

Impact of Climate Change-Induced Rainfall on the Agriculture Pattern of Goa – A Geographical Perspective

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Received January 28, 2023; revised and accepted February 19, 2023

Abstract: “Climate change poses a roadblock. The number of droughts increasing year after year. Climate change is not only affecting farmers, government officials, politicians, and lawmakers but also every citizen of the country. Many famous academicians are also opining that the recent onion and tomato crisis is an example of the challenge from climatic change”. Goa is a tiny emerald land situated well on the west coast of India. Apart from Mining, Tourism, and Fishing, Agriculture is one of the major occupations; it plays a crucial role in the economy of the State. The above-said occupations provided the main livelihood to rural, urban, and coastal populations. According to FAO (2018), the share of the agricultural population in the study area is less than 32% among the working population and accounts for just 16% of the GDP. The statistical data for the agricultural scenario in Goa is indicating that traditional agriculture is declining concerning the area as well as production. Though agriculture is the backbone of the State’s economy, which provides a source of livelihood to the majority of Goan people, it is now rapidly declining due to physical as well as cultural factors. Researchers clearly say that, global warming is also one such factor, which is responsible for the reduction in agricultural pursuits. The present study discusses the trends, growth, and impact of global warming and climate change on agriculture patterns in Goa. Farmers, academicians, scientists, and politicians of the State think that there is an impact of climate change and global warming on Goan agriculture. The study further revealed that there is a reduction in area under staple crops, and most significantly yield/productivity is also declining (Economic Survey, 2020-21). Given global warming and climate change, coastal plains are exhibiting various problems like floods and landslides. Government officials have already revealed that the land-use pattern has already taken place in the study area, and a lot of damage has taken place concerning forests and mangroves. These are the main concern for our study to know the agricultural activities in Goa are largely impacted by global warming and climatic changes. Hence, all the hypotheses quoted tested positive.

Keywords: Droughts; Sensitive industry; Shift in agriculture; Backbone; Crops.

Introduction

Recently, the concept of climate change in agriculture is concerning, especially at the global and regional levels. Extremities in temperature and precipitation cause a reduction in area under agricultural land and

productivity. India is a country that represents unity in diversity in terms of physical and cultural aspects, physical aspects including topography, altitude, forest cover, coasts, humidity, etc causing climate variations and global warming. Agriculture is the backbone of the Indian economy; we depend more on agriculture for our

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livelihood as well as our economy. Nearly 55% of the Indian population is involved in agricultural pursuits. But recently we are experiencing an increase in the temperature as well as precipitation, an increase in the number of floods, severe soil erosion, reduction in area under cultivation and productivity.

Many research organisations clearly say that the agricultural growth is dependent on physical as well as cultural behaviour. The current climate change is visible and many scholars are anticipating that agriculture is mostly affected at a larger scale than in recent times. Agriculture and Food Climate Action Initiative (CAI) supports state agriculture by adopting climatic changes. Climate change is increasing the number of hot days, changes in the rainfall distribution, and more frequently they experience extreme weather occurrences which impact agriculture. The climatic impact is mainly associated with an increased number of flooding, excess weathering, soils holding moisture for a longer time, frequent occurrences of wildfires causing harm to human beings, and an increased population more than the economic threshold level. Climate change is making agriculturists more uncertain and farm management more and more complex, i.e., difficult. Ultimately these changes impact largely Ministry of Agriculture Programs like; Production, Insurance, and Management of Agricultural Emergencies.

Due to the rapid growth of the population, many research organisations are carrying out research and innovations to increase the productivity and sustainability of agriculture regionally and globally, but much less information is available on specific means to achieve this aim. Many agricultural scientists, researchers, academicians, and even politicians are much more varied about the impact of global warming on agriculture. Given this, it is very difficult to increase agricultural productivity to meet the growing population and to achieve food security objectives by expanding the area under cultivation since the fertile land is not increasing over time.

Undoubtedly agriculture is a more sensitive industry than many other industries in the world, more specifically traditional agricultural geography focusses on spatial patterns and changes in agricultural systems, based on economic geography and the other hand land use also. It is inevitable and time immemorial, as time has changed, modern agriculture has become more human-centric, where the environment plays an important role. Man is using natural resources at an optimum level, concerned about sustainability, health, and the food system. Given modernisation

in agricultural pursuits, the concept of agriculture is changing year after year, presently agriculture has got status of being an industry, and its importance is spread across the world and changes within the region with greater variability. Modern agricultural geography focuses especially on farms and types of farming with considering the social and economic conditions of the given region. Agricultural geography got greater momentum after 1970 concerning the production of food, fibre, and fuel; economic, policy, and resource issues related to agriculture; and farm household and livelihood concerns.

As of today, agriculture in India is losing its importance mainly because of farming communities moving to other activities. Agriculture in the study area is declining, many institutions and researchers, and academicians writing more and more the factors why the area under agriculture is declining. The factors which control agriculture vary from region to register, but the factors that mainly determine agriculture in Goa are: 1. Natural Factors 2. Economic Factors 3. Social Factors 4. Political Factors and 5. Global warming also.

Review of Literature

A review of literature is an essential part of any investigation as it not only gives an idea of the work completed in the past but also provides the basis for interpretation and discussion of the findings. The present study was intended to know the extent of knowledge, and the impact of global warming on production and productivity.

According to De Salvo et al. (2013) agriculture is one of the sectors most affected by ongoing climate change and global warming. Normally damage due to climate change is relevant concerning cropping patterns and livestock-related activities. Climate change is undoubtedly acting significantly on rural landscapes and forest ecosystems. Climate change leads to loss of productivity, profitability, and employability, and climate change witnesses changes in agricultural dimensions. Food security is threatened by climate change. Due to the instability of crop production, and induced changes in markets, food prices will soar.

Ellis (2008) strongly opined that climate change and agriculture are inseparable. Agriculture still depends fundamentally on the weather. Climate change has already hurt agriculture in many parts of the world because of increasingly severe weather patterns. Climate change is expected to continue to cause floods, worsen desertification, and disrupt growing seasons. The recent

warning by the Food and Agriculture Organization (FAO) that an increase in average global temperatures of just 2°C to 4°C above pre-industrial levels could reduce crop yields by 15-35 percent in Africa and western Asia, an increase of two degrees alone could potentially cause the extinction of millions of species. This is about 25-35 percent in Middle Eastern countries.

Jayaraman (2011) published an article with the title “Climate Change and Agriculture”: A Review Article with Special Reference to India confined that the importance of understanding the ongoing impact of climate change on agriculture is often underestimated. Domestic policy considerations require that climate change be factored into development activities that are influenced by the weather and climate. Along a similar line, scientific studies carried out by researchers show the impact of climate change and its vulnerability are essential to consideration of national policy framing and negotiating with international climate changes. An early and equitable international agreement on climate change is beneficial to less-developed countries, but the question of how much delay developed countries can tolerate on this issue is of critical strategic interest to them.

Kumar and Gautam (2014) scholars concluded that climate change seriously impacts the availability of natural and cultural resources on the earth, especially water, which sustains life on this planet. Accordingly, changes caused due to the existence of living and non-living life, the number of plants and animals that exist on a particular part of the earth and unevenly available natural resources are negatively affecting human health and quality of life. Both the writers projected the warning to India too, this country will also experience more seasonal variations, especially unseasonal precipitation, fluctuation in temperature, and extremity in winter as well as summer. They also anticipated that the average temperature is going to increase from approximately 2.3°C to 4.5°C, which ultimately increases the CO₂ concentration. If it happens, there will be increased variability in summer monsoon precipitation, which ultimately results in a drastic influence on the agricultural sector in India.

Study Area

Goa is a tiny emerald land situated well on the coast of India located between 14°53'54" North to 15°48'00" North Latitude and 73°40'33" East to 74°21'13" East Longitude. The geographical area is 3702 square kilometres with a total population of 1,458,545 (2011). Figure 1 indicates the administrative setup of Goa; the



Figure 1: Goa – The study area.

study area consists of taluk, district and district borders. Its geographical position is marked b. Its immediate neighbours are the Arabian Sea (West), Karnataka (East), Maharashtra (South East), and Terekol river (North), its coastline is 105 kilometres, its east-west distance is 60 kilometres, and the territory touches Belgaum and Karwar district of Karnataka. Goa State being part of the west coast region of India has many physical features which are similar to the neighbouring states of Maharashtra and Karnataka. For administrative purposes, the state has been divided into two districts, namely; North Goa and South Goa. with twelve (12) talukas comprising 391 settlements. There are six talukas in the North and South Goa districts it is located in the Sahyadri mountain region, and due to orographic influence.

The Objectives of the Study

1. To trace out the influence of global warming on Goan agriculture
2. To identify the influence of global warming on agriculture and the future development of agriculture in Goa.
3. To suggest planning strategies to improve agricultural productivity in Goa.

Hypothesis

The present investigation has formulated the following hypothesis. It is hypothesised:

- That climate-controlling factors like precipitation and temperature influence the growth of agriculture in Goa.
- That the increased rainfall and increase in temperature are responsible to reduce agricultural activities in Goa.
- That the coastal plain is known for rice cultivation, but due to unseasonal rainfall, floods, and topsoil erosion, there is a reduction in the area under crops and productivity.

Database

The information related to the area under different crops, land-use patterns, use of fertilizers, pesticides, and other information were collected through the Directorate of Agriculture, Agricultural Produce Marketing Committee Census Office, Directorate of Statistics and Planning, research articles, and discussion outcomes with experts and academicians. The collected information has been compiled and put in the form of tables and charts for further analysis.

Methodology

The researcher has collected information from the Directorate of Agriculture, since 2001 and applied simple statistical tools such as graphs and tables, analysed the tables and graphs thoroughly, and tested the hypothesis. The theoretical and empirical methods have been employed for the analysis of the agricultural scenario in Goa.

Significance of the Study

Since 1970 the concept of global warming and climate change on agriculture made the researcher study the impact of climate changes concerning global warming in the state, i.e., Goa. All of us know that climate change causes ecological imbalance resulting in scarcity of food and water resources affecting the well being of human and animal life. Climate change is responsible for an increase in temperature, changes in rainfall patterns, extreme weather events, and reductions in the availability of water for agricultural activities may lead to reduced agricultural productivity. Climate change is already affecting agriculture, greenhouse gas production, and a decline in food crop production, and to know future land infertility and adaptation of planning strategies.

Status of Agriculture in Goa

Being the smallest state of India and its geographical

conditions have not favoured the growth and development of agriculture, it is dependent on neighbouring states of Maharashtra, Karnataka and T.N, Andhra Pradesh, Gujarat, and others for the consumption of vegetables, groceries, milk, poultry, and others. Though rice is the staple crop of the State, it is cultivated from June to September but nearly 50-60 percent of imports from neighbouring states. The other notable crops of the State are pulses and millets, areca nuts, coconuts, cashew nuts, garden crops such as pineapple, mango, jackfruits, and banana.

As per the Economic Survey report of the State (2020-21), the contribution of the primary sector there increased from 7.72% in 2015-16 to 9.71% in 2016-17, but this is not mentioned in the subsequent years. Quarters of the population in Goa are dependent on agriculture, but it contributes only 15-16% of income attributed to the primary sector. The financial year 2018-19 indicates 6.65% of the total Gross State Domestic Product.

About 78% of the agricultural area still practices humid farming, commercial agriculture is most difficult because of the geology of the State, Department of Irrigation was established very recently, i.e., 1980. The size of landholding is also another mentionable factor presently it is less than 2 hectares and the marginal farmers are more in number. The agricultural land is also sinking because of urbanisation and industrialisation, these are issues of concern, and due to these factors also the production of crops is reducing in Goa.

Goa has a very rich coastline which is 105 km in length from north to south, this coastline is dominated by the fishing community, variety of fishes are caught by the fishing community, the main varieties of fish include prawns, sardines, mackerels, sharks, seer fish, silver belly, pomfrets, crabs, butterfish, and squids.

Global Warming and its Impact on Goan Agriculture

Climate change and agriculture are inextricably linked. Agriculture still depends fundamentally on the weather. Climate change has already hurt agriculture in many parts of the world because of increasingly severe weather patterns. Climate change is expected to continue to cause floods, worsen desertification, and disrupt growing seasons.

The FAO of the United Nations is working on warning the developed and developing countries that, an increase in temperature by 2°C to 4°C above pre-industrial levels could reduce crop yields by 15-35 percent in Africa and western Asia and it is more severe

in the Middle East, there it may reduce by 25 to 35 percent and even this increase may destroy millions of species and even exit from the world.

Researchers of the world confined and gave consent that there is a change in the climate of the world, further they opined that, this increase may be the result of human interaction with the climate of the earth. Undoubtedly scientists are proven that Earth's temperature is increasing slowly and surely. Man is responsible for the increase of these gases, the increased concentration in the atmosphere causes global warming. Of the greenhouse gases that contribute to global warming, carbon dioxide (CO_2) is by far the most significant, although other gases also play this role, notably methane. Carbon dioxide (CO_2) is added when fossil fuels are burnt. Over use of conventional energy resources by modern man causes higher levels of air pollution which are responsible for rise in air and earth's temperature.

Goa is the smallest state in Indian territory concerning area and even in terms of population, representing complex geological, geographical, and ecological history. The Study area is virtually a miracle of nature; Earth's ancient history survives in Goa. Many people argue that Goa is a very small state and the impacts of global warming and climate changes on agriculture are not well defined. But the recent Monsoon of 2015 and 2019 are messaging Government, administrators, scientists, academicians, and others that the impact of climate change on agriculture can be seen in the following sectors, namely,

(a) Agriculture, (b) Forestry, (c) Fisheries, Coastal and Marine Conservation, d) Energy and Sustainable Development. (e) Education and Capacity Building, (f) Land Use, (g) Mining (h) Biodiversity, (i) Health, (j) Industry, (k) Waste Management (l) Tourism, (m) Urbanisation, (n) Water and Sanitation, etc.

The Government of Goa's recent publications is giving messages that the growth rate of Agriculture (Primary Sector) over the previous year was negative or it was fluctuating, and the growth rate under the primary sector (including Mining and Forestry) has own merger improvement of 0.03 percent (State Action Plan on Change for The State of Goa, 2019-20). concerning the Secondary sector, there is an improvement only after 2015-16 onwards, similarly, the Tertiary sector has shown little improvement. The question here is how come the primary sector has shown negative growth?

Observations of Goa's Climate

The weather pattern of Goa is unique because of its

peculiar geographical conditions – the Arabian Sea on the west and Sahyadri on the east. Indian Meteorological Department data reveals that Goa is witnessing higher levels of temperature increases as compared to the national average of more than 1°C from 1901 to 2018, the increase is more after 1970 (Figure 2).

Similarly, the mean annual rainfall figures also exhibit that, there is an increase of about 68% over the last century. Statistical data about the rainfall of North Goa District support the same, whereas mean annual rainfall is found to have increased by 300 cm to 500 cm which is an increase of 66% (Figure 3).

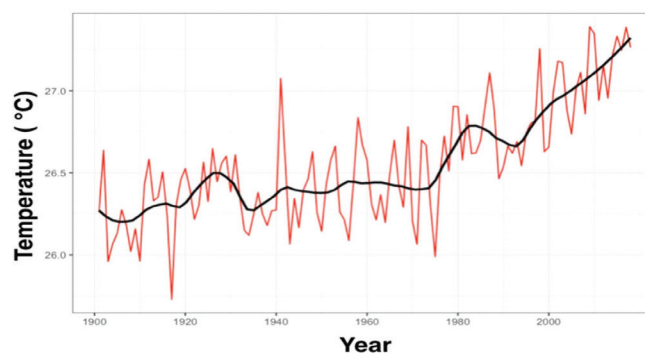


Figure 2: Observed changes in mean annual temperature in Goa (1901-2018).

Source: Goa State Action Plan on Climate Change (2019-20)

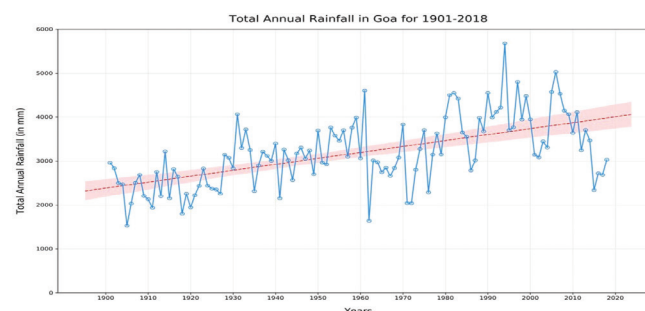


Figure 3: Observed changes in mean annual rainfall in Goa (1901-2018).

Source: Goa State Action Plan on Climate Change (2019-20)

The researcher has made a humble attempt to know the impact of climate change and global warming in the study area, i.e., Goa. An attempt has been made by taking the criterion of area under different crops from 2001-02 to 2017-18, though the period is insufficient to prove the impacts, this is a humble attempt to say that there is a climate impact in Goa. Table 1 shows the gross cropped area in Goa during 2003-04 to 2018-19.

There are many reasons that are responsible for the declining gross area under cultivation, but climate

Table 1: Gross cropped area in Goa (2003-04 to 2018-19)

S. No	Year	Gross cropped area (hectare)	Major crops (Five leading crops)
1	2003-04	1,68,634	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
2	2004-05	1,68,634	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
3	2005-06	1,70,327	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
4	2006-07	1,70,327	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
5	2007-08	1,70,327	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
6	2008-09	1,65,953	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
7	2009-10	1,60,320	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
8	2010-11	1,59,916	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
9	2011-12	1,63,991	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
10	2012-13	1,62,505	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
11	2013-14	1,57,852	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
12	2014-15	1,57,702	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
13	2015-16	1,56,462	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
14	2016-17	1,54,721	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
15	2017-18	1,54,721	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables
16	2018-19	1,51,957	Cashewnut, Rice, Coconut, Mango & Banana, Pulses, Vegetables

Source: Personal Computation, Planning, and Statistics, Govt Printing Press, 2011-12 to 2017-18

change is one among them. ICAR also expresses the same concern that due to global warming and climate change not only gross area but also productivity is decking. The Directorate of Agriculture and associate researchers expressed their view that due to global warming, there is a change in the pattern of agriculture in Goa too, and farmers started growing different crops. Similarly in the future changes in the climate elements like temperature and precipitation will affect not only the production pattern of crops but also agricultural productivity. This change will affect more on poor farmers and landless labourers.

Further, an attempt has been made to know that, whether climate has made an impact on irrigation, to analyse the situation, the researcher considered the indicators of total cropped area and total irrigated area, from 2011 to 2018 the area under-cropped was conserved as 100% and total irrigated was (in %) calculated, the result is as not much shocking. The below table and figures indicate that due to variations in monsoon, the study area witnessing a decline in irrigated area this is an example say that the State of Goa is witnessing the impact of global warming and annual as well as monthly rainfall changes with its coefficient in the monsoon season (Table 2 and Figures 4-6 and 8).

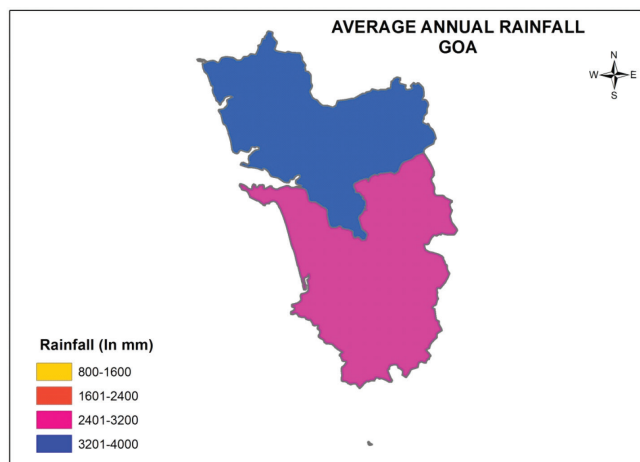
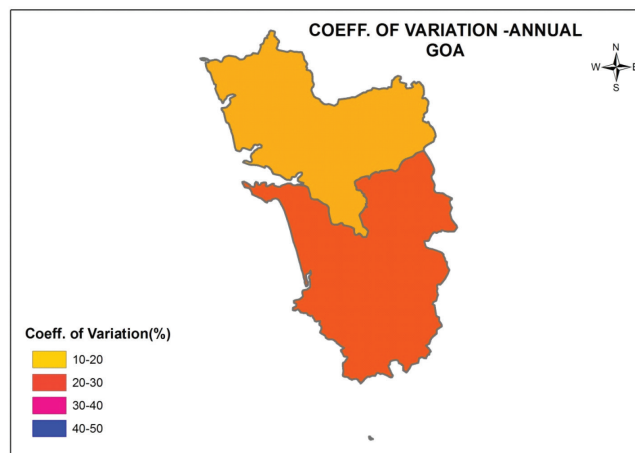
**Figure 4: Annual distribution of rainfall of Goa in mm.****Figure 5: COEFF of variation of annual rainfall of Goa.**

Table 2: Total area under principal crops and irrigated area (2011-2018)

2011-12		2012-13		2013-14		2014-15		2015-16		2016-17		2017-18	
Area (Ha)	% Irrigated Area	Area (Ha)	% Irrigated Area	Area (Ha)	% Irrigated Area	Area (Ha)	% Irrigated Area	Area (Ha)	% Irrigated Area	Area (Ha)	% Irrigated Area	Area (Ha)	% Irrigated Area
100	22.65	100	22.37	100	24.28	100	24.60	100	24.67	100	23.88	100	23.88

Source: Personal Computation, Planning, and Statistics, Govt Printing Press, 2011-12 to 2017-18

Table 3: Land utilisation pattern in Goa (2010-11 to 2017-18)

S. No	Years item	2010-11 Area in ha	2011-12 Area in ha	2012-13 Area in ha	2013-14 Area in ha	2014-15 Area in ha	2015-16 Area in ha	2016-17 Area in ha	2017-18 Area in ha
1	Area under forest	125473	125473	125473	1,25,473	1,25,473	125473	125473	125473
2	Land not available for cultivation	37137	37137	37137	37,137	37,137	37137	37137	37137
3	a) Permanent pastures & Another grazing land	1305	1305	1305	1,305	1,305	1305	1305	1305
4	b) Land under Miscellaneous	580	580	580	580	580	580	580	580
5	c) Cultivable waste	65598	64796	64733	67,412	52,533	66509	66480	67487
6	Net area sown	131020	131822	131885	1,29,206	1,29,243	130109	130138	129131
7	Area sowed more than once	28896	32169	30620	28,646	28,459	26353	24583	22826
8	Gross cropped area	159916	163991	162505	1,57,852	1,57,702	156462	154721	151957

Source: Personal Computation, Planning, and Statistics, Govt Printing Press, 2011-12 to 2017-18

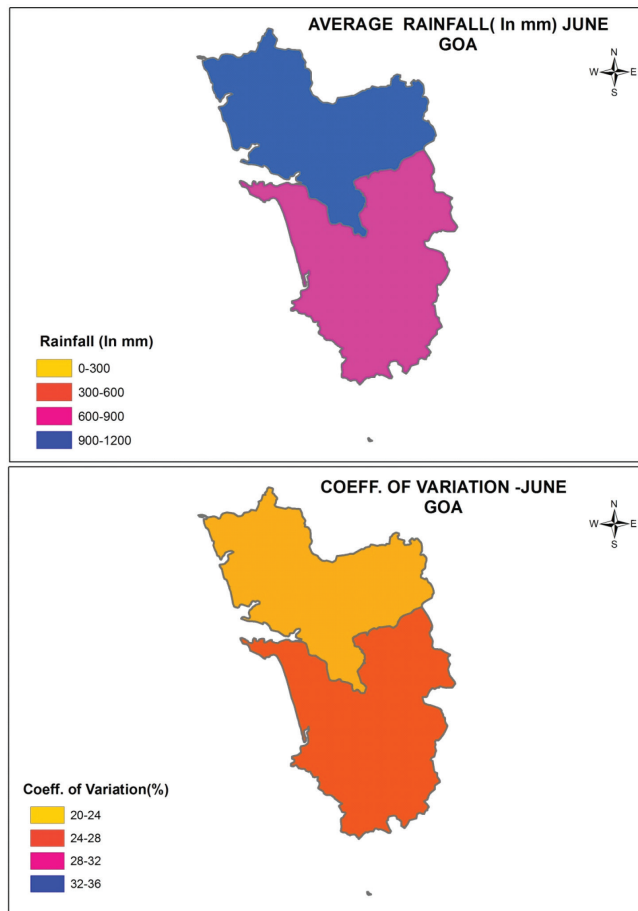


Figure 6: Rainfall variation.

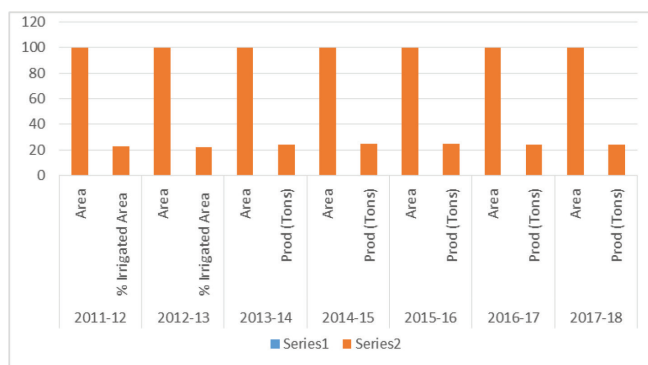


Figure 7: Total area under principal crops and irrigated area (2011-2018).

Figure 7 states graphical representation of total area under principal crops and irrigated area from 2011-2018.

The main concerns of human beings across the State are climate change and climatic variables. Droughts and floods are also threatening seriously in the study area, these two things are not only threatening Goans but also across the world. The loss of forest cover, which normally intercepts rainfall and allows it to be absorbed by the soil, the type of rainfall Goa experiences is also

a major concern, due to its general slope towards the Arabian Sea, and the runoff is towards the western side. The same is also responsible for eroding topsoil and responsible for causing floods as well as droughts. Paradoxically, the lack of trees also exacerbates drought in dry years by making the soil dry more quickly.

The year 2019 was the year of heat and cold waves across India as well as in Goa. The states of India suffered to a large extent due to the heatwave that occurred in the summer of 2019. Untimely rains destroyed the Cashewnut crop in the Study area i.e., Goa. As stated earlier, like tourism, agriculture is also known as a sensitive industry, extremity in temperature, as well as precipitation, are held responsible for the reduction in area under crops and decline in productivity also.

To test the above sector i.e., change in the land use pattern due to climate change an attempt is made here to know any impacts, researcher taken consideration of land use pattern in the study area, and analyzed with the data provided by the Directorate of Planning and Statistics are used and derived conclusion (see Table 3).

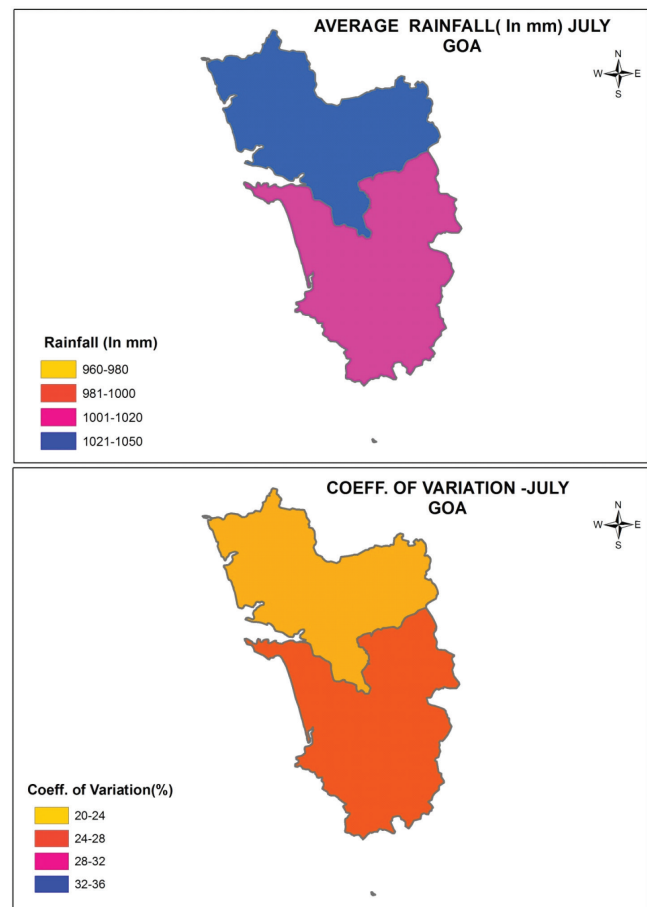


Figure 8: Goa variation of rainfall.

During the pre-monsoon May 2019 – 46 percent of the total agriculture area had moderate depth of water while others experienced low depth which constitutes nearly 31 percent of the total area of Goa. Goa also considers some hilly areas and which comprise nearly 20% of the total area (Figure 8). As these data are from the pre-monsoon phase and in this phase, most of the areas are having an abundance of medium water depth. These scenarios are very much favourable to agriculture mainly for Zaid crops in the state.

The following Figure 9 shows various water levels based on the water depth 0-2 – very low, 2-5 – low, 5-10 – medium and 10-20 – deep in various parts of Goa. On the other hand, in the month of November (Post-Monsoon) in 2019 near about 1060 sq. km (30%) area is having a medium water depth where the range is from 5-10 m. This shows a significant recharge of groundwater during monsoon in the state. The water depth range of 0-5 m comprised nearly 50% of the total area which clearly shows the trend and effect of rainfall on groundwater recharge (Figure 9). These changes in groundwater depth are only due to rainfall whereas natural recharges are still facing issues as far as state conditions are concerned. Figure 10 indicates

depth of water level in the month of November 2019 in the study area.

Goa is experiencing global warming and climate change, but last year's experience of the untimely rain and floods in some parts of Goa is still in our mind, so authorities should wake up and take necessary steps to curb the impacts of these and start planning in this context. Very recently ICAR (2020-21) Goa researched global warming, and they highlight that Rabi crops are greatly influenced. Mere increase in temperature and precipitations and landslides significantly affects the quality of rice, Cashewnut, vegetables, fruits, and other floricultural crops. Other impacts on agricultural and related sectors include lower yields from dairy cattle and a decline in fish breeding, migration, and harvest of crops.

Other Factors Controlling Agriculture

- Goa has a huge population of over 15 lakhs it is increasing at a very fast rate. This has created a great demand for land. Every bit of land has been brought under the plow. Global warming is intensifying not only in the world but also in Goa (TOI), due to topography mostly rainwater is also

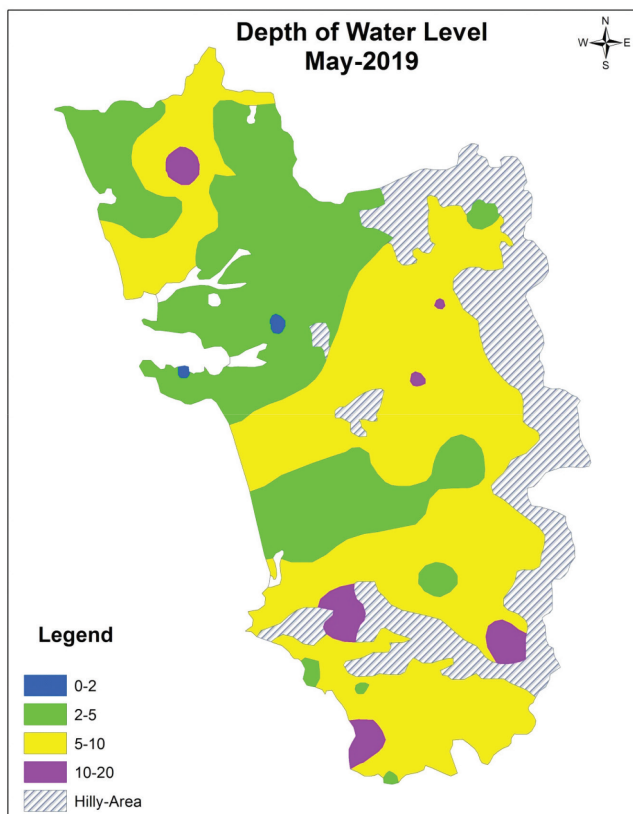


Figure 9: Goa – Depth of water levels during May 2019.

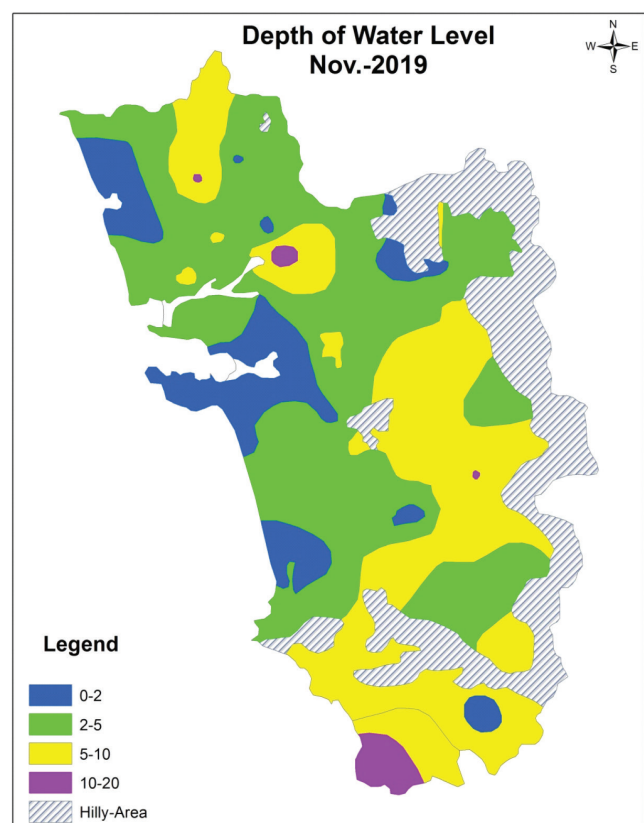


Figure 10: Goa – Depth of water levels during November 2019.

joining the Sea and causing floods, and weather elements are making a supernatural power bringing bad luck for Goa's declining agriculture.

- Researchers already anticipated that the impact of climate change is likely to be continuing with executing digital campaigns, especially in coastal and Khazan lands. So, since rice is the staple crop, the government is thinking seriously about revival with mechanisation and reducing labour costs and farmers' problems.
- The coastal plains of Goa are vulnerable to and experience dangers due to the discharge of rainwater, this plain is known for rice cultivation, and the talukas which fall under this plain have more paddy fields and also grow vegetables, but due to unseasonal lashes of rain, the area under crops and production is declining.
- Scientists from NIO established the evidence that the number of rainy days is changed. The process of Urbanisation is also increasing day by day, which could lead to waterlogging and the creation of floods, further low-lying areas are also increasing and this leads to a reduction in area under crops and productivity.
- Goan soils have been used for growing crops for thousands of years which have resulted in the depletion of soil fertility. With deforestation, the sources of maintaining the natural fertility of the soil have been drying out. Lack of material resources and ignorance of scientific knowledge has further depleted the soils of natural fertility.
- The storage of food grains is a big problem. Nearly 10 percent of the Goan harvest goes to waste every year in the absence of proper storage facilities. This colossal wastage can be avoided by developing scientific warehousing facilities.
- Most of the farmers are poor and do not have enough resources to purchase modern farm implements and tools. This hampers the development of agriculture.
- Adequate and timely credit is not given to the farmers which makes them wait for the materials needed for the betterment of their farms.
- There is a huge difference in retail price and farm gate price which makes the farmers unhappy because they never get enough profit.
- Labour and other cultivation costs of rice are increasing year after year. Agriculture is greatly impacted by rising costs associated with the production and operation of the farm – input costs, operational costs, land costs, etc. These aspects make it difficult to practice agriculture in Goa.

Correlation and Variation

Table 4 was tabulated using the linear regression test in SPSS. It explains the fundamental aspects of the model, such as how the level of groundwater depth acts as a dependent variable, while the mean annual rainfall acts as an independent variable. Table 5 summarises the model.

Table 4: Variables Entered/Removed^b

<i>Model</i>	<i>Variables entered</i>	<i>Variables removed</i>	<i>Method</i>
1	Annual ^a	.	Enter

^a All requested variables entered.

^b Dependent Variable: Gw_max

Table 5: Predictors and dependent variables

<i>Model</i>	<i>R</i>	<i>R square</i>	<i>Adjusted R square</i>	<i>Std. The error in the estimate</i>
1	1.000(a)	1.000	.	Enter

^a Predictors: (Constant), Mean Annual Rainfall

^b Dependent Variable: Groundwater minimum depth

The R-value represents the correlation between maximum groundwater depth, and the amount of rainfall received; the value is greater than 0.4 or 40%, which is considered for further analysis; and the value is 1.000 or 100 percent (Table 5), which is very good for model fit. Because the R-squared value is larger than 0.4, the total variance explained by the variables is greater than 0.4, indicating that the model is successful and accurate enough to describe water usage, which is 0.100 or 100.0 percent. The reduced R-square informs us how common the discoveries are.

The adjusted R-square indicates the generalisation of the results or the variation in the sample results. It is essential to have a minimum difference between R-square and Adjusted R-square, but the value of R and R square is the same so there are no differences in it. As a result, the model summary (Table 6) is a great place to start.

Table 6: ANOVA^b

<i>Model</i>	<i>Sum of squares</i>	<i>Sum of squares</i>	<i>df</i>	<i>Mean square</i>	<i>F</i>	<i>Sig</i>
1	Regression	.419	1	419		a
	Residual	.000	0			
	Total	.419	1			

Table 7: Coefficients^a

Model	Sum of Squares	Unstandardized Coefficients	Standardized Coefficients	t	Sig
		B	Std.	Beta	
1	(Constant)	3.886	.000	1.000	.
	A_B	.092	.000		

^a Dependent Variable: Gw_max

The estimated (predictors) of the independent variables and the dependent variable were shown to be related in this study. The anticipated value increases or decreases by the same percentage for each unit change in parameter estimates. The use of effect size and parameter estimates in univariate analysis of variance, which is also used in cross-sectional approaches, is still an option. Regression parameters like R square and adjusted R square value (1 and 1) are identical to those in the previous approach, which is fixed effects dummy variable (t values, significant levels), but the regression value of the dummy variable is different because it is coexisting with different dummy coexistence. This is shown in the tables above. As a result of this study, it is clear that the depth of groundwater and mean annual rainfall has a strong correlation with the factors examined (Table 8).

Table 8: Residuals Statistics^a

	Minimum	Maximum	Mean	Std. deviation	N
Predicted Value	*****	*****	*****	*****	2
Residual	*****	*****	*****	*****	2
Std. Predicted Value	-707	.707	.000	1.000	2
Std. Residual	-	-	-	-	0

^a Dependent Variable: Gw_max

To overcome global warming and climatic changes effecting agriculture, the Government, farmers, academicians, and the public should practice the following planning strategies: 1. Putting carbon back in the soil, 2. Efficient Irrigation Management, 3. Renewable Energy, 4. Organic Practices, 5. Keeping Agriculture Green, 6. Reducing Livestock Methane Emissions, 7. Pasture-Based Livestock Management, 8. Protecting Farmland, 9. Supporting Farmer's Markets and Local Food, 10. Pushing for Climate-Friendly Policies.

Conclusion

Agriculture is an important economic activity but over a period of time it has lost its significance due to several factors including climate change. In a short period of time in Goa. Farmers, academicians, scientists, and politicians of the State think that there is an impact of climate change and global warming on Goan agriculture. The study further reveals that there is a reduction in area under staple crops, and most significantly yield/productivity is also declining (Economic Survey, 2020-21). Given global warming and climate change, coastal plains are exhibiting various problems like floods and landslides. The land-use pattern has already been observed by the government officials in the study area, and a lot of damage has taken place concerning forests and mangroves. These are the main concern, and researchers have concluded that agricultural activities in Goa are largely impacted by global warming and climatic changes. Thus on the overall observation and study I state that all the hypotheses have been quoted tested positive.

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