AN ANALYSIS OF RAINFALL PATTERNS AND RICE PRODUCTION IN MINING –AFFECTED TALUKAS OF GOA: POST-BAN TRENDS AND IMPROVEMENTS.

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DECLARATION BY STUDENT

I hereby declare that the data presented in this Dissertation report entitled, "**An Analysis of Rainfall Patterns and Rice Production in Mining-Affected Talukas of Goa: Post-ban Trends and Improvements** " is based on the results of investigations carried out by me in the (M.A. Economics) at the Goa Business School/Economics Dept., Goa University/College under the Supervision of **Prof. Pranab Mukhopadhyay** and the same has not been submitted elsewhere for the award of a degree or diploma by me. Further, I understand that Goa University or its authorities / College will be not be responsible for the correctness of observations / experimental or other findings given the dissertation.

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COMPLETION CERTIFICATE

This is to certify that the dissertation report "An Analysis of Rainfall Patterns and Rice Production in Mining-Affected Talukas of Goa: Post-Ban Trends and Improvements" is a bonafide work carried out by Ms. Riya Ratnakar Gaunkar under my supervision in partial fulfilment of the requirements for the award of the degree of M.A. in Economics in the Discipline (Economics) at the Goa Business School, Goa University.

Signature & name of supervisor

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Date: 20/04/2024

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Signature of Dean of the School/HOD of Dept.

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PREFACE

This research project represents the culmination of months of study and dedication to exploring the impacts of rainfall patterns on rice production in the mining- affected talukas of Goa and to analyse the trend and improvement in pre-ban and post-ban period. The motivation behind this study stemmed from a deep interest in understanding the intricate relationship between environmental factors and agricultural outcomes, particularly in regions undergoing significant industrial changes. This preface sets the stage for an in-depth exploration of these objectives, encompassing methodologies, data sources, analytical frameworks, and the invaluable contributions of individuals and institutions that have facilitated this study.

ACKNOWLEDGEMENTS

As a student of Goa University, Taleigao, I would like to express my gratitude to Professor, Department of Economics, and Goa University for providing me an opportunity to undertake this dissertation as a part of my course and for guiding me in my study. And also to all those who helped us in completion of our project work.

I take great pleasure in presenting this project report on 'an analysis of rainfall patterns and rice production in mining-affected talukas of Goa: post-ban trends and improvements'. I would like to thank Prof. Jyoti Pawar (Dean of Goa Business School), and Asst. Prof. Heena Gaude (Programme Director, Economics), for their encouragement and moral support.

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ABSTRACT

Mining is one of the economic activities practiced in the state of Goa apart from other activities like agriculture, tourism and fishing. Mining has brought lucrative incomes to state but it also came with lots of environmental hazards. The protest and agitation that took place against mining operations compelled the Supreme Court to order ban in October 2012. With this background, the current study investigates the relationship between rainfall productions in the mining affected talukas of Goa, specifically Sattari, Sanguem and Quepem, following the ban on mining activities in 2012. The objective is to analyse the trends in rainfall and rice production over time, comparing pre-ban and post-ban periods, and examining potential improvements in rice production post-ban. Secondary data on annual rainfall (in mm) and rice production (in tons) for the selected talukas were collected from government reports and agricultural sources. Descriptive statistics were calculated for each taluka and time period. Trends over time were analysed using linear regression to determine the direction and magnitude of changes. Additionally, correlation analysis was conducted to measure the strength and direction of the relationship between rainfall and rice production. Scatter plots were generated to visually represent these correlations for each taluka, aiding in the interpretation of the data. The study provides valuable insights into the impact of rainfall patterns on rice production in mining – affected talukas of Goa post-ban. Understanding these relationships is crucial for agricultural planning and sustainable development in the region.

CHAPTER 1

INTRODUCTION

INTRODUCTION

1.1 Background

Goa has rich history of mining from early 20th century. Mining has been playing an important role in the economy of Goa apart from agriculture, tourism and fishing. With the arrival of mining activities, the practice of traditional occupations was difficult in the areas of mining. Mining industry has brought lucrative incomes but it also came with lots of environmental hazards. Mining activities have largely affected the nature around the mining area region. It also resulted in generation of different types of pollution that has stopped production of agricultural crops along with trees bearing the fruits. The mining industry in Goa has long been a significant contributor to the state's economy but has also faced criticism for its environmental impacts. In response to concerns about environmental degradation and the protest and agitation that took place against rampant mining operations forced Supreme Court to order ban in September 2012. (Terence Jorge, 2013)

Goa's mining operations were suspended first by the Goa government on 10.09.2012 after the Justice M.B Shah Commission. Then 139 Environmental Clearance were suspended by the Ministry of Environment and forests on 14.09.2012, followed by the Supreme Court order for ban on mining operations in the state on 05.10.2012, in the context of the Goa Foundation petition 435/2012. The ban on mining should not hinder the process of reclamation in order to prevent any further damage to the state's environment, social well-being and traditional occupations. The present environmental, social and economic scenario largely indicates that the state overall could make a successful recovery from about 60years of continued mining operations, if the

ban prevails. Mining was earlier stopped in the state in 2012, after a previous apex court order. It restarted again in 2014, before being banned again in 2018 after the Supreme Court scrapped all existing mining leases citing irregularities in renewal processes. (Terence Jorge, 2013)

The Indian state of Goa, known for its picturesque landscapes and vibrant culture, has faced significant environmental challenges due to extensive mining activities. Goa was major iron ore exporting state and 60% of India's iron ore was exported from Goa. Iron ore mining in goa was done by open cast method of extraction that has serious effects on the environment, which requires deforestation, removal of the topsoil below which there are mineral deposits, and finally digging out the ore body from the earth bed. On an average about 2.5 to 3 tons of mining waste was excavated so has to produce a tone of iron ore. The extraction of iron ore has caused degradation and pollution of soil, water and air in the areas under mining. It has also led to soil erosion and loss of fertility of land. The heavy rainfall during the monsoons leads to surface runoffs of heavy metals and siltation in fields and rivers, which caused huge problems for fertility of the soil. It has resulted in crop loss and fall in the agricultural yield. The overburden and other materials from the pile up at the mining area flow down into the rivers, which have also created problems of survival and adaption for various aquatic animals.

The destruction of forests in the mining regions that was previously inhabited by vast fauna in the region were threatened and forced to relocate in far interior regions of very dense forests and some were been even killed during the explosions while mining activities were conducted. Deforestation and loss of forest cover essential for maintaining the temperature balance in the nature

were been destroyed which led to rise in the temperature in the state. Mining and the other associated activities present have largely affected the nature around the mining area region by removal of vegetation, top soil, waste and ore, brought about inevitable natural consequences, through deforestation, climate change, erosion, air and water pollution and health hazards. The most noticeable impacts on the ecosystem are degradation of land, deforestation, displacement of wildlife, effect on aquatic ecosystem, loss of habitat for biodiversity including rare flora and fauna.

In the middle of these environmental shifts, the agricultural sector, particularly rice production, has played a vital role in sustaining local livelihoods in mining affected talukas. Rice cultivation is a cornerstone of Goan agriculture, serving as a staple food for its residents and a significant economic contributor. Understanding the interplay between environmental factors, such as rainfall patterns, and agricultural productivity is crucial for ensuring food security and sustainable development in these talukas. This study seeks to analyse the impact of the mining ban on rainfall patterns and subsequent rice production in three mining affected talukas of Goa: Sattari, Sanguem, and Quepem. The temporal scope of the study covers the period from 2009 to 2019, encompassing both pre-ban and post-ban periods. By examining the trends in rainfall and rice production, as well as the comparative analysis between talukas and time-period, this research aims to provide insights into the impact of mining ban on rainfall patterns. The mining ban in 2012 marked a significant shift in land use and environmental dynamics in Goa's talukas. By analysing historical rainfall data, this study aims to investigate any discernible changes in rainfall patterns post-ban and their implications for agricultural productivity.

Rice cultivation is a fundamental aspect of agriculture in Goa. By examining annual rice production data, the study aims to identify trends in rice production over the study period. This includes an analysis of pre-ban and post-ban periods to assess any shifts or improvements in rice productivity. The study will compare rainfall patterns and rice production levels between the four talukas under study. By utilizing statistical tools such as descriptive statistics and linear regression, the aim is to elucidate any disparities or similarities in agricultural performance among these talukas. Ultimately, this study seeks to contribute to the understanding of sustainable agriculture in mining-affected regions.

STUDY AREA

Most of the mines in goa are concentrated in three talukas that are Sattari, in North Goa District and Sanguem and Quepem talukas of South Goa District largely fall in the mining belt. This accounts for almost $1/5^{th}$ of the area of Goa i.e., approximately 700sq.km. The inhabitants in these areas were largely dependent on agriculture and forest for their livelihoods. In terms of area under mining, maximum area is in Sanguem taluka followed by Sattari and Quepem.

Sattari is a taluka of North Goa district in the state of Goa. It lies in north eastern region of Goa where it is known for its greenery and dense forest. It has geographical area of 490 sq. km. primarily agricultural, with rice, pulses, coconuts, and areca nut as major crops. Sattari taluka is rich in natural resources with dense forests and rivers. It is known for its scenic beauty and biodiversity. Sattari is known for its mining of manganese ore. This mineral is used in various industries, including steel production. The mining activities in sattari have had

an impact on the local environment and communities, leading to both benefits and challenges for the region.

Quepem is a taluka in South Goa district of Goa historically known for mining activities such as iron ore and manganese ore. Quepem has an average elevation of 21 metres.it is located on the bank of river kushawati. Rice, pulses, and coconuts are among the major crops grown in taluka. It is also known for its historical sites, natural beauty, and tourist attractions. Like other mining areas, Quepem has seen economic growth from mining activities, but there have also been environmental concerns and social impacts on the local communities.

Sanguem is one of the larger taluka's in south goa district. It is blessed by dense vegetation and hidden gems belonging to ancient times. It has an average elevation of 22 metres .Sanguem is famous for its iron ore extraction plays a significant role in the economy of Sanguem. Over the years, mining activities in Sanguem have faced scrutiny due to environmental degradation and social issues arising from displacement and livelihood changes.

These talukas have been central to Goa's mining industry, which have been major economic driver for the state. However, the talukas have been significantly affected by mining activities in the past, particularly iron ore mining. Understanding the impact of mining ban on these talukas agriculture, specifically rice production and rainfall patterns, is important in assessing their economic and environmental sustainability.

1.2 Research gap

- In the existing literature, there is lack of detailed studies focusing specifically on the changes in agricultural outcomes, like rice production, in talukas affected by the mining ban in Goa.
    - There is a gap in understanding the study long-term trends in both rainfall patterns and rice production post the mining ban.
    - Previous studies may have looked at either rainfall patterns or rice production individually, but there is a gap in research that comprehensively examines both factors together, especially in the context of the mining ban.

1.3 Aims and Objectives

- To determine the trends and patterns of rainfall in the talukas of Sattari, Sanguem, Quepem and Bicholim post the mining ban.
- To assess the trends and changes in rice production in the mining-affected talukas of Goa after the mining ban.
- To determine if there have been improvements or declines in rice production.
- To explore the correlation between rainfall patterns and rice production in the specified talukas post the mining ban.
- Determine if variations in rainfall have influenced rice production in these areas.

- To identify any significant differences or similarities in rice production between these periods.

1.4 Hypothesis

- Alternative Hypothesis (H1): There is a significant relationship between rainfall patterns and rice production in the mining-affected talukas of Goa post the mining ban.
- Null Hypothesis (HO): There is no significant relationship between rainfall patterns and rice production in the mining-affected talukas of Goa post the mining ban.
- Alternative Hypothesis (H1): There has been a significant improvement in rice production in the talukas of Sanguem, Sattari, and Quepem post the mining ban.
- Null Hypothesis (H0): There has been no improvement in rice production in the talukas of Sanguem, Sattari, and Quepem post the mining ban.

1.5 Research Questions

- How have rainfall patterns changed in the talukas of Sanguem, Sattari and Quepem following the ban on mining in 2012?
- What are the trends in rice production in the mining-affected talukas of Goa after the mining ban?

- Has there been a correlation between rainfall patterns and rice production in the selected talukas post the mining ban?
- What improvements, if any, have been observed in rice production following the cessation of mining activities in the talukas of Bicholim, Sanguem, Sattari, and Quepem?
- How do the post-ban trends in rainfall and rice production compare to the pre-ban period in the mining-affected talukas of Goa?

1.6 Scope

- The study will focus on three talukas of Goa: Sanguem, Sattari, and Quepem.
- Data collection and analysis will be limited to these specific talukas to provide a detailed understanding of the impact of the mining ban on agriculture.
- The study will cover a specific period that is pre-ban period (2009-2011) and post-ban period (2012-19).
- The study will primarily focus on two variables that are rainfall pattern and rice production.

Chapter II

LITERATURE REVIEW

LITERATURE REVIEW

1. (murthy, 2017) the post ban period tremendously affected the mining dependent. Closing of mines left the laborers jobless, trade and business witnessed decline, and some businesses had to shut down. The agriculture showed a positive change with people diverting to this sector left with no other source of living. The pre-mining phase has seen an increase in the incomes of the households, with a simultaneous increase in the monthly expenditures and savings.

2. (Sadique Anyame Bawa, 2022)The study assessed the trend in the water quality of raw water abstracted at the konongo water treatment plant for treatment before and after implementing the ban on mining operations. The result showed a statistically significant upward trend in color, turbidity, temperature, total iron ore and sulphate before the ban on mining activities. Overall, there was improvement in the quality of raw water after the ban.

3. (Terence Jorge, 2013)Mining has caused wanton destruction of the state's environment, which is irreparable and irreversible. The aim of the study is to review positive and negative environmental and socio- economic impacts in Goa due to suspension of all mining operations. The change in demographics due to unplanned influx of migrants had also caused damage to the social fabric and cultural aspects in the areas affected due to mining. There was

decrease in the air, water and noise pollution. Rise in amount of fish in rivers, local agricultural produce increased.

4. (Manoranjan Mishra, 2022).Mining activities has caused severe changes in the landscape. The study provides a regional view on the extent of forest cover loss in the mineral rich districts of Odisha state. The study suggest the need to prioritize management, preservation of forest cover and conservation of biodiversity around mines and refineries. The study offers cost effective methodology to monitor forest cover loss in mining areas, which eventually contributed to the protection of forest biodiversity and forest dwelling tribal population.

5. (Naik, 2017)the study had intended to find out the impacts of indiscriminate mining on the economy of goa. Mainly the study is based on both primary and secondary data. Primary data obtained from talukas respectively one each from the north and south goa district. Stratification, pre-structured questionnaire, interview method were used to collect data. The pre period shows fall in crop yields, post-mining ban clearly shows the improvement in the crop yield, and even in some cases, the area under crops during the post mining ban period has gone up.

6. (Suresh P, 2021) Analyzing the social, economic, and environmental impacts on ban on mining in the state of goa. The survey results shows that most of the people within the mining belts were affected because of the mining ban because of dependence on mining for their livelihood. It is revealed from the study that

if systematic and scientific mining practices are taken place with sustainable manner, mining practices as well as environmental restoration and socio economic development can go parallel.

7. (Dnyandev C. Talute, 2014)the paper aims at studying the impacts of mining on biodiversity and agriculture in the state of goa. In addition, it focuses on other impacts of the longstanding mining in the state of Goa such as the impacts on the quality of air, water, river and forests, etc. Goa is a state, which has an abundant availability of mineral resources. All these mineral resources are indiscriminately mined for decades together, which have earned huge amounts of income and foreign exchange for state, but at the same time, it also had its strong negative impact on the other sectors of the state.

8. (Jakati, 2021)mining is an important extractive occupation of humankind lead to development of human civilizations in different parts of the world. Over exploitation of iron, ore have caused grave environmental damage in the mining belt and surrounding areas. Although at beginning, mining industry appeared to be beneficial to the goan economy, with time it proved that it caused more damage to the society and environment. Mining activity is ephemeral and does not compensate for all the damage caused. It would need goa, years and years to recover from the damage.

9. (Comely, 2018) the research identifies two dominant discourses that work in practice, through carrying out and challenging, environmental impact assessment, corporate social responsibility and resistance. These discursive

practices are treated as ‘corporate social technologies’ as they influence the way people think about mining and land use. The research examines the anti- mining discourse and the causes and impacts of its fragmentation. The analysis employs Stuart Kirch’s term ‘corporate social technologies’ to refer to practices that manage corporate relations with the public.

10. (Usmani, 2011) There is an inherent conflict between mining and environment; it would be unrealistic to expect that the mining of minerals could be accomplished without affecting the environment. It is generally perceived that the environmental conservation is an obstacle in the development of mining and other industry. It is argued that the cost of environmental degradation at a sensible and affordable cost is not such a farfetched idea. It is possible to prevent long-term side effects to the environment by incorporating some of the mitigating measures.

11. (Banerjee, 2020) this paper analyses some of the flagship judgements and directions pronounced by the Supreme Court of India with respect to non-fuel minerals over the past decades, particularly concerning environmental and community issues as these as these are key factors concerning the sustainability of the mining sector. The paper also highlights some of the major policy developments that followed the courts observations and directions. The court has responded to specific petitions or applications as it appeared before the bench, in the process, the judiciary has tried to address the fundamental philosophies of resource management and exploitation, and has dealt with the complexities of balancing the interests of environment, the local community, as well as the economy.

12. (Saalim, 2017) all the mining-related activities abruptly stopped throughout India, including that in goa in 2012, and were reinstated in 2015. Therefore, it provided a fit case to test the effectiveness of benthic foraminifera as an indicator of environmental impact due to mining activities. The year 2013 represent a time interval immediately after the closure of extensive mining activity, and the sampling during 2016 represents minimal mining. The living benthic foraminiferal abundance was higher during 2013 and decreased substantially during 2016, suggesting an adverse effect of activities associated with mine closure on benthic foraminifera. Additionally, the relative abundance of Ammonia was also significantly low during the year 2016.

13. (Rao, 2015) the study focuses on the environmental magnetic properties of sediments from the catchment area, upstream and downstream of these estuaries, and adjacent shelf during peak mining time. The overall content of magnetic minerals decreased after mining ban but there is an increase observed at some stations associated with older ore minerals and related to enrichment due to transportation from the stored ore on the banks during the monsoon time, gravity separation, and older ore. The decrease in the mining input can be seen by decrease in the SIRM after mining ban.

CHAPTER III

METHODOLOGY

METHODOLOGY

The study aims to analyze the relationship between rainfall patterns and rice production in the mining affected talukas of Goa. It also investigates post-ban trends and improvements in production. The study focuses on three talukas under mining, which are Sattari, Sanguem and quepem in Goa. The study period spans from 2009 to 2019, covering both pre-ban and post-ban in 2012. Secondary data of rainfall for the study period is collected from statistical handbook of Goa. Data includes annual rainfall measurements in millimeters for each taluka. Annual rice production data for the study period was obtained from the statistical handbook. Data includes annual rice production in tons for each taluka. Descriptive statistics of rainfall and rice production is calculated. Trends in rainfall and rice production over the study period were analyzed. Correlation between rainfall patterns and rice production levels was examined using Pearson correlation coefficient.

2.2 Significance of this study

The significance of the study “An analysis of rainfall pattern and rice production in mining-affected talukas of Goa, post-ban trends and improvements” lies in its potential contributions to both academic research and practical applications. The study sheds light on the impact of mining ban in 2012 on rainfall patterns and subsequently on rice production in Goa’s talukas. It contributes to the understanding of how large-scale mining activities can affect local ecosystems and agricultural productivity. Findings can inform policy makers about the importance of sustainable agricultural practices in mining affected regions. Helps in allocating resources and

developing strategies for improved agricultural productivity in the post-mining ban era. Understanding the impact on rice production may encourage diversification of crops for better resilience against environmental changes.

2.3 Limitation of study

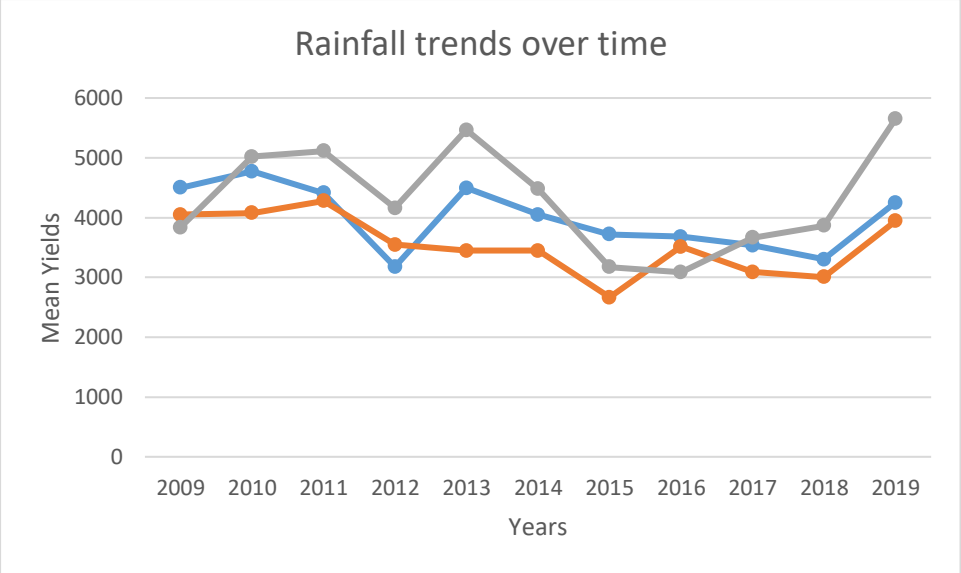
- The study relies on secondary data from statistical handbook of goa and agricultural data, which may have limitations in terms of accuracy and completeness.
- The study focuses on the period from 2009 to 2019.
- The study primarily examines the relationship between rainfall and rice production, but other factors such as soil quality, agricultural practices, and market conditions can also influence production.
- The study focuses on a specific set of talukas (Sattari, Sanguem, Quepem), which might not represent the entire diversity of agricultural conditions in Goa.

CHAPTER IV

RESULTS AND ANALYSIS

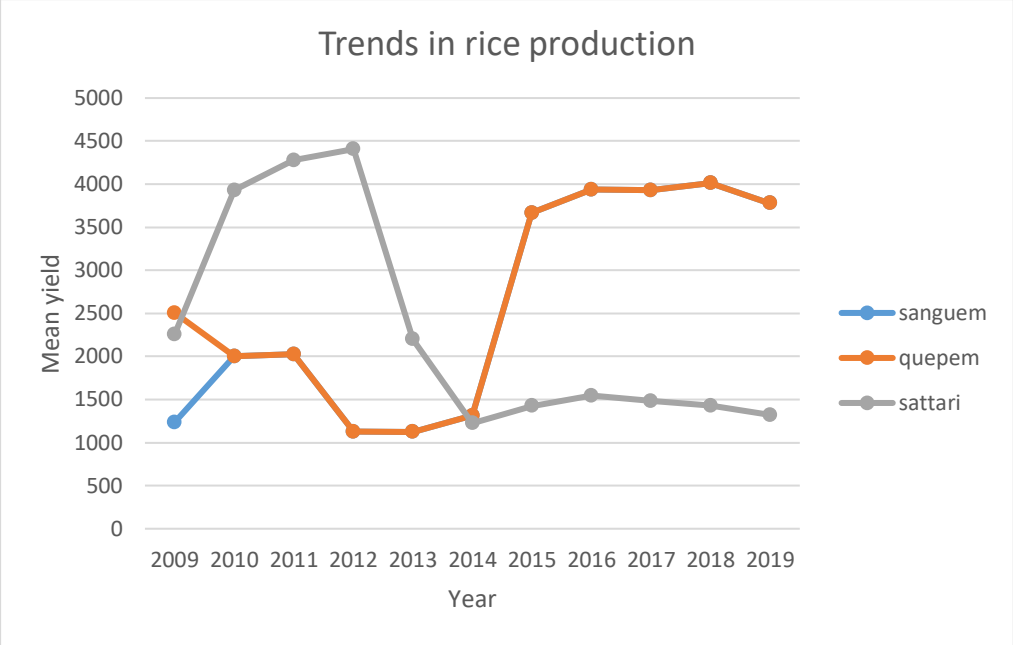
RESULTS AND ANALYSIS

4.1 Trends in rainfall levels over time



The data from the year 2009 to 2019 focuses on the rainfall trends of sattari, sanguem and quepem taluka. There is vicissitudes in measurement over time. In quepem taluka, the rainfall trends are decreasing between pre- ban and post- ban period. Whereas in sanguem taluka there has been decreasing trends post-ban on mining. In sattari, talukas there is variation in the trends which shows decreasing trend during the year of ban and increase in trend post ban on mining.

4.2 Trends in rice production



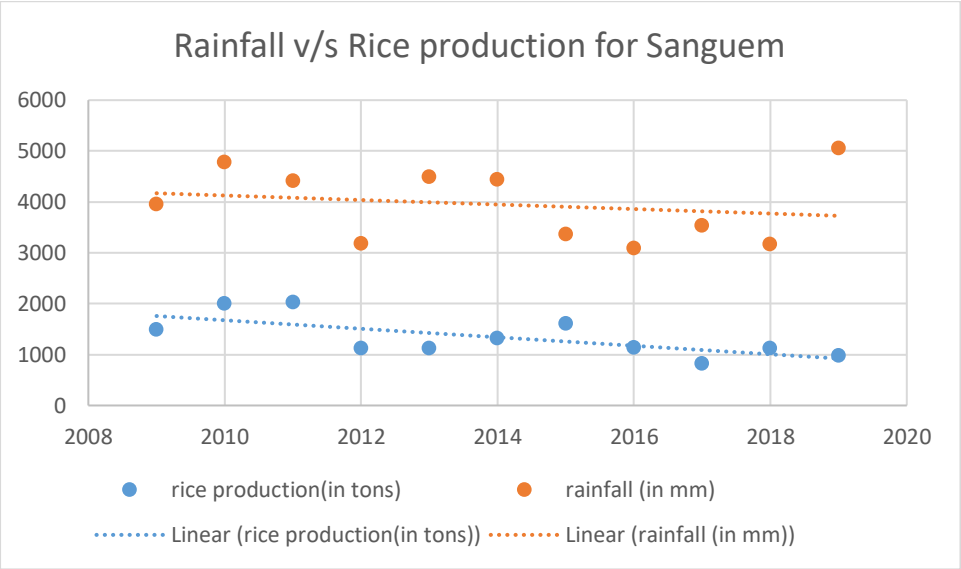
The data shows the trends in rice production of sattari, sanguem and quepem taluka with mean yields on y-axis and years on x-axis. The data clearly shows decreasing trends post-ban period in rice production of quepem taluka and increasing trend pre-ban period. There are similar trends in rice production of sattari and sanguem taluka, which shows decreasing, trends in pre- ban and post-ban period. The sanguem and sattari taluka shows significantly higher mean rice production post-ban period compared to quepem taluka.

4.3 Rice Production and Rainfall Data

Rice production and rainfall data of Sanguem taluka

	SANGUEM	
YEAR	rice production(in tons)	rainfall (in mm)
2009	1493	3947.8
2010	2002	4774.8
2011	2024	4412.2
2012	1125	3177.7
2013	1123	4493.2
2014	1311	4434.5
2015	1606	3365.8
2016	1134	3085.6
2017	825	3529.8
2018	1125	3158.6
2019	976	5057.3

4.4 Rainfall V/S rice production in sanguem

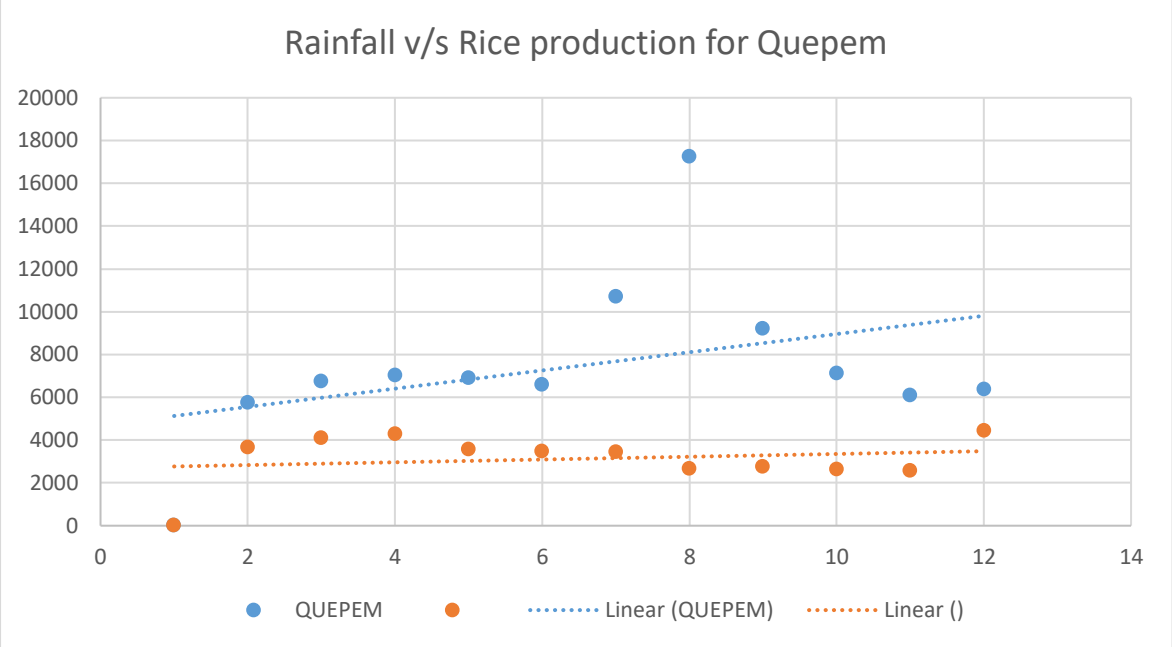


The result of Pearson correlation coefficient is 0.31654978, which indicates a moderate positive correlation between rainfall and rice production in the Sanguem taluka of Goa. Since it is not very close to 1, this suggests a moderate, but not strong, correlation. A positive sign indicates a positive correlation. This means that as one variable increases, the other tends to increase as well. A positive correlation of 0.31654978 suggests that there is a tendency for rice production to increase as rainfall increases in the mining affect talukas. A positive correlation of 0.31654978 might mean that in years with higher rainfall, there tends to be higher rice production in the taluka. Conversely, in years with lower rainfall, rice production might tend to be lower.

4.5 Rice production and rainfall data of Quepem taluka

	QUEPEM	
YEAR	rice production(in tons)	rainfall (in mm)
2009	5723	3661.3
2010	6741	4078.9
2011	7030	4277.6
2012	6900	3547.4
2013	6580	3448.5
2014	10679	3444.4
2015	17236	2668.2
2016	9194	2746.9
2017	7111	2629.8
2018	6068	2566.6
2019	6367	4439

4.6 Rainfall V/S rice production in Quepem

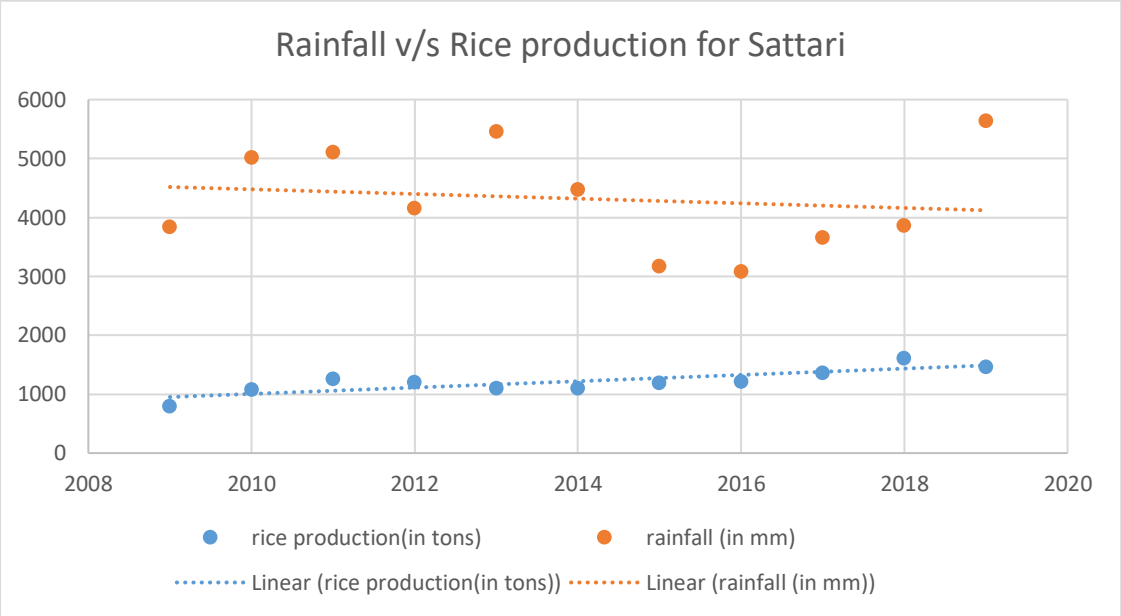


The absolute value of the correlation coefficient obtained from above data is -0.410791013 that indicates a moderate strength of association between the two variables. Since it is not close to one, this suggest a moderate, but not strong, correlation. It suggest a moderate negative correlation between rainfall and rice production in Quepem taluka. This means that as rainfall increases, there tends to be a decrease in rice production, and vice versa. A negative correlation of -0.410791013 might mean that in years with higher rainfall, there tends to be lower rice production in these talukas.

4.7 Rice production and rainfall data of Sattari taluka

	SATTARI	
YEAR	rice production(in tons)	rainfall (in mm)
2009	794	3839.1
2010	1083	5017.8
2011	1261	5114.6
2012	1210	4158.7
2013	1103	5463.4
2014	1107	4480.4
2015	1196	3172.9
2016	1216	3086.3
2017	1361	3663.2
2018	1612	3866.8
2019	1470	5647.1

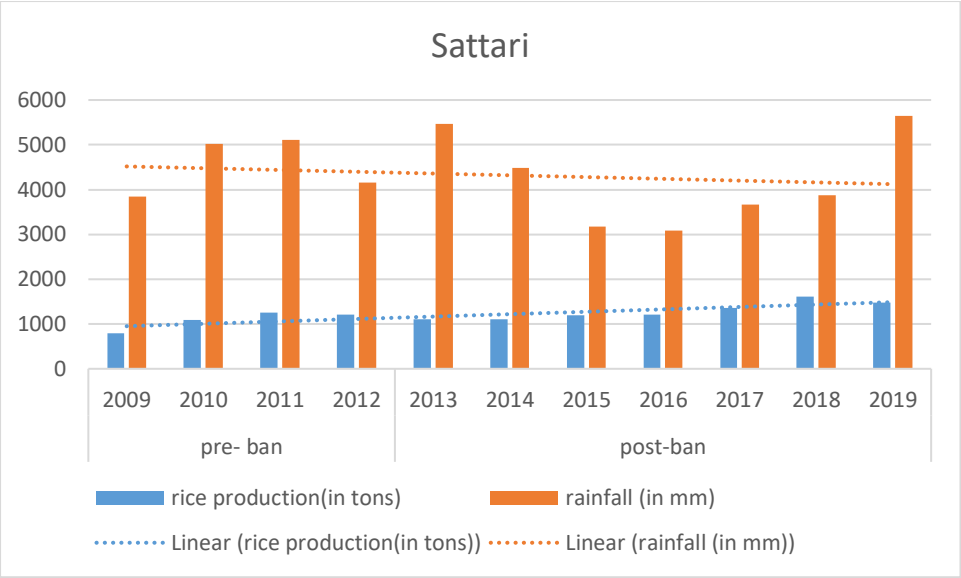
4.8 Rainfall V/S rice production in sattari



A Pearson correlation coefficient obtained from the above data is 0.044491275 that suggest a very weak positive correlation between rainfall and rice production in the Sattari taluka of goa. This means that there is almost no relationship between rainfall and rice production, indicating that changes in one variable do not consistently predict changes in the other. It implies that changes in rainfall do not consistently lead to changes in rice production. A correlation of 0.044491275 means that there is almost no discernible pattern between rainfalls and rice production in these talukas. It implies that changes in rainfall in rainfall do not consistently lead to changes in rice production.

Comparing rice production and rainfall levels between talukas and time period (pre-ban and post-ban)

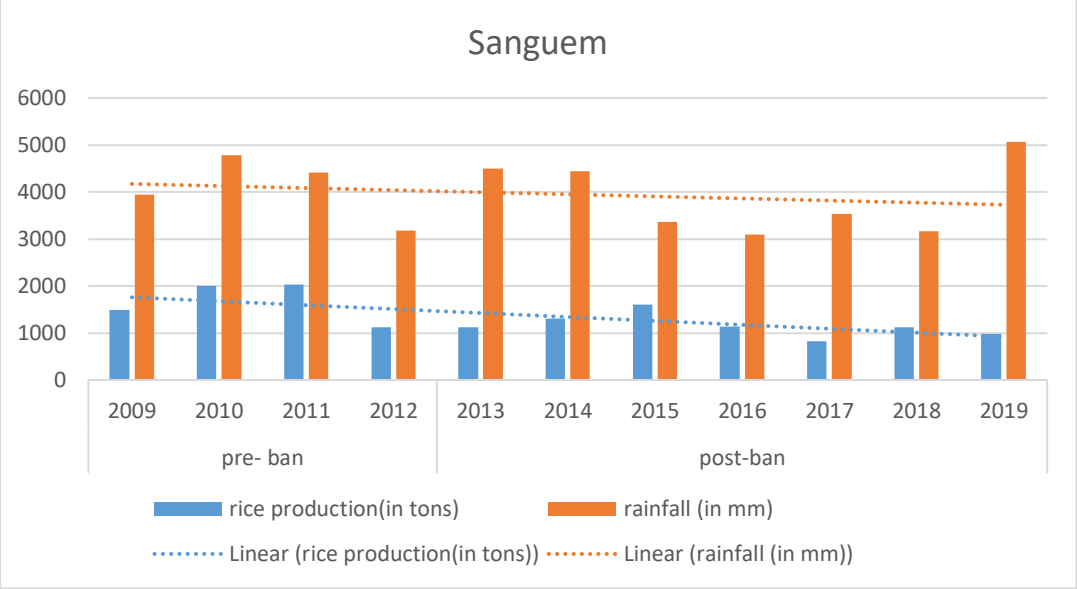
4.9 Comparing pre & post ban period for Sattari



The cluster column bar chart above shows comparisons of pre- ban period (2009-2012) and post-ban period (2013-19) of rice production and rainfall data. The column in blue shows rice production data of sattari taluka and the blue dotted line is the trend line. The trend line of rice production data shows a slight increasing trend line from pre-ban to post-ban period. The trend line of rainfall levels shows decreasing trends, which means there is inverse relationship. There is improvement in agricultural practice as there is increase in rice production post-ban despite decreasing rainfall. Despite relatively

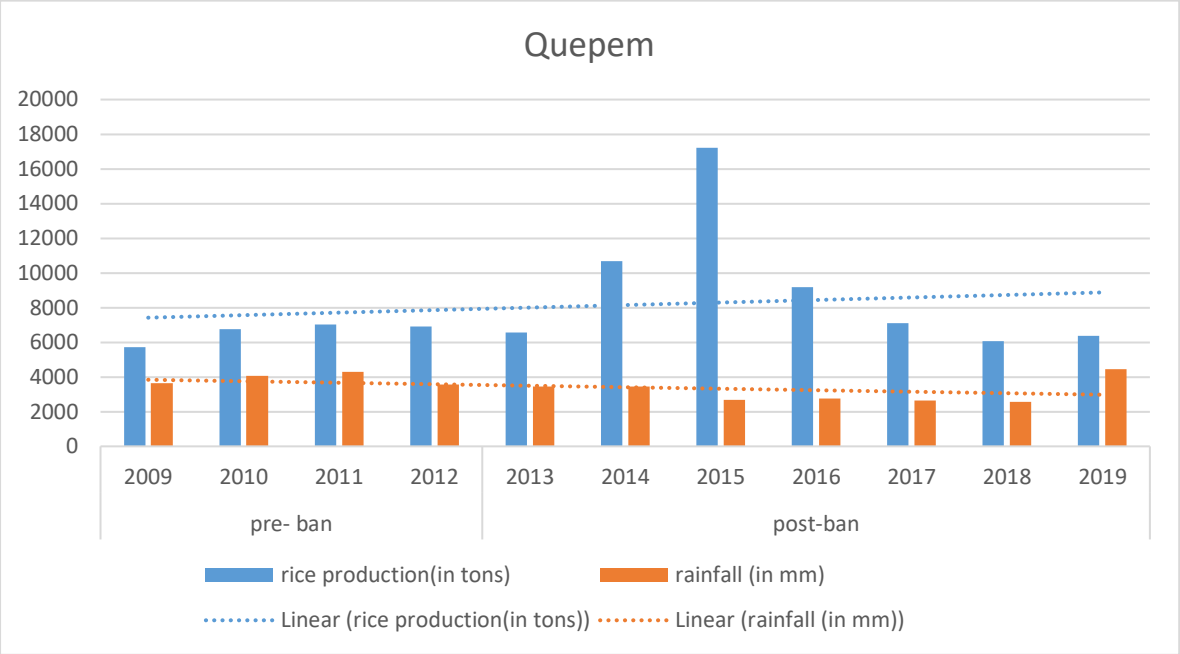
stable rainfall levels, rice production in sattari has shown steady increase post-ban, indicating potential improvements in agricultural practices or other factors contributing to increasing productivity.

4.9 Comparing pre & post ban period for Sanguem



The data above on x-axis shows years from 2009 to 2012, divided into pre-ban (2009 to 2019) and post- ban (2013-2019). Right y- axis shows rainfall levels (in mm) and left y- axis shows rice production (in tons). The trend line of rice production and rainfall levels move in the same direction it suggest a positive correlation. The ban on mining activities in sanguem taluka shows an increasing short-term trend in rice production but after 2015 there was a decreasing trend in rice production this could be because of other factors affecting the production of rice.

4.11 Comparing pre & post ban period for Quepem



The cluster column bar chart above shows comparisons of pre- ban period (2009-2012) and post-ban period (2013-19) of rice production and rainfall data of Quepem taluka. There is increasing trend of rice production in pre-ban period. The rainfall trend shows that there was increase in rainfall during pre-ban period and decreasing or stable trend post- ban period. The trend line shows that there is increase in rice production post- ban and stable or decreasing trend in rainfall, which indicates improvements in agriculture practices. The ban on mining in quepem taluka had led to increase in rice production whereas the rainfall shows a stable trend.

CONCLUSION

The comprehensive analysis of rainfall pattern and rice production in mining affected talukas of Sattari, Sanguem, and Quepem was done. Since mining was banned in 2012, so the data from 2009 to 2019 that is before (2009-2012) and after (2013-2019) the ban was consider seeing how rainfall patterns and rice production have changed. A descriptive study was conducted to see the trends and improvements in the mining post ban. A secondary data on rainfall and rice production for the specified talukas was collected.

Comparison on rainfall patterns and rice production levels between talukas and pre-ban/post-ban periods was done. The cluster column bar chart was used to see the trends between rainfall and rice production. The trend line of sattari taluka shows slight increasing trends of rice production from pre-ban to post ban period whereas there was decreasing trend in rainfall pattern, which means there is inverse relationship that indicates improvement in agriculture after ban. The data collected of sanguem taluka shows a positive relation between rainfall and rice production. It shows an increasing short-term trends in rice production for some period and then decreasing trend, which suggest that other factors affecting the production rather than rainfall or mining. There were increasing trends of rice production and rainfall levels in quepem taluka. The ban on quepem taluka had led to increase in rice production.

Line graphs were created to illustrate trends in rainfall and rice production of specified talukas over time. There is variability in the rainfall and rice production trends. To find the correlation between rainfall pattern and rice production correlation coefficient between these variables were calculated. The result of Pearson correlation coefficient of Sanquem taluka obtained indicates moderate

positive correlation between rainfall and rice production. It suggest that there is tendency for rice production to increase as rainfall increases.

The correlation value obtained from Quepem data indicates that there was a moderate negative correlation between the two variables which means as rainfall increases there tends to be a decrease in rice production and vice versa. The value obtained from Sattari taluka suggest a very weak positive correlation between variables. This means that there is almost no relationship between the two variables.

Based on the study on the analysis of rainfall patterns and rice production in mining- affected talukas of Goa (sattari, sanguem and Quepem) pre and post mining ban (2009-2019), there is fluctuating trends in rainfall levels over the study period. There is no clear long-term increase or decrease in overall rainfall. There is short-term variability due to factors like seasonal changes, climate events or local weather patterns.

Fluctuating trends in rice production over the study period were there are peaks and valleys in rice production levels with no distinct long-term trend. There are short-term variability, which may be influenced by factors such as weather, agricultural practices, and possibly mining ban effects. Rice production levels were relatively stable in some taluka before the mining ban whereas rainfall patterns were consistent or showed minor fluctuations. Rice production levels continued to fluctuate in some taluka after the mining ban. Rainfall patterns also exhibited fluctuations, possibly influenced by ban's effects on local ecosystems and climate.

Positive correlation observed between rainfall and rice production in some years, indicating that higher rainfall often led to increased rice production. Negative correlation observed in other years, where excessive rain or droughts

negatively influenced rice production. Factors beyond the mining ban may have contributed to fluctuations, such as changes in agricultural practices, soil health, or pest infestations.

The mining ban's impact on rice production and rainfall patterns is not entirely clear from the study. Other factors, such as climate variability and agricultural practices, also influenced the observed trends. The study concludes that while there are fluctuations in the mining-affected talukas of Goa, the direct impact of the mining ban on these variables requires more investigation that is detailed.

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