rainfall variability over five major meteorological stations of the Jharkhand state from 1901 to 2018. The seasonal and yearly mean time series data were used to detect the temporal rainfall trends calculated using MK test, Sequential Mann Kendall tests, and Sen's slope estimators. The study observed a positive increasing trend in the pre-monsoon season, and the significant downward rainfall trends recorded in the rainy and cold season. In contrast, monotonic precipitation trends were detected in the winter and pre-monsoon season.

Caloiero, (2015) identified the temporal rainfall variability using the average of daily time-series datasets over the 294 rain gages in New Zealand for the 50 years. The daily rainfall data

series has been converted into different rainfall categories. The Mann Kendall non-parametric has been applied to detect seasonal and monthly rainfall trends over the study area. The monthly and seasonal series data analysis results have not observed any noticeable trends. In warmest and autumn period a negative downward trend recorded, however the upward trends recorded in cold and spring season.

Sadeghi & Hazbavi, (2015) tried to examine the trends of the Rainfall Erosivity Index (RAI) by using a Mann-Kendal non-parametric identification method at different time scales like monthly, seasonal, and yearly over 18 metrological stations in Iran from 1970 to 1992, for 23 years. The RAI observed the downward trends at different time scales (monthly, seasonal and annual) from 1970 to 1992 over the data conducted stations.

Yadav et al., (2021) conducted a temporal analysis of rainfall from the Diu, Kutch, and Saurashtra regions of Gujrat, India during the period of 1871 to 2015 for a maximum of 146 years. The study found very high inter-annual rainfall variability among the Diu, Kutch, and Saurashtra regions over the long-term data (1871 to 2015). The Annual, south-west, and post-monsoon rainfall time series have reported increasing trends, whereas winter and post-monsoon seasons have not reported any trends. These regions were obtained maximum rainfall from the south-west monsoon compared to other seasons. The precipitation concentration index value observed decreasing trend in annual rainfall, which has found high variability in the annual rainfall. Overall periods where maximum rainfall was received in one and two months, the Seasonality Index value showed a greater seasonality value.

Machiwal et al., (2017) inspected long-time precipitation trends in the hot and cold arid areas in India from 1901 to 2002 for 100 years. The analysis results of the Mann Kendall and Kendell Rank Correlation test have observed significant favourable rainfall annual trends, while similar trends have been recorded in wet and dry seasons at 1%, 5%, and 10 % significance levels.

Elzopy et al., (2021) investigated long-term rainfall trend analysis of Ethiopia during the period of 1901 to 2015. The Modified Mann-Kendall test analysis results were found statistically declining rainfall trends in the Kiremt season from 1901 to 1960, meanwhile a favourable momentous rainfall trend was highlighted in Bega season. In contrast, in the Belg season, no significant trend was observed. The statistical investigation of rainfall series data showed no significant trends had been recorded in annual or seasonal rainfall from 1961 to 2015.

Hajani et al., (2017) studied the yearly maximum precipitation (YMP) intensity series trends in Australia's New South well (NSW) areas. The data was collected from 60 stations during the period of 1955 to 2010. The study periods were divided into three parts, the first period was (1955 to 2010), the second was (1965 to 2010), and the last was (1978 to 2010). The analysis results of the MK test observed that over 11 (26 %) stations out of 42 had found favourable growing rainfall trends, for the 6 min interval rainfall strong effects from 1978 to 2010, which study period was (33-year data). At a 10 % significance threshold, just two stations or (5%) reported a negative and statistically substantial trends. Furthermore, MK test interpretation has shown a strong growing trend at a 5% level in three, nine, and two stations for 6 min interval and over three period of time. Moreover, the MK test results revealed that no strong remarkable and negative trends were recorded in YMP intensity where NSW measured a on its own region due to geographical correlation was taken into account.

Hartmann & Buchanan, (2014) scrutinized trends in rainfall by utilizing daily precipitation records that converted into a time-series which depicted occurrences of major precipitation events with one day and ten-day periods which is specified related to benchmark exceedances at ninety (th) and ninety-nine (th) of the point percentage. This has covered Pakistan's the whole Indues river basin and flooding. The analysis results have mentioned that significant increasing trends were recognized in extreme precipitation statistics over the very high mountain areas of the Himalayas and Trans Himalaya. In addition, significant decreasing trends were recorded in the western region of Indues basin, and the highest significant level was recorded in the Suleiman Mountains areas.

Bana Himanshu & Gerg R. D., (2021) examined the rainfall trend analysis over the eight districts of the Marathwada region of Maharashtra state. The rainfall trends detected by the MK and Sen's slope magnitude test. The numerical analysis carried out during the period of 1980 to 2018 over pre-monsoon and monsoon season. The study results found that all districts of Marathwada region have observed decreasing rainfall annual trends, while Parbahni and Latur district observed the highest downwards trend. Moreover, only the Nanded district reported statistically significant decreasing rainfall trends among all.

Kundu & Mondal, (2019) investigated the long-term (1901 to 2002) seasonal and annual trends using monthly time series data over the 18 rainfall stations in the West Bengal state of India. This study used MK, and Theil-Sen slop tests to determine rainfall trends and magnitude of change over the study region and identify the annual rainfall change points standard normal

homogeneity and Pettitt-Mann-Whitney tests were used. The study results have shown that significant trends were reported in annual rainfall over the five stations; after that, six stations were observed in monsoon rainfall, and eight stations were reported in post-monsoon rainfall. The Maldah station reported the highest negative magnitude of change in the annual and monsoon rainfall (-14 %) and (-20 %). On the other hand, South Pargana stations have observed the highest positive change in the magnitude of annual and monsoon rainfall (13.98 %) and (13.27 %), respectively. The Northern, southern, and western parts in West Bengal have reported the highest probable change points in the annual rainfall years 1956, 1967, and 1952.

Porto de Carvalho et al., (2014) analysed annual daily maximum precipitation trends in the Midwest, south and southwest regions of Brazil for 71 years. The study observed that daily maximum precipitation trends increasing over the three regions of Midwest, south and southwest.

Liuzzo et al., (2016) examined the annual, seasonal, and monthly rainfall trends using observational data series over the 245 rain gauges stations of Sicily, Italy. The significant rainfall trends were identified using the Mann Kendal test at regional scales during the period of 1921 to 2012. The analysis results have shown that a declining trend were found in the rainfall data in Sicily over the study period. upward trends were detected in the entire annual precipitation data, whereas decreasing trends were frequently observed in the autumn and winter months. Furthermore, rainfall was unpredictable and erratically dispersed in the two distinct seasons.

Mumo et al., (2019) focused on the temporal-spatial changeability, trends and size of observed rainfall, over 33 synoptic stations during 1979–2017 in Kenya. The study used non-parametric methods such as the MK test, Sequential Mann-Kendall (SMK), and SSE were employed to identify the trends, change points, and magnitude. Before applying the MK test, the study checked the serial correction at a 5 % significance level in the time series, which has not observed in the data. The results identified that boreal spring and annual rainfall were reported statistically falling at a rate of 1.58 and 0.93 millimetres per year, respectively. Large number of stations (27/33) were observed decreasing trends in boreal spring out of those four stations had significant negative rainfall trends. Out of the total stations, the remaining eight stations observed inconsequential negative trends in the boreal spring. Boreal spring is the primary crop growing season in Kenya, where observed a high fluctuation in rainfall over the study period, while 27/33 stations examined decreasing rainfall trends that harm the nation's food security.

In the boreal autumn season, rainfall recorded statistically positive insignificant, which was 1.48 per millimetre years, meanwhile 8 stations verified significant upward trends at 10 % level.

Incoom et al., (2020) investigated rainfall trends in the monthly, yearly long-run data using the MK (distribution free) test over the nine metrological stations from 1960 to 2015 in the Savannah arid areas of Ghana. The analysis results of the Mann-Kendell have shown that no meaningful trends were recorded in the annual rainfall of the entire zone and separate climate stations. At the same time, only when chi-square has recorded a meaningful negative trend at the 5 % level. Furthermore, no significant trends have been recorded for all months except August and September, showing increasing trends. It also mentioned that decreasing rainfall amount had adverse influence on agricultural crop production, such as sorghum and millet.

Sinha et al., (2019) examined the current pre-monsoon (March, April, May) season rainfall variability over 34 metrological subdivisions in India using observed rainfall datasets from 1951 to 2013. The Mann-Kendall test has been employed to assess the rainfall trends in the March to May months, which has called before monsoon. The study found that out of the total annual rainfall, pre-monsoon contributes a maximum of 12 % of rainfall and its separate months contributed as March 3 %, April 4%, and May 5%, respectively. Furthermore, the maximum quantity of rainfall was obtained in Arunachal Pradesh over the season (6.60 mm/day) after that Meghalaya and Assam (5.86 mm/day). The lowest amount was observed in Gujrat, Saurashtra, and Kutch subdivisions. The pre-monsoon rainfall has detected increasing trends in the current period over the south-peninsular of India, while the downward rainfall trend observed in JK, HP, and northeast domain of India. In addition, it is observed a significant rising in precipitation quantity over Thailand and Myanmar in the latest period, while a decrease in precipitation recorded in the Chinn and the west of the western mountain of India. The above studies reported increasing and decreasing rainfall trends using parametric and non-parametric test over a long period data.

Guhathakurta & Rajeevan, (2008) created a newly month, year and season-wise rainfall time series for 103 years to find out pattern. For that, it has utilized the monthly rainfall data over entire thirty-six atmospheric sub-divisions, across country between the period from 1901–2003 for the 1476 static rain gauge stations. The study applied linear regression method to inspect the long-term trends in rainfall overall subdivisions. It is also calculated every month of monsoon share of total annual rainfall using mean, SD and CV. The study has reported that

the share of each month of rainfall such as June, September and July to yearly rainfall which has been decreasing for a few sub-divisions, while the share of August rainfall is growing in a few other sub-divisions. Furthermore, it was also detected that 10 years high fluctuations in the June and September months. In the same period July recorded similar fluctuation to monsoon.

Sivasami, (2000) analysed south-west monsoon rainfall data from 1877 to 1999 and shows drought, cyclical trends, and rainfall pattern by calculating cumulative percentage deviations from the normal. The study found that regarding the south-west monsoon rainfall departure from usual, the most significant deficit occurred in the years 1872 (-33.3 %), 1899 (-29.4 %), 1918 (-24.9 %) and 1972 (-23.9 %).

Kothawale & Rajeevan, (2017) reported area-weighted rainfall time series data for India at monthly, seasonal and annual basis during the period 1871 to 2016. The study generated 5 identical regions and 30 meteorological subdivisions which were depend on fixed and sound distributed network of 306 rain gauge stations in entire country. In the present study they apply few basic statistical tools like as Mean, Standard Deviation and shows trend for different periods with the help of diagrams (entire period 1871 to 2016 and 1981 to 2016 recent period). It found that, east and Kutch, Saurashtra, Rajasthan and Diu which has showed a notable growing trend in the rainy season at 10% and 5% substantial scale, during the latest period 1981–2016 at the sub-divisional level. Furthermore, in the periods between 1871–2016 and 1981–2016, rainfall over the entire rainy season across India has recorded a relatively slight downward tendency, with yearly declines of 0.18 mm and 0.17 mm.

3.3 Drought, agriculture and rural livelihoods

Hermans & Garbe, (2019) ascertained the influences of drought on human migration and livelihood in the rural hills of northern Ethiopia during the drought year 2015. The study revealed that as a result of the drought, an extensive majority of the individuals faced food shortages, a decrease of wealth, reduced spending capacity, and increasing market prices. They adopted many livelihood strategies to combat with drought. However, the migration and selling of livestock for generating income activities were the most common strategies adopted among them. Out of ten, four households were migrated in both region of the northern highlands of Ethiopia.

Nadkarni, (1985) examined the socio-economic conditions of rural households, irrigation strategy, and strategies of rural development. The study found that development strategies and irrigation programmes did not improve the quality of rural life. It was observed that irrigation

has completely failed, and it negatively affects particularly on the of poorly constructed houses and school-going children, mainly in the Coimbatore district. The study also reported that the proportion of the poor and the inequality of income are not positively correlated. The average income level of households in a village is increased; the proportion of the poor decreased but inequality increased.

Borkar and Nadkarni, (1975) examined the impact of drought on rural life. It found the extreme impact of drought on marginal agriculture households, followed by agriculture labourer, agriculture productivity, assets (animal livestock and jewellery), land cultivation, income, and consumption. The households have belonged to different occupation groups and different communities. Maratha community household's percentage was higher than other community households; they were found dominant in large cultivators and land size. Muslim, Scheduled Cast, and Scheduled tribe found agriculture labour and small farmers, Other Backward classes found mainly artisans. Furthermore, the study also indicated that drinking water was another problem in the drought region. All small, medium and landless households' labours, and school-going children were worst affected by drought. Moreover, it was highlighted that the government relief programme was not successful in drought-prone areas due to its ad- hoc nature.

Ambhore and Bhise, (2012) examined the distress conditions of the rural farm households in the drought-prone parts of the Maharashtra's Marathwada region. The study has measured the distress in order to their income earning from farming, experiences about input delivery, marketing, and the extension facilities. Resource-rich, core drought-prone and developing which were three segments made for the study. It has observed that the per capita net one year revenue of the cultivators in the main drought zone was very much lower in comparison to the resource-rich region and developing region. In addition, it was found that 4 % of the total sample households had been received negative net income from all sources. Lastly, it is suggested that there was a need to enhance the prices and quality of farm products and provide an adequate and quality supply of inputs to the farmers, including electricity and agricultural marketing.

Udmale et al., (2015) evaluated the severity of the impact of drought on regional supply of water, crop production, non-skilled jobs, and rural households' economic conditions during the drought year 2012. The finding of the study observed the negative influences of drought on residential water supply. People fetched more water from distant sources in the drought year

than a normal year, and they spent more time fetching water from remote areas with the help of bicycles, bullock-kart, tanker. Some people fetched water on their heads. It also indicated the consequences of drought on reduction in income, damage of crop production, loss in employment. Furthermore, one of the important findings was that farmers were compelled to borrow money from various sources such as money lenders, self-help groups, and relatives for different purposes.

McCabe T. & Quandt A., (2020) observed drought influences on different kinds of livelihood in East Africa, mainly in Kenya and Northern Tanzania. It is revealed that drought had both indirect and straightforward worst effects on the society's living practices. It is observed that the indirect effects of droughts on respondents' health and conflict in the society for water and the long run drought converted into famine. Meanwhile, it is also identified that increasing heat ecological damages and poverty. In addition, it has highlighted the direct effects of drought on people's daily life, such as income, food and crop production, livestock rearing, infrastructure, and significant losses of local, regional, and state economies.

Sivakumar and Kerbart, (2004) examined 'Maha Akal' in rural Rajasthan from a conducted survey in March-April 2003. The study revealed the long-run impact of drought on people's assets and livelihood, and it is also identified their coping strategies, which they adopted in the drought period. It also observed that drought effect on peoples' daily lives. The study shows that people were suffering from food and water. Consumption of the household's members was low, and inequality between age and gender has increased. Many children have left their school education because of weakness. Furthermore, it was revealed that child labour was increased due to drought. The study also mentioned that migration and lack of purchasing power increased during the drought period, and the major asset of land and livestock (cow, buffalo, and camel) has declined in rural households of Rajasthan. The study also observed that the government's drought relief programme helped to create employment opportunities during the drought.

Carpna, (2019) highlighted the effects of drought among the Nation's countryside families on intake of micronutrient and food spending. It found that the nutrition of rural residents which had negatively affected by dry shocks in a significant manner. Families expended less than one percent per capita revenue for every month on food consumption in relation to median dry shock. After that, 1.4 % less money was expended including fat, protein and calories. Furthermore, it is observed that families' foods become imbalanced due to droughts. Because

of the dry shock, people depend mostly on cereals and purchase fewer vegetables, fruits, pulses, and foods that come from animals. As a result, droughts drastically influenced rural family's diets (quantity and quality). Finally, the study argued that during the drought, reduction in the family market and non-market earnings, the fundamental cause was lower family food intake and nutrition related to higher food prices.

Tirlapur & Desai, (2016) examined the impact of drought on agriculture production in North Karnataka. The study revealed that during the drought year majority of crop production decreased compared to a normal year. It was identified that about 74.28 % reduction in brajara yield in the drought year. After that, a 61.34 % reduction in Tur yield and about 53.26 % reduction was recorded in jawar yield in the Belagavi district. In addition, approximately 31.66 % and 20 % of cultivators have done double sowing due to drought in the Vijayapura and Belagavi districts. Nearly 71.25 % of cultivators have diversified their income in the drought year, and 70 % of cultivators have stored crops for future consumption.

Dutta et al., (2019) investigated the farm practices of small and marginal land owing agrarians in the Banda district of Bundelkhand region in Uttar Pradesh, India. The study found that 30 % of farmers used local seeds, 32.5 % used high-yielding variety (hybrid) seeds, and 35.7 % applied both kinds of seeds. Chemical and organic fertilizers were utilized by 90 % of farmers, while only 10 % applied chemical fertilizers. In addition, it has shown that 75 % of farmers had known about Minimum Support Prices (MSP), and 25 % of farmers did not become aware of that. Animals such as cows, buffaloes, oxen, goats, and sheep were used as farming animals in drought-prone areas, and about 20 % of families have used biogas plants. Furthermore, the study revealed that livestock rearing was bad due to fodder and water shortages, whereas many of them destroyed the farming crops which have grown by farmers to provide fodder or pasture to their livestock. More than 80 % of farmers have reported a lack of irrigation facilities in the study area.

Singh, (1998) highlighted the impact of drought on rural people's income and found changes in employment patterns and expansion of depletion of assets and indebtedness due to drought in the study area. The study observed that in 1987, the whole state severely suffered from drinking water problems, and the Kharif, Rabi crop production was declined due to drought. All the district of the state, reservoirs, ponds, and tanks has dried up; during the Kharif season, around 55, 66, 887 hectares of sown area was affected by drought, which resulted in crop losses running into crores of rupees.

Edwards et al., (2019) investigated the socio-economic influence of drought on families of countryside in agricultural sectors from Australia using the data of Rural Regional Families Survey (RRFS), in 2007. The effect of the severity of drought on respondent's socio-economic consequences have estimated using regression models. According to the findings, the drought dramatically increased mental illnesses. The negative impact of drought on mental health problems reported only for farmers and farm workers. Drought caused a significant effect on farm household income. The main finding of this study is the impact of drought directly on the farm community, which was working in the agriculture sector.

Nagarjuna et al., (2010) inspected the impact of drought on Dalit and Adivasi in five villages of Mahbubnagar district of Andhra Pradesh in 2006. The study shows that drought relief programmes did not reach to Dalit and Adivasis. Drought created a number of socio-economic problems like as lack of employment opportunities, drinking water in villages, lack of livestock fodder, starvation, minor irrigation, and financial problems. Due to drought, the caste discrimination problems increased with Dalit and Adivasi in study areas villages. Many Dalits and Adivasi moved from countryside areas to urban areas in their urban areas where they stayed; they have faced many problems such as sanitary, child education, drinking water. The study suggested that employment generation should generate in these villages particularly in the period of drought, and essential health care facilities should provide by the government for improving standards of living in drought-prone villages people. They also suggested that government should provide free food grain through Fair Prices Shops and the financial support for agriculture equipment and employment schemes etc.

Khayyati & Aazami, (2016) studied how droughts affected Iranian rural people's ability to survive. It also concentrated on the role of livelihood assets as a mediator in association to drought and livelihood outcomes. The study constructed a conceptual model based on literature review, which was tested and employed on primary data from 2002 to the end of 2012, with each variable averaged across 11 years. It was also used a multiple regression model for secondary data analysis. The study showed that traditional rural livelihood practices were threatened by drought. It is highlighted that drought episodes directly affected agriculture and an indirect impact by the mediator of livelihood assets. It was observed that over the entire state, temperature trends increased, and rainfall trends decreased due to extreme weather events.

Katalakute et al., (2016) examined the relationship of rainfall pattern with agriculture production and farmer suicide in Maharashtra state from 2011 to 2015. The study found that rainfall decreased drastically in the Pune and Aurangabad divisions, along with drought's severe impact on the agriculture sector and employment. The farmers have shifted from traditional crops to cash crops like turmeric, banana, and sugarcane, which have required more water than cereals and pulses. Furthermore, it is reported that people migrated from rural areas to city areas to find out temporary jobs. The Maharashtra's cotton belt areas like Vidarbha and Marathwada region, where the highest number of farmer suicidal cases were reported in 2015. Moreover, it has observed that crop production has been deceased tremendously in the drought year.

Delaporte & Maurel, (2018) assessed the effects of climate shocks on households' agriculture income. According to the survey, 86.25 % of agricultural households have adjusted their cultivation practices as a result of climate change. The result also showed that most essential adaptation measures cited by the farmers such as adapting new crop variety (64.14%), strengthening irrigation (63.59%), watering fields (62.48%), constructing a water harvesting system (23.31%), changing crop type (19.59%), expanding the area where production occurs (16.69%), and seeking job outside of farming sector.

Miyan, (2015) analysed the impact of drought in Asian under developed countries such as Bangladesh, Nepal, Cambodia, Bhutan, Lao PDR. The study identified that LDCs were severely impacted by drought rather than developed countries because of differences in the social, economic, physical, and knowledge gaps and skill development. It was also shown that increased biophysical vulnerability due to drought in the LDCs has resulted in food shortages, dried-up water resources, health conditions, hydropower development, human livelihood, and wild and fish life. Some other problems induced by the drought include migration of rural people, pollution, diseases, and famine. In addition, it is observed that extended drought events had increased incidences of wildfire in grasslands and woodland areas and range-lands. It has also revealed that reducing the yearly water stream flows that declined in the ground and surface water availability harmed agriculture output and industrial and local water supply bodies.

Rathore M., (2005) analysed the impact of drought on farm income, production, and employment. The study also investigated drought relief spending and its impact on the Rajasthan budget. The study found that the agro-based industrial sector was directly affected

due to drought, the lower agro domestic production declined tremendously as non-agro domestic production. The rivers and reservoirs were dried up as a result of that, there was less water available, and the power cut ratio was increased in the rural area. Livestock and productive capital were also damaged. Furthermore, it is reported that drought mainly impacts on government's budgetary policy because of that government reduces taxes therefore governments income, export declined and employment also declined. Expenditure on drought relief programme, community welfare, healthcare, water supplies and subsidies for consumption on distribution of food which all were increased. People were suffering from starvation, deprivation and robbery, and the government failed to control on law-and-order condition in the drought period. In addition, the study also revealed that the kharif crop agricultural production also declined which had significant impact on farmers' occupation. They lost their jobs and join in the labour market and they migrated from their villages to near the town places for getting jobs.

Lal et al., (2011) examined the socio-economic consequences by climate change on rural communities. The study found that human health was indirectly impacted due to climate change, such as increased water distress, degradation of water quality, increased temperature. For several indigenous groups, it has reduced the availability and accessibility of traditional food sources. Additionally, the considerable effects of climate change on forests, water resources, hydropower, fishing, recreation, and tourism were also observed.

Purandare P., (2013) studied the water governance programmes in drought-prone areas of the Marathwada region in Maharashtra during 2012-13. The study observed that marginal and small farmers could not get benefits from the de-silting work of reservoirs due to their financial limitations. The study has reported that total 1,8,75 water tankers were provided through few sources over 1,5,15 villages and 746 hamlets across the region. The maximum number of tankers reported in Aurangabad district followed by Jalna and Beed district. The Employment Guaranty Scheme have not provided enough employment in drought-prone areas of the Marathwada region. Also, the cattle camp pictures were not good as they were failed to provide fodder for cattle. Then due to lack of water and employment, the seasonal migration was increased around 0.5 million sugar cane cutters and transport workers shifted from Marathwada to western Maharashtra.

A study by (Sambrani S., 2010) highlighted Central Statistical Organization (CSO) advanced estimate on agriculture sector output from 2009 to 2010. He also evaluated the latest number

of food grain output changes, and compared output (GDP) changes in the drought year 2002-03 and 2009-10. The study found that the Kharif crops like food grain, sugar cane, and oilseeds production declined compared to the previous year 2009-10, such as 7.5%, 12%, and 5%, respectively. But the production was the same. Additionally, The Indian Meteorological Department and Ministry of Agriculture Department have depicted false statistical pictures of the crop sector throughout the monsoon from CSO data.

Singh R. et al., (2012) found that farmers sold their livestock during the drought due to green fodder and water unavailability. Furthermore, income from the various sources was negatively impacted by drought, such as the income of fisheries was heavily affected, followed by rice, vegetables, other crops, and animals, respectively.

Kabubo-Mariara, (2008) examined how climate change impacted cultivators' judgment on whether or not to participate in livestock farming. The empirical investigation based on cross-section data which is collected from 816 sample households in the 38 districts of Kenya, 2004. The Probit model applied to check the relationship between framers' decision probability to engage in livestock activities or not engage to climate change. It is reported that 88 % of the households were keep livestock. The model results found that all climate factors have a major influence on the judgement to rear cattle. A non-linear association between global warming and the decision to participate in cattle production was also reported. The miner effect of temperature was significantly greater than the precipitation effect. In addition, it was also identified that large size households were more likely to raise animals than small size households. The decision to keep cattle was negatively connected with summer and spring precipitation, but positively correlated with winter and fall precipitation.

3.4 Drought and economy

Kilimani et al., (2018) studied the influences of drought on crop yields that could affect the whole economy. The study also highlighted the key issues of implementing drought mitigation programmes that have mitigated drought impact. The study employed a computable general equilibrium model that analysed drought's impact on agriculture productivity. The study results found that the drought shock destructively affected important macroeconomic factors such as actual GDP, industrial output, occupation, trade balance, and family consumption.

Boyd & Ibarrarán, (2009) examined extended drought events and its impact on the Mexican economy using a computable general equilibrium model. The model's macroeconomic variables included investment, sectors output, household consumption, foreign trade, relative

prices, salaries, revenues, aggregate wage income, government spending, rate of interest, and capital accumulation. The study found maximum production loss in livestock, forestry, agriculture, and hydropower development in the rural economy. On the other hand, minor losses have been found in the urban economy since failures in the industrial sector, such as manufacturing, chemicals, refining, and power while the service sector found similar losses as industrial. In addition, it observed the drastic impact of drought on investment, GDP growth, and consumers' wellbeing. Moreover, it revealed that climate change increased the temperature, frequency, and intensity of hurricanes and higher rainfall variability.

Ziolkowska, (2016) examined the consequences of the 2011 drought on Texas agriculture and the overall state economy using an input-output social accounting matrix technique. It has shown the straight impact of drought on corn, wheat, sorghum, cotton, timber production, and livestock. It reported that \$ 16.9 billion economic losses overall Texas economy. Furthermore, it reported that the unemployment has increased around 166,895 community members and 106,000 jobs has been lost only in the agriculture sector due to the 2011 drought. Additionally, it revealed that the failure of cotton farming about 91% of revenue reduced compared to 2010 normal year, whereas livestock assets lost income approximately 32 %.

Sangkhaphan & Shu, (2020) investigated the impact of rainfall on the progress of the Gross Provincial Product (GPP) using division level panel statistics between 1995 to 2015 in the financial sector and allied sector of Thailand. The study employed regression model in which that applied the FGLS estimator with fixed effect to examine association between climatic variables and GPP growth. The study found that temperature has not recorded significant impact on economic growth, whereas the rainfall recorded substantial negative impact at the provincial level. The analysis results also observed that precipitation was the most climatic influential factor which effects historical growth of the country. Furthermore, it is stated that rainfall had negative impact on service and agriculture sector, whereas positive impact on industrial sector but which was not significant.

3.5 Drought and vulnerability

Thao et al., (2019) analysed the living susceptibility of five farm communities in response to drought in the Krong No district of Vietnam in the drought year 2015-16. The study used LVI and IPCC vulnerability Index to calculate vulnerability in the study area using survey data. The study found that farmers belonging to the Quang Phu community which were most vulnerable among all communities, after that Nam N'dir, Dak Nang, Duc Xuyen, and Dark D'ro in

diminishing order of vulnerability, which has indicted by LVI and IPCC values. In addition, the study has shown that water deficiencies (sensitivity) and livelihood tactics (adaptive capacity) were major factor which determined high vulnerability to drought impact over the study region and overall farmer groups. Furthermore, it is reported frequency of drought in the district was sixteen percent in which that modest drought occupied larger than sixty six percent of the area, followed by rigorous drought covered nearly twenty percent area and about fourteen percent occupied by extreme drought, which was most worried in the district.

Maru et al., (2021) examined small farmers' livelihood vulnerability related to drought in the upper Awash sub-basin of Ethiopia. Farmers' livelihoods vulnerability identified in terms of drought overall agro-ecological zones (AEZ) and farm typologies in the study area. The household survey and hydro-metrological data employed on sensitivity, exposure, and adaptive capacity components, which determine drought vulnerability in the region. The study revealed three basic farm topologies based on their assets and livelihood features. Topology farmers received 68 % income from livestock and on-farm operations in the first farm. In the second farm topology, farmers have obtained 23 % income from off-farm income and marginal farm activities. And the last farm topology is based on an intensive-irrigation farming community which is received 9 % income. Furthermore, the study also highlighted that midland had the highest exposure with a 0.439 index value related to climate change and variability; after that, the highest exposure value was calculated from lowland and highland areas. High temperature and low rainfall are recorded over midland compared to the rest of all AEZs. Drought risks are another indicator of exposure that has recorded the largest value (0.61) in the lowland among all AEZs. Farm community in the upper Awash sub-basin has faced the largest risk consequences to climate change. In addition, it identified eight indicators that have determined drought sensitivity of small farmers in the study region, such as Crop losses, decreased production, diseases among crops, livestock and human community, food shortages, conflict in the society, and rain-fed land. Moreover, the study results show that the family members' social and demographic features in the midland AEZ had maximum adaptive capacity rest of other AEZ to drought and climate change. It was also noted that younger, working population, large household size, and male family heads who had found more resistance to drought shocks in the area over a long period. Health and education organizations, transports, markets, electricity utility, and health insurance facilities had found the highest mean weight value (0.507) in the midland AEZ. In contrast, lowland recorded the lowest value (0.284) for access

to infrastructure. Moreover, livelihood typology based on intensive irrigation cultivation had observed more adaptive capacity in terms of health and market and transport facilities.

Babugura, (2008) studied the vulnerability among the youngsters and children to drought in the drought period from a Matsheng village, district of Kgalagadi in southwestern rural Botswana. A random sampling technique was used for the surveyed data collection through face-to-face interviews and participatory data collection methods. The study found that they voiced concern about food availability, family stress and tension, lost educational incentives, and a lack of emotional support at the family level. Furthermore, it revealed that the caretakers of boys and girls had lost their formal employment during drought. They said that relief programmes were beneficial for them because they did not struggle to search for employment, where they have easily got employment through labour-intensive relief programmes. Moreover, it reported that children were fortunate in the Matsheng village; they had not suffered from famine and starvation because they received food from government-subsidized food programmes. Many boys and girls shared their experience, and they said that their parents borrowed money from neighbours, but they could not return it. More than half of the sample respondents mentioned that many children taken out of school to provide financial support to the family and they also have taken charge of family when their parents must be migrated for jobs to other places.

3.6 Drought and food security, poverty and children's education

Sen Amartya, (1984) examined the causes of famines from four case studies in the recent history during the twentieth century (the Bengal famine in 1943, Ethiopian famine in 1972-74, the famine in Sahel countries in the 1970s, and the Bangladesh famine in 1974). The study concluded that in the three-case studies of famine which was not occurred due to the food availability decline, the only exception of Sahelian famine. In the 6th chapter of this book, the author argued that the Bengal famine in 1943 was not occurred by food availability declined but the cause was declined in their exchange entitlements, and its main reason was that some people who were consequently unable to afford food grains due to loss of entitlements. Also, it analysed the relationship between poverty and famine. Some empirical evidence found the worst drastic impact of famine on consumption, employment, and income in the study. Individuals' food consumption level declined due to famine; after that, starvation and deaths were increased. Individual farmers and herdsman who were suffered from food deprivation because they did not have any entitlements. Service providers and labourers lost their jobs, and tenants were left their lands. The study also found that food prices were increased in the famine

region due to lack of food supply and people also lost their purchasing power decline in the famine period.

Patnaik, (2012) examined the drought impact on the food security pattern and economic conditions of households. It was also described the various coping measures implemented by households in the drought period. It has revealed that the households' food consumption depended on-farm production, who have always been preferred to eat staple food which has been cultivated on their farm, but due to monsoon failure, they lost food security and income also. The study observed coping practices accepted by rural households to deal with droughts in the drought period, such as livestock selling and reduction in assets (gold, silver jewels), change in consumption pattern, and shifting the employment pattern. Many people engaged in NAREGA, but they have not received adequate employment under the programme. The study suggested that the government should be informed/trained cultivators to cultivate drought-resistant crops. The government should make proper institutional arrangements to provide appropriate work through MANREGA in drought-prone areas.

Joshi, (2019) explored how the drought affected children's academic performance in rural Maharashtra. The study employed the difference-in-differences technique to analyse the drought impact, using pooled section data on children's t score. The study found that about 4.14 % declined in children's math scores due to drought. Besides that, drought-affected about 2.67 % reduction in reading scores of the children.

3.7 Drought: perceptions, coping, adaptation and mitigation strategies

A study by (**Alemayehu & Bewket, 2017**) highlighted numerous coping and adaption techniques employed by the smallholder farmers to mitigate the negative impact of climate change and variability in Ethiopia's central highlands. The study calculated a composite index of adaptation to recognize the intensity of adaptation of farmers' coping and adaptation techniques. Farmers over the area used two forms of strategies to combat climate uncertainty and changes: one for short-term (coping) and the other for long-term (adaptation). In this study, the farmers' coping and adaptation strategies have been divided into four categories viz, land management, crop management, livelihood diversification/adjustment, and livestock management. The study found that the most dominant coping strategies adopted by the farmers such as selling livestock and reducing consumption. About 80 % of the smallholder farmers sold their livestock to gain income to satisfy their food needs. About 77 % of the farmers who changed their consumption patterns included changes in their eating habits, such as eating less

and smaller meals and eating less-preferred foods. In addition, the study reported that they changed their social expenditure to spending less on weddings, funerals, and so on. Furthermore, accessing credit and assistance from Productive Safety Nets Programmes (PSNP), these two strategies were also reported in the area. Other way, the study pointed out the most effective adaptation plans accepted by the farmers. Near about 89 % of farmers changed crop planting dates; after that, 89 % of the farmers have done soil and water conservation. Moreover, the farmers in the study part adopted crop diversification, income diversification, soil fertility management, and watershed management adaptation strategies.

Rakgase & Norris, (2015) determined the relationship between cultivators' economic- social features and their perception related to climate variation and visible drought phenomenon. The study used the discriminant function method for the primary data analysis. It found that socio-economic factors of the farmers' such as age, schooling, level of literacy, farming type, gender and location had a significant relationship with how they perceive climate and drought events. Besides that, the study also found a high-level consciousness among cultivators to climate variation and drought incidences.

A cross-country level study by **Bhatta & Aggarwal, (2016)** investigated coping strategies and adaptation measures adopted by the smallholder farmers towards whether adversity and climate variability from the Bihar, India, Coastal Bangladesh, and Nepal's Terai. The analysis incorporated both qualitative and quantitative research approaches for collecting data and processing it on coping strategies and adaptive solutions in the context of regional climate variability. The paper revealed that migration was the most common coping technique used by the farmers in Bihar and seaside Bangladesh; borrowing money from the credit markets was Terai's most important coping strategy.

The study of **(Mardero et al., 2015)** investigated the adaptation strategies adopted by Mexican maize smallholder farmers against drought and climate variability. The occurrence and severity of meteorological droughts were estimated using a quintile approach over the study region. Study revealed that peasants used broad adaptation plans in response to drought and climate change, such as adjusting the agriculture calendar, planting and combining maize varieties, minimizing working hours, storing water and maize, and revenue diversification and government economic support.

Fanadzo et al., (2021) investigated the effect of the 2018-2015 drought on small scale farmers' living conditions and their coping and adaptation practices in two districts in South Africa's

Western Cape division. Private tankers were used to bring water from various sources, including rivers and dams, to the farm, which was the most common widely used coping plan in West coast (right) and Overberg (left) districts. Coping and adaptation measures accepted by small scale farmeres in the West Coast and Overberg districts such as regular livestock treatment, buying extra livestock food, mixing water rights, reducing herd size, multiple water use, saving, conservation farming, gray water use, migrate livestock, private business income, government support, insurance, alternative job income, etc.

Quandt, (2021) illustrated the coping mechanism of smallholder farmers in the couple communities including Burant and Kinna, Isiolo County's arid and semi-arid regions of Kenya. The study used a qualitative research approach for primary data analysis. In this study, coping strategies against the drought impacts were divided into four groups, namely, over livelihood divergence, long-term enhancements to living techniques, short-term coping plans, and destructive coping strategies with long-term adverse influences. During the drought, farmers used both long-term and short-term coping strategies, as discussed in this article. A few long-term strategies were highlighted in this paper: poultry farming, agroforestry, business, beekeeping, casual labour, and drought-tolerant crop. A few of the short-term strategies employed such as selling cattle, depending on traditional wild foods, and cutting agricultural waste or grasses for cattle.

Gebre et al., (2021) analysed ex-post risk coping techniques among vulnerable rural households and their determinants in, Bale Zone of Oromia Regional State's Rayitu district, Ethiopia. The survey data has been evaluated using a three-stage Least Square Method to examine the risk coping techniques of households against drought, and step-wise regression analysis used to determine risk coping mechanisms. Furthermore, the correlation method was applied to examine the relationship between response and explanatory variables. Consumption of less favoured and less costly foods, these coping strategies used near about 40 % of the sample households. After that borrowing food from neighbour and relatives that was the second most general coping strategy used by the household. Other ex-post coping techniques were used by respondents including sending family members to eat somewhere else, picking wild fruits, hunting or harvesting undeveloped crops, reducing the number of meals, purchasing food on credit, and feeding children first. Furthermore, the study indicated that these coping strategies were regulated by access to resources and earning of the sample households, their marketability and creditworthiness, and their socio-demographic characteristics.

Chandan Kumar Jha and Vijaya Gupta, (2021) investigated farmers' perceptions towards climate change and their socio-economic determinates of farm households that affect adaptive decisions and adaptation plans choices to climate change. Descriptive statistics and a binary logistic regression technique were used for analysis of the survey data. The key socioeconomic factors were affected farmers' adaptation choices including their age, sex, length of household, education level, size of the land and off-farm earning. It is found a substantial connection between the few socio-economic, demographic factors and adaptation practices which were adopted by them. The study revealed the most common adaptation strategies used by farmers in the Kharif season against rainfall and temperature in the study area; such as increased land irrigation about (66-68 %), altered crop seeds (51-56. %), area used for farming (46-51 %), migration to metropolitan areas (49-52 %), and crop protection (43.00 %). In addition to, minor plans adopted by farmers during the Kharif season, including switch farm to non-farm activity, growing vegetables, water conservation, and lease land. During the Rabi season, strategies were including irrigation (76-81 %), a changing area under crop cultivation (61-51 %), used various crop varieties (68-83 %), migrated from rural to urban areas (55-57 %), etc. The study's analysis findings indicated that because of their social connections, access to information and knowledge, male-headed families' ability to adapt to climate change was stronger than that of female-headed families. Furthermore, the study also revealed that young farmers, dependency ratio, secondary occupations, soil characteristics, farm mechanism, and family labour had found a strong correlation with adaptation plans.

Omerkhil et al., (2020) assessed smallholding size farmers' adaptability techniques against climate change. A pre-tested questionnaire is used to obtain survey information from 260 agricultural households in 26 villages spread over both plain and mountainous terrain in Afghanistan's Yangi Qala region. In this study, four main adaptation mechanisms of smallholder farmers were studied using logistic regression models, which included systematic techniques used during crop cultivation, farming of drought-resistant varieties, cultivation of new crops, and movement of household respondents. The study identified that LPG, livestock populace, schooling, and a secondary career were the key determinants of smallholder farmers' adaptation measures in both regions. The empirical results found that systematic technique-based cultivation and migration which were the best choices for adaptation preferred by them.

Amfo & Ali, (2020) evaluated that income diversification was the main mechanism of Ghana's cocoa cultivators to combat climate change. The study reported that income diversification was the principal coping mechanism of cocoa farmers. Crop and livestock diversification, multiple

coping practices, and off-farm economic activities were also examples of diversification techniques. A Heckman two-step regression model employed over survey data which was collected from 400 randomly selected farmers to highlight the degree of cocoa farm income diversification. Also, the study employed a beta regression model to find out that what ratio of annual farm earning was created by diversification. The study revealed that around 18 % of cocoa cultivators' yearly earnings came from diversification of income. When adopting climate change coping and adaptation measures, the primary significant factors used such as distance from the provincial capital, loans availability, links with extension agencies, FBO affiliation, source of climate change information, state funding, agricultural training programme and the farm's age.

Sertse et al., (2020) investigated adaptation strategies of farming households towards climate change. It is also highlighted factors which was affected household adaptability in the Tigray area of Ethiopia's Raya Azebo district. A survey data from 397 land households was gathered over the study zone using a multi-stage sampling technique, and data were analysed employing inferential as well as descriptive numbers. Farmers adopted several adaptation practices to mitigate climate threats at the farm level. Alternative tillage practices (74 %), water and soil management techniques (78 %), mulching (88 %), and crop diversification (99 %) were the most commonly utilized adaptation strategies. Farming arrangements from home (3 %), which was the least widely used technique, followed by hybrid farming (12 %), tree planting (26 %), and. The binary logistic regression model results revealed that the age of the household head, literacy level, credit use, extension usage, and access to farm water which were all important elements to adaptation behaviour. This study tries to be recommended that administration could expand coverage for rural households throughout several organizational-led programmes (including advice, finance, and environmental knowledge) to enhance their survival resilience and adaptability.

Belay et al., (2017) highlighted smallholder farmers' adaptation strategies about climate change and factors that influence their adaptive decisions. Cross-section as well as secondary data sources have been used in the study. The determinants influencing smallholder farmers' adaption strategies were identified by employing the multinomial logit model. According to the survey, roughly 85% of farmers tried to utilise adaptation strategies such crop diversity, planting trees adjusting planting dates, conserving and managing soil and water, using more inputs and uniting crops and livestock. The econometric model identified that most crucial variables influencing farmers' adaptation measures which were schooling, access to climate

information, household size, sex, maturity level, earning, cattle possession, communication frequency with extension staff, land size, access to markets, and agriculture understanding.

Mardero et al., (2015) investigated adaptation practices among smallholder farmers towards drought in the Southern Yucatan Peninsula region of Mexico. It's observed the most vital adaptation practices were used by respondents in response to drought and climate variability such as changes to the agricultural calendar, a mixture of maize varieties and various planting, working hours reduction, kipping water and maize in storage, income diversification, governmental financial support program etc. To fulfilment the above objective of this chapter its reviewed extensive literature from various levels such as reginal, state, national and world-wide. It has shown that many studies used different coping and adaptation strategies against the drought and climate change at their local levels.

Alary et al., (2014) evaluated the role of livestock to deal with livelihood adaptation practices of rural households in respect to a 15-year drought in the Coastal Zone of Western Desert, Egypt. The study results found that livestock had played a major role in productive capital and saving of households in the study zone. It revealed the two main traditional income generation activities of livestock from the Bedouin community, the first was sheep breeding, and the second was goat rearing for milk and meat household consumption. In addition, it found that cattle were kept in the Shiva and eastern areas to breed calves to use of sale and milk production. Furthermore, it highlighted those camels were more important buffer than sheep and goats during prolonged droughts due to their resistance in the southern region.

Singh & Chudasama, (2017) highlighted rural community's experiences of the influence of drought on livelihood assets and adaptation practices using the Fuzzy Cognitive Maps (FCMs) in nine villages of Mahbubnagar district of Telangana, India. The study found that human, natural and financial capital was largely affected by drought. Furthermore, it is observed that agro-crop production, water resources, livestock fodder, lang resources had severely influenced by drought.

Muralikrishnan et al., (2022) investigated farmers' understandings of drought consequences, adaptability, and prevention techniques in drought-prone area's semi-arid pastoral and farming watersheds from four major states of South India. The study found that surface and groundwater availability were reduced due to drought. Furthermore, there has been a significant loss of biodiversity, a decrease in agricultural yield, soil degradation, an increase in agriculture follows and wastelands, and a shortage of cattle fodder. In drought-prone study

areas of four states, about 16–26% of cultivators reported a decrease in agricultural cultivation and output of marketable crops and millets. Meanwhile, it found minor modifications in the cropping of oilseeds, pulses, horticulture, and pasture crops cultivations. In addition, nearly 57–92 % of members reported reducing fruits, vegetables, dairy products, and fish consumption. The study highlighted socio-economic problems which the drought has created, such as tremendous loss in employment, increased malnutrition, and people migrating from the countryside to urban areas. Moreover, it is observed the less involvement of farmers in agriculture information 8-65% and drought adaptation 7–36 %.

Udmale et al., (2014) pointed out that how the drought was perceived by the rural farming society, ecology, and household-level adaptation measures. Additionally, according to the study, the average air temperature increased more in a dry year than a normal year. It is also highlighted that drought harms fish habitant, wild animal life and declined ground water level. The coping practices used by farmers which were minimising water wastage, water harvesting, altering soil dates, adapting new watering system in farm etc. On the basis of these outcomes, the study suggests that the government should help farmers to promote various micro and macro-level administrative strategies to combat drought. Farmers should be changed their traditional irrigation and adopt new irrigation techniques such as sprinkler and drip watering to increase yield production.

Ashraf and Routray, (2013) analysed drought impact on orchard farmer's agro-based practices. The paper mainly focused on understanding drought perceptions by agricultural families and their coping and adaptive practices. The study pointed out that the farmers' perception of climate change and drought variability factors. They mentioned that day by day warmness was increased, and rainfall had declined, rainy season has also changed, and other factors like the inadequate supply of power for irrigation, excessive uses of underground water, and upward population. Moreover, they also reported that farmers significantly lost their orchard output of apples, grapes, and apricot.

Habiba et al., (2012) evaluated farmers' perceptions and awareness about drought and climate change amongst the large, medium, marginal and small farmers in irrigated and non-irrigated areas. The study also identified adaptation mechanism used by farmers in a short period to cope with drought. They pointed out that climate and weather have changed for over 30 years. Those non-climatic issues were accelerated drought severity in the irrigated and non-irrigated areas like to stop over-exploitation of groundwater, increasing population, sediment on the river,

deforestation, lack of dragging river and canal. Furthermore, it has shown the tremendous impact of drought on agriculture, animal husbandry, fisheries, education, health, and daily life.

Opiyo et al., (2015) pointed out various features of drought, long-term mitigation, provisional and coping measures followed by the Turkana herdsman of north-western Kenya. The study shows that the vast majority of the individuals engaged in activities to diversify their sources of income. They were engaged in both climatic and non-climatic activities for the complement of pastoralism. A maximum pastoralist adopts a long-term adaptation strategy. They believe in education, which helps a family member to find better jobs in the modern sector. In addition, many respondents sent their children to school to get quality food through school nutritional programmes. Pastoralists employed some coping strategies in the drought period; meanwhile, they slaughtered old and weak livestock and sell bush products, fuelwood, charcoal, migrated urban areas for searching jobs, and reduces food consumption.

Iqbal et al., (2018) highlighted that the ecological as well as socio-economic impacts of drought on farmers and their coping and mitigation measures at the local level. The results show that farmers' perceptions of drought that they were mentioned day to day temperature has increased, less precipitation received in the study region, economic instability, lack of power supply, destruction of jungle, and excessive uses of groundwater etc. Drought also caused severe economic and social impacts, including lost on-farm jobs, crop yield damaged enormously and decreased maximum number of livestock, respondents travelling villages to city location for temporary jobs, a sense of desperation and loss, water conflicts, impacts on children's schooling, hunger, and food selection restrictions. Moreover, it is highlighted significant environmental impacts of the drought all over pasture erosion, worsening water quality, damage to fish and wildlife surroundings.

Sam et al., (2020) studied households' perceptions about drought and their coping and adaptation practices used by households during the drought. The study reported that agricultural production decreased tremendously, and various health issues arose during the drought period. The most general short-term practice used by the households, which was limitation in rice and cereal foods eating. Furthermore, the study has found significant positive relationship among family size, sex, and schooling of household head and distance to a near town and coping and adaptation strategies. The study suggested that fair-price stores should be developed in villages, and weather-based micro insurance should be implemented to manage the loss of yields.

Dhanya & Ramachandran, (2016) studied adaptation strategies of the rural farmers' households and their understanding regarding climate change and variations in the semi-arid region of south India. The study reveals that farmers' understanding of climate variabilities such as increased temperature, delayed onset of monsoon, prolonged droughts, and reduced moisture levels which were the serious factors threatening their farming. It also found a reduction in the production of rice and cereal due to water scarcity. The study recommended some anticipated adaptation practices that the farmers would adopt where they can be cultivated short-duration heat tolerance crops, construction of small check dam, uses of modern micro-irrigation technology, changing the farm operations and crop calendars, crop whether insurance and early warning system.

Jin et al., (2016) identified farmers' modern adaptation measures against the drought hazard and analysed the factor which had influence their decisions to adapt over the Yongqiao district of the north Anhui province, China. The farmers followed the ongoing adaptation strategies such as growing drought-resistance crop seeds, increasing asset in irrigation equipment, and invest more money in whether index crop insurances. The study reported that maximum farmers were conscious of climate change. The regression analysis results found a significant important association in between farmers' literacy levels and includes more assets in irrigation equipment, invest more money in whether index crop insurances, growing different crops in agriculture.

Alauddin & Rashid, (2014) studied rice-growing farmers' adaptation choices and techniques to climate change in Bangladesh's drought-prone and groundwater-scarce regions in eight districts. Binary logit model and multinomial logit model employed for primary data analysis. The binary logit model used for adaptation decision of respondents to climate change followed by multinomial technique was applied for choices of adaptation practices. The results have shown that in the cultivator's choices to adapt to climate change, the intensity of the drought had the most positive substantial factor reported. The schooling level of household head had reported the minimum positive effects on adaptation decisions. Moreover, it was mentioned that the severity of surface water level depletion prompted farmers to switch to straightforward rice varieties and enhance boro rice irrigation. Changing planting dates practice found a numerically significant but minor beneficial influence by land size. Land size had also reported a positive significant impact on horticultural crops and adopting water-saving non-rice. Change planting dates, horticultural crops and limited water growing rice both adaptation measures had a favourable significant impacted by livestock ownership. The decision to employ limited water

growing rice and gardening crops, as well as types of rice that are directly sown, were statistically adversely impacted by agriculture household's access to previous weather information. Moreover, getting subsidy in the drought had found positive impact on early drought-tolerant rice varieties as well as non-rice and gardening crops.

Bryan et al., (2009) observed the factors influencing farmers' decisions to adapt as well as farmers' perceptions of environmental issues and the adaptation tactics which they have followed in Ethiopia and South Africa. The investigation found that farmers' most prominent adaptation techniques were switching to different crops or crop varieties, planting trees, conserving soil, irrigation and altering planting dates. In addition, both countries farmers adopted other coping strategies which were less frequent such as migration to urban areas, changing cultivation type, using new equipment, trying to find work off-farm and conserving water. Inability to acquire credit in South Africa and a lack of access to land, information, and inaccessibility credit in Ethiopia which were the main obstacles to adaptations highlighted by the farmers. In Ethiopia, wealth, accessibility to credit, and knowledge of the climate those factors were influenced farmers' decisions to adapt. In South Africa, wealth, state agricultural support, access to fertile land, and credit were factors that affected farmers' choices. The study reported that family size, location to production markets (km), obtaining formal credit, availability of extension facilities, broadcasting and land area (ha), these exoplanetary variables' marginal effects were statistically significant with decision making to adapt to climate change.

Al-Amin et al., (2019) investigated ladies and husbands' perceptions in a similar family in response to climate change. Utilizing survey data from 360 farm households in Bangladesh's drought-prone area, it is also investigated the importance of intra-household family decision-making in choosing adaptation measures. According to the study, husbands and spouses had observed very different opinions about climate change. Furthermore, the study's results indicate that there was a negative relationship between family size and adaption choices. The decision of farm households to adapt which was significantly influenced by financings. The severity of the drought was one of the most affected factors which have made adaptation decisions.

Khan et al., (2020) studied farmers' risk factors related to extreme weather, adaptation measures, and multiple dimensions of climate change sensitivity at the farm level from six districts of the KP Province in rural Pakistan. The findings indicated that farmer households' attitudes and understanding of whether extreme events and the phenomenon of climate change

which were directly correlated with drought, deforestation, decreased crop output and high temperatures. Countryside households used different types of adaptation techniques to deal with the changing climate and extreme weather events, including crop variety changes, alterations of crop calendar, modifications in fertilization, mulching, agricultural insurance and crop readjustment. Rural households believed that extreme weather situations and climate change posed a serious threat to the future of the agricultural industry. The Binary logit model analysis results have revealed that perception of decreased rainfall and increased temperature as well as few socio-economics and demographic variables found significant impact on choosing the adaptation practices in the study area.

Karki et al., (2020) examined the three agro-ecological zones of Nepal's smallholder farmers' subsistence-oriented adaptation techniques for coping with climate change. The results have shown that farmers employ various adaptation techniques to mitigate the negative effects of climate change. The techniques that farmers used including shifting crop types and varieties, managing fertiliser, scheduling farm work, implementing technologies, managing soil and water, taking risk mitigation measures, migrating, having access to financial resources, and diversifying their sources of income and agricultural practices.

Tazeze et al., (2012) revealed the factors that influence farmers' decision to use adaptation measures to climate change, such as the repeatedly drought in Babilie district of Eastern Ethiopia. The factors influencing households' decisions regarding adaptation measures to climate change were examined using a multinomial logistic regression model in the study. The regression analysis revealed that factors such as family size, household head's education, ownership of cattle, access to financing, etc. which had found significant effect on the usage of adaptation techniques. The following adaptation techniques were employed by farmers in the study area: adjusting crop planting dates, using soil and water conservation techniques, adapting improved crop varieties (such as early crop varieties and drought-tolerant crops), crop diversification (combined cropping, crop rotations, and trying to divide farmlands into different crops).

Tessema et al., (2013) analysed factors influencing adaptation decisions, barriers to adaptation, and smallholder farmers' perceptions of climate change in Ethiopia's Eastern Hararghe Zone. This study found that about 91.2 % of farmers noted that rise in the warming trend over the last 20 years. Besides that, 90.3 % of farmers noted a decrease in precipitation for the last 20 years. Eight different forms of adaptation strategies were observed in the research area, including

planting trees, sowing seeds early, terracing, watering, water gathering, engaging in non-farm activities, and growing plants that mature quickly. According to Hausman specification tests, several factors impacting choice and adaptation variables' coefficients which were not significantly different from one another. According to the paper, the most significant barrier to adaptation was a lack of knowledge. The absence of agriculture inputs, lack of available land, lack of funding, lack of water, and labour scarcity were the additional obstacles reported.

Deressa et al., (2011) acknowledged main features which had affected farmers 'perceptions and adaptation to climate events during the production year 2004-05 in Ethiopia's Nile Basin. The current study is based on household survey information which has gathered from 1000 farmers who grown mixed crops and cattle farming. The findings of the study revealed that farmers' perceptions of climate change were substantially correlated with factors such as belongings, human capital, information of climate change, household head's age, and the agro-ecological context. Furthermore, it is reported that Education of the family chief, family size, if the male head of the household, livestock possession, extension services on the crop, cattle production, access to credit, and the environmental temperature which factors have found a significant impact on choosing factor adaptation to climate change.

Bakhsh & Kamran, (2019) revealed that factors relating to rural farmers, such as education, farming experience, family size, and farm ownership area, were positively and statistically strongly correlated with bund-making adaptation. Age, farming experience, and livestock herds of the respondents which were all significant determinants in the case of income diversification. Crop diversity was highly correlated with distance from the city, household size, number of adults, tractors, and schooling.

Adimassu & Kessler, (2016) in their study multivariate probit model results, found a significant negative correlation between livestock holding and migration. It means that farmers who had more livestock had less probability of migrating in the period of food shortage. It found that significant positive correlations between Livestock holding and changing crop varieties to rainfall variability. Farmers who had more livestock there had more probability of adapting to change crop varieties in their farms. There were substantial positive connections between livestock keeping and crop diversification to rainfall variability. This result indicates that individuals with more animals had a higher chance of adapting crop diversification practices.

A study by Gupta et al., (2010) observed the adaptation strategies of the poorest farmers to cope climate change in drought-prone Gujarat and also evaluated the government programmes' influence on farmer behaviour. Farmers adopted some ex-post and ex-ante strategies at the micro-level. The ex-post strategies were adopted, such as crop diversification, changing crops and their locations, and changes coping intensity and the ex-ante strategies, at market level they adopted, including crop insurance, price strategies, and opening up to trade and investment. Ex-ante policies at the administrative level followed by farmers including promoting diversification of income-generating opportunities, an extension of services, diversification of income earning and employment opportunities, etc. Further, the study indicated that farmers were changing their traditional rain-fed farming practices and preferred modern farming. They have been used tractors to cultivate and sow the farm and reduced the uses of bullocks. Farmers have also given preference to those crops which gave higher economic returns in a drought period. They moved farming to non-farm activities along with that many farmers were involved in income-generating activities. This paper recommended that small-scale credit schemes should be offered to farmers even if they have a poor credit rating with respect to support them establish a good credit rating in the long term. Or, it is also suggested that poor farmers' top priority should be to figure out that how to obtain their bullocks return after the drought.

3.8 Conclusion

The above literature review has been classified into six broad categories to easily identify research gaps, support the study's objectives and methodologies, and to make conclusions, limitations, and policy measures. In the first part of this chapter tries to cover some studies which are focused on temporal rainfall trends and its variability in the various region of the globe. These literature reviews have observed that some studies have reported increasing and decreasing rainfall trends which of that some have found statistically significant and some of that have insignificant. Most of the studies have used parametric and non-parametric technique to detect the rainfall trends in the time series data over the long period. Furthermore, second, third, and fourth and fifth part which have stated the impact of drought on agriculture and rural life, drought impact on economy and the drought and vulnerability, drought and economy, drought and food security, poverty and children's Education. The above categories of the literature had reported adverse impact of drought on crop production, domestic drinking water, livestock assets, children's schooling, migration and rural economy also. Furthermore, it is highlighted that drought affected their daily life, mental health, reduction in income and consumption. Few studies reported that due to drought famine and starvations situation had

faced in many reasons due to that poverty increased. Some study mentioned that it has disturbed ecosystem, due to that many ecological and biological problems has been organised in many areas to reduce drought severity. The last part of the literature review which has been focused on Drought and perceptions, coping, adaptation and mitigation strategies. The various types of coping and adaptation strategies reported across the world which of those the most common adaptation strategies used by farmers such as crop diversification, diversification of income sources and agriculture practices, access to financial resources, changing crop varieties, changing crop calendar, changing fertilizer and planting trees, migration to urban areas, seeking off-employment, applying new technologies, income diversification, governmental financial support programmes and crop insurance etc.

Chapter 4

Temporal rainfall Trend analysis and variability of three drought-prone (Beed, Osmanabad, and Latur) districts and the history of rainfall (drought) of Marathwada region of Maharashtra

4.1 Introduction

Climate change harms the rural community's livelihood in the developing world because it mainly depends on agriculture-related activities, and agriculture is heavily reliant on rainfall (Aribi & Sghaier, 2021). The farming sector is most vulnerable to climate change and climate variability, which affects both precipitation and temperature. Rainfall and temperature are the most crucial physical factor of the environment which are associated to climate change. It regulates the weather situation in particular areas that affect agriculture production (Shree & Kumar, 2018). In the last century, both increasing and decreasing rainfall patterns have been recorded in different regions and seasons in Asia. Frequent heavy rainfall events have increased in South Asia; simultaneously, light rainfall events are declining. Seasonal rainfall is decreased overall in India due to the declining number of rainy days in the monsoon seasons (IPCC, 2014). The Indian economy is based on agriculture. Almost 75% of the working population, directly and indirectly depended on the farm sector. Rainfall is a crucial natural factor in the growth of Indian agriculture that significantly affects crop production across the country. Both Kharif and Rabi are the highest crop growing seasons in the country that largely depend on rainwater (Prasanna, 2014). The south-west monsoon rainfall (June to September) received about 75% of annual rainfall over India. It plays an crucial role in developing the state's economy, providing drinking water, hydro-power, food protection, and fodder for livestock (Guhathakurta et al., 2015; Shree & Kumar, 2018). Indian Metrological Department (IMD) has classified annual seasons into four parts, viz. Winter (January to February), Pre-monsoon (March, April, May), South-west monsoon (June, July, August, September), and Post-Monsoon (October, November, and December) (Attri & Tyagi, 2010). IMD has 36 metrological subdivisions across the county. These subdivisions come under India's five central homogenous regions: Northwest, Central Northwest, Northeast, West-central, and Peninsular (Subash & Sikka, 2014). Maharashtra state is subdivided into four major metrological subdivisions such as Konkan, Madhya Maharashtra, Marathwada, and Vidarbha (Guhathakurta et al., 2020). The majority of crop production area in the Marathwada region has come under rain-fed farming, and crop productivity is determined by monthly rainfall availability and distribution (Mandale et al., 2019). The main research query of the chapter is that, what are the temporal rainfall

trends and variability of the three districts of Maharashtra from 1901 to 2018. This chapter's main objective is to analyse rainfall trends and variability in the annual seasonal and monthly time series data over the 37 stations of Beed, Osmanabad, and Latur districts of Maharashtra for the period of 1901 to 2018. This chapter has been divided into two main sections, the first section includes brief overview of the studies, data and methodology, and analysis of rainfall trends and variability using parametric, non-parametric tests, and calculates RAI to identify frequency and intensity of dry and rainy years over three districts. The section two highlights the history of Marathwada drought (rainfall) using long-term time series data.

Section I

4.2 Brief overview of the studies

In first part of the 3rd chapter, we have reviewed some literature on rainfall trends and its variability across the world. These studies have observed increasing and decreasing rainfall trends in India and worldwide. Overall, India has received more than 75 % rainfall from southwest monsoon in June, July, August and September month's which has also called kharif season. The country's agriculture mostly depends on southwest monsoon rainfall which is plays crucial role in the development of agriculture in the rural area and other sector also. A good amount of foodgrain production has mostly depended on timely and spatially well distribution of rainfall, whereas the erratic nature of the rainfall has observed negative effects. Some Indian studies have reported statistically insignificant trends in annual rainfall data series (Goyal, 2014; Shree & Kumar, 2018), whereas some of which have found positive and negative statistically significant trends in monthly and seasonal data (Chandniha et al., 2017; Chatterjee et al., 2016;). Most of the studies have used parametric and non-parametric technique to detect the rainfall trends in the time series data over the long period. Many studies used slope-based and rank-based methods to detect the trends in climatic variables. Rank-based techniques are Kendell, and Spearman's rank correlation which applies to identify the trends from climatic variables over the time series data.

4.3 Data and methodology

The monthly rainfall time-series data is obtained from the website of the Indian Water Portal (<https://www.indiawaterportal.org/metdata>) during the period from 1901 to 2002. This monthly time series is used in several studies to analyse the rainfall trend (Shree & Kumar, 2018; Duhan & Pandey, 2013; Chandniha et al., 2017). The remaining time series data have been collected from the Department of Agriculture Government of Maharashtra (maharain.gov.in) from 2003

to 2018 over 37 rainfall stations of Beed, Osmanabad, and Latur districts in the Marathwada region of Maharashtra state, India. The study used both parametric and non-parametric tests to examine the trends and seasonal variation in the time series data. Now a days, The Mann-Kendall (MK) test is broadly applied to determine the monotonic trend in the rainfall and temperature time series and hydro-metrological data. The test result is not affected by outliers (Rahman et al., 2017; Patra et al., 2012; Duhan & Pandey, 2013; Subash & Sikka, 2014; Ingle et al., 2018; Yang et al., 2020; Bryan et al., 2009; Asfaw et al., 2018). Furthermore, the magnitude of change in the data series is determined using the Sen's slope estimator (Sen, 1968). Overall, the statistical analysis of the three district rainfall data has been prepared using an excel sheet and XLSTAT software. The south-west monsoon and annual rainfall deviation were derived to identify drought years over the Marathwada region and India using the monthly time series data sets. The Indian Institute of Tropical Metrology data sets were used to calculate deviation over the Marathwada region from 1971 to 2016 for 146 years. Furthermore, the rainfall deviation has been calculated using the Open Government Data (OGD) platform data sets of India to identify drought years over India from 1901 to 2016.

4.3.1 Mann-Kendall test for rainfall trend analysis

Mann-Kendall trend test (Mann, 1945; Kendall, 1975) is a non-parametric (distribution-free) test that is commonly used to detect trends in climatic variables over a long-term data series. It observes a decreasing and increasing trend in monthly/seasonal/annual time series. This hypothesis-based test interprets that if the computed p-value (alpha) is lower than at 5 % significance level. That means one can reject the null hypothesis, H_0 , when it shows a significant trend in the data series. On the other hand, the computed p-value is greater than a 5 % significance level. That means one can accept, H_0 , when it indicates an insignificant trend in the data series. (Sa'adi et al., 2019; Mallick et al., 2021; Alemu & Dioha, 2020).

The MK test statistics (S) were calculated applying the following equations.

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^n \text{sign}(-X_k), \quad (1)$$

Where, The number of observations is expressed by the letter n., while X_j and X_k are represented by the rank of ith ($i = 1, 2, 3, \dots, n-1$) and jth ($j = 123 \dots n$) sample size (Mallick et al., 2021; Praveen et al., 2020).

$$Sign (X_j - X_k) = \begin{cases} +1, & \text{if } x_j - x_k > 1 \\ 0, & \text{if } x_j - x_k = 0 \\ -1, & \text{if } x_j - x_k < 1 \end{cases} \quad (2)$$

While the S statistics is assumed that normally distributed. When, $n > 18$ with Zero mean and variance $var (S)$ is defined as (Ackom et al., 2020).

$$Var (S) = \frac{n(n-1)(2n+5)}{18} \quad (3)$$

When the number of data points in the data series has tied values, we can use the following equation to calculate Z scores (Byakatonda et al., 2018; Caloiero, 2015).

$$Var (S) = \frac{1}{18} \left[n(n-1)(2n+5) - \sum_{k=1}^n tk (tk-1)(2k+5) \right] \quad (4)$$

The positive z-score indicates an upward trend, and the negative z-score indicates a downward trend (Dinpashoh et al., 2014; Keshavarz et al., 2017).

$$Z_{mk} = \begin{cases} \frac{s-1}{\sqrt{var(s)}} \dots & \text{if } s > 0 \\ 0 \dots & \text{if } s = 0 \\ \frac{s+1}{\sqrt{var(s)}} \dots & \text{if } s < 0 \end{cases} \quad (5)$$

4.3.2 The magnitude of the trend

Sen's method is widely used to determine the magnitude of the trend in the climatic and hydro-metrological variables (Shree & Kumar, 2018). Sen's slope estimator requires a minimum 10 data points to detect the trend line's magnitude in the time series data (Alemu & Dioha, 2020). This method gives more reliable slope estimators than the least-square method. Outliers, missing values, and gross data errors have no effect on the slope estimator (Sayemuzzaman et al., 2015; Kiros et al., 2016). The Sen's slope estimator (β) is calculated by using the following formula.

$$Qi = \frac{x_j - x_k}{j - k}, i = 1, 2, \dots, N, j > k \quad (6)$$

Where,

Qi = Slope between data point x_j and x_k

x_j = data measurement of time j

x_k = data measurement of time k

Sen's slope estimator has shown the medium of the slope.

$$Q = \begin{cases} Q \frac{N+1}{2} & \text{if, } N \text{ is odd} \\ \frac{1}{2} \left(Q \frac{N}{2} + Q \frac{N+1}{2} \right) & \text{if, } N \text{ is even} \end{cases} \quad (7)$$

Where,

$$N = \frac{n(n-1)}{2} \quad (8)$$

When, the N slope observations are found as Odd, the Sen's estimator is calculated as $Q_{med} = (N+1)/2$, and while the N Slope observations are found as Even, the Slope estimate is calculated as $Q_{med} = [(N/2) + ((N+1)/2)]/2$. The non-parametric two-tailed test is performed at 100 $(1-\alpha)$ % of the confidence interval to obtain the true slope. When the measured slope estimator (β) value is positive, it has shown an increasing trend. The slope estimator (β) value is negative; then, it has shown a decreasing trend.

4.3.3 Rainfall variability test: Coefficient of Variations (CV)

In this study, CV is employed to calculate rainfall variability. CV is one of the most important statistical techniques to evaluate each data point's variability in its mean values. CV is calculated to examine the seasonal and annual variability in the long-term rainfall data. The maximum value of CV indicates higher variability, and the minimum value of CV indicates lower variability (Shree & Kumar, 2018; Asfaw et al., 2018; Bari et al., 2017; Miheretu, 2020), which is computed as:

$$CV = \frac{\sigma}{\mu} * (100) \quad (9)$$

Where,

σ = Standard deviation,

μ = Mean

4.3.4 Rainfall Anomaly Index (RAI)

Rainfall Anomaly Index (RAI) of the annual rainfall of Beed, Osmanabad, and Latur district for 118 years (1901 to 2018). In this chapter, the Rainfall Anomaly Index (drought index) is calculated to analyse the frequency and intensity of dry and rainy years. It is developed by Rooy (1965) and accepted by Freitas (2005), which poses the following equations (Costa & Rodrigues, 2017).

$$RAI = 3 \left[\frac{N - \bar{N}}{\bar{M} - \bar{N}} \right], \text{ for positive anomalies..... (1)}$$

$$RAI = - 3 \left[\frac{N - \bar{N}}{\bar{X} - \bar{N}} \right], \text{ for negative anomalies..... (2)}$$

Where,

N = Recent monthly/Seasonal/yearly rainfall (mm)

$\bar{N}$ = Monthly/yearly/seasonal mean rainfall of the chronological series (mm),

$\bar{M}$ = Mean of the ten highest monthly/yearly/Seasonal precipitations of the historical series (mm),

$\bar{X}$ = Mean of the ten lowest monthly/ Seasonal/yearly precipitations of the historical series (mm), and positive anomalies have their values above average, and negative anomalies have their values below average.

4.3.5 Rainfall deviation

The rainfall deviation (RF dev) is expressed in percentage which terms is calculated as below:

$$RF \text{ dev} = \{(RF_i - RF_n)/RF_n\} * 100$$

Where,

RF_i = current rainfall for a comparable period (in mm) and

RF_n = normal rainfall (at least 30 years average) for the same period (in mm).

The IMD classification of rainfall deviation is given below (see in table 4.14).

4.3.6 Reasons for using few statistical tools in this chapter (the Rainfall Anomaly Index, deviations and parametric and non-parametric tests)

There are several studies which have used different indices to calculate of dry and rainy years or calculation of metrological, hydrological and agriculture drought but those have some limitation such as data readability and availability (time and space). In this chapter, we used RAI, and deviations to calculate frequency and intensity of dry and rainy years. The calculation of RAI anyone can used monthly, seasonal and annual rainfall data series for long and short period in any area. The rainfall deviation is also important technique to identify drought years which has used in many studies ([Parthasarathy et al., 1988](#), [Sivasami K., 2000](#); [Reddy & Sreenivas, 2016](#)), and that has recommended by Indian Metrological Department for drought determination. The Mann Kendall non-parametric test and Sen's-slop estimator used for detecting rainfall trends in the long-term monotonic data series and it is robust against outliers and missing values and the coefficient of variations used to calculation of rainfall variability.

Table 4. 1: Classification of Rainfall Anomaly Index

Rainfall Anomaly Index Range	Classification
Above 4	Extremely humid
2 to 4	Very humid
0 to 2	Humid
-2 to 0	Dry
-2 to - 4	Very dry
Below - 4	Extremely dry

(Source: Freitas, [2005](#)), adapted by Araújo et al., ([2009](#))

Table 4.1 shows the classifications of rainfall anomaly index and its range, it indicates that if the range of anomaly index is above four, then it identified that the year is extremely humid. When it ranges between 2 to 4, it indicates the particular year is very humid. Followed by it rang between 0 to 20 then it has shown particular year is humid, when its values in between -2 to 0 then it has shown particular year is dry, -2 and -4 indicated very dry, and below -4 indicated extremely dry year. Rainfall Anomaly Index is used in many studies to identify rainfall variably in monthly, seasonal and annual data series ([Costa et al., 2017](#); [Aryal et al., 2022](#), [Waghmare et al., 2020](#)).

4.4 Results and discussion

Rainfall Anomaly Index, The Mann Kendall trend test, Kendall Tau, Sen's slope estimators, mean, standard deviations, co-efficient of variations has calculated to identify rainfall trends and variability in monthly, seasonal and annual data from 1901 to 2018. Furthermore, the graphical presentation has been done to observe rainfall fluctuations.

Table 4. 2: Range of annual RAI of Beed district over the period from 1901 to 2018

Years	RAI range	Classification
1901	1.21	Humid
1902	-0.10	Dry
1903	1.95	Humid
1904	-0.26	Dry
1905	-2.69	Very dry
1906	-0.19	Dry
1907	-1.33	Dry
1908	-1.38	Dry
1909	0.88	Humid
1910	1.59	Humid
1911	-1.34	Dry
1912	-2.67	Very dry
1913	-2.33	Humid
1914	0.25	Humid
1915	1.65	Humid
1916	5.16	Extremely humid
1917	3.35	Very humid
1918	-3.02	Very dry
1919	-0.10	Dry
1920	-3.67	Very dry
1921	-2.23	Very dry
1922	-0.68	Dry
1923	-1.18	Dry
1924	-1.06	Dry
1925	-1.63	Dry
1926	-0.27	Dry
1927	-0.61	Dry
1928	1.24	Humid
1929	-1.29	Dry
1930	-1.07	Dry
1931	1.61	Humid
1932	0.30	Humid
1933	2.44	Very humid
1934	1.61	Humid
1935	2.39	Very humid
1936	-1.68	Dry
1937	-1.19	Dry
1938	3.61	Very humid
1939	-2.56	Very dry
1940	-0.07	Dry

1941	-1.47	Dry
1942	-0.71	Dry
1943	1.84	Humid
1944	-0.67	Dry
1945	-1.78	Dry
1946	0.18	Humid
1947	0.95	Humid
1948	0.31	Humid
1949	2.19	Very humid
1950	-0.25	Dry
1951	-0.14	Dry
1952	-0.97	Dry
1953	2.22	Very humid
1954	2.75	Very humid
1955	2.88	Very humid
1956	1.99	Humid
1957	0.76	Humid
1958	0.08	Humid
1959	2.36	Very humid
1960	0.15	Humid
1961	1.62	Humid
1962	2.05	Humid
1963	0.82	Humid
1964	-0.26	Dry
1965	-1.44	Dry
1966	-0.31	Dry
1967	-0.87	Dry
1968	-0.46	Dry
1969	-0.61	Dry
1970	1.42	Humid
1971	-0.33	Dry
1972	-3.80	Very dry
1973	0.99	Humid
1974	1.48	Humid
1975	1.83	Humid
1976	-1.70	Dry
1977	-0.90	Dry
1978	0.21	Humid
1979	0.56	Humid
1980	-1.26	Dry
1981	1.34	Humid
1982	-0.32	Dry

1983	2.47	Very humid
1984	-1.45	Dry
1985	-0.74	Dry
1986	-0.93	Dry
1987	-0.47	Dry
1988	2.33	Very humid
1989	-0.22	Dry
1990	1.03	Humid
1991	-1.26	Dry
1992	-0.64	Dry
1993	-0.43	Dry
1994	0.94	Humid
1995	0.73	Humid
1996	1.78	Humid
1997	0.56	Humid
1998	1.64	Humid
1999	0.53	Humid
2000	-1.43	Dry
2001	-1.81	Dry
2002	-1.59	Dry
2003	-0.64	Dry
2004	-0.38	Dry
2005	1.35	Humid
2006	0.20	Humid
2007	0.04	Humid
2008	-0.60	Dry
2009	0.54	Humid
2010	2.59	Very humid
2011	0.31	Humid
2012	-2.50	Very dry
2013	0.21	Humid
2014	-2.88	Very dry
2015	-2.52	Very dry
2016	1.18	Humid
2017	-0.04	Dry
2018	-3.68	Very dry

(Source: Author's own calculation from secondary data)

Table 4. 3: Dry and rainy years in Beed district over the period from 1901 to 2018

Classification	Years	Mean	Percentage (%)
Dry	51	0.43	43.2
Extremely humid	1	0.008	0.8

Humid	43	0.36	36.4
Very dry	11	0.093	9.3
Very humid	12	0.10	10.2
Total years	118	-	100

(Source: author's own calculation from secondary data)

Table 4.3 illustrates the Beed district's dry and rainy years from 1901 to 2018. It was discovered that out of 118 years, 51 (43.2 %) were dry years, and 11 (9.3 %) were very dry. On the other hand, 43 (36.4 %) of the years were humid, 12 (10.2 %) were highly humid, and 1916 was the most humid year. According to the RAI Calculation, the Beed district is highly vulnerable to drought, where more than half of the years have been dry. It was also revealed that drought only occurred once every two years.

Table 4.4: Range of annual RAI of Osmanabad district over the period from 1901 to 2018

Years	RAI range	Classification
1901	-0.21	Dry
1902	-0.54	Dry
1903	3.67	Very humid
1904	-1.01	Dry
1905	-2.66	Very dry
1906	0.00	Very humid
1907	-1.02	Dry
1908	-0.94	Dry
1909	0.76	Dry
1910	1.19	Humid
1911	-1.60	Dry
1912	-2.41	Very dry
1913	-2.80	Very dry
1914	-0.05	Dry
1915	0.54	Humid
1916	5.11	Extremely humid
1917	2.57	Very humid
1918	-2.79	Very dry
1919	0.03	Very humid
1920	-3.52	Very dry
1921	-1.82	Dry
1922	-1.79	Dry
1923	-1.43	Dry
1924	-1.51	Dry
1925	-0.97	Dry

1926	-0.54	Dry
1927	-0.25	Dry
1928	1.40	Humid
1929	-1.41	Dry
1930	-1.05	Dry
1931	0.74	Humid
1932	0.36	Humid
1933	1.31	Humid
1934	0.83	Humid
1935	1.51	Humid
1936	-2.17	Very dry
1937	-1.10	Dry
1938	2.84	Very humid
1939	-3.01	Very dry
1940	-0.25	Dry
1941	-1.66	Dry
1942	-2.27	Very dry
1943	1.78	Humid
1944	-1.34	Dry
1945	-1.95	Dry
1946	0.21	Humid
1947	0.58	Humid
1948	0.84	Humid
1949	2.12	Very humid
1950	-0.52	Dry
1951	-0.32	Dry
1952	-1.37	Dry
1953	2.21	Very humid
1954	2.09	Very humid
1955	2.36	Very humid
1956	3.11	Very humid
1957	0.93	Humid
1958	-0.69	Dry
1959	1.27	Humid
1960	-0.20	Dry
1961	1.55	Humid
1962	2.26	Very humid
1963	0.87	Humid
1964	0.87	Humid
1965	-2.27	Very dry
1966	0.55	Humid
1967	-0.22	Dry

1968	-0.68	Dry
1969	-0.51	Dry
1970	1.16	Humid
1971	-1.11	Dry
1972	-4.26	Extremely humid
1973	1.03	Humid
1974	1.43	Very humid
1975	2.25	Very humid
1976	-1.40	Dry
1977	-1.00	Dry
1978	1.32	Humid
1979	0.93	Humid
1980	-2.33	Very dry
1981	2.14	Very humid
1982	0.05	Humid
1983	2.30	Very humid
1984	-1.24	Dry
1985	-1.33	Dry
1986	-1.34	Dry
1987	0.07	Humid
1988	1.94	Humid
1989	0.19	Humid
1990	1.17	Humid
1991	-0.48	Dry
1992	-0.81	Dry
1993	-0.71	Dry
1994	1.24	Humid
1995	1.40	Humid
1996	1.69	Humid
1997	0.62	Humid
1998	1.38	Humid
1999	-0.49	Dry
2000	-0.64	Dry
2001	-0.97	Dry
2002	-2.00	Very dry
2003	-2.65	Very dry
2004	0.27	Humid
2005	1.21	Humid
2006	0.12	Humid
2007	0.83	Humid
2008	0.59	Humid
2009	0.38	Humid

2010	3.55	Humid
2011	-1.80	Dry
2012	-3.38	Very dry
2013	0.29	Humid
2014	-2.19	Very dry
2015	-2.51	Very dry
2016	1.78	Humid
2017	1.91	Humid
2018	-2.20	Very dry

(Source: Author's own calculation from secondary data)

Table 4.5: Dry and rainy years in Osmanabad district over the period from 1901 to 2018

Classification	Years	Mean	Percentage (%)
Dry	43	0.36	36.4
Extremely dry	1	0.008	0.8
Extremely humid	1	0.008	0.8
Humid	43	0.36	36.4
Very dry	16	0.13	13.6
Very humid	14	0.11	11.9
Total years	118	-	100

(Source: Author's own calculation from secondary data)

Table 4.5 illustrate the dry and rainy years of the Osmanabad district from 1901 to 2018. Out of 118 years, it was revealed that 43 (36.4 %) were dry years, and 16 (13.6 %) were very dry, and only 1972 was the extremely dry year. On the other hand, 43 (36.4 %) of the years were humid, 14 (11.9 %) were very humid, and 1916 was the most humid year in the rain history of Osmanabad district. The RAI Estimation reveals that the Osmanabad district is severely vulnerable to drought, with more than half of the years were dry. In the Osmanabad district where drought generally occurred after every two years.

Table 4.6: Range of annual RAI of Latur district over the period from 1901 to 2018

Year	RAI	Classification
1901	-0.3	Dry
1902	-1.5	Dry
1903	4.6	Very humid
1904	-1.2	Dry
1905	-3.0	Very dry
1906	0.7	Humid
1907	-2.6	Very dry
1908	-0.1	Dry

1909	1.5	Humid
1910	2.1	Very humid
1911	-1.6	Dry
1912	-2.5	Very dry
1913	-3.3	Very dry
1914	1.3	Humid
1915	0.6	Humid
1916	6.4	Extremely humid
1917	4.7	Extremely humid
1918	-3.2	Very dry
1919	-0.6	Dry
1920	-3.5	Very dry
1921	-2.6	Very dry
1922	-2.2	Very dry
1923	-2.0	Dry
1924	-2.4	Very dry
1925	-1.6	Dry
1926	0.0	Humid
1927	-0.9	Dry
1928	2.0	Very humid
1929	-2.2	Very dry
1930	-0.8	Dry
1931	1.7	Dry
1932	-0.3	Dry
1933	2.2	Very humid
1934	1.6	Humid
1935	1.8	Humid
1936	-2.8	Very dry
1937	-1.4	Dry
1938	2.4	Humid
1939	-3.4	Very dry
1940	-1.0	Dry
1941	-2.3	Very dry
1942	-1.8	Dry
1943	2.7	Very humid
1944	-1.5	Dry
1945	-1.4	Dry
1946	-1.1	Dry
1947	1.0	Humid
1948	-0.5	Dry
1949	3.3	Very humid
1950	-1.3	Dry

1951	-1.2	Dry
1952	-1.1	Dry
1953	2.8	Very humid
1954	4.5	Extremely humid
1955	4.1	Extremely humid
1956	2.7	Very humid
1957	0.1	Humid
1958	0.8	Humid
1959	2.1	Very humid
1960	-0.5	Dry
1961	2.7	Very humid
1962	3.7	Very humid
1963	2.6	Very humid
1964	0.5	Humid
1965	-2.9	Very dry
1966	-0.2	Dry
1967	-0.9	Dry
1968	-0.8	Dry
1969	-1.7	Dry
1970	1.5	Humid
1971	-1.7	Dry
1972	-5.1	Extremely dry
1973	1.4	Humid
1974	1.8	Humid
1975	2.6	Very humid
1976	-2.4	Very dry
1977	-2.0	Very dry
1978	1.7	Humid
1979	1.1	Humid
1980	-2.6	Very dry
1981	1.7	Humid
1982	1.5	Humid
1983	4.6	Extremely humid
1984	-3.4	Very dry
1985	-2.2	Very dry
1986	-1.4	Dry
1987	-0.6	Dry
1988	2.5	Very humid
1989	0.3	Humid
1990	1.3	Humid
1991	-1.1	Dry
1992	-1.0	Dry

1993	-0.9	Dry
1994	1.0	Humid
1995	2.2	Very humid
1996	2.5	Very humid
1997	0.0	Humid
1998	2.1	Very humid
1999	-0.6	Dry
2000	-0.5	Dry
2001	-1.5	Dry
2002	-2.2	Very dry
2003	-0.1	Dry
2004	0.8	Humid
2005	3.2	Very humid
2006	0.9	Humid
2007	0.5	Humid
2008	-1.0	Dry
2009	-3.0	Very dry
2010	3.3	Very humid
2011	-1.1	Dry
2012	-0.5	Dry
2013	2.2	Very humid
2014	-3.8	Very dry
2015	-3.9	Very dry
2016	4.4	Extremely humid
2017	-0.2	Dry
2018	-3.2	Very dry

(Source: Author's own calculation from secondary data)

Table 4.7: Dry and rainy years in the Latur district over the period from 1901 to 2018

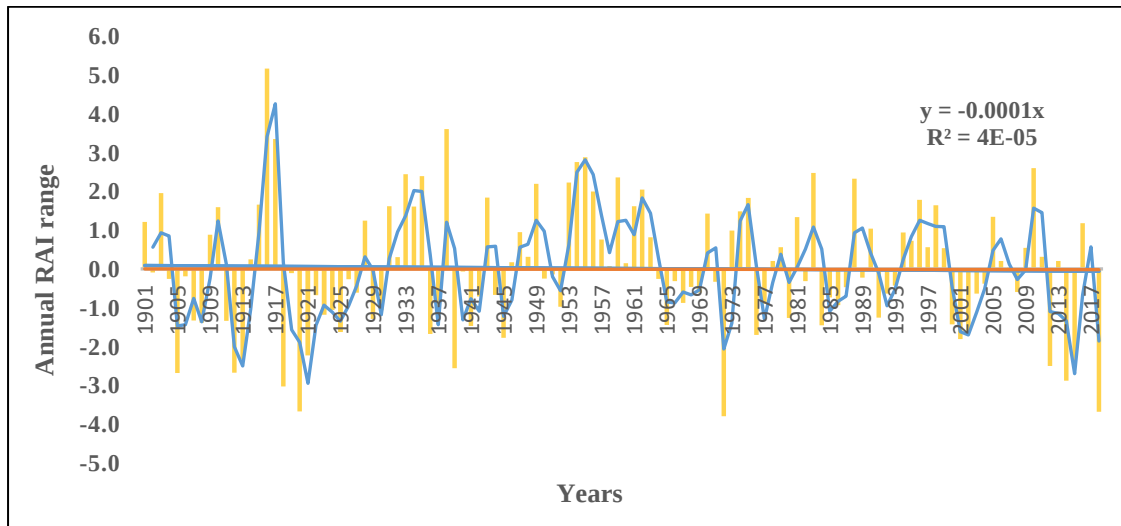
Classification	Years	Mean	Percentage (%)
Dry	41	0.34	34.7
Extremely dry	1	0.008	0.8
Extremely humid	7	0.05	5.9
Humid	26	0.22	22
Very dry	24	0.20	20.3
Very humid	19	0.16	16.1
Total years	118	-	100

(Source: Author's own calculation from secondary data)

Table 4.7 explains the Latur district's dry and rainy years from 1901 to 2018. Out of 118 years, 41 (34.7 %) were dry years, and 24 (20.3 %) were very dry, and only 1972 was the extremely dry year. On the other hand, 26 (22.0 %) of the years were humid, 19 (16.1 %) were very

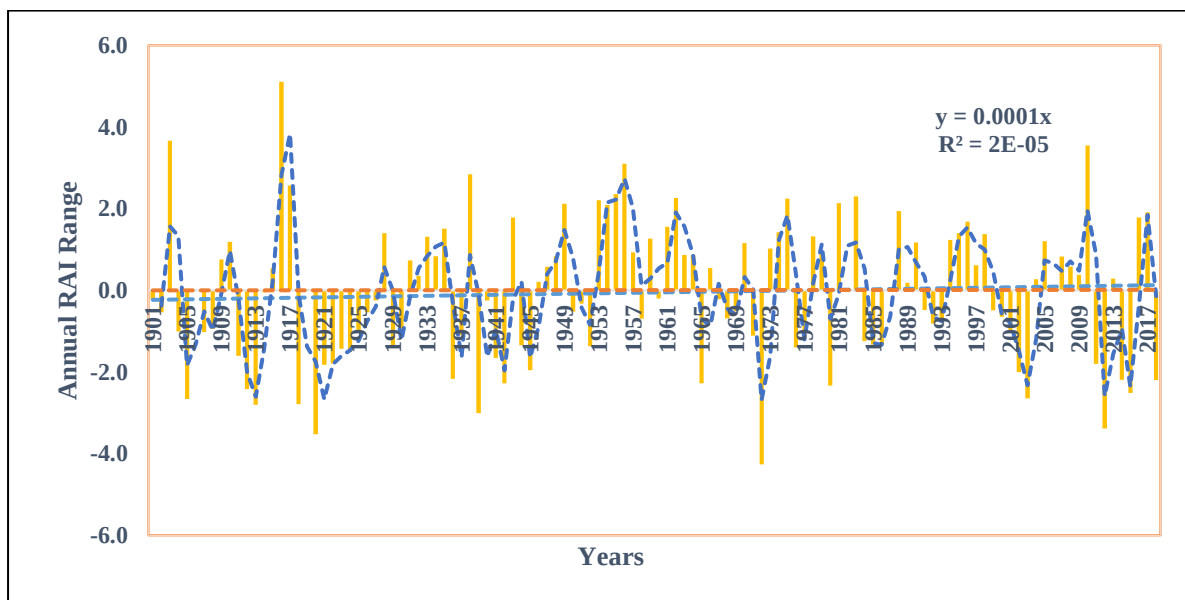
humid, and 7 (5.9 %) was the extremely humid years in the rain history of the Latur district. As per the RAI calculation, the Latur district is severely affected by drought, where more than half of the years were dry. Droughts occurred every two years on average in the area from 1901 to 2018.

Figure 4.1: Ranges of annual RAI of Beed district over the period from 1901 to 2018



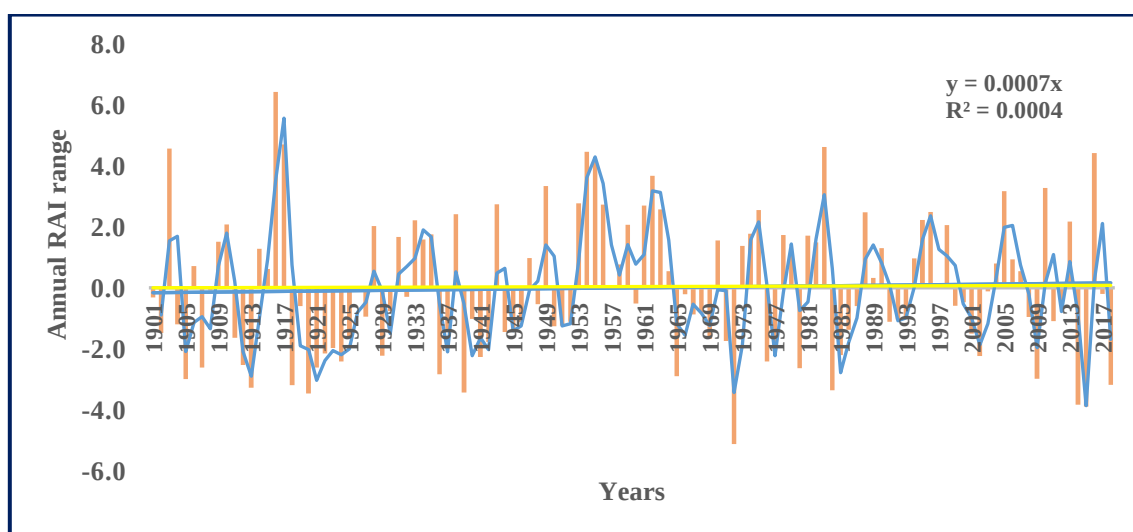
(Source: Author's own calculation from secondary data)

Figure 4.2: Ranges of annual RAI of Osmanabad district over the period from 1901 to 2018



(Source: Author's own calculation from secondary data)

Figure 4.3: Ranges of annual RAI of Latur district over the period from 1901 to 2018



(Source: Authors' own calculation from secondary data)

Table 4.8: Statistical summary of monthly, seasonal and annual rainfall of Beed district during from 1901 to 2018

Months	Total Observations	Mean	Std. deviation	C.V.	Contribution to rainfall (%)
Jan	118	2.82	5.63	199.99	0.40
Feb	118	3.32	6.46	194.18	0.47
Mar	118	6.62	9.21	139.13	0.93
Apr	118	11.33	12.87	113.61	1.60
May	118	21.72	24.91	114.71	3.06
Jun	118	114.06	46.54	40.80	16.07
Jul	118	145.12	67.44	46.47	20.44
Aug	118	123.94	64.68	52.19	17.46
Sep	118	186.27	97.92	52.57	26.24
Oct	118	65.64	52.72	80.32	9.25
Nov	118	23.96	30.63	127.86	3.37
Dec	118	5.11	9.52	186.30	0.72
Seasonal/annual	Total observations	Mean	Std. deviation	C.V.	Contribution to rainfall (%)
Winter	118	6.14	9.03	147.13	0.86
Pre-monsoon	118	39.67	28.51	71.87	5.59
South-west monsoon	118	569.39	142.51	25.03	80.21
Post-monsoon	118	94.71	58.96	62.25	13.34
Annual	118	709.91	163.20	22.99	100.00

(Source: Author's own calculation from secondary data)

Table 4.8 shows the statistical summary of descriptive statistics of the monthly, seasonal and annual rainfall data over the 14 stations in the Beed district. Statistics include such as mean, standard deviation, and total observations (data points). On the other hand, the table illustrates the coefficient of variations and annual rainfall contribution from all variables. The analysis found the highest mean value in the annual rainfall (709.91) and the lowest in January (2.82). The season-wise rain largest mean value was calculated from the south-west monsoon and vice versa for the winter season. In the annual rainfall series, the maximum rainfall value of 1212.43 (mm) was recorded in 2016, and the minimum rainfall value of 333.32 (mm) was observed in 1972. The lowest rainfall value, 0.07 (mm), was registered in the winter season in January month in 2005.

4.4.1 Rainfall variability pattern of Beed district

The coefficient of variations shows the variability in the data series. The statistical analysis shows that out of the 12 months, only four months, such as June, July, August, and September, observed low variability in the monthly rainfall data series. The Winter season found the highest rainfall variability in the four seasons, which is 147.13 %. The south-west monsoon and annual rainfall showed the lowest variability in the data series, which is (25.03 %) and (22.99 %). The south-west monsoon rainfall contributed 80.21 % of annual rainfall, which is crucial for agriculture, drinking water, hydro-power production, reservoir, food production and livelihood ([Mishra, 2020](#); [Thomas & Prasannakumar, 2016](#); [Prasanna, 2014](#); [Saha et al., 1979](#)). The above studies agreed that the south-west monsoon is very vital in the development of the entire county. After that, post-monsoon received 13.34 %, pre-monsoon received 5.59 %, and the winter season obtained 0.86 %. This kind of similar result was observed in the study of ([Chandniha et al., 2017](#); [Shree & Kumar, 2018](#); [Patra et al., 2012](#); [Hussain & Lee, 2016](#); [Rana et al., 2012](#)), who found the high inter-annual variation in the rainfall pattern using a statistical technique of the coefficient of variations. A study by ([Shree & Kumar, 2018](#)) employed C.V. on the time series data to investigate the season-wise rainfall variability over a period of 113 years. They found high inter-annual variation in the post-monsoon, winter and pre-monsoon seasons which has observed high variations, while monsoon and annual rainfall has observed the lowest variations.

Table 4.9: Statistical summary of monthly, seasonal and annual rainfall of Omarabad district during from 1901 to 2018

Months	Total observations	Mean	Std. deviation	C.V.	Contribution to rainfall (%)
Jan	118	3.06	6.54	214.02	0.44
Feb	118	3.12	6.08	194.57	0.45
Mar	118	5.54	7.82	141.15	0.79
Apr	118	14.91	14.57	97.72	2.13
May	118	27.88	29.02	104.07	3.99
Jun	118	108.37	46.62	43.02	15.51
Jul	118	136.97	64.53	47.11	19.60
Aug	118	113.68	59.21	52.09	16.27
Sep	118	178.29	90.09	50.53	25.51
Oct	118	78.30	60.91	77.79	11.20
Nov	118	24.09	28.84	119.73	3.45
Dec	118	4.60	7.82	170.01	0.66
Seasonal/ annual	Total observations	Mean	Std. deviation	C.V.	Contribution to rainfall (%)
Winter	118	6.18	8.86	143.35	0.88
Pre-monsoon	118	48.33	32.24	66.69	6.92
South-west monsoon	118	537.32	136.01	25.31	76.89
Post-monsoon	118	106.99	66.05	61.73	15.31
Annual	118	698.83	156.93	22.46	100

(Source: Author's own calculation from secondary data)

The above table 4.9 shows descriptive statistics of monthly, seasonal and annual rainfall data series over ten stations of Osmanabad district from 1901 to 2018. The analysis found the highest mean value in the annual rainfall (698.83) and the lowest in January in the Latur district (3.06). The most significant mean value for season-wise rain was estimated from the south-west monsoon and vice versa for the winter season. In the annual rainfall series, the maximum rainfall of 1183.85 (mm) was recorded in 2016, and the minimum rainfall of 322.93 (mm) was observed in 1972. The lowest rainfall value, 0.02 (mm), was registered in the winter season of January month in 1944. The studies by (Singh et al., 2021; Alemu & Dioha, 2020) used descriptive statistics in their analysis, such as Mean, Standard deviation, variation, the maximum and minimum value of rainfall, to describe the variations and characteristics of the data series.

4.4.2 Rainfall variability pattern of Osmanabad district

The coefficient of variations calculates to evaluate rainfall variability for all motherly, seasonal and annual datasets. In comparison to June, July, August, and September, the months of

January, February, March, April, May and October, November, and December had higher rainfall variability, which has been revealed (see table 4.9). In the seasonal wise variability, the winter season had higher variability in the rainfall data series from 1991 to 2018, that is (143.35 %), and southwest monsoon seasons had lower variability, that is (25.31 %). The annual rainfall data series found lower variability among all variables, that is, (22.46 %). Out of the total annual rainfall, south -west monsoon rainfall contributed around (76.89 %). After that, post-monsoon rain contributed around (15.13 %). Pre-monsoon contributed around (6.92 %), and the winter season received only (0.88 %), which is very low compared to other seasons.

Table 4.10: Statistical summaries of monthly, seasonal and annual rainfall of Latur district during from 1901 to 2018

Months	Total observations	Mean	Std. deviation	C.V.	Contribution to rainfall (%)
Jan	118	3.65	7.41	203.02	0.46
Feb	118	4.62	9.35	202.47	0.58
Mar	118	8.75	11.23	128.37	1.10
Apr	118	14.63	14.71	100.55	1.84
May	118	24.76	28.76	116.14	3.11
Jun	118	124.55	54.92	44.09	15.64
Jul	118	155.70	74.48	47.83	19.56
Aug	118	149.08	76.68	51.43	18.73
Sep	118	210.06	106.14	50.53	26.39
Oct	118	75.04	62.74	83.62	9.43
Nov	118	21.60	28.70	132.88	2.71
Dec	118	3.66	6.42	175.22	0.46
Seasonal/annual	Total observations	Mean	Std. deviation	C.V.	Contribution to rainfall (%)
Winter	118	8.27	11.60	140.29	1.04
Pre-monsoon	118	48.14	33.38	69.34	6.05
South-west monsoon	118	639.39	154.46	24.16	80.32
Post-monsoon	118	100.30	68.89	68.68	12.60
Annual	118	796.10	178.77	22.46	100.00

(Source: Author's own calculation from secondary data)

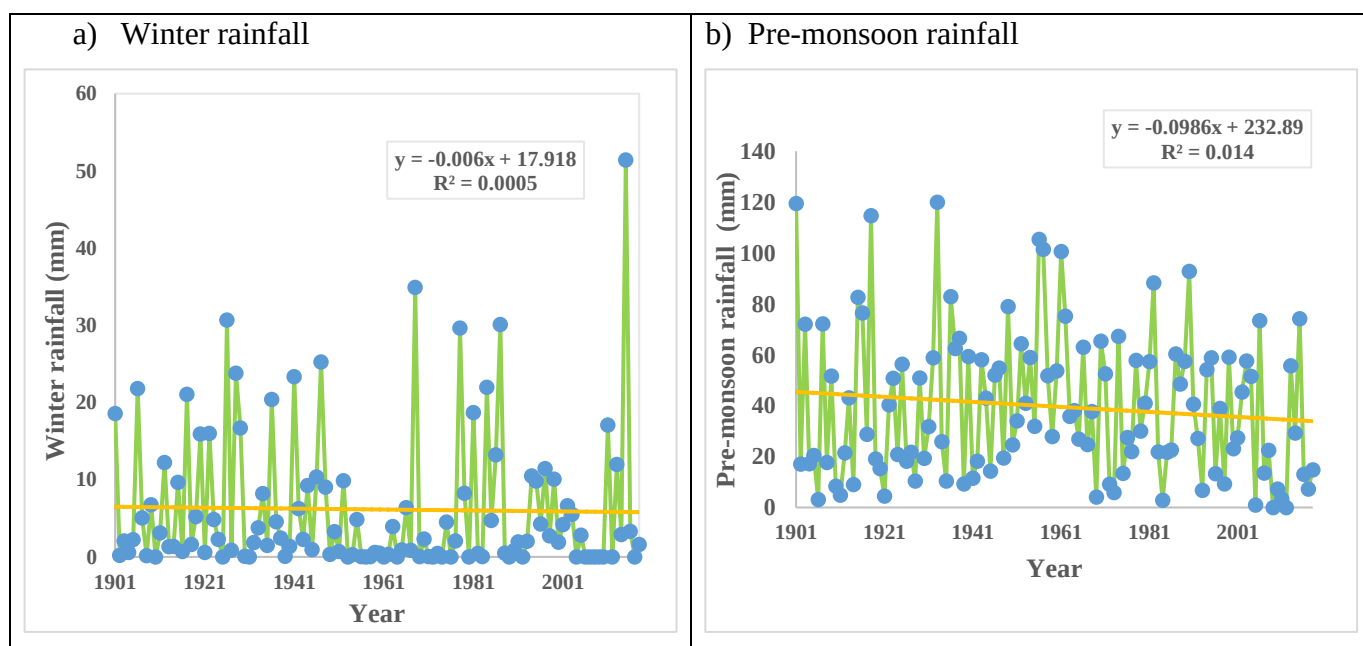
Table 4.10 shows descriptive statistics of monthly, seasonal, and annual rainfall data series over ten stations of Latur district from 1901 to 2018. The analysis found the highest mean value in the annual rainfall (178.77) and the lowest in January (3.65). The most significant mean value for season-wise rainfall was estimated from the south-west monsoon and vice versa for the winter season. In the annual rainfall series, the maximum rainfall of 1299.72 mm was

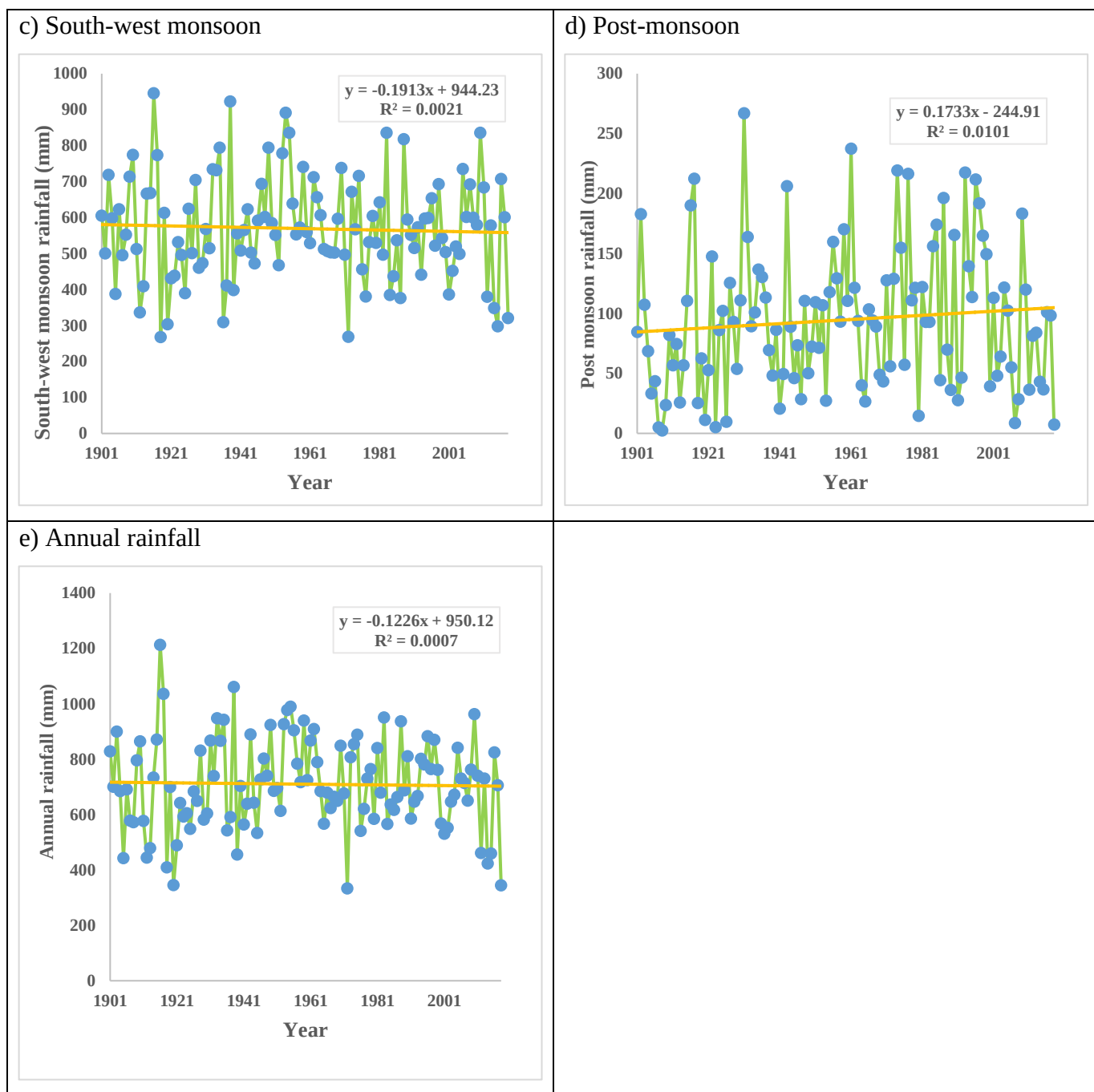
recorded in 2016, and the minimum rain of 349.56 mm was recorded in 1972. The lowest rainfall value, 0.009 mm, was registered in the winter season of December month in 1991.

4.4.3 Rainfall variability pattern of Latur district

The coefficient of variations calculates to evaluate rainfall variability for all motherly, seasonal and annual datasets. In comparison to June, July, August, and September, the months of January, February, March, April, May and October, November, and December had higher rainfall variability, which has been revealed (see table 9). In the seasonal wise variability, the winter season had higher variability in the rainfall data series from 1991 to 2018, which is 154.46 %, and south-west monsoon seasons had lower variability, 24.16 %. The annual rainfall data series found lower variability among all variables, that is, 22.46 %. Out of the total annual rainfall, south-west-monsoon rainfall obtained around 80.32 %. After that, post-monsoon rain obtained around 12.60 %. Pre-monsoon contributed around 6.05 %, and the winter season received (only 1.04 %), which is very low compared to other seasons.

Figure 4.4: Temporal variations and trends in seasonal and annual rainfall of Beed District for the period 1901 to 2018

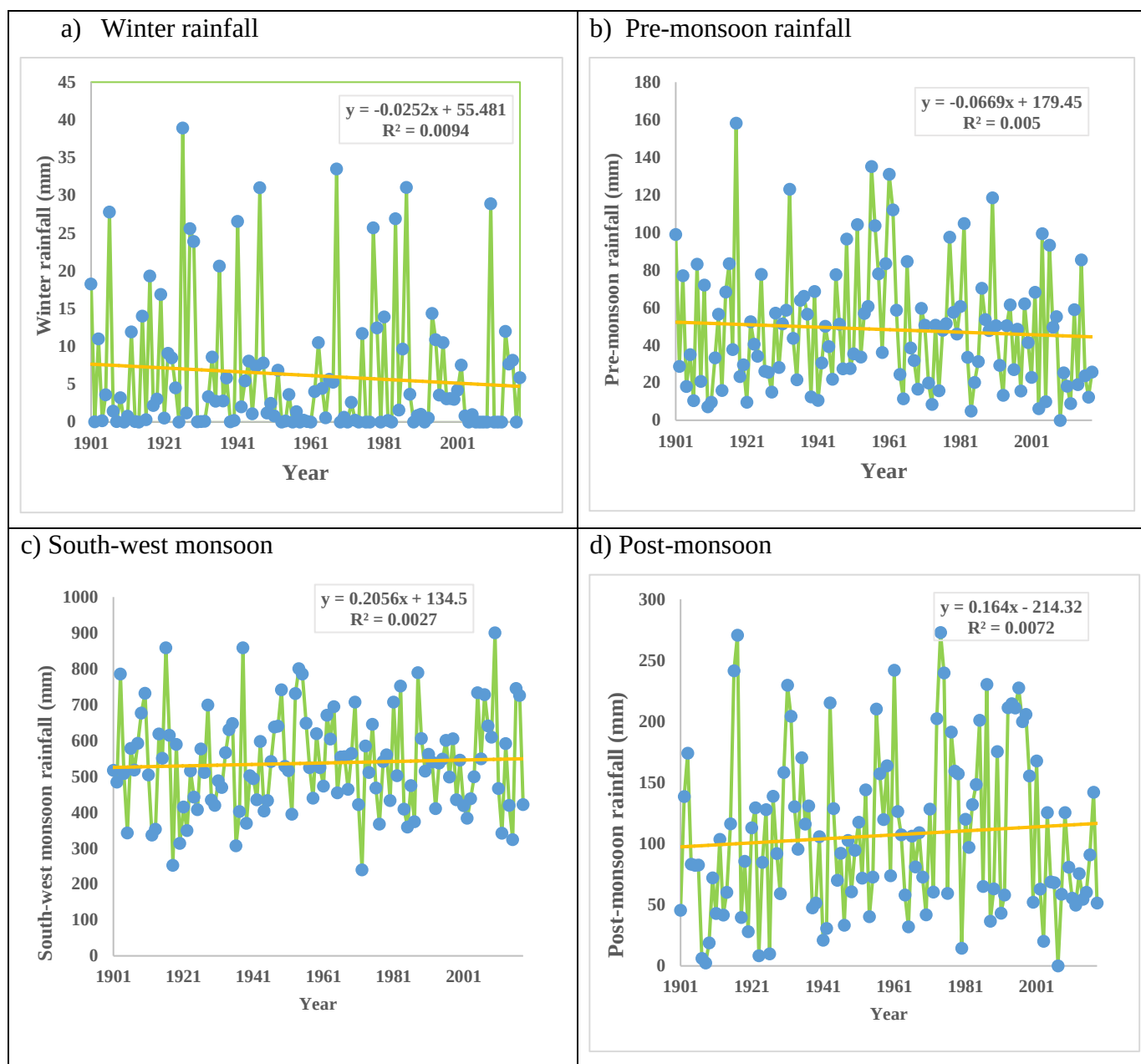




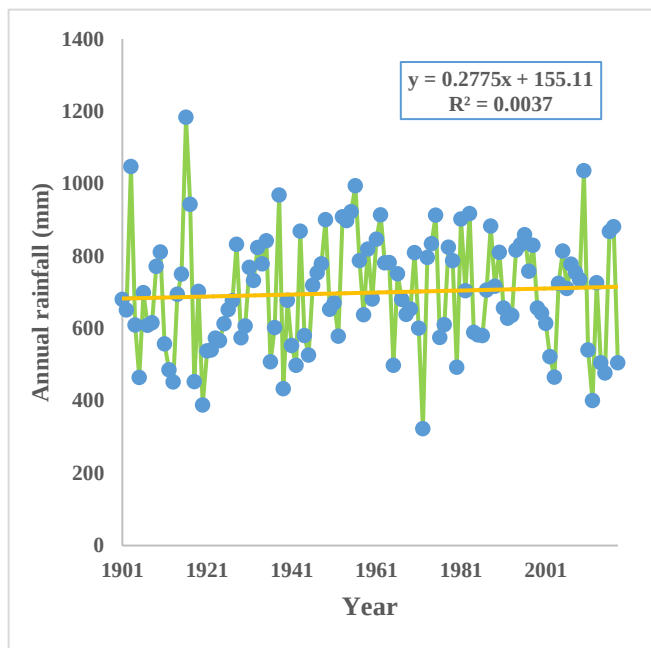
(Author's own calculations from secondary data)

Above figure 4.4 shows temporal variations and trends in the seasonal and annual rainfall time series data of Beed District from 1901 to 2018. It has shown negative trends in all the seasons and annual series except of post-monsoon rainfall. The coefficient indicators were negative for all seasons, such as winter (-0.06), pre-monsoon (-0.986), and southwest monsoon (-0.1913) annual rainfall (-0.1226), only post-monsoon shows a positive sign of coefficient, which is (0.1733). The annual rainfall trend line is slightly observed, similar to X-a

Figure 4.5: Temporal variations and trends in seasonal and annual rainfall of Osmanabad District for the period 1901 to 2018



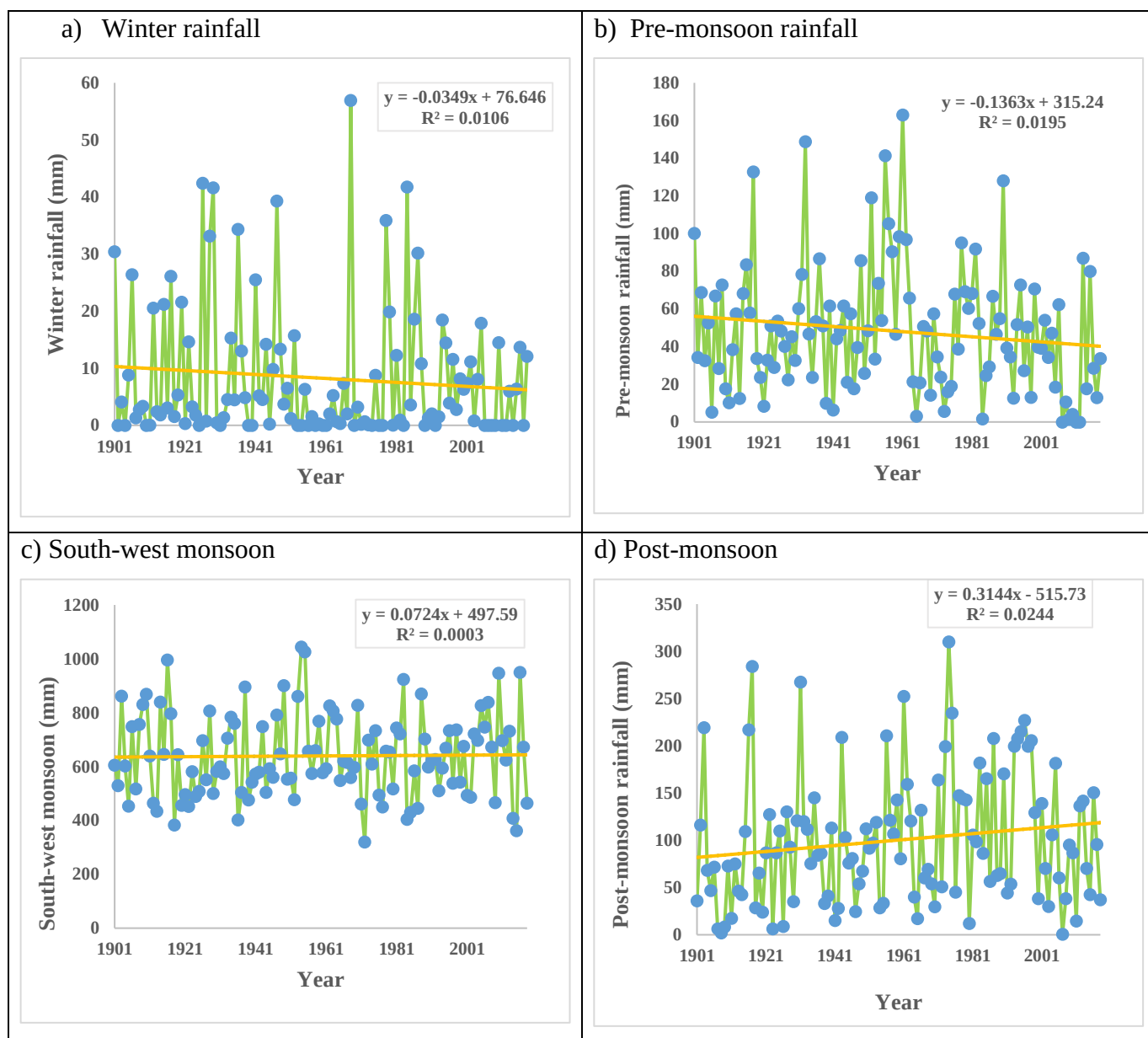
e) Annual rainfall

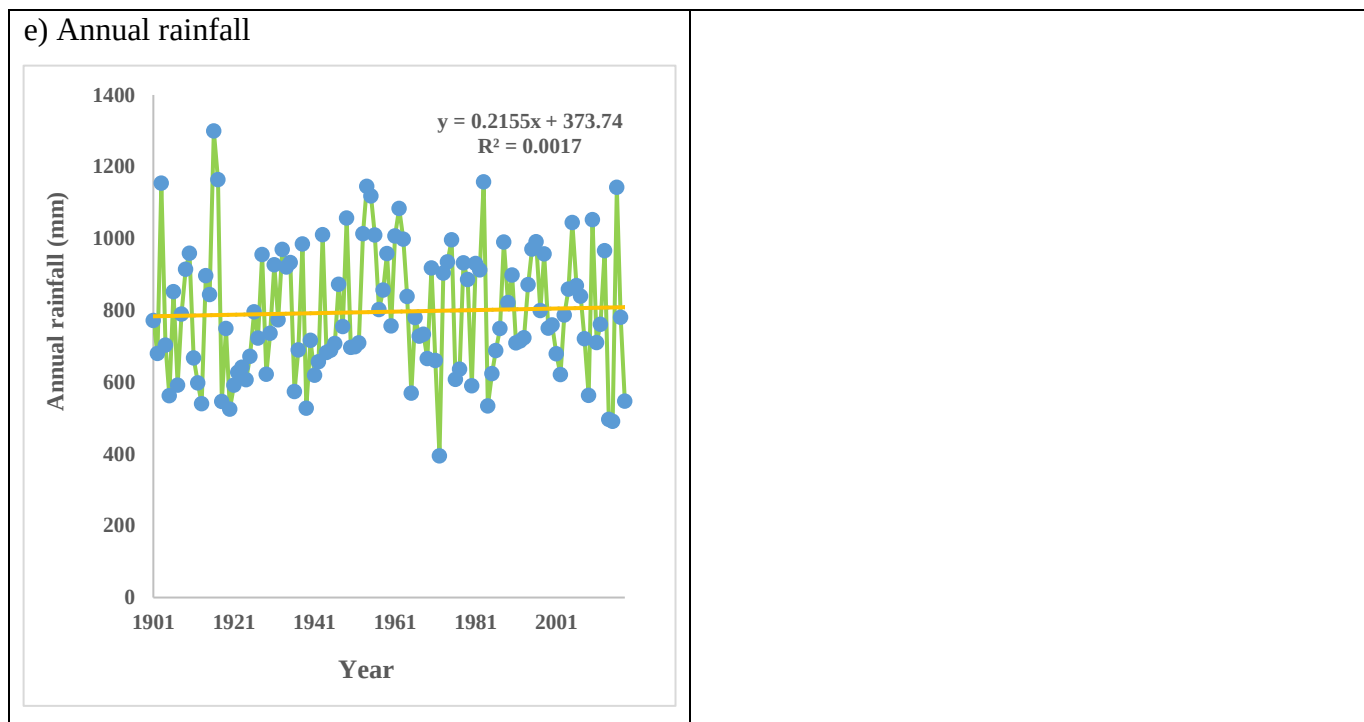


(Author's own calculations from secondary data)

Figure 4.5 shows temporal variations and trends in the seasonal and annual rainfall time series data of Osmanabad District from 1901 to 2018. It has observed positive and negative trends in annual and seasonal rainfall. Here, annual rainfall shows positive trends with a positive coefficient value (0.2775); after that, post-monsoon rainfall (0.164), and south-west monsoon (0.2056) have indicated a positive increasing trend. On the other hand, winter rainfall (-0.0252), and pre-monsoon rainfall (-0.669) values have shown a negative trends line in the observed data set, which has identified decreasing trends over the period.

Figure 4.6: Temporal variations and trends in seasonal and annual rainfall of Latur District for the period 1901 to 2018





(Author's own calculations from secondary data)

Figure 4.6 shows temporal variations and trends in seasonal and annual rainfall of the Latur district for the period 1901 to 2018. Winter and pre-monsoon seasons indicated negative trends with coefficient value (-0.0349), (-0.1363) respectively and annual, post-monsoon south-west monsoon and annual rainfall has shown positive trends with coefficient value (0.0724), (0.3144) and (0.2155). The sub-figure (d) shows slightly increasing positive trends among all seasonal and annual rainfall series data. These kinds of same trends were observed in (Shree & Kumar's, 2018) study, where they showed increasing in the per-monsoon and post-monsoon seasons and a downward trend for the winter season. Patra et al., (2012) have also observed similar kinds of trends in their study. They have recorded an overall decreasing trend in post-monsoon rainfall (0.0352). The rainfall trend line was constant over the study period for the winter season. In the monsoon season trend line was decreasing, and in the pre- monsoon season, it was found in the opposite direction.

Table 4.11: Mann-Kendall test results and magnitude of trend of the Beed district rainfall (Sen's slope estimators) from 1901 to 2018

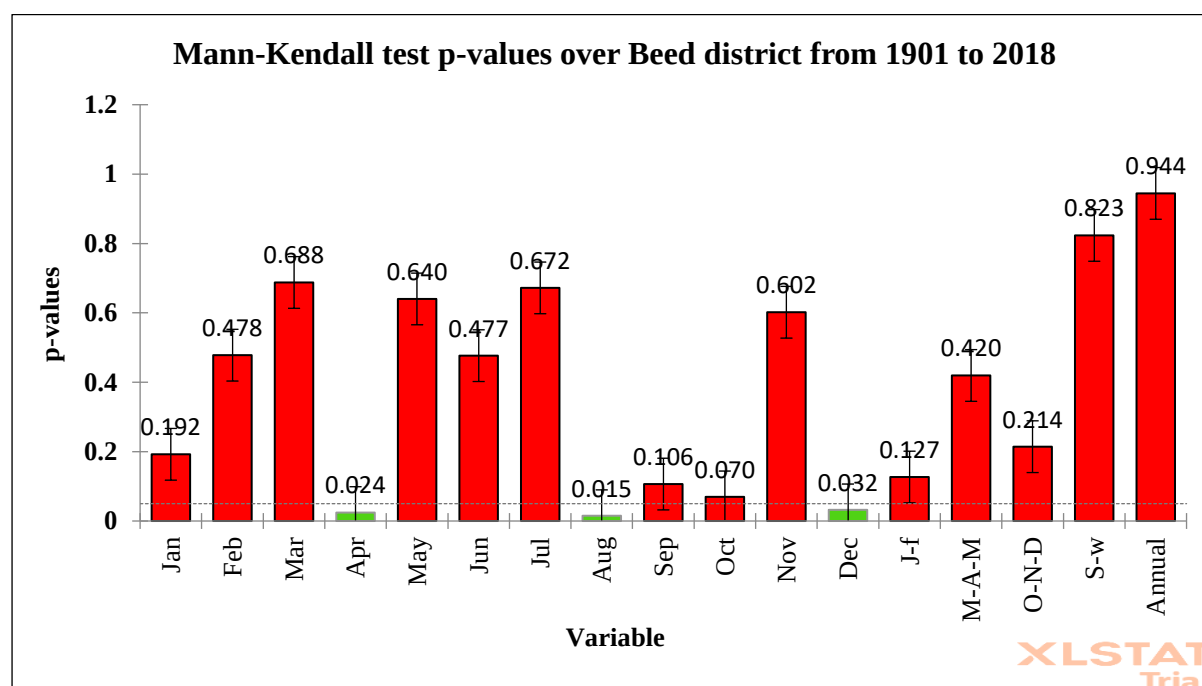
Time series	Kendal's tau	P-value (two-tailed test)	Sen's slope	Hypothesis	Model interpretation Accepted/ Rejected
Jan	-0.086	0.192	0.000	Ho: accepted	No significant trend
Feb	-0.047	0.478	0.000	Ho: accepted	No significant trend
Mar	0.026	0.688	0.000	Ho: accepted	No significant trend
Apr	-0.141**	0.024	-0.035	Ho: rejected	Negative significant trend
May	-0.029	0.640	-0.009	Ho: accepted	No significant trend
Jun	-0.044	0.477	-0.093	Ho; accepted	No significant trend
Jul	-0.027	0.672	-0.091	Ho; accepted	No significant trend
Aug	0.151**	0.015	0.416	Ho; rejected	Positive significant trend
Sep	-0.101	0.106	-0.424	Ho; accepted	No significant trend
Oct	0.113	0.070	0.226	Ho: rejected	Positive significant trend
Nov	-0.033	0.602	-0.002	Ho: accepted	No significant trend
Dec	-0.142**	0.032	0.000	Ho: rejected	Negative significant trend
Winter	-0.096	0.127	-0.005	Ho: accepted	Negative significant trend
Pre-monsoon	-0.050	0.420	-0.059	Ho: accepted	No significant trend
Post-monsoon	0.078	0.214	0.180	Ho: accepted	No significant trend
South-west monsoon	-0.014	0.823	-0.083	Ho: accepted	No significant trend
Annual	0.004	0.944	0.042	Ho: accepted	No significant trend

(***, **, * indicates that statistically significant trends at 1 % 5 % and 10 % level, respectively)

The above table 4.11 shows Mann-Kendall test results and magnitude of Beed district's trend (Sen's slope estimators) over the period 1901 to 2018. The Mann-Kendall test results show that only August month observed a positive significant increasing trend among all months, while April and December months recorded statistically negative significant rainfall trends. There are no trends observed in seasonal and annual rainfall data. The statistical results shows that approximately all months and seasons have recorded no significance trends in rainfall over the district from 1901 to 2018 except of April, December and August. This is not good sign for rainfed agriculture which is mostly depends on rainfall. If there is no enough rainfall in the crop growing season to grow crops; its negative impact on crop production, employment in the agriculture sector. Likewise, rural livelihood faces several problems due to inadequate rainfall. Furthermore, it is damages of wildlife, fish habitant, ecosystem, temperature increased, water

resources dried up, and degradation of pasture and forest. It also creates several socio-economics problems such as out-migration, schooling of children's, health impacts, haplessness scene of loss, sensitization etc.

Figure 4.7: Mann- Kendall test p-values over Beed district from 1901 to 2018



(Author's own calculations from secondary data)

Table 4.12: Mann-Kendall test trend results and Sen's slope (magnitude of trend line) of Osmanabad district

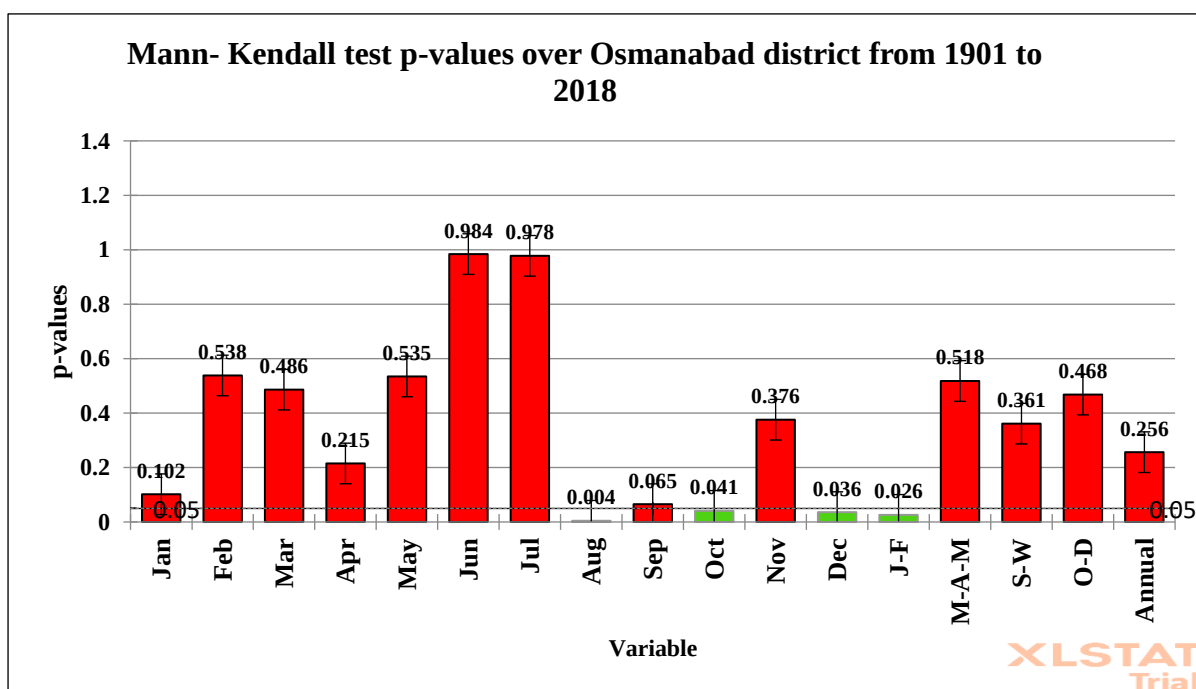
Time series	Kendal's tau	P-value (two-tailed test)	Sen's slope	Hypothesis	Model interpretation Accepted/ Rejected
Jan	-0.110	0.102	0.000	Ho: accepted	No significant trend
Feb	-0.047	0.538	0.000	Ho: accepted	No significant trend
Mar	0.032	0.486	0.000	Ho: accepted	No significant trend
Apr	-0.077	0.215	-0.029	Ho: rejected	Negative significant trend
May	-0.039	0.535	-0.027	Ho: accepted	No significant trend
Jun	-0.002	0.984	-0.004	Ho; accepted	No significant trend
Jul	0.002	0.978	0.010	Ho; accepted	No significant trend
Aug	0.188***	0.004	0.471	Ho; rejected	Positive significant trend
Sep	-0.089***	0.065	-0.369	Ho; accepted	Negative significant trend
Oct	0.109**	0.041	0.226	Ho: rejected	Positive significant trend
Nov	-0.045	0.376	-0.003	Ho: accepted	No significant trend
Dec	-0.138**	0.036	0.000	Ho: rejected	Negative significant trend
Winter	-0.100**	0.026	-0.002	Ho: accepted	Negative significant trend

Pre-monsoon	-0.040	0.518	-0.048	Ho: accepted	No significant trend
South-west monsoon	0.033	0.361	0.216	Ho: accepted	No significant trend
Post-monsoon	0.053	0.468	0.155	Ho: accepted	No significant trend
Annual	0.071	0.256	0.513	Ho: accepted	No significant trend

(***, **, * indicates that statistically significant trends at 1 % 5 % and 10 % level, respectively)

The above table 4.12 shows that Mann-Kendall test trend results and Sen's slope (magnitude of trend) of Osmanabad district from 1991 to 2018. The analysis results show that significant positive rainfall trends have been observed in the August and October months at a 1 % and 5 % significance level (P-value = 0.004 and 0.041), respectively. September, December, and winter series recorded significant negative trends at 10 % and 5 % significance levels (p = values September 0.065, December 0.036, and winter 0.026).

Figure 4.8: Mann- Kendall test p-values over Beed district from 1901 to 2018



(Author's own calculations from secondary data)

Table 4.13: Mann-Kendall trend test results and Sen's slope (magnitude of trend line) of Latur district from 1901 to 2018

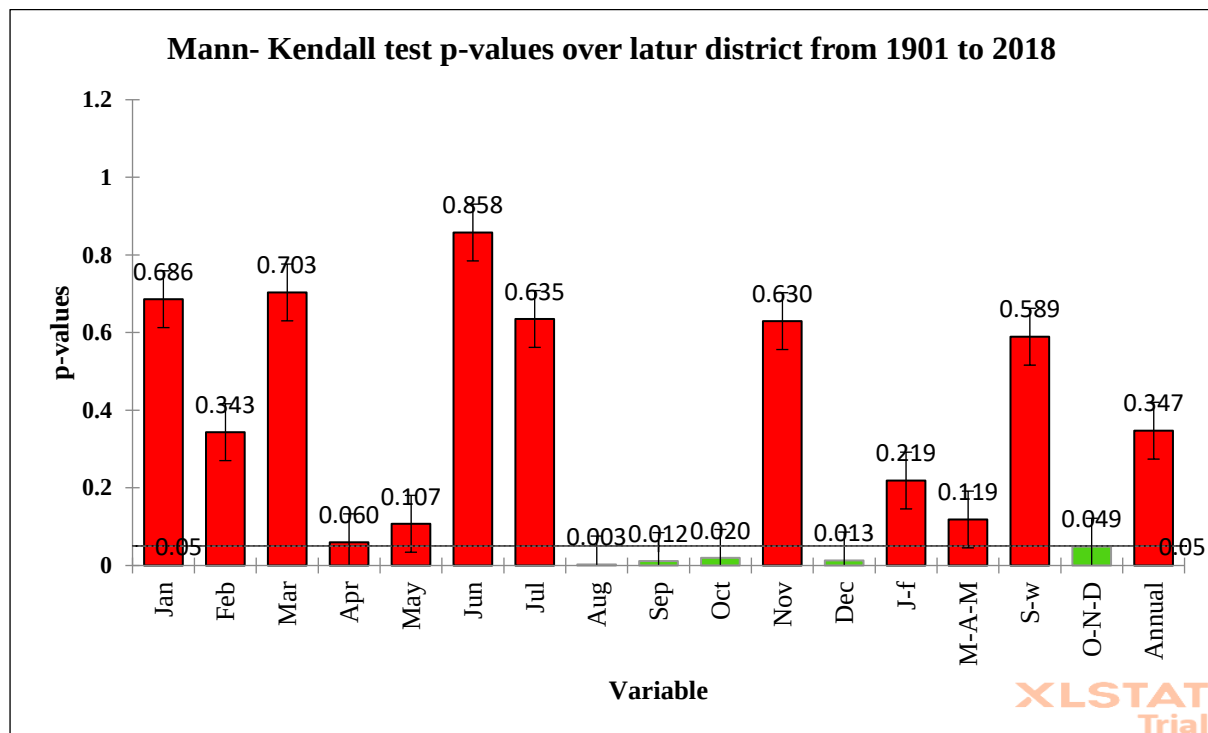
Time series	Kendal's tau	P-value (two-	Sen's slope	Hypothesis	Model interpretation Accepted/ Rejected

		tailed test)			
Jan	-0.027	0.686	0.000	Ho: accepted	No significant trend
Feb	-0.062	0.343	0.000	Ho: accepted	No significant trend
Mar	0.024	0.703	0.000	Ho: accepted	No significant trend
Apr	-0.118	0.060	-0.038	Ho: rejected	Negative significant trend
May	-0.100	0.107	-0.050	Ho: accepted	No significant trend
Jun	0.011	0.858	0.029	Ho; accepted	No significant trend
Jul	0.030	0.635	0.121	Ho; accepted	No significant trend
Aug	0.187***	0.003	0.600	Ho; rejected	Positive significant trend
Sep	-0.157**	0.012	-0.771	Ho; accepted	Negative significant trend
Oct	0.145**	0.020	0.314	Ho: rejected	Positive significant trend
Nov	-0.030	0.630	-0.001	Ho: accepted	No significant trend
Dec	-0.165**	0.013	0.000	Ho: rejected	Negative significant trend
Winter	-0.078	0.219	-0.002	Ho: accepted	Negative significant trend
Pre- monsoon	-0.097	0.119	-0.135	Ho: accepted	No significant trend
South- west monsoon	0.034	0.589	0.272	Ho: accepted	No significant trend
Post- monsoon	0.123**	0.049	0.348	Ho: accepted	No significant trend
Annual	0.059	0.347	0.489	Ho: accepted	No significant trend

(***, **, * indicates that statistically significant trends at 1 % 5 % and 10 % level, respectively)

The above table 4.13 shows that Mann-Kendall test trend results and Sen's slope estimators (magnitude of trend) in rainfall data over 1901 to 2018 of the Latur district. The results found that there has positive and negative significant trend has been observed in the monthly and seasonal rainfall time series data. Only post-monsoon rainfall season has recorded positive significance trends at 5% significance level ($P = 0.049$). Out of the total months, only August and October recorded a significant positive trend at 1 % and 5% significant level, while September and December recorded a significant negative trend at a 5 % significance level (P -value = 0.012, and .013, respectively). No significant trends were observed in the annual rainfall data series over the study period for three districts.

Figure 4.9: Mann- Kendall test p-values of Latur district from 1901 to 2018



(Author's own calculations from secondary data)

Section II

4.5. History of Marathwada drought (rainfall)

The southwest monsoon rainfall long-run data series used to identify dry and rainy years over the Marathwada region from 1871 to 2016 and the annual long-run rainfall data conducted from 1901 to 2016. The data have been conducted from Indian Institute of Topological Metrology, Pune. Furthermore, south west monsoon rainfall of data set has been conducted from (<https://data.gov.in>) over India. The following studies have used the same kinds of data sets and rainfall deviation technique to examine rainfall variability and trends.

Monthly, seasonal and annual area-weighted rainfall time series data observed over India during the period 1871 to 2016. In the present study they apply few basic statistical tools like as Mean, Standard Deviation and shows trend for different periods with the help of diagrams (entire period 1871 to 2016 and 1981 to 2016 recent period), (Kothawale & Rajeevan, 2017). All India monthly, seasonal, and annual homogeneous rainfall data series obtained from Indian Metrological Department Pune for the period 1871-1993. This study used the same data to calculate drought intensity. The key variables used for Monitoring Drought (Parthasarathy et al., 1994).

State Governments monitored drought by obtaining information from various sources of drought variables, including rainfall, reservoir / lake water levels, surface water / groundwater, soil moisture, and sowing/crop conditions etc ([Drought Manual, 2016](#)).

Table 4.14: Classifications of rainfall deviations (IMD)

Deviation from normal rainfall (%)	Classification
+ 19 to -19	Normal
-20 to -59	Deficient
-60 to -99	Large Deficient
-100	No Rain

(Source: drought Manual (2016) gov. of India)

Table 4.14: Marathwada region south-west monsoon rainfall data from 1871 to 2016 obtained from the Indian Institute of Tropical Meteorology (IITM).

Years	Deviation (%)	Drought category
1871	-64.68	L.D.
1872	57.66	N
1873	14.31	N
1874	15.08	N
1875	46.90	E
1876	-30.51	D
1877	-35.20	D
1878	28.69	N
1879	11.49	N
1880	2.49	N
1881	-12.78	N
1882	31.44	N
1883	54.53	N
1884	-8.50	N
1885	-26.64	D
1886	11.79	N
1887	16.52	N
1888	-24.09	D
1889	16.36	N
1890	8.19	N
1891	-10.92	N
1892	88.60	N
1893	34.87	N
1894	32.88	N

1895	22.04	N
1896	-20.84	D
1897	5.51	N
1898	-11.95	N
1899	-56.06	D
1900	-8.41	N
1901	1.67	N
1902	-22.67	D
1903	18.74	N
1904	-11.92	N
1905	-34.10	D
1906	6.85	N
1907	-29.64	D
1908	-5.11	N
1909	22.86	N
1910	42.89	N
1911	-15.52	N
1912	-38.42	D
1913	-18.00	N
1914	31.05	N
1915	8.12	N
1916	42.70	N
1917	31.98	N
1918	-53.66	D
1919	-12.02	N
1920	-53.95	D
1921	-26.86	D
1922	-16.36	N
1923	-2.60	N
1924	-17.33	N
1925	-34.26	D
1926	-7.67	N
1927	-16.48	N
1928	5.41	N
1929	-29.17	D
1930	-20.28	D
1931	8.28	N
1932	1.54	N
1933	27.12	N

1934	19.25	N
1935	20.19	N
1936	-36.69	D
1937	-25.93	D
1938	38.10	N
1939	-25.70	D
1940	4.35	N
1941	-30.75	D
1942	16.36	N
1943	-0.30	N
1944	-16.49	N
1945	-19.68	D
1946	-10.98	N
1947	9.95	N
1948	3.23	N
1949	28.77	E
1950	-8.69	N
1951	-17.46	N
1952	-20.17	D
1953	21.16	N
1954	30.96	N
1955	46.18	N
1956	7.09	N
1957	0.88	N
1958	25.48	N
1959	33.84	N
1960	-14.45	N
1961	6.15	N
1962	7.63	N
1963	31.05	N
1964	0.38	N
1965	-4.64	N
1966	-14.81	N
1967	-9.64	N
1968	-15.78	N
1969	5.51	N
1970	32.62	N
1971	-30.91	D
1972	-53.82	D

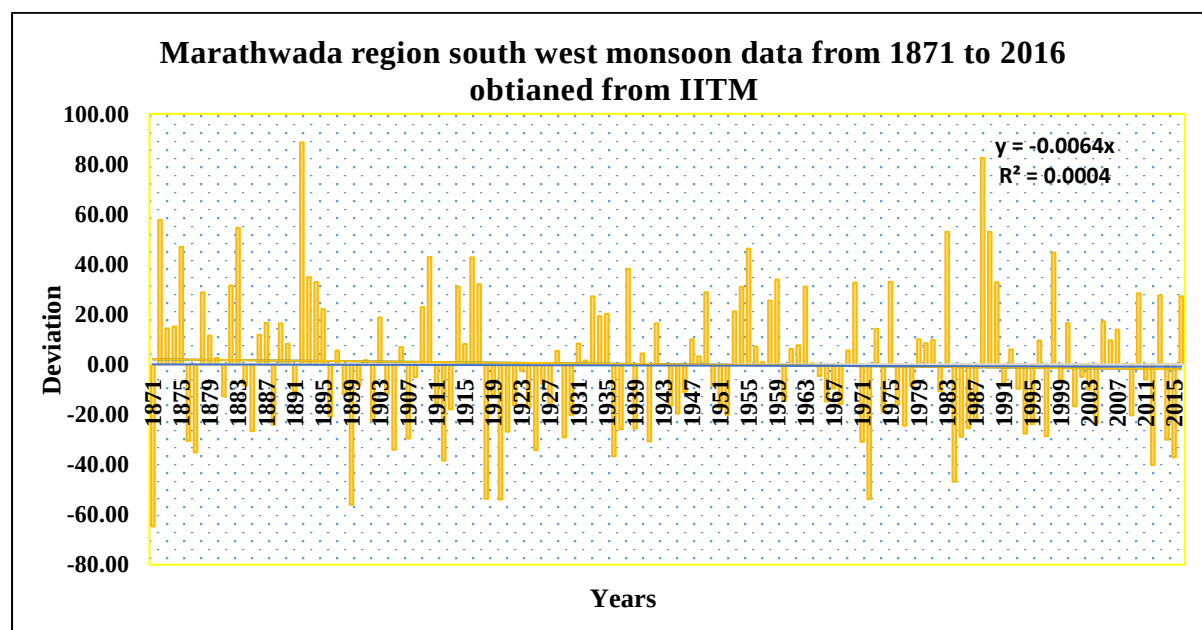
1973	14.18	N
1974	-19.09	D
1975	32.95	N
1976	-15.98	N
1977	-24.45	D
1978	-8.64	N
1979	10.01	N
1980	8.43	N
1981	9.73	N
1982	-10.72	N
1983	52.88	N
1984	-46.85	D
1985	-28.93	D
1986	-25.40	D
1987	-22.19	D
1988	82.39	N
1989	52.88	N
1990	32.75	N
1991	-8.12	N
1992	5.98	N
1993	-9.75	N
1994	-27.64	D
1995	-23.90	D
1996	9.47	N
1997	-28.64	D
1998	44.63	N
1999	-6.09	N
2000	16.43	N
2001	-16.78	N
2002	-4.99	N
2003	-10.11	N
2004	-23.60	D
2005	17.11	N
2006	9.57	N
2007	13.88	N
2008	0.19	N
2009	-20.36	D
2010	28.37	N
2011	-6.06	N

2012	-40.20	D
2013	27.54	N
2014	-30.05	D
2015	-37.11	D
2016	27.16	N

(Author's own calculations from secondary data)

Table 4.14 shows the south-west monsoon rainfall deviations calculated using monthly time series data over the Marathwada region of Maharashtra. There are 38 rainfall deficit years and only one 1871 (large deficit) rainfall year (-64.68 %) recorded. In Marathwada, there were many consecutive drought years from 1984 to 1987, which were four continuous drought years, and 2014 (-30.05 %) and 2015 (-38.11 %) were recent severe drought years. Furthermore, 1988 year was recorded (88.92 %) the largest excess rainfall year.

Figure 4.10: Marathwada region south west monsoon data from 1871 to 2016 obtained from Indian Institute of tropical Metrology (IITM)



(Author's own calculations from secondary data)

The south-west monsoon rainfall deviations derived from their normal values which are depicted in Figure 4.10. According to records only 1871 was recorded large deficient rainfall year (-64.68 %). Furthermore, 38 rainfall deficit years were recorded out of 146 years. Moreover, eight consecutive droughts years has been recorded over the study period which are mentioned following (1876, 1877; 1920, 1921; 1929, 1930; 1936, 1937; 1971, 1972; 1984, 1985, 1986, 1987; 1994, 1995 and 2014, 2015), respectively. From 1984 to 1987, that was

the longest four consecutive drought years in the history over the region. Its means that, the drought has been occurred every three or four years in the Marathwada region.

Table 4.15: South-west monsoon rainfall percentage departure from normal all over India from 1901 to 2017

Years	Deviation from normal (%)	Drought category
1901	-13.1	N
1902	-9.1	N
1903	2.6	N
1904	-11.8	N
1905	-17.4	N
1906	4	N
1907	-10	N
1908	7.4	N
1909	7.1	N
1910	8.1	N
1911	-14.7	N
1912	-4.5	N
1913	-10	N
1914	10.4	N
1915	-9.4	N
1916	13.2	N
1917	22.9	N
1918	-24.9	D
1919	5.9	N
1920	-16.8	N
1921	3.7	N
1922	3.5	N
1923	-2.5	N
1924	4.1	N
1925	-3.3	N
1926	6.9	N
1927	2	N
1928	-8.6	N
1929	-6.5	N
1930	-5.4	N
1931	2.9	N
1932	3.7	N
1933	15.1	N
1934	4.7	N
1935	-2.9	N

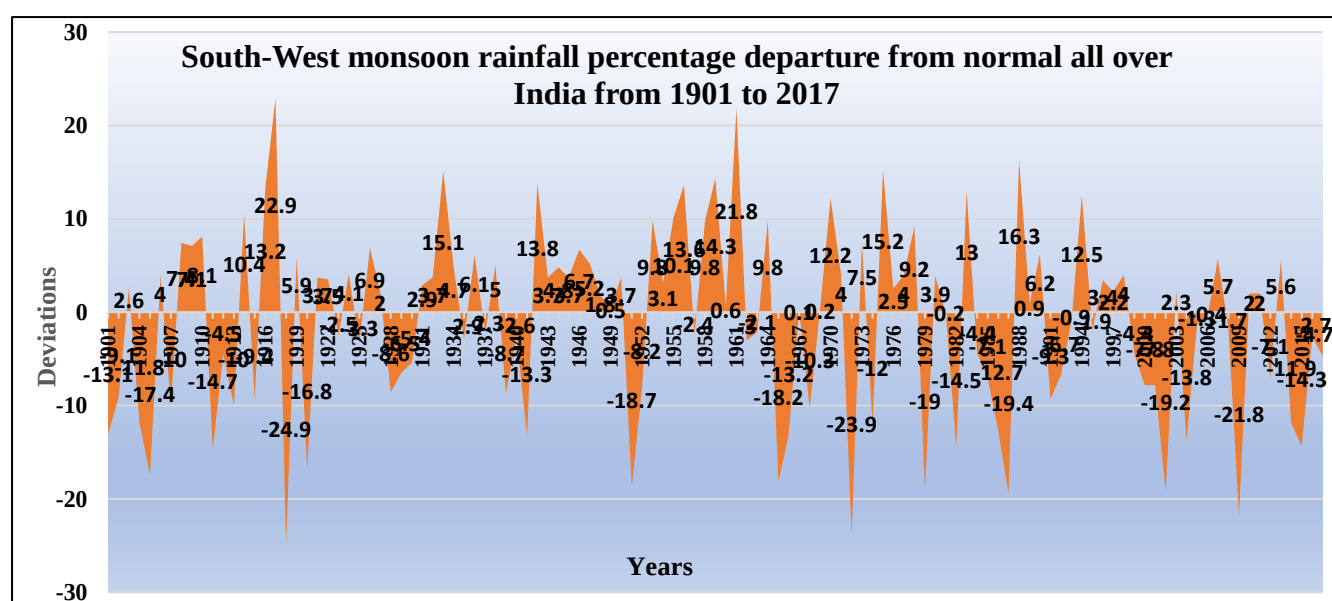
1936	6.1	N
1937	-2.3	N
1938	5	N
1939	-8.7	N
1940	-2.6	N
1941	-13.3	N
1942	13.8	N
1943	3.7	N
1944	4.8	N
1945	3.7	N
1946	6.7	N
1947	5.2	N
1948	1.8	N
1949	0.5	N
1950	3.7	N
1951	-18.7	N
1952	-8.2	N
1953	9.8	N
1954	3.1	N
1955	10.1	N
1956	13.6	N
1957	-2.4	N
1958	9.8	N
1959	14.3	N
1960	0.6	N
1961	21.8	N
1962	-3	N
1963	-2.1	N
1964	9.8	N
1965	-18.2	N
1966	-13.2	N
1967	0.1	N
1968	-10.3	N
1969	0.2	N
1970	12.2	N
1971	4	N
1972	-23.9	D
1973	7.5	N
1974	-12	N
1975	15.2	N
1976	2.5	N
1977	4	N

1978	9.2	N
1979	-19	N
1980	3.9	N
1981	-0.2	N
1982	-14.5	N
1983	13	N
1984	-4.4	N
1985	-7.1	N
1986	-12.7	N
1987	-19.4	D
1988	16.3	N
1989	0.9	N
1990	6.2	N
1991	-9.3	N
1992	-6.7	N
1993	-0.9	N
1994	12.5	N
1995	-1.9	N
1996	3.4	N
1997	2.2	N
1998	4	N
1999	-4.4	N
2000	-7.8	N
2001	-7.8	N
2002	-19.2	D
2003	2.3	N
2004	-13.8	N
2005	-1.3	N
2006	-0.4	N
2007	5.7	N
2008	-1.7	N
2009	-21.8	D
2010	2	N
2011	2	N
2012	-7.1	N
2013	5.6	N
2014	-11.9	N
2015	-14.3	N
2016	-2.7	N
2017	-4.7	N

(Author's own calculations from secondary data)

The above table 4.15 illustrates the South-West monsoon rainfall percentage departure from normal all over India from 1901 to 2017. It shows normal and deficient years calculated using the deviation method from normal over monthly rainfall time series data from 36 metrological subdivisions of India. The largest deficit occurred in the years 1918 (-24.9 %) and 1972 (-23.9 %), 1987 (-19.4 %), 2002 (-19.2 %), 2009 (-21.8 %). There were only two excess years, 1917 (22.9 %) and 1961 (21.8 %).

Figure 4.11: South-west monsoon rainfall percentage departure from normal all over India from 1901 to 2017



(Author's own calculations from secondary data)

Figure 3.12 shows that the south-west monsoon rainfall percentage departure from the normal all over India from 1901 to 2017. In this long period there are four deficit rainfall years 1918 (-24.9 %) and 1972 (-23.9 %), 1987 (-19.4 %), 2002 (19.2 %), and 2009 (-21.8 %).

Table 4. 16: Annual rainfall data all over the Marathwada Region of Maharashtra from 1871 to 2016

Years	Actual Rainfall	Normal rainfall	Deviation (%)	Drought category
1871	243.5	732.83	-66.77	L.D.
1872	1081.8	732.83	47.62	N*
1873	788.2	732.83	7.56	N
1874	793.5	732.83	8.28	N
1875	1012.9	732.83	38.22	N*
1876	479.3	732.83	-34.60	D
1877	447.1	732.83	-38.99	D
1878	887.7	732.83	21.13	N

1879	767.8	732.83	4.77	N
1880	706.8	732.83	-3.55	N
1881	601.7	732.83	-17.89	N
1882	906.5	732.83	23.70	N
1883	1065.6	732.83	45.41	N*
1884	631.1	732.83	-13.88	N
1885	506.1	732.83	-30.94	D
1886	770.9	732.83	5.19	N
1887	803.5	732.83	9.64	N
1888	523.7	732.83	-28.54	D
1889	802.4	732.83	9.49	N
1890	746.2	732.83	1.82	N
1891	614.4	732.83	-16.16	N
1892	1300.6	732.83	77.48	N*
1893	930	732.83	26.91	N
1894	916.2	732.83	25.02	N
1895	841.6	732.83	14.84	N
1896	545.9	732.83	-25.51	D
1897	727.8	732.83	-0.69	N
1898	607.4	732.83	-17.12	N
1899	303.2	732.83	-58.63	D
1900	631.7	732.83	-13.80	N
1901	701.2	631.36	11.06	N
1902	533.4	631.36	-15.52	N
1903	818.9	631.36	2.97	N
1904	607.5	631.36	-3.78	N
1905	454.5	631.36	-28.02	D
1906	736.9	631.36	16.72	N
1907	485.2	631.36	-23.15	D
1908	654.4	631.36	3.65	N
1909	847.2	631.36	34.19	N
1910	985.4	631.36	56.08	N
1911	582.6	631.36	-7.72	N
1912	424.7	631.36	-32.73	D
1913	565.6	631.36	-10.42	N
1914	903.6	631.36	43.12	N
1915	745.7	631.36	18.11	N
1916	984.1	631.36	55.87	N
1917	910.2	631.36	44.16	N
1918	319.7	631.36	-49.36	D
1919	606.9	631.36	-3.87	N
1920	317.8	631.36	-49.66	D

1921	504.6	631.36	-20.08	D
1922	576.8	631.36	-8.64	N
1923	671.7	631.36	6.39	N
1924	570.2	631.36	-9.69	N
1925	453.5	631.36	-28.17	D
1926	636.7	631.36	0.85	N
1927	576.1	631.36	-8.75	N
1928	727	631.36	15.15	N
1929	488.8	631.36	-22.58	D
1930	549.9	631.36	-12.90	N
1931	747.1	716.18	4.32	N
1932	700.4	716.18	-2.20	N
1933	876.8	716.18	22.43	N
1934	822.6	716.18	14.86	N
1935	825.8	716.18	15.31	N
1936	436.8	716.18	-39.01	D
1937	511.1	716.18	-28.64	D
1938	952.3	716.18	32.97	N
1939	512.4	716.18	-28.85	D
1940	719.8	716.18	0.51	N
1941	477.7	716.18	-33.30	D
1942	803.2	716.18	12.15	N
1943	687.8	716.18	-3.96	N
1944	576	716.18	-19.57	D
1945	554.2	716.18	-22.62	D
1946	614.1	716.18	-14.25	N
1947	758.3	716.18	5.88	N
1948	711.9	716.18	-0.60	N
1949	888.1	716.18	24.01	N
1950	629.9	716.18	-12.05	N
1951	569.2	716.18	-20.52	D
1952	550.6	716.18	-23.12	D
1953	835.6	716.18	16.67	N
1954	903.2	716.18	26.11	N
1955	1008	716.18	40.75	N
1956	738.8	716.18	3.16	N
1957	695.9	716.18	-2.83	N
1958	665.3	716.18	20.82	N
1959	922.8	716.18	28.85	N
1960	589.9	716.18	-17.63	N
1961	732	700.46	4.50	N
1962	742.1	700.46	5.94	N

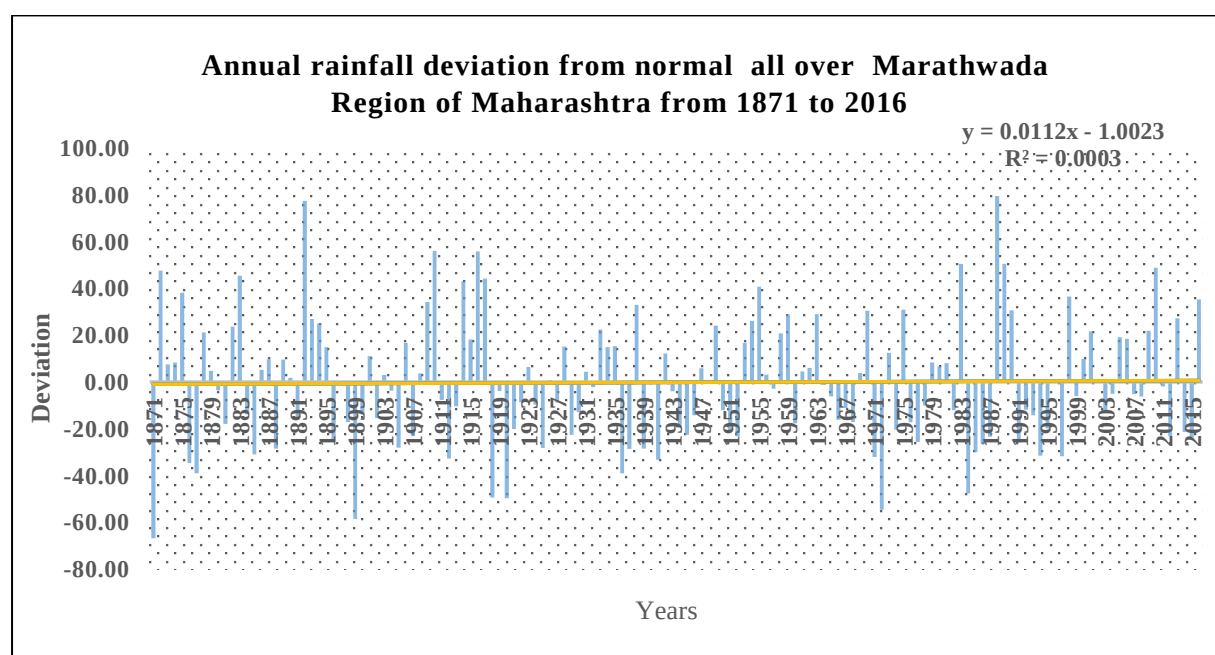
1963	903.6	700.46	29.00	N
1964	692.1	700.46	-1.19	N
1965	657.5	700.46	-6.13	N
1966	587.4	700.46	-16.14	N
1967	623	700.46	-11.06	N
1968	580.7	700.46	-17.10	N
1969	727.5	700.46	3.86	N
1970	914.4	700.46	30.54	N
1971	476.4	700.46	-31.99	D
1972	318.4	700.46	-54.54	D
1973	787.3	700.46	12.40	N
1974	557.9	700.46	-20.35	D
1975	916.7	700.46	30.87	N
1976	579.3	700.46	-17.30	N
1977	520.9	700.46	-25.63	D
1978	629.9	700.46	-10.07	N
1979	758.5	700.46	8.29	N
1980	747.6	700.46	6.73	N
1981	756.6	700.46	8.01	N
1982	615.6	700.46	-12.11	N
1983	1054.1	700.46	50.49	N*
1984	366.5	700.46	-47.64	D
1985	490	700.46	-30.05	D
1986	514.4	700.46	-26.51	D
1987	536.5	700.46	-23.41	D
1988	1257.6	700.46	79.54	N*
1989	1054.1	700.46	50.49	N*
1990	915.3	700.46	30.67	N
1991	517.8	698.2	-25.84	D
1992	615.9	698.2	-11.79	N
1993	599	698.2	-14.21	N
1994	478.6	698.2	-31.45	D
1995	559.4	698.2	-19.88	D
1996	697.5	698.2	-0.10	N
1997	476.5	698.2	-31.75	D
1998	953.1	698.2	36.51	N*
1999	656.1	698.2	-6.03	N
2000	766.6	698.2	9.80	N
2001	849	698.2	21.60	N
2002	706	698.2	1.12	N
2003	613	698.2	-12.20	N
2004	663	698.2	-5.04	N

2005	832	698.2	19.16	N
2006	827	698.2	18.45	N
2007	662	698.2	-5.18	N
2008	655	698.2	-6.19	N
2009	851	698.2	21.88	N
2010	1039	698.2	48.81	N*
2011	648.90	698.2	-1.90	N
2012	537	698.2	-23.09	D
2013	887.90	698.2	27.17	N
2014	548.9	698.2	-21.38	D
2015	532.8	698.2	-23.69	D
2016	944.18	698.2	35.23	N

(Author's own calculations from secondary data) (N* = more than 1000 mm rainfall recorded)

The above table 4.16 shows time series annual rainfall data, and it has been calculated annual rainfall deviation from the normal all over the Marathwada Region of Maharashtra from 1871 to 2016. The deviation shows that there was only one large deficient (scanty) drought year 1871 (-66.77 %), 38 deficit rainfall years, 99 normal years and 9 excess years (N*, more than 1000 mm) rainfall recorded. Its means that after every three years, drought occurs in the Marathwada region. There are many consecutive drought years 1976 (34.60 %), 1977 (-38.99 %); 1920 (-49.66%), 1921(-20.08 %); 1936 (-39.01%), 1937(-20.64%); 1944(-19.75%), 1945 (22.62 %); 1950 (-20.52 %), 1951(-23.12 %); 1971(-31.99%), 1972 (54.54 %); etc. from 1984 to 1987 had long period successive drought years. In contrast, from 2002 to 2008, there were no reported single drought years.

Figure 4.12: Annual rainfall deviation from normal all over Marathwada Region of Maharashtra from 1871 to 2016



(Author's own calculations from secondary data)

Figure 4.12 shows the deficit rainfall years all over the Marathwada region of Maharashtra and calculated deviation from the normal using monthly annual rainfall data from 1871 to 2016. The figure detected that 38 deficit rainfall years and only one was a large deficient rainfall year had ever in Marathwada history, 1871 (-66.77 %), which is identified by calculating deviations. Recently 2014-15 and 2015-16 have also been rainfall deficit years. There were four consecutive drought years from 1984 to 1987 and many a couple of consecutive drought years; after every three-four year, the region faces a drought problem. A study by Indian Institute of Tropical Meteorology (IITM) and the Indian Institute of Science (IISc) found that in between 1870 and 2015 the Marathwada faced 22 severe droughts, out of these 22, five instances were two years consecutive drought, in the recent period 2014 and 2015 the region had near about 40 per cent deficit rainfall (<https://economictimes.indiatimes.com>).

Table 4.17: Annual rainfall deviation from normal all over India from (1901 to 2016)

Years	Deviations (%)	Drought category
1901	-10.43	N
1902	-9.77	N
1903	3.92	N
1904	-10.92	N
1905	-15.06	N
1906	-0.14	N

1907	-10.08	N
1908	-6.38	N
1909	-1.94	N
1910	2.88	N
1911	-10.59	N
1912	-6.99	N
1913	-7.73	N
1914	3.05	N
1915	-2.29	N
1916	15.12	N
1917	27.21	E
1918	-11.35	N
1919	11.91	N
1920	-9.71	N
1921	6.45	N
1922	4.64	N
1923	-0.19	N
1924	8.26	N
1925	3.36	N
1926	6.55	N
1927	8.15	N
1928	4.29	N
1929	3.68	N
1930	4.14	N
1931	4.7	N
1932	-2.54	N
1933	11.17	N
1934	-1.35	N
1935	-8.61	N
1936	7.10	N
1937	-2.41	N
1938	4.56	N
1939	-9.93	N
1940	-2.67	N
1941	-12.99	N
1942	3.14	N
1943	2.84	N
1944	5.21	N
1945	-0.99	N
1946	8.35	N
1947	0.17	N
1948	8.75	N

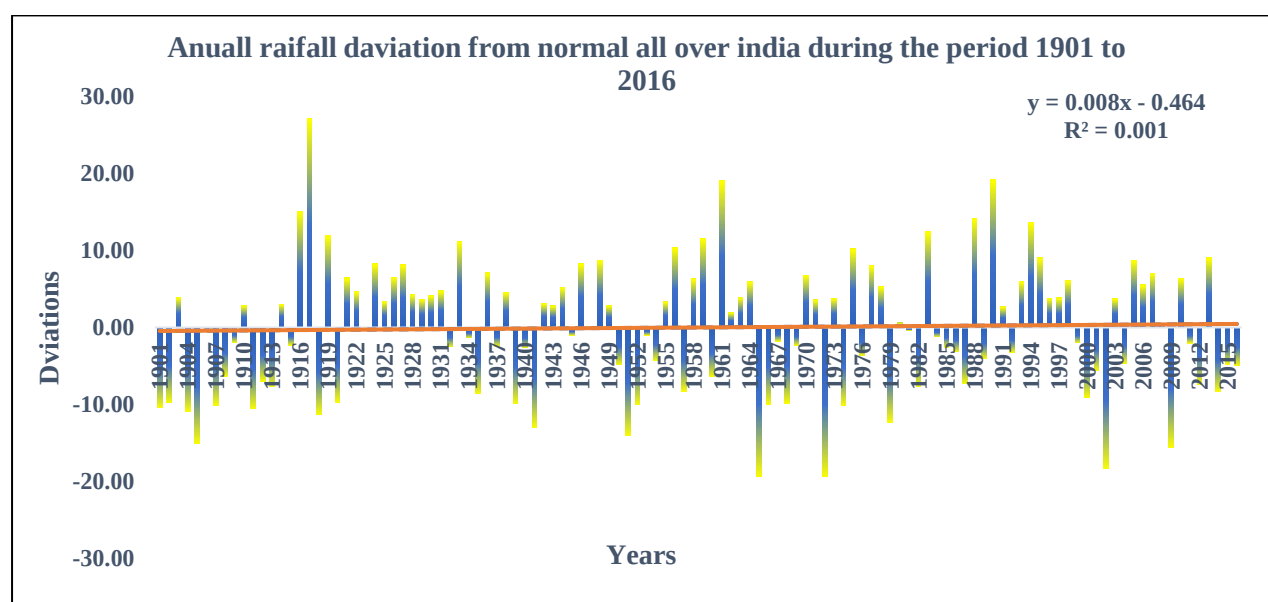
1949	2.87	N
1950	-4.86	N
1951	-14.07	N
1952	-10.06	N
1953	-0.98	N
1954	-4.28	N
1955	3.34	N
1956	10.40	N
1957	-8.29	N
1958	6.33	N
1959	11.56	N
1960	-6.43	N
1961	19.09	N
1962	1.97	N
1963	3.92	N
1964	5.92	N
1965	-19.36	D
1966	-9.95	N
1967	-1.78	N
1968	-9.84	N
1969	-2.31	N
1970	6.82	N
1971	3.57	N
1972	-19.39	D
1973	3.80	N
1974	-10.18	N
1975	10.21	N
1976	-3.69	N
1977	8.07	N
1978	5.30	N
1979	-12.32	N
1980	0.63	N
1981	-0.36	N
1982	-7.70	N
1983	12.43	N
1984	-1.20	N
1985	-2.55	N
1986	-3.17	N
1987	-7.32	N
1988	14.23	N
1989	-4.04	N
1990	19.28	N*

1991	2.70	N
1992	-3.22	N
1993	6.00	N
1994	13.68	N
1995	9.04	N
1996	3.82	N
1997	3.84	N
1998	6.09	N
1999	-2.00	N
2000	-9.13	N
2001	-5.55	N
2002	-18.37	N
2003	3.77	N
2004	-4.67	N
2005	8.72	N
2006	5.53	N
2007	7.06	N
2008	0.41	N
2009	-15.59	N
2010	6.38	N
2011	-2.03	N
2012	-7.43	N
2013	9.06	N
2014	-8.32	N
2015	-4.77	N
2016	-4.93	N

(Author's own calculations from secondary data)

The above table 4.17 shows the annual rainfall deviation calculated from normal over India from 1901 to 2016. In this table, the two deficit rainfall years were recorded, which were 1965 (-19.36 %) and 1972 (-19.39 %), respectively.

Figure 4.13: Annual rainfall deviation from normal all over India during the period 1901 to 2016



(Author's own calculations from secondary data)

Figure 4.13 shows all of India annual rainfall deviation from the normal and depicts normal and drought years from 1901 to 2016. The bars above show normal, and excess rainfall, and below shows deficient rainfall. It has shown a positive sign of coefficient that is 0.446. The red line indicates as trend line which shows slightly increasing trend in the rainfall from 1901 to 2016.

4. 6 Conclusion

The main aim of the chapter is that to observe rainfall trends and variability from monthly, seasonal and annual time series data over the Beed, Osmanabad and Latur districts of the Marathwada region of Maharashtra from 1901 to 2018. The data has been examined using parametric and non-parametric tests. The Mann-Kendell test and Sen's slops estimators used to detect trends and magnitude of the trends and the coefficient of variation is used to calculate rainfall variability. Furthermore, it is presented the descriptive statistics of the monthly. Seasonal and annual time series data and the Rainfall Anomaly Index has been employed to identify the dry and rainy years.

RAI has observed that, out of the 118 years, from 1901 to 2018, there were 51 (43.20 %) dry years for Beed districts, and 11 (9.30 %) were very dry years, which means a total of 118 years, 62 (52.54%) dry years were reported, which is more than half of the years. In the Osmanabad district, there were 43 (36.40 %) dry years, 16 (13.60 %) very dry years, and only one extremely dry year reported; out of the total years, 60 (50.84 %) were drought years. Likewise, there were

41 (34.70 %) dry years, 24 (20.30 %) very dry years, and only one extremely dry year recorded in the Latur district. A total of 118 years, 66 (55.93 %) drought years have been reported. It means that drought occurs once every two years in the region.

Furthermore, the rainfall variability test has found that the winter season observed higher rainfall variability among all seasons over the three districts from 1901 to 2018. The June, July, August and September months reported low rainfall variability out of the 12 months. The southwest monsoon has contributed about 80 % of rainfall of the annual rainfall.

The figure 4.4 has observed negative coefficient for three seasons, such as winter (-0.06), pre-monsoon (-0.986), and southwest monsoon (-0.1913) and annual rainfall (-0.1226); only post-monsoon shows a positive sign of coefficient, which is (0.1733). The annual rainfall trend line is slightly similar to X-axis for the Beed district. The figure 4.5 have shown positive trends in the annual rainfall with a positive coefficient value (0.2775); after that, post-monsoon rainfall (0.164), and the southwest monsoon (0.2056) have indicated a positive increasing trend over the Osmanabad district. The figure 4.6 has observed negative trends for winter and pre-monsoon seasons in the Latur district with coefficient values (-0.0349), (-0.1363) and the annual, post-monsoon, south-west monsoon and annual rainfall have shown positive trends with coefficient values (0.0724), (0.3144) and (0.2155).

The Mann-Kendall test results show that only August month observed a positive significant increasing trend among all months, while April and December months recorded statistically negative significant rainfall trends. There are no significant trends observed in seasonal and annual rainfall data. The statistical results show that approximately all months and seasons have recorded no significant trends in rainfall over the district from 1901 to 2018 except for April, December and August. Furthermore, Mann-Kendall test trend results and Sen's slope (magnitude of trend) for the Osmanabad district are observed. It shows that significant positive rainfall trends have been observed in the August and October months at a 1 % and 5 % significance level. September, December, and winter series recorded significant negative trends at 10 % and 5 % significance levels. Lastly, the results found a significant trend in the Latur district's monthly and seasonal rainfall time series data. Only the post-monsoon rainfall season has recorded positive trends at a 5% significance level. Out of the total months, only August and October recorded a significant positive trend at 1 % and 5%, while September and December recorded a significant negative trend at a 5 % significance level. Over the study period, no significant trends were observed in the three districts' annual rainfall data series.

In the second section, the rainfall deviation has been calculated to observe the drought and normal years over the Marathwada region and India. It has been calculated using the southwest monsoon and annual rainfall time series data. For the Marathwada region, from 1871 to 2016, data period was used, and overall, India 1901 to 2016 data were used. The Marathwada region has reported more drought years compared to India. As per the records, only 1871 (- 64.68 %) year was recorded large deficient in rainfall over the region. Furthermore, 38 rainfall deficit years were recorded out of 146 years. The eight consecutive droughts years has been recorded over the study period for the Marathwada region. India's annual and south-west monsoon rainfall series was recorded in only two deficit years, which were 1965 (-19.36 %) and 1972 (-19.39 %). Marathwada is a drought-prone region where many deficit rainfall years recorded during 1871 to 2018. The study indicated that drought has been occurred after every two or three years in the region, which is one of the important parts in central India. It is famous for its recurring drought events.

The results of the present chapter will assist policymakers, researchers, metrologists, agronomists, and hydrologists to develop a better drought management plan to solve the water-related crisis and provide a better understanding of the current drought scenario through in-depth trend analysis of rainfall.

Chapter 5

Socio-economics conditions in the drought prone-areas among rural households in irrigated and rain-fed villages – (An Empirical investigation from primary as well as secondary data)

5.1 Introduction

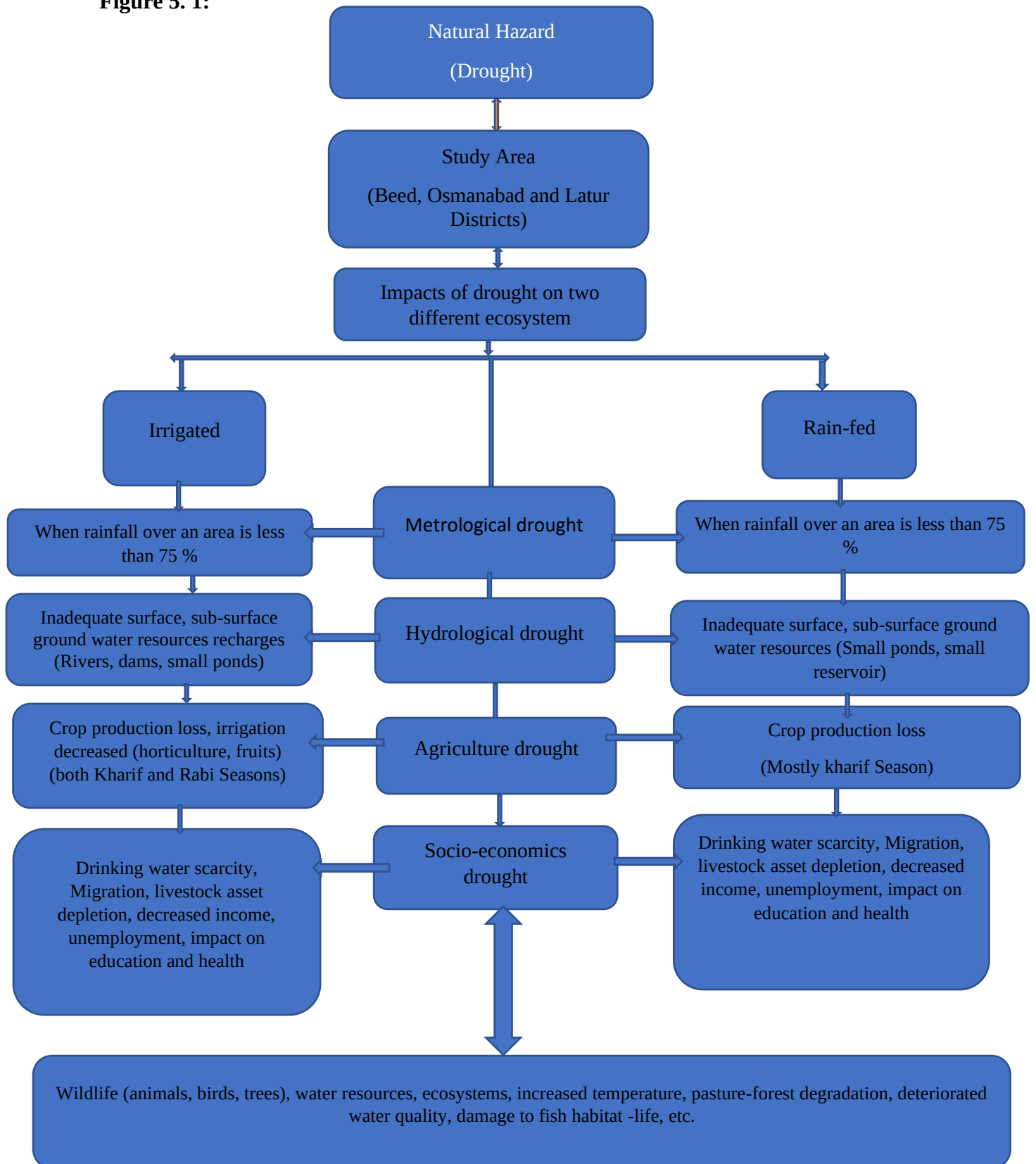
Natural disasters cause economic losses worldwide. Drought is a natural disaster that largely affects agricultural and rural life (Wilhite D., 2000). The agricultural sector plays a crucial role in the economy of India. More than 56 % of the net cultivated area depends on monsoon rainfall. Rainfall is a climatic factor that plays a significant role in the development of agriculture production, drinking water, cattle fodder, power production, and reconstruction. About 73 % of rain is obtained from the South-West monsoon all over India (Drought Management Plan, 2017). A recurring drought led to famine, and the famine led to starvation, which killed millions of people during the colonial period in India. Six major famines were recorded during (1873-74, 1876, 1877, 1896-97, 1899, and 1943). Out of that, five were occurred due to drought; only in 1943 famine was not related to drought. For the period 1870 to 2016 in India, where there were seven significant droughts occurred during (1870 -1882, 1895-1900, 1908 -1924, 1937 -1945, 1982 -1900, 1997-2004, and 2011-2015) (Mishra et al., 2019; Drought manual, 2016). The severe drought years were calculated using the SPI index across Maharashtra for the period (1871 to 2012); which those were 1877, 1899, 1911, 1918, 1920, 1951, 1965, 1972, 1986, 1987, 2002, 2008, and 2012 (Chavdekar and Kashid, 2018). Marathwada region is one of the most severe drought-affected areas in the Maharashtra among its five regions which has namely Vidarbha, Marathwada, Kokan, Western Maharashtra, and Khandesh. The media has called which is a “Graveyard of Farmer” (Huchhe et al., 2020). Maharashtra has a prolonged history of drought that occurs every year in one area or another. The state's rainfall pattern is highly variable, both spatially and temporally (Amrit et al., 2021).

Beed, Osmanabad, and Latur districts have been selected from the Marathwada region of Maharashtra for the study where there were severe drought conditions reported. Due to that, the highest number of water tankers were developed during the drought by local and state governments in 2015-16 and 2018-19 (Central Water Commission, 2015-16). The study is used a multistage sampling method for primary data collections. In the first stage, the three districts (Beed, Latur, and Osmanabad) have been selected purposively from the Marathwada region based on low rainfall and scarcity of water. These three districts are fallen under

Balaghat rang and coming under the Godavari and Manjara sub-river basins. In the second stage, two blocks/talukas have been selected purposively from each district based on one block is developed and high irrigated. The second block comparatively is non-developed and low irrigated (rain-fed). In the third stage, also the villages have been selected purposively. From each block, one village is selected. The irrigated village selected based on that the village is situated on the bank of the river. The dam is near the village, and the Canal facility is available. Furthermore, the village is highly irrigated and it has extensive cultivation of sugarcane and cotton areas. On the other hand, the remaining three villages have been selected from non-developed blocks based on the villages are situated on Balaghat rang (hilly area). The rain-fed village selected on the basis of the village cultivation totally depend on rainfall. Second criteria is that it is situated on hilly areas in Balaghat rang. Ultimately total six villages have been selected for the study (Three are irrigated, and three are rain-fed villages). Finally in the fourth stage, the farm households have been selected randomly. The total sample is 290.

This chapter imposes following research questions. Does the drought negatively influence on rural farm households? And what problems do they face during the drought, such as (drinking water, education, credit, insurance, livestock fodder, out-migration and crop production, etc.)? Do the marginal and small and medium land holding households face more severe problems than large size landholding households? Does the drought decrease more agriculture crop production compared to rain-fed villages? The main objective of this chapter is to study the impact of drought on farm household's livelihood in irrigated and rain-fed villages in the study area. This chapter has been divided into four sections such as, the first section is socio-economic profile of the sample households, second section is on impact of drought on various factors (social, economic and environment) and governments drought programmes, the third section analyse impact of drought on total foodgrain production in the study area using multiple regression model and the last section describes information of the cattle camps, drinking water takers position in the drought years, and describes the block wise crop annewari/paisewari over the three districts.

Figure 5. 1:



(Source: Author's own chart using various studies)

Section I

5.2 Socio-economic profile of the sample households

The socio-economic profile includes, characteristics of irrigated and rain-fed villages, in the normal and drought year, selected villages sample household percentages, religious status, social groups-wise information, family types, housing facility of the households, heads sex ratio, age groups, marital status, level of education and occupational status of the households and landholding size.

Table 5.1: Selected district, block, and villages information in the study area

Districts	Blocks	Villages	Ecosystem (areas)
Beed	Manjalgaon	Lukhegaon	Irrigated
	Patoda	Karanjwan	Rain-fed
Osmanabad	Osmanabad	Bhandarwadi	Irrigated
	Washi	Jawalka	Rain-fed
Latur	Latur	Takalgaon	Irrigated
	Ausa	Yellorewadi	Rain-fed

(Source. Field survey, 2018-19)

Table 5.1 indicates districts, blocks, and villages names that have been selected for the study. The above six blocks and six villages have been chosen from irrigated and rain-fed areas of the three districts of the Marathwada regions of Maharashtra.

Table 5. 2: Characteristics of irrigated and rain-fed villages in both normal and drought years

Sr. No.	Village	Village Characteristics	Normal year crops	Drought year crops
1)	Lukhegaon (Irrigated village)	It is situated on the bank of Sindaphana river, near about six km from Manjalgaon dam, canal is available, (it has extensive crop area cultivation of sugarcane and cotton, if rainfall is adequate).	Kharif: Sugarcane, Cotton, Vegetables, Soybean, Tur, Jawar, Groundnut, Maize etc.	Kharif: Soybean, Tur, Bajara, Jawar, Cotton Maize etc.
			Rabi: Wheat, Bengal gram, Onion,	Rabi: Wheat, Bengal gram.

			Turmeric, Sunflower, all vegetables.	If water is available; otherwise, no
2)	Karanjwan (Rain-fed village)	The village agriculture mostly depends on rainfall, no dam or river near, it is situated on Balaghat rang,	Kharif: Soybean, Tur, Bajara, Jawar, Cotton, Maize etc.	Kharif: Soybean, Tur, Bajara, cotton, Jawar, maize
			Rabi: Wheat, Bengal gram, Jawar.	Rabi: No crop cultivation
3)	Bhandarwadi (Irrigated village)	It is situated on the bank of Terna river, near about 11 km from Terna dam, canal is available, (it has extensive crop area cultivation of sugarcane and cotton, if rainfall is adequate).	Kharif: Sugarcane, cotton, vegetables, soybean, Tur, Jawar Groundnut, Maize etc.	Kharif: Soybean, Tur, Bajara, Jawar, Cotton etc.
			Rabi: Wheat, Bengal gram, Onion, Turmeric, Sunflower, mostly all vegetables.	Rabi: Wheat, Bengal gram. If water is available; otherwise, no
4)	Jawalka (Rain-fed village)	It's agriculture mainly depended on rainfall, no dam or river near the village. It is situated on Balaghat rang	Kharif: Soybean, Tur, Bajara, Jawar (pivala), cotton, Maize, etc.	Kharif: Soybean, Tur, Bajara, Cotton, Jawar (pivala), Maize.
			Rabi: Wheat, Bengal gram, Jawar etc.	Rabi: No crop cultivation

5)	Takalgaon (Irrigated village)	It is situated on the bank of Manjra River, near about 25 km from Manjara dam, canal is available, (it has extensive crop area cultivation of sugarcane and cotton, if rainfall is adequate)	Kharif: Sugarcane, Cotton, vegetables, soybean, tur, Jawar, Green gram (mung), Black gram etc.	Kharif: Soybean, Tur, Bajara, Jawar, Cotton etc.
			Rabi: Wheat, Bengal gram, Onion, Turmeric, Sunflower, all vegetables.	Rabi: Wheat, Bengal gram. If water is available; otherwise, no
6)	Yellorewadi (Rain-fed village)	The village agriculture mostly depends on rainfall, no dam or river near the village. It is situated on Balaghat rang	Kharif: Soybean, Tur, Bajara, Jawar (pivala), Cotton, Maize, etc.	Kharif: Soybean, Tur, Bajara, Cotton, Jawar (pivala), Maize
			Rabi: Wheat, Bengal gram, Jawar.	Rabi: No crop cultivation

(Source. Field survey, 2018-19)

Table 5.2 shows the characteristics of irrigated and rain-fed villages. Six villages have been selected for the primary data collection, in irrigated and rain-fed areas, from three districts of the Marathwada region of Maharashtra, India. The Lukhegaon, Bhandarwadi, Takalgaon are irrigated villages, and Karanjwan, Jawalka, and Yellorewadi are the mainly rain-fed villages. The irrigated villages were selected based on those which are situated on the bank of the rivers and near from the dams; canal is available, and there is extensive area cultivation of sugarcane, cotton, and vegetables. More than 80 % of the village land is irrigated. On the other hand, Karanjwan, Jawalka, and Yellorewadi, the three rain-fed villages selected based on agriculture which is mainly dependent on rainfall, where there is no dam or river near the village. Furthermore, the village is also situated on Balaghat rang. In the Kharif season, farmers are cultivated such as soybean, jawar, bajara, corn, and cotton, which are the main crops. In a normal year for Rabi season, sometimes they are cultivated Wheat, Bengal gram, and Jawar.

The above villages were selected after visited local offices and the discussion with local officers, representatives and village people. Local offices such as Village Grampancharat,

Block Development Office, Irrigation Department, Agriculture Department, Zila Parishad, District Collector Office, Godavari, Krishna Irrigation Department, MGNREGA office, District Central Water Ground Board, and Divisional Office Aurangabad. Local level officers and representatives who are Sarpanch (Gram Pradhan), Gram sevak, Talathi, School teachers, village Agriculture Assistant, block/district Agriculture Officer, Block Development Officer, Mandal Adhikari and Deputy Collector. Before selecting the village, I met and discussed many village people wherever/wherever I went/visited in the study area, including bus stands, common markets, streets, Temples, Majid, Vihars, Farms, Mondis, small Kirana, primary school, and by traveling. Furthermore, I met many local political leaders in front of the local government offices (places) such as Gram Panchayats, the Block Development Office, the Tehsil office, Zilla Parishad, and the District Collector office.

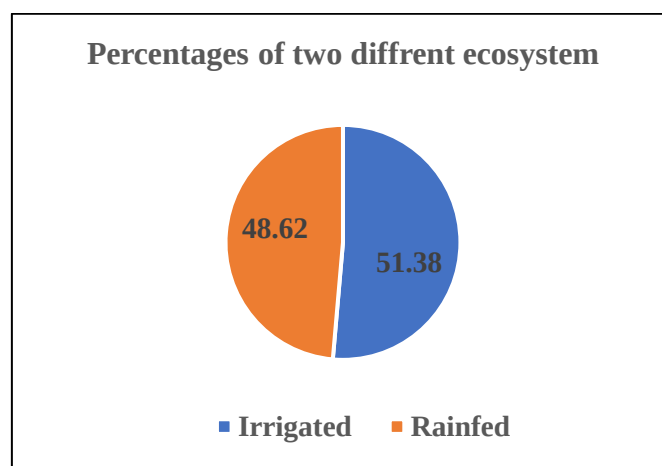
Table 5.3: Total sample households' percentages of irrigated and the rain-fed villages

The percentages of two different ecosystems (areas)	Total
Irrigated	149
	(51.38)
Rain-fed	141
	(48.62)
Total	290
	(100)

(Source. Field survey, 2018-19), (parenthesis shows the percentages)

The above table 5.3 describes the total percentages of irrigated and rain-fed areas. Out of the total sample size, 149 (51.38 %) households are from the irrigated village, and 141 (48.62 %) belong to the rain-fed village.

Figure 5.2: Percentage of two different ecosystems irrigated and Rain-fed (areas)



(Source. field survey, 2018-19)

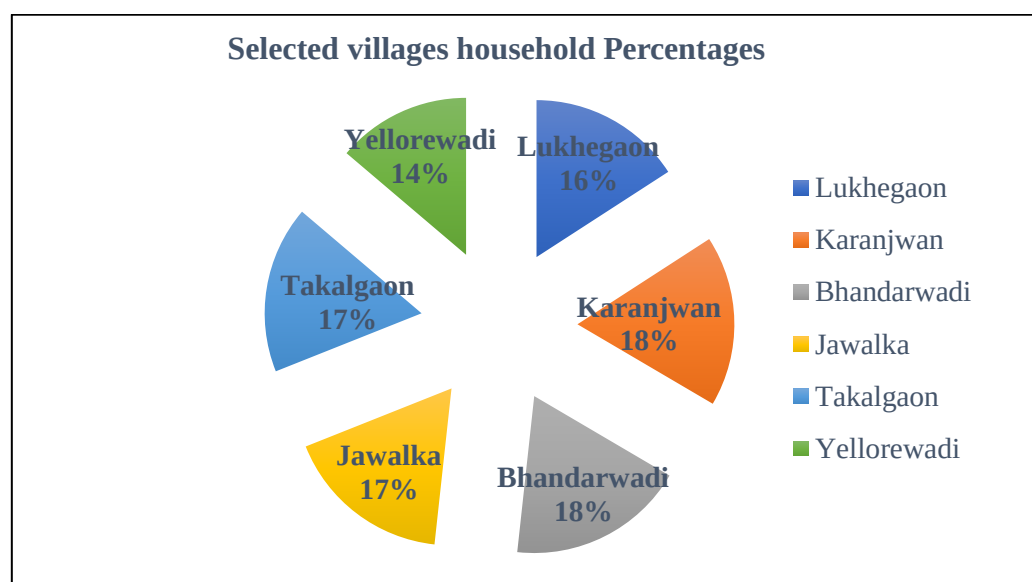
Table 5.4: Each district and each village-wise percentage of the total sample Households

District name	Total	Percentage	Selected villages names	Total	Percentage
Beed	97	33.45	Lukhegaon	46	15.86
			Karanjwan	51	17.59
Osmanabad	103	35.52	Bhandarwadi	53	18.28
			Jawalka	50	17.24
Latur	90	31.03	Takalgaon	50	17.24
			Yellorewadi	40	13.79
Total	290	100	Total	290	100

(Source. Field survey, 2018-19)

The above table 5.4 illustrates the district and village-wise percentage of the sample households in the study area. The 97 (33.45 %) farm households were selected from the Beed district (Lukhegaon 15.86 % and Karanjwan 17.59 %); after that, 103 (35.52 %) households were selected from the Osmanabad district (Bhandarwadi, 18.28 %, and Jawalka, 17.24 %). Lastly, out of the total sample size, 90 (31.03 %) households were selected from the Latur district in irrigated and rain-fed villages (Takalgaon, 17.24% and Yellorewadi, 13.79 %), respectively.

Figure 5.3: Selected village-wise percentages among the sample households of the study area



(Source. Field survey, 2018-19)

Table 5. 5: Each village sample household’s percentages according to total village households

Village Names	Household size	Sample Size	Percentages
Lukhegaon	181	46	(25.41)
Karanjwan	253	51	(20.16)
Bhandarwadi	446	53	(11.88)
Jawalka	184	50	(27.17)
Takalgaon	227	50	(22.02)
Yellorewadi	131	40	(30.53)
Total	1422	290	(20.39)

(Source. field survey, 2018-19)

The above table 5.5 shows the village-wise sample households’ percentages according to total village households size. As per the census, 2011, out of the 181 households’ size of the Lukhegaon irrigated village, the study randomly selected 46 (25.41 %) of households. Furthermore, out of the 253 household’s size of the Karanjwan rain-fed village, the study randomly selected 51 (20.16 %) households in the Beed district. Moreover, in the irrigated village of Bhandarwadi, the study randomly selected 53 (11.88 %) households out of a total of 446 households; on the other hand, 50 (27.17 %) of the households were selected from Jawalka rain-fed village which total of households size is 184. Lastly, out of 227 households’ size of the Takalgaon irrigated village, 50 (22.02 %) households were randomly selected, and out of 131 households in the Yellorewadi rain-fed village, 40 (20.39 %) households were selected for the study from the Latur district.

Table 5.6: Religion status according to irrigated and rain-fed villages’ areas

Villages areas (Ecosystem)	Hindu	Buddhist	Muslim	Total
Irrigated	106	15	28	149
	(71.14)	(10.07)	(18.79)	(100)
Rain-fed	138	3	0	141
	(97.87)	(2.13)	(0.00)	(100)
Total	244	18	28	290
	(84.14)	(6.21)	(9.66)	(100)

(Source. Field survey, 2018-19)

The above table 5.6 depicts the religious status of farmer’s households in irrigated and rain-fed villages. Out of 149 farm households of irrigated villages 106, (71.14 %) were Hindu, 15 (10.07 %) were Buddhist and, 28 (18.79 %) were Muslim. Out of 141 farm households in the rain-fed villages, 138 (97.87 %) were Hindu, and only 3 (2.13 %) were Buddhists. Out of 290 total farm

households, 244 (84.14%) were Hindu, 18 (6.21 %) were Buddhists and 28 (9.66 %) were Muslim. The study found that most of the households belonging to Hindu Religions in the rain-fed villages only (2.13 %) were Buddhist, and no one household belonged to the Muslim religion.

Table 5.7: Religion status according to landholding size from irrigated and rain-fed village's areas

Landholding size	Hindu	Buddhist	Muslim	Total
Marginal	55	10	17	82
	(67.07)	(12.2)	(20.73)	(100)
Small	92	6	10	108
	(85.19)	(5.56)	(9.26)	(100)
Medium	65	1	1	67
	97.01	1.49	1.49	100
Large	32	1	0	33
	(96.97)	(3.03)	(0.00)	(100)
Total	244	18	28	290
	(84.14)	(6.21)	(9.66)	(100)

(Source. Field survey, 2018-19)

The above table 5.7 shows religious status according to landholding size from irrigated and rain-fed villages areas. Out of the total of 290 farm households both in irrigated and ran-fed areas, 244 (84.14 %) belonged to the Hindu religion, 18 (6.21 %) were Buddhists, and 28 (9.66 %) were Muslims. Out of 82 Marginal farmers' households, 55 (67.07 %) were Hindu. Out of 108 small farmers' households, 92 (85.19 %) belonged to Hindu, and out of 67 marginal farmer households, 65 (97.01%) belonged to Hindu, only one household belonged to Buddhist and Muslim. Out of 33 large farmers' households, 32 (96.97%) belonged to Hinduism, and only one family belonged to Buddhist. The study found that most marginal, small, medium, and large farm households belonged to Hindu; only (6.21 %) were Buddhist, and (9.66 %) were Muslim.

Table 5.8: Religion status according to social groups from irrigated and rain-fed villages' areas

Social groups	Hindu	Buddhist	Muslim	Total
OCs	116	0	28	144
	(80.56)	(0.00)	(19.44)	(100)
OBC	75	0	0	75
	(100)	(0.00)	(0.00)	(100)
SC	12	18	0	30
	(40.00)	(60.00)	(0.00)	(100)

ST	41	0	0	41
	(100)	(0.00)	(0.00)	(100)
Total	244	18	28	290
	(84.14)	(6.21)	(9.66)	(100)

(Source. Field survey, 2018-19), Note 1: Figures in the parenthesis are in percentage terms, note 2: OCs = Other castes (Maratha, Muslim, Brahmin and Lingayat), OBCs = Other Backward Castes including NTs = Nomadic Tribes (OBCs are Mali, Sutar), (NTs = Kolhati, Gosavi (NT-B), Dhargar (NT-C), Vanjari (NT-D). SCs = Scheduled Castes (Mahar, Mang), STs= scheduled tribes (Mahadeo Koli). Source: <https://sjsa.maharashtra.gov.in> (Note 2: Figures in parentheses represent percentages)

The above table 5.8 describes the religious status according to social groups from irrigated and rain-fed village's areas. It is reported that 244 (84.14 %) have belonged to the Hindu religion, 18 (6.21 %) have belonged to Buddhist, and 28 (9.66 %) are Muslims. In the general category, most of the households belong to Hinduism, which is 116 (80.56 %), and only 28 (19.44 %) belong to the Muslim religion. All OBCs households are practiced the Hindu religion, and also all STs households practice the Hindu religion. In the SCs category, 12 (40 %) are Hindu, and 18 (60 %) are Buddhist.

Table 5.9: Rural household's classification of irrigated and rain-fed villages according to social groups

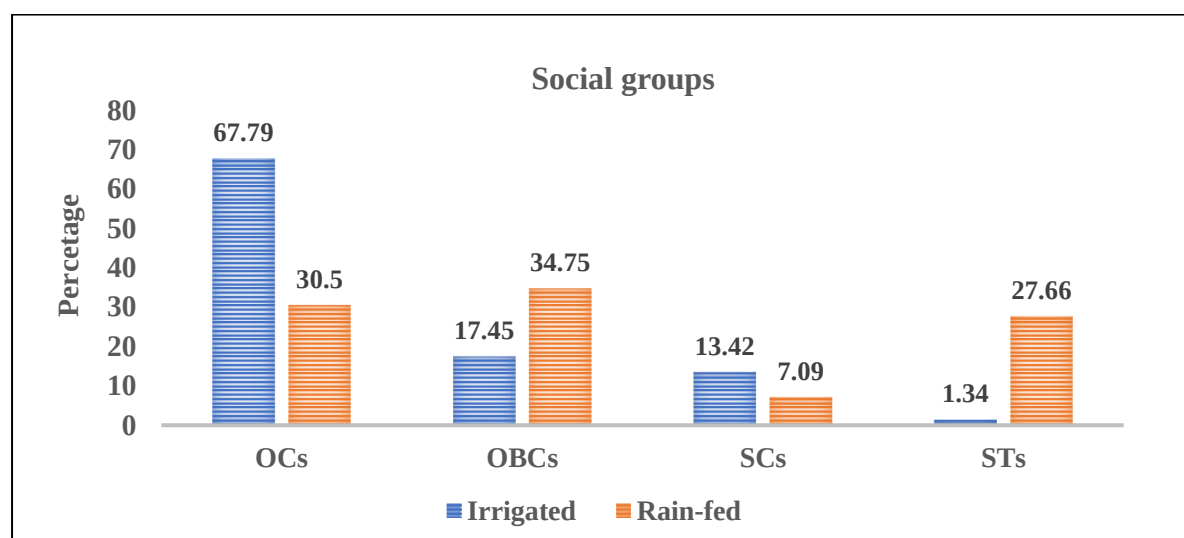
Social Groups	Irrigated Village households	Rain-fed village households	Total
OCs	101	43	144
	(67.79)	(30.50)	(49.66)
OBCs	26	49	75
	(17.45)	(34.75)	(25.86)
SCs	20	10	30
	(13.42)	7.09	10.34
STs	2	39	41
	(1.34)	(27.66)	(14.14)
Total	149	141	290
	(100)	(100)	(100)

(Source. Field survey, 2018-19)

Table 5.9 shows the category-wise rural household's' information in the irrigated and rain-fed villages. Out of 290 households, 149 belong to irrigated villages, and 141 belong to rain-fed villages. It is also observed that social group-wise percentages of sample households. About 144 (49.66 %) households belong to OCs, which is the highest among all categories, then 75 (25.68 %) belong to OBCs. Furthermore, about 30 (10.34 %) are SCs, and 41 (14.14 %) are STs. Likewise, in the total of 149 households of the irrigated villages, 101(67.79 %) belong to OCs, 26 (17.45 %) belong to OBCs, 20 (13.42 %) are SCs, and only 2 (1.34 %) belong to the STs category. Moreover, a total of 141 households in the rain-fed villages, 43(30.50 %) belong

to OCs, followed by 49 (30.50 %) are belonged to OBCs, 10 (7.09 %) are SCs, then 39 (27.66 %) belong to STs. Overall, the highest number of households belongs to OCs, 144 (49.66 %), and the lowest number of households from the SCs category which is (10.34 %).

Figure 5.4: Classifications of social groups among irrigated and rain-fed villages



(Source. Field survey, 2018-19)

Table 5.10: Family types position in the irrigated and rain-fed village in the study area

Ecosystems	Joint	Nuclear	Total
Irrigated	36	113	149
	(24.16)	(75.84)	(100)
Rain-fed	43	98	141
	(30.50)	(69.50)	(100)
Total	79	211	290
	(27.24)	(72.76)	(100)

(Source. Field survey, 2018-19)

The above table 5.10 shows the family types position in the irrigated and rain-fed village in the study area. It is highlighted that out of the total sample households 79 (27.24 %) are joint families and 211 (72.76 %) are the nuclear families. In the irrigated village 36 (24.16 %) are joint families and 113 (75.84 %) are nuclear families, on the other hand, in the rain-fed village 43 (30.50 %) are joint families and 98 (69.50 %) are nuclear families. It is found that the nuclear families are more than the joint families in the both villages.

Table 5.11: Percentages classification of family type according to landholding size

Landholding size	Joint	Nuclear	Total
Marginal	13	69	82
	(15.85)	(84.15)	(100)
Small	27	81	108

	(25.00)	(75.00)	(100)
Medium	24	43	67
	(35.82)	(64.18)	(100)
Large	15	18	33
	(45.45)	(54.55)	(100)

(Source. Field survey, 2018-19)

Table 5.11 depicts the household classification of family type according to landholding size. It is reported that out of the 82 marginal farm households 13 (15.85 %) are Joint and 69 (84.15 %) are nuclear, then out of the total 108 small farm households 27 (25.00 %) are joint and 81 (75.00 %) are nuclear. Furthermore, out of total 67 medium farm households 24 (35.82 %) are joint and 43 (64.18 %) nuclear, and finally out of 33 large farm households 15 (45.45 %) are joint and 18 (54.55) are nuclear.

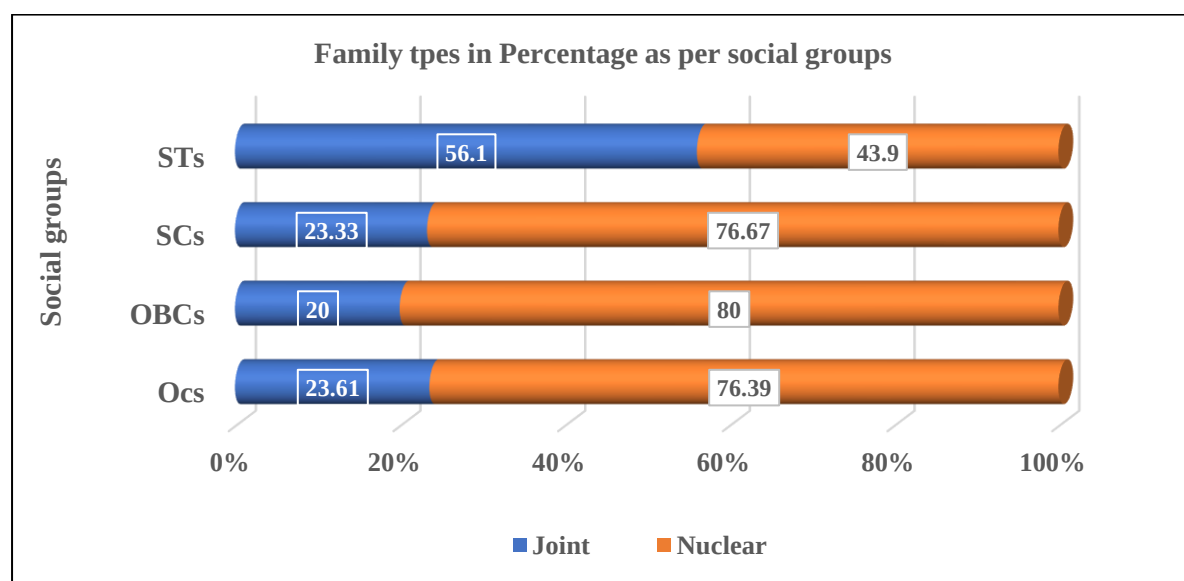
Table 5. 12: Percentages classification of family type according to social groups

Social groups	Joint	Nuclear	Total
OCs	34	110	144
	(23.61)	(76.39)	(100)
OBCs	15	60	75
	(20)	(80)	100
SCs	7	23	30
	(23.33)	(76.67)	(100)
STs	23	18	41
	(56.10)	(43.90)	(100)
Total	79	211	290
	(27.24)	(72.76)	(100)

(Source. Field survey, 2018-19)

Table 5.12 depicts the household classification of family type according to social groups. The family type of households has been divided into two groups: nuclear and joint families. Out of the total sample households, 79 (27.24) percent are Joint Families, and 211 (72.76 %) are nuclear families. Out of the total OCs households, 34 (23.61 %) are joint families, and 110 (76.39 %) are nuclear families. Out of 75 OBCs households, 15 (20.00 %) are joint families, and 60 (80.00 %) are OBC families. Out of 30 SCs households, 7 (23.33 %) are joint families, and 23 (76.67 %) are nuclear families. Out of 41 STs households, 23 (56.10 %) are joint families, and 18 (43.90 %) are nuclear families. Overall, the study reported that maximum families are nuclear and minimum families are Joint.

Figure 5.5: Classifications of social groups according to family type



(Source. Field survey, 2018-19)

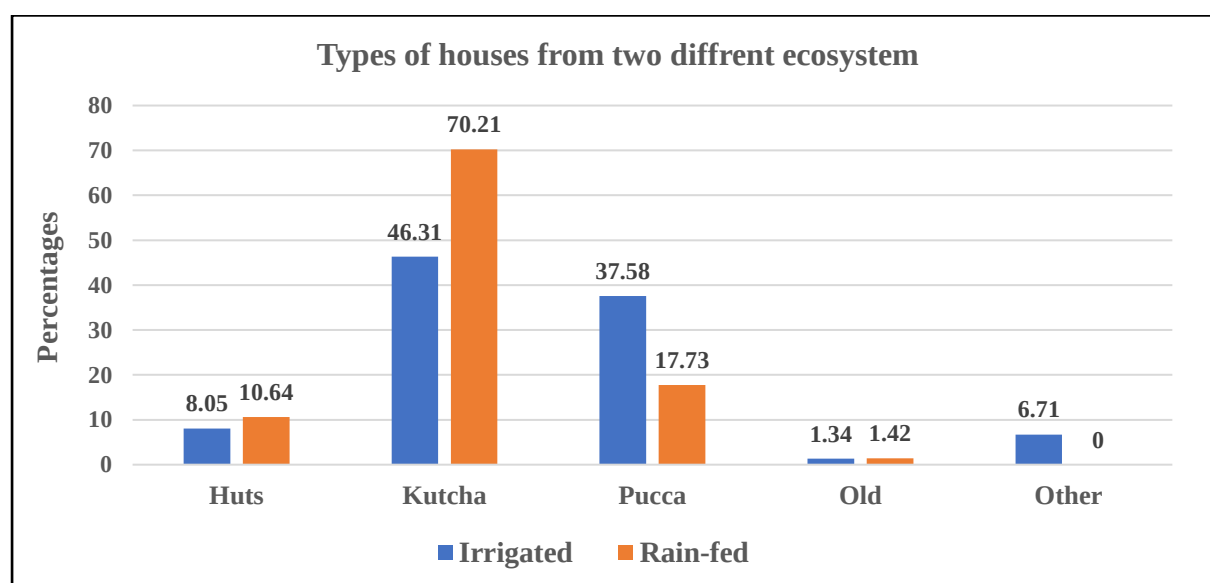
Table 5.13: Types of the houses of sample households in the irrigated and rain-fed village

Village	Huts	Kutchha	Pucca	Old house	Other	Total
Irrigated	12	69	56	2	10	149
	(8.05)	(46.31)	(37.58)	(1.34)	(6.71)	(100)
Rain-fed	15	99	25	2	0	141
	(10.64)	(70.21)	(17.73)	(1.42)	(0)	(100)
Total	27	168	81	4	10	290
	(9.31)	(57.93)	(27.93)	(1.38)	(3.45)	100

(Source. Field survey, 2018-19)

The above table 5.13 shows the housing condition of households among the irrigated and rain-fed villages. It is identified that 149 households of irrigated villages, 12 (8.05 %) houses are huts, 69 (46.31 %) are kutchha houses, 56 (37.58 %) are pucca houses, 2 (1.34 %) are old houses, and 10 (6.71 %) houses are other types. Furthermore, 141 households of the rain-fed villages, 15 (10.64 %) are huts, 99 (70.21 %) are kutchha houses, 25 (17.73 %) are pucca houses, and 2 (1.42 %) are old houses. Out of the total sample size households, 27 (9.31%) houses are huts, 168 (57.93 %) houses are kutchha, 81 (27.93 %) are pucca houses, 4 (1.38 %) are old houses, and 10 (3.45 %) are other types of houses. Overall, the table highlighted that kutchha houses are more than any other kind of houses in both irrigated and rain-fed villages. In the irrigated village, pucca houses more than the rain-fed village. Only four old houses have existed among the total sample.

Figure 5.6: Types of the houses of the sample households in the irrigated and rain-fed village



(Source. Field survey, 2018-19)

Table 5.14: Classification of houses by landholding size

Landholding size	Huts	Kutcha	Pucca	Old	Other	Total
Marginal	6 (7.32)	50 (60.98)	25 (30.49)	0 (0)	1 (1.22)	82 (100)
Small	11 (10.19)	65 (60.19)	24 (22.22)	4 (3.7)	4 (3.7)	108 (100)
Medium	8 (11.94)	38 (56.72)	16 (23.88)	0 (0)	5 (7.46)	67 (100)
Large	2 (6.06)	15 (45.45)	16 (48.48)	0 (0)	0 (0)	33 (100)
Total	27 (9.31)	168 (57.93)	81 (27.93)	4 (1.38)	10 (3.45)	290 (100)

(Source. Field survey, 2018-19)

Above table 5.14 shows the housing conditions of farm households according to landholding size. It is reported that out of 82 marginal farmer's households, 6 (7.32 %) have lived in huts, 50 (60.98 %) have kutcha houses, 25 (30.49 %) have pucca houses, and only 1 (1.22 %) have another kind of houses. Total of 108 small farmer's households, 11(10.19 %) are lived in hut, 65 (60.19 %) have kutcha houses, 24 (22.22 %) have pucca houses, 4 (1.38 %) are old houses, and 10 (3.45 %) are other types of houses. In addition to, 67 households of marginal farmers, 8 (11.94 %) are lived in huts, 38 (56.72 %) are lived in kutcha houses, 16 (23.88 %) are lived Pucca houses, and 5 (7.46 %) are lived in other kinds of houses. Finally, total 33 large farmer's households, 2 (6.06 %) have huts, 15 (45.45) percent live in kutcha houses, and 16 (48.48 %)

live in pucca houses. Overall, table 5.12 depicts that, out of 33 large farmers, nearly 16 (48.48 %) have Pucca houses. About 50 (60.98 %) and 65 (60.19 %) are marginal, and small farmers have kutcha houses.

Table 5.15: Classification of houses within social groups

Social groups	Huts	Kutcha	Pucca	Old	Other	Total
OCs	19	65	55	3	2	144
	(70.37)	(38.69)	(67.9)	(75.00)	(20.00)	(49.66)
OBCs	3	54	10	1	7	75
	(11.11)	(32.14)	(12.35)	(25.00)	(70.00)	(25.86)
SCs	4	18	8	0	0	30
	(14.81)	(10.71)	(9.88)	(0)	(0)	(10.34)
STs	1	31	8	0	1	41
	(3.7)	(18.45)	(9.88)	(0)	(10)	(14.14)
Total	27	168	81	4	10	290
	(100)	(100)	(100)	(100)	(100)	(100)

Source. Field survey, 2018-19

The above table 5.15 shows the classification of houses within social groups. It is highlighted that out of 27 huts, 19 (70.37 %) huts belong to OCs, 3 (11.11 %) huts belong to OBCs, 4 (14.81 %) huts belong to SCs, and 1 (3.7 %) hut belong to STs. In the category of Kutcha houses, 65 (38.69 %) belong to OCs, 54 (32.14 %) belong to OBCs, 18 (10.71 %) belong to SCs, 31 (18.45 %) belong to STs. Out of 81 pucca houses, 55 (67.9 %) belong to OCs, 10 (12.35 %) belong to OBCs; similarly, 8 (9.88 %) belong to SCs and STs. Finally, out of 4 old houses, 3 (75.00 %) belong to OCs, and only one belongs to OBCs. Overall, the table depicts that OCs have dominant among all kinds of houses.

Table 5.16: Toilet facility available among farmers' households in the both ecosystem

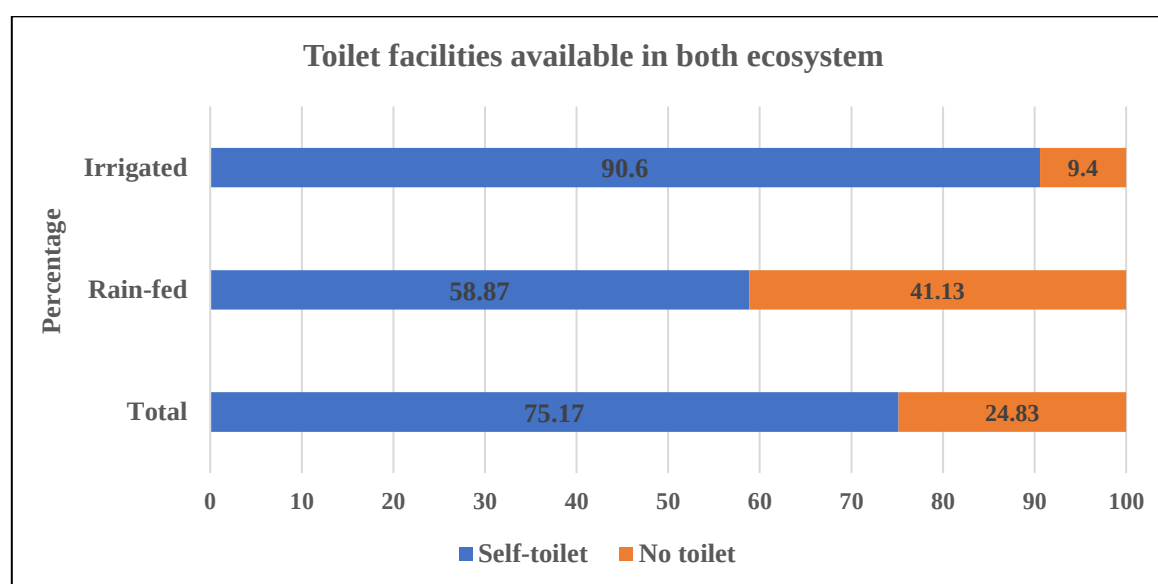
Ecosystem	Self-toilet	No toilet	Total
Irrigated	135	14	149
	(90.60)	(9.40)	(100)
Rain-fed	83	58	141
	(58.87)	(41.13)	(100)
Total	218	72	290
	(75.17)	(24.83)	(100)

(Source. Field survey, 2018-19)

The above table 5.16 highlights the toilet facilities available in the irrigated and rain-fed villages. Out of the total sample households 218 (75.17 %) have toilet facilities available and 72 (24.83 %) does not have toilets. In the irrigated villages toilet facilities are more compared

to rain-fed villages. Out of the total 149 irrigated village, 135 (90.60 %) households have latrine and, in the rain-fed villages only (58.87 %) have toilet facilities.

Figure 5.7: Toilet facilities available in both ecosystem



(Source. Field survey, 2018-19)

Table 5. 17: Toilet facility available among farmers' households according to landholding size

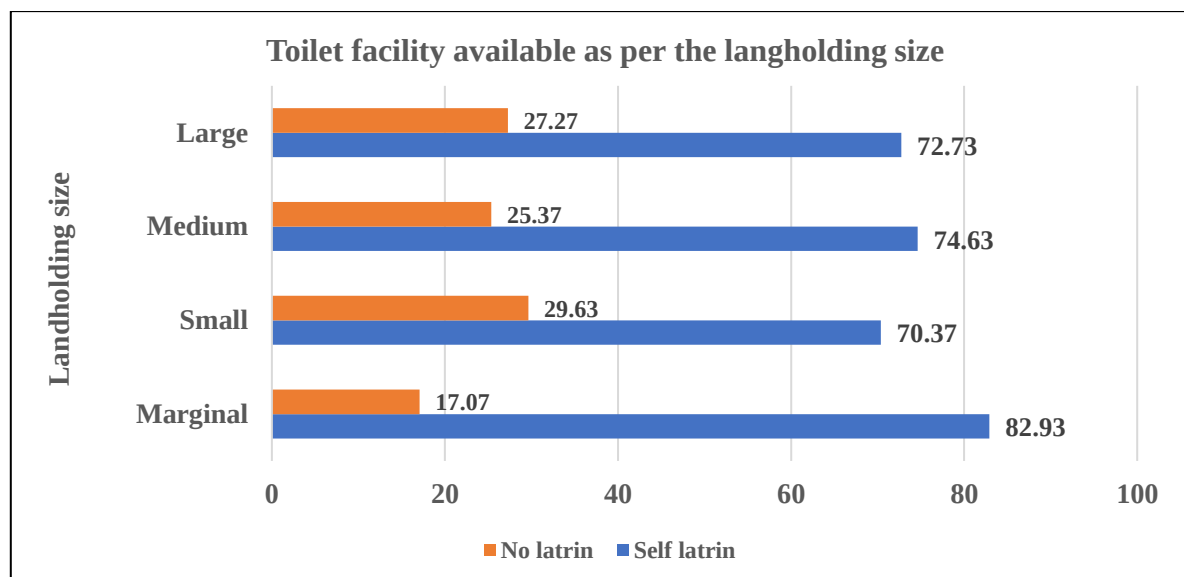
Landholding Size	Self-toilet	No toilet	Total
Marginal	68	14	82
	(82.93)	(17.07)	(100)
Small	76	32	108
	(70.37)	(29.63)	(100)
Medium	50	17	67
	(74.63)	(25.37)	(100)
Large	24	9	33
	(72.73)	(27.27)	(100)
Total	218	72	290
	(75.17)	(24.83)	(100)

(Source. Field survey, 2018-19)

Table 5.17 reveals the toilet facility among the households' farmers by landholding size. It is shown that a total of 82 marginal farmers, 68 (82.93 %) of farmers have toilet facilities, and 14 (17.07 %) have no toilet facility available. Meanwhile, 108 of the small farmers, 76 (70.37 %) of the small farmers have a toilet, and 32 (29.63 %) do not have a latrine facility. Likewise, 67 of medium farmers, 50 (74.63 %) have toilet facilities, and 17 (25.37 %) have no toilets. And lastly, 33 of large farmers, 24 (72.73 %) have toilet facilities, and 9 (27.27 %) have no toilet.

Overall, 218 (75.17 %) of farmers' households have a toilet out of the total sample size, and 72 (24.83 %) have no toilets.

Figure 5.8: Toilet facility available among rural households in irrigated and rain-fed areas



(Source. Field survey, 2018-19)

Table 5. 18: Social group-wise toilet facility available in sample households

Social groups	Self-toilet	No toilet	Total
OCs	130	14	144
	(90.28)	(9.72)	(100)
OBCs	28	47	75
	(37.33)	(62.67)	(100)
SCs	26	4	30
	(86.67)	(13.33)	(100)
STs	34	7	41
	(82.93)	(17.07)	(100)
Total	218	72	290
	(75.17)	(24.83)	(100)

(Source. Field survey, 2018-19)

Table 5.18 illustrates the social group-wise toilet facility available in sample households in the both ecosystems. It is highlighted that out of total 144 OCs households, 130 (90.28 %) have toilet facilities, out of the 75 OBCs households 28 (37.33 %) have self-toilets, 26 (86.67) SCs and 34 (82.93) have toilets available.

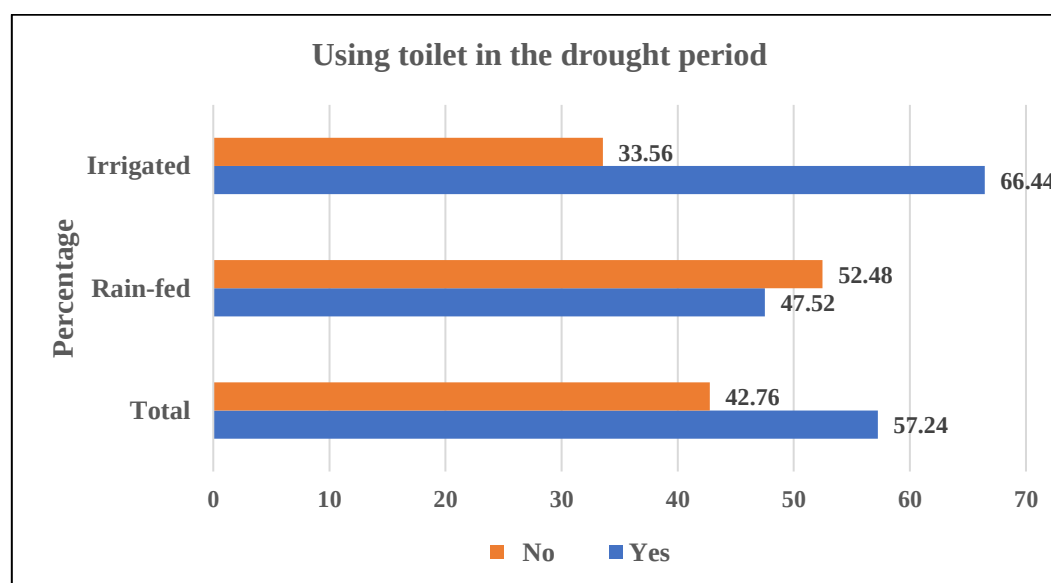
Table 5. 19: Percentage of the households that used toilets in the drought period in both ecosystem

Ecosystems	Yes	No	Total
Irrigated	99	50	149
	(66.44)	(33.56)	(100)
Rain-fed	67	74	141
	(47.52)	(52.48)	(100)
Total	166	124	290
	(57.24)	(42.76)	(100)

(Source. Field survey, 2018-19)

Table 5.19 Percentage of the households which have used toilets in the drought period in both ecosystems. Out of 290 households, 166 (57.24) have used toilets in the drought, then out of 149 irrigated households 99 (66.44) have used the toilet and out of 141 rain-fed village households only 67 (47.52) have used toilets due to water scarcity.

Figure 5.9: Using toilets in the drought in the both ecosystem



(Source. Field survey, 2018-19)

Table 5. 20: Various drinking water sources of households used in the drought period from the two different ecosystems (irrigated and rain-fed villages)

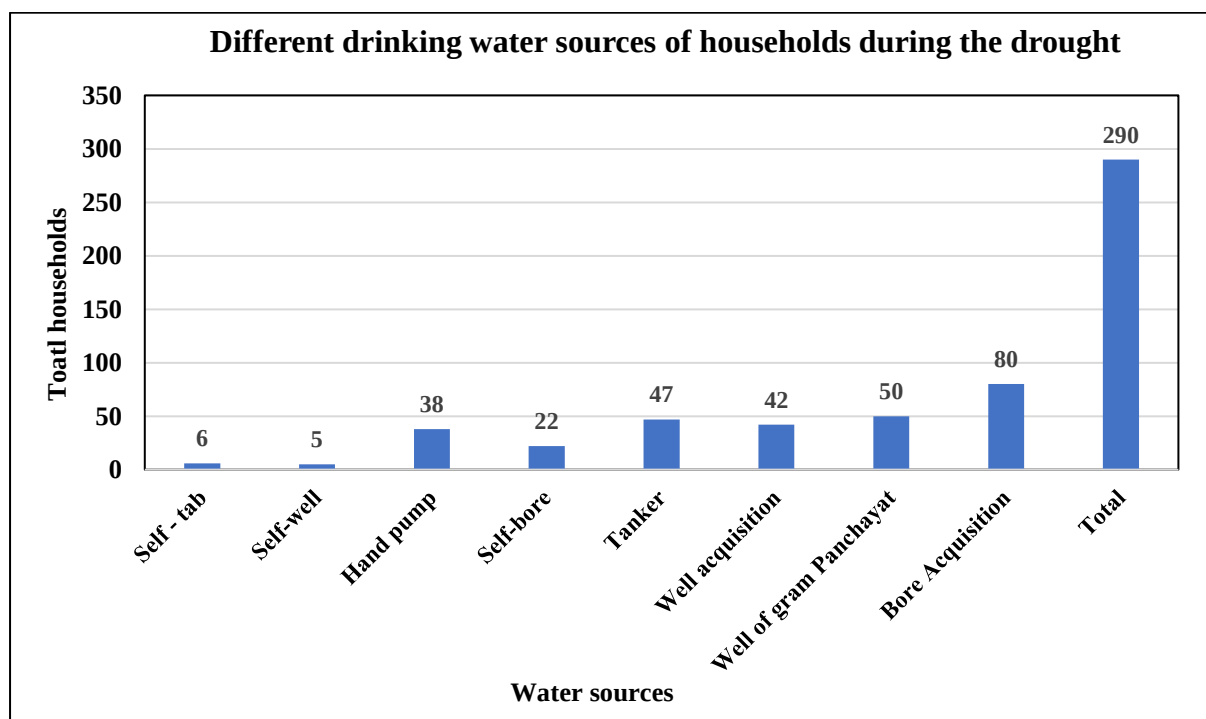
Ecosystem	Self - tab	Self-well	Hand pump	Self-Bore	Water tanker	Well acquisition	Well of gram Panchayat	Bore Acquisition	Total
Irrigated	6	5	38	18	0	42	0	40	149
	(4.03)	(3.36)	(25.5)	(12.08)	(0)	(28.19)	(0)	(26.85)	(100)
Rain-fed	0	0	0	4	48	0	50	40	141
	(0)	(0)	(0)	(2.84)	(33.33)	(0)	(35.46)	(28.37)	(100)
Total	6	5	38	22	47	42	50	80	290

	(2.07)	(1.72)	(13.1)	(7.59)	(16.21)	(14.48)	(17.24)	(27.59)	(100)

(Source. Field survey, 2018-19) (Note: bore = borewell)

The above table 5.20 depicts the different drinking water sources of households in the drought period from the two different ecosystems (irrigated and rain-fed villages). Out of the total sample households, only 6 (4.03 %) of households have a self-water tab, 5 (1.72 %) of households have self well, 22 (7.59 %) households have borewell facility. Furthermore, 38 (13.10 %) of households fetched water from the Gram panchayat hand pump, 47 (16.21 %) households fetched from government water tanker. Likewise, 42 (14.48 %) households fetched water from gram panchayat well acquisition, 50 (17.24 %) household fetched ware from gram panchayat well which was reported second highest percentages. Finally, 80 (27.59 %) households fetched water from a private bore that reported the highest number of households percentages among all water sources. It was also acquired by the gram panchayat. In the drought period, households fetched water from different water resources, which the local government managed. They also fetched water from outside the village when the local government filed to provide it.

Figure 5.10: Different drinking water sources of households in the drought period from the two different ecosystems (irrigated and rain-fed villages)



(Source. Field survey, 2018-19)

Table 5. 21: Classifications of drinking water sources according to landholding from the two different ecosystems (irrigated and rain-fed villages)

Landholding size	Self-tab	Self-well	Hand pump	Self-Bore	Tanker	Well acquisition	Well of gram panchayat	Bore acquisition	Total
Marginal	0	0	22	2	10	17	7	24	82
	(0)	(0)	(26.83)	(2.44)	(12.2)	(20.73)	(8.54)	(29.27)	(100)
Small	1	1	15	5	22	15	24	25	108
	(0.93)	(0.93)	(13.89)	(4.63)	(20.37)	(13.89)	(22.22)	(23.15)	(100)
Medium	2	3	1	6	11	10	14	20	67
	(2.99)	(4.48)	(1.49)	(8.96)	(16.42)	(14.93)	(20.9)	(29.85)	(100)
Large	3	1	0	9	4	0	5	11	33
	(9.09)	(3.03)	(0)	(27.27)	(12.12)	(0)	(15.15)	(33.33)	(100)
Total	6	5	38	21	47	42	50	80	290
	(2.07)	(1.72)	(13.1)	(7.59)	(16.21)	(14.48)	(17.24)	(27.59)	(100)

(Source. Field survey, 2018-19)

According to landholding size from the two different ecosystems (irrigated and rain-fed), the above table highlights the classifications of drinking water sources. Overall, the table reported that most of the farm households fetched water from different sources. Only a few marginal, medium and large farmers' households have their water sources such as self-tab, self-well, and self-bore. It also depicts that most of the marginal farmers households were entirely dependent on local water resources management. Government lead agencies are, such as state government departments of water supply, irrigation, rural development, public health engineering, relief, and the district administration all were involved in water supply ([Drought manual, 2016](#)).

Table 5.22: Social groups-wise classification of drinking water sources from the two different ecosystems (irrigated and rain-fed)

Social groups	Self-tab	Self-well	Hand pump	Self bore	Tanker	Well acquisition	Well gram panchayat	Bore acquisition	Total
OCs	5	5	27	12	0	16	43	36	144
	(3.47)	(3.47)	(18.75)	(8.33)	(0)	(11.11)	(29.86)	(25.00)	(100)
OBCs	1	0	2	9	45	16	0	2	75
	(1.33)	(0)	(2.67)	(12.00)	(60.00)	(21.33)	(0)	(2.67)	(100)
SCs	0	0	9	1	2	8	7	3	3)
	(0)	(0)	(30)	(3.33)	(6.67)	(26.67)	(23.33)	(10)	(100)
STs	0	0	0	0	0	2	0	39	41
	(0)	(0)	(0)	(0)	(0)	(4.88)	(0)	(95.12)	(100)
Total	6	5	38	22	47	42	50	80	290
	(2.07)	(1.72)	(13.1)	(7.59)	(16.21)	(14.48)	(17.24)	(27.59)	(100)

(Source: Field survey, 2018-19)

The above table 5.22 describes the social group's wise classification of drinking water sources from the two different ecosystems (irrigated and rain-fed). Total of 144 OCs households, 36 (25.00 %) were fetched from bore acquisition, 43 (29.86 %) households were fetched from well of the gram panchayat, 16 (11.11 %) household fetched water from Well acquisition, 27 (18.75 %) households were fetched from the Hand pump. Furthermore, 12 (8.33) percent of households have a self- bore, and 5 (3.47) percent of households have both self-tab and self-well. Some of the household members have fetched water from the local government-managed water sources.

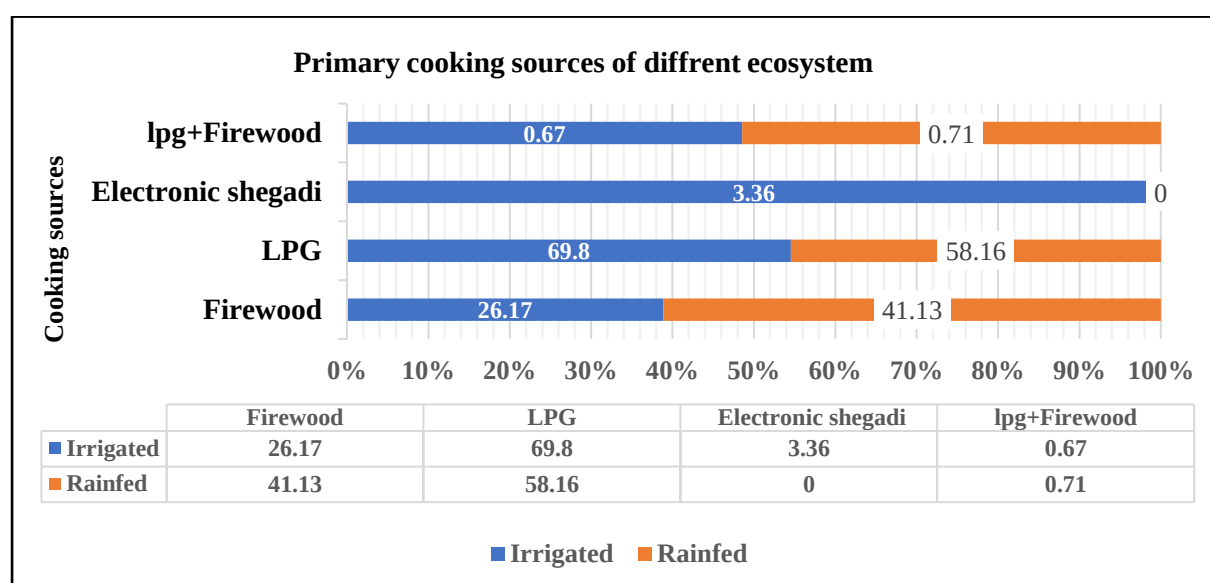
Table 5.23: Primary sources of cooking in the irrigated and rain-fed villages

Ecosystems	Firewood	LPG	Electronic Shegadi	LPG + Firewood	Total
Irrigated	39	104	5	1	149
	(26.17)	(69.8)	(3.36)	(0.67)	(100)
Rain-fed	58	82	0	1	141
	(41.13)	(58.16)	(0)	(0.71)	(100)
Total	97	186	5	2	290
	(33.45)	(64.14)	(1.72)	(0.69)	(100)

(Source. Field survey, 2018-19)

The above table 5.23 shows the primary sources of information on cooking facilities available to farm households in irrigated and rain-fed villages. Out of the total sample of farm households, 97 (26.17 %) households cooking depend on firewood, 186 (64.14 %) households are used LPG (Liquefied Petroleum Gas), 5 (1.72 %) households are used Electronic Shegadi, and only 2 (0.69 %) households are used both cooking sources. It reported that rain-fed village households used more firewood than the irrigated villages, and Irrigated households have more LPG connections than rain-fed village households.

Figure 5.11: Primary sources of cooking in the irrigated and rain-fed village



(Source. Field survey, 2018-19)

Table 5. 24: Classifications of social groups according to primary cooking sources

Social groups	Firewood	LPG	Electronic Shegadi	LPG + Firewood	Total
OCs	43	96	5	0	144
	(29.86)	(66.67)	(3.47)	(0)	(100)
OBCs	38	36	0	1	75
	(50.67)	(48)	(0)	(1.33)	(100)
SCs	13	16	0	1	30
	(43.33)	(53.33)	(0)	(3.33)	(100)
STs	3	38	0	0	41
	(7.32)	(92.68)	(0)	(0)	(100)
Total	97	186	5	2	290
	(33.45)	(64.14)	(1.72)	(0.69)	(100)

(Source. Field survey, 2018-19)

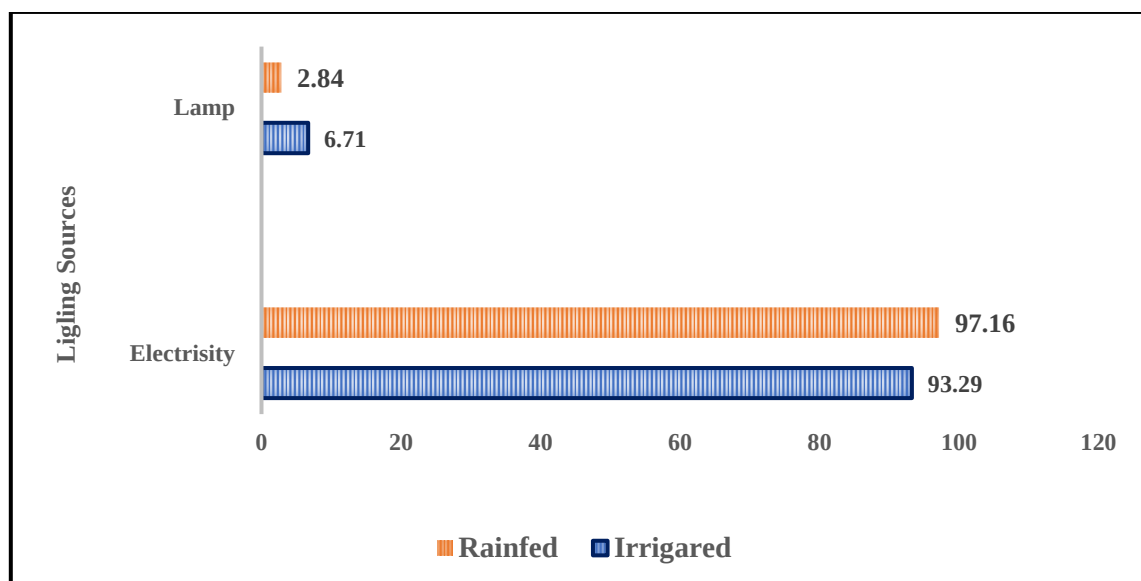
Above table 5.24 illustrates the information of primary cooking sources according to social groups. Out of the total OCs farm households, 43 (29.86 %) households cooking depend on firewood, 96 (66.67 %) have LPG connections, and 5 (3.47 %) used electronic shegadies. A total of 75 OBCs farm households, 38 (50.67 %) depended on firewood, 36 (48 %) have LPG connections, and only one household used both sources. Out of 30 SCs farm households, 13 (43.33 %) cooking depends on firewood, and 16 (53.33 %) have LPG connections. Lastly, 41 STs farm households, 3 (7.32 %) have depended on firewood, and 38 (92.68 %) have LPG gas connections.

Table 5.25: Main lighting sources of households in the different ecosystem

Ecosystem	Electricity	Lamps	Total
Irrigated	139	10	149
	(93.29)	(6.71)	(100)
Rain-fed	137	4	141
	(97.16)	(2.84)	(100)
Total	276	14	290
	(95.17)	(4.83)	(100)

(Source. Field survey, 2018-19)

The above table 5.25 shows the households' lighting status in the irrigated and rain-fed village. It has been observed that around 276 (95.17 %) households have been using electricity at their houses from Maharashtra State Electricity Board. Only 14 (4.83 %) households do not have electricity connections. Furthermore, it is observed that most of the households have electricity connections; only a few households do not have connections because some of them live away from the villages, or some of them live in their farms.

Figure 5.12: Main lighting sources of households

(Source. Field survey, 2018-19)

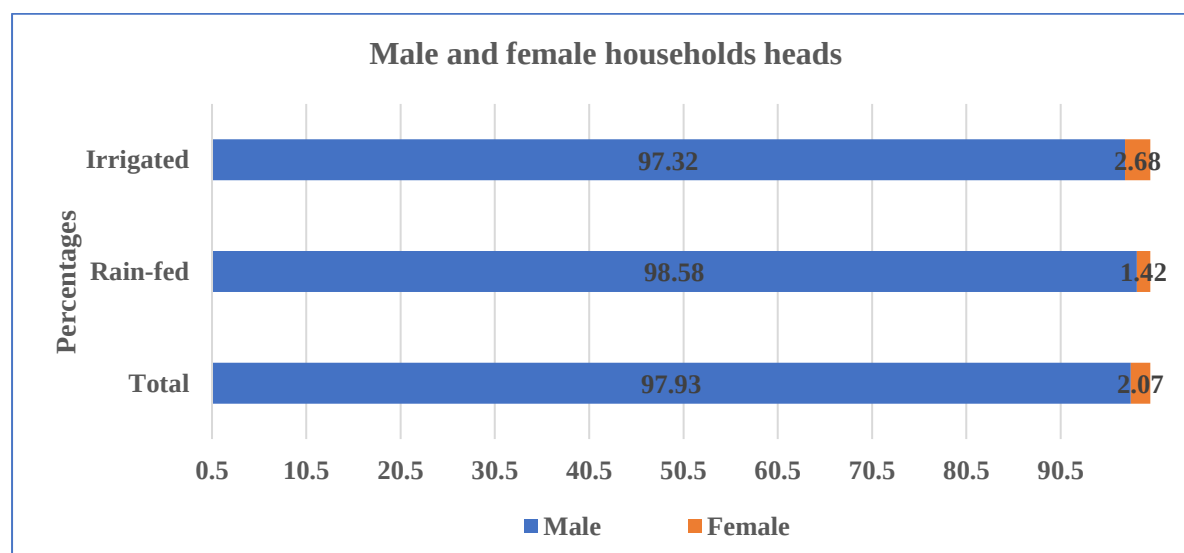
Table 5.26: Male and female heads out of the total households in the study area

Household heads	Male	Female	Total
Irrigated	145	4	149
	(97.32)	(2.68)	(100)
Rain-fed	139	2	141
	(98.58)	(1.42)	(100)
Total	284	6	290
	(97.93)	(2.07)	(100)

(Source. Field survey, 2018-19)

Table 5.26 describes that total male and female households' heads in the study area. It is highlighted that out of the total household heads 284 (97.93 %) are male head and only 6 (2.07 %) are the female heads. In the irrigated village 145 (97.32 %) are male and 4 (2.68 %) are the female. In the rain-fed village 139 (98.58 %) are male and only (1.42 %) are female.

Figure 5.13: Male and female households head out of the total households



(Source. Field survey, 2018-19)

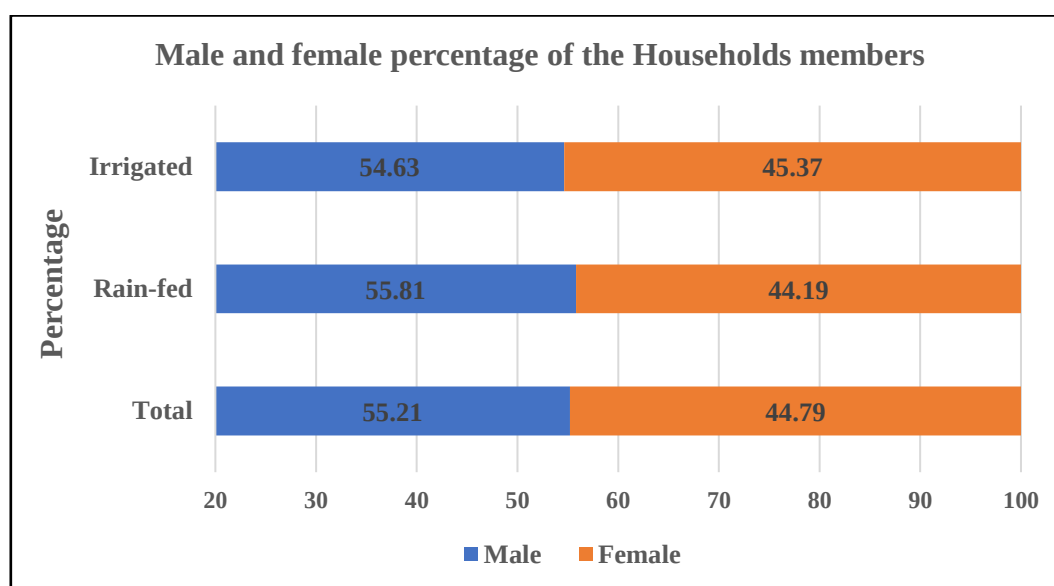
Table 5.27: Male and female percentage of the total households' members in the study area

Gender	Male	Female	Total
Irrigated	401	333	734
	(54.63)	(45.37)	(100)
Rain-fed	389	308	697
	(55.81)	(44.19)	(100)
Total	790	641	1,431
	(55.21)	(44.79)	(100)

(Source. Field survey, 2018-19)

Table 2.27 describes the male and female percentage of the total households' members in the study area. It is found that out of the total 1,431 households' members, 790 (55.21%) are males and 641 (44.79 %) are female. In the irrigated village out of the total households' members 401 (54.63 %) are male and 333 (45.37 %) females. And in the rain-fed village out of the total sample households, 389 (55.81 %) are male and 308 (44. 19 %) are the female.

Figure 5.14: Male and female percentages of the total households' members in the study area



(Source. Field survey, 2018-19)

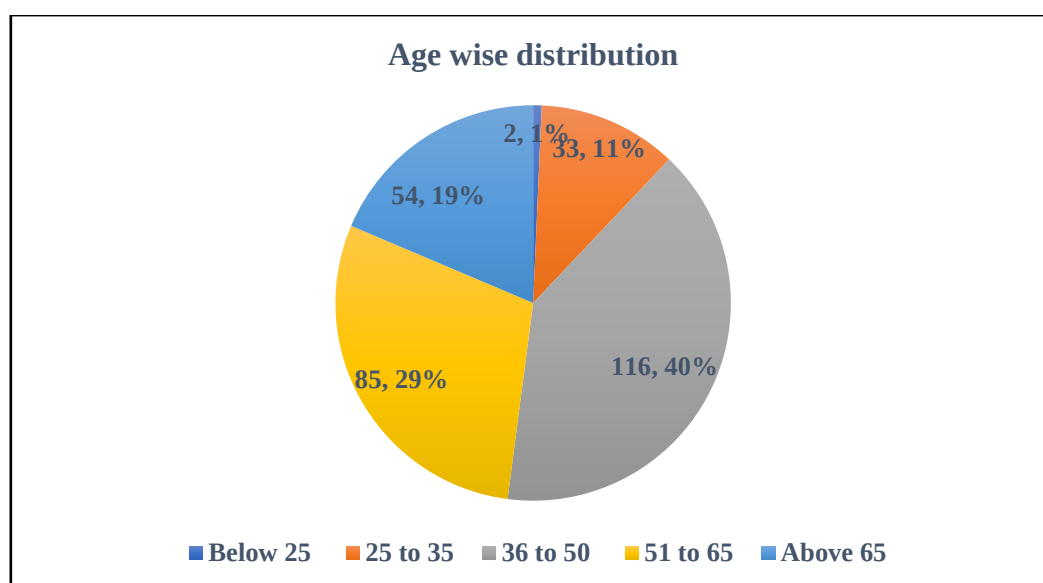
Table 5.28: Age-wise distribution of rural farm household heads in irrigated and rain-fed villages

Age groups	Below 25	25 to 35	36 to 50	51 to 65	Above 65	Total
Irrigated	0	23	57	43	26	149
	(00.00)	(15.44)	(38.26)	(28.86)	(17.45)	(100)
Rain-fed	2	10	59	42	28	141
	(1.42)	(7.09)	(41.84)	(29.79)	(19.86)	(100)
Total	2	33	116	85	54	290
	(0.69)	(11.88)	(40.00)	(29.31)	(18.62)	(100)

(Source. Field survey, 2018-19)

The above table 5.28 describes the age-wise distribution among rural households in the study area. It is observed that 116 (40.00 %) households heads come between the age group 36 to 50, which is the highest among all age groups. Then 85 (29.31 %) of households' head comes between the age group of 51 to 65, followed by 54 (18.62 %) of household heads above the age of 65, while 33 (11.88 %) of the households head is between 25 to 35, and only two household heads age is below 25 which is lowest among all age group.

Figure 5.15: Age-wise distribution among all sample household heads in the study area



(Source. Field survey, 2018-19)

Table 5.29: Marital status of households' heads in both irrigated and rain-fed regions

Villages areas	single	Married	Widow	Separate	Widower	Total
Irrigated	0	140	3	1	5	149
	(0)	(93.96)	(2.01)	(0.67)	(3.36)	(100)
Rain-fed	1	136	2	0	2	141
	(0.71)	(96.45)	(1.42)	(0.00)	(1.42)	(100)
Total	1	276	5	1	7	290
	(0.34)	(95.17)	(1.72)	(0.34)	(2.41)	(100)

(Source. Field survey, 2018-19)

The above table 5.29 describes the marital status of households heads in both irrigated and rain-fed regions. Out of 290 sample farm households in both areas, 276 (95.17 %) were married, 7 (2.41 %) were widowers, 5 (1.72 %) were widows, and only one household head was single and separate. It is found that most of the heads of the household were married in both irrigated and rain-fed areas.

Table 5.30: Marital status of the household heads according to landholding size in irrigated and rain-fed regions

Landholding size	single	Married	Widow	Separate	Widower	Total
Marginal	0	77	2	1	2	82
	(0)	(93.90)	(2.44)	(1.22)	(2.44)	(100)
Small	0	104	2	0	2	108
	(0)	(96.30)	(1.85)	(0.00)	(1.85)	(100)
Medium	1	62	1	0	3	67

	(1.49)	(92.54)	(1.49)	(0.00)	(4.48)	(100)
Large	0	33	0	0	0	33
	(0.00)	(100)	(0.00)	(0.00)	(0.00)	100
Total	1	276	5	1	7	290
	(0.34)	(95.17)	(1.72)	(0.34)	(2.41)	(100)

(Source. Field survey, 2018-19)

The above table 5.30 shows the marital status of the household heads according to landholding size in irrigated and rain-fed villages areas. The table depicts that most of the heads of the household were married as per marginal, small, medium, and large landholding size. Only single household heads are not married, 5 are widows, one is separate, and 7 are widowers.

Table 5.31: The marital status of the household heads according to landholding size in irrigated and rain-fed villages areas

Social groups	Single	Married	Widow	Separate	Widower	Total
OCs	0	137	1	0	6	144
	(0.00)	(95.14)	(0.69)	(0.00)	(4.17)	(100)
OBC	1	72	2	0	0	75
	(1.33)	(96)	(2.67)	(0.00)	(0.00)	(100)
SC	0	27	2	1	0	30
	(0.00)	(90.00)	(6.67)	(3.33)	(0.00)	100
ST	0	40	0	0	1	41
	(0.00)	(97.56)	(0.00)	(0.00)	(2.44)	(100)
Total	1	276	5	1	7	290
	(0.34)	(95.17)	(1.72)	(0.34)	(2.41)	(100)

(Source. Field survey, 2018-19)

The above table 5.31 shows the marital status of the household heads according to social groups in irrigated and rain-fed villages areas. The table depicts that most of the heads of the household were married in all social groups such as Open, OBC, SCs, and STs.

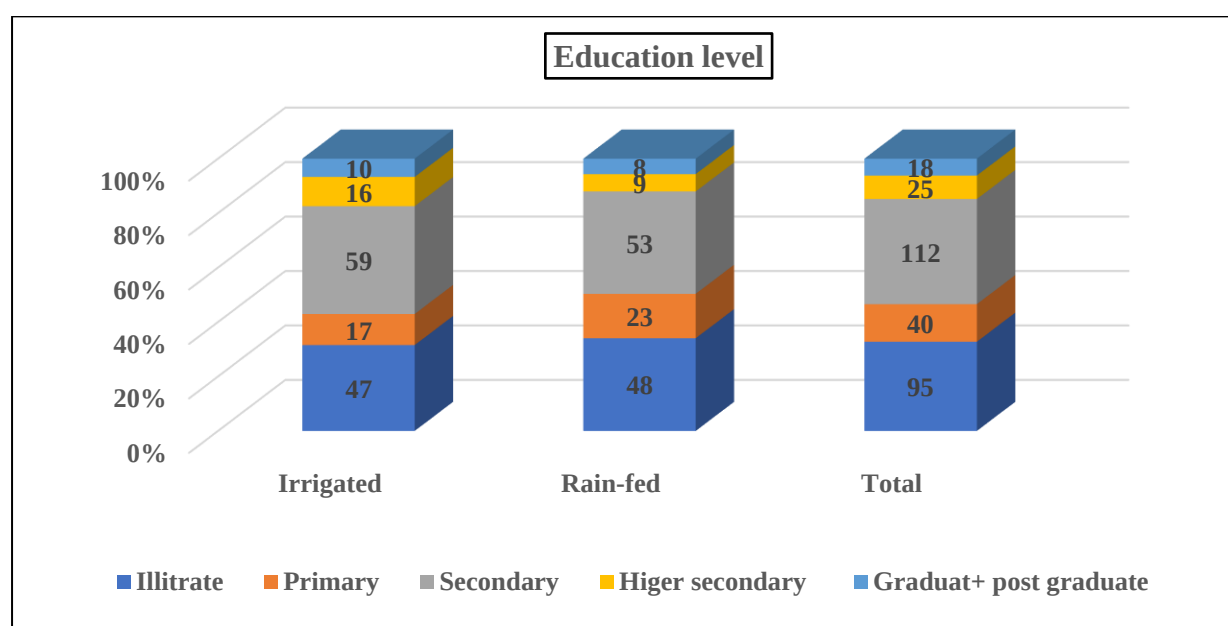
Table 5.32: Education level status of households heads among the irrigated and rain-fed villages

Education level	Illiterate	Primary (1 to 4)	Secondary (5 to 10)	Higher secondary (11 to 12)	Graduate+ post graduate	Total
Irrigated	47	17	59	16	10	149
	(31.54)	(11.41)	(39.60)	(10.74)	(6.71)	(100)
Rain-fed	48	23	53	9	8	141
	(34.04)	(16.31)	(37.59)	(6.38)	(5.67)	(100)
Total	95	40	112	25	18	290
	(32.76)	(13.79)	(38.62)	(8.62)	(6.21)	(100)

(Source. Field survey, 2018-19)

The above table 5.32 describes the education level of households heads among the irrigated and rain-fed regions. It is stated that out of the entire sample of households, heads 95 (32.76 %) have do not educated (illiterate, never goes to school or colleges), their percentage is in irrigated villages is 47 (31.54 %) and 48 (34.04 %) are in rain-fed villages. Nearly 40 (13.79 %) households heeds have completed their primary education, 17 (11.41 %) are from irrigated, and 23 (16.31%) are from rain-fed. About 112 (38.62 %) of households heads have done their secondary education, 59 (39.60 %), from irrigated and 53 (37.59 %) from rain-fed respectively. After that, 25 (8.62 %) households heads completed their higher secondary education, 16 (10.74 %) are from irrigated areas, and 9 (8.62 %). Finally, only 18 (6.21 %) households heads completed their higher education like graduate and post-graduates, 10 (6.71 %), from irrigated and 8 (5.67 %) from rain-fed villages. It is observed that most of the farm households heads are illiterate and higher education percentage is low in both areas.

Figure 5.16: Education level status of households heads among the irrigated and rain-fed villages



(Source. Field survey, 2018-19)

Table 5.33: Education level status of households heads among marginal, small, medium, and large farmers in the irrigated and rain-fed villages

Landholding size	Illiterate	Primary (1 to 4)	Secondary (5 to 10)	Higher secondary (11 to 12)	Graduate+ post-graduate	Total
Marginal	26	14	31	4	7	82
	(31.71)	(17.07)	(37.80)	(4.88)	(8.54)	(100)
Small	39	19	37	9	4	108

	(36.11)	(17.59)	(34.26)	(8.33)	(3.7)	(100)
medium	23	6	28	8	2	67
	(34.33)	(8.96)	(41.79)	(11.94)	(2.99)	(100)
Large	7	1	16	4	5	33
	(21.21)	(3.03)	(48.48)	(12.12)	(15.15)	(100)
Total	95	40	112	25	18	290
	(32.76)	(13.79)	(38.62)	(8.62)	(6.21)	(100)

(Source. Field survey, 2018-19)

The above table 5.33 described the education level status of farm households heads among marginal, small, medium, and large farmers in the irrigated and rain-fed villages. It is identified that among all landholding groups, more households' heads have illiterate and do not have highly educated.

Table 5.34: Occupational status of farm household heads in irrigated and rain-fed villages

Cultivators /Farmers	Cultivators + Self-bossiness	Housewife + farmers	Cultivator + Student	Cultivator +livestock	Cultivator + Causal labour in farm sector	Cultivator + Causal labour In non-farm sector	Cultiv. +other occup.	Cultiv. +Govt. servant	Total
124	4	1	3	2	5	5	4	1	149
(83.22)	(2.68)	(0.67)	(2.01)	(1.34)	(3.36)	(3.36)	(2.68)	(0.67)	(100)
131	0	0	1	0	0	2	3	4	141
(92.91)	(0.00)	(0.00)	0.71	(0.00)	(0.00)	(1.41)	(2.13)	(2.84)	(100)
255	4	1	4	2	5	7	7	5	290
(87.93)	(1.38)	(0.34)	(1.38)	(0.69)	(1.72)	(2.41)	(2.41)	(1.72)	(100)

(Source. Field survey, 2018-19, Note: Cultiv. = Cultivator)

Table 5.34 describes the occupation-wise status of farm households heads in irrigated and rain-fed villages. It is reported that out of the total sample size 255 (87.93 %) are main farmers who have been cultivating only farm without any additional occupations, 4 (1.34 %) are cultivators and their additional business such as welding shops, seeds shops, pan shops, small hotel, Kirana shops etc. Then 4 (1.34 %) are cultivators as well as studding in colleges, 2 (0.69 %) are cultivators, but the main occupation is livestock rearing, 5 (1.72 %) are cultivators plus causal labour in the farm sector, while 7 (2.41 %) are cultivators and causal labour in the non-farm sector. Followed by 7 (2.41 %) are cultivators with other business such as Kirana shops, small hotels, Pan shops, etc. and 5 (1.72 %) are cultivators plus government servants; only one

household's heads are a housewife. Most of the household's heads totally depend on agriculture farming without any side businesses.

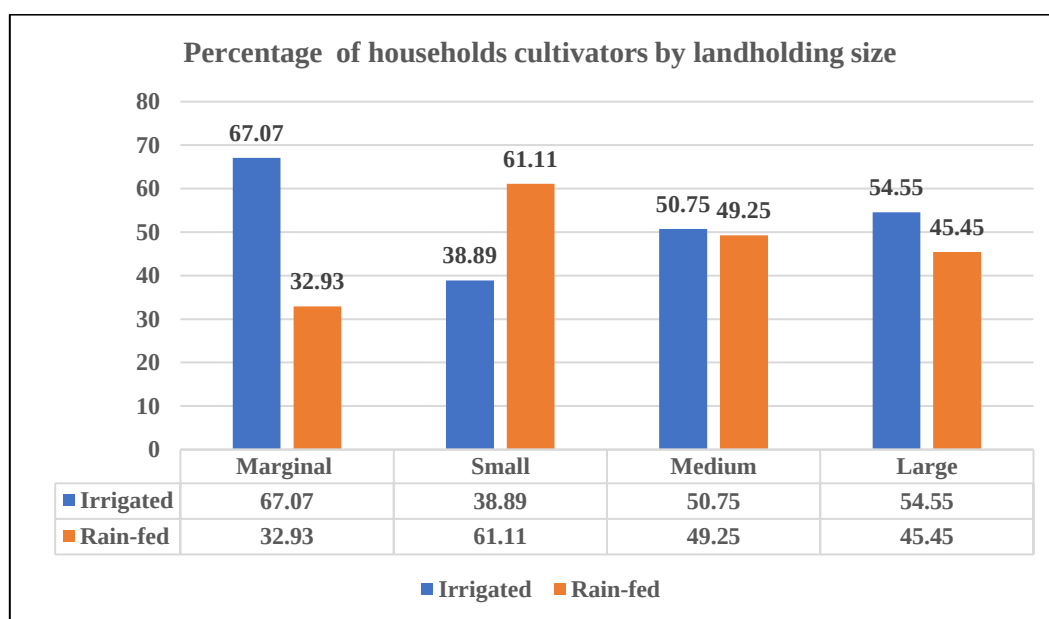
Table 5.35: Classification of household cultivators by landholding size

Landholding size	Irrigated	Rain-fed	Total
Marginal	55	27	82
	(67.07)	(32.93)	(100)
Small	42	66	108
	(38.89)	(61.11)	(100)
Medium	34	33	67
	(50.75)	(49.25)	(100)
Large	18	15	33
	(54.55)	(45.45)	(100)
Total	149	141	290
	(51.38)	(48.62)	(100)

(Source. Field survey, 2018-19)

Table 5.35 shows the row wise classification of rural farm households according to landholding size. It is calculated percentage in accordance with total landholding size in each category of irrigated and rain-fed village. It is highlighted that out of 290 households, 149 (51.38 %) are from irrigated villages, and 141(48.64 %) are from rain-fed villages. Then the total of 82 marginal cultivators, 55 (67.07 %) belong to the irrigated village, and 27 (32.93 %) belong to the rain-fed village. After that total of 108 small households' cultivator, 42 (38.89 %) from the irrigated village and 66 (61.11 %) from the rain-fed village. Then the total of 67 medium household cultivators, 34 (50.57 %) of irrigated villages, and 33 (49.25 %) of rain-fed villages. Finally, the total of 33 large household cultivators, 18 (54.55 %) are from irrigated villages, and 15 (45.45 %) are from rain-fed villages. Overall, the table depicts that small cultivators are high and large cultivators are low in number. The Landholding size of the households is based on the Agriculture Census, Ministry of Agriculture Government of India, 2010-11. The same kinds of landholding size patterns used in many studies which have classified into four groups [households with marginal (below 1 hectare), small (1 to 2 hectares), medium (2 to 4 hectors), and large (above 4 hectares)] ([Khetwani et al., 2020](#); [Udmale et al., 2014](#)).

Figure 5.17: Percentages of household cultivators by landholding size



(Source. Field survey, 2018-19)

Table 5.36: Distribution of landholding size according to social groups from irrigated and rain-fed villages areas

Landholding size	OCs	OBCs	SCs	STs	Total
Marginal	40	16	15	11	82
	(48.78)	(19.51)	(18.29)	(13.41)	(100)
Small	46	30	13	19	108
	(42.59)	(27.78)	(12.04)	(17.59)	(100)
Medium	38	21	1	7	67
	(56.72)	(31.34)	(1.49)	(10.45)	(100)
Large	20	8	1	4	33
	(60.61)	(24.24)	(3.03)	(12.12)	(100)
Total	144	75	30	41	290
	(49.66)	(25.86)	(10.34)	(14.14)	(100)

(Source. Field survey, 2018-19)

The above table 5.36 describes the distribution of Landholding size according to social groups from irrigated and rain-fed villages areas. Out of 290 sample farm households, 144 (49.66 %) belonged to the general category (Including Maratha, Pathan Muslim, Brahmin, Lingayat, etc.), 75 (25.86 %) have belonged to the OBCs category (including Mali, Banjara, Wanjara, Dhobi, Dombari, etc.), 30 (10.34%) have belonged to SC category, and 41 (14.14 %) belonged to ST category. The study found that out of 33 large farmers' households, most of the large landholding size farm households belong to the general category that we call the Open category; only 1 (3.03%) and 4 (12.12 %) belonged to the SC and ST category. After that, most

of the medium-size landholding farming groups belonged to the Open category; only 1 (1.49 %) and 7 (10.45 %) were from SCs and STs.

Section II

5.3 Impact of drought on various factors (social, economic and environment) and describes the few governments drought mitigation measures and programmes in the drought

The section two tries to attempt the impact of drought on various factors (social, economic and environment) including, income in normal and drought years, fetching water from long distances, livestock status, fodder situation, agriculture input subsidy, crop insurance status, the loan and debt position, drought impact on school-going children and, out-migration, impact on health, Jalyukt Shivar programme, participation in SHGs, below poverty line status and perceptions of various environment impacts.

Table 5.37: Income level distribution among rural households in the normal year from the irrigated and rain-fed areas

(Villages Areas)	Low-income (Below < 45000)	Lower middle- (46000 to 100000)	Upper-middle (101000 to 200000)	Lower-high (201000 to 300000)	High (300000 < above)	Total
Irrigated	11 (7.38)	60 (40.27)	38 (25.5)	13 (8.72)	27 (18.12)	149 (100)
Rain-fed	17 (12.6)	92 (65.25)	24 (17.02)	6 (4.26)	2 (1.42)	141 (100)
Total	28 (9.66)	152 (52.41)	62 (21.38)	19 (6.55)	29 (10)	290 100

(Source. Field survey, 2018-19)

The above table 5.37 shows the income distribution among rural households in the normal year from the irrigated and rain-fed areas of the three drought-prone districts in the Marathwada region. Out of the total sample size of the study area, 28 (9.66 %) of households have come under the low-income group (below < 45000). About 152 (52.41 %) of the households are in the lower-middle-income group (46000 to 100000). About 62 (21.38 %) of households are in higher lower-income groups (101000 to 200000). About 19 (6.55 %) of households come under the lower high-income group (201000 to 300000), and 29 (10.00 %) of households are in the high-income group (above > 300000). Most high-income group households have existed in the irrigated villages, which are 27 (93.10 %). Only 2 (6.10 %) of households are under high-income groups in the rain-fed villages. Low income and lower-middle-income group's

households are more in the rain-fed village, and upper-middle, lower-high, and high-income group's households are more in the irrigated villages. The above classification of income categories was formed using the World Bank's income group criteria.

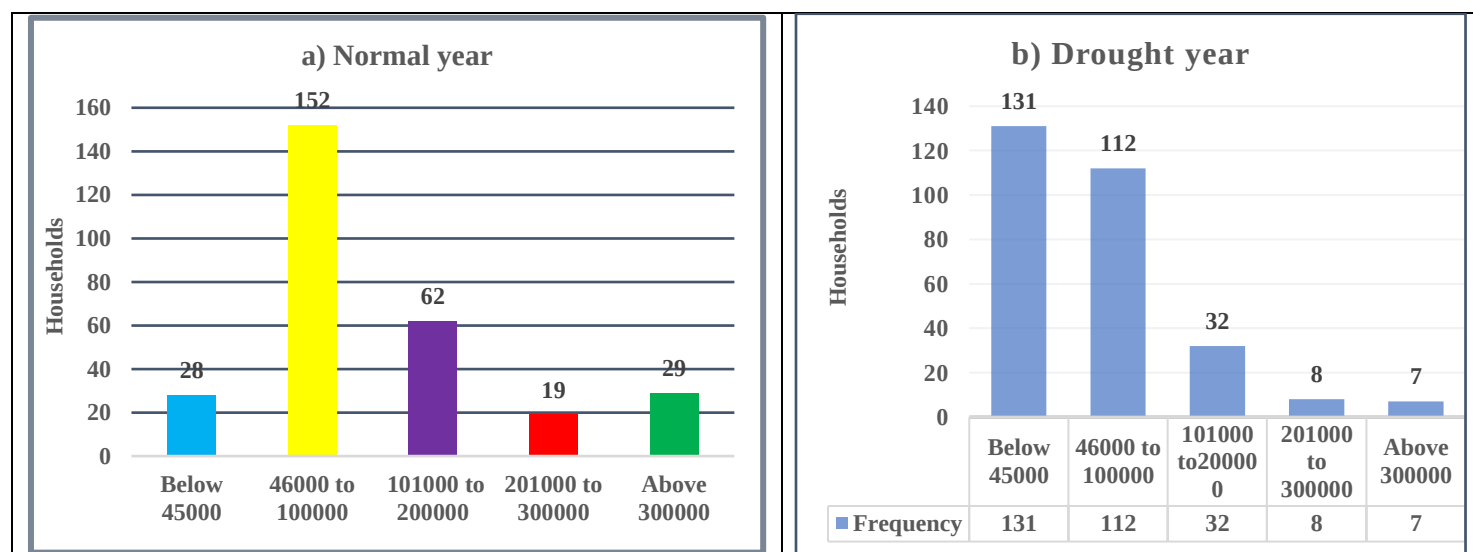
Table 5.38: Income level distribution among rural households in the drought year from the irrigated and rain-fed areas

(Villages Areas)	Low-income (Below < 45000)	Lower middle- (46000 to 100000)	Upper-middle (101000 to 200000)	Lower-high (201000 to 300000)	High (300000 < above)	Total
Irrigated	55	58	21	8	7	149
	(36.91)	(38.93)	(14.09)	(5.37)	(4.7)	(100)
Rain-fed	76	54	11	0	0	(141)
	(53.9)	(38.3)	(7.8)	(0)	(0)	(100)
Total	131	112	32	8	7	290
	(45.17)	(38.62)	(11.03)	(2.76)	(2.41)	(100)

(Source. Field survey, 2018-19)

The above table 5.38 shows the income distribution information between irrigated and rain-fed areas in the drought year. Out of 290 sample households, 131 (45.17 %) were in the low-income group (below 45000). About 112 (38.62 %) of households came under the lower-middle-income group (46000 to 100000). Furthermore, 32 (11.03 %) were in the upper-middle-income group. In the lower high and high-income groups, there were only 15 (5.17 %) households that had obtained 201000 to 30000 and more than 300000 incomes in the irrigated villages. During the drought year, no one household came under lower-high and high-income groups from the rain-fed village.

Figure 5.18: Households income distribution during normal and drought years in the irrigated and rain-fed areas



(Source. Field survey, 2018-19)

Table 5.39: Descriptive statistics of normal and drought years' income (continuous variable)

Years	Obs.	Mean	SD	Min	Max
NY	290	151420.7	167871.4	30000	900000
DY	290	77620.69	74222.81	15000	450000

(Source. Field survey, 2018-19), Note: NY- Normal year, DY –Drought year

Table 5.39 illustrates income distribution during normal and drought years. It shows that most household income falls into the low and lower-middle-income groups during the drought year. Only a few households are in the lower-high and high-income groups, which is from the irrigated areas.

Table 5.40: Distribution of income level according to landholding size in the normal year

Landholding size	Low-income (Below < 45000)	Lower middle- (46000 to 100000)	Upper-middle (101000 to 200000)	Lower-high (201000 to 300000)	High (300000 < above)	Total
Marginal	23	53	6	0	0	82
	(28.05)	(64.63)	(7.32)	(0)	(0)	(100)
Small	5	76	24	3	0	108
	(4.63)	(70.37)	(22.22)	(2.78)	(0)	(100)
Medium	0	23	25	8	11	67
	(0)	(34.33)	(37.31)	(11.94)	(16.42)	(100)
Large	0	0	7	8	18	33

	(0)	(0)	(21.21)	(24.24)	(54.55)	(100)
Total	28	152	62	19	29	290
	(9.66)	(52.41)	(21.38)	(6.55)	(10.0)	(100)

(Source. Field survey, 2018-19)

The above table 5.40 shows the distribution of income levels in order to landholding size. The table reported that the maximum number of marginal and small landholding households came under low, lower-middle, and upper-middle-income groups. Furthermore, a minimum number of medium and large landholding households came under the low and lower-middle-income groups.

Table 5.41: Category wise and income groups wise analysis of rural households in the normal year from the irrigated and rain-fed areas

Social groups	Low-income (Below < 45000)	Lower middle- (46000 to 100000)	Upper-middle (101000 to 200000)	Lower-high (201000 to 300000)	High (300000 < above)	Total
OCs	11	61	38	12	22	144
	(7.64)	(42.36)	(26.39)	(8.33)	(15.28)	(100)
OBCs	9	45	11	4	6	75
	(12.00)	(60.00)	(14.67)	(5.33)	(8.00)	(100)
SCs	6	20	3	0	1	30
	(20.00)	(66.67)	(10)	(0)	(3.33)	(100)
STs	2	26	10	3	0	41
	(4.88)	(63.41)	(24.39)	(7.32)	(0)	(100)
Total	28	152	62	19	29	290
	(9.66)	(52.41)	(21.38)	(6.55)	(10)	(100)

(Source. Field survey, 2018-19)

The above table 5.41 shows the category and income groups wise analysis of rural households in the irrigated and rain-fed areas. Out of 144 OCs households, 11 (7.64 %) have come under the low-income group (below 45000). About 61 (42.36 %) households has come in the category of lower-middle-income group (46000 to 100000). After that 38 (26.39 %) has come in the upper-middle-income group (101000 to 200000), and 12 (8.33 %), 22 (15.28 %) were in lower-high and high-income groups. Maximum households have come under a lower-middle-income group (46000 to 100000). Out of total 75 OBCs, 9 (12.00 %) was in low-income group, 45 (60.00 %) was in lower-middle income group, 11 (14.67 %) was in upper-middle income group, 4 (5.33 %) was in lower high income group and 6 (8.00 %) was in high income group. Furthermore, a total of 30 SCs households, 6 (20.00 %) was in low-income group, 20 (66.67 %) was in lower-middle income group, 3 (10.00 %) was in lower-high income group and only

one household has found more than 3 lakh income in the scheduled caste. Among the 41 households in the category of scheduled tribes, 2 (4.88 %) households annul income was below 45,000, 26 (63. 41 %) households annul income was in between 46,000 to 100,000, 10 (24.39 %) households' income was in upper-middle income group and 3 (7.32 %) households' income was in lower-middle income group.

Table 5.42: Income distribution of rural households according to landholdings size in the drought year from irrigated and rain-fed areas

Landholding size	Low-income (Below < 45000)	Lower middle- (46000 to 100000)	Upper-middle (101000 to 200000)	Lower-high (201000 to 300000)	High (300000 < above)	Total
Marginal	61	21	0	0	0	82
	(74.39)	(25.61)	(0)	(0)	(0)	(100)
Small	58	45	5	0	0	108
	(53.7)	(41.67)	(4.63)	(0)	(0)	(100)
Medium	12	39	13	3	0	67
	(17.91)	(58.21)	(19.4)	(4.48)	(0)	(100)
Large	0	7	14	5	7	33
	(0)	(21.21)	(42.42)	(15.15)	(21.21)	(100)
Total	131	112	32	8	7	290
	(45.17)	(38.62)	(11.03)	(2.76)	(2.41)	(100)

(Source. Field survey, 2018-19)

The above table 5.42 depicts rural household's income distribution according to landholdings size in the drought year in irrigated and rain-fed areas. It shows that maximum household incomes are under low and lower-middle-income groups. Merely a few large landholding households' income more than three lakhs.

Table 5.43: Category-wise income distribution of rural households from irrigated and rain-fed areas in the drought year

Social groups	Low-income (Below < 45000)	Lower middle- (46000 to 100000)	Upper-middle (101000 to 200000)	Lower-high (201000 to 300000)	High (300000 < above)	Total
OCs	48	65	20	6	5	144
	(33.33)	(45.14)	(13.89)	(4.17)	(3.47)	(100)
OBCs	45	18	9	2	1	75
	(60.0)	(24.0)	(12.0)	(2.67)	(1.33)	(100)
SCs	23	6	0	0	1	30
	(76.67)	(20.0)	(0)	(0)	(3.33)	(100)

STs	15	23	3	0	0	41
	(36.59)	(56.10)	(7.32)	(0)	(0)	(100)
Total	131	112	32	8	7	290
	(45.17)	(38.62)	(11.03)	(2.76)	(2.41)	(100)

(Source. Field survey, 2018-19)

The above table 5.43 shows the category-wise income distribution of rural households from irrigated and rain-fed areas in the drought year. In drought, most of the households came under low, lower-middle, and upper-middle-income groups. Only some OCs, a few OBCs, and one SCs household's income were in the high group category.

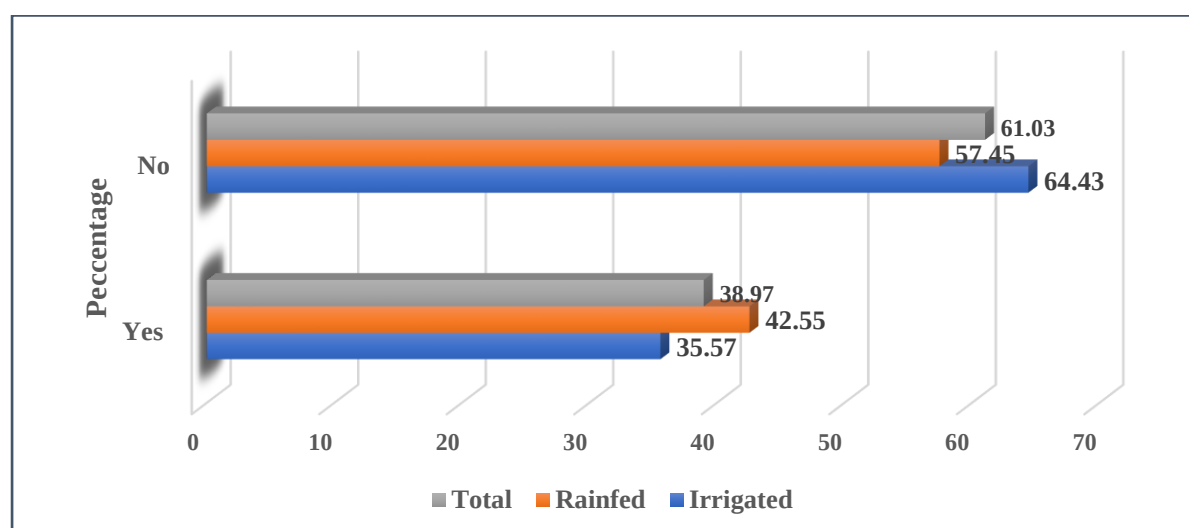
Table 5.44: Condition of households who fetches water from long distances during the drought period in the both ecosystems

Villages areas	Yes	No	Total
Irrigated	53	96	149
	(35.57)	(64.43)	(100)
Rain-fed	60	81	141
	(42.55)	(57.45)	(100)
Total	113	177	290
	(38.97)	(61.03)	(100)

(Source. Field survey, 2018-19)

The above table 5.44 shows the household information about fetching water from long distances. Water was not available in the village's ground water bodies due to that many households' member fetched water from long distance sources. The second reason is irregularities of the government water tanker and poor management. In the irrigated villages 53 (35.57 %) households fetched water from long distances, and in the rain-fed villages, 60 (42.55 %) of households fetched from long distances. Out of the total sample size, 113 (38.97 %) of households were fetching from long distances. There are several problems with government tankers. It did not provide water on a daily basis, sometimes the tanker was not functioned, sometimes the water was not available, and several times the tanker's driver was on leave. In addition, one of the biggest problems faced in rural areas is irregular electricity; without that, tanker could not fetch the water.

Figure 5.19: Households fetching water from long distances in the drought period in both kinds of villages



(Source. Field survey, 2018-19)

Table 5.45: Households fetching water condition from long distances in the drought period in both kinds of villages according to Landholding size

Landholding size	Yes	No	Total
Marginal	38	44	82
	(46.34)	(53.66)	(100)
Small	46	62	108
	(42.59)	(57.41)	(100)
Medium	23	44	67
	(34.33)	(65.67)	(100)
Large	6	27	33
	(18.18)	(81.82)	(100)
Total	113	177	290
	(38.97)	(61.03)	(100)

(Source. Field survey, 2018-19)

The table 5.45 describes the Households fetching position water from long distances by landholding size. It is observed that out of the 82 marginal farm households, 38 (46.34 %) has been fetched water from outside the villages, followed by 108 of the total small farm households (42.59 %) has been fetched from long distances, total of 67 medium farm households 23 (34.33 %) has fetched from outside the village and only 6 (18.18 %) large farm households fetched water from outside the village.

Table 5.46: Social group-wise households fetching water condition from long distances in the drought period in both kinds of ecosystems by social groups

Social groups	Yes	No	Total

OCs	25	119	144
	(17.36)	(82.64)	(100)
OBCs	62	13	75
	(82.67)	(17.33)	(100)
SCs	12	18	30
	(40.00)	(60.00)	(100)
STs	14	27	41
	(34.15)	(65.85)	(100)
Total	113	177	290
	(38.97)	(61.03)	(100)

(Source. Field survey, 2018-19)

Table 5.46 highlights the households drinking water condition who fetched water from long distances during the drought by social group-wise. Out of the 114 OCs households 25 (17.36 %) farm households have been fetching water from the long distances. Then out of the total 75 OBCs 62 (82.67 %) have fetched water from long distances and, 12 (40.00) SCs, and 14 (38.97 %) have fetched water from the long distances.

Table 5.47: Household fetching water from long distances in the drought period in (km)

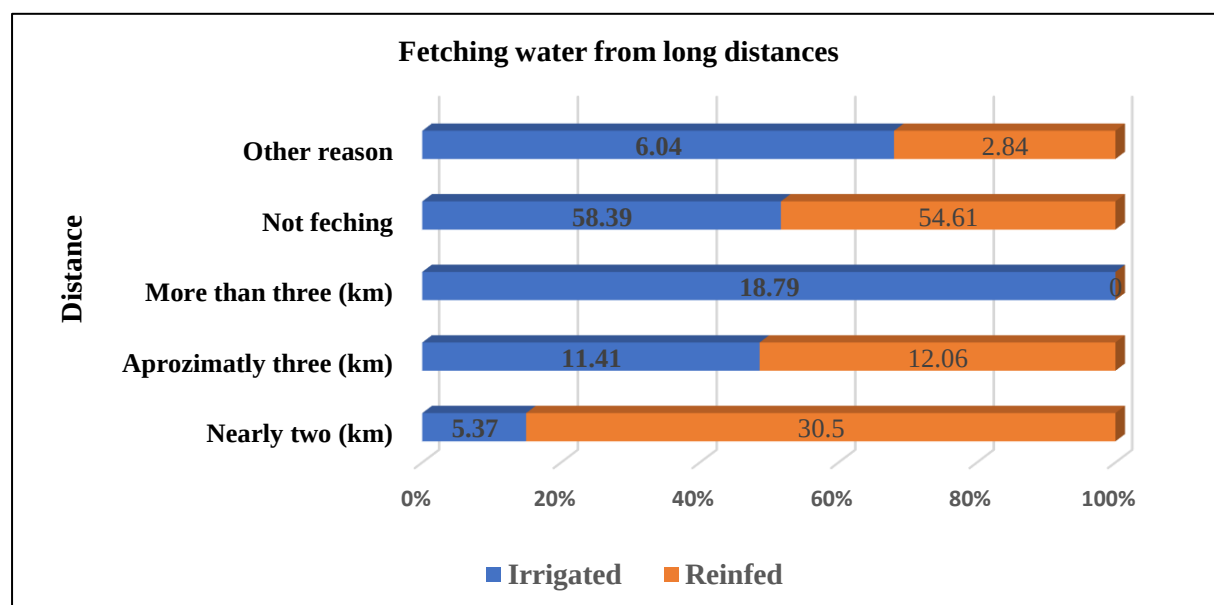
Villages	Nearly two (km)	Approximately three (km)	More than three (km)	Not fetching (km)	Other Reason (Not fetched-got from neighbour and relatives)	Total
Irrigated	8	17	28	87	9	149
	(5.37)	(11.41)	(18.79)	(58.39)	(6.04)	(100)
Rein-fed	43	17	0	77	4	141
	(30.5)	(12.06)	(0)	(54.61)	(2.84)	(100)
Total	51	34	28	164	13	290
	(17.59)	(11.72)	(9.66)	(56.55)	(4.48)	(100)

(Source. Field survey, 2018-19)

Irregularities of the local government water tankers and poor management the households' respondent fetched water from distance sources such as well and bore. The above table revealed that among the irrigated area villages, 87 (58.39) percent of household respondents did not fetch water from remote sources, 8 (5.37 %) household respondents fetched water from nearly two Kilometre. About 17 (11.41 %) households fetched water from more than 2 K.M. Furthermore, 28 (18.79 %) of household respondents fetched water from more than three km. Among the rain-fed area villages, 43 (30.5 %) of households fetched water from nearly two

km, and about 17 (12.06 %) of household respondents fetched water from approximately three km. Out of the total sample size of household respondents, about 113 (38.97 %) of households respondents fetched water from remote sources by doing physical activities. Besides, 13 (4.48 %) of household respondents fetched water due to other reasons. Sometimes, they brought water from their relatives and neighbours. Even though the government managed above water resources, many household respondents fetched water from remote sources.

Figure 5.20: Households fetching water from long distances in the drought period in



(km)

(Source. Field survey, 2018-19)

Table 5.48: Classification among household respondents who is fetched water from long distances in the drought period

Villages	Men	Women	All family member	Not fetched (directly)	Total
Irrigated	18	13	22	96	149
	(12.08)	(8.72)	(14.77)	(64.43)	(100)
Rain-fed	3	48	9	81	141
	(2.13)	(34.04)	(6.38)	(57.45)	(100)
Total	21	61	31	177	290
	(7.24)	(21.03)	(10.69)	(61.03)	(100)

(Source. Field survey, 2018-19)

The table 5.48 shows the information of household respondents who were fetched water from remote sources. About 177 (61.03 %) household respondents were not fetched water directly from remote sources, but sometimes they were also fetched. Most of the time, women of the households fetched water from remote sources. About 31 (10.69 %) of entire family members

engaged in fetching water. Furthermore, the study reported that sometimes only the male member of the households fetched water from remote sources.

Table 5.49: Livestock status among farm households in irrigated and rain-fed villages

Livestock	Yes	No	Total
Irrigated	102	47	149
	(68.46)	(31.54)	(100)
Rain-fed	110	31	141
	(78.01)	(21.99)	(100)
Total	212	78	290
	(73.10)	(26.90)	(100)

(Source: Field survey, 2018-19)

Table 5.49 describes livestock status among farm households in irrigated and rain-fed villages. It has been reported that out of 290 households, 212 (73.10 %) had livestock, and 78 (26.90 %) had no livestock. Many households sold their livestock, and many of them reduced the number of livestock due to fodder and water problems.

Table 5.50: Livestock status by landholding size among farm households in irrigated and rain-fed villages

Landholding size	Yes	No	Total
Marginal	44	38	82
	(53.66)	(46.34)	(100)
Small	79	29	108
	(73.15)	(26.85)	(100)
Medium	57	10	67
	(85.07)	(14.93)	(100)
Large	32	1	33
	(96.97)	(3.03)	(100)
Total	212	78	290
	(73.1)	(26.90)	(100)

(Source: Field survey, 2018-19)

Table 4.50: illustrate the livestock status among farm households in irrigated and rain-fed villages by landholding size. It is reported that among the all category of the farmers, the marginal landholders have found only 44 (53.66 %) livestock in the drought year, which is less compared to all, whereas large handholds have more livestock.

Table 5.51: Livestock status among farm households by social groups in irrigated and rain-fed villages

Social groups	Yes	No	Total
OCs	105	39	144
	(72.92)	(27.08)	(100)
OBCs	60	15	75
	(80.00)	(20.00)	100
SCs	16	14	30
	(53.33)	(46.67)	100
STs	31	10	41
	(75.61)	(24.39)	(100)
Total	212	78	290
	(73.10)	(26.90)	(100)

(Source: Field survey, 2018-19)

Table 4.51: illustrate the livestock status among farm households in irrigated and rain-fed villages by social groups. It is observed that among all social groups SCs have less livestock available in the drought period.

Table 5.52: Fodder situations among farm households in irrigated and rain-fed villages during the drought

Livestock	Yes	No	Total
Irrigated	63	86	149
	(42.28)	(57.72)	(100)
Rain-fed	54	87	141
	(38.30)	(61.70)	(100)
Total	117	173	290
	(40.35)	(59.65)	(100)

(Source. Field survey, 2018-19)

Above table 5.52 highlights fodder situations among farm households in irrigated and rain-fed villages during the drought. It is indicated that, out of the total sample households, 117 (40.35 %) had fodder available, and 173 (59.65 %) had no fodder available. Some household's fodder was available because they had stored crop residuals, and sometimes they bought. Some households did not have fodder; they sent their livestock to cattle camps and purchased fodder to save livestock.

Table 5.53: Agriculture input subsidy (drought relief) availed by farm households in irrigated and rain-fed villages during the drought

Villages areas	Yes	No	Total
Irrigated	73	76	149
	(48.99)	(51.01)	(100)
Rain-fed	87	54	141
	(61.70)	(38.30)	(100)
Total	160	130	290
	(55.17)	(44.83)	(100)

(Source. Field survey, 2018-19)

According to the norms of SDRF/NFRF over natural calamities, it provides assistance to the farmers who are affected by notified natural disasters, including drought. According to the modified rules, farmers are eligible for input subsidy for crop loss of 33% and above. Rs. 6800/- per hectare is for the rain-fed areas and Rs. 13500/- per hectare is for regions with assured irrigation and Rs. 18000/- per hectare is for all types of perennial crops (not like annual crops, plants do not require replacement each year), ([Drought management plan, 2017](#)). The above table 5.44 shows agriculture input subsidy availed by farm households in the drought period 2018-19 under the norm of SDRF/NFRF. Out of total households, about 160 (55.17 %) of households were availed of agriculture input subsidies in both irrigated and rain-fed villages. In the rain-fed village, 87 (61.70 %) of households were availed of agriculture input subsidy. In the irrigated village, 73 (48.99 %) of the households were availed of agriculture input subsidy out of the total irrigated village households sample size.

Table 5.54: Agriculture input subsidy (drought relief) availed by farm households according to landholding size in irrigated and rain-fed villages during the drought

Landholding size	Yes	No	Total
Marginal	38	44	82
	(46.34)	(53.66)	(100)
Small	68	40	108
	(62.96)	(37.04)	(100)
Medium	40	27	67
	(59.70)	(40.30)	(100)
Large	14	19	33
	(42.42)	(57.58)	(100)
Total	160	130	290
	(55.17)	(44.83)	(100)

(Source. Field survey, 2018-19)

The above table 5.54 depicts the agriculture input subsidy (drought relief) availed by farm households according to landholding size in irrigated and rain-fed villages. It is shown that, out of total marginal farmers' households, 38 (46.34 %) were availed of agriculture input subsidy, and 44 (53.66 %) were not availed. Out of 108 small farmers' households, 68 (62.96 %) received agriculture input subsidy, and 40 (37.04 %) were not received. Out of 67 medium farmers' households, 40 (59.70 %) received agriculture input subsidy, and 27(40.30 %) did not receive it. Lastly, out of 33 large farmers' households, 14 (42.42 %) were received, and 19 (57.58 %) were not received. It found that most small and medium farmer's households benefited from agriculture input subsidies in the drought period compared to marginal and large farmers' households.

Table 5.55: Agriculture input subsidy (drought relief) availed by farm households according to social groups in irrigated and rain-fed villages during the drought

Social groups	Yes	No	Total
OCs	74	70	144
	(51.39)	(48.61)	(100)
OBCs	67	8	75
	(89.33)	(10.67)	(100)
SCs	17	13	30
	(56.67)	(43.33)	(100)
STs	2	39	41
	(4.88)	(95.12)	(100)
Total	160	130	290
	(55.17)	(44.83)	(100)

(Source. Field survey, 2018-19)

The above table 5.55 describes agriculture input subsidy (drought relief) availed by farm households according to social groups in drought the period among irrigated and rain-fed villages. It is reported that out of 144 general category farmers' households, 74 (51.39 %) were received agriculture input subsidies from the state governments, and 70 (48.61 %) were not received. Out of the 75 OBCs farmers' households, 67 (89.33%) were received agriculture input subsidies, and only 8 (10.67 %) were not received it. Furthermore, out of 30 SCs farmers' households, 17 (56.67 %) were received, and 13 (43.33%) were not obtained. And out of 41 ST farmers households, only 2 (4.88 %) were obtained agriculture input subsidies from the state government in the drought year. In conclusion, most of the OBC farmers households have benefited from agriculture input subsidies of state governments under the norms decided by SDRF and NDRF in the drought period. Only 2 % of STs farmers' households benefited from

the scheme because the state government did not declare the Yellorewadi village of the Latur district in AUSA taluka. This village has most population belong to ST category. In the drought period, the village people protested and demanded that their block come under that scheme.

Table 5.56: Crop insurance status among the rural household during the drought

Crop insurance	Yes	No	Total
Irrigated	63	86	149
	(42.28)	(57.72)	(100)
Rain-fed	69	72	141
	(48.94)	(51.06)	(100)
Total	132	158	290
	(45.52)	(54.48)	(100)

(Source. Field survey, 2018-19)

Table 5.56 displays crop insurance status among the rural household during the drought in the irrigated and rain-fed villages. It is pointed out that about 132 (45.52 %) farm households benefited from crop insurance schemes in the drought, and 158 (54.48 %) farm households have not benefited. It is also financially helpful for farm households in a drought period when they lose their crops when they feel little satisfaction with crop insurance. Many households have not benefited from the above scheme because they do not have awareness about that. And many of them do not know how to apply? and where to apply?

Table 5. 57: Crop insurance status among the rural household during the drought according to landholding size

landholding size	Yes	No	Total
Marginal	30	52	82
	(36.59)	(63.41)	(100)
Small	56	52	108
	(51.85)	(48.15)	(100)
Medium	33	34	67
	(49.25)	(50.75)	(100)
Large	13	20	33
	(39.39)	(60.61)	(100)
Total	132	158	290
	(45.52)	(54.48)	(100)

(Source. Field survey, 2018-19)

Table 5.57 describes the crop insurance status among the rural household during the drought according to landholding size. It is observed that out of the 290 farm households, 132 (45.52 %) household received crop insurance from different insurance companies. Furthermore, it is

highlighted that marginal and large households which were less benefited from crop insurance scheme and the small and medium farmers not more than (50 %). So, there is a need to implement crop insurance scheme properly particularly in the drought period result of that farmer will less suffer from loss of crop production.

Table 5.58: Social groups-wise crop insurance status among the rural household during the drought

Social groups	Yes	No	Total
OCs	65	79	144
	(45.14)	(54.86)	(100)
OBCs	50	25	75
	(66.67)	(33.33)	(100)
SCs	12	18	30
	(40.00)	(60.00)	(100)
STs	2	39	41
	(4.88)	(95.12)	(100)
Total	129	161	290
	(44.48)	(55.52)	(100)

(Source. Field survey, 2018-19)

Table 5.58 shows the social groups-wise crop insurance status among the rural household during the drought, it is observed that out of the total 114 OCs households, 54 (54.86 %) have benefited from crop insurance scheme, then out of the 75 OBCs households 25 (33.33 %) have benefited, out of the 30 SCs households (60.00 %) benefited, and out of total 41 STs households 39 (95.12 %) have benefited. It is found that STs households have more benefited from the other social categories.

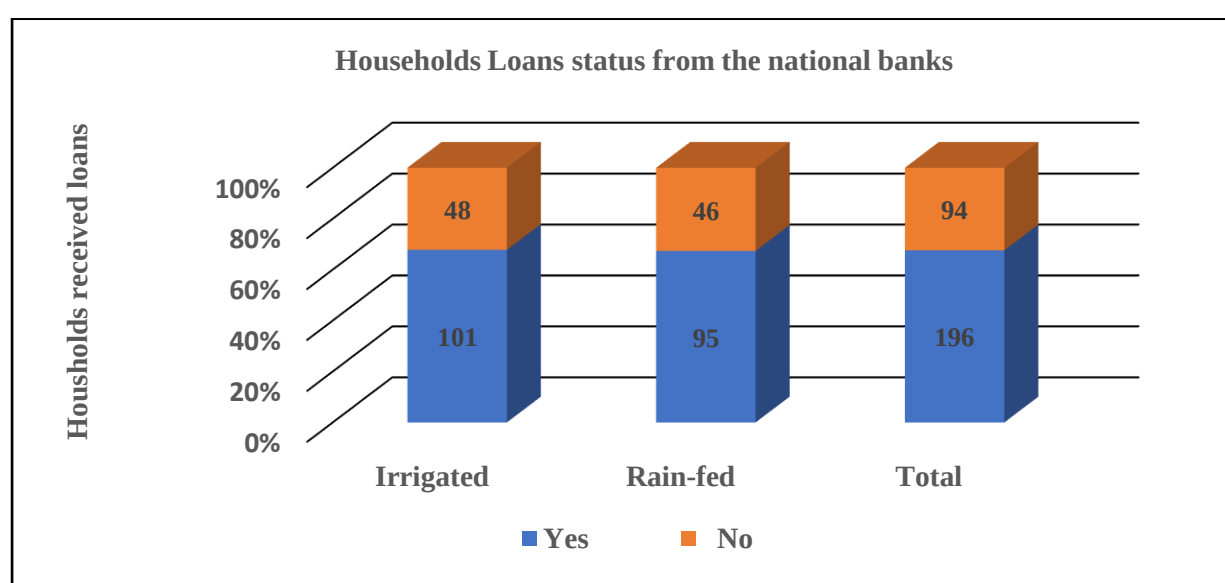
Table 5.59: The loan or debt position of farm households that have obtained from major banks during drought

Loan debt from various national and state banks	Yes	No	Total
Irrigated	101	48	149
	(67.79)	(32.21)	(100)
Rain-fed	95	46	141
	(67.38)	(32.62)	(100)
Total	196	94	290
	(67.59)	(32.41)	(100)

(Source. Field survey, 2018-19)

Table 5.59 shows the loan or debt position of agricultural households that have obtained from major banks. It is indicated that about 196 (67.59 %) farm households obtained loans/debts from various national and district level banks. Those institutions are the State Bank of India, Maharashtra Bank, Central Bank of India, ICICI Bank, Punjab National Bank, Maharashtra Gramin Bank, district central co-operative banks, etc. It is very helpful in the drought period; many households received loans from various banks, so they could not take debt from moneylenders, and private debt interest is very high compared to the bank. Indebtedness is one of the reasons due to that farmers' suicide cases increased in both Marathwada and Vidarbha regions.

Figure 5.21: The loan or debt position of farm households that have obtained from major banks during drought



(Source. Field survey, 2018-19)

Table 5.60: Landholding size -wise loan or debt situation of the sample farm households

Landholding size	Yes	No	Total
Marginal	43	39	82
	(52.44)	(47.56)	(100)
Small	71	37	108
	(65.74)	(34.26)	(100)
Medium	56	11	67
	(83.58)	(16.42)	(100)
Large	26	7	33
	(78.79)	(21.21)	(100)
Total	196	94	290
	(67.59)	(32.41)	(100)

(Source. Field survey, 2018-19)

Table 5.60 describes the landholding size-wise loan or debt position of farm households. It has been observed that small and large farm households have more loans obtained than medium and marginal farmers.

Table 5.61: Social groups-wise loan or debt situation of farm households

Social groups	Yes	No	Total
OCs	105	39	144
	(72.92)	(27.08)	(100)
OBCs	48	27	75
	(64.00)	(36.00)	(100)
SCs	9	21	30
	(30.00)	(70.00)	(100)
STs	34	7	41
	(82.93)	(17.07)	(100)
Total	196	94	290
	(67.59)	(32.41)	(100)

(Source. Field survey, 2018-19)

Table 5.61 shows farm households' loan or debt situation that acquired loan/debt from financial institutions during the drought. It is indicated that 105 (72.92) general category households acquired loan/debt from financial institutions several financial institutions, followed by 48 (64.00 %) other backward classes obtained loan/debt from various banking institutions. About 34 (82.93 %) Scheduled tribes obtained loan/debt from many banking institutions, and only 9 (30.00 %) scheduled castes obtained loan/debt from many financial firms.

Table 5.62: Drought effect on school going children in the both ecosystems

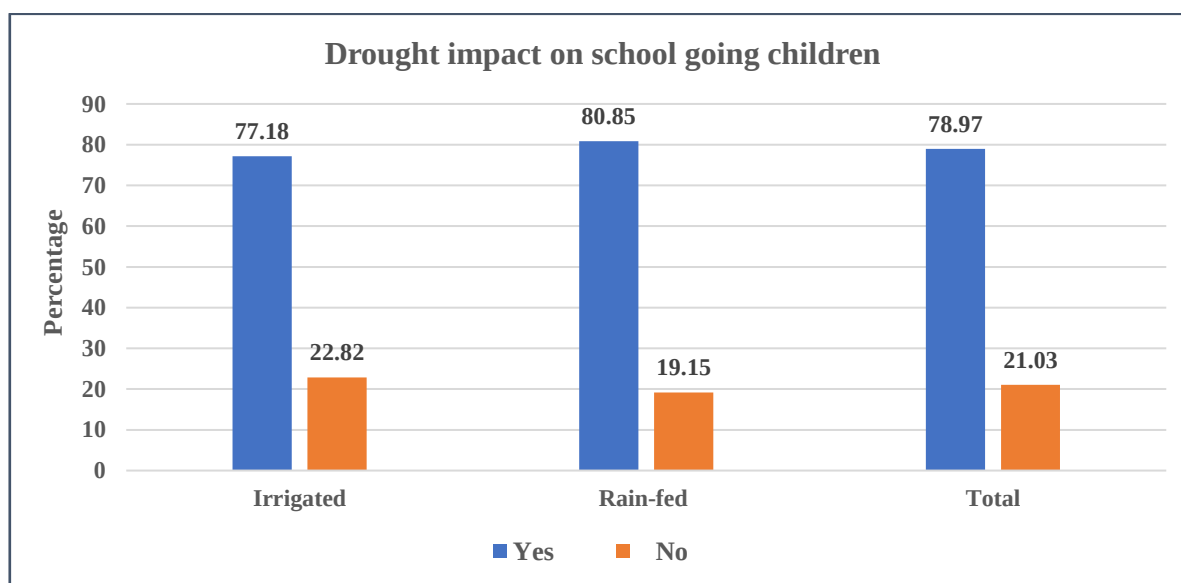
Ecosystems	Yes	No	Total
Irrigated	115	34	149
	(77.18)	(22.82)	(100)
Rain-fed	114	27	141
	(80.85)	(19.15)	(100)
Total	229	61	290
	(78.97)	(21.03)	(100)

(Source. Field survey, 2018-19)

The above table 5.62 shows the information of drought effect on school going children in the drought period. The study highlighted that out of 290 households, 229 (78.97 %) has mentioned that drought had adverse effect on school going children, in the irrigated village it has reported that about 115 (77.18 %) and in the rain-fed village about 114 (80.85 %) households have mentioned the adverse effect of drought on their children. In the drought there was not enough

water for drinking, second reason was that many children joined to fetch water from long distances due to water scarcity therefore they could not attend the classes. Many households' member migrated to urban areas to get employment with and without their children so due to that negligence some children left the school.

Figure 5.22: Drought impact on the school going children in the different ecosystem



(Source. Field survey, 2018-19)

Table 5.63: Drought impact on school going children by landholding size

Landholding size	Yes	No	Total
Marginal	67	15	82
	(81.71)	(18.29)	(100)
Small	86	22	108
	(79.63)	(20.37)	(100)
Medium	55	12	67
	(82.09)	(17.91)	(100)
Large	21	12	33
	(63.64)	(36.36)	(100)
Total	229	61	290
	(78.97)	(21.03)	(100)

(Source. Field survey, 2018-19)

The table 5.63 illustrates the drought impact on school going children by landholding size. It is reported that marginal, small and medium farmers have observed more impact of drought on school going children compared to large farm households. Marginal, small and medium households' percentages reported near by 80 %, whereas large farm households' percentages reported nearby 64 %.

Table 5.64: Social groups-wise impact of drought on school going children

Social groups	Yes	No	Total
OCs	119	25	144
	(82.64)	(17.36)	(100)
OBCs	49	26	75
	(65.33)	(34.67)	(100)
SCs	20	10	30
	(66.67)	(33.33)	(100)
STs	41	00	41
	(100)	(0.00)	(100)
Total	229	61	290
	(78.97)	(21.03)	(100)

(Source. Field survey, 2018-19)

Table 5.64: describes the social groups-wise impact of drought on school going children, out of the 114 OCs households, 119 (82.64 %) have faced school going education difficulties in the drought. After that out of the 75 OBCs, 49 (65.33%) have faced problems, then 20 (66.67 %) SCs households have reported to face problems and total STs households have said their children faced that kind of problems during the drought.

Table 5.65: Migration status among rural household's respondents during drought in the irrigated and rain-fed villages

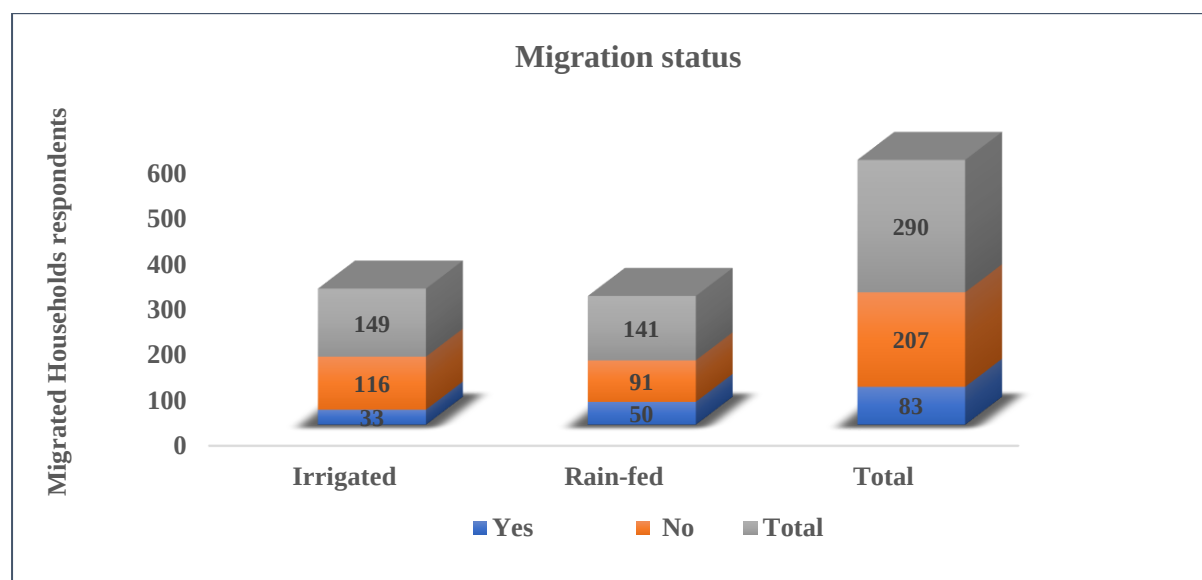
Migration	Yes	No	Total
Irrigated	33	116	149
	(22.15)	(77.85)	(100)
Rain-fed	50	91	141
	(35.46)	(64.54)	(100)
Total	83	207	290
	(28.62)	(71.38)	(100)

(Source. Field survey, 2018-19)

The table above 5.65 describes migration status among rural households' respondents who were migrated during the drought from irrigated and rain-fed villages. It is indicated that 83 (28.62 %) households' respondents were migrated from rural to rural and rural to urban areas. They migrated to western Maharashtra, such as Ahmednagar and Kolhapur districts, in the rural-to-rural areas, where they worked as farm labour. At the same time, some respondents migrated to urban areas such as Pune, Mumbai, and Latur, where they worked in the non-farm sector as labour and working as truck/tempo drivers, security guards, cement, and construction

workers, vendor, vegetable vendor, etc. The table also illustrated that rain-fed villages households' respondents had more migrated than irrigated villages.

Figure 5.23: Migration status among rural households' respondents during drought in the irrigated and rain-fed villages



(Source. Field survey, 2018-19)

Table 5.66: Migration status according to landholding size among rural households' respondents during drought in the irrigated and rain-fed villages

Migration	Yes	No	Total
Marginal	27	55	82
	(32.93)	(67.07)	(100)
Small	40	68	108
	(37.04)	(62.96)	(100)
Medium	13	54	67
	(19.40)	(80.60)	(100)
Large	3	30	33
	(9.09)	(90.91)	(100)
Total	83	207	290
	(28.62)	(71.38)	(100)

(Source. Field survey, 2018-19)

Table 5.66 shows the migration status according to landholding size among rural household's respondents during drought in the irrigated and rain-fed villages. It is reported that, out of a total 82 marginal farm households, 27 (32.93 %) of the respondents migrated from rural to rural and rural to urban areas, which was more in numbers among all landholding sizes. meanwhile, out of 108 small farm households' respondents, 40 (37.04 %) migrated, followed by 13 (19.40

%) medium migrated farm household respondents migrated out of 67. And lastly, out of 33 large farm household respondents, only 3 (9.09 %) migrated. It is observed that marginal and small farm household's respondents migrated more than medium and large farmers.

Table 5.67: Migration status according to social groups among rural household's respondents during drought in the irrigated and rain-fed villages

Migration	Yes	No	Total
OCs	27	117	144
	(18.75)	(81.25)	(100)
OBCs	26	49	75
	(34.67)	(65.33)	(100)
SCs	14	16	30
	(46.67)	(53.33)	(100)
STs	16	25	41
	(39.02)	(60.98)	(100)
Total	83	207	290
	(28.62)	(71.38)	(100)

(Source. Field survey, 2018-19)

Table 5.67 illustrates migration status according to social groups among respondents of farm households during drought in the irrigated and rain-fed villages. It is observed that SCs and STs were more migrated compared to the general category (Open) and other backward classes (OBC). Village livelihood mostly depends on agriculture and allied sector activities, particularly during the Kharif season. When agriculture fails, then many people migrated from urban to rural areas for searching jobs.

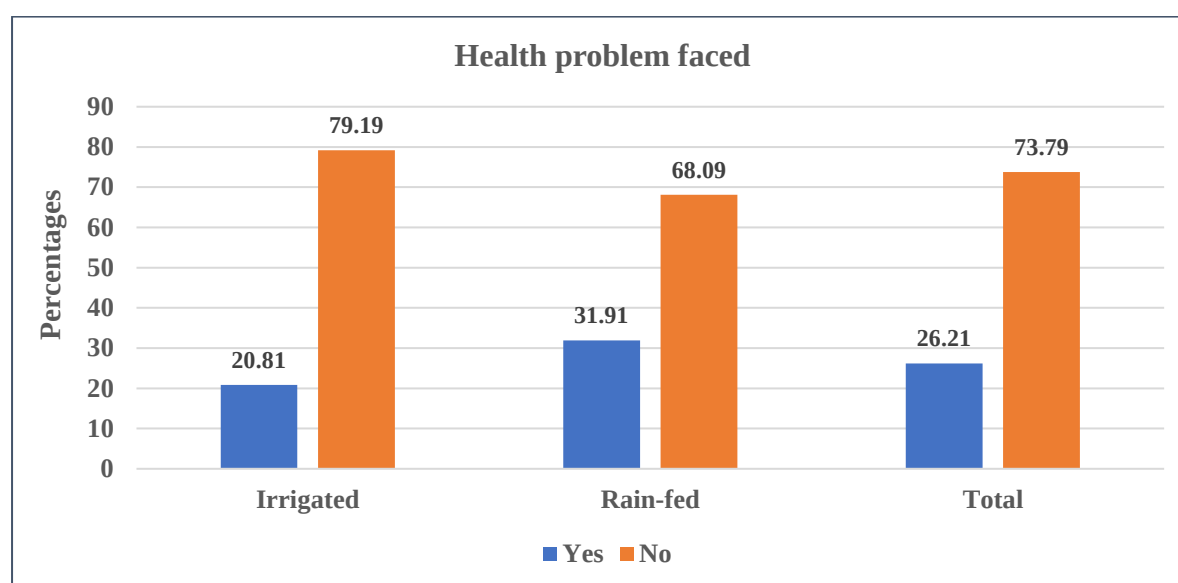
Table 5.68: Impact of drought on health in the both ecosystem of the study area

Health impact	Yes	No	Total
Irrigated	31	118	149
	(20.81)	(79.19)	(100)
Rain-fed	45	96	141
	(31.91)	(68.09)	(100)
Total	76	214	290
	(26.21)	(73.79)	(100)

(Source. Field survey, 2018-19)

The table 5.68 highlights the impact drought on households' members health. It is observed that around 76 (26.21%) of the households members said that they have faced few health problems due to drought. These problems are, stomach ache, headache, throat pain, electric shocks, and some injuries on body while they were fetching water from remote areas.

Figure 5.24: Health problem faced by households' respondents during the drought



(Source. Field survey, 2018-19)

Table 5.69: Work done under the Jalyukt Shivar programme in the irrigated and rain-fed village

Jalyukt Shivar	Yes	No	Total
Irrigated	53	96	149
	(35.57)	(64.43)	(100)
Rain-fed	(0.00)	141	141
	(0.00)	(100)	(100)
Total	53	237	290
	(18.28)	(81.72)	(100)

(Source. Field survey, 2018-19)

Table 5.69 illustrates that work has been done under the Jalyukt Shivar programme in the irrigated and rain-fed village. It is noticed that only 53(18.28 %) households heads said that river bund, Nala widening, watershed development programme has been completed under the Jalyukt Shivar. In the rain-fed village, no one said that work had been done under the above scheme.

Table 5.70: Households members participation in drought period in SHGs from the both ecosystems

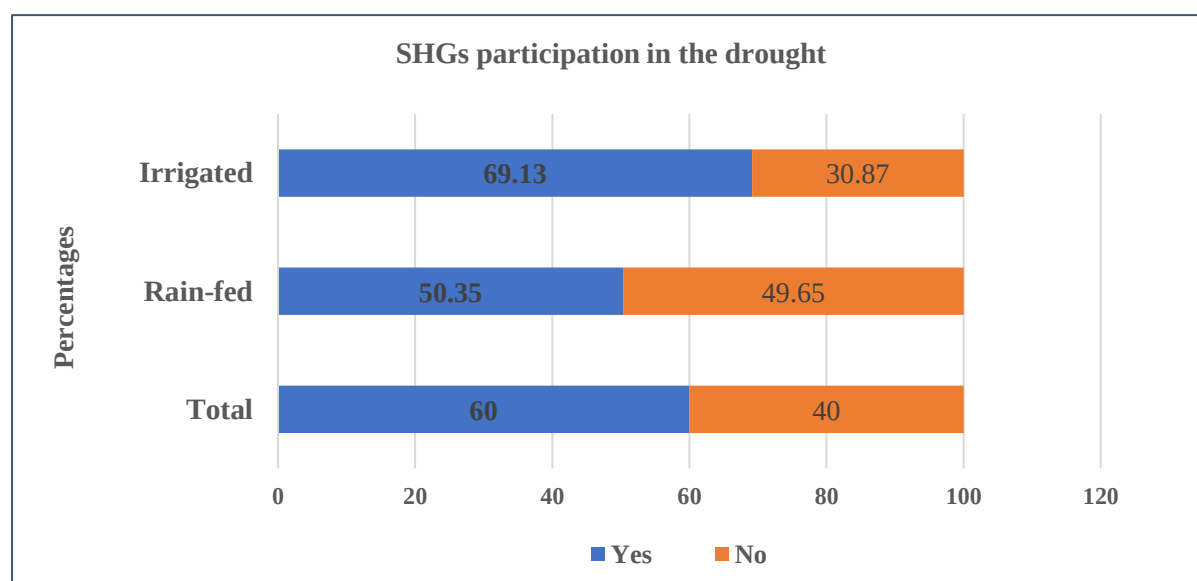
SHGs	Yes	No	Total
Irrigated	103	46	149
	(69.13)	(30.87)	(100)
Rain-fed	71	70	141
	(50.35)	(49.65)	(100)

Total	174	116	290
	(60.00)	(40.00)	(100.00)

(Source. Field survey, 2018-19)

The table 5.70 illustrates that about 170 (60.00 %) households' members (particularly female) have participated in SHGs in the drought period. These SHGs financially heled the households, sometimes few households' members from SHGs have taken debt in a below interest rates like 2 % month, which very low cambered to private and bank debt. This loan they have used for agriculture purposes.

Figure 5.25: Households members Self Help Groups participation in the drought



(Source. Field survey, 2018-19)

Table 5.71: Below poverty line status according to irrigated and rain-fed areas

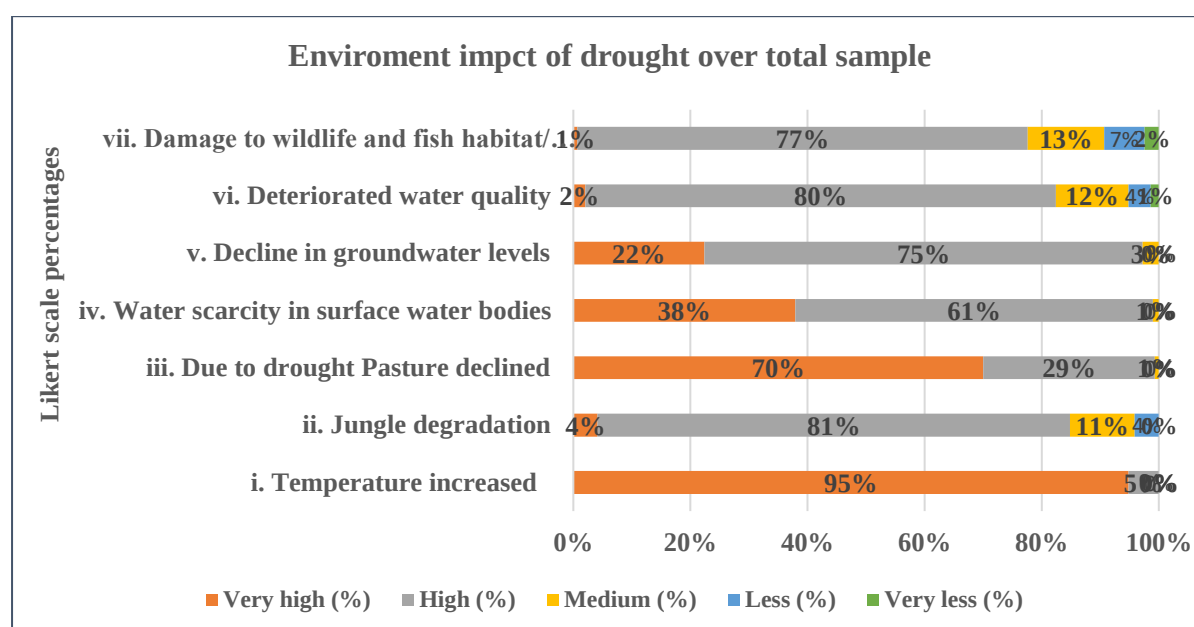
Ecosystem	Below Poverty Line	Above Poverty Line	Do not have a card	Total
Irrigated	76	68	5	149
	(51.01)	(45.64)	(3.36)	(100)
Rain-fed	74	64	3	141
	(52.48)	(45.39)	(2.13)	(100)
Total	150	132	8	290
	(51.72)	(45.52)	(2.76)	(100)

(Source. Field survey, 2018-19)

The above table 5.71 shows below poverty line status in irrigated and rain-fed areas. It is described that, out of 290 total sample households, 150 (51.72 %) were below the poverty line, and 132 (45.52 %) were above the poverty line, and 8 (2.76 %) did not have any kind of BPL and APL cards. Furthermore, the study reported that most households had received food grain

(wheat and rice and 1 kg dal) from the fair price shops in the drought year; only a few families have not received from fair-price shops because they are rich.

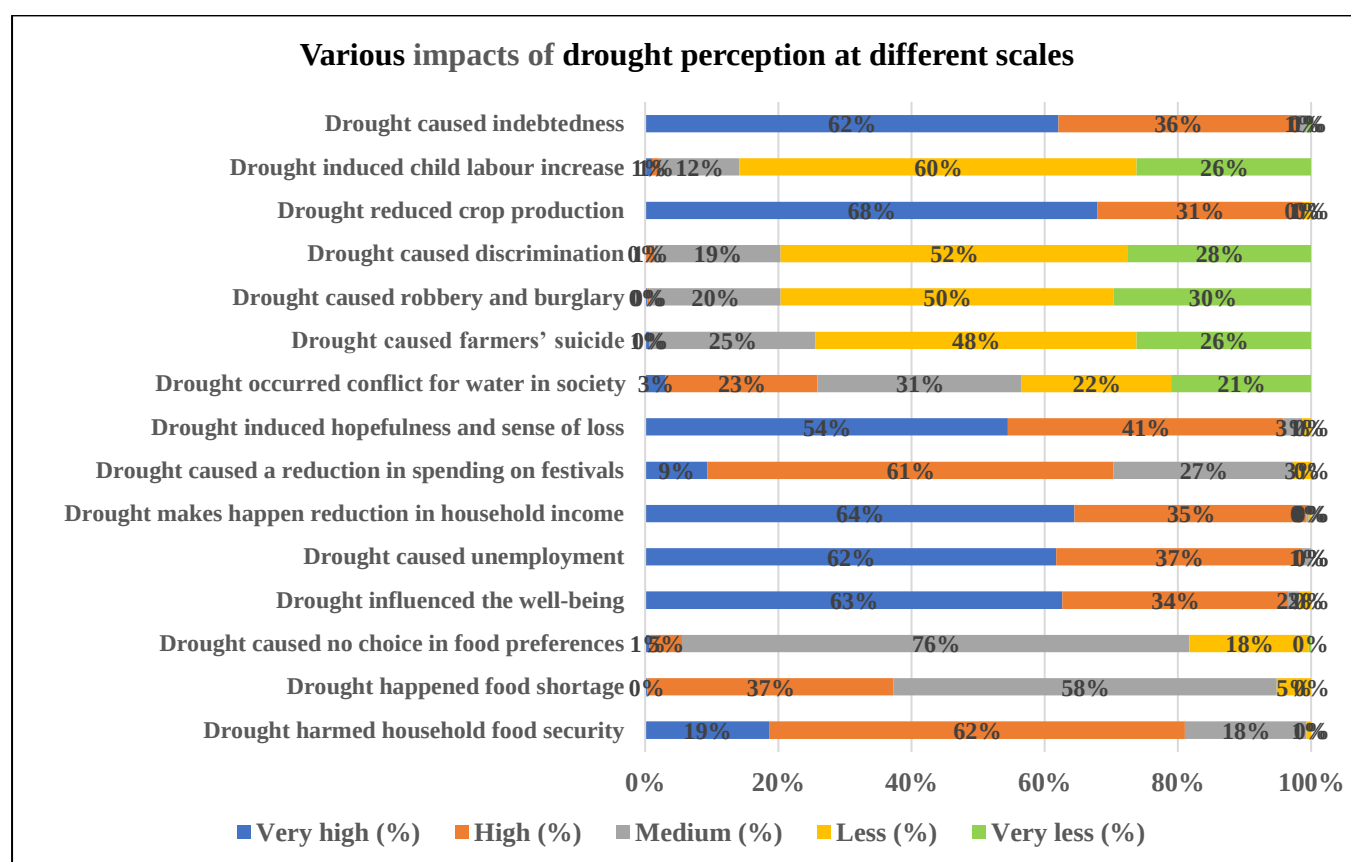
Figure 5.26: Farmers perceptions of various environment impact of drought in the study area



(Source. Field survey, 2018-19)

The above figure 5.26 describes perceptions of environmental impact of drought on farmers in the both irrigated and rain-fed villages. It is reported that out of the total sample households, 95 % perceived that temperature has been increased very high in the drought year compare to the normal year. Furthermore, 81 % farmers perceived that jungle degradation increased in high scale due to drought. Then the near about 70 % farmers perceived that pasture declined in a very high scale and 39 % reported that pasture declines in high scale. About 38 % and 61 % farmers perceived that water scarcity in the surface water bodies (well, river, small pond and dam) reduced tremendously in the drought. Then about 22 % and 75 % farmers perceived that the ground water level also declined (around 300 to 500 foot bore well has no water). Lastly, about 80 %, 77 % farmers perceived that water quality and damage to wildlife and fish habitant declined in the drought period.

Figure 5. 27: Various impacts of drought perception at different scales in the study area by farmers



(Source. Field survey, 2018-19)

Figure 5.27 shows the various impacts of drought perceptions at different scales on rural households. It is observed that about 62 % of the farmers have replied that drought damaged food security at a high scale and 19 % said very high scale. Near about 37 % of the farmers replied that drought has caused food shortages at a high scale. About 63 % and 34 % reported that drought affected well-being at a very high and high rate. Furthermore, it is reported that due to drought unemployment increased at a very high and high scale. Nearly 3 % and 23 % of farmers reported that drought occurred in conflict for water in a society at a very high and high scale. It is also highlighted that very high and high-scale drought perception impacts have been reported by farmers for drought-caused indebtedness, reduced crop production and hopelessness and a sense of loss. On the other hand, drought increased child labour, drought arisen discrimination, drought forced robbery and suicide that impact perceptions have observed at less and very less scale.

Section III

5.4 Impact of drought on total foodgrain production in the study area using multiple regression model

Analysed drought Impact on food grain production among three districts of the study area using a multiple regression model. This study tries to examine the drought impact on the Beed Osmanabad and Latur district's total food grain production for 19 years from 2000 to 2018. A multiple regression model was employed to determine the relationship between climatic variables and total food grain production. The study used three climate variables such as annual rainfall, maximum temperature, and minimum temperature. The study considered that climatic variables are independent variables and food grain production as the dependent variable. Many studies used a multiple regression model (ordinary least square technique) to evaluate the impact of climate change on agriculture crop production and productivity (Guntukula, 2020; Parthasarathy et al., 1988; Kelkar et al., 2020; Sarker et al., 2014). The study developed a multiple linear regression model, which is used following the regression equation.

$$y_i = b_1 + b_2 \text{rainf}_t + b_3 \text{maxtemp}_t + b_4 \text{mintemp}_t + u_t \dots \dots \dots (1)$$

y_i = total foodgrain production (“00” tonnes), rainf_t = annual rainfall (mm), maxtemp_t = average maximum temperature(°C), mintemp_t = average minimum temperature (°C), u_t = error term. It is used three regression equations, one for each district, to examine the relationship between total food grain and climatic variables.

Table 5.72: Beed district multiple regression model results, (model-1)

Beed district multiple regression model results		
Variables	Coefficient	P. value
Rainfall	7.804462***	0.0009
Max Temp	292.0508	0.5923
Min Temp	-1676.810**	0.0398
Constant	22489.07	0.2422
R ²	0.67	-
No of observations	19	-

(Author’s own calculation from secondary data)

The regression results found a statistically significant impact of rainfall and average minimum temperature on food grain production, which are significant at 1% and 5 % significance levels (minimum temperature has a significant negative impact on food grain production). $R^2 = 0.67$, the Durbin-Watson statistic is 1.91, and the F statistics probability is 0.000631. There is no

autocorrelation in the series; a Breusch-Godfrey Serial Correlation LM Test shows the probability value is 0.89 (more than 0.5%). If the p-value is greater than the 5 % significance level, it means that there is no serial correlation in the residuals. The data are normally distributed (Jarque-Bera probability Value is 0.62). Here we accept the null hypothesis, which is stated that if the P-value is greater than the 0.5% significance level when data is normally distributed. Parthasarathy et al., (1988) reported the same result in their study; they examined the relationship between all India summer monsoon rainfall and all India annual foodgrain production of India. The simple regression model was applied to estimate Indian foodgrain production and summer monsoon rainfall. They found a significant relationship between percentage departure from all India summer monsoon rainfall and the annual foodgrain production index (significance at the 0.01 % level). Guntukula, (2020) analysed the effect of climate change on the yields of primary food and non-food crops all over India. The study used time-series data for 58 years from 1961 to 2017. A multiple regression model was employed for examining the associations between climate variables yield of primary food and non-food crops. The analysis results found that significant effect on major crop yields from rainfall, maximum and minimum temperatures, but the level of impact varies across the crops studied. The average maximum temperature has been observed a favourable effect on food and non-food crops only excluding rice. The average minimum temperature has negatively affected non-food crops but has a favourable impact on food crops.

Table 5.73: Osmanabad district multiple regression model results, (Model-2)

Osmanabad district multiple regression model result		
Variables	Coefficient	P. value
Rainfall	3.272015*	0.0795
Max Temp	-918.6022	0.1087
Min Temp	-817.5905	0.2669
Constant	48026.61	0.0191
R ²	0.60	-
No of observations	19	-

(Source: Author's own calculation from secondary data)

The regression results found a statistically significant impact of rainfall on food grain production, which is significant at 10 % significance levels. R² =0.60, the Durbin-Watson statistic is 1.83, and the F statistics probability is 0.002642. There is no autocorrelation in the series; a Breusch-Godfrey Serial Correlation LM Test shows the probability value is 0.18 (more than 0.5%). The data are normally distributed (Jarque-Bera probability Value is 0.48).

Table 5.74: Latur district multiple regression model results, (Model. 3)

Latur district multiple regression model results		
Variables	Coefficient	P. value
Rainfall	8.428834***	0.000
Max Temp	882.0531*	0.067
Min Temp	-38.93838	0.952
Constant	-30951.26	0.065
R ²	0.73	-
No of observations	19	-

(Source: Author's own estimation from secondary data)

The regression results found a statistically significant impact of rainfall and average maximum temperature on food grain production, which are significant at 1% and 10 % significance levels. $R^2 = 0.73$, the Durbin-Watson statistic is 1.78, and the F statistics probability is 0.000138. There is no autocorrelation in the series; a Breusch-Godfrey Serial Correlation LM Test shows the probability value is 0.79 (more than 0.5%). The data are normally distributed (Jarque-Bera probability Value is 0.48). A total of 355 talukas in the state (Mumbai city and suburban Mumbai districts were not added), 278 talukas were obtained from deficient rainfall, 75 were talukas obtained normal, and two talukas received excess. About 59.40 % deficient was reported in rainfall in 2015 over the state. In the year 2015, the total Area Under Cultivation (AUC) declined about 6 % in the Kharif season compared to the previous year, when 18 % of food grains and 2 % of oilseeds production decreased. In the rabi, seasons 16 % of AUC declined due to total food grain and oilseeds production falling by 27 % and 50 %, respectively ([Economic Survey of Maharashtra, 2015-16](#)). The government of Maharashtra (with central funds) have spent around rupees 300.53 crores on the water supply to mitigate the severe drought impact in the drought year 2015-16. The total amount has been distributed in six divisions of Maharashtra to the severity of the drought. Out of the total amount, 17.30 crore has been spent in Pune division, 9.20 crore has been given to Konkan division, 50.20 core has spent in Nashik division, 27.32 crores and 14.40 crore have spent in Amaravati and Nagpur division. In the Aurangabad division, where the highest amount was spent on water supply among all divisions, 181.85 crore. The water supply has been provided by various sources such as water tankers, pipe water, rejuvenating old government well and bore wells, acquisition of private wells and bore wells, etc. ([Economic Survey of Maharashtra, 2015-16](#)). Furthermore, in 2018-19, low rainfall was recorded over the state, which was 73.60 %. Out of 335 talukas in the state, 192 talukas recorded deficient rainfall, 138 recorded normal rainfall and 25 recorded surplus rainfall. During the Kharif and rabi season in 2018, the crop production decreased

tremendously; in the Kharif season, cereals and pulses production lost around 6 % and 35 %, respectively. Furthermore, the rabi crop production declined by approximately 50 % ([Economic Survey of Maharashtra, 2018](#)). The state government declared the drought over 151 talukas in 26 districts, which of that severe drought in 112 and moderate drought in 28 talukas. Near about 85. 76 lakh hectares of the total area under cultivation were affected in the Kharif and rabi season ([Economic Survey of Maharashtra, 2018](#)).

Section IV

5.5 Information of the cattle camps, drinking water takers position in the drought years, and describes the block wise crop annewari/paisewari over the tree districts

5.4.1 Concept of cattle camp: State governments support their farmers to protect their cattle population due to severe drought conditions during a drought. The government provides the necessary facilities in the cattle camp, such as dry and wet fodder, drinking water, cattle health services, and green sheds for cattle. Mostly in the rural areas, farmers join the cattle camps with their livestock to rear or save them. The owner of the cattle camp and a few block-level government servants had responsibility for maintaining the camp. They were responsible for all activities that happened in the camp or (something wrong going in the camp). Sometimes, fodder or drinking water was not available in the camp then farmers could make complaints against the camp owner.



Table 5.75: Taluka wise cattle (fodder) camps in the Beed district. Maharashtra, 2015-2016.

Sr. No.	Taluka/Block	Cattle Camps	Small Cattle	Big Cattle	Total
1	Beed	83	6464	73366	79830
2	Ashti	114	5794	104353	110146
3	Patoda	34	999	14308	15307
4	Shirur Kasar	14	872	11476	12348
5	Georai	22	533	8535	9068
6	Ambajogai	1	86	1096	1182
7	Wadwani	3	160	2688	2848
8	Kaij	0	0	0	0
9	Dharur	1	40	993	1033
10	Parali	1	183	1531	1714
11	Majalgaon	1	43	459	502
	Total	274	16159	233855	250014

(Source: Department of revenue, district collector office of Beed, 2015-2016)

Table 5.75 shows the position of cattle camps in the Beed district in the year 2015-2016. There was total 274 cattle camps existed in 2015-16. More cattle camps were organized in the Ashti block/taluka than in other blocks/talukas. Total 114 cattle camps were functioned in the Ashti block, whereas in the Kaij block there was no cattle camp existed; after that Darur, Parli, and Majalgaon blocks, only one cattle camp working. Out of total camps, about 72 % of cattle camps existed in Beed and Ashti Blocks. In these cattle camps total 2, 50,014 small and big cattle were staying. Maximum, about 75 % of cattle were belonged to Beed and Ashti Block.

Table 5.76: Cattle camps in Beed District of Maharashtra until 1 April 2018 -2019

Sr. No.	Taluka/Block	Sanction cattle camps	Working cattle camps	Non-working cattle camps	Small cattle	Big cattle	Total cattle
1	Beed	313	181	108	9394	99387	108781
2	Ashti	303	175	115	6740	97770	104510
3	Patoda	61	44	9	2954	22380	25334
4	Shirur Kasar	50	40	8	2479	23200	25679
5	Georai	59	45	0	2008	24452	26460
6	Ambajogai	1	1	0	0	0	0
7	Wadwani	22	9	6	396	3600	3996
8	Kaij	57	32	22	1842	19132	20974
9	Dharur	4	3	0	139	1875	2014

10	Parali	1	0	0	0	0	0
11	Majalgaon	1	1	0	54	344	398
	Total	872	531	268	26006	292140	318146

(Source: Department of Revenue, district collector office of Beed, 2018-2019)

There were no drought like-conditions in 2017-18. That was the normal rainfall year for the Beed district. However, 2018-19 was a severe drought year. Among all talukas / Blocks of the district, the state government declared drought conditions regarding that government had organized many cattle camps in the district to protect or save livestock assets. Table 5.68 illustrates that the cattle camp position in the district. Total 531 cattle camps were worked in the Beed district of Maharashtra in the drought year 2018- 2019. In the Parali books, there was no cattle camp working. It reported that the highest cattle camps exist in Beed and, Ashti Blocks. And also, a maximum number of cattle were joined from the Beed and Ashti blocks. It same situation reported in the drought year 2015-16 (see in table 5.67).

Table 5.77: Annewari/ paisewari of Kharif crops (yield production) of Beed district in 2016-17

Sr. No.	Taluka/Block	Total villages in a block	Operated area	Cultivated area	Uncultivated area	Paisewari/ annewari (yield production)
1	Beed	239	132745	125523	7222	59.90
2	Ashti	177	132881	96488	36393	58.00
3	Patoda	107	67990	57199.12	8145.79	54.36
4	Shirur Kasar	95	54652	49582	10432	57.90
5	Georai	193	131798	120152	11646	60.00
6	Ambajogai	106	78229	75100	3119	57.00
7	Wadwani	49	34191	32137	2054	56.30
8	Kaij	135	100118.51	95833	4285.51	58.00
9	Dharur	74	46167	42244	3923	58.33
10	Parali	107	69612	64168	5444	65.40
11	Majalgaon	121	79046.57	70623.02	8393.55	64.40
	Total	1403	9272430.08	829089.14	101037.85	58.24

(Source: Department of Revenue, district collector office of Beed, 2016-17)

Annewari/ Paisewari is a traditional drought declaration indicator of state governments. Suppose annewari is less than 50 paise through crop cutting experiments in Kharif and Rabi seasons after that government declares drought. Annewari calculated by Annewari committee, including Revenue Mondal officer, Gram sevak, Sarpanch, Developed farmer, co-operative banking chairpersons, Talathi, and agriculture assistant ([Drought manual, 2009](#); [Drought](#)

manual, 2016). Table 5.69 shows the district annewari of all taluks in the Beed district. It is also indicated that annewari more than 50 paise; therefore, 2016-17 was not a drought year according to the government's crop cutting experiments. Total district annewari was 58.24 paise.

Table 5.78: Annewari/paisewari of Kharif crops (yield production) of Beed district in 2017-18

Sr. No.	Taluka/Block	Total villages in a block	Operated area	Cultivated area	Uncultivated area	Paise aanewari (yield production)
1	Beed	239	150661	122075	28586	60.00
2	Ashti	177	133049	96553	36496	58.00
3	Patoda	107	63607.37	57876	5731.38	52.00
4	Shirur Kasar	95	54752	49582	5170	59.63
5	Georai	192	133305.97	121524	11781.97	53.00
6	Ambajogai	106	78077	74500	3577	66.00
7	Wadwani	49	34432	32055	2377	57.00
8	Kaij	135	112731.08	104774	7975.08	57.10
9	Dharur	74	46170	43496	2674	54.04
10	Parali	107	68892	93687	5202	55.20
11	Majalgaon	121	79199.22	67543	11656.22	53.74
	Total	1402	954876.65	833665	121211.65	56.88

(Source: Department of Revenue, district collector office of Beed, 2017-18)

Table 5.78 illustrates the annewari/paisewari of Beed district in 2017-18. It shows that paisewari was more than 50 paise; therefore, that was not a drought year both in Kharif and rabi season. The average annewari was recorded 56.88 paise for the Beed district in the year 2017-18.

Table 5.79: Annewari/ paisewari of Kharif crops (yield production) of Beed district in 2018-19

Sr. No.	Taluka/Block	Total villages in a block	Operated area	Cultivated area	Uncultivated area	Paise aanewari (yield production)
1	Beed	239	153771.7	133306.26	20465.44	39.00
2	Ashti	177	130746	98503	32243	42.00

3	Patoda	107	645140.78	58150	6364.78	31.00
4	Shirur Kasar	95	54814.3	50798	4016.3	37.19
5	Georai	192	134339.3	122544	11795.3	40.30
6	Ambajogai	106	76994	71904	5090	42.00
7	Wadwani	49	344342	32055	2377	43.90
8	Kaij	135	102951	89341	13610	40.48
9	Dharur	74	46606	45360	1246	42.33
10	Parali	107	68187	58694	9493	46.40
11	Majalgaon	121	84330	84330	18020	43.80
	Total	1402	951686.08	828965.23	124720.82	40.80

(Source: Department of Revenue, District collector office of Beed. (One village shifted from Georai to Paithan taluka, Aurangabad district))

Table 5.79 describes the Kharif crop production annewari/paisevari of Beed districts in 2018-19. The annewari was below 50 paise, and the total district annewari was 40.80 paise. Among all 11 talukas, Patoda block annewari was 31.00 paise. It is significantly less. At the same time, Parali taluka annewari was 46.40, which was more among all blocks, but below 50 paise. Therefore, according to Maharashtra government, 2018-19 was a severe drought year.

Table 5.80: Kharif annewari of Osmanabad District, in the drought year 2018-19

Sr. No.	Blocks	Total annewari declared villages	Below 50 paise annewari villages	Final annewari
1	Osmanabad	128	128	48.00
2	Tulgapur	123	123	45.00
3	Umerga	96	96	47.57
4	Lohara	46	46	43.00
5	Bhum	96	96	47.00
6	Paranda	96	96	43.00
7	Kalamb	97	97	46.00
8	Washi	54	54	43.00
	Total	736	736	45.32

(Source: Department of Revenue, district collector office of Osmanabad, 2019)

Table 5.80 shows the Kharif annewari of Osmanabad District, 2018. It observed that all villages annewari of the districts were below 50 paise. Washi, Paranda, and Lohara blocks annewari was 43.00 paise, and the remaining blocks annewari was more than 43.00 paise but less than 50 paise. It shows an agricultural drought, and the state government also declared drought in 2018.

Table 5.81: Position of water tankers provided by the government in the drought year 2018-19.

Sr. No.	Blocks	Total villages population	Total villages	Total wadya (hamlet)	Gov. tankers	Private tankers	Total tankers	Total sanctions trips	Total tankers provided
1	Osmanabad	143505	27	4	1	58	59	147	95
2	Tuljapur	77996	26	1	0	32	32	79	60
3	Omerga	30619	11	3	0	19	19	47	47
4	Lohara	1644	1	1	1	1	2	6	4
5	kalamb	59284	21	0	0	29	29	74	64
6	Bhoom	55821	43	0	1	44	45	74	69
7	Washi	21235	20	0	1	26	27	56	52
8	Paranda	27144	18	2	1	19	20	32	29
Total		417248	167	11	5	228	233	515	420

(Source: Department of Revenue district collector office of Osmanabad, 2019)

Table 5.81 shows the local government provided total water tankers situation to the villages of Osmanabad district in the drought year 2018-19. The water tanker 137 was worked in the villages and 11 hamlets out of the total 733 villages of the Osmanabad district. Zilla Parishad had only five tankers. The remaining 228 private tankers worked on rent which has sanctioned by Zilla Parishad. Total sanctioned trips were 515, but 420 trips were actually delivered.

Table 5.82: Status of the private well requisition in the drought period 2018-19

Private well requisition							
Total village					Total well		
Sr. No.	Blocks	With Tankers	Without Tankers	Total	For Tankers	Without Tankers	Total
1	Osmanabad	32	84	116	49	199	248
2	Tuljapur	26	63	89	26	129	155
3	Umerga	14	44	58	19	108	127
4	Lohara	2	35	37	2	80	82
5	kalamb	21	55	76	32	107	139
6	Bhum	43	12	55	43	12	55
7	Washi	20	23	43	22	31	53
8	Paranda	20	54	74	20	101	121
Total		178	370	548	213	767	980

(Source: Department of Revenue, district collector office of Osmanabad, 2019)

Table 5.82 shows the status of a private well acquisition in the drought period 2018-19. It is reported that the government acquired 980 wells to provide drinking water to the village community and livestock and for sanitization purposes in their village. The water came through PVC pipes in the village; after that, it poured into a dry well or whatever water bodies were available to pour water in the village, then people fetched water from that water bodies. Like

that, they faced severe water scarcity problems. Maximum well acquired in Osmanabad block and minimum well acquired in Lohara block.

Table 5.83: Total livestock in Osmanabad district in 2018

Sr. No.	Blocks	Revenue Dep.	Total villages	Total livestock			
				Big livestock	Small livestock	Goats/Sheeps	Total
1	Osmanabad	8	128	75103	21316	40397	136816
2	Tulgapur	7	123	72627	20217	47978	140822
3	Umerga	5	96	52589	15942	22530	91061
4	Lohara	3	46	30315	7998	14789	53102
5	Bhum	5	96	52149	13418	23635	89202
6	Paranda	5	96	39641	10389	23042	73072
7	Kalamb	6	97	58116	15528	25150	98794
8	Washi	3	54	31447	8983	14021	54478
	Total	42	736	412014	113791	211542	737347

(Source: Department of Revenue, district collector office of Osmanabad, 2019)

Table 5.83 shows the total livestock position in Osmanabad district for the year 2018. It is reported that 737347 was the total livestock population including, cows, buffalos, oxen, and goats/ships. Osmanabad and Tulgapur blocks had more livestock than the other blocks. Washi and Lohara have less livestock among all blocks.

Table 5.84: Cattle camps in Osmanabad district until 31/05/2016

Sr. No.	Blocks	Sanctions cattle camps	Working cattle camps	Livestock details		
				Big livestock	Small livestock	Total
1	Osmanabad	13	7	4089	453	4542
2	Tulgapur	5	2	876	235	1111
3	Umerga	2	0	0	0	0
4	Lohara	0	0	0	0	0
5	Bhum	43	43	42806	4444	47250
6	Paranda	21	18	15435	1576	17011
7	Kalamb	12	9	4531	476	5007
8	Washi	7	4	1714	210	1924
	Total	103	83	69451	7394	76845

(Source: Department of Revenue, district collector office of Osmanabad, 2019)

Table 5.84 illustrates the cattle camps status in Osmanabad district until 31/05/2016. It is observed that total 83 cattle camps were sanctioned and maintained by the state government to protect the livestock assets in the rural areas of the district. Overall, 76845 small and big

livestock was survived in the camps. Maximum camps existed in Boom block, then Paranda and Osmanabad, Kalamb and Washi.

Table 5.85: Cattle camps in Osmanabad district until 07/06/2019

Sr. No.	Blocks	Sanctions cattle camps	Working cattle camps	Livestock details		
				Big livestock	Small livestock	Total
1	Osmanabad	9	8	7220	863	8083
2	Tuljapur	1	1	599	158	757
3	Umerga	0	0	0	0	0
4	Lohara	0	0	0	0	0
5	Bhum	61	50	38221	3850	42071
6	Paranda	23	20	12125	1274	13399
7	Kalamb	5	5	5886	992	6878
8	Washi	6	6	4224	409	4633
	Total	105	90	68275	7546	75821

(Source: Department of Revenue, district collector office of Osmanabad, 2019)

Table 5.85 illustrates cattle camps in Osmanabad district until 07/06/2019. It is observed that Bhum and Paranda blocks had maximum cattle camps than other blocks. On the other hand, Umerga, Lohara, have reported zero blocks and only one camp was worked in Tuljapur block.

Table 5. 86: Kharif crops annewari of the Latur district in 2016-17 (including major crops soybean, jwari, tur, moong, ulid)

Sr. No.	Blocks	Total villages	Total operated area	Total crop area (hectare)	Annewari
1	Latur	118	89673	82594	46
2	Ausa	130	111345	107263	47
3	Renapur	76	52025	51262	48
4	Udgir	99	69488	64865	47
5	Jalkot	47	31491	28682	41
6	Ahmadpur	124	69498	64810	46
7	Chkur	85	62947	59799	47
8	Nilanga	162	100930	98798	47
9	Devani	54	36601	34552	47
10	Shi. Anantpal	48	28368	27042	46
	Total	943	652366	619667	46

(Source, Department of revenue, district collector office of Latur, 2019)

The above table 5.86 shows that Kharif crops annewari of the Latur district in 2016-17. The table depicts that out of total 943 villages of the Latur district highest number of the villages (162) situated in Nilanga block and the lowest number of villages (48) situated in Shirur Anantpal block. The largest hectare cultivation area (107263) was in the Ausa block, and the

lowest hectare cultivation area (27042) was in the Shirur Anantpal block. The average annewari of the district was 46, lowest in Jalkot (41) and highest in Renapur (48).

Table 5.87: Kharif crops Annewari of the district in 2017-18 (Including major crops soybean, jwari, tur, moong, ulid)

Sr.No .	Blocks	Total villages	Total operated area	Total crop area (hectare)	Annewari
1	Latur	118	88865	82083	58
2	Ausa	130	112650	108100	58.3
3	Renapur	76	52287	51620	57.8
4	Udgir	99	70159	65294	65.84
5	Jalkot	47	31491	29328	44.34
6	Ahmadpur	124	69517	68199	47.47
7	Chakur	85	62947	60097	58
8	Nilanga	162	100929	99472	57
9	Devani	54	36520	34326	58
10	Shi. Anantpal	48	28421	27971	57
	Total	943	656786	626490	56.17

(Source, Department of revenue, district collector office of Latur, 2019)

Above table 5.87 shows that Kharif crops Annewari of the Latur district in 2017-18. The table depicts that out of 943 villages of the Latur district, the highest number of villages (162) are situated in Nilanga block and the lowest number of villages (48) in Shirur Anantpal block. The largest hectare cultivation area (108100) was in the Ausa block, and the lowest hectare cultivation area (27971) was in the Shirur Anantpal block. The average annewari of the district was 56.17, the lowest in Jalkot (44.34) and highest in Udgir (65.84). According to the state government, 2017-18 was not a drought year for the Latur district because its annewari is more than 50 paise.

Table 5.88: Kharif crops annewari of the Latur district in the year 2018-19

Sr.No .	Blocks	Total villages	Total operated area	Total crop area	Annewari
1	Latur	118	88865	82612	46.00
2	Ausa	130	113491	108013	46.06
3	Renapur	76	52260	51873	48.42
4	Udgir	99	69866	65132	44.00
5	Jalkot	47	31050	30175	43.00
6	Ahmadpur	124	70195	68104	47.93
7	Chakur	85	62826	60221	45.00
8	Nilanga	162	101212	99488	46.00
9	Devani	54	36313	34777	46.00

10	Shi. Anantpal	48	28304	27399	46.21
	Total	943	658382	627794	45.66

(Source: Department of revenue, district collector office of Latur, 2019)

The above table 5.88 illustrates Kharif crops annewari of the district in 2018-19. It reported that 45.66 paise was the average annewari of the district. The Jalkot block annewari was lowest among all blocks, and 47.93 paise was highest in Ahmadpur blocks but below 50 paise. Ultimately, it is indicated that 2018-19 was the severe drought year.

Table 5.89: Water tanker status of Latur district during the years 2015-16 and 2018-19

Sr.No.	Blocks Years	2015 - 16		2018 - 19	
		Total no. of villages	Total no. of tankers	Total no. of villages	Total no. of tankers
1	Latur	49	62	35	36
2	Ausa	22	27	12	17
3	Renapur	25	25	13	13
4	Udgir	51	55	21	25
5	Jalkot	30	37	12	16
6	Ahmadpur	44	57	11	11
7	Chakur	32	38	5	5
8	Nilanga	27	30	8	8
9	Devani	21	21	6	6
10	Shirur Anantpal	8	8	0	0
	Total	309	360	123	137

(Source, Department of revenue, district collector office of Latur, 2019)

Table 5.89 observes the water tanker status of the Latur district during 2015-16 and 2018-19. Out of 948 villages of the Latur district, 309 villages' people fetched water from 360 government water tankers in 2016. And in 2018-19 total of 113 villages depended on 137 government water tankers. Despite that, many villages of gram panchayat acquitted private wells for drinking water.

Table 5.90: Total pubic water tankers in Aurangabad division of Maharashtra (2018-19)

District	Villages	Hamlet (wadi)	Tankers		
			Public	Private	Total
Aurangabad	686	258	11	989	1000
Jalna	384	78	21	438	459
Beed	553	291	14	747	761
Parbhani	28	9	6	36	42
Hingoli	24	8	6	32	38
Nanded	43	18	9	64	73
Osmanabad	95	7	5	118	123
Latur	28	8	6	32	38

Total	1841	677	78	2456	2538

(Source, Department of Revenue, the divisional commissioner office of Aurangabad division, 2019)

Table 5.90 shows the public water tanker condition in Marathwada Region, which has run until now. The total number of tankers is 2538 worked in the drought year 2018-19. Aurangabad and Beed districts received more tankers than any other district, with a total of 69.38 percent. Only 1000 tankers operated in the Aurangabad district, followed by Beed, Jalna, and Osmanabad districts. Nanded, Hingoli, Parbhani, and Latur districts total 191 tankers were working.

5.6 Conclusion

The present chapter is mainly based on primary and secondary data sources, primary data collected irrigated and rainfed villages of three districts of Marathwada region and the secondary data compiled from various sources such as district offices and online websites of state and central governments.

It is observed that out of the total farm households, Hindus religion follows more households which is 244 (84.14%), followed by 28 (9.66 %) is Muslim and 18 (6.21 %) is the Buddhists. Within the social groups wise percentages OCs are more compared to other categories those are 144 (49.66 %) and on the other hand SCs households' percentage is lower which is 30 (10.34 %). It is found that nuclear families are more than joint families in both irrigated and rain-fed villages. According to category-wise analysis, STs families have more joint families compared to the other categories. The kutcha houses are more than other kinds of houses in both irrigated and rain-fed villages. In the irrigated village, pucca houses were more than in the rain-fed village and only four old houses existed among the total sample households. Large size farm households have more pucca houses which are (48.48 %) and the small and medium farmers have more kutcha houses which are (60.98 %) and (60.19 %), respectively. In order to social groups-wise percentages, OCs are dominant in all types of houses. Irrigated villages have more toilet facilities available compared to rain-fed villages. Different water sources used during the drought period by the sample households, tanker water, well of the gram panchayat, bore acquisition which sources are used largely used in the rain-fed village on the other side hand pump, self-borewell, well and bore acquisition which sources are largely used in the irrigated villages. Most of the marginal, small and medium farm households have used hand pump, well, bore acquisition and tanker water, only few OCs and OBCs households have self-borewells.

A large number of the households' cooking depends on LPG gas and firewood in the irrigated and rain-fed villages. At the same time, irrigated village households' percentages were found to be slightly more than the uses of gas cooking in comparison to rain-fed villages. The rain-fed villagers' households used more firewood for cooking purposes. More than 95 % of households have electricity available in their houses, but only a few households which are situated outside the village those only use kerosene lamps. Furthermore, we have found that most of the household heads are male and out of the total members of the sample households' male percentages are more than female. The highest number of farmers came in between the age group of 36 to 50 which is (40 %); the above 65 age group farmers were (18.82 %) and only two farmers age was below 25. It is observed that most of the farm households heads are illiterate and the higher education percentage is low in both areas. Most of the household heads' main occupation is cultivation, even though few household heads engage in business and government jobs. Marginal farmers are reported more in the irrigated villages, and small farmers are more in the rain-fed villages and medium and large farmers' percentages nearby similar. All kinds of landholding size OCs are dominant, only one SCs household is found under the large landholding size in the irrigated village and only three STs households came in the large landholding size from the Yellorewadi village.

Huge income losses have been reported among the households of irrigated and rain-fed villages during the drought year; however, irrigated villages' income decreased more compared to rain-fed villages. During the normal year, there are 41 households is between the lower-high- and high-income groups in the irrigated village and in the drought year only 15 households remain in the same groups, whereas in the rain-fed village, the groups percentage is zero. All, social categories income has decreased during the drought but SCs and STs as well as marginal and small farm households find more vulnerable to drought. In both irrigated and rain-fed villages, most of the households have fetched water from long distances; however, marginal and small farm households' percentage have reported more compared to large and medium farmers. A large number of livestock have been sold during the drought by farmers in the irrigated and rain-fed villages due to fodder and water scarcity; however, SCs households and marginal farmers have sold more livestock compared to others. Around 60 % of the farm households have faced fodder problems due to that some households send their livestock to cattle camps and some of them purchase fodder wherever it is available according to their convenience. Many farmers have got benefited from agriculture input subsidies in both ecosystems, but marginal, small and medium farmers have got more benefits from the scheme. Even though

less awareness about the crop insurance scheme, many households benefited from it. In the category-wise analysis, the STs have reported fewer benefits than others. Farmers have availed loans/debt from several national and local level banks during the drought, whereas large farmers, OCs and STs have used maximum loan/debt than the others.

Furthermore, school-going children have faced several difficulties during the drought from the maximum number of households, whereas marginal and small farmers' children have been observed more affected than others. Meanwhile, many household members have migrated from rural to urban areas, whereas marginal and small farm household members have migrated more compared to other groups.

Furthermore, it is also reported that cattle camp organization had useful to save livestock assets, whereas complain has been raised by farmers against cattle camps organizers; while water tankers facilities have been provided by the local government for drinking and sanitizations purposes in the drought period. The multiple regression results have found a statistically significant impact of rainfall and average minimum temperature on food grain production, which are significant at 1% and 5 % significance levels (average minimum temperature has a significant negative impact on food grain production) for the Beed district. Furthermore, in the second model it is found that a statistically significant impact of rainfall on food grain production for Osmanabad district, which is significant at 10 % significance levels. (Coefficient 3.272015*, p-value 0.0795) The third regression model found a statistically positive significant impact of rainfall and average maximum temperature on food grain production, which are significant at 5% and 10 % significance levels.

Schemes such as agriculture input subsidies and crop insurance, cattle camps, water tankers and SHGs have financially, mentally supported farmers in the drought to mitigate the severe drought impact in the study areas.

Chapter 6

Determinates of farm household's choice of coping and adaptation strategies to cope with drought from three districts of Marathwada region of Maharashtra

6.1 Introduction

Climate change harms rural livelihoods, agriculture, water shortages, and other natural resources which are necessary for human survival (Thinda et al., 2020). Drought is an important part of climate or climate change like as floods, hurricanes, blizzards, and cyclones. Drought has a wide range of effects on the economy, including water supplies, farming, and natural habitats. It's effect differ among Persons, households, firms, institutions, societies, governments, communities, and regional level (Jha C. Kumar and Gupta V., 2021; Fanadzo et al., 2021). South Asian countries are most influenced by climate change due to vulnerability and divergence of socio-economic, and demographic problems. India belongs to the South Asian countries which is mostly affected by drought, floods, cyclones, extreme weather conditions, and losses with poor adaptation management. The agriculture sector plays a crucial role in the economy of developing countries. Marginal and smallholder farmers are highly vulnerable to climate changes that harm livelihood and crop production particularly in rural areas (Menike & Arachchi, 2016). Drought ranks first among all-natural disasters in terms of the number of people affected worldwide, despite that being the most complex but least-understood phenomenon among all environmental hazards (Quandt A., 2021). Recurrent drought leads to occurred devastating effects on rural livelihood. These effects are food shortages, malnutrition, the depletion of economic assets and landlessness, human resources loss, extreme poverty and poverty traps, health conditions, and deaths (Gebre et al., 2021). Globally, India is one of the most vulnerable developing countries towards climate change hazards among all developing countries (Chandan Kumar & Jha Vijaya Gupta, 2021). Adaptation to climate change challenges in developing countries has been hampered by various socio-economic, geographical, ecological, and meteorological influences (Chandan Kumar and Jha Vijaya Gupta, 2021; Omerkhil et al., 2020). Countries of South Asia are the most vulnerable to climate change, mainly due to poverty, socio-economics, and demographics challenges. India is a part of South Asian country that is severely affected by climate change, extreme weather events, and its poor adaptation status (Chandan Kumar and Jha Vijaya Gupta, 2021; Omerkhil et al., 2020). Farm households' adaptive capacity is determined by various socio-economic and demographic variables, including family size, farm size, gender, level of

education, and age, which are differed by region and locality (Niles et al., 2015). Adaptation and coping mechanisms are required to mitigate vulnerability from drought shocks, and it prepares a plan to overcome the future adverse climatic incidence (Opiyo et al., 2015). Adaptation is crucial for farmers to know climate fluctuations and their consequences in the farming sector to react with the appropriate set of adaptations (Omerkhil et al., 2020). Agricultural adaptation differs in terms of time (short-term vs. long-term); it also differs at a farm, regional, and national level. Farm-level adaptation choices can be divided into three core parts such as farm management strategies, farm-level technical innovations, and financial planning for farm protection. This chapter focused on the two main following research questions: which coping and adaptation strategies have been adopted by the rural farmers to cope with drought? Whether the socio-economics and demographic characteristics affect their adoption choices to adapt strategies? The chapter's main objective is to examine the determinates of farm households' choice of coping and adaptation strategies to cope with drought.

6.2 Overview of the study

In this 6th chapter we are highlighted coping and adaptation strategies adopted by farmers in the study area to cope drought. In many studies, farmer used coping and adaptation strategies across the world to cope drought and climate change. Here, we are tried to reviewed the extensive literature on coping and adaptation strategies at regional, national and global levels (see in chapter 3, part 6). Khetwani et al., (2020) observed the drought adaptation strategies adopted by marginal, small, medium, and large farmers during the drought period in the Marathwada region. The various adaptation strategies adopted by farmers include early crop sowing, shift to drought-tolerant crops, migration for livelihood, off-farm employment, reduction in day-to-day spending, and stored crop harvest. Furthermore, many studies which are (Alemayehu & Bewket, 2017; Mardero et al., 2015; Fanadzo et al., 2021; Gebre et al., 2021 Omerkhil et al., 2020; Bhatta & Aggarwal, 2016; Belay et al., 2017) highlighted various coping and adaptation strategies employed by the farmers to mitigate the negative impact of drought and climate change in India and across the world.

6.3 Concept of coping and adaptation strategies

In the context of disaster response, coping and adaptation strategies are adopted by farmers in the rural area to cope climate change and rainfall variability, which are closely connected to each other. They may be employed alternatively in the different time periods (Alemayehu & Bewket, 2017). Furthermore, coping techniques are used by households and communities in

the short term to challenge, control, and recover from bad conditions, crises, or catastrophes. They can be implemented ex-post to climate shocks and other ecological threats (Mayanja et al., 2020 ; Assan et al., 2018). Worldwide, communities have a long history of adapting adaptation plans against weather and climate disasters including floods, droughts and cyclones (IPCC, 2007). Long-term plans are primarily designed to respond to change in the wider ecological conditions which are called adaptation strategies. In addition, the purpose of adaptation practices is to make people less vulnerable from the negative influences of climate change while maintaining sustainability (Alemayehu & Bewket, 2017; Zheng & Byg, 2014; Nyberg et al., 2020).

6.4 Statistical analysis

This study investigates farm households' coping and adaptation strategies and identifies the determinants that influence farmers' drought-induced adaptation techniques. The logit regression model is employed to analyse the relationship between coping and adaptation strategies and socio-economic and demographic characteristics (determinants) of the farm household from the irrigated and rain-fed villages in the drought-prone areas of the three districts of the Marathwada region in rural Maharashtra. The model shows whether there is a statistically significant association between dependent and independent variables. Coping and adaptation strategies are the dependent variables, and socio-economics and demographic factors are the independent variables. Household size, age of the household head, family types, land size, loan/debt from the national banks, SHGs access, Education, Farming Experience, livestock ownership, and annual income are the explanatory/independent variables that determine the choices of adaptation strategies. The explanatory factors are determined based on a review of the literature and the availability of data. This study identified several copings and adaptation strategies, which adopted by the farmers to cope with the drought in the drought period 2015, and 2018. But out of the total coping and adaptation practices we have found some of them are statistically significant. These coping strategies are such as borrowing money from relatives and moneylender, reduction in consumption, migration, seeking off-farm employment, stop marriage ceremony, store crop residuals, crop insurance, selling livestock and the adaptation strategies are including crop diversification, rejuvenation, income diversification, long term-management.

Let's assume that (Y_{ij}^*) in our study, the decision of an individual to adapt and not to adapt depends on unobservable utility index Y_{ij}^* , which depends on independent variables which are household size, age of the household head, family type, land size, loan/Debt from the national

bank (credit access), SHGs access, education, farming experience, livestock ownership, annual income.

$$Y_{ij}^* = \alpha + \beta_j X_i + \varepsilon_{y_{ij}^*}$$

Where, Y_{ij}^* = expected outcomes, i = i th farm households which is adapting j th adaptation strategies. X_i , denotes explanatory variables, and i , indicate particular household features. (Gujarati, 2011; Atube et al., 2021).

We assume that,

$$Y_{ij} = \begin{cases} 1 & \text{if } Y_{ij}^* > 0 \\ 0 & \text{if } Y_{ij}^* < 0 \end{cases}$$

Where, Y_{ij} is a described expected probabilities of j th adaptation strategies adopted by the i th farm households. If the expected probabilities are greater than zero, then it indicates farmers or farm household adapt the specific coping and adaptation strategy (1 if $Y_{ij}^* > 0$). If the expected probabilities are smaller than zero, then they do not adapt particular coping and adaptation strategies (0 if $Y_{ij}^* < 0$).

6.4.1 Binary logit regression model

A binary logistic model specification is applied to model respondents' drought coping and adaptation strategies involving dummy dependent variables with binary choices (Marie et al., 2020). Logistic model specification according to (Green, 2011):

$$\log\left(\frac{P_i}{1-P_i}\right) = \log(P_i) = \beta_0 + \beta_i X_i \dots \dots \dots (1)$$

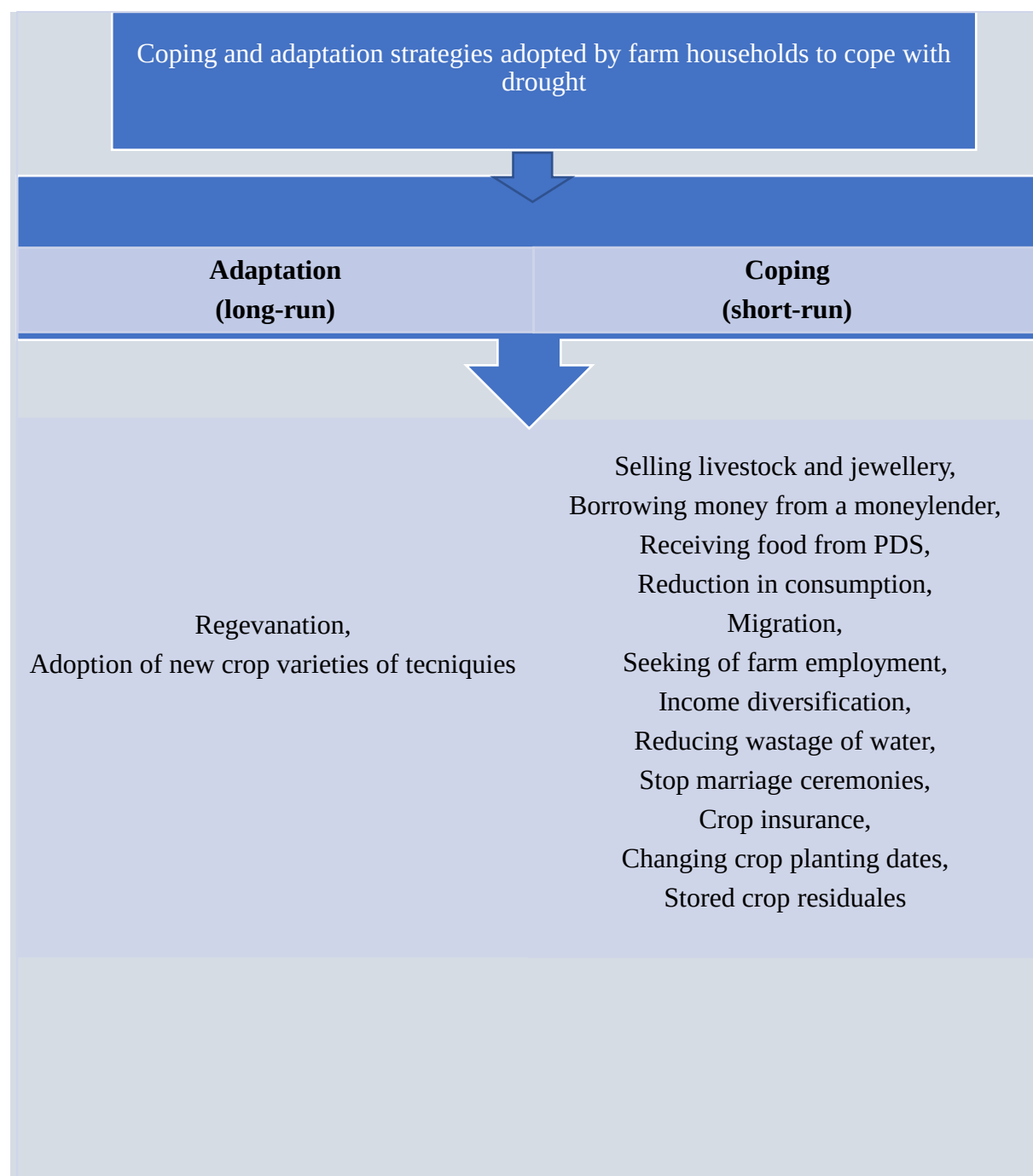
Where, P_i is the probability of adopting specific adaptation strategies from the given set dummy dependent variable, X_i is the explanatory or independent variables. Therefore, the β_i parameter shows the log odds for the dependent or outcomes variable. The probability of odds is defined as P_i = the farm household adopt and, $(1 - P_i)$ = not adopt (Jha and Gupta, 2021; Jin et al., 2016). The log odd defines as:

$$\frac{P_i}{1 - P_i} = \exp(\beta_0 + \beta_i X_i) \dots \dots \dots (2)$$

6.5 Results and discussion

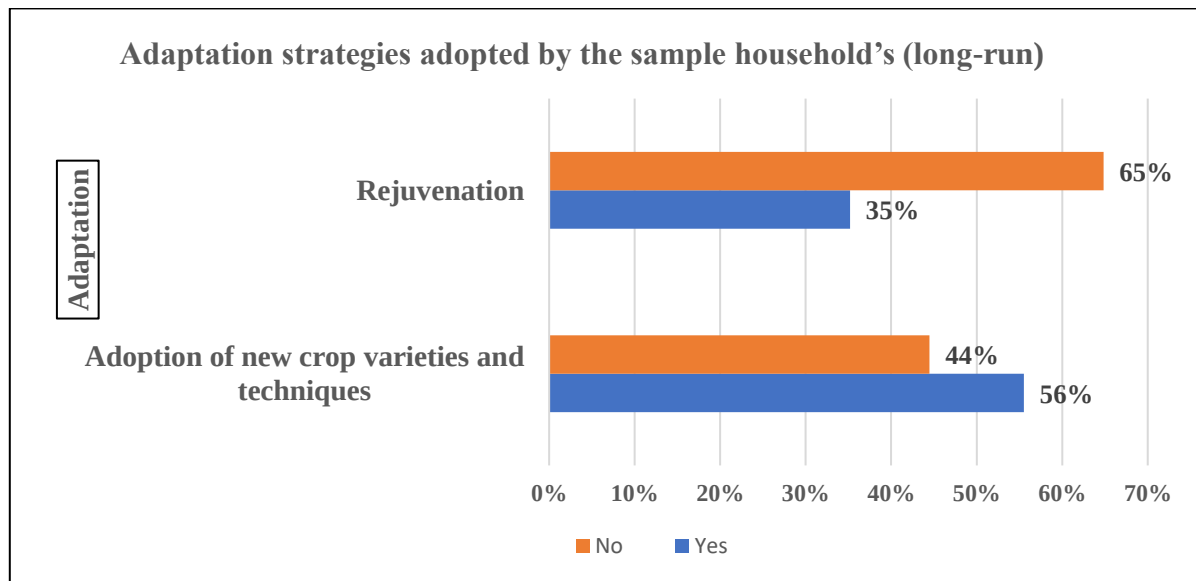
The drought adaptation (mitigation) strategies have been divided into two parts; shorts run as coping and long-run as adaptation strategies. The analysis results have been calculated applying binary logit regression model from cross-section data. The figure has been drawn using Likert scale percentages in the excel data seats.

Figure 6.1: Coping and adaptation strategies adopted by farm households to cope with drought



(Author's own diagram using various studies and IPCC framework, 2007)

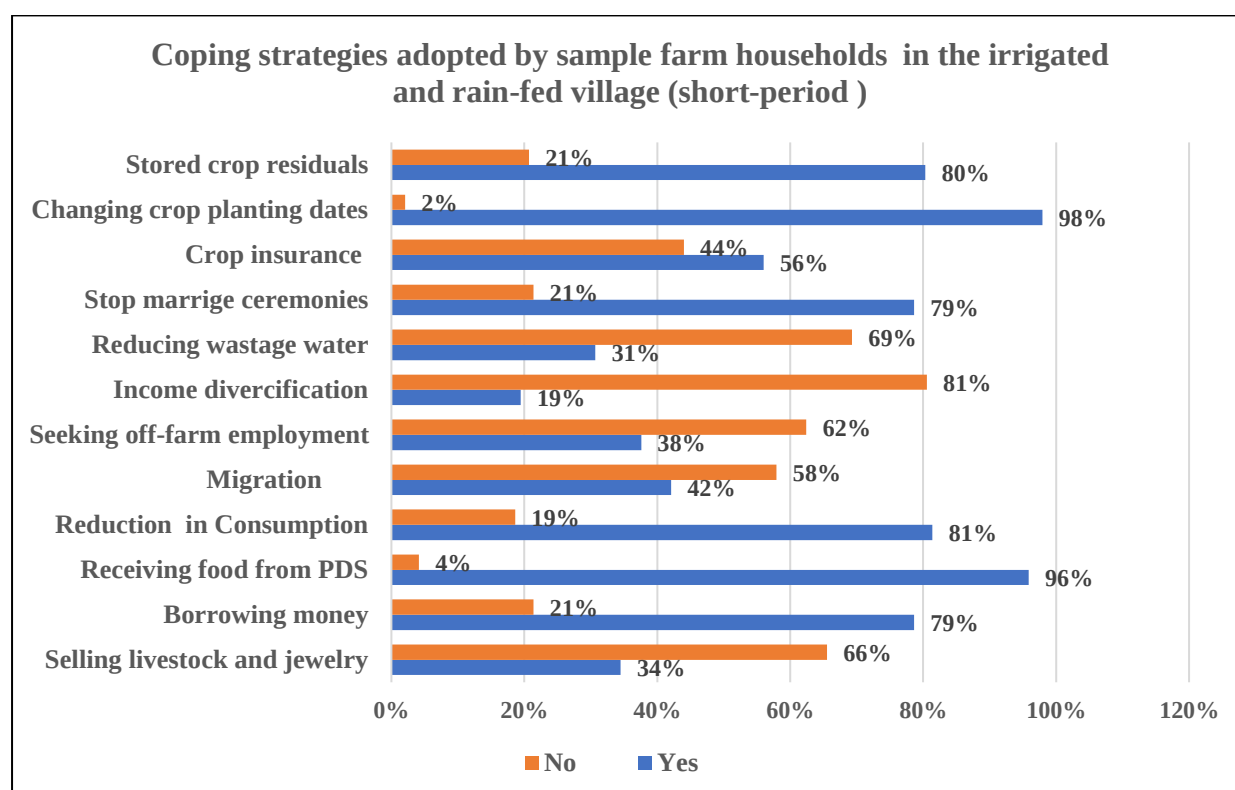
Figure 6.2: Drought adaptation strategies of the sample farm households, both irrigated and rain-fed villages (long-term strategies)



(Author's own calculations from filed survey 2018-19)

Figure 6.2 shows the adaptation strategies adopted by the sample households (both irrigated and rain-fed villages) to cope with drought in the study area. It is observed that most of the farmers or farm households adopted adaptations strategies during the drought period for a long time, about (56 %) of farmers have changed crop varieties and techniques; they have used modern varieties which have sustained during drought. Maximum farmers cultivate their farms using tractors, different machines and also used fertilizer spreader. Then about (35 %) of the farmers have participated in rejuvenation programmes in their villages mostly in irrigated villages; they have done rejuvenation of Nala, river, small ponds, small reservoirs and dams. In the rain-fed village there are very small flows of Nala and reservoirs compared to irrigated villages.

Figure 6.3: Coping strategies of drought adopted by village households, both irrigated and rain-fed (short-run coping strategies)



(Author's own calculations from filed survey 2018-19)

Figure 6.2 highlighted the coping strategies adopted by farmers in both irrigated and rainfed areas during the drought. The most favoured coping strategies were adopted by farmers, such as changed crop planting dates (98 %). There is irregularity of monsoon, people can not be assured about it, therefore they have changed their crop planting dates, sometimes they have done double sowing in their farms. Due to drought and rainfall variability, farmers changed their crop planting dates to avoid double (again and again) cultivation or sowing that was not affordable for farmers. Then, the study reported that about (96 %) of households received food grains from the Public Distribution System (fair prices shops), most of the households in the both irrigated and rain-fed villages have been received food from PDS; followed by about (81 %) of households reduced their consumptions. Loss of agriculture and decrease of income households have reduced their consumption during the drought year compared to normal year. Nearly (80 %) of the total sample farm households stored crop residuals for their livestock. They have stored soyabean, jawar, and bajara residuals. Furthermore, the study observed that about (79 %) of households stop marriages ceremonies and also (79 %) of them borrowed money from relatives and moneylenders. About (56 %) of the households benefited from crop insurance schemes. In addition, (42 %) of household's members migrated from rural to urban

areas and rural to rural places to get temporary jobs in a drought period, while (38 %) of families (farmers) worked in the off-farm sector due to failure of agriculture.

Table 6 1: Descriptive statistics of explanatory variables and dependent variables

Sr. No.	Explanatory variables	Sample size	Mean	Std. Dev.	Min	Max
1	Household size	290	4.993103	1.869428	1	12
2	Age of the household head	290	52.21379	13.70408	23	82
3	Family type	290	0.272414	0.445971	0	1
4	Land size	290	5.407862	4.481171	0.17	30
5	Loan/Debt from the national bank	290	0.675862	0.468861	0	1
6	SHGs access	290	0.6	0.490745	0	1
7	Education	290	5.524138	4.924457	0	17
8	Farming Experience	290	21.87931	9.02683	6	70
9	Livestock Ownership	290	0.731035	0.444189	0	1
10	Annual income	290	144920.7	162379.3	30000	1000000
Dependent variables						
1	Borrowing money from relatives and moneylender	290	0.786207	0.410691	0	1
2	Reduction in consumption	290	0.817241	0.387137	0	1
3	Migration	290	0.42069	0.494523	0	1
4	Seeking off-farm employment	290	0.375862	0.485182	0	1
5	Stop marriage ceremony	290	0.786207	0.410691	0	1
6	Store crop residuals	290	0.793103	0.405781	0	1
7	Adoption of new crop varieties and techniques	290	0.555172	0.497806	0	1

8	Rejuvenations	290	0.351724	0.478334	0	1
9	Income diversification	290	0.289655	0.454386	0	1
10	Crop insurance	290	0.444828	0.497806	0	1

(Author's own calculation from the survey data)

Descriptive statistics assist in describing and understanding the features of a specific data set by giving summaries of the sample and data measures. Measures of central tendency and measures of variability (spread) are two types of descriptive statistics. The average (mean), median, and mode are examples of central tendency measures, and standard deviation, variance, minimum and maximum variables, kurtosis, and skewness are examples of variability measures ([Anderson et al., 2011](#)). Many studies used descriptive statistics to describe the characteristics of the data set, including explanatory and response or outcome or dependent variables. Table 6.1 describes the descriptive statistics of dependent and independent variables of survey households in the six irrigated and rain-fed villages. The farmers' or farm household head characteristics that affected their adaptive decisions to adopt coping and adaptation strategies against the study area's drought. The descriptive statistics show that the average household's size of the surveyed farm households is five respondents, the maximum number of members is 12, and the minimum number of members is 1. The average age of the households' head is 52, and the ages of the youngest and oldest heads of the households are 23 and 82. Family types are divided into two categories: nuclear, and the second one is joint family. The study found (72.76 %) are nuclear families, and (27.24 %) are joint families. It is a categorical variable that shows a positive and negative relationship with choices of adaptation behaviour of the farmers' adaptations; maximum families are nuclear farmers in the study area. The total land size of farm households shows in an acre, the average land size of the farmers or farm households is 4 acres, the minimum land size is 1 acre, and the maximum land size is 30 acres. Farmer's category sub-divided into four groups Such as marginal, small, medium, and large groups. Out of the total sample size, (28 %) are marginal farm households, (37.24 %) are small farmers, (23.10 %) are medium farmers, and (11.38) are the large farmers. The land size has found statistically significant positive and negative impacts of farmers' decision to adopt adaptation behaviour in the study area to combat drought. About (67.59 %) of farm households used loans/debt from various national banks (credit access) like the State bank of India (SBI), Maharashtra Bank, Marathwada Gramin Bank, Central Bank of India, and local level Co-operative societies. The average size of SHGs or microfinance access is (0.60). It means that microfinance played a crucial role in the drought period. It helps farm households

cope with drought. It is a crucial factor that positively affects farmers' decision to adopt adaptation. Many studies found that education is the most significant factor that affects adaptation choices to adapt in the urban and rural areas. This study divided education levels into five categories: primary, secondary, higher secondary, graduate, post-graduate, and illiterate. The average size year of schooling is six years. The maximum number of years of education is 17 years (post-graduate). It is found that (32.76 %) of farm households' heads were illiterate. Only 2 (0.69 %) have completed a post-graduate degree; mostly farm household heads have completed their primary and secondary level education. The average farming experience is 22 years, maximum farming experience is 70 years, and minimum farming experience is six years. Many studies observed that livestock ownership and annual income of the farm households were essential factors that were affected the adaptation behaviour of the farmers to adapt to climate change and drought. Here, the results show that the average annual income of the farmers is 145 000, the maximum annual income of the farmers is 100,000, and the minimum annual income is 30,000. The average livestock of the farmers is 0.73.

Table 6.2: Definition of exoplanetary variables used in this model

	Explanatory variable	Description of explanatory variable
1	Total household members	Continues
2	Age of the household head	Continues
3	Family type	Binary, (<i>Joint</i> =1, <i>Nuclear</i> = 0)
4	Land size	Continues (land in acre)
5	Loan/Debt from the national bank	Binary, (Yes =1, No= 0)
6	SHGs access	Binary, (Yes =1, No= 0)
7	Education	Continues (Illiterate = 0, primary =1, secondary = 2, Higher secondary =3, Graduate =4, Post graduate = 5)
8	Farming Experience	Continues
9	Livestock Ownership	Binary, (Yes =1, No= 0)
10	Annual income	Continues

(Source: Author's own calculation from survey data)

Table 6.2 describes the definition of explanatory variables which are used in the study. Five continuous and five categorical variables are explained to determine the adaptation behaviour of the farm households in the drought period of irrigated and rain-fed villages from the three districts (Beed, Osmanabad, and Latur) in the Marathwada region of Maharashtra. The total household's survey sample size is 290.

Table 6 3: Farmers major coping and adaptation strategies adopted by farm households against drought

Sr. No.	Strategies	Description of dependent variables	No. of farmers adaptations	Percentage
1	Borrowing money from relatives and moneylender	Borrowing money from moneylenders and relatives and paying interest rates with 5 %, 7% for 100-rupees per month	228	78.62
2	Reduction in consumption	Less money spending on daily consumption compared to a normal year	237	81.72
3	Migration	Migrated from rural to urban areas and rural to rural areas. for a searching job (temporary migration)	122	42.07
4	Seeking off-farm employment	Worked as a mason, cement workers, bricks making, digging well, drivers, security jobs, driving water tankers etc.	109	37.59
5	Stop marriage ceremony	Due to water shortages and failure of agriculture, could not conduct marriage ceremony	228	78.62
6	Store crop residuals	Due to shortage of fodder, they store crop residuals like soybean, jawar, maize, pulses etc.	230	79.31
7	Adopting new crop varieties and techniques	Cultivating/growing drought tolerance crops that needs less rainfall like as soyabean, bajara, jawar, maize and used tractors, fertilizer spreader etc.	161	55.52
8	Rejuvenation	River, small dam, ponds, runnel etc.	102	35.17
9	Income diversification	Jobs (Business, daily wages, hotel, employment, driver etc.)	84	28.97

10	Crop insurance	Applying for crop insurance before sowing the crops if there is less rainfall or crop failure, the beneficiary will get money after a season	129	44.48

(Author's own calculations from survey data)

Table 6.3 describes coping, and adaptation strategies of farm households in the irrigated and rain-fed villages of the three districts in the Marathwada region of Maharashtra. Out of the total sample size, about (81.72 %) of farm households reduced their consumption; after that, (78.62 %) of farm households borrow money from moneylenders and relatives, (78.62 %) of farm households did not arrange marriages of their sons and daughter, and (79.31 %) of farm households stored crop residuals for livestock to survive them in drought periods. These are the large number of coping strategies adopted by the farm household both in irrigated and rain-fed villages. Furthermore, (44.48 %) of the farm household's availed crop insurance from different insurance companies. (42.07 %) of farm households' members temporary migrated from rural to urban areas as well rural to rural areas wherever places they wanted to go in accordance with their convenience to find out jobs, (37.59 %) of farm households' members were seeking off-farm employment and (About (28.97 %) farm households diversified their income in various category like as (Business, daily wages, hotel, employment, driver etc.). These are the short-term adaptation strategies adopted by farmers to mitigate the immediate impact of drought. Long term-strategies adopted by farmers to combat with drought in the future also. Out the total 290 sample household's (56 %) of them adopted new crop varieties and techniques, (35.17 %) of the farm households participated in rejuvenation of rivers and small ponds.

Table 6.4: Binary logit model results for coping and adaptation strategies

Sr. No.		Borrowing money from relatives and moneylender		Reduction in consumption	
	Explanatory variable	Coefficient, (P-value)	Marginal effects (dy/dx) (P-value)	Coefficient (P-value)	Marginal effects (dy/dx) (P-value)
1	Household size	-0.31194 (0.009) ****	-0.04116 (0.007) ***	-0.13670 (0.244)	-0.1367 (0.242)

2	Age of the household head	-0.06903 (0.010) **	-0.00911 (0.008) *****	0.01908 (0.420)	0.01908 (0.419)
3	Family type	1.085113 (0.037) **	0.143185 (0.033) **	0.234275 (0.628)	0.234275 (0.628)
4	Land size	0.147907 (0.028) **	0.019517 (0.025)	-0.04591 (0.324)	-0.04591 (0.323)
5	Loan/Debt from national bank	1.897951 (0.000) ***	0.250442 (0.000) ***	0.334715 (0.356)	0.334715 (0.355)
6	SHGs access	0.230154 (0.495)	0.03037 (0.494)	0.581837 (0.090) *	0.581837 (0.088)
7	Education	-0.00121 (0.976)	-0.00016 (0.976)	0.002666 (0.947)	0.002666 (0.947)
8	Farming Experience	0.123118 (0.006) ***	0.016246 (0.004) ***	-0.02496 (0.485)	-0.02496 (0.485)
9	Livestock Ownership	-0.30432 (0.439)	-0.04016 (0.438)	-0.08631 (0.839)	-0.08631 (0.839)
10	Annual income	-2.85E-06 (0.052) *	-3.75E-07 (0.048) **	-3.43E-06 (0.004) ***	-3.43E-06 (0.003) ***
	Constant	2.295546 (0.017) **		2.052286 (0.033) **	2.052286
	Number of observations	290		290	
	LR chi2(10)	60.08		30.08	
	Prob > chi2	0.0000***		0.0008***	
	Pseudo R2	0.1996		0.1090	
	Log likelihood	-120.45131		-122.87132	
	Hosmer-Lemeshow chi2(8)	2.38		8.41	
	Prob > chi2	0.9670		0.3942	

		Migration		Seeking off-farm employment	
Sr.No.	Explanatory variable	Coefficient (P-value)	Marginal effects (dy/dx) (P-value)	Coefficient (P-value)	Marginal effects (dy/dx) (P-value)
1	Household size	0.315042 (0.002) ***	0.061566 (0.001) ***	0.376503 (0.000) ***	0.070243 (0.000) ***
2	Age of the household head	-0.00684 (0.722)	-0.00134 (0.722)	-0.02563 (0.183)	-0.00478 (0.177)
3	Family type	-0.28459 (0.491)	-0.05561 (0.490)	-0.57426 (0.182)	-0.10714 (0.177)
4	Land size	0.146297 (0.006) ***	0.028589 (0.004) ***	-0.00018 (0.997)	-3.4E-05 (0.997)
5	Loan/Debt from the national banks	0.024166 (0.933)	0.004723 (0.933)	-0.19084 (0.513)	-0.03561 (0.512)
6	SHGs access	0.13943 (0.614)	0.027248 (0.614)	-0.10706 (0.704)	-0.01997 (0.704)
7	Education	0.002961 (0.927)	0.000579 (0.927)	-0.02492 (0.450)	-0.00465 (0.448)
8	Farming Experience	-0.01605 (0.608)	-0.00314 (0.607)	0.037855 (0.211)	0.007063 (0.206)
9	Livestock ownership	-0.41813 (0.182)	-0.08171 (0.176)	-1.03237 (0.001) ***	-0.19261 (0.000) ***
10	Annual income	-1.7E-05 (0.000) ***	-3.25E-06 (0.000) ***	-1E-05 (0.001) ***	-1.95E-06 (0.000) ***
	Constant	0.178354 (0.817)		0.450845 (0.567)	
	Number of observations	290		290	
	LR chi2(10)	69.00		68.90	
	Prob > chi2	0.0000***		0.0000***	
	Pseudo R2	0.1748		0.1794	

	Log likelihood	-162.84759		-157.53133	
	Hosmer-Lemeshow chi2(8)	23.70		8.33	
	Prob > chi2	0.0026		0.4020	

		Stop marriage ceremony		Store crop residuals	
Sr. No.	Explanatory variable	Coefficient (P-value)	Marginal effects (dy/dx) (P-value)	Coefficient (P-value)	Marginal effects (dy/dx) (P-value)
1	Household size	0.218126 (0.082) *	0.029944 (0.077) *	-0.11081 (0.449)	-0.00975 (0.447)
2	Age of the household head	-0.01005 (0.668)	-0.00138 (0.668)	-0.03621 (0.272)	-0.00319 (0.269)
3	Family type	0.583257 (0.277)	0.080068 (0.274)	1.13092 (0.101)	0.099512 (0.096)
4	Land size	-0.04214 (0.423)	-0.00579 (0.421)	0.568411 (0.000) ***	0.050015 (0.000) ***
5	Loan/Debt from national bank	-0.27294 (0.450)	-0.03747 (0.448)	-0.17855 (0.683)	-0.01571 (0.683)
6	SHGs access	1.85764 (0.000) ***	0.255011 (0.000) ***	1.382832 (0.001) ***	0.121678 (0.001) ***
7	Education	0.058791 (0.133)	0.008071 (0.128)	0.163607 (0.002) ***	0.014396 (0.001) ***
8	Farming experience	0.040214 (0.277)	0.005521 (0.274)	0.154386 (0.008) ***	0.013585 (0.005) ***
9	Livestock Ownership	0.696112 (0.061) **	0.09556 (0.055) **	2.497096 (0.000) ***	0.219724 (0.000) ***
10	Annual income	-2.41E-06 (0.055) **	-3.32E-07 (0.051) **	-6.96E-06 (0.004) ***	-6.13E-07 (0.003) ***

	Constant	-1.13777 (0.236)		-3.98288 (0.002) ***	
	Number of observations	290		290	
	LR chi2(10)	52.11		130.20	
	Prob > chi2	0.0000***		0.0000***	
	Pseudo R2	0.1731		0.4403	
	Log likelihood	-124.43965		-82.745188	
	Hosmer-Lemeshow chi2(8)	5.63		6.34	
	Prob > chi2	0.6883		0.6092	

		Rejuvenation		Income diversification	
Sr. No.	Explanatory variable	Coefficient (P-value)	Marginal effects (dy/dx) (P-value)	Coefficient (P-value)	Marginal effects (dy/dx) (P-value)
1	Household size	0.272212 (0.017) **	0.041571 (0.013) **	0.184575 (0.072) *	0.033224 (0.066) *
2	Age of the household head	0.091452 (0.001) ***	0.013966 (0.000) ***	-0.01727 (0.375)	-0.00311 (0.372)
3	Family type	-0.98858 (0.041) **	-0.15097 (0.036) **	-0.18993 (0.654)	-0.03419 (0.654)
4	Land size	-0.24741 (0.000) ***	-0.03778 (0.000) ***	-0.05409 (0.353)	-0.00974 (0.351)
5	Loan/Debt from the national bank	0.105997 (0.755)	0.016187 (0.755)	0.393047 (0.199)	0.07075 (0.195)
6	SHGs access	2.016889 (0.000) ***	0.308007 (0.000) ***	-0.92387 (0.001) ***	-0.1663 (0.000) ***
7	Education	0.034445 (0.342)	0.00526 (0.339)	-0.00961 (0.776)	-0.00173 (0.776)
8	Farming Experience	-0.13106 (0.003) ***	-0.02001 (0.002) ***	0.026279 (0.389)	0.00473 (0.386)

9	Livestock Ownership	0.647214 (0.092) *	0.098839 (0.087) *	0.154637 (0.633)	0.027835 (0.633)
10	Annual income	9.30E-06 (0.000) ***	1.42E-06 (0.000) ***	-5.19E-06 (0.027) **	-9.34E-07 (0.024) **
	Constant	-5.84289 (0.000) ***		-0.41972 (0.598)	
	Number of observations	290		290	
	LR chi2(10)	106.86		39.92	
	Prob > chi2	0.0000***		0.0000***	
	Pseudo R2	0.2841		0.1144	
	Log likelihood	-134.63787		-154.57222	
	Hosmer-Lemeshow chi2(8)	1.32		3.60	
	Prob > chi2	0.9953		0.8910	

		Crop insurance		Adaptation of new crop varieties	
Sr. No.	Explanatory variable	Coefficient (P-value)	Marginal effects (dy/dx) (P-value)	Coefficient (P-value)	Marginal effects (dy/dx) (P-value)
1	Household size	0.105328 (0.258)	0.022667 (0.254)	0.102624 (0.328)	0.018869 (0.325)
2	Age of the household head	0.059199 (0.004) ***	0.01274 (0.003) ***	-0.01676 (0.407)	-0.00308 (0.405)
3	Family type	-1.43692 (0.000) ***	-0.30924 (0.000) ***	0.676321 (0.116)	0.124349 (0.110)
4	Land size	0.129002 (0.005) ***	0.027762 (0.003) ***	-0.19061 (0.001) ***	-0.03505 (0.001) ***
5	Loan/Debt from national bank	0.493562 (0.083) *	0.106218 (0.077) *	0.460169 (0.123)	0.084607 (0.117)
6	SHGs access	-0.2771	-0.05963	0.493934	0.090815

		(0.298)	(0.295)	(0.081) *	(0.075) *
7	Education	-0.02893 (0.353)	-0.00623 (0.351)	0.047286 (0.159)	0.008694 (0.154)
8	Farming experience	-0.10458 (0.002) ***	-0.02251 (0.001) ***	0.070903 (0.035) **	0.013036 (0.030) **
9	Livestock Ownership	-0.06992 (0.819)	-0.01505 (0.819)	0.744198 (0.020) **	0.136829 (0.016) **
10	Annual income	-4.14E-06 (0.002) ***	-8.92E-07 (0.001) ***	1.18E-05 (0.0000) ***	2.17E-06 (0.0000) ***
	Constant	-1.26899 (0.096) *		-2.92793 (0.000) ***	
	Number of observations	290		290	
	LR chi2(10)	40.18		85.98	
	Prob > chi2	(0.0000) ***		0.0000***	
	Pseudo R2	0.1008		0.2158	
	Log-likelihood	-179.15126		-156.25559	
	Hosmer-Lemeshow chi2(8)	8.45		16.91	
	Prob > chi2	0.3912		0.0311	

(***, ** and * indications that it is statistically significant at 1%, 5%, and 10% levels, respectively)

6.6 Role of socio-economics and demographic characteristics in adaptation decisions

A large form of research has focused on farm households' demographic and socio-economic features as important determinants influencing their adaptable potential and adaptation decisions ([Chandan Kumar and Jha Vijaya Gupta, 2021](#); [Alauddin & Rashid, 2014](#); [Ashraf et al., 2014](#); [Jin et al., 2016](#); [Alemayehu & Bewket, 2017](#); [Deressa et al., 2009](#)). A binary logit model is employed to analyse the factors influencing farmers' adoption of different adaptation measures. The study examines the relationship between coping and adaptation strategies and socio-economic characteristics, which affects the adoption choices to choose adaptation of rural farmers in the drought-prone areas of irrigated and rain-fed villages. It also examined the determinants of rural farmers which affect adaptation choices towards drought to adopt adaptation behaviour. A binary logit model has been employed to find significant associations

between factors influencing their decisions of adaption behaviour among rural farmers to cope with drought. Several studies on climate change and drought ([Jha C. Kumar and Vijaya Gupta, 2021](#); [Marie et al., 2020](#)) employed binary logistic regression to analysed the relationship between determinats of smallholder farmers and their coping and adaptaion. They found significat relashonship between them. In this study, we have run 10 logit regression equations separately for each coping and adaptation strategies to exclude the interaction among them. Several studies have highlighted farm household's socio-economics characteristics as crucial elements in shaping farm-level adaptive capacities and choices.

6.6.1. Household size

In many studies, households size has been found a significant demographic factor that has a positive and negative influence on the adaptation behavior of the farmers to adapt towards drought and climate change. [Ashraf et al., \(2014\)](#) observed the farm households determinants such as household size, land size, farming experience, and livestock asset had found positively insignificant influence on farmers' choice over water management coping strategy adopted in the drought year. It also depicted that farmers' experience, landholding, and credit access significantly positively affected farmers' decisions over consumption smoothing practices in the drought period. Moreover, farming experience and livestock ownership had statistically significant influences on the probability of adaptation choices of semi-small and small farmers over migration. It was also indicated that livestock ownership and credit access had significant positive influences on farmers' choice of adaptation like asset depletion. The results of the binary regression model found significant and a positive relationship between farmers' households size and coping, adaptation practices such as migration coefficient (0.315042), p-value (0.002), seeking of farm employment coefficient (0.376530), p-value (0.000), rejuvenation, coefficient (0.0272212), p-value (0.017) which are higly significant; then stop marriage ceremony, coefficient is (0.218126), and p-value (0.082), and income diversification, coefficient (0.184575), p-value (0.072). It means that the increase in household size in the result of that migration increased (many household members migrated), more households stopped marriage ceremonies, more households participated in rejuvenation (nala and river and small ponds), and more households diversified their incomes. It also shows a significant negative association between household size and borrowing money from relatives and moneylenders (see in table 6. 4). It means that large household size less borrowing money from relatives and moneylenders in the study area. These results were calculated using a binary logit regression model for dichotomous variables in nature with explanatory variables. [Chandan Kumar and](#)

Jha Vijaya Gupta, (2021) revealed the positive association between household size and adaptation options in both Kharif and Rabi seasons over the study area. Household size of the farm household has been found a significant positive relationship on farmers' adaptation choices over soil and water conservation, migration from rural to an urban area, leased land, and planting horticulture, vegetables, and increasing irrigation.

6.6.2 Age of the farm households heads

Age plays a significant role in decisions making of farm households to adopt coping and adaptation strategies against drought in the study area. This study revealed that a significant positive association between age of the farm households heads or farmers and adaptation and coping practices such as rejuvenation, coefficient (0.091452), p-value (0.001), crop insurance, coefficient (0.059199), p-value (0.004), long term irrigation management, coefficient is (0.068269), p-value (0.017) all are highly significant. It means that the farm households' age had significant and positive influences on decision choices over coping and adaptive options. Furthermore, it found a significant negative correlation between age and borrowing money from relatives and moneylenders (see in table 6.4). It means that households farmers' age is more than they did not borrow more money from relatives and moneylenders. Chandan Kumar and Jha Vijaya Gupta, (2021) revealed that the farmers' age had a significant negative influence on farmers' adaptation choices such as livelihood diversification and financial diversification. The study also reported that young farmers are more interested in adopting adaptation measures compared to aged farmers. The young farmers were more eager and open to adopting knowledge-intensive adaptation practices such as soil and water conservation techniques, insurance, income and livelihood diversification practices, and adaptation of new crop varieties strategies such as planting horticulture and vegetables in response to sudden changes in environmental variations.

6.6.3 Family types

The results of the binary logit model show positive and negative correlations between farmers' family types as a determinant factor and coping and adaptation strategies as adaptive choices against drought in the study area. Here, the study divided family types into two groups: the joint family and the nuclear family. The joint family considers more members living in the family (average size more than 6), and the nuclear family considers as less members living (average size less than 5). The results show joint family had significant positive influences on farmers coping and adaptation strategies such as borrowing money from relatives and

moneylenders, coefficient (1.085113), p-value- (0.037), It shows that a family with a large member; as a result, they store more crop residuals during the drought. In addition to it also shows negative significant relationship between family types and rejuvenation, coefficient (-0.98858), p-value (0.041) and crop insurance, coefficient (-143692), p-value (0.000). It means that family size increases result of that the adapting capacity of farmers decreases with the adaptation of, rejuvenation, and crop insurance.

6.6.4 Land size

Most of the rural population, directly and indirectly, depends on agriculture land (cultivation), an important source of livelihood for the rural community. This study found a statistically significant positive and negative relationship between land size and adaptation strategies of farmers' adaptation strategies such as migration, storing crop residuals, adaptation of new crop varieties, rejuvenation, and crop insurance. The binary logit regression model shows that significant and positive influences of land size on migration, coefficient 0.146297 p-value (0.006), store crop residuals, coefficient (0.568411), p-value (0.000), and crop insurance, coefficient (0.129002), p-value (0.005), which are highly significant. It means that farmers have more land size result of that they stored more crop residuals, migrated from rural to urban areas, and benefited more from insurance (crop). In addition to, the study found significant inverse relationship between land size and adaptation of adaptation of new crop varieties and techniques, and rejuvenation. These results are shown in table 6.4. [Thinda et al., \(2020\)](#) found that the farm size of the surveyed households was a significantly significant influence on the adoption of adaptation practices.

6.6.5. Credit access or loan/debt get from national and private banks

Credit access is an important factor in rural farming. If farmers have more credit access, they will invest more into the farming sector, which increases their income and crop productivity. The study shows a significant positive relationship between credit access and adaptation strategies of farmers such as borrowing money from relatives and moneylenders, coefficient 1.897951, p-value (0.000), which is highly significant. It means that farmers had more credit access; they had borrowed more money from moneylenders and relatives, and invested more into crop insurance. [According to Deressa et al., \(2009\)](#), credit availability had a favourable and considerable impact on the likelihood of modifying planting dates, preserving soil, and irrigating. This finding suggests that enhanced institutional support is critical in encouraging the use of adaptation strategies to mitigate the adverse effects of climate change.

6.6.6. SHGs access

The study has found that SHGs access is the most significant factor among all explanatory variables. It shows a positive and significant correlation with several adaptation strategies adopted by farmers such as reduction in consumption, stop marriage ceremony, store crop residuals, adaptation of new crop varieties, and income diversification, and long term irrigation management (see in table 6.4) in the drought-prone study areas. [Jordan, \(2021\)](#) found that microcredit supported farmers and its positive effect on coping and adaptation measures to adapt against climate shocks.

6.6.7 Education

The study found a statistically positive significant association between the education of the farmers and stored crop residuals as a coping strategy. It indicates that highly educated farmers stored more crop residuals (coefficient 0.163607, p-value-0.002) in the drought period for rearing their livestock in the study area. Illiterate farmers had stored crop residues but educated farmers had stored crop residues better than illiterate. [According to Deressa et al., \(2009\)](#), farmers' education is a vital determinant in adopting adaptation techniques in response to drought and climate change. It has been observed that farm household's head education had a substantial favourable influence on soil conservation and planting date adaptability. Previous findings of the following studies ([Sajjad Ali, Liu Ying, Adnan Nazir, Abdullah, Muhammad Ishaq, Tariq Shah, Xinyue Ye, Aasir Ilyas, 2020](#); [Abid et al., 2015](#); [Bryan et al., 2013](#)([Deressa et al., 2009](#); [Maddison & Bank, 2007](#)) indicated that a significant positive relationship between the education of farm household heads and adaptation towards climate change (hazard). [Jha C. Kumar and Vijaya Gupta, \(2021\)](#) observed a significant relationship between the education level of farm households head and adaptation strategies such as different crop varieties, changing land area, increasing irrigation, soil, water conservation, as well as risk diversification strategies including buying insurance and planting horticulture and vegetables.

6.6.8 Farming experience

The study observed a positive and negative significant relationship between farming experience determinant and coping and adaptation strategies of farmers adopted in the study area. It found that farming experience has significant positive influences on adaptation strategies such as borrowing money from relatives and moneylender (coefficient 0.123118, p-value 0.006), stored crop residuals (coefficient, 0.163607, p-value -0.002), and adaptation of new crop

varieties (coefficient 0.070903, p-value 0.035), Furthermore, it is also found farming experience has a significant negative association with rejuvenation, and crop insurance.

6.6.9 Livestock ownership

The study shows a significant positive relationship between livestock ownership and adaptation strategies of rural farmers to cope with the drought in the study area. It found that livestock ownership had significant positive influences on stop marriage ceremonies (coefficient 0.09556, p-value - 0.055), stored crop residuals (coefficient 2.497096, p-value 0.000), adaptation of new crop varieties (coefficient 0.744198, p-value -0.020), rejuvenation (marginal effects 0.647214, p-value 0.092) and. Furthermore, livestock ownership had significant negative influences on long-term irrigation. [Adimassu & Kessler, \(2016\)](#), in their study multivariate probit model results, found a significant negative correlation between livestock holding and migration. It means that farmers who had more livestock had less probability of migrating in the period of food shortage. It is also found that significant positive correlations between Livestock holding and changing crop varieties to rainfall variability. Farmers who had more livestock there had more probability of adapting to change crop varieties in their farms. There was a substantial positive connection between livestock keeping and adaptation of new crop varieties to rainfall variability. This result indicates that individuals with more animals had a higher chance of adapting adoption of new crop varieties and techniques practices.

6.6.10 Annual income

This study shows positive and negative significant associations between annual income and coping and adaptation strategies in the study area. Annual income has a significant positive impact on adaptation strategies such as adoption of new crop varieties and rejuvenation. Furthermore, it is also found a significant negative correlation between annual income as a determinant factor and coping and adaptations behaviours of farmers, including borrowing money from moneylenders and relatives, reduction in consumption, migration, seeking off-farm employment, stop marriage ceremony, and stored crop residuals. [According to Deressa et al., \(2009\)](#), farm income of the sample households had a favourable and significant positive influence on soil conservation, crop variety usage, and planting dates adaptation. [According to Deressa et al., \(2009\)](#), farm income of the sample households had a favourable

and significant positive influence on soil conservation, crop variety usage, and planting dates adaptation.

6.7 Conclusion

This chapter is based on primary data source which is collected from village households in the three severe drought-prone districts of the Marathwada region of Maharashtra. It is mainly focused on farm households coping and adaptation strategies which are adopted by the farmers to cope with drought. It is also examined factors affecting the choices of adaptation decision to adopt strategies using the binary logit regression model. During the drought and after the drought long-term adaptations are used for present and future management of agriculture.

The binary regression model results show a positive relationship between household size and seeking off-farm employment, migration, stopping marriage ceremonies and reinvention, whereas it is observed negative association with borrowing money from moneylenders and relatives. The age of the heads of the household has been reported positive significant associations with rejuvenation and crop insurance, whereas a negative significant association has been observed with borrowing money from moneylenders and relatives. Between the family types and borrowing money from moneylenders and relatives, rejuvenation has found a statistical positive significant relationship, whereas crop insurance found a negative relationship. The land size of the farm households and borrowing money from moneylenders and relatives, migration, stored crop residuals, and crop insurance have detected statistical positive significant relationships, whereas rejuvenation and adoption of new crop varieties and techniques have found a negative relationship. Credit access has been reported significant association with crop insurance and borrowing money from moneylenders. Furthermore, SHGs access has also reported positive and negative significance associations with few coping and adaptation measures. Farming experiences of the farm households and borrowing money from moneylenders and relatives, stored crop residuals and adoption of new crop varieties and techniques have found a positive relationship between them, whereas crop insurance and rejuvenation have observed a negative relationship. Then livestock ownership and stored crop residuals and adoption of new crop varieties have reported a significant association. Lastly, the annual income of the farm households and few coping and adaptations have observed positive and negative relationships between them

The figures presented in this chapter have highlighted the coping and adaptations strategies adopted by farmers in both areas during the drought. The most favoured coping strategies were

adopted by farmers, such as changed crop planting dates (98 %). Then, the study reported that about (96 %) of households received food grains from the Public Distribution System (fair prices shops), followed by about (81 %) of households reduced their consumptions and nearly (80 %) of the total sample farm households stored crop residuals for their livestock to survived and save them. Furthermore, the study observed that about (79 %) of households stored crop residuals and also (79 %) of them borrowed money from relatives and moneylenders. About (56 %) of the households benefited from crop insurance schemes. In addition, (42 %) of household's members migrated from rural to urban areas and rural to rural places to get temporary jobs in a drought period, while (38 %) of families (farmers) worked in the off-farm sector due to failure of agriculture. In addition, about (56 %) of farmers have adopted new crop varieties and techniques; they have used modern varieties which have sustained during drought. Then (35 %) of the farmers participated in rejuvenation programs like the river, dam, small ponds, and small reservoirs. Despite adapting of several coping and adaption strategies against drought, they have not learned any lesson form the recurring past events of drought in the study area.

Chapter 7

Summary, conclusion and policy implication

7.1 Introduction

The present study seeks to analyse the impact of drought on rural households in the three drought-prone districts of the Marathwada region of Maharashtra. It is based on secondary as well as primary data sources, the primary data is obtained from rural farm households applying a multistage sampling method by a pre-tested (investigation) questionnaire. A total of six villages have been selected for the study (three villages are from the irrigated ecosystem, and the remaining three are from the rain-fed ecosystem), and the total sample size is 290. The secondary data has been collected from various online and offline resources at local, state and national levels. It has been analysed using a parametric and non-parametric test, multiple regression model, and rainfall deviations.

Drought is a natural hazard its severe effects have been reported in various sectors not only regional level but also globally. South Asian countries have also faced server drought problems in recent as well in the past, and India is one of them. India's many regions' drought events have occurred, recurrently. Marathwada or Aurangabad division is one of the most drought-affected regions in the country as well as the state, historically and recently it has faced severe drought events and problems. The region's livelihood mainly engages in the agriculture sector and related activities, and agriculture is mostly dependent on rainfall. Therefore, agriculture production decreased tremendously especially in drought years due to the inadequate rainfall during the crop growing season. Furthermore, it has faced several socio-economics and environmental issues, including migration, water scarcity, fodder problems, bad impact on school-going children, decreased income, reduction in consumption, unemployment, reduction in livestock assets, food and increased temperature, etc. in both irrigated and rain-fed ecosystem. Moreover, considering the earlier issues the state administration has instigated some drought relief and mitigation programmes to mitigate the severe drought impact at the village/local level in the study region, whether a few of them are effective against the drought and few are not. With this broad issue in mind, the present study has examined the three main and two sub-objectives, to highlight the drought impact on rural households in the study zone. These objectives are specified following. The first one is, to understand the history of drought (rainfall) over the Marathwada region and analyse the temporal rainfall trends and variability of the three districts of Beed, Osmanabad, and Latur districts of Maharashtra. The second one includes sub-objectives, to study the socio-economic conditions among rural farm households

in rain-fed and irrigated villages in the drought prone-region (study area), i) To study the impact of drought on marginal, small, medium and large farmers as well as different social groups, ii) to study the severe effects of drought on native drinking water supply and which are the water sources available during the drought. The last one is, to examine the determinates of farm households' choice of coping and adaptation practices to cope with drought in three districts of the Marathwada region of Maharashtra. The first objective has calculated drought and rainy years using long-term data series in the study area after that it also examined the intensity and frequency of rainfall. It has been observed that there are many severe and consecutive drought years which is supported to investigate and carried out research on drought over the study region. On the basis of the first objective, the second and third objectives have been formed for evaluating the drought impact at the household level. The second objective and sub-objectives have reported the drought impact on various categories such as farmers and social groups as well as different ecosystems. And the third objective has taken into consideration how they combat drought through adopting several adaptation strategies and also highlighted which determinants are significant for adaptation strategies.

The present study has been divided into seven chapters. The first chapter highlights an introduction/background of the study. The second chapter is illustrated the profile of the study area. The third chapter has presented reviews of the literature on various aspects of droughts. The fourth chapter presents a temporal rainfall trend analysis of three districts of the Marathwada region and rainfall deviation of the southwest and annual rainfall of the Marathwada region and India. The fifth chapter is examined socio-economic conditions in the drought prone-areas among rural households in irrigated and rain-fed villages - (an empirical investigation from primary as well as secondary data). The sixth chapter analyses the determinates of farm household choice of coping and adaptation strategies to cope with drought in the three districts of the Marathwada region of Maharashtra during the drought years 2015-16 and 2018 –19. The final chapter is highlighted the study's conclusion, policy measures, and limitations, including the main findings and future recommendations.

7.2 Chapter-wise findings

The 4th, 5th and 6th, which are the core chapters in the study, their main findings are observed in the following.

7.2.1 Temporal rainfall Trend analysis and variability of three drought-prone (Beed, Osmanabad, and Latur) districts and the history of rainfall (drought) in the Marathwada region of Maharashtra: The following section summarises the major results of chapter 4.

a) Rainfall Anomaly Index (RAI) results of the three districts

The RAI has revealed the dry and rainy years of the three drought-prone (Beed, Osmanabad and Latur) districts using yearly rainfall time series data for 118 years from 1901 to 2018.

i) It is found that out of 118 years, 51 (43.2 %) were dry, and 11 (9.3 %) were very dry years have been recorded in the Beed District. On the other hand, 43 (36.4 %) years were humid, 12 (10.2 %) were highly humid, and 1916 was the most humid year reported.

ii) It is revealed that out of a total of 118 years, 43 (36.4 %) were dry years, 16 (13.6 %) were very dry, and only 1972 was an extremely dry year reported in the Osmanabad district. Besides that, 43 (36.4 %) were humid years, 14 (11.9 %) were very humid, and only 1916 was the most humid year reported in the rain history of the Osmanabad district.

iii) RAI explains the Latur district's dry and rainy years from 1901 to 2018. Out of 118 years, 41 (34.7 %) were dry years, 24 (20.3 %) were very dry, and only 1972 was an extremely dry year. On the other hand, 26 (22.0 %) of the years were humid, 19 (16.1 %) were very humid, and 7 (5.9 %) were extremely humid years in the rainy history of the Latur district.

According to the RAI Calculation, the Beed, Osmanabad and Latur districts are observed that highly vulnerable to drought, where more than half of the years have been recorded dry. It was also detected that drought occurs once every two years in the study region.

b) Monthly, seasonal and annual variations in rainfall (Coefficient of variations) and their contribution to annual rainfall over three districts from 1901 to 2018

i) The analysis results found the highest mean value in the annual rainfall (709.91) and the lowest in January (2.82) for 118 years of the Beed district. In the season-wise rain largest mean value was calculated from the southwest monsoon and vice versa for the winter season. In the annual rainfall series, the maximum rainfall value of 1212.43 (mm) was recorded in 2016, and the minimum rainfall value of 333.32 (mm) was observed in 1972. The lowest rainfall value, 0.07 (mm), was registered in the winter season in January month in 2005. Furthermore, the winter season found the highest rainfall variability of the four seasons, which is 147.13 %. The

southwest monsoon and annual rainfall showed the lowest variability in the data series, which is (25.03 %) and (22.99 %).

ii) The analysis results have revealed for the Osmanabad district, is that the highest mean value in the annual rainfall (698.83) and the lowest in January (3.06). The most significant mean value for season-wise rain was estimated from the southwest monsoon and vice versa for the winter season. In the annual rainfall series, the maximum rainfall of 1183.85 (mm) was recorded in 2016, and the minimum rainfall of 322.93 (mm) was observed in 1972. The lowest rainfall value of 0.02 (mm) was registered in the winter season of January month in 1944. Furthermore, in the seasonal-wise variability, the winter season had higher variability in the rainfall data series from 1991 to 2018, which is (143.35 %), and southwest monsoon seasons had lower variability, that is (25.31 %). The annual rainfall data series found lower variability among all variables, that is, (22.46 %). Out of the total annual rainfall, southwest monsoon rainfall contributed around (76.89 %). After that, post-monsoon rain contributed around (15.13 %). Pre-monsoon contributed around (6.92 %), and the winter season received only (0.88 %), which is very low compared to other seasons.

iii) The analysis results have observed the highest mean value in the annual rainfall (178.77) and the lowest in January (3.65) over the Latur district. The most significant mean value for season-wise rainfall was estimated from the southwest monsoon and vice versa for the winter season. In the annual rainfall series, the maximum rainfall of 1299.72 (mm) was recorded in 2016, and the minimum rain of 349.56 (mm) was recorded in 1972. The lowest rainfall value, 0.009 mm, was registered in the winter season of December month in 1991. Furthermore, in the seasonal-wise variability, the winter season had higher variability in the rainfall data series from 1991 to 2018, which is 154.46 %, and southwest monsoon seasons had lower variability, 24.16 %. The annual rainfall data series found lower variability among all variables, that is, 22.46 %. Out of the total annual rainfall, the maximum rainfall has been obtained from the southwest monsoon which is around (80.32 %). After that, post-monsoon rain obtained around 12.60 %. Pre-monsoon contributed around 6.05 %, and the winter season received (only 1.04 %), which is very low compared to other seasons.

Overall, southwest monsoon rainfall has been reported low variability among the four seasons and it is played a significant role in the annual rainfall contribution. In the moth-wise rainfall, January moth has been observed highest rainfall variably among all months and its contribution to annual rainfall is reported that very low for 118 years over three districts.

C) Mann-Kendall test trend analysis results for Beed, Osmanabad, and Latur districts from 1901 to 2018

i) The MK test results have shown that August month observed a positive significant increasing trend among all months, while April and December months recorded statistically negative rainfall trends in the Beed district. There are not remarkable trends have been observed in yearly and seasonal rainfall data.

ii) Likewise, the analysis results have asserted that a positive substantial rainfall trend have been seen in the August and October months for the Osmanabad district, at a 1 % and 5 % significance level (P -value = 0.004 and 0.041), respectively. September, December, and winter series have been recorded significant negative trends at 10 % and 5 % significance levels (p = values September 0.065, December 0.036, and winter 0.026).

iii) Moreover, a positive and negative substantial trend have been observed in the monthly and seasonal rainfall time series data over the Latur district. Only the post-monsoon rainfall season has recorded positive significance trend at a 5% significance level (P = 0.049). Out of the total months, only August and October recorded a significant positive trend at 1 % and 5% level, respectively, while September and December have been recorded a significant negative trend at a 5 % significance level (P -value = 0.012, and .013, respectively). Notable thing is that in the three districts' annual rainfall data series over the study period, there has no substantial trends have been observed.

d) Deviations calculations results of Marathwada and India for annual and South-west monsoon rainfall.

i) The southwest monsoon rainfall deviations were calculated using monthly time series data over the Marathwada region of Maharashtra from 1871 to 2016. There are 38 rainfall deficit years, and only one (large deficit) rainfall year, 1871 (-64.68 %) has been reported. In Marathwada, there are many consecutive drought years observed in the long-term data series, such as from 1984 to 1987, which were four continuous drought years, then 2014 (-30.05 %) and 2015 (-38.11 %) were the recent drought years. Furthermore, 1988 year has recorded excess rainfall, which is (88.92 %). Furthermore, annual rainfall deviation from the normal all over the Marathwada region has been calculated. It shows that there was only one large deficient (scanty) drought year which is 1871 (- 66.77 %), 38 deficit rainfall years, 99 normal years, and only nine excess years have been recorded, (see table 4.16). There many consecutive drought years reported which were 1976 (34.60 %), 1977(-38.99%); 1920 (-49.66%), 1921(-

20.08 %). Furthermore ,1936 (-39.01%), 1937(-20.64%); 1944(-19.75%), 1945 (22.62%); 1950 (-20.52%), 1951(-23.12%); 1971(-31.99%), 1972 (54.54 %) etc. were also reported. Moreover, from 1984 to 1987, a long period of successive drought years was observed. In contrast, from 2002 to 2008, there were no reported single drought years.

ii) The southwest monsoon rainfall percentage departure was calculated from normal all over India from 1901 to 2017. The largest deficit was occurred in the years 1918 (-24.9 %) and 1972 (-23.9 %), 1987 (-19.4 %), 2002 (-19.2 %), 2009 (-21.8 %). There are only two excess years reported which are 1917 (22.9 %) and 1961 (21.8 %). Furthermore, annual rainfall deviation from calculated from normal over India from 1901 to 2016. There are only two deficit rainfall years have been recorded, 1965 (-19.36 %) and 1972 (-19.39 %).

7.2.2 Socio-economics conditions of rural households in the three drought-prone districts in irrigated and rain-fed villages – (an empirical investigation from primary as well as secondary data): The following section summarizes the major findings of chapter 5. The present chapter used primarily as well as secondary data sources. The primary data describes the socio-economic profile of sample households and the impact of drought on rural livelihood. The secondary data sources used the multiple regression model results to observe climatic variables' impact on foodgrain production in the study region. Further, the district-wise crop annewari, cattle camps and waters tankers data are used to observe drought intensity in the study region.

i) The study shows that out of the total sample size, 149 (51.38 %) households are from irrigated villages, and 141 (48.62 %) belong to rain-fed villages. The 97 (33.45 %) farm households were selected from the Beed district (Lukhegaon 15.86 % and Karanjwan 17.59 %). After that, 103 (35.52 %) households were selected from the Osmanabad district (Bhandarwadi, 18.28 %, and Jawalka, 17.24 %). Lastly, out of the total sample size, 90 (31.03 %) households were selected from the Latur district in irrigated and rain-fed villages (Takalgaon, 17.24% and Yellorewadi, 13.79 %).

ii) It is also observed that social group-wise percentages of sample households. About 144 (49.66 %) households belong to OCs, which is the highest among all categories, and then 75 (25.68 %) belong to OBCs. Furthermore, about 30 (10.34 %) are SCs, and 41 (14.14 %) are STs. Likewise, in a total of 149 households in irrigated villages, 101(67.79 %) belong to OCs, 26 (17.45 %) belong to OBCs, 20 (13.42 %) are SCs, and only 2 (1.34 %) belong to the STs category. In a total of 141 households in the rain-fed villages, 43(30.50 %) belong to OCs,

followed by 49 (30.50 %) are belonged to OBCs, 10 (7.09 %) are SCs, then 39 (27.66 %) belong to STs. Overall, the highest number of households belongs to OCs, 144 (49.66 %), and the lowest number of households from the SCs category is (10.34 %).

iii) Furthermore, it is reported that, out of 290 household cultivators, 82 (28.28 %) are marginal cultivators, 108 (37.24 %) are small cultivators; their percentages higher among landholding size, 67 (23.10 %) are medium cultivators, and 33 (11.38 %) are large cultivators. In the irrigated village, total of 149 households' cultivators, 55 (36.91 %) are marginal cultivators, 42 (28.19 %) are small cultivators, 34 (22.82 %) are medium cultivators, and 18 (12.08 %) are large cultivators. On the other hand, in the rain-fed village, 27 (19.15 %) are marginal cultivators, 66 (46.18 %) are small cultivators, 33 (23.40 %) are medium cultivators, and 15 (10.64 %) are large cultivators.

iv) The study reported that maximum families are nuclear and minimum families are Joint in both ecosystems. Family type analysis according to social groups shows that the STs household groups have reported more joint families compared to other categories which are 23 (56.10 %). The large farm households also have more joint families compared to other landholding sizes. Furthermore, it is observed that kutchra houses are more than any other kind of houses in both irrigated and rain-fed villages. In the irrigated villages pucca houses are reported more compared to rain-fed villages. Only four old houses existed among the total sample households. More pucca houses have belonged to large farm households and the OCs category. Most of the households have toilet facilities, however, due to water scarcity, some of them have not been used in the drought. It is also reported that most households have used LPG and firewood for their daily cooking purposes. Further, it is reported that most of the heads of the household are illiterate and very few household heads have completed their higher education. Farming cultivation is the main occupation of the maximum number of household heads.

v) Moreover, it highlighted the different drinking water sources used by the households in the drought period from the two different ecosystems, out of the total sample households, only 6 (4.03 %) of the total sample households have a self-watering tab, 5 (1.72 %) have a self well, and 22 (7.59 %) have a borewell facility. Furthermore, 38 (13.10%) households obtained water from the gram panchayat hand pump, while 47 (16.21%) were fetching water from the government's water tanker. Similarly, 42 (14.48 %) of households obtained water from gram panchayat well acquisition, 50 (17.24 %) of households obtained water from gram panchayat well acquisition, which was reported as the second-highest percentage, and 80 (27.59 %) of

households obtained water from a private bore acquired by the gram panchayat. Besides, water was not available in the village's groundwater bodies during drought due to that many household members fetched water from distant sources. The second reason is that poor management and irregularities of the government water tanker. In the irrigated villages 53 (35.57 %) households have fetched water from long distances, and in the rain-fed villages, 60 (42.55 %) of households fetched from long distances. Out of the total sample size, 113 (38.97 %) households fetching from long distances. Furthermore, most of the marginal and small farm households' members have been observed to fetch water from long distances on their heads and some of them have used bicycles, and motorcycles.

vi) During the drought year, income decreased tremendously. Out of 290 sample households, 131 (45.17 %) were in the low-income group (below 45000). About 112 (38.62 %) of households came under the lower-middle-income group (46000 to 100000). Furthermore, 32 (11.03 %) were in the upper-middle-income group. In the lower high and high-income groups, only 15 (5.17 %) households had obtained 201000 to 30000 and more than 300000 incomes in the irrigated villages. During the drought year, no one household came under lower-high and high-income groups in the rain-fed village. It is also reported that, out of 290 total sample households, 150 (51.72 %) were below the poverty line, 132 (45.52 %) were above the poverty line, and 8 (2.76 %) did not have any kind of BPL and APL cards. Furthermore, the study reported that most households had received food grain (wheat and rice and 1 kg dal) from the fair-price shops during the drought year; only a few families have not received from fair-price shops because they are rich. Mostly SCs and STs farm households' annual income has come in between low-income and lower-middle incomes groups in the normal as well as draught years.

vii) It is indicated that 83 (28.62 %) household respondents have migrated from rural to rural and rural to urban areas. They migrated to western Maharashtra, such as Ahmednagar and Kolhapur districts from rural-to-rural areas, where they worked as farm labour. At the same time, some respondents migrated to urban areas such as Pune, Mumbai, and Latur, where they worked in the non-farm sector as labour and worked as truck/tempo drivers, security guards, cement, and construction workers, vendor, vegetable vendor, etc. Furthermore, marginal and small farm households' members have migrated more compared to others and in the category-wise analysis, the SCs household members have migrated more than other groups.

viii) It has been observed that agriculture input subsidy availed by farm households in the drought period 2018-19 under the norm of SDRF/NFRF. Out of total households, about 160 (55.17 %) of households availed of agriculture input subsidies in both irrigated and rain-fed villages. In the rain-fed village, 87(61.70 %) households were availed of agriculture input subsidy. In the irrigated village, 73 (48.99 %) of the households were availed of agriculture input subsidy out of the total irrigated village households sample size.

ix) In addition, it has shown the loan or debt position of agricultural households that have obtained from major banks. It is indicated that about 196 (67.59 %) farm households obtained loans/debts from various national and district level banks. Those institutions are the State Bank of India, Maharashtra Bank, Central Bank of India, ICICI Bank, Punjab National Bank, Maharashtra Gramin Bank, District Central Co-operative Banks, etc. Further, it is reported that most of the large farm households availed loans from the various banks compared to others and the STs have reported using very less loan/debt from various financial institutions. It is very helpful during the drought period; many households received loans from various banks, so they could not take debt from moneylenders, and private debt interest is very high compared to the bank. Indebtedness is one of the reasons due to that farmers' suicide cases increased in both Marathwada and Vidarbha regions.

xi) The study also illustrates that work has been done under the Jalyukt Shivar programme in the irrigated and rain-fed villages (see chapter 5). It is noticed that only 53(18.28 %) household heads replied that the river bund, Nala widening, and watershed development programme had been completed under the Jalyukt Shivar.

xii) It has been reported that out of 290 households, 212 (73.10 %) had livestock, and 78 (26.90 %) had no livestock. Many households sold their livestock, and many of them reduced the number of livestock due to fodder and water problems. Furthermore, it is indicated that out of the total sample households, 117 (40.35 %) had fodder available, and 173 (59.65 %) had no fodder available. Some households had fodder available because they had stored crop residuals, and sometimes they purchased fodder to save livestock. Some households did not have fodder and they would not purchase it; therefore, they sent their livestock to cattle camps. In addition, the large farm cultivators have found more livestock than others during the drought while the SCs category has reported less livestock during the drought.

xiii) It is reported crop insurance status among the rural household during the drought in the irrigated and rain-fed villages. It is pointed out that about 132 (45.52 %) farm households

benefited from crop insurance schemes in the drought, and 158 (54.48 %) farm households have not benefited. It is also financially helpful for farm households in a drought period when they lose their crops when they feel little satisfaction with crop insurance. Many households have not benefited from the above scheme because they do not have an awareness of that. And many of them do not know how to apply? and where to apply.

xiv) The regression results found a statistically significant impact of rainfall and average minimum temperature on food grain production, which are significant at 1% and 5 % significance levels (food grain production has a considerable negatively impacted by average minimum temperature) for the Beed district. Furthermore, in the second model, it is found that a statistically significant impact of rainfall on food grain production for the Osmanabad district, which is significant at 10 % significance levels (Coefficient 3.272015*, p-value 0.0795). The third regression model found a statistically positive significant impact of rainfall and average maximum temperature on food grain production, which are significant at 1 % and 10 % significance levels. Ultimately, it is observed that rainfall has a substantial impact on food grain production in the study period.

xv) Moreover, it is acknowledged perceptions of the environmental impact of drought on farmers in both irrigated and rain-fed villages. It is reported that out of the total sample households, 95 % perceived that temperature has increased very high in the drought year compared to the normal year. Furthermore, 81 % of farmers perceived that jungle degradation increased on a high scale due to drought. Then the near about 70 % of farmers perceived that pasture declined on a very high scale and 30 % reported that pasture declined on a high scale. About 38 % and 61 % of farmers perceived that water scarcity in the surface water bodies (well, rivers, small ponds and dams) reduced tremendously in the drought. Lastly, approximately 80 farmers have believed that water quality was negatively affected by drought at high scale and around 77% of the farmers have believed that drought damaged life of wild animal and fish habitat.

7.2.3 Farm household choice of determinates for coping and adaptation strategies to cope with drought from three districts of the Marathwada region of Maharashtra during the drought years 2015-16 and 2018 –19: The section follows summaries of the key findings of Chapter 6. This chapter highlighted coping as the (short-period) strategy and adaptation as the (long-period) strategy. Furthermore, the chapter also investigated the association between

farmers choices of determinants and adaptation practices using a binary logistic regression model.

i) The results of the binary regression model have indicated that a positive correlation between household size and seeking off-farm employment, migration, stopping marriage ceremonies and reinvention, whereas it is observed negative association with borrowing money from moneylenders and relatives.

ii) Furthermore, the age of the heads of the household has been reported positive significant associations with rejuvenation and crop insurance, whereas a negative significant association has been observed with borrowing money from moneylenders and relatives. Between the family types and borrowing money from moneylenders and relatives, rejuvenation has found a statistical positive significant relationship, whereas crop insurance found a negative relationship.

ii) It is observed that the land size of the farm households and borrowing money from moneylenders and relatives, migration, stored crop residuals, and crop insurance have detected statistical positive significant relationships, whereas rejuvenation and adoption of new crop varieties and techniques have been found a negative relationship. Credit access has been reported significant association with crop insurance and borrowing money from moneylenders. Furthermore, SHGs access has also reported positive and negative significance associations with few coping and adaptation measures.

iv) Moreover, it is reported that the farming experiences of the farm households and borrowing money from moneylenders and relatives, stored crop residuals and adoption of new crop varieties and techniques have found a positive relationship between them, whereas crop insurance and rejuvenation have been observed a negative relationship. Then livestock ownership and stored crop residuals and adoption of new crop varieties have reported a significant association. Lastly, the annual income of the farm households and few coping and adaptations have observed positive and negative relationships between them

v) In addition, the presented figures have highlighted the coping and adaptation practices used by farmers in both areas during the drought. The most favoured coping strategies were adopted by farmers, such as changing crop planting dates (98 %). Then, the study reported that about (96 %) of households received food grains from the Public Distribution System (fair prices shops), followed by about (81 %) of households that reduced their consumption and nearly (80 %) of the total sample farm households stored crop residuals for their livestock to survived and save them. Furthermore, the study observed that about (79 %) of households stored crop

residuals and also (79 %) of them borrowed money from relatives and moneylenders. About (56 %) of the households benefited from crop insurance schemes. In addition, (42 %) of household members migrated from rural to urban areas and rural to rural places to get temporary jobs during a drought period, while (38 %) of families (farmers) worked in the off-farm sector due to the failure of agriculture.

v) Finally, about (56 %) of farmers have adopted new crop varieties and techniques; they have used modern varieties which have sustained during drought. Then (35 %) of the farmers participated in rejuvenation programs like the river, dams, small ponds, and small reservoirs.

7. 3 Policy measures and suggestions

The policy measures or suggestion has been mentioned the follows.

i) The study suggested that the government should provide subsidies to marginal and small farmers for purchasing new advanced irrigation equipment such as drip irrigation, sprinklers, and PVC pipes to improve their irrigation. It also takes incentive to increase irrigation, mainly in the rain-fed region.

ii) There is a need to include the various topics on environment and ecology in the primary school syllabus for children from their childhood to make awareness about weather and climate change and to cope with future climatic events in the study region as well as across the state.

iii) The cattle camps for livestock that kind of similar programme should be organized by the government for goats and sheep to save small animals, particularly in drought-prone areas of the Marathwada region as well as across Maharashtra. Or as per the number of small and big cattle ownership of the particular households during the drought, the fodder should be provided through ration cards like fair price shops (PDS system) to avoid corruption from cattle camp owners.

iv) Farmers or landlords of the animals should store more crop residuals to feed their livestock when fodder shortages occur in consecutive drought years. Moreover, they have utilized it for more than one year to remove fodder scarcity.

v) Private and public banks should provide more debts to Self Help Groups (SHGs) in drought-prone areas like Marathwada based on lower interest rates in the drought period. However, they should organize their business at the local level to cope with severe drought conditions.

vi) Village people should conserve (save) groundwater bodies like government wells, bores, small ponds, and traditional water bodies to avoid water scarcity during the drought period.

vii) In the drought-prone region villagers should actively participate in watershed development/management programmes themselves, like Pani Foundation, pond, Nala, and river, water harvesting and conservation and channel rejuvenation, to reduce water intensity and increase groundwater levels in the groundwater bodies in the villages during the drought period.

viii) Government should encourage (aware) people through various channels/programmes to save water, be forced to stop cutting trees, plant trees in every house, and stop the wastewater.

xi) Agriculture input subsidies should be increased as per the hectares wise and according to inflation rates in the drought.

x) Crop insurance cover should be made compulsory for each farm household to sustain itself financially and get little relief from agriculture losses in the drought period.

xi) It is a necessary to develop drought-tolerant crop varieties which should be easily accessible and affordable to farmers to stop losses in agriculture production and for sustainable agriculture development. Lack of weather and climate information, farmers have faced major problems in the drought prone-region; therefore, a weather and climate information centre should be established at the district level to get daily weather information.

x) Many household members have migrated from rural to urban areas due to the loss of employment or lack of earning sources in the drought. Therefore, the MANREGA programme should be implemented properly for whoever has needed work in order to stop migration and get employment in their own village.

6.4 Directions for the upcoming research

The existing study is mainly based on cross-section data which is only focused on rural farm sector households, the non-farm sector rural households particularly those who are landless, which have not been covered. Such kind of research may be carried out in the future. Furthermore, there is extensive area cultivation of sugarcane and cotton production, particularly in the irrigated ecosystem, which is largely impacted by drought, and Kharif and Rabi seasons crops particularly in the rain-fed ecosystem; the result of that, the crop-wise panel regression analysis needs to be done using district-wise panel data in both seasons for all crops. Furthermore, the electric power plant and sugar industry collapsed during the drought period.

And lastly, what is the impact of greenhouse gases in the particular region due to climate change? Drought vulnerability, barriers to adaptation, perceptions, and shock would be the future investigation research topics.

6.5 Final remark

The study tries to examine severe drought impacts on rural households, particularly in the six villages (three are irrigated and three are non-irrigated) of the Beed, Osmanabad and Latur districts of the Marathwada region. The study has observed the worst drought impact on rural livelihood mainly in agriculture and related sector activities after identifying many droughts and consecutive years. Therefore, getting some assistance from government relief programmes they have tried to mitigate the severe drought impacts. In addition, at the household level, they have adopted several coping and adaptation strategies to cope with drought, however which are not adequate.

Bibliography

- Abid, M., Scheffran, J., Schneider, U. A., & Ashfaq, M. (2015). Farmers' perceptions of and adaptation strategies to climate change and their determinants: The case of Punjab province, Pakistan. *Earth System Dynamics*, 6(1), 225–243. <https://doi.org/10.5194/esd-6-225-2015>
- Ackom, E. K., Adjei, K. A., & Odai, S. N. (2020). Spatio-temporal rainfall trend and homogeneity analysis in a flood-prone area: A case study of Odaw river basin-Ghana. *SN Applied Sciences*, 2(12). <https://doi.org/10.1007/s42452-020-03924-3>
- Adimassu, Z., & Kessler, A. (2016). Factors affecting farmers' coping and adaptation strategies to perceived trends of declining rainfall and crop productivity in the central Rift valley of Ethiopia. *Environmental Systems Research*, 5(1). <https://doi.org/10.1186/s40068-016-0065-2>
- Al-Amin, A. K. M. A., Akhter, T., Islam, A. H. M. S., Jahan, H., Hossain, M. J., Prodhan, M. M. H., Mainuddin, M., & Kirby, M. (2019). An intra-household analysis of farmers' perceptions of and adaptation to climate change impacts empirical evidence from drought-prone zones of Bangladesh. *Climatic Change*, 156 (4), 545–565. <https://doi.org/10.1007/s10584-019-02511-9>
- Alary, V., Messad, S., Aboul-Naga, A., Osman, M. A., Daoud, I., Bonnet, P., Juanes, X., & Tourrand, J. F. (2014). Livelihood strategies and the role of livestock in the processes of adaptation to drought in the Coastal Zone of Western Desert (Egypt). *Agricultural Systems*, 128, 44–54. <https://doi.org/10.1016/j.agsy.2014.03.008>
- Alauddin, M., & Rashid, A. (2014). Climate change and farm-level adaptation decisions and strategies in drought-prone and groundwater-depleted areas of Bangladesh :an empirical investigation. *Ecological Indicator*, 106, 204–213. <https://doi.org/10.1016/j.ecolecon.2014.07.025>
- Alemayehu, A., & Bewket, W. (2017). Smallholder farmers' coping and adaptation strategies to climate change and variability in the central highlands of Ethiopia. *Local Environment*, 22(7), 825–839. <https://doi.org/10.1080/13549839.2017.1290058>
- Alemu, Z. A., & Dioha, M. O. (2020). Climate change and trend analysis of temperature: the case of Addis Ababa, Ethiopia. *Environmental Systems Research*, 9 (1). <https://doi.org/10.1186/s40068-020-00190-5>.
- Alok k. Mishra and Vijay P. Singh. (2010). A review of drought concepts. *Journal of*

- Hydrology*, 391(1–2), 202–216. <https://doi.org/10.1016/j.jhydrol.2010.07.012>
- Amfo, B., & Ali, E. B. (2020). Climate change coping and adaptation strategies: How do cocoa farmers in Ghana diversify farm income? In *Forest Policy and Economics* (Vol. 119). <https://doi.org/10.1016/j.forpol.2020.102265>
- Anderson, D. R., Cincinnati, D. J., & Cincinnati, Williams T. A. (2011). *Statistics for Bussiness and Economics* (6th ed.). Bosatn, MA: South-Western Cengana Larning.
- Annual Report, (2018). Department of Agriculture, Cooperation & Farmers Welfare. *Ministry of Agriculture & Farmers Welfare Government of India Krishi Bhawan, New Delhi-110001* www.agricoop.nic.in.
- Ari, G., Bao, Y., Asi, H., Zhang, J., Na, L., Angge, L., Bao, Y., & Han, A. (2021). *Impact of global warming on meteorological drought : a case study of the Songliao Plain, China. Theoretical and applied climatology* 146, pages1315–1334 .<https://doi.org/10.1007/s00704-021-03775-x>
- Aribi, F., & Sghaier, M. (2021). Livelihood vulnerability assessment to climate change and variability: the case of farm households in South-East Tunisia. *Environment, Development and Sustainability*, 0123456789. <https://doi.org/10.1007/s10668-020-01172-4>
- Aryal, A., Maharjan, M., Talchabhadel, R., & Thapa, B. R. (2022). Characterizing Meteorological Droughts in Nepal: A Comparative Analysis of Standardized Precipitation Index and Rainfall Anomaly Index. *Earth*, 3(1), 409–432. <https://doi.org/10.3390/earth3010025>
- Asfaw, A., Simane, B., Hassen, A., & Bantider, A. (2018). Variability and time series trend analysis of rainfall and temperature in northcentral Ethiopia: A case study in Woleka sub-basin. *Weather and Climate Extremes*, 19, 29–41. <https://doi.org/10.1016/j.wace.2017.12.002>
- Ashraf, M., Routray, J. K., & Saeed, M. (2014). Determinants of farmers’ choice of coping and adaptation measures to the drought hazard in northwest Balochistan, Pakistan. *Natural Hazards*, 73(3), 1451–1473. <https://doi.org/10.1007/s11069-014-1149-9>
- Assan, E., Suvedi, M., Olabisi, L. S., & Allen, A. (2018). Coping with and adapting to climate change: A gender perspective from smallholder farming in Ghana. *Environments - MDPI*, 5(8), 1–19. <https://doi.org/10.3390/environments5080086>
- Attri, S. D., & Tyagi, A. (2010). Climate profile of India, Met (monograph). *Environment Meteorology*, 01, 1-129

- Atube, F., Malinga, G. M., Nyeko, M., Okello, D. M., Alarakol, S. P., & Okello-Uma, I. (2021). Determinants of smallholder farmers' adaptation strategies to the effects of climate change: Evidence from northern Uganda. *Agriculture and Food Security*, 10(1), 1–14. <https://doi.org/10.1186/s40066-020-00279-1>
- Ayugi, B., Eresanya, E. O., Onyango, A. O., Ogou, F. K., Okoro, E. C., Okoye, C. O., Anoruo, C. M., Dike, V. N., Ashiru, O. R., Daramola, M. T., Mumo, R., & Ongoma, V. (2022). Review of Meteorological Drought in Africa: Historical Trends, Impacts, Mitigation Measures, and Prospects. *Pure and Applied Geophysics*, 179 (4), 1365–1386. <https://doi.org/10.1007/s00024-022-02988-z>
- Babugura, A. A. (2008). Vulnerability of Children and Youth in Drought Disasters: A Case Study of Botswana. *Child. Youth Environ.*, 18(1), 126–157. <http://www.jstor.org/stable/10.7721/chilyoutenvi.18.1.0126>
- Bakhsh, K., & Kamran, M. A. (2019). Adaptation to climate change in the rain-fed farming system in Punjab, Pakistan. *International Journal of the Commons*, 13 (2), 833–847. <https://doi.org/10.5334/ijc.887>
- Bana Himanshu & R. D. Gerg. (2021). Rainfall Trend And Seasonality Estimation For Marathwada Region. *Research Square*, 1–17. <https://doi.org/10.21203/rs.3.rs-1147643/v1>
- Bari, S. H., Hussain, M. M., & Husna, N. E. A. (2017). Rainfall variability and seasonality in northern Bangladesh. *Theoretical and Applied Climatology*, 129 (3–4), 995–1001. <https://doi.org/10.1007/s00704-016-1823-9>
- Bhatta, G. D., & Aggarwal, P. K. (2016). Coping with weather adversity and adaptation to climatic variability: a cross-country study of smallholder farmers in South Asia. *Climate and Development*, 8 (2), 145–157. <https://doi.org/10.1080/17565529.2015.1016883>
- Belay, A., Recha, J. W., Woldeamanuel, T., & Morton, J. F. (2017). Smallholder farmers' adaptation to climate change and determinants of their adaptation decisions in the Rift Valley of Ethiopia. *Agriculture and Food Security*, 6 (1), 1–13. <https://doi.org/10.1186/s40066-017-0100-1>
- Bhagat N., & Nagarjuna, B. (2022). Impact of the 2015 Drought on Rural Livelihood - A Case Study of Masurdi Village in Latur District of Maharashtra, India. *International Journal of Science and Research (IJSR)*, 11(3), 1317–1327. <https://doi.org/10.21275/SR22326212841>
- Biradar, N., & Sridhar, K. (2009). Consequences of 2003 Drought in Karnataka with Particular Reference to Livestock and Fodder. *Journal of Human Ecology*, 26 (2), 123–130. <https://doi.org/10.1080/09709274.2009.11906173>

- Bokil, M. (2000). Drought in Rajasthan. *Economic & Political Weekly*, 35 (48), 4171–4175. <http://www.jstor.org/stable/4409995>
- Borkar and Nadakani. (1975). Impact of Drought on Rural Life (1st ed). *Popular Prakashan private limited, Bombay*.
- Bouklikha, A., Habi, M., Elouissi, A., Benzater, B., & Hamoudi, S. (2020). The innovative trend analysis applied to annual and seasonal rainfall in the tafna watershed (Algeria). *Revista Brasileira de Meteorologia*, 35 (4), 631–647. <https://doi.org/10.1590/0102-77863540068>
- Boyd, R., & Ibararán, M. E. (2009). Extreme climate events and adaptation: An exploratory analysis of drought in Mexico. *Environment and Development Economics*, 14(3), 371–395. <https://doi.org/10.1017/S1355770X08004956>
- Bryan, E., Deressa, T. T., Gbetibouo, G. A., & Ringler, C. (2009). Adaptation to climate change in Ethiopia and South Africa: options and constraints. *Environmental Science and Policy*, 12 (4), 413–426. <https://doi.org/10.1016/j.envsci.2008.11.002>
- Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., & Herrero, M. (2013). Adapting agriculture to climate change in Kenya: Household strategies and determinants. *Journal of Environmental Management*, 114, pp. 26–35. <https://doi.org/10.1016/j.jenvman.2012.10.036>
- Byakatonda, J., Parida, B. P., Kenabatho, P. K., & Moalafhi, D. B. (2018). Analysis of rainfall and temperature time series to detect long-term climatic trends and variability over semi-arid Botswana. *Journal of Earth System Science*, 127 (25), 1-20, <https://doi.org/10.1007/s12040-018-0926-3>
- Caloiero, T. (2015). Analysis of rainfall trend in New Zealand. *Environmental Earth Sciences*, 73 (10), 6297–6310. <https://doi.org/10.1007/s12665-014-3852-y>
- Chandan Kumar and Jha Vijaya Gupta. (2021). Farmer's perception and factors determining the adaptation decisions to cope with climate change: An evidence from rural India, *Environment and Sustainability Indicator*, (10), 100112. <https://doi.org/10.1016/j.indic.2021.100112>
- Chandniha, S. K., Meshram, S. G., Adamowski, J. F., & Meshram, C. (2017). Trend analysis of precipitation in Jharkhand State, India: Investigating precipitation variability in Jharkhand State. *Theoretical and Applied Climatology*, 130 (1–2), 261–274. <https://doi.org/10.1007/s00704-016-1875-x>
- Chatterjee, S., Khan, A., Akbari, H., & Wang, Y. (2016). Monotonic trends in Spatio-temporal

- distribution and concentration of monsoon precipitation (1901–2002), West Bengal, India. *Atmospheric Research*, 182, 54–75. <https://doi.org/10.1016/j.atmosres.2016.07.010>
- Costa et al. (2017). Space-time distribution of rainfall anomaly index (RAI) for the Salgado Basin, Ceará State Brazil. *Biology-Botany*, 39, (3), 627–634. [10.5902/2179460X26080](https://doi.org/10.5902/2179460X26080)
- Costa, J. A., & Rodrigues, G. P. (2017). Space-Time Distribution of Rainfall Anomaly Index (Rai) for the Salgado Basin, Ceará State - Brazil. *Ciência e Natura*, 39 (3), 627. <https://doi.org/10.5902/2179460x26080>
- Damania, R., Desbureaux, S., & Zaveri, E. (2020). Does rainfall matter for economic growth? Evidence from global sub-national data (1990–2014). In *Journal of Environmental Economics and Management*, 102, 102335. <https://doi.org/10.1016/j.jeem.2020.102335>
- Delaporte, I., & Maurel, M. (2018). Adaptation to climate change in Bangladesh. *Climate Policy*, 18(1), 49–62. <https://doi.org/10.1080/14693062.2016.1222261>
- Department of Agriculture, Annual Report (2018). Department of Agriculture, Cooperation & Farmers Welfare Ministry of Agriculture & Farmers Welfare Government of India Krishi Bhawan, New Delhi-110 001 www.agricoop.nic.in
- Department of Agriculture, Annual Report (2021). Department of Agriculture, Cooperation & Farmers Welfare Ministry of Agriculture & Farmers Welfare Government of India Krishi Bhawan, New Delhi-110 001 www.agricoop.nic.in
- Deressa, T. T., Hassan, R. M., & Ringler, C. (2011). Perception of and adaptation to climate change by farmers in the Nile basin of Ethiopia. *Journal of Agricultural Science*, 149(1), 23–31. <https://doi.org/10.1017/S0021859610000687>
- Deressa, T. T., Hassan, R. M., Ringler, C., Alemu, T., & Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change*, 19 (2), 248–255. <https://doi.org/10.1016/j.gloenvcha.2009.01.002>
- Dhaktode, N. (2020). *Drought and Farmer Suicides in Marathwada: A Natural or Manmade Disaster?* Social welfare in India china - a Comparative perspective. G. Jianguo Gao, Sheng-Li Cheng, Rajendra Baikady (Eds). *Social Welfare in India and China* (1st ed, 279-295). Palgrave Macmillan, Springer Nature Singapore, <https://doi.org/10.1007/978-981-15-5648-7>
- Dhanya, P., & Ramachandran, A. (2016). Farmers' perceptions of climate change and the proposed

- agriculture adaptation strategies in the semi-arid region of south India. *Journal of Integrative Environmental Sciences*, 13 (1), 1–18. <https://doi.org/10.1080/1943815X.2015.1062031>
- Dinpashoh, Y., Mirabbasi, R., Jhajharia, D., Abianeh, H. Z., & Mostafaeipour, A. (2014). Effect of Short-Term and Long-Term Persistence on Identification of Temporal Trends. *Journal of Hydrologic Engineering*, 19 (3), 617–625. [https://doi.org/10.1061/\(asce\)he.1943-5584.0000819](https://doi.org/10.1061/(asce)he.1943-5584.0000819)
- Directorate of Economics & Statistics, Government of Maharashtra (2018). *Handbook of basic statistics of Maharashtra*, Mumbai. <http://mahaes.maharashtra.gov.in>
- Directorate of Economics and Statistics, Government of Maharashtra (2021). *Socio-economics review Maharashtra*, Mumbai. <https://mahades.maharashtra.gov.in>
- Directorate of Economics and Statistics, Government of Maharashtra (2016). *Socio-economics review Maharashtra*, Mumbai. <https://mahades.maharashtra.gov.in>
- Directorate of Economics and Statistics, Government of Maharashtra (2017). *Socio-economics review*, Osmanabad, Mumbai. <https://mahades.maharashtra.gov.in>
- Directorate of Economics and Statistics, Government of Maharashtra (2017). *Socio-economics review*, Beed, Mumbai. <https://mahades.maharashtra.gov.in>
- Directorate of Economics and Statistics, Government of Maharashtra (2017). *Socio-economics review*, Latur, Mumbai. <https://mahades.maharashtra.gov.in>
- District Census Handbook (2011). *Village and town-wise primary census abstract (PCA), Beed, Directorate of Census Operations Maharashtra*. 2-298. <https://censusindia.gov.in>
- District Census Handbook (2011). *Village and town-wise primary census abstract (PCA), Osmanabad, Directorate of Census Operations Maharashtra*. 2-202. <https://censusindia.gov.in>
- District Census Handbook (2011). *Village and town-wise primary census abstract (PCA), Latur, Directorate of Census Operations Maharashtra*. 2-46. <https://censusindia.gov.in>
- Duhan, D., & Pandey, A. (2013). Statistical analysis of long-term spatial and temporal trends of precipitation during 1901-2002 in Madhya Pradesh, India. *Atmospheric Research*, 122, 136–149. <https://doi.org/10.1016/j.atmosres.2012.10.010>
- Dutta, V., Vimal, M., Singh, S., & Singh, R. P. (2019). Agricultural practices in a drought-prone region of India: opportunities for S & T innovations. *World Journal of Science, Technology and Sustainable Development*, 16 (4), 208–226. <https://doi.org/10.1108/WJSTSD-04-2018-0019>

- Economic Survey of Maharashtra (2017). Directorate of economics and statistics, Planning Department, Government of Maharashtra, Mumbai. <https://mahades.maharashtra.gov.in>
- Edwards, B., Gray, M., & Hunter, B. (2019). The social and economic impacts of drought. *Australian Journal Of Social Issues*, 54, 22–31. <https://doi.org/10.1002/ajs4.52>
- Elzopy, K. A., Chaturvedi, A. K., Chandran, K. M., Gopinath, G., Naveena, K., & Surendran, U. (2021). Trend analysis of long-term rainfall and temperature data for Ethiopia. *South African Geographical Journal*, 103 (3), 381–394. <https://doi.org/10.1080/03736245.2020.1835699>
- Fanadzo, M., Ncube, B., French, A., & Belete, A. (2021). Smallholder farmer coping and adaptation strategies during the 2015-18 drought in the Western Cape, South Africa. *Physics and Chemistry of the Earth, June 2020*. <https://doi.org/10.1016/j.pce.2021.102986>
- Ghadyalpatil A. (2018, October 24). Maharashtra declares a ‘drought-like situation’ in 180 tehsils. Mint. <https://www.livemint.com>
- Gebre, B., Ayenew, H. Y., & Biadgilign, S. (2021). Drought, hunger and coping mechanisms among rural households in Southeast Ethiopia. *Heliyon* 7, (3). <https://doi.org/10.1016/j.heliyon.2021.e06355>
- Government of India, Ministry of Agriculture and Farmers Welfare, Department of Agriculture, Cooperation & Farmer Welfare (2016). Manual for Drought Management, December 2016, Krishi Bhavan, New Delhi. <https://agricoop.nic.in>
- Goyal, M. K. (2014). Statistical Analysis of Long Term Trends of Rainfall During 1901-2002 at Assam, India. *Water Resources Management*, 28 (6), 1501–1515. <https://doi.org/10.1007/s11269-014-0529-y>
- Guhathakurta, P., & Rajeevan, M. (2008). Trends in the rainfall pattern over India. In *International Journal of Climatology* 28, (11), 1453–1469. <https://doi.org/10.1002/joc.1640>
- Guhathakurta, P., Rajeevan, M., Sikka, D. R., & Tyagi, A. (2015). Observed changes in southwest monsoon rainfall over India during 1901-2011. *International Journal of Climatology*, 35(8), 1881–1898. <https://doi.org/10.1002/joc.4095>
- Gujarati, D. (2011). *Econometrics by Example* (2nd ed). Palgrave Macmillan, New York
- Guntukula, R. (2020). Assessing the impact of climate change on Indian agriculture: Evidence from major crop yields. *Journal of Public Affairs*, 20 (1), 1–7. <https://doi.org/10.1002/pa.2040>
- Gupta, N., Banerjee, A., & Gupta, S. K. (2021). Spatio-temporal Trend Analysis of Climatic

- Variables over Jharkhand, India. *Earth Systems and Environment*, 5 (1), 71–86.
<https://doi.org/10.1007/s41748-021-00204-x>
- Hajani, E., Rahman, A., & Ishak, E. (2017). Trends in extreme rainfall in the state of New South Wales, Australia. *Hydrological Sciences Journal*, 62 (13), 2160–2174.
<https://doi.org/10.1080/02626667.2017.1368520>
- Hartmann, H., & Buchanan, H. (2014). Trends in extreme precipitation events in the Indus River Basin and flooding in Pakistan. *Atmosphere-Ocean*, 52 (1), 77–91.
<https://doi.org/10.1080/07055900.2013.859124>
- Hermans, K., & Garbe, L. (2019). Droughts, livelihoods, and human migration in northern Ethiopia. *Regional Environmental Change*, 19(4), 1101–1111. <https://doi.org/10.1007/s10113-019-01473-z>
- Hussain, M. S., & Lee, S. (2016). Investigation of summer monsoon rainfall variability in Pakistan. *Meteorology and Atmospheric Physics*, 128 (4), 465–475.
<https://doi.org/10.1007/s00703-015-0423-z>
- Incoom, A. B. M., Adjei, K. A., & Odai, S. N. (2020). Rainfall variabilities and droughts in the Savannah zone of Ghana from 1960-2015. *Scientific African*, 10. <https://doi.org/10.1016/j.sciaf.2020.e00571>
- Indira Gandhi Institute of Development Research (2015). State of Environment Report: Maharashtra, 400065, <https://www.nswai.org>
- Ingle, S. T., Patil, S. N., Mahale, N. K., & Mahajan, Y. J. (2018). Analyzing rainfall seasonality and trends in the North Maharashtra region. *Environmental Earth Sciences*, 77 (18).
<https://doi.org/10.1007/s12665-018-7837-0>
- Intergovernmental panel on climate change Working Group II Contribution to the Fifth Assessment Report. (2014). Impacts, Adaptation, and Vulnerability Part A: Global and Sectoral Aspects. Cambridge University Press, New York. <https://www.ipcc.ch/site/assets>
- Iqbal, M. W., Donjadee, S., Kwanyuen, B., & Liu, S. yin. (2018). Farmers' perceptions of and adaptations to drought in Herat Province, Afghanistan. *Journal of Mountain Science*, 15(8), 1741–1756. <https://doi.org/10.1007/s11629-017-4750-z>
- James Thurlow, Tingju Zhu, X. D. (2009). The Impact of climate variability and change on the economic growth and poverty in Zambia. GTAP Resource 3144. <https://www.gtap.agecon.purdue.edu>
- Jin, J., Wang, W., & Wang, X. (2016). Adapting agriculture to the drought hazard in rural

- China: household strategies and determinants. *Natural Hazards*, 82(3), 1609–1619. <https://doi.org/10.1007/s11069-016-2260-x>
- Jordan, J. C. (2021). Climate shocks and adaptation strategies in coastal Bangladesh: does microcredit have a part to play? *Climate and Development*, 13 (5), 454–466. <https://doi.org/10.1080/17565529.2020.1799737>
- Joshi, K. (2019). The impact of drought on human capital in rural India. *Environment and Development Economics*, 24 (4), 413–436. <https://doi.org/10.1017/S1355770X19000123>
- Kabubo-Mariara, J. (2008). Climate change adaptation and livestock activity choices in Kenya: An economic analysis. *Natural Resources Forum*, 32 (2), 131–141. <https://doi.org/10.1111/j.1477-8947.2008.00178.x>
- Katalakute, G., Wagh, V., Panaskar, D., & Mukate, S. (2016). Impact of Drought on Environmental, Agricultural and Socio-economic Status in Maharashtra State, India. *Natural Resources and Conservation*, 4 (3), 35–41. <https://doi.org/10.13189/nrc.2016.040301>
- Kelkar, S. M., Kulkarni, A., & Rao, K. K. (2020). Impact of climate variability and change on crop production in Maharashtra, India. *Current Science*, 118(8), 1235–1245. <https://doi.org/10.18520/cs/v118/i8/1235-1245>
- Kendall, M. G. (1975). Rank correlation methods. *Rank correlation methods*. (4th ed), Charles Griffin.
- Keshavarz, M., Maleksaeidi, H., & Karami, E. (2017). Livelihood vulnerability to drought: A case of rural Iran. *International Journal of Disaster Risk Reduction*. 21, 223–230. <https://doi.org/10.1016/j.ijdr.2016.12.012>
- Khan, I., Lei, H., Shah, I. A., Ali, I., Khan, I., Muhammad, I., Huo, X., & Javed, T. (2020). Farm households' risk perception, attitude and adaptation strategies in dealing with climate change: Promise and perils from rural Pakistan. In *Land Use Policy*. 91. <https://doi.org/10.1016/j.landusepol.2019.104395>
- Khavse, R., Deshmukh, N., Manikandan, N., Chaudhary, J., & Kaushik, D. (2015). Statistical Analysis of Temperature and Rainfall Trend in Raipur District of Chhattisgarh. *Current World Environment*, 10 (1), 305–312. <https://doi.org/10.12944/cwe.10.1.38>
- Khayyati, M., & Aazami, M. (2016). Drought impact assessment on rural livelihood systems in Iran. *Ecological Indicators*, 71, 19. <https://doi.org/10.1016/j.ecolind.2016.06.047>

- Khetwani, S., & Singh, R. B. (2020). Drought vulnerability of Marathwada region, India: A spatial analysis. *GeoScape*, 14 (2), 108–121. <https://doi.org/10.2478/geosc-2020-0010>
- Khetwani, S., Singh, R. B., & Moin, K. (2020). Impact of drought, farmers' adaptation strategies and administrative mitigation measure in the Marathwada region, India. *Environmental and Socio-Economic Studies*, 8 (2), 1–11. <https://doi.org/10.2478/environ-2020-0007>
- Kilimani, N., van Heerden, J., Bohlmann, H., & Roos, L. (2018). Economy-wide impact of drought-induced productivity losses. *Disaster Prevention and Management: An International Journal*, 27(5), 636–648. <https://doi.org/10.1108/DPM-05-2018-0155>
- Kiros, G., Shetty, A., & Nandagiri, L. (2016). Analysis of variability and trends in rainfall over northern Ethiopia. *Arabian Journal of Geosciences*, 9 (6). <https://doi.org/10.1007/s12517-016-2471-1>
- Kothawale, D. R., & Rajeevan, M. (2017). Monthly, Seasonal and Annual Rainfall Time Series for All-India, Homogeneous Regions and Meteorological Subdivisions : 1871-2016. *Indian Institute of Tropical Meteorology (IITM) Earth*, 02, 1871–2016.
- Kulkarni, S. S., Wardlow, B. D., Bayissa, Y. A., Tadesse, T., Svoboda, M. D., & S., G. S. (2020). Developing a Remote Sensing-Based Combined Drought Indicator Approach for Agricultural. *Remote Sensing*, 12 (2091)
- Kundu, S. K., & Mondal, T. K. (2019). Analysis of long-term rainfall trends and change points in West Bengal, India. *Theoretical and Applied Climatology*, 138(3–4), 1647–1666. <https://doi.org/10.1007/s00704-019-02916-7>
- Lal, P., Alavalapati, J. R. R., & Mercer, E. D. (2011). Socio-economic impacts of climate change on the rural United States. *Mitigation and Adaptation Strategies for Global Change*, 16(7), 819–844. <https://doi.org/10.1007/s11027-011-9295-9>
- Latif, M., Syed, F. S., & Hannachi, A. (2017). Rainfall trends in the South Asian summer monsoon and its related large-scale dynamics with focus over Pakistan. *Climate Dynamics*, 48(11–12), 3565–3581. <https://doi.org/10.1007/s00382-016-3284-3>
- Liuzzo, L., Bono, E., Sammartano, V., & Freni, G. (2016). Analysis of spatial and temporal rainfall trends in Sicily during the 1921–2012 period. *Theoretical and Applied Climatology*, 126(1–2), 113–129. <https://doi.org/10.1007/s00704-015-1561-4>

- Machiwal, D., Dayal, D., & Kumar, S. (2017). Long-term rainfall trends and change points in hot and cold arid regions of India. *Hydrological Sciences Journal*, 62(7), 1050–1066. <https://doi.org/10.1080/02626667.2017.1303705>
- Maddison, D., & Bank, T. W. (2007). *The Perception of and Adaptation to Climate Change in Africa. The world bank development research group sustainable and urban development, Policy Research Working Paper*, 4308
- Mahajan, D. R., & Dodamani, B. M. (2016). Spatial and temporal drought analysis in the krishna river basin of Maharashtra, India. *Cogent Engineering*, 3 (1). <https://doi.org/10.1080/23311916.2016.1185926>
- Mallick, J., Talukdar, S., Alsubih, M., Salam, R., Ahmed, M., Kahla, N. Ben, & Shamimuzzaman, M. (2021). Analysing the trend of rainfall in the Asir region of Saudi Arabia using the family of Mann-Kendall tests, innovative trend analysis, and detrended fluctuation analysis. *Theoretical and Applied Climatology*, 143(1–2), 823–841. <https://doi.org/10.1007/s00704-020-03448-1>
- Mandale, SH, J., & MY, K. (2019). Spatio-temporal Trends of Rainfall and Rainy Days in the Marathwada region of Maharashtra state. *Climate Change*, 5(17), 54–61.
- Mardero, S., Schmook, B., Radel, C., Christman, Z., Lawrence, D., Millones, M., Nickl, E., Rogan, J., & Schneider, L. (2015). Smallholders' adaptations to droughts and climatic variability in southeastern Mexico. *Environmental Hazards*, 14(4), 271–288. <https://doi.org/10.1080/17477891.2015.1058741>
- Marie, M., Yirga, F., Haile, M., & Tquabo, F. (2020). Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from northwestern Ethiopia. In *Heliyon* (Vol. 6, Issue 4). <https://doi.org/10.1016/j.heliyon.2020.e03867>
- Maru, H., Hailelassie, A., Zeleke, T., & Esayas, B. (2021). Analysis of smallholders' livelihood vulnerability to drought across agroecology and farm typology in the upper awash sub-basin, Ethiopia. *Sustainability (Switzerland)*, 13(17). <https://doi.org/10.3390/su13179764>
- Marzieh Keshavarz and Ezatollah Karami. (2012). Drought and Happiness in Rural Iran. *Journal of Soil Science and Environmental Management*, 3(3), 63–73. <http://www.academicjournals.org>
- Mayanja, M. N., Rubaire-Akiiki, C., Morton, J., & Kabasa, J. D. (2020). Pastoral community coping and adaptation strategies to manage household food insecurity consequent to climatic hazards in the cattle corridor of Uganda. *Climate and Development*, 12(2), 110–

119. <https://doi.org/10.1080/17565529.2019.1605283>
- Menike, L. M. C. S., & Arachchi, K. A. G. P. K. (2016). Adaptation to Climate Change by Smallholder Farmers in Rural Communities: Evidence from Sri Lanka. *Procedia Food Science*, 6, 288–292. <https://doi.org/10.1016/j.profoo.2016.02.057>
- Miheretu, B. A. (2020). Temporal variability and trend analysis of temperature and rainfall in the Northern highlands of Ethiopia. *Physical Geography*. <https://doi.org/10.1080/02723646.2020.1806674>
- Mishra, V. (2020). Long-term (1870–2018) Drought reconstruction in context of surface water security in India. *Journal of Hydrology*, 580. <https://doi.org/10.1016/j.jhydrol.2019.124228>
- Miyan, M. A. (2015). Droughts in asian least developed countries: Vulnerability and sustainability. In *Weather and Climate Extremes*, 7, 8–23). <https://doi.org/10.1016/j.wace.2014.06.003>
- Mumo, L., Yu, J., & Ayugi, B. (2019). Evaluation of spatiotemporal variability of rainfall over Kenya from 1979 to 2017. *Journal of Atmospheric and Solar-Terrestrial Physics*, 194(December 2018). <https://doi.org/10.1016/j.jastp.2019.105097>
- Muralikrishnan, L., Padaria, R. N., Choudhary, A. K., Dass, A., Shokralla, S., Zin El-Abedin, T. K., Abdelmohsen, S. A. M., Mahmoud, E. A., & Elansary, H. O. (2022). Climate change-induced drought impacts, adaptation and mitigation measures in semi-arid pastoral and agricultural watersheds. *Sustainability (Switzerland)*, 14 (1). <https://doi.org/10.3390/su14010006>
- Nadkarni M. N. (1985). *Socio-Economic Condition in Drought-Prone Areas- A Bench Mark study of Drought District in Andhra Pradesh, Karnataka and Tamil Nadu*,. Concept Publication Company, New Delhi.
- Nagarguna B. et. al. (2010). *Impact of Drought on Dalits and Adiwashis-A Socio-Economic Analysis*". Global Research Publication New Delhi.
- Nair, S. C., & Mirajkar, A. B. (2021). Spatio-temporal rainfall trend anomalies in Vidarbha region using historic and predicted data: a case study. *Modeling Earth Systems and Environment*, 7(1), 503–510. <https://doi.org/10.1007/s40808-020-00928-1>
- Niles, M. T., Lubell, M., & Brown, M. (2015). How limiting factors drive agricultural adaptation to climate change. *Agriculture, Ecosystems and Environment*, 200, 178–185. <https://doi.org/10.1016/j.agee.2014.11.010>
- Nyberg, Y., Jonsson, M., Laszlo Ambjörnsson, E., Wetterlind, J., & Öborn, I. (2020).

- Smallholders' awareness of adaptation and coping measures to deal with rainfall variability in Western Kenya. *Agroecology and Sustainable Food Systems*, 44 (10), 1280–1308. <https://doi.org/10.1080/21683565.2020.1782305>
- Omerkhil, N., Kumar, P., Mallick, M., Meru, L. B., Chand, T., Rawat, P. S., & Pandey, R. (2020). Micro-level adaptation strategies by smallholders to adapt climate change in the least developed countries (LDCs): Insights from Afghanistan. In *Ecological Indicators*, 118. <https://doi.org/10.1016/j.ecolind.2020.106781>
- Opiyo, F., Wasonga, O., Nyangito, M., Schilling, J., & Munang, R. (2015). Drought Adaptation and Coping Strategies Among the Turkana Pastoralists of Northern Kenya. *International Journal of Disaster Risk Science*, 6 (3), 295–309. <https://doi.org/10.1007/s13753-015-0063-4>
- Panda, A. (2016). Exploring climate change perceptions, rainfall trends and perceived barriers to adaptation in a drought-affected region in India. *Natural Hazards*, 84(2), 777–796. <https://doi.org/10.1007/s11069-016-2456-0>
- Parthasarathy, B., Munot, A. A., & Kothawale, D. R. (1988). Regression model for estimation of Indian foodgrain production from summer monsoon rainfall. *Agricultural and Forest Meteorology*, 42 (2–3), 167–182. [https://doi.org/10.1016/0168-1923\(88\)90075-5](https://doi.org/10.1016/0168-1923(88)90075-5)
- Parthasarathy, B., Munot, A. A., & Kothawale, D. R. (1994). All-India monthly and seasonal rainfall series: 1871-1993. *Theoretical and Applied Climatology*, 49(4), 217–224. <https://doi.org/10.1007/BF00867461>
- Patra, J. P., Mishra, A., Singh, R., & Raghuwanshi, N. S. (2012). Detecting rainfall trends in twentieth century (1871-2006) over Orissa State, India. *Climatic Change*, 111 (3), 801–817. <https://doi.org/10.1007/s10584-011-0215-5>
- Phuong, D. N. D., Hai, L. M., Dung, H. M., & Loi, N. K. (2022). Temporal Trend Possibilities of Annual Rainfall and Standardized Precipitation Index in the Central Highlands, Vietnam. *Earth Systems and Environment*, 6 (1), 69–85. <https://doi.org/10.1007/s41748-021-00211-y>
- Porto de Carvalho, J. R., Assad, E. D., de Oliveira, A. F., & Silveira Pinto, H. (2014). Annual maximum daily rainfall trends in the midwest, southeast and southern Brazil in the last 71 years. *Weather and Climate Extremes*, 5(1), 7–15. <https://doi.org/10.1016/j.wace.2014.10.001>

- Prasanna, V. (2014). Impact of monsoon rainfall on the total foodgrain yield over India. *Journal of Earth System Science*, 123 (5), 1129–1145. <https://doi.org/10.1007/s12040-014-0444-x>
- Praveen, B., Talukdar, S., Shahfahad, Mahato, S., Mondal, J., Sharma, P., Islam, A. R. M. T., & Rahman, A. (2020). Analyzing trend and forecasting of rainfall changes in India using non-parametrical and machine learning approaches. *Scientific Reports*, 10 (1), 1–21. <https://doi.org/10.1038/s41598-020-67228-7>
- Pulak Guhathakurta, Shirish Khedikar, Preetha Menon, A. K. P., & Advani, S. T. S. and S. C. (2020). Observed Rainfall Variability and Changes over Maharashtra State. (Met monograph) No.ESSO/IMD/HS/RainfallVariability/16(2020)/40),1–30. <https://imdpune.gov.in/hydrology/rainfall%20variability>
- Quandt, A. (2021). Coping with drought: Narratives from smallholder farmers in semi-arid Kenya. In *International Journal of Disaster Risk Reduction*, 57. <https://doi.org/10.1016/j.ijdr.2021.102168>
- Quandt, T. M. and A. (2020). Drought A Challenge to Livelihoods, Sustainability, and Resilience. Smith O. A., Hoffman S., Hoffman M.S., (2nded). *The Angry Earth: Disaster in Anthropological Perspective*, 212–226. Routledge.
- Rahman, M. A., Yunsheng, L., & Sultana, N. (2017). Analysis and prediction of rainfall trends over Bangladesh using Mann–Kendall, Spearman’s rho tests and ARIMA model. *Meteorology and Atmospheric Physics*, 129(4), 409–424. <https://doi.org/10.1007/s00703-016-0479-4>
- Rakgase, M. A., & Norris, D. (2015). Determinants of livestock farmers ’ perception of future droughts and adoption of mitigating plans. *International Journal of Climate Change Strategies and Management*, 7 (2), 191–205. <https://doi.org/10.1108/IJCCSM-01-2014-0011>
- Rana, A., Uvo, C. B., Bengtsson, L., & Sarthi, P. P. (2012). Trend analysis for rainfall in Delhi and Mumbai, India. *Climate Dynamics*, 38(1–2), 45–56. <https://doi.org/10.1007/s00382-011-1083-4>
- Reay, D., Sabine, C., Smith, P., & Hymus, G. (2007). Intergovernmental Panel on Climate Change. Fourth Assessment Report. Geneva, Switzerland: Inter-governmental Panel on Climate Change. In *Intergovernmental Panel on Climate Change*. <https://doi.org/10.1038/446727a>

- Reddy, D. R., & Sreenivas, G. (2016). Agricultural drought monitoring and management at sub district level in Telangana. *Mausam*, 67 (1), 259–266. <https://doi.org/10.54302/mausam.v67i1.1190>
- Sa’adi, Z., Shahid, S., Ismail, T., Chung, E. S., & Wang, X. J. (2019). Trends analysis of rainfall and rainfall extremes in Sarawak, Malaysia using modified Mann–Kendall test. *Meteorology and Atmospheric Physics*, 131(3), 263–277. <https://doi.org/10.1007/s00703-017-0564-3>
- Sadeghi, S. H. R., & Hazbavi, Z. (2015). Trend analysis of the rainfall erosivity index at different time scales in Iran. *Natural Hazards*, 77(1), 383–404. <https://doi.org/10.1007/s11069-015-1607-z>
- Saha, K. R., Mooley, D. A., & Saha, S. (1979). The Indian monsoon and its economic impact. *GeoJournal*, 3 (2), 171–178. <https://doi.org/10.1007/BF00257706>
- Sainath P. (1996). *Everybody loves a good drought, stories from India’s poorest districts*. Penguin Random House, India
- Sajjad Ali, Liu Ying, Adnan Nazir, Abdullah, Muhammad Ishaq, Tariq Shah, Xinyue Ye, Aasir Ilyas, A. T. (2020). Rural Farmers Perception and Coping Strategies towards Climate Change and their Determinants: Evidence from Khyber Pakhtunkhwa Province, Pakistan. *Science of the Total Environment*, 291, 135907. <https://doi.org/10.1016/j.scitotenv.2019.135907>
- Sangkhaphan, S., & Shu, Y. (2020). The Effect of Rainfall on Economic Growth in Thailand: A Blessing for Poor Provinces. *Economies*, 8 (1), 1–17. <https://doi.org/10.3390/economies8010001>
- Sarker, M. A. R., Alam, K., & Gow, J. (2014). Assessing the effects of climate change on rice yields: An econometric investigation using Bangladeshi panel data. In *Economic Analysis and Policy*, 44, (4), 405–416. <https://doi.org/10.1016/j.eap.2014.11.004>
- Sayemuzzaman, M., Jha, M. K., & Mekonnen, A. (2015). Spatio-temporal long-term (1950–2009) temperature trend analysis in North Carolina, United States. *Theoretical and Applied Climatology*, 120 (1–2), 159–171. <https://doi.org/10.1007/s00704-014-1147-6>
- Selamawit Fantahun Sertse, Nasir Abbas Khan, Ashfaq Ahmad Shah, Yonggong Liuc, S. A. N. (2020). Farm households’ perceptions and adaptation strategies to climate change risks and their determinants evidence from Raya Azebo district, Ethiopia. *International Journal of Disaster Risk Reduction*, 60. <https://doi.org/10.1016/j.ijdr.2021.102255>
- Sen A. (1981). *Poverty and Famine: an essay on entitlement and deprivation*. Oxford University Press, New York

- Sen, P. K. (1968). Estimates of the regression coefficient based on Kendall's Tau. *American Statistical Association*, 63 (324), 1379–1389. <http://www.jstor.org/stable/2285891>
- Shree, S., & Kumar, M. (2018). Analysis of seasonal and annual rainfall trends for Ranchi district, Jharkhand, India. *Environmental Earth Sciences*, 77 (19). <https://doi.org/10.1007/s12665-018-7884-6>
- Shreekant S. (2010). Impact of the 2009 Drought on Agricultural Output: Fantasy or Reality? *Economic & Political Weekly*, xlv 9, 14-15. <http://indiaenvironmentportal.org.in>
- Singh, P. K., & Chudasama, H. (2017). Pathways for drought resilient livelihoods based on people's perception. *Climatic Change*, 140 (2), 179–193. <https://doi.org/10.1007/s10584-016-1817-8>
- Singh, R., Sah, S., Das, B., Vishnoi, L., & Pathak, H. (2021). Spatio-temporal trends and variability of rainfall in Maharashtra, India: Analysis of 118 years. *Theoretical and Applied Climatology*, 143 (3–4), 883–900. <https://doi.org/10.1007/s00704-020-03452-5>
- Singh, R., Saravanan, R., Feroze, S. M., Devarani, L., & Paris, T. R. (2012). A Case Study of Drought and its Impact on Rural Livelihood in Meghalaya. *Indian J. Dryland Agric. Res. & Dev*, 27, (1), 90–94. <http://www.drylandagri.org.in>
- Sinha, P., Nageswararao, M. M., Dash, G. P., Nair, A., & Mohanty, U. C. (2019). Pre-monsoon rainfall and surface air temperature trends over India and its global linkages. *Meteorology and Atmospheric Physics*, 131 (4), 1005–1018. <https://doi.org/10.1007/s00703-018-0621-6>
- Sivakumar S., Kerbart E. (2004). Drought, sustenance and livelihoods, 'Akal' survey in Rajasthan. *Economic and Political Weekly*, 39 (3), 285–294. DOI:[10.2307/4414528](https://doi.org/10.2307/4414528)
- Subash, N., & Sikka, A. K. (2014). Trend analysis of rainfall and temperature and its relationship over India. *Theoretical and Applied Climatology*, 117(3–4), 449–462. <https://doi.org/10.1007/s00704-013-1015-9>
- Tannehill, I. R. (1949). Drought-Its Causes and Effects. *Journal of the South African Forestry Association*, 18(1), 83–84. <https://doi.org/10.1080/03759873.1949.9630655>
- Tazeze, A., Haji, J., & Ketema, M. (2012). Climate Change Adaptation Strategies of Smallholder Farmers: The Case of Babilie District, East Harerghe Zone of Oromia Regional State of Ethiopia. *Issn*, 3(14), 2222–1700. www.iiste.org

- Tessema, Y. A., Aweke, C. S., & Endris, G. S. (2013). Understanding the process of adaptation to climate change by small-holder farmers: the case of east Hararghe Zone, Ethiopia. *Agricultural and Food Economics*, 1(1), 1–17. <https://doi.org/10.1186/2193-7532-1-13>
- Thao, N. T. T., Khoi, D. N., Xuan, T. T., & Tychon, B. (2019). Assessment of Livelihood Vulnerability to Drought: A Case Study in Dak Nong Province, Vietnam. *International Journal of Disaster Risk Science*, 10 (4), 604–615. <https://doi.org/10.1007/s13753-019-00230-4>
- Thinda, K. T., Ogundeji, A. A., Belle, J. A., & Ojo, T. O. (2020). Understanding the adoption of climate change adaptation strategies among smallholder farmers: Evidence from land reform beneficiaries in South Africa. In *Land Use Policy*, 99). <https://doi.org/10.1016/j.landusepol.2020.104858>
- Thomas, J., & Prasannakumar, V. (2016). Temporal analysis of rainfall (1871-2012) and drought characteristics over a tropical monsoon-dominated State (Kerala) of India. *Journal of Hydrology*, 534, 266–280. <https://doi.org/10.1016/j.jhydrol.2016.01.013>
- Tirlapur, L. N., & Desai, N. R. M. (2016). Impact of drought on agriculture in North Karnataka - An economic analysis. *Asian Journal of Environmental Science*, 11(1), 87–93. <https://doi.org/10.15740/has/ajes/11.1/87-93>
- Udmale, P. D., Ichikawa, Y., Manandhar, S., Ishidaira, H., Kiem, A. S., Shaowei, N., & Panda, S. N. (2015). How did the 2012 drought affect rural livelihoods in vulnerable areas ? Empirical evidence from India. *International Journal of Disaster Risk Reduction*, 13, 454–469. <https://doi.org/10.1016/j.ijdr.2015.08.002>
- Udmale, P., Ichikawa, Y., Manandhar, S., Ishidaira, H., & Kiem, A. S. (2014). Farmers' perception of drought impacts, local adaptation and administrative mitigation measures in Maharashtra State, India. *International Journal of Disaster Risk Reduction*, 10(PA), 250–269. <https://doi.org/10.1016/j.ijdr.2014.09.011>
- Venkateswarlu et. al. (2014). Revisiting drought-prone districts in India. *Economic and Political Weekly*, 49 (25), 71–75. <https://www.jstor.org/stable/24479682>
- Waghmare, P. T., Panhalkar, S. S., & Pawar, S. D. (2020). Drought Assessment of Eastern Satara District of Maharashtra Using Rainfall Anomaly Index. REsearch Square . DOI:10.21203/rs.3.rs-52305/v1
- Yadav, S. M., Bhagat, S. R., & Yadav, V. G. (2021). Temporal analysis of precipitation in

- Saurashtra, Kutch, and Diu sub-division of Western Indian region. *Theoretical and Applied Climatology*, 144 (1–2), 521–533. <https://doi.org/10.1007/s00704-021-03564-6>
- Yang, H., Xiao H., Guo C., Sun Y., & Gao R. (2020). Innovative trend analysis of annual and seasonal precipitation in Ningxia, China. *Atmospheric and Oceanic Science Letters*, 13 (4), 308–315. <https://doi.org/10.1080/16742834.2020.1752616>
- Zheng, Y., & Byg, A. (2014). Coping with climate change: Households' response strategies to drought and hailstorm in Lijiang, China. *Environmental Hazards*, 13 (3), 211–228. <https://doi.org/10.1080/17477891.2014.902799>
- Ziolkowska, J. R. (2016). Socio-economic implications of drought in the agricultural sector and the state economy. *Economies*, 4(3), 1–11. <https://doi.org/10.3390/economies4030019>

Appendix A. Questionnaire

School of Economics
University of Hyderabad

Questionnaire on “Impact of Drought on Rural Households - A Study of three Districts of Marathwada Region of Marathwada”

Research Scholar: Bhagat Nitin Dattuji (PhD)

(The reference year 2018-19)

Date:

Form No.....

A) General features of household:

a) (Village Details)

1) Name of the village

2) Gram panchayat.....

3) Block/Taluka.....

4) District.....

b) Details of household:

A total number of household members.....

1) Religion: 1) Hindu 2) Buddhist 3) Muslim 4) Others

2) Category: 1) Open 2) OBCs 3) SCs 4) STs

5) VJNT 6) Others

3) Family Type: 1) Joint 2) Nuclear

c) Housing facility of the household:

01) Housing facilities					
S. No.	Housing type	Toilet facility	Sources of drinking water	Main sources of cooking	Main sources of lighting
1					
2					
3					

Codes for block 1:

Housing type: (Hut = 1, Kucha = 2, Pucca = 3, Old House = 4, Other = 5), **Toilet facility :** (Self toilet =1, No toilet = 2, Not using in the drought), **Sources of drinking water:** (Self-Water Tap = 1, Common water tap = 2, Well = 3, Hand pump = 4, Tanker = 5, Any other = 6, **Type of Fuel:** (Firewood = 1, LPG = 2, Electric shegadi = 3, Kerosene stove = 4, Any other = 5), **Main sources of lighting:** (Electricity = 1, Lamp = 2, Any other = 3).

d) Demographic characteristics of the household members:

Sr. No.	Name of the Person	Relation to the head of households	Sex (Male/Female)	Age group	Marital status	Level of education	Type of household	Main occupation
1								
2								
3								
4								
5								
6								
7								
8								

Codes for block 2:

Relation to head of the household: (Self = 1, Spouse/ Husband =2, Son/Daughter = 3, Grandchild = 4, Draughter-in-law / Son-in-law = 5, Father-in-law / Mother-in-law = 6, Father / Mother = 7, Brother-in-law = 8, Nephew / Nice = 9, Sister-in-law = 10, others = 11), **Gender:** (Male = 1, Female = 2), **Age Groups:** (Below 6 = 1, 6 to 18 = 2, 19 to 30 = 3, 31 to 45 = 4, Above 45 = 5), **Marital Status:** (Single = 1, Married = 2, Widow = 3, Separate = 4, Widower = 5, Divorced = 6), **Level of Education:** Primary (1-4) =1, Higher-Secondary (5-9) = 2, Secondary School Certificate (SSC), (10) = 3, Higher Secondary Certificate (HSC), (11-12) = 4, Graduate = 5, Post-Graduate=6, Illiterate = 7), **Type of Household:** (Self-employed in Agriculture = 1, self-employed in non-Agriculture = 2, Regular wage/salary earning = 3, Casual Labour in Agriculture = 4, Casual labour in non-Agriculture = 5, both causal in agriculture and non-agriculture = 6 other = 7) **Main occupation:** (Student =1, Government. servant =2, Cultivator/Farmer = 3, Agriculture Labour = 4, Non-agriculture Labour =5, Self-business = 6, Livestock = 7, Casual Labour in Agriculture = 8, Causal labour in non-Agriculture = 9, Housewife = 10)

B) Classification of landholding size:

Classification	Size	Irrigated	Non-irrigated	Kharif crops	Rabi crops
Marginal (Below 0.5 ha to 1.0 ha.)					
Small (1.0 – 2.0 ha.)					
Medium (2.0 ha – 4.0 ha.)					
Large (More than 5.0 ha.)					

Note: (ha=hectare)

C) Economic impact of drought:

01) Household's income				
Total average income				
Income	(1) Annual income (farm/livestock)	(2) Monthly income	(3) Daily income	(4) 1) Increased 2) Decreased 3) Same
Now (farm/livestock/wage)				
Before Drought (farm/livestock/wage)				
After Drought (farm/livestock/wage)				
Total average consumption expenditure				
02) Household consumption expenditure	(1) Total consumption expenditure	(2) Monthly consumption expenditure	(3) Daily consumption expenditure	(4) 1) Increased 2) Decreased 3) Same
Now (farm/livestock/wage)				
Before Drought (farm/livestock/wage)				
After Drought (farm/livestock/wage)				

Codes for block 3:

Total average annual income: (below 25000 = 1, 25000 to 35000 = 2, 36000 to 45000 = 3, 46000 to 55000 = 4, above 55000 = 6)

03) Have you spent money on drinking water in the drought period?					
Drinking water spending	Yes-1, No-2	If yes, daily	Monthly	Seasonally	Yearly
How many litre					
How much money					
Are you fetching from the water general tanker?					
If yes, who is fetching water from the general tanker,1) men 2) women 3) all family members					
Are you fetching water from outside the village?					
If yes, from how many kilometres? 1) Nearly one 2) two 3) more than two?					

04) Ownership of livestock					
Livestock (In village)	Before drought	After drought	Was fodder available during the drought period? 1)Yes, 2) No	What kind of fodder was available in a drought period?	How many rupees have you spent on fodder in a day/month?
Bullocks					
Cows					
Buffalo					
Goats					
Hens					
No livestock					
Total					

Codes for block 04:

What type of fodder available in drought period: (Green grass = 1, Dry grass = 2, Green crop residue = 3, Dry crop residue = 4, Any other =5)

05) During the drought period, did you send your livestock to the cattle camp?					
Cattle camp	Yes-1, No-2	If yes, what kind of fodder is available in the cattle camp	If no, what are the reasons	How many days 1) one month 2) three months 3) six months) one year	How many cattle 1) one 2) two 3) three 4) four 5 more than four
Bullocks					
Cow					
Buffalo					
Total					

05) Did you get any subsidies/loans/debit from a private bank, national bank or moneylenders?

1. Yes, 2. No

If yes, fill the details in the following table:

11) Subsidy	How much (acre/hectare)	How much (rupees)	Loan/Debit	How much	Interest rate	Bank Name/ Moneylender/Relative
Crops name			Crops name			
Irrigated			Irrigated			
Non-irrigated			Non-irrigated			
Cash crops			Cash crops			
Horticulture crops			Horticulture crops			
Monthly/ Seasonally/Yearly			Monthly/ Seasonally/Yearly			
Any other type			Any other type			

06) Are you a member of a crop insurance scheme?

Crop insurance	Yes-1 No-2	If yes, how much acre?	How much money for 1 acre?	How much to cash crops?	How much do horticulture crops?	How many periods 1) seasonally, 2) yearly	If no, what are the reasons
Irrigated							
Non-Irrigated							
Total							
In drought period							
After the drought							

D) Social impact:

a) Drought affects school-going children	Yes-1, No-2 No change-3	If yes, what are the reasons/what kind of problems they faced	If no, what are the reasons
b) Out-migration	Yes-1, No-2 No change-3	If yes, why have you migrated reasons? /Where?	If no, what are the reasons?
c) Health	Yes-1, No-2 No change-3	If yes, what kind of health problems do you face?	Diseases name

E) Environmental impact (farmers' perceptions about the environmental impact of drought):

How do you rate the following environmental changes caused by drought?

Scale	Very high	High	Medium	Less	Very less
i. Temperature increased					
ii. Jungle degradation					
iii. Due to drought Pasture declined					
iv. Water scarcity in surface water bodies					
v. Decline in groundwater levels					
vi. Deteriorated water quality					
vii. Damage to wildlife and fish habitat/ migrate wildlife					

F) Local government's role to mitigate drought impact:

01) Drought mitigation programmes	Participated in Yes-1, No-2	If yes, how many days	How much salary (daily)	What kind of work was available?	What kind of benefits got from this programme?	If no, what are the reasons ?
Food for work						
Through gram panchayat (Gram Sabha)						
Jalyukt Shivar Abhiyaan under (NAREGA)						
Any other institutions/NGO						
SHGs						

*CMRF/ MP/ MLA						
Waiver of land revenue						
Education fee						
Electricity bill						

02) Fair price shops (Role of the public distribution system)	(Yes-1, No-2)	If yes, why? How much kg food grain have you got per month for each person?	Food grain name 1) wheat 2) rice 3) pulses 4) kerosene (how many litres per month)	If, no, what are the reasons?
Drought year				
Below poverty line				
Above poverty line				
Others				
NGOs				
Mid-day mill				
Normal year				

G) i) What are the coping and adaptation strategies adopted by the households during the drought period to cope with drought?				
S. No	Coping Strategies	Yes=1/No=2	Adaptation Strategies	Yes=1/No=2
1	Selling livestock and jewellery		Crop diversification	
2	Borrowing from a relative or the bank or moneylenders		Soil conservation	
3	Receiving food from PDS		Planting trees	
4	Participating food for work programme		Changing crop planting dates	
5	1)Reducing Consumption 2) consumption of low-cost foods		Changing traditional irrigation practices	
6	Migration 1) Temporary 2) Permanent		Water harvesting	

7	Seeking off-farm employment		Reducing wastage of water during the drought period	
8	Used waste child bath water to clean houses and newspapers for eating meals to save water (Water conservation)		River/Dam rejuvenation	
9	Stop the marriage ceremony and not celebrate festivals		Income diversification	
10	Stored crop residues		Long-term irrigation management	

ii) Please degree the following various drought impacts perception:

Scales	Very high	High	Medium	Less	Very less
i. Drought harmed household food security					
ii. Drought happened food shortage					
iii. Drought caused no choice in food preferences					
iv. Drought caused malnutrition					
v. Drought influenced well-being					
vi. Drought caused unemployment					
vii. Drought makes happen reduction in household income					
viii. Drought caused a reduction in spending on festivals					
ix. Drought induced hopefulness and sense of loss					
x. Drought occurred conflict for water in society					
xi. Drought caused farmers suicide					
xii. Drought caused robbery and burglary					
xiii. Drought caused discrimination					
xiv. Drought reduced crop production					
xv. Drought induced child labour increase					
xvi. Drought caused indebtedness					

Impact of the 2015 Drought on Rural Livelihood - A Case Study of Masurdi Village in Latur District of Maharashtra, India

Bhagat Nitin Dattuji¹, B. Nagarjuna²

¹Research Scholar, School of Economics, University of Hyderabad, India

²Professor, School of Economics, University of Hyderabad, India

Email: [nitinbhagat2011\[at\]gmail.com](mailto:nitinbhagat2011[at]gmail.com), [nagarjuna.boppana\[at\]gmail.com](mailto:nagarjuna.boppana[at]gmail.com)

Abstract: Drought is a global phenomenon. It mainly affects on agriculture and allied sector activities. Agriculture plays a substantial role in the development of rural economies in the least developed countries, where agriculture largely depends on rainfall. The present study examines the impact of the 2015 drought on rural livelihoods in a Masurdi village of Latur district of Marathwada region, Maharashtra state. This paper is based on both primary as well as secondary data sources. The multistage sampling method is used for primary data collection. The 100 households sample survey data has been collected from the village through a semi-structured questionnaire. The rainfall data were obtained from the Department of Revenue, Office of Divisional Commissioner, Aurangabad, from 1991 to 2018. The study also examines climate variables' impact on the Latur district's total food grain production from 2000 to 2018 for 19 years. A multiple regression model is used to analyze the relationship between climatic variables and the total food grain production. The study finds that, out of 100 households, 24 are landless, 41 are marginal cultivators, 30 are small cultivators, 4 are medium cultivators, and only one is large. In the OBCs category, out of 42 households, 8 (19.05 %) are landless, 18 (42.85 %) are marginal, 15 (35.51 %) are small, and only one is a medium cultivator household. In the open category, 9 (28.12 %) are small cultivators, 6 (18.75 %) are landless households, 15 (86.87 %) are marginal cultivators, and only two households are large and medium cultivators. In the SCs category, out of 26 households, 8 (30.76 %) are marginal, 6 (23.07 %) are small cultivators, 10 (38.86 %) households are landless, which is more proportion than other categories, and only two are medium cultivators. The study has recorded a significant deficiency in rainfall in 1991, 1992, 1994, 1997, 2009, 2014, 2015, and 2018, whereas in 1988, 1996, 1998, 2005, 2010, and 2016, there was recorded excess rainfall. The 2016 was the most excess rainfall year reported over the years from 1991 to 2018, where there was 1110.92 mm rainfall recorded, and in the year 2015 found a significant deficit in the rainfall where there was 413.48 mm rainfall recorded. The study found a significant depletion in livestock assets; farmers sold their livestock due to severe water scarcity and fodder problems; before the drought, the total number of livestock of the sample households was 85 (including goat, bullock, buffalo, etc cows). It is reduced tremendously in the drought year 2015, which was only 25. Crop production decreased tremendously due to inadequate rainfall in the drought year 2015. Approximately 27.43 % of the workforce migrated from rural to urban areas to search for jobs. About 48 % of the households' children faced education difficulties; they were not going to school during the drought. Many households benefited from state government schemes, like drought subsidies, crop insurance, and bank loans. Out of 100 households, about 50 (50 %) have obtained financial support from the state government's subsidy scheme, 58 (58 %) have got crop insurance, and 41 (41 %) irrigated households have got bank loans from National banks; besides that, only two families have obtained loans from their relatives and moneylenders.

Keywords: Rainfall, Drought, Agriculture, Maharashtra, Household

1. Introduction

During the twentieth century, human and animal deaths, migration, financial losses, and social effects were widespread in Asia, Africa, America, Europe, and Oceania. Frequent drought in Africa and Asia still results in misery, erodes livelihood, damages the natural ecosystem's integrity, and causes disease and deaths due to poor-quality water and hunger (Sharma, 2004). Drought is extensively known as an insidious hazard because of its complex and unique features. Drought disasters have brought enormous economic losses and significant social and environmental impacts worldwide (Xinyu Fu et al., 2013). In South Asia, millions of people face numerous challenges regarding food security and stability for their livelihood due to the climate's erratic nature (Hariharan et al., 2018). According to the IPCC report 2014, climate changes have affected over the past century in Asia, where it is reported that increasing the number of warm days and temperature extremes. Variability and trends in extreme rainfall have been found among various regions

of Asian countries. Climate change has created many challenges in Asia, such as water scarcity, food security, food production, human health, livelihood, poverty, rapid urbanization, and sustainable development (IPCC, 2014). India has a long history of famines. Millions of people died due to starvation in the nineteenth and twentieth centuries (Mishra et al., 2019). According to the World Bank report 2006, India is the second-highest severe drought-affected country in Asia (Sam et al., 2020). Approximately 90 lakh farmers were adversely affected by drought in Maharashtra, its massive impact mainly in the Marathwada and Vidarbha regions. The 2015 Drought negatively impacted agriculture and allied activities, which has declined Kharif and Rabi crop production (Kakodkar, 2015). The government officially declared that the drought influenced over 29000 villages in Maharashtra, mostly in the Marathwada and Vidarbha regions (2016, May 12, Economics Time). It poses the following question. What is the drought impact on agriculture cultivators and labor in the study area? What difficulties did they face in the drought period, such as

Volume 11 Issue 3, March 2022

www.ijssr.net

Licensed Under Creative Commons Attribution CC BY

Conference certificates

 ISERS INTERNATIONAL SOCIETY OF ENVIRONMENTAL RELATIONSHIP AND SUSTAINABILITY		 BioLEAGUES Integrating Medicines...Incubating Research !!!	
CERTIFICATE _____ OF PRESENTATION _____			
2ND INTERNATIONAL CONFERENCE ON CLIMATE CHANGE			
25th & 26th May 2021 Kuala Lumpur, Malaysia (Virtual Conference)			
This is to certify that		Bhagat Nitin Dattuji	
.....		 of	
.....		 presented his/her worthy Oral	
Presentation titled			
.....		 in the	
“2 nd International Conference on Climate Change” Organized by BioLEAGUES Worldwide and International Society of Environmental Relationship and Sustainability (ISERS) on 25 th & 26 th May 2021.			
 Dr. Narayan Prasad Shrestha Climate Change Project Manager Aberdeen Multicultural Centre United Kingdom	 Dr. Peiman Kianmehr Chair and Associate Professor Department of Civil Engineering American University in Dubai, UAE	 Dr. Rashmi Sharma Associate Professor Department of Zoology SPCGA MDSU, Ajmer, India	 Mr. Rudra B. Satpathy CEO & Founder BioLEAGUES Worldwide

CERTIFICATE — OF PRESENTATION —

7th GoGreen Summit

14th & 15th October 2021 | Virtual Conference

This is to certify that of
Bhagat Nitin Dattuji
..... presented his/her worthy Oral
.....
Presentation titled
Effect of Drought on Rural Farm Households A Study of Two villages of Beed district of
Maharashtra state, India. in the

“7th GoGreen Summit” Organized by International Society of Environmental Relationship and Sustainability (ISERS) held on
14th & 15th October 2021.



Dr. Bambang Sugiyono Agus Purwono
Associate Professor
State Polytechnic of Malang - Indonesia
Manila



Dr. Bert J. Tuga
President
Philippine Normal University
Philippines



Dr. Mohamad Faiz Bin Mohd Amin
Associate Professor and Dean
Faculty of Earth Science
Universiti Malaysia Kelantan
Malaysia





Mr. Rudra B. Satpathy
CEO & Founder
International Society of
Environmental Relationship and
Sustainability (ISERS)



Asia for
Earth 2022
1st to 3rd June 2022 | Bali, Indonesia



3rd INTERNATIONAL CONFERENCE ON
CLIMATE CHANGE

ISERS
INTEGRATING SUSTAINABILITY
ENVIRONMENTAL RELATIONSHIP AND SUSTAINABILITY

BioLEAGUES®
Integrating Medicine... Inspiring Research!!!!

3RD INTERNATIONAL CONFERENCE ON CLIMATE CHANGE

— OF PRESENTATION —

02nd June 2022 | Bali, Indonesia



Certificate No: ISERS20220206-ICCC JUNE 240251639

This is to certify that Mr/Ms/Mrs/Dr of

University of Hyderabad

presented his/her worthy

Virtual Presentation titled Impact of Drought on Rural Livelihood A Case Study of Masurdi Village in the

Marathwada Region of Maharashtra during

the “3rd International Conference on Climate Change” Organized by International Society of Environmental Relationship and Sustainability (ISERS) on 02nd June 2022 at Bali, Indonesia.

[Signature]

Dr. Ir. Gede Sedana
Rector
Dwijendra University
Bali, Indonesia

[Signature]

Dr. Bambang Sugiyono AP
General Secretary
International Society of Environmental
Relationship and Sustainability (ISERS)
Malang, Indonesia

[Signature]

Dr. Jayanta Choudhury
Founder
Global Forum for Sustainable
Rural Development, India

[Signature]

Dr. Bert J. Tuga
President
Philippine Normal University
Philippines



[Signature]

Mr. Rudra Bhanu Satpathy
General Chair - Asia for Earth 2022
CEO & Founder
ISERS & Technoare Group
India

Probing structural organisation of chromatin during B cell development through mechanistic modelling

by Anubhooti .



Librarian
Indira Gandhi Memorial Library
UNIVERSITY OF HYDERABAD
Central University P.O.
HYDERABAD-500 046

Submission date: 27-Dec-2022 12:28PM (UTC+0530)
Submission ID: 1986849759
File name: Thesis_Anubhooti_13LAPH19_Final.pdf (26.87M)
Word count: 21571
Character count: 118580

Impact of Drought on Rural Households- A Study of Three Districts of the Marathwada Region of Maharashtra

ORIGINALITY REPORT

6%

SIMILARITY INDEX

3%

INTERNET SOURCES

5%

PUBLICATIONS

2%

STUDENT PAPERS

PRIMARY SOURCES

1

link.springer.com

Internet Source

<1 %

2

"Handbook of Climate Change Resilience",
Springer Science and Business Media LLC,
2020

Publication

<1 %

3

Chandan Kumar Jha, Vijaya Gupta. "Farmer's
perception and factors determining the
adaptation decisions to cope with climate
change: An evidence from rural India",
Environmental and Sustainability Indicators,
2021

Publication

<1 %

4

agricoop.nic.in

Internet Source

<1 %

5

Anurag Malik, Anil Kumar. "Spatio-temporal
trend analysis of rainfall using parametric and
non-parametric tests: case study in
Uttarakhand, India", Theoretical and Applied
Climatology, 2020

<1 %

-
6	Kiatpathomchai, Sirirat(Institut für Agrarpolitik und Marktforschung). "Assessing economic and environmental efficiency of rice production systems in Southern Thailand : An application of data envelopment analysis", Justus-Liebig-Universität Gießen, 2008. Publication	<1 %
-
7	www.omicsonline.org Internet Source	<1 %
-
8	publications.waset.org Internet Source	<1 %
-
9	Zinabu Assefa Alemu, Michael O. Dioha. "Climate change and trend analysis of temperature: the case of Addis Ababa, Ethiopia", Environmental Systems Research, 2020 Publication	<1 %
-
10	Sanjaykumar M. Yadav, Shivani R. Bhagat, Vipinkumar G. Yadav. "Temporal analysis of precipitation in Saurashtra, Kutch, and Diu sub-division of Western Indian region", Theoretical and Applied Climatology, 2021 Publication	<1 %
-
11	"Handbook of Climate Change Adaptation", Springer Science and Business Media LLC, 2015 Publication	<1 %

12	"Observed Climate Variability and Change over the Indian Region", Springer Science and Business Media LLC, 2017 Publication	<1 %
13	agritech.tnau.ac.in Internet Source	<1 %
14	beed.nic.in Internet Source	<1 %
15	Submitted to Osmania University, Hyderabad Student Paper	<1 %
16	baadalsg.inflibnet.ac.in Internet Source	<1 %
17	Review of Accounting and Finance, Volume 13, Issue 2 (2014-09-16) Publication	<1 %
18	shodhganga.inflibnet.ac.in Internet Source	<1 %
19	Sajjad Ali, Liu Ying, Adnan Nazir, Abdullah, Muhammad Ishaq, Tariq Shah, Xinyue Ye, Aasir Ilyas, Azam Tariq. "Rural farmers perception and coping strategies towards climate change and their determinants: Evidence from Khyber Pakhtunkhwa province, Pakistan", Journal of Cleaner Production, 2021 Publication	<1 %

hotellook.com

20	Internet Source	<1 %
21	Taye Tesfaye, Diptimayee Nayak. "Climate Change Adaptation Measures by Farm Households in Gedeo Zone, Ethiopia: An Application of Multivariate Analysis Approach", Environment, Development and Sustainability, 2022 Publication	<1 %
22	Submitted to UNESCO-IHE Institute for Water Education Student Paper	<1 %
23	repository.tudelft.nl Internet Source	<1 %
24	assets.researchsquare.com Internet Source	<1 %
25	www.coursehero.com Internet Source	<1 %
26	Jyotish Prakash Basu. "Climate Change Adaptation and Forest Dependent Communities", Springer Science and Business Media LLC, 2017 Publication	<1 %
27	Mwinjaka, Omari, Joyeeta Gupta, and Ton Bresser. "Adaptation strategies of the poorest	<1 %

farmers in drought-prone Gujarat", Climate and Development, 2010.

Publication

28

Submitted to National Institute of Industrial Engineering

Student Paper

<1 %

29

Sagar Khetwani, Ram Babu Singh, Khusro Moin. "Impact of drought, farmers' adaptation strategies and administrative mitigation measure in the Marathwada region, India", Environmental & Socio-economic Studies, 2020

Publication

<1 %

30

www.researchgate.net

Internet Source

<1 %

31

www.tandfonline.com

Internet Source

<1 %

32

Parmeshwar D. Udmale, Yutaka Ichikawa, Sujata Manandhar, Hiroshi Ishidaira, Anthony S. Kiem, Ning Shaowei, Sudhindra N. Panda. "How did the 2012 drought affect rural livelihoods in vulnerable areas? Empirical evidence from India", International Journal of Disaster Risk Reduction, 2015

Publication

<1 %

33

krishikosh.egranth.ac.in

Internet Source

<1 %

34	africa.iwmi.cgiar.org Internet Source	<1 %
35	Jianjun Jin, Wenyu Wang, Xiaomin Wang. "Adapting agriculture to the drought hazard in rural China: household strategies and determinants", Natural Hazards, 2016 Publication	<1 %
36	Raju Guntukula. "Assessing the impact of climate change on Indian agriculture: Evidence from major crop yields", Journal of Public Affairs, 2019 Publication	<1 %
37	iaras.org Internet Source	<1 %
38	Submitted to Midlands State University Student Paper	<1 %
39	"Challenges of Disasters in Asia", Springer Science and Business Media LLC, 2022 Publication	<1 %
40	Evan Hajani, Zahraa Klari. "Trends analysis in rainfall data series in Duhok city, Kurdistan region, Iraq", Modeling Earth Systems and Environment, 2022 Publication	<1 %
41	commons.wmu.se Internet Source	<1 %

42	Imran Khan, Hongdou Lei, Irshad Ali Shah, Imad Ali, Inayat Khan, Ihsan Muhammad, Xuexi Huo, Tehseen Javed. "Farm households' risk perception, attitude and adaptation strategies in dealing with climate change: Promise and perils from rural Pakistan", Land Use Policy, 2020 Publication	<1 %
43	careersdocbox.com Internet Source	<1 %
44	1min.in Internet Source	<1 %
45	Mequannt Marie, Fikadu Yirga, Mebrahtu Haile, Filmon Tquabo. "Farmers' choices and factors affecting adoption of climate change adaptation strategies: evidence from northwestern Ethiopia", Heliyon, 2020 Publication	<1 %
46	ferdi.fr Internet Source	<1 %
47	edit.jornada.nmsu.edu Internet Source	<1 %
48	www.acmua.org Internet Source	<1 %
49	Feng Gao, Xiaoling Chen, Wenfu Yang, Wenwen Wang, Lijiang Shi, Xiaolong Zhang,	<1 %

Yaomeng Liu, Yaofei Tian. "Statistical characteristics, trends, and variability of rainfall in Shanxi province, China, during the period 1957–2019", Theoretical and Applied Climatology, 2022

Publication

50 High-Impact Weather Events over the SAARC Region, 2015. <1 %
Publication

51 eprajournals.com <1 %
Internet Source

52 spb.kerala.gov.in <1 %
Internet Source

53 Aimro Likinaw, Woldeamlak Bewket, Aragaw Alemayehu. "Smallholder farmers' perceptions and adaptation strategies to climate change risks in northwest Ethiopia", International Journal of Climate Change Strategies and Management, 2022
Publication

54 B. Parthasarathy, A.A. Munot, D.R. Kothawale. "Regression model for estimation of indian foodgrain production from summer monsoon rainfall", Agricultural and Forest Meteorology, 1988
Publication

55	Singh, Naveen P., Ma Cynthia S. Bantilan, A. Ashok Kumar, Pasupuleti Janila, and Abu Wali R. Hassan. "Climate Change Impact in Agriculture: Vulnerability and Adaptation Concerns of Semiarid Tropics in Asia", Crop Adaptation to Climate Change Yadav/Crop Adaptation to Climate Change, 2011. Publication	<1 %
56	Submitted to Kampala International University Student Paper	<1 %
57	T.O. Ojo, A.A. Adetoro, A.A. Ogundeji, J.A. Belle. "Quantifying the determinants of climate change adaptation strategies and farmers' access to credit in South Africa", Science of The Total Environment, 2021 Publication	<1 %
58	onlinelibrary.wiley.com Internet Source	<1 %
59	orbi.uliege.be Internet Source	<1 %
60	M.P. Mabuku, A. Senzanje, M. Mudhara, G.P.W. Jewitt, W.O. Mulwafu. "Strategies for coping and adapting to flooding and their determinants: A comparative study of cases from Namibia and Zambia", Physics and Chemistry of the Earth, Parts A/B/C, 2019 Publication	<1 %

61	Rashi Dhanraj, Varun Punnathanam, Yogendra Shastri. "Multi objective optimization of ethanol production based on regional resource availability", Sustainable Production and Consumption, 2021 Publication	<1 %

62	www.ijmra.us Internet Source	<1 %

63	Husen Maru, Amare Hailelassie, Tesfaye Zeleke, Befikadu Esayas. "Analysis of Smallholders' Livelihood Vulnerability to Drought across Agroecology and Farm Typology in the Upper Awash Sub-Basin, Ethiopia", Sustainability, 2021 Publication	<1 %

64	Javed Mallick, Swapan Talukdar, Majed Alsubih, Roquia Salam, Mohd Ahmed, Nabil Ben Kahla, Md. Shamimuzzaman. "Analysing the trend of rainfall in Asir region of Saudi Arabia using the family of Mann-Kendall tests, innovative trend analysis, and detrended fluctuation analysis", Theoretical and Applied Climatology, 2020 Publication	<1 %

65	journals.covenantuniversity.edu.ng Internet Source	<1 %

66	Afaf Bouklikha, Mohammed Habi, Abdelkader Elouissi, Saaed Hamoudi. "Annual, seasonal and monthly rainfall trend analysis in the Tafna watershed, Algeria", Applied Water Science, 2021 Publication	<1 %
67	Madsen, H.. "Prevalence of Schistosoma japonicum infection of Oncomelania quadrasi snail colonies in 50 irrigated and rain-fed villages of Samar Province, the Philippines", Acta Tropica, 200803 Publication	<1 %
68	etd.aau.edu.et Internet Source	<1 %
69	openresearch-repository.anu.edu.au Internet Source	<1 %
70	Muhammad Ashraf, Jayant Kumar Routray. "Perception and understanding of drought and coping strategies of farming households in north-west Balochistan", International Journal of Disaster Risk Reduction, 2013 Publication	<1 %
71	Amarendra Singh, A.K. Srivastava, Virendra Pathak, A.K. Shukla. "Quantifying the impact of biomass burning and dust storm activities on aerosol characteristics over the Indo-	<1 %

Gangetic Basin", Atmospheric Environment,
2022

Publication

-
- 72 Sneha S. Kulkarni, Brian D. Wardlow, Yared A. Bayissa, Tsegaye Tadesse, Mark D. Svoboda, Shirishkumar S. Gedam. "Developing a Remote Sensing-Based Combined Drought Indicator Approach for Agricultural Drought Monitoring over Marathwada, India", Remote Sensing, 2020 $<1\%$
Publication
-
- 73 Syed Asif Ali Naqvi, Syed Ale Raza Shah, Muhammad Abuzar Mehdi. "Revealing empirical association among ecological footprints, renewable energy consumption, real income, and financial development: a global perspective", Environmental Science and Pollution Research, 2020 $<1\%$
Publication
-
- 74 www.preventionweb.net $<1\%$
Internet Source
-
- 75 Luni Piya, Keshav Lall Maharjan, Niraj Prakash Joshi. "Socio-Economic Issues of Climate Change", Springer Science and Business Media LLC, 2019 $<1\%$
Publication
-
- 76 Submitted to German Jordanian University $<1\%$
Student Paper
-

77	Bryan, E.. "Adaptation to climate change in Ethiopia and South Africa: options and constraints", Environmental Science and Policy, 200906 Publication	<1 %
78	G. A. Rose. "Atmosphere–Ocean Coupling and Atlantic Cod Migrations: Effect of Wind-Forced Variations in Sea Temperatures and Currents or Nearshore Distributions and Catch Rates of <i>Gadus morhua</i> ", Canadian Journal of Fisheries and Aquatic Sciences, 07/1988 Publication	<1 %
79	Isabel Ruiz-Mallén, Esteve Corbera, Diana Calvo-Boyero, Victoria Reyes-García, Katrina Brown. "How do biosphere reserves influence local vulnerability and adaptation? Evidence from Latin America", Global Environmental Change, 2015 Publication	<1 %
80	ibic.lib.ku.ac.th Internet Source	<1 %
81	Submitted to Australian Institute of Business Student Paper	<1 %
82	mahades.maharashtra.gov.in Internet Source	<1 %
83	Submitted to Covenant University Student Paper	<1 %

84	Submitted to Indira Gandhi Institute of Development Research Student Paper	<1 %
85	Anghesom A. Ghebrehiwot, D. V. Kozlov. "Spatial and Statistical Variability Analyses of Satellite-Based Climatic Data in Mereb-Gash Basin", Water Resources, 2021 Publication	<1 %
86	Christoph Funk, Archana Raghavan Sathyan, Peter Winker, Lutz Breuer. "Changing climate - Changing livelihood: Smallholder's perceptions and adaption strategies", Journal of Environmental Management, 2020 Publication	<1 %
87	Mushfiqur R Tarafder, Ernesto Balolong, Hélène Carabin, Patrick Bélisle, Veronica Tallo, Lawrence Joseph, Portia Alday, Ryan O'Neil Gonzales, Steven Riley, Remigio Olveda, Stephen T McGarvey. "A cross-sectional study of the prevalence of intensity of infection with Schistosoma japonicum in 50 irrigated and rain-fed villages in Samar Province, the Philippines", BMC Public Health, 2006 Publication	<1 %
88	Submitted to Vrije Universiteit Brussel Student Paper	<1 %
89	Yin, Xiaogang, Jørgen E. Olesen, Meng Wang, Kurt-Christian Kersebaum, Huang Chen,	<1 %

Sanmohan Baby, Isik Öztürk, and Fu Chen.
"Adapting maize production to drought in the
Northeast Farming Region of China",
European Journal of Agronomy, 2016.

Publication

90	portalrevistas.uct.cl Internet Source	<1 %
91	www.scribd.com Internet Source	<1 %
92	(2-7-15) http://164.100.154.90/files/HRVA.pdf Internet Source	<1 %
93	Bahram Mohammadi Golrang. "Mixed- Method Evaluation of Watershed Management", Springer Science and Business Media LLC, 2017 Publication	<1 %
94	Woldeamlak Bewket. "A note on the temporal and spatial variability of rainfall in the drought-prone Amhara region of Ethiopia", International Journal of Climatology, 09/2007 Publication	<1 %
95	research.csiro.au Internet Source	<1 %
96	"Anthropogeomorphology", Springer Science and Business Media LLC, 2022 Publication	<1 %

97 Aadil Towheed, Thendiyath Roshni. "Linking climate change to soil loss estimation in the Kosi river basin, India", Journal of Water and Climate Change, 2021

Publication

<1 %

98 Chemed Edossa Desalegn, Mukand Singh Babel, Ashim Das Gupta, Bekele Awulachew Seleshi, Douglas Merrey. "Farmers' Perception of Water Management under Drought Conditions in the Upper Awash Basin, Ethiopia", International Journal of Water Resources Development, 2007

Publication

<1 %

99 D T Chabalala, J M Ndambuki, R W Salim, S S Rwanga. "Impact of climate change on the rainfall pattern of Klip River catchment in Ladysmith, KwaZulu Natal, South Africa", IOP Conference Series: Materials Science and Engineering, 2019

Publication

<1 %

100 Debdatta Pal, Subrata Kumar Mitra. "Asymmetric impact of rainfall on India's food grain production: evidence from quantile autoregressive distributed lag model", Theoretical and Applied Climatology, 2016

Publication

<1 %

101 Submitted to Federal University of Technology

Student Paper

<1 %

102 Govind Pal, K Bhaskar, S Kumar, K Sripathy, D Agarwal. "A Study on Sources and Management of Paddy Seed in Eastern Uttar Pradesh, India", Journal of Economics, Management and Trade, 2018 $<1\%$

Publication

103 Md. Kamruzzaman, A. T. M. Sakiur Rahman, Md. Shakil Ahmed, Md. Enamul Kabir et al. "Spatio-temporal analysis of climatic variables in the western part of Bangladesh", Environment, Development and Sustainability, 2016 $<1\%$

Publication

104 Merihun Meja, Ashenafi Mathewos, Alemtsehay Kassa Kebede, Woldemedhin Goa. "Does Food Insecurity Exist in Rural Households of Wolayta? Evidence in Wolayta Zones, Southern Ethiopia", Research Square Platform LLC, 2022 $<1\%$

Publication

105 Pritha Datta, Soumik Das. "Analysis of long-term precipitation changes in West Bengal, India: An approach to detect monotonic trends influenced by autocorrelations", Dynamics of Atmospheres and Oceans, 2019 $<1\%$

Publication

106 educationdocbox.com $<1\%$

Internet Source

107	oar.icrisat.org Internet Source	<1 %
108	www.ilo.org Internet Source	<1 %
109	Bright K. D. Tetteh, Isaac G. K. Ansah, Samuel A. Donkoh, Mark Appiah-Twumasi et al. "Perceptions of weather variability and climate change on goat producers' choice of coping and adaptation strategies: evidence from climate-smart and non-climate-smart villages in the Jirapa and Lawra districts", Climate and Development, 2019 Publication	<1 %
110	Submitted to Monash South Africa Student Paper	<1 %
111	Submitted to University of Wolverhampton Student Paper	<1 %
112	iwaponline.com Internet Source	<1 %
113	journal.stieamkop.ac.id Internet Source	<1 %
114	pubag.nal.usda.gov Internet Source	<1 %
115	Submitted to Asian Institute of Technology Student Paper	<1 %

116 Muhammad Ashraf, Jayant K. Routray, Muhammad Saeed. "Determinants of farmers' choice of coping and adaptation measures to the drought hazard in northwest Balochistan, Pakistan", Natural Hazards, 2014 <1 %

Publication

117 Parmeshwar Udmale, Yutaka Ichikawa, Sujata Manandhar, Hiroshi Ishidaira, Anthony S. Kiem. "Farmers' perception of drought impacts, local adaptation and administrative mitigation measures in Maharashtra State, India", International Journal of Disaster Risk Reduction, 2014 <1 %

Publication

118 Submitted to Wageningen University <1 %

Student Paper

119 desktop.arcgis.com <1 %

Internet Source

120 ir.knust.edu.gh <1 %

Internet Source

Exclude quotes On

Exclude matches < 14 words

Exclude bibliography On