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THE IMPACT OF IRRIGATION INTENSITY ON FOOD SECURITY IN CHHATTISGARH, INDIA

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ABSTRACT
Crop diversification is one of the most important risk management, stability of soil fertility, income-enhancing strategies for farmers and food security. The study found that double cropping is being done well in only 1535123ha.(33%) of the net sown area. The highest positive relationship between crop diversification index and irrigation intensity found to be in Kabirdham district followed by Balrampur and Bemetra district and negative relationship showed in Janjgir-Champa district followed by Raipur and Sakti districts. For the expansion of crops other than paddy, irrigation facilities and infrastructure will have to be increased in the for double cropping and food security.

KEYWORDS: dominance crop, simpson diversity index, crop diversification, sources of irrigation, food security.

INTRODUCTION

Chhattisgarh was established on 1 November, 2000 by carving it out of Madhya Pradesh. Silver Jubilee will be celebrated this year on completion of 25 years of establishment of Chhattisgarh. Mineral and forest resources are found in abundance in Chhattisgarh, and along with this, agricultural products are produced in abundance. The main crop of Chhattisgarh is rice; consequently, this state is known as the "Bowl of Rice". After Chhattisgarh came into existence as separate state, its economic growth has increased rapidly along with the increase in resources required for development. With time, Chhattisgarh state is moving forward, fulfilling the goals of sustainable development. There is improvement in agriculture, education, increase in the number of hospitals and banks.

In Chhattisgarh, along with paddy, several other crops are produced such as pulses, oilseeds, commercial crops and horticultural crops. The reason for growing crops other than paddy here is due to the geographical structure of the place and it is an agro climatic zone. Geographically, Chhattisgarh has been divided into 3 agro-climatic zones which are as follows: Chhattisgarh plains, Bastar Plateau and Northern hills. There are a total of 20 districts in Chhattisgarh plains, 7 districts in Bastar plateau and 6 districts in northern hills. Here, due to only one type of crop growing, the available resources are not being used properly. The fertility of the land is decreasing along with that there is a decrease in the areas of pulses and oilseeds. This means that the diversity of crops is getting directly affected.

Major share of the country's food production is dominated by the rice-wheat system in Indo Gangetic plains of India, but the continuous growing of the rice-wheat cropping system has a serious negative impact on soil health and environmental-related problems in the Indo Gangetic plains (IGP) of India (Nambiar, 1994)Present there is an agricultural system that does not have a negative effect on the fertility of the soil. Its name is the crop diversification system (Bommarco, Kleijn, & Potts, 2013). Crop diversification is one of the most important risk management and income-enhancing strategies for farmers (Mithiya,D., Mandaland, K., and Datta, L., 2018). Diversification is a kind of risky method and also it is very difficult to make changes in the traditional method, but the need to increase of income of the farmers and increase of sources of livelihood in rural areas are necessary requires the change of cropping system, meaning the adoption of a crop diversification system(Birthal, Roy, & Negi, 2015) Crop diversification means cultivation of different crops in a cultivable geographical land in a specific calendar year (Pal, 2011). The diversification towards high-value crops not only augments livelihoods also offers multiple ecosystem services benefits compared to traditional cropping systems Studying crop diversity is crucial for fostering a more inclusive and modern cropping system. Irrigation is a vital input of agriculture and has a strong impact on crop diversification (Saha and Rudra,2017). It enables individuals to appreciate diverse perspectives, challenge their own biases, and cultivate empathy and open-mindedness. This, in turn, leads to stronger agriculture practices, more effective problem-solving and greater innovation in cropping systems. There is a need to know the status of irrigation intensity and crop diversification as well as its impact and trend so that forecasting and policy making can be done. Hence, this topic has been chosen for study.

METHODOLOGY

Data collection: In order to know the status of crop diversification and its growth in the state of Chhattisgarh, we have collected area-related data of crops grown here for the year 2015 to 2023. Chhattisgarh state has a total of 33 districts, and

all districts were selected for study, which was taken from the *Department of Land Revenue& Disaster Management, Raipur, Chhattisgarh*.

Statistical Tools:
Diversification index of Crop was estimated using two popular approaches (Shannon Diversity Index and Simpson Diversity Index).

1. **Shannon Diversity Index:** The Shannon diversity index, also known as the Shannon-Wiener index, is a widely used measure of biodiversity in a community. It quantifies the diversity of species based on their relative abundance and distribution within a species. The index was originally developed by Claude Shannon in 1948 as a way to measure uncertainty in a communication channel.

The Shannon index (H') is calculated using the following formula:

H' = - Σ [pi * ln(pi)]

Where:

H' is the Shannon diversity index.
pi is the proportion of individuals belonging to the i^{-th}crops.
ln is the natural logarithm (log base e).
Σ (sigma) indicates the summation of the values for all crops in the area.

2. **Simpson Diversity Index:** The Simpson Diversity Index is a measure of diversity in a community, often used in ecology. It quantifies the probability that two individuals randomly selected from a sample will belong to the same species. The index ranges from 0 to 1, with higher values indicating greater diversity. It The index is measured by considering both the number of species (richness) and the evenness of their distribution (how equally represented each species is).

$D = \Sigma [n_i(n_i-1) / N(N-1)]$

Where:

n_i = the number of individuals of crop *i* in the area.
N = the total number of individuals of all crops in the area.
Σ (sigma) = the sum of all crops in the area.

Simpson's Index of Diversity (1 - D): This is the more commonly used and intuitive version. It represents the probability that two randomly selected individuals will be from different crops in the selected area.

3. **Irrigation Intensity:** Irrigation Intensity is the percentages of the irrigation land proposed to be irrigated annually. Irrigation Intensity = (Gross Irrigated Area/Grossed Cropped Area) X 100.

4. **Compound Growth Rate(CGR):** The Compound Annual Growth Rate (CGR) represents the average growth rate of an investment over a specified period, assuming profits are reinvested at the end of each year. It provides a smoothed rate of return, considering the effects of compounding, and is a useful metric for evaluating investment performance and growth:

Formula- **$Y= \alpha\ \beta t$**

$\text{Log } Y= \log \alpha + t \log \beta$

Where,

Y= Shannon diversity index of crops
α= Constant
β= Regression coefficient
t= time in year
Compound growth rate (%) = (Antilog β-1)100.

5. Hypothesis :

a). H_0 = Increasing area under crop with respect to Simpson Diversity Index.
H_a = Decreasing area under crop with respect to Simpson Diversity Index.

RESULT AND DISCUSSION:

1. Crop Diversification Index in Districts of Chhattisgarh state -It is known that the Shannon Diversity Index measures the diversification present in the district of Chhattisgarh, which is presented in Table A1 and Figures A1. The table was revealed that the high level Shannon Diversity Index (SDI) observed were Mungeli, Durg, Jashpur, Surajpur, MCB, Sarguja, KCG, Balrampur, Bemetra, Kabirdham districts and very low level SDI found to be in Janjgir, Bijapur, Sakti, Mahasamund, Bilaspur, Baloda-Bazar districts. The maximum & minimum SDI were found in Kabirdham (1.565) and Janjgir-Champa (0.063). There are 33 districts in Chhattisgarh with diversity in the geographical structure and availability of resources in the entire state. The state is divided into three types of agro-climate zones having their own distinct characteristics. Higher SDI observed was in Kabirdham district and its neighboring district Bemetra, is because of the higher crop diversity, although they receive less rainfall than other districts due to the presence of Makal Mountain. In these two districts, the source of irrigation is mostly tube wells and the groundwater level is good due to the presence of

four reservoirs. Owing to this, double cropping is possible in these areas. The presence of the black soil and the favorable geographical structure support the above diversity. The literacy rate of Kabirdham district is 60.85%. Additionally, the district has one Agriculture College, one Fisheries College, and one KVK, which provide guidance and education to farmers regularly. In these districts, agro-processing centers *like* dal mills, rice mills, traditional oil mills, jaggery factories and sugar mills are operating in sufficient numbers, hence the farmers here face no problem during the marketing of agricultural produce. In these areas, due to an increase in irrigation facilities as well as effective extension of technical knowledge, apart from food grain, pulses and oilseed crops, the area of horticultural crops is also increasing.

Based on total irrigated area, Janjgir-Champa district ranks first, and Sakti district ranks third, yet it ranks last and third last, respectively, in the crop diversification index. Two reasons for the lower crop diversification are 1. Lack of irrigation facility: As the main source of irrigation here is canals, so in the absence of a source of irrigation, mono-cropping of paddy can be seen here as canalsflow seasonally and last only for one season.2. The geographical structure and low land with big bunds: Due to this, it is difficult to grow pulses and oilseeds here. Further, Red and yellow (*Matasi*) soil is found in this district and other districts of the northern hills, which is suitable for paddy production. For the expansion of other crops in the plain areas of Chhattisgarh, irrigation facilities should be increased, especially for in *Rabi* season. Motivation and awareness among the farmers are required for pulses and oilseeds cultivation. A policy or fine will have to be made and implemented by the government.

When we talk about Bijapur district and other districts of Bastar plateau, there is more forest area here, and the occurrence of red sandy (*Tikra*) soil with less productivity, are suitable for paddy and coarse cereals. In the Bastar plateau and northern hilly areas, the expansion of pulses, oilseeds and horticultural crops can be done by proper management, adaptation of micro irrigation and proper water conservation.

Diversity index of total cereals rangebetween 0.47 -0.64 during 1960-61 to 2010- 11. This indicated that over the years, total cereals experienced a decrease in diversification in terms of area under crops. In the case of pulses range was from 0.71 to 0.52. The study revealed that crop diversification has been taking place at a higher pace over the year in pulses. In the case of the oilseed crop also a reduction in the year 2010-11 compared to 1960-61. While the Herfindahl index for all cropsincreased ranging from 0.37 to 0.51 during this period, means decrease in diversification has been taking place over the year(Satish,R.S. and Nirgude,R. R., 2023). The overall crop diversification in Gujarat state was moderately high with CEI 0.8081 and 0.7908 in the first and last triennia, respectively, which secured farmers against climate risk. It showed that the level of crop diversification had slightly declined by 2.14 per cent during the study period, but it had slightly declined during the last decade, which secured farmers against climate risk(Gondalia*et al.*, 2017).

Table A1: Shannon Diversity Index(SDI) of Crops in district of Chhattisgarh

S. n.	Range (in %)	Shannon Crop Diversification Index	Name of Districts
1.	<35	Very low	Janjgir, Bijapur, Sakti, Mahasamund, Bilaspur, Baloda-Bazar.
2.	35-70	Low	Korba, Raipur, Gariyaband, Sukma, Kanker, Sarangarh, Dhamtari, GPM, Dantewada, Narayanpur, Raigarh, Balod.
3.	70-105	Moderate	MMA, Kondagaon, Bastar, Rajnandgaon, Koriya.
4.	>105	High	Mungeli, Durg, Jashpur, Surajpur, MCB, Sarguja, KCG, Balrampur, Bemetra, Kabirdham.

Diversification index and multiple regression analysis over the years 2001-02 to 2014-15 in the eastern region of India. The study revealed that the diversification was found to be lower in the regions with dominance of traditional system farming. Strengthening crop diversification depends on the market and mitigation of production risks through technological support, quality input supply, insurance cover and the existence of modern storage-processing centers in the region(Singh *et al.*, 2018). The number of rural markets, the distance of cultivated land from farmers homes, and the number of adult family members engaged in agriculture, were important factors affecting crop diversification in the Damodar Valley Corporation command area in West Bengal (Kundu and Chattopadhyay, 2018). Shannon-Weiner index for crop diversity ranged from 0.347 for tubers to 0.998 for fruits. They stated that the crop diversity was influenced by local ecology, cultural practices, and socio-economic factor s(Thampi *et al.*, 2024)

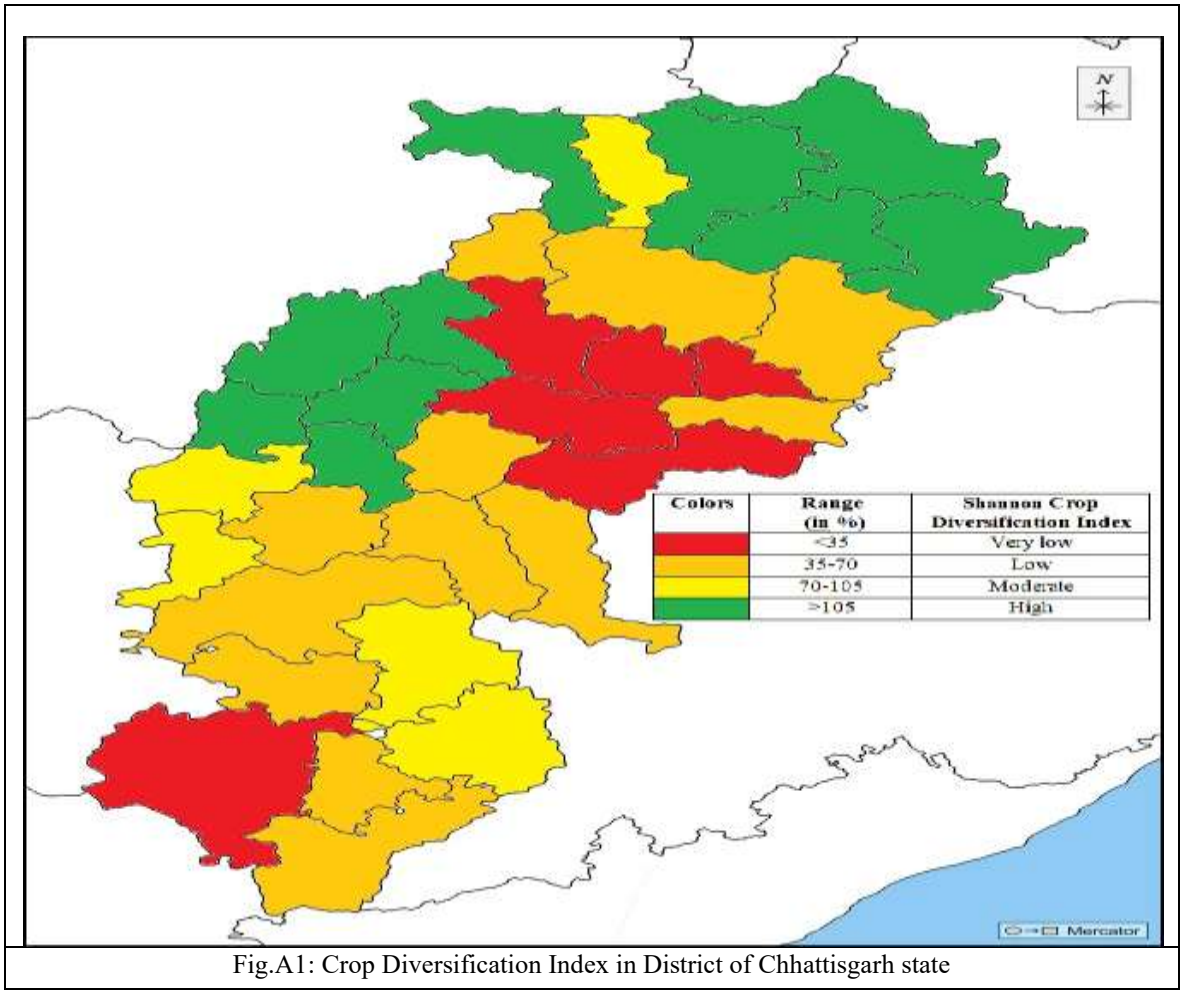

Fig.A1: Crop Diversification Index in District of Chhattisgarh state

2. **Simpson Diversity (Dominance)Index of Crops in district of Chhattisgarh state:**Simpson Diversity Index measures the dominance of a species in a community, hence it is called the dominance index.The Simpson Diversity Index of different districts of Chhattisgarh is depicted in Table A2 and Figure A2.From this, we can observe that the overall Simpson Diversity Index (Dominance) of Chhattisgarh was 0.368 i.e. only 36.8% of crops other than paddy are grown in the Chhattisgarh state, hence paddy is the dominant crop in Chhattisgarh. The table shows that the three lowest crop dominance indicesare in Janjgir-Champa (0.017), followed by Bijapur (0.028) and Shakti (0.035),owing to their geographical structure, soil type and available resources. The lowes tcrop dominance index means a low chance of the availability of second or other crops in the area. The table represented that the majority of the area is under paddy cultivation. On the other hand, the highest three Simpson Diversity Indexeswere reported in Kabirdham(0.699), Khairagarh-Chhuikhadan-Gandai (0.644) and Bemetra (0.625). The highest crop dominance index implies greater chance of availability of other crops than paddy in these districts. Where the Simpson Diversity Index is high, crops other than paddy are being grown, resulting in optimum use of resources.

The study shows that usually, SDI was highest in Northern Hills (0.467), followed by Bastar Plateau (0.299) and Chhattisgarh plain (0.234). The intensity of diversity in any region depends on the availability of natural resources as well as the social, economic and technological levels. Based on the data, it seems that Chhattisgarh Plain Zone has more social, economic and agro-technological levels as compared to Bastar Plateau and Northern hills Zones, but typically SDI was low as compared to other zones as farmers replace field crops with horticulture & commercial crops. Apart from paddy, many coarse cereals are growing the hills and plateau areas of Chhattisgarh. In the districts of Durg Division of C.G. plain zone, mostly Paddy is grown; for this reason, the average SDI in the plain zone is less.

Paddy ranks first in crop dominance with an average of 0.212 Simpson Diversity Index in the last 5 years.The study revealed that the paddy is dominant crop in Chhattisgarh state. To decrease the dependency on paddy, we need to adopt appropriate measures. It is a well-known fact that repeated cultivation of only one type of crop, i.e. paddy, will lead to lower fertility, increase pest incidences, and enhance the cost. Improvement in irrigation facilities in the Rabi season in required for the expansion of crops other than paddy. Additionally, there is need of bring awareness and motivation among the farmers to adapt pulses and oilseed crops. Government support in form of a policy or fine for the summer paddy should also be made and implemented. Procurement of major oilseeds (like mustard, linseed) and pulses (Lathyrus, chickpea) at Minimum Support Price (MSP) by the government will be a good initiative. Growing of fiber crops like Jute and Sun hemp in *Kharif* to bring crop diversity can also reduce the dependency on the import of jute bags from other states. Establishment of agro-processing units near farmer fields and involvement of SHGs and FPO can effectively enhance the area of a particular crop. For all this effective extension of scientific packages & practices related to oilseeds, pulses & horticulture crops need to be implemented.

Crop specialization was more in the Surguja and Balrampur district (Tribal area) than Durg and Raipur districts of the non-tribal area. The study observed that higher crop diversity indices were reported in the tribal area than non-tribal area due to the presence of lower cultivated area, inadequate facilities for irrigation, less marketing and infrastructural facilities and lack of awareness of government policy and programs(Kaushal, R. and Jain, B. C., 2023). The trend, pattern and determinants of crop diversification of small holder farmers in17 different districts of West Bengal. The study stated that the value of Simpson's index is the highest in Nadia district, followed by Murshidabad, showing the highest crop diversification in Nadia, followed by Murshidabad. Malda is an important district in terms of crop diversification, consistently showing a high value of Simpson's index. The study found that the 7 districts out of 17 districts continuously exhibited higher value of crop diversification index compared to the state as a whole. On the contrary, 10 districts always had crop diversification indices lower than the state figure. The study also noticed that the Nadia, Murshidabad and Malda districts have remained in the top five. Purulia, Birbhum, Bankura and South 24 Paragon's were the bottom five districts in terms of diversification of crops(Mithiya et al., 2018b).

Table A2: Simpson Diversity Index (Dominance) of crops in Chhattisgarh state (2022-23)

S.n.	Range(in %)	Simpson Diversity Index	Name of Crops
1.	<5	Very low	Cotton, Sorghum, Ragi, Sawa, Moog bean, Pean, Lentil, Sesamum, Linseeds, groundnut, Sugercane, Mustard, Niger, Pigeon pea,
2.	5-10	Low	Kodo millet, Soybean, Urdbean, Wheat, Maize,
3.	10-15	Moderate	Lathyrus
4.	>15	High	Chickpea, Paddy

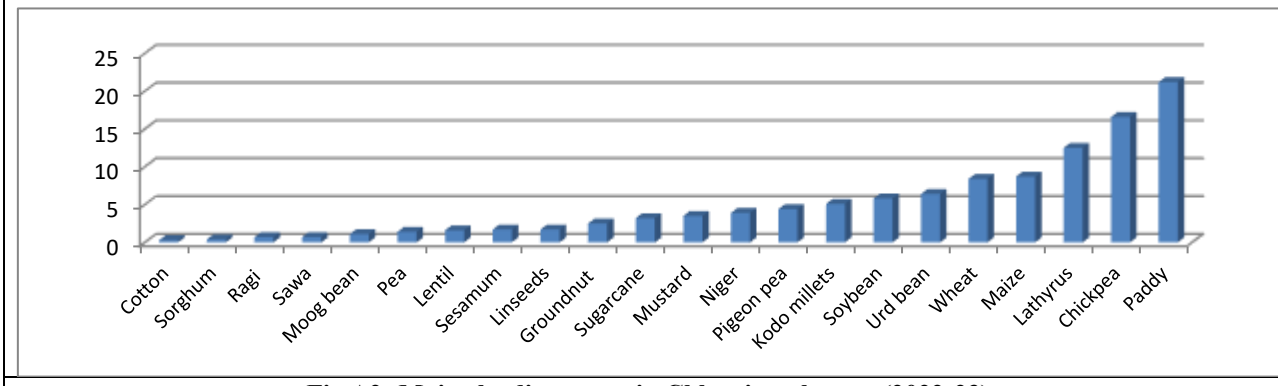

Fig.A2: Major leading crops in Chhattisgarh state (2022-23)

3. Trend analysis of Simpson Diversity Index of Crops in Chhattisgarh-The trend of Shannon Diversity Index of crops in Chhattisgarh was presented in Table A3 and Figures A3. The study is showing the decreasing trend of selected 21 crops out of 25 crops in Chhattisgarh except Cotton (58.07%), Sugarcane (40.07%), Wheat (30.38%), Maize (30.45) and Chickpea (23.46%). The main crop of the state is Paddy (-21.39); however, its area has been declining for the past few years (from 2015 to 2023). Likewise, the area of other cereal crops like Sorghum (-59.61%), Sawa (-55.19%) & Ragi (-54.05%) and pulse crops like Moog Bean (-51.5%) & Pea(-47.48%) and oilseeds like Linseeds(-47.7%) & Sesamum (-45.99%) have also declined.

The main reason for the decline in other crop areas, leaving some crops aside, is the cultivation of valuable crops or commercial crops. After the formation of the state, the total area under irrigation has increased to 8.48 lakh hectares. Additional irrigation capacity has been created in the area. The total irrigated area in the state has reached up to 39.27%. Horticultural crops (52.59%), 97.24% of the total water area has been developed for fish farming and livestock production (108.58%) during the 2019-20 to 2023-24. Apart from this, there is improvement in incentives, budget, effective extension, technology, education, infrastructure & empowerment in Chhattisgarh.

The study revealed that significant change was observed in the area under paddy, sorghum, maize, sawa, chickpea, pea, sugarcane and linseed, whereas an ineffective change was observed in wheat, kodo millets, ragi, pigeon pea, moog bean, urd bean, lathyrus, cotton, groundnut, sesamum, soybean, mustard and niger in Chhattisgarh state. This means that the area under only 8major crops is increasing or decreasing at a faster pace than the remaining crops.

Table A3: Average SimpsonDiversity Index &Compound Growth Rate (CGR) of Crops inChhattisgarh (During: 2015-2023)

Crops name	AverageSDI (Duration:2015-2023)	Rank	CGR (in %)	p-value	Crops name	AverageSDI (Duration:2015-2023)	Rank	CGR (in %)	p-value

Paddy	0.212	1	-21.400	0.000*	Pea	0.014	19	-47.489	0.676
Wheat	0.084	5	30.384	0.009	Lentil	0.016	17	-27.937	0.045*
Sorghum	0.004	23	-59.610	0.000*	others pulses	0.037	11	-40.963	0.000*
Maize	0.087	4	30.453	0.076	Sugarcane	0.032	13	40.070	0.100
Kodo millets	0.051	8	-37.459	0.000*	Cotton	0.003	25	58.075	0.000*
Ragi	0.007	22	-54.057	0.000*	Groundnut	0.025	14	-42.991	0.007
Sawa	0.007	21	-55.194	0.000*	Sesamum	0.017	15	-45.996	0.002*
others cereals	0.016	18	-48.051	0.008	Soybean	0.058	7	-37.330	0.000*
Chickpea	0.166	2	23.469	0.331	Niger	0.039	10	-40.788	0.000*
Pigeon pea	0.044	9	-38.461	0.022*	Mustard	0.035	12	-40.350	0.000*
Moog bean	0.011	20	-51.598	0.000*	Linseeds	0.017	16	-47.712	1.46
Urd bean	0.064	6	-34.476	0.000*	others oilseed	0.003	24	-60.939	0.000*
Lathyrus	0.125	3	-27.937	0.000*	**Total**	**1.173**	**-**	**1.487**	**1.368**

Note: * sign represented the figure was significance at 5 % level.

The trend of CEI of pulse group was ranged from0.704 to 0.722, and in the case of oilseed index, was varied between 0.505 and 0.644 during the years 2005-06 and 1986-87. The result showed that there is no specific trend of diversification in the study area. Commercial crops showed the lowest CEI (0.480) for the year 1982-83 and the highest index (0.658) for 2007-08,representing the increase in area under commercial crops. The overall diversification index for commercial crops was 0.616. It can be stated that the overall CEI was higher in the initial years of the study and relatively lower in recent years in the case of vegetables and oilseeds in Karnataka(Acharya *et al.,* 2011).The Simpson Index of Diversity (SID) ranged from 0.59 to 0.64 in South Asia during the 1981-82 to 1999-2000. The study shows that gradual diversification in South Asia under the high-value crop sector, like fruits and vegetables. Further, the agricultural diversification in India is gradually picking up momentum in favor of high value crops/livestock/fishery activities to augment incomes rather than a copping strategy to manage risk and uncertainty. However, the nature of diversification differs across regions due to wide heterogeneity in agro-climatic and socio-economic conditions(Joshi, P.K. *et al.,* 2003a).The crop sector is steadily diversifying in India. The SID slowly moved up from 0.63 in TE 1981-82 to 0.66 in TE 1998-99. The trends showed that the nonfood grain crops have gradually replaced food grain crops and later went up from about 30% of area in TE 1981-82 to 35% in TE 1998-99, but in value terms, it went up significantly from about 52% to 60% in the respective periods. In search of higher income, non-food grain crops, like oilseeds, fruits, vegetables, spices and sugarcane have mainly been substituted by coarse cereals. The level of crop diversity was also significantly decreased during 1990 -2008 in most regions except Faridpur, Khulna and Sylhet in all area of Bangladesh due to an increase in the relative prices of vegetables and urea fertilizer, extension expenditure, labour stock per farm, average farm size, irrigation and a reduction in livestock per farm increase crop diversity(Rahman and Kazal, 2015). The percentage share of Gross cropped area has shifted from food crops to non-food crops, and crop production has mainly diversified towards the horticulture sector, mostly in favor of fruits and vegetables, during 1991-92 to 2015-16 in India(Ansari, 2018).Diversification was high in the northern and southern blocks, such as Nighasan, Dhaurehra, Isanagar, Mitauli, and Pasgawan, while the blocks in the western and central regions registered low intensity of diversification in Kheri District, Uttar Pradesh(Khan and Ahmad, 2019). Food grain crops, the area under superior cereals, i.e., rice and wheat, is increasing; while that of coarse cereals (millets) is on decline. The area share of jute and allied fibers has also gone down substantially during the 1966-67 to 1996-97 in India(Hazra, C.R., 2001).

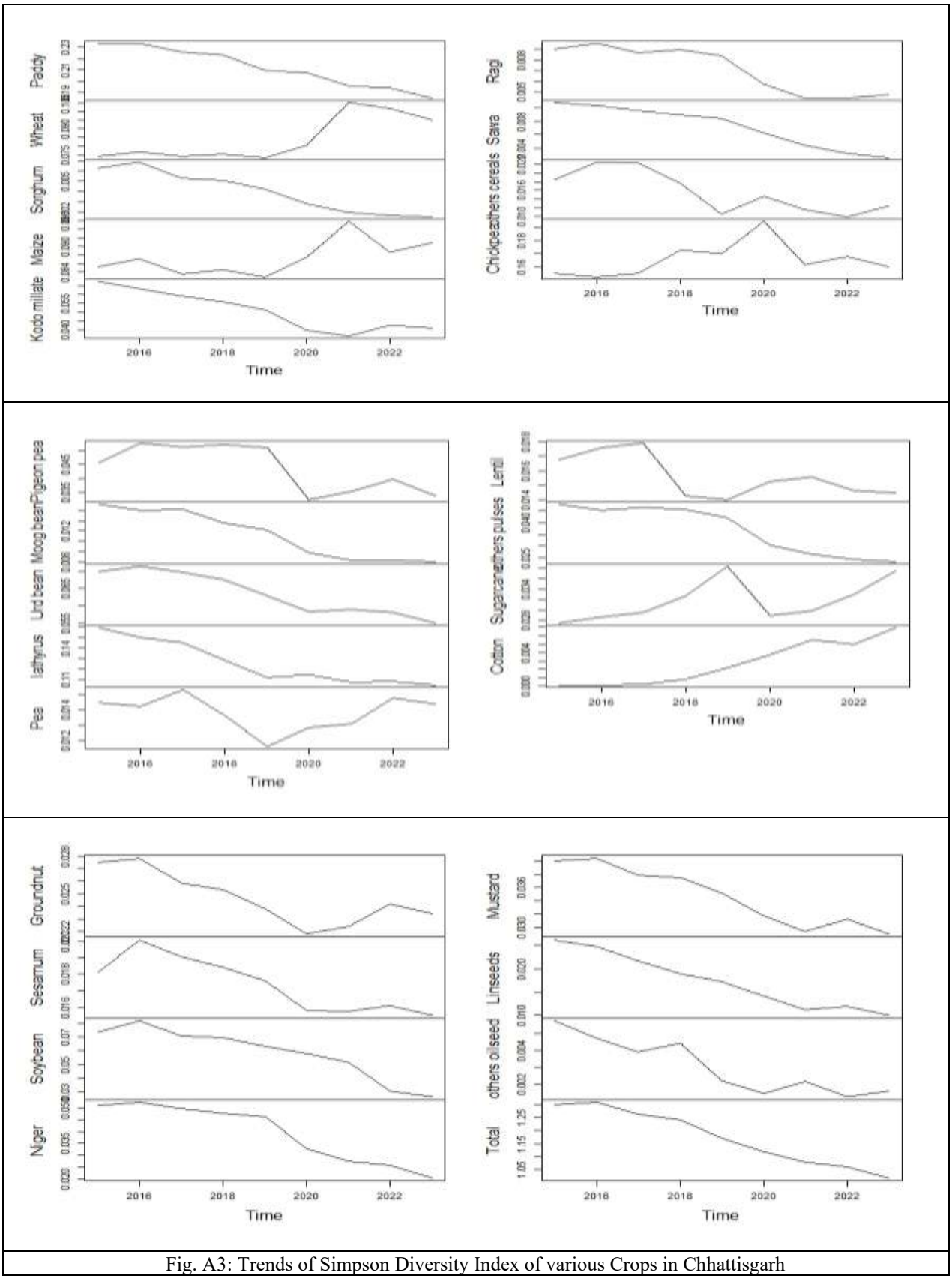

Fig. A3: Trends of Simpson Diversity Index of various Crops in Chhattisgarh

4. Irrigation Intensity of Chhattisgarh:- The Irrigation intensity distribution in districts of Chhattisgarh presented in Table A4 and figure A4. The districts of Chhattisgarh dividend into 4 categories very low(<25%), low(25-50%), moderate(50-75%) and high(>75%) on the basis of irrigation intensity. The table was revealed that the 18 districts belong to very low categories,6 district fall in low categories, 7 districts fall in moderate categories and only 2 districts fall in high categories out of 33 districts of Chhattisgarh.

TableA4: Irrigation Intensity distribution in district of Chhattisgarh state

S. n.	Range (in %)	Irrigation Intensity	Name of districts
1.	<25	Very low	Dantewada, Sukma, Narayanpur, Bijapur, MCB, Korba, Jashpur, Balrampur, Bastar, Kondagaon, Koriya, GPM, Surajpur, Sarguja, MMA, Kanker, Raigarh, Sarangarh.
2.	25-50	Low	KCG, Rajnandgaon, Mahasamund, Mungeli, Gariyaband, Kabirdham.
3.	50-75	Moderate	Bemetra, Bilaspur, Balod, Baloda-Bazar, Durg, Dhamtari, Sakti.
4.	>75	High	Raipur, Janjgir-Champa.

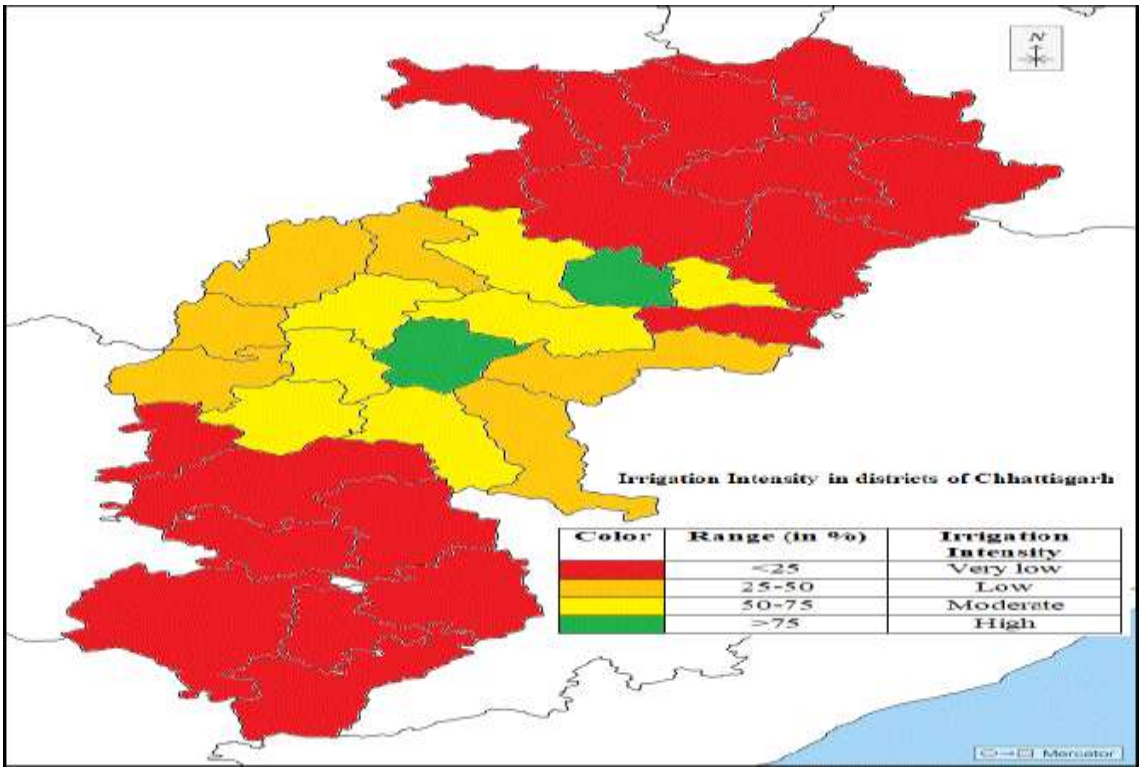

Fig.A4: Irrigation Intensity in district of Chhattisgarh state.

The study was showed that the few no. of districts namely Raipur and Janjgir-Champa were fall in high categories because well develop of irrigation canals in Hasdev, Kharun and Mahanadi rivers, whereas more than 70 % district fall under low categories due to less develop of irrigation canals and lack of infrastructure. Should be focus on extension of canals and increases by irrigated area along with increases of budget in this sector. Should be effectively implication of (PM Micro Irrigation Scheme) drip irrigation in Northetn hills and Bastar Plateau Zones. Effective consider of VB-RAM-G scheme in water conservation and water resources development.

5. Relation between Crop diversification and Irrigation Intensity in Chhattisgarh state: The relationship between Crop diversification index and irrigation intensity in Chhattisgarh state showed in Table A5 and Figure A5. Irrigation is vital for crops because it supplies essential water for germination, nutrient transport, and growth, especially in dry areas, boosting yields, enabling year-round cultivation, ensuring food security, supporting multiple cropping stabilizing food production and supporting high-quality produce by mitigating drought and creating optimal soil conditions. It allows for better control over water availability, leading to more reliable and productive agriculture. Highest crop diversification found to be in Northern hills 120.61 % followed by Chhattisgarh Plain (65.16%) and Bastar Plateau (55.19%). In case of irrigation intensity, highest value has Chhattisgarh Plains (45.68%), followed by Northern Hills (6.85%) and Bastar Plateau (4.93%). The good efficient use of water for grow of many crops in a around year in Northern Hills due management practices, effective scheme implication, soil type, adopted good water conservation technique, and mutual irrigation management of tubewell and wells . The crop diversification & irrigation intensity of Chhattisgarh state was only 101.60 % and 36.06%.The table was presented that the significantly negative relationship between crop diversification index and irrigation intensity in Chhattisgarh state. Major cultivated area fall under Chhattisgarh Plains zone, but irrigation facilities was not sufficient for grown of many no. of crops in around the year. The main source of irrigation here is only canal, which is seasonal. In the state of Chhattisgarh, paddy is mainly cultivated as a single crop and the dependence on paddy is very high. The highest positive relationship found to be in Kabirdham district followed by Balrampur district and negative relationship showed in Janjgir-Champa district followed by Raipur and Sakti districts.

Irrigation intensity and groundwater irrigation are positively related to the diversification in northern and eastern region of Birbhum District of West Bengal(Sahal and Rudra, 2017).

Development of agriculture is possible only through proper use of water and efficient use of irrigation facilities. Therefore, to achieve double cropping, it is necessary to build dams, extension of canals, as well as develop traditional irrigation methods. Currently, pulses and oilseeds should be expanded by reducing the dependence on paddy crop. Consolidation of cultivated land is essential for proper use of irrigation resources and effective scheme implementation. For consolidation of land, the government should give relaxation in registration of land and make efforts in this area.

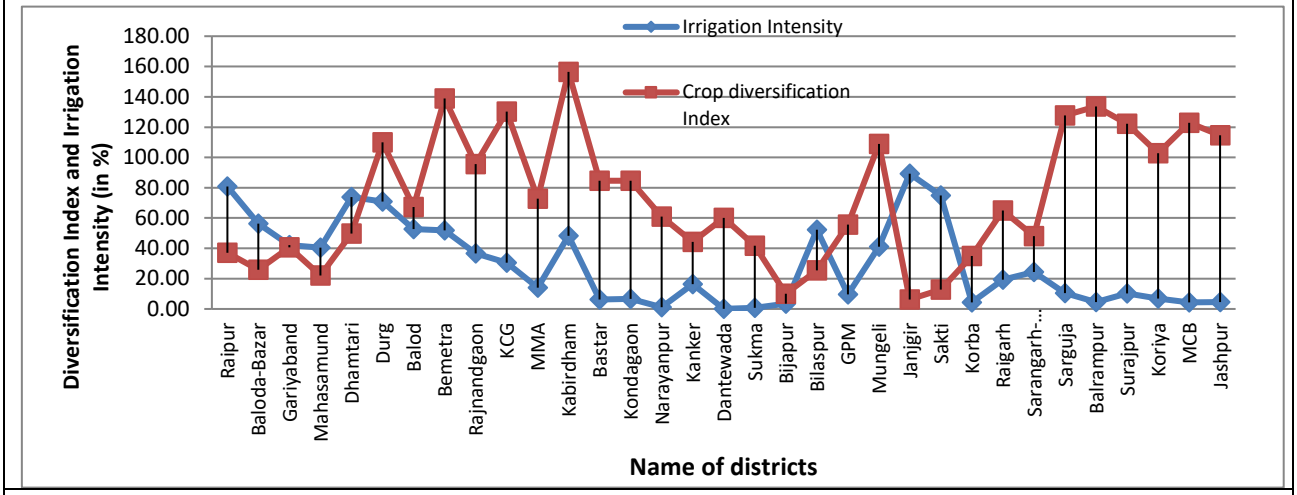

Fig. A5: Relationship between crop diversification and irrigation intensity in district of Chhattisgarh.

Table A5: Relationship Analysis of between Crop Diversification and Irrigation Intensity in Agro-climatic Zones of Chhattisgarh.

Area	Crop diversification Index (in %)	Irrigation Intensity (in %)	Correlation Coefficient (r)	Direction	Regression Coefficient (*b*)	p-value
C.G. Plains	65.16	45.68	-0.186	Negative	-0.338	0.432
Northern Hills	120.61	6.85	0.063	Positive	0.235	0.905
Bastar Plateau	55.19	4.93	0.046	Positive	0.214	0.920
Overall Chhattisgarh state	101.60	36.06	-0.25	Negative	-0.40	0.147

***Sing represents the significant at 5% level of significance*.

CONCLUSIONS

The relationship between crop diversification index and irrigation intensity in Chhattisgarh state was found to be non-significantly negative. Major cultivated area fall under Chhattisgarh Plains zone, but irrigation facilities was not sufficient for grown of many no. of crops in around the year. The main source of irrigation here is only canal, which is seasonal, means less chance of increases of area under crops in Chhattisgarh a whole year. In the state of Chhattisgarh, paddy is mainly cultivated as a single crop and the dependence on paddy is very high. The highest positive relationship found to be in Kabirdham district followed by Balrampur and Bemetra district due to field irrigated by tube well, good groundwater level and fertile black soil. Various geographical structures are favorable for the growth of many crops and a sufficient number agro-based processing units are available, while the negative relationship showed in Janjgir-Champa district followed by Raipur and Sakti districts due to main source of irrigation in these areas is the seasonal canal, which lasts only for one season, supporting mono cropping of paddy here, geographical structure, low land with big bunds. Paddy ranks first in crop dominance with an average of 0.212 Simpson Diversity Index in the last 5 years.To decrease the dependency on paddy, we need to adopt appropriate measures. Improvement in irrigation facilities in the Rabi season in required for the expansion of crops other than paddy. Additionally, there is need of bring awareness and motivation among the farmers to adapt pulses and oilseed crops. Government support in form of a policy or fine for the summer paddy should also be made and implemented. Procurement of major oilseeds (like mustard, linseed) and pulses (Lathyrus, chickpea) at Minimum Support Price (MSP) by the government will be a good initiative. Growing of fiber crops like Jute and Sun hemp in *Kharif* to bring crop diversity can also reduce the dependency on the import of jute bags from other states. Should be develop genetic modify varieties against the climate realigned special drought registrant varieties of pulses and oilseed crops. Establishment of agro-processing units near farmer fields and involvement of SHGs and FPO can effectively enhance the area of a particular crop. For all this effective extension of scientific packages & practices related to oilseeds, pulses & horticulture crops need to be implemented.

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