Research Article

Changing Farming Patterns in the West Kameng District, Eastern Himalaya

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Abstract
Farming practices form a cornerstone of rural livelihoods but remain highly dynamic. These practices exhibit considerable geographical variation across regions, shaped by a wide range of socio-economic factors. West Kameng District, located in the westernmost part of Arunachal Pradesh, has recently emerged as the state's "agricultural bowl" owing to its substantial and diverse agricultural output. The district benefits from a favourable agro-climatic zone that supports a wide array of field and horticultural crops. This study surveyed 423 farming households across 15 purposively selected villages identified as agricultural hotspots. Only active farmers were included, with a sample size fixed at 35% of the total households in each village. Data were analysed using the F-test and Compound Annual Growth Rate (CAGR) to assess the statistical significance of crop production differences and long-term growth trends. Results revealed a statistically significant difference in the production of kharif and rabi crops across years ($P = 0.0047$). However, CAGR values indicated only a marginal increase over time (0.038 for kharif and 0.004 for rabi), and the associated significance value of zero suggests no meaningful change in overall production levels in recent years. The study also identifies the primary drivers of shifts in farming patterns and recommends the adoption of climate-resilient and sustainable agricultural practices in the region.
Keywords: Farming, change, patterns, Kharif, Rabi

Introduction

Agricultural practices and crops are highly dependent upon a particular geographical area. A cropping pattern refers to the distribution and arrangement of different crops cultivated in a specific area. In simple words, it is the sequential arrangement of the crops grown in different seasons over an allotted agricultural land. The cropping types and patterns are influenced by various physical and socioeconomic factors, including rainfall, temperature, humidity, and soil quality, as well as socio-economic factors like demand, supply, value, and minimum support price (MSP). The cropping pattern, defined as the proportion of land allocated to different crops at a specific time, is a crucial indicator of agricultural practices and reflects the complex interactions between ecological, economic, and social factors (Kaur, 2025). Existing literature highlights the complex nature of cropping pattern changes and their diverse impacts. Numerous studies have explored that the shift from traditional crops to cash crops is mostly driven by market demand and profitability; moreover, others have explained the role of technological advancements, such as high-yielding varieties and irrigation infrastructure, in enabling diversification and increased productivity (Chand & Gulati, 2012; Birthal et al., 2015). Farming systems are dynamic, complex socio-ecological systems that provide food, feed, and cash and result from past farmers' livelihood strategies and land use decisions. Consequently, farming system changes and their drivers are heterogeneous and complex, varying between households, locations, and time (Carswell, 2000; Tittonell et al., 2011; Kebede et al., 2019).

Additionally, the growing impact of climate change on cropping patterns has led farmers to adapt their practices to cope with changing temperature and rainfall patterns (Aggarwal et al., 2004). Such variations in temperature, humidity, and rainfall drive the nature of the soil, agricultural practices, and patterns. Additionally, an understanding of how certain crops respond to specific soil types and underlying climatic conditions that support their growth and yield (Thongdok & Sati, 2024). Cropping patterns are significantly influenced by various socio-economic factors, while underlying climatic conditions play a critical role in shaping changes in crop patterns and production. Notably, under rain-fed conditions, the production potential of a crop depends on the climatic conditions of an area. Therefore, each crop will flourish within a specific climatic setting that can be improved by management, yet climate change will alter the output of these requirements and subsequently, the geography of crop suitability and patterns (Travis, 2016; Chemura et al., 2020).

Nowadays, farming patterns have shifted from the cultivation of traditional crops to the cultivation of modern or cash crops, and with such a shift, farmers have adopted the practice of cultivating crops with higher demand and economic value. Traditional crops, which had high traditional value but no demand or economic value. The crops grown were fully subsistence, self-consumed, and lacked commercial value. Consequently, determinants such as population and climate change immensely influence the agricultural scenario of a region. As rising food crop demand led farmers to adopt those crops that have higher demand and price in the market, for the economic incentives and viability of the marginal farmers, on the other hand, due to socio-economic and climate variability; fluctuation of temperature, humidity, and rainfall and varying demand, and value of the crops have significantly modified the cropping patterns and farming systems (Thongdok & Sati, 2024). A study conducted by Thongdok et al. (2025) deliberates that due to a shift in farming patterns, like the introduction of fresh commercial crops replacing the traditional crops, has also enhanced the livelihood of the farmers, as commercial crops have higher demand and value in the market, hence, improving the revenue and livelihood sustainability of the farmers.

Study Area

West Kameng district is among the largest districts in the state of Arunachal Pradesh. The district is the westernmost region, sharing its international boundary with Bhutan to the west, the Pakke-Kesang district to the east, and Assam to the south. The district lies between 91° 30′ and 92° 40′ East longitudes and 26° 54′ to 28° 01′ North latitudes (Figure 1.1). The district's topography is undulating, and it ranges from 229 m up to 7090 m above mean sea level. The agroclimatic conditions also vary as the region is characterised by mainly five major climatic zones: sub-tropical, temperate, sub-temperate, alpine, and tundra, respectively. There are five major ethnic groups, which are the Shertukpen, Monpa, Sartang, Bugun (Khowa), and Aka (Hrusso). They have an agrarian-based occupation or economy; approximately 69.49 % of the total population is engaged in agriculture and allied activities in the district.

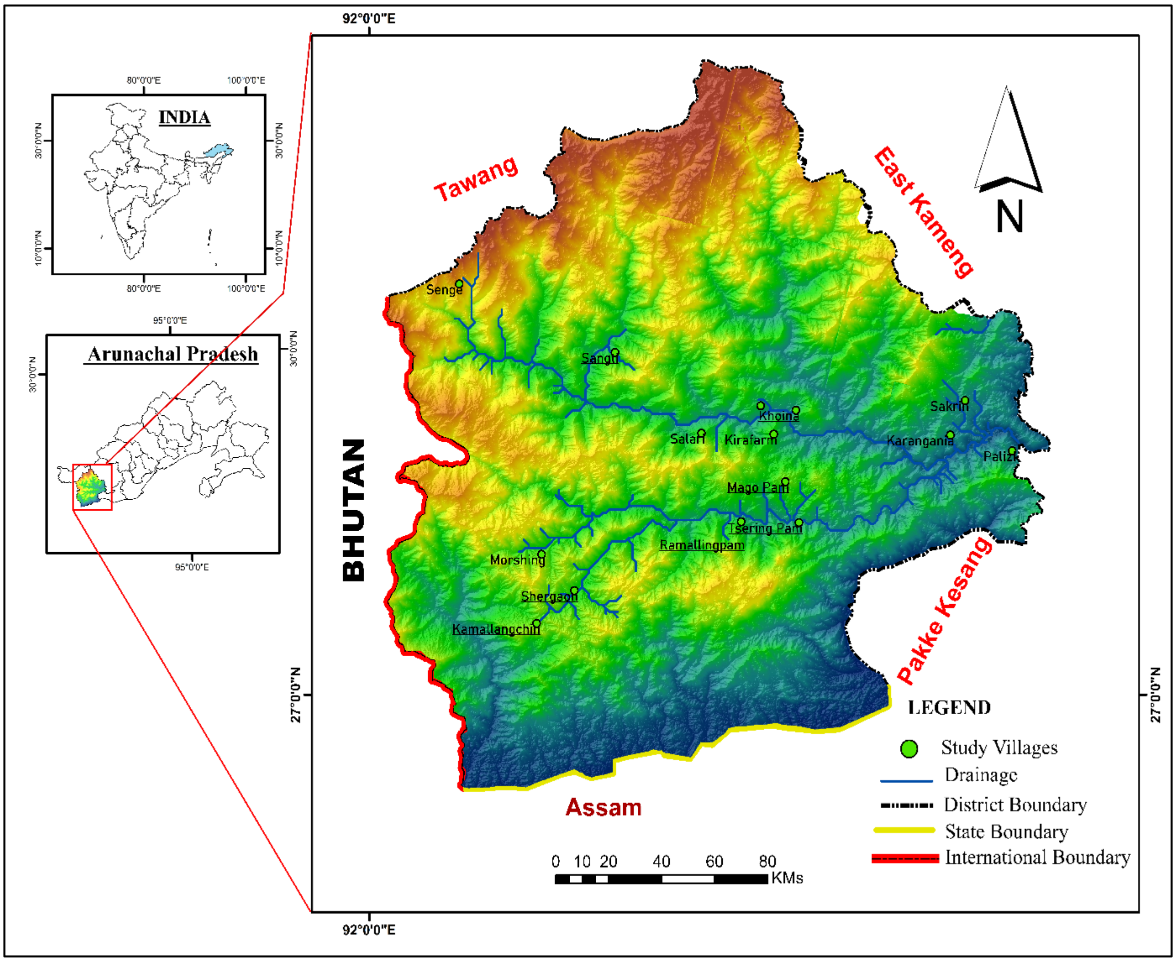

Figure 1.1. Map of the West Kameng District, Arunachal Pradesh

Methods

Data Collection

The study encompasses a wide range of data sources. Both primary and secondary sources have been broadly applied. Primary sources on demographic characteristics were acquired through a field survey. Moreover, primary data on agriculture production and productivity for the year 2022 were also obtained from respective fields. In this study, the purposive sampling technique was employed, where only farmers and contractors were surveyed and questions were asked on farming systems, production, productivity, demand and supply, and average prices of the different crops. The interviews were conducted using schedules and both open- and closed-ended questionnaires. Fifteen villages were surveyed from five CD blocks (three villages from a block). Altogether, 423 households were surveyed, with a sample size of 35% of the total HHs present in the village (Table 1.1).

Secondary sources of data, including agricultural production records from 2015 to 2021, were obtained from the records of the Office of the District Agriculture Office, Bomdila, West Kameng District, and partial demographic records from the data of Accredited Social Health Activists (ASHA).

Table 1.1. Salient information of the study villages

Village	CD Block	Number of the HHs surveyed	Total number of HH	% of HH surveyed	Elevation (in m)	Location
Morshing	Kalaktang-Rupa Block	13	35	35	2063	27°10’26’’N;92°12’23’’E
Kamallangchin		19	54	35	1725	27°09’58’’N;92°15’76’’E
Shergaon		38	106	35	1957	27°14’71’’N;92°27’95’’E
Ramallingam	Sinchung Block	7	20	35	1935	27°18’38’’N;92°46’51’’E
Tsering Pam		11	30	35	1377	27°20’24’’N;92°49’47’’E
Mago Pam		14	40	35	2252	27°24’96’’N;92°52’34’’E
Salari	Dirang Block	53	149	35	1253	27°32’58’’N;92°43’76’’E
Sangti		74	210	35	1611	27°24’10’’N;92°16’40’’E
Senge		56	160	35	2805	27°44’75’’N;92°17’95’’E
Jerigaon	Nafra Block	41	117	35	1777	27°33’94’’N;92°47’95’’E
Kirafarm		12	35	35	1950	27°35’50’’N;92°47’69’’E
Khoina		13	36	35	1734	27°35’75’’N;92°48’61’’E
Karangania	Thrizino Block	11	29	35	1284	27°17’56’’N;92°42’26’’E
Sakrin		21	59	35	1144	27°21’03’’N;92°43’35’’E
Palizi		40	112	35	752	27°17’30’’N;92°46’46’’E
	Σx=	423	1192	35.48		

Source: Thongdok et al., 2025

Data Analysis

To understand the changing pattern between the kharif and rabi productions, a parametric trend approach was adopted. The F-test is a statistical test used to compare the variances of two or more groups to determine if there is a significant difference between them. It calculates an F-statistic, which is the ratio of two variances, and uses the F-distribution to test the null hypothesis that the variances are equal. It is a fundamental factor of Analysis of Variance (ANOVA) and is also used in linear regression to assess a model's goodness of fit. Moreover, the compound annual growth rate (CAGR) was used. It is mainly employed for analysing trends and assessing agricultural productivity, and it also provides a steady, average yearly growth rate for crops.

F-test,

$$\sigma^2 = \frac{\sum(x - \bar{x})^2}{n - 1}$$

Where,

σ^2 = Variance

x = Values given in a set of data

$\bar{x}$ = Mean of the data

n = Total number of values

Compound Annual Growth Rate (CAGR),

$$CAGR = \left(\left(\frac{EV}{BV}\right)^{\frac{1}{n}} - 1\right) \times 100$$

where:

EV = Ending value

BV = Beginning value

n = Number of years

Results

Production and Productivity of Crops

The area's favourable climate enables the cultivation of a wide range of cruciferous and non-cruciferous crops, with farming practices featuring both Kharif and Rabi seasons. Kharif crops include paddy, maize, millet, cabbage, tomatoes, chillies, ginger, garlic, and various other vegetables. Rabi crops comprise potato, green peas, wheat, barley, and mustard.

The comprehensive study findings reveal that the production and productivity rate of crops are significant. However, the intensity and rate of production of Rabi crops have seen a decreasing trend over the years. On the other hand, the production and productivity rate of Kharif crops have been witnessing an increasing trend. Farming practices have shifted, particularly in crop selection and cultivation methods. There is a transition from traditional to modern farming practices. Traditional crops have lower demand and economic value than modern or commercial crops, which have higher demand and economic value in the market. Due to such factors, the region is witnessing a drastic shift in farming patterns, such as crop choice and cultivation methods.

The study encompasses the crop production data of eight consecutive years, starting from 2015-2022, including both Kharif and Rabi crops. Table 1.2 figures from the years 2015 and 2016 show fluctuations in certain crops and productions; maize, garlic, wheat, and millets have shown a decreasing trend, whereas crops like tomato, cabbage, green peas, and potato have seen an increasing trend.

Table 1.2. Production and productivity of Kharif and Rabi crops (2015-2016)

Season	Crops	Area (in Ha)		Production (in MT)		Productivity (MT/ha)	
		2015	2016	2015	2016	2015	2016
Kharif	Paddy	882	882	1199.52	1199.52	1.36	1.36
	Maize	2815	2900	4785.5	4885.5	1.7	1.68
	Millet	1081	820	1016.14	946	0.94	1.15
	Cabbage	190	200	2584	2800	13.6	14
	Tomato	220	223	2901.8	3100	13.19	13.9
	Other vegetables	107	107	1886.48	1395.28	17.63	13.4
	Ginger	52	52	189.28	189.28	3.64	3.64
	Chillies	59	62	230.1	245	3.9	3.10
	Garlic	16.5	16	41.25	40	2.5	2.5
Rabi		5422.5	5438	14834.1	14770.7	58.46	54.54
	Wheat	227	226	211.11	210.18	0.93	0.93
	Barley	93	92	69.75	69	0.75	0.75
	Mustard	34	34	31.62	31.62	0.93	0.93
	Potato	392	390	3316.32	3299.4	8.46	8.46
	Green peas	60	63	144	152	2.4	2.42
		806	805	3772.8	3762.2	13.47	13.49

Source: Office of the ADO, Bomdila, and Primary field survey, 2023

Similarly, the data from the 2017-2018 shows a declining trend of wheat, paddy, maize, other vegetables, and an increasing trend of tomato, cabbage, chilies, potato, and green peas.

Moreover, the period also depicts the abandonment of various crops like millet, ginger, garlic, and barley (Table 1.3).

Table 1.3. Production and productivity of Kharif and Rabi crops (2017-2018)

Season	Crops	Area (in Ha)		Production (in MT)		Productivity (MT/ha)	
		2017	2018	2017	2018	2017	2018
Kharif	Paddy	883	820	1200	975	1.35	1.18
	Maize	2814	2245	4789	3020	1.72	1.34
	Cabbage	225	210	2995	3500	13.32	16.67
	Tomato	231	300	3000	4100	12.98	13.66
	Other vegetables	108	--	1408.32	--	13.4	--
	Chilies	65	100	251	1134.65	3.87	11.34
Rabi		4326	3675	13643.32	12729.65	46.64	44.19
	Wheat	227	200	211.11	187.89	0.93	0.94
	Mustard	35	--	32	--	0.91	--
	Potato	395	398	3416	3879	8.65	15.29
	Green peas	67	70	160	178	2.39	2.55
		724	668	3819.11	4244.89	12.88	18.78

Source: Office of the ADO, Bomdila, and Primary field survey, 2023

Table 1.4 shows an increasing production trend of crops like tomato, cabbage, chilies, potato, and green peas. The period also shows the introduction of fresh cash crops like cauliflower, capsicum, and green beans in the year 2019, and the abandonment of crops like paddy, maize, other vegetables, wheat and mustard. In addition, the figures from the year 2020 show extremely low production owing to the COVID-19 outbreak.

Table 1.4. Production and productivity of Kharif and Rabi crops (2019-2020)

Season	Crops	Area (in Ha)		Production (in MT)		Productivity (MT/ha)	
		2019	2020	2019	2020	2019	2020
Kharif	Tomato	390	280	7254.5	2700	18.61	25.90
	Cabbage	230	98	3890	1500	16.91	15.3
	Cauliflower	--	66	--	515	--	7.8
	Capsicum	--	35	--	216	--	6.17
	Chilies	78	25	376	75	4.8	3
Rabi		698	504	11520.5	5006	40.32	58.17
	Potato	404	130	4000	2700	9.10	20.6
	Green Pea	58	14	135.8	31	2.34	2.21
	Green beans	39	33	309	41	7.92	1.24
		462	177	4135.8	2772	11.44	24.05

Source: Office of the ADO, Bomdila, and Primary field survey, 2023

Lastly, the figures from Table 1.5 display a high production rate of both Kharif and Rabi crops. There is an increase in cash crop cultivation and production. Of all the crops, tomato, cabbage, and potato have the highest production and productivity. Viewing the flourishing of the cultivation of various cash crops in the region.

Table 1.5. Production and productivity of Kharif and Rabi crops (2021-2022)

Season	Crops	Area (in Ha)		Production (in MT)		Productivity (MT/ha)	
		2021	2022	2021	2022	2021	2022
Kharif	Tomato	420	428	7800	8200	18.57	19.15
	Cabbage	245	247	3900	4100	15.91	16.59
	Cauliflower	116	131	1500	1605	12.93	12.25
	Capsicum	80	94	1200	1320	15	14.04
	Chillies	89	98	1050	1280	11.79	13.06
		950	998	15450	16505	74.2	75.09
Rabi	Potato	415	423	5300	5890	12.77	13.92
	Green Pea	69	76	157	178	2.27	2.34
	Green beans	41	35	360	375	8.78	10.71
		525	534	5817	6443	23.82	26.97

Source: Office of the ADO, Bomdila, and Primary field survey, 2023

Figures 1.2 and 1.3 show the production and trend of both the kharif and Rabi crops. Although it is apparent that the trend of both Kharif and Rabi crop production is increasing, a positive trend has been observed over the last eight years.

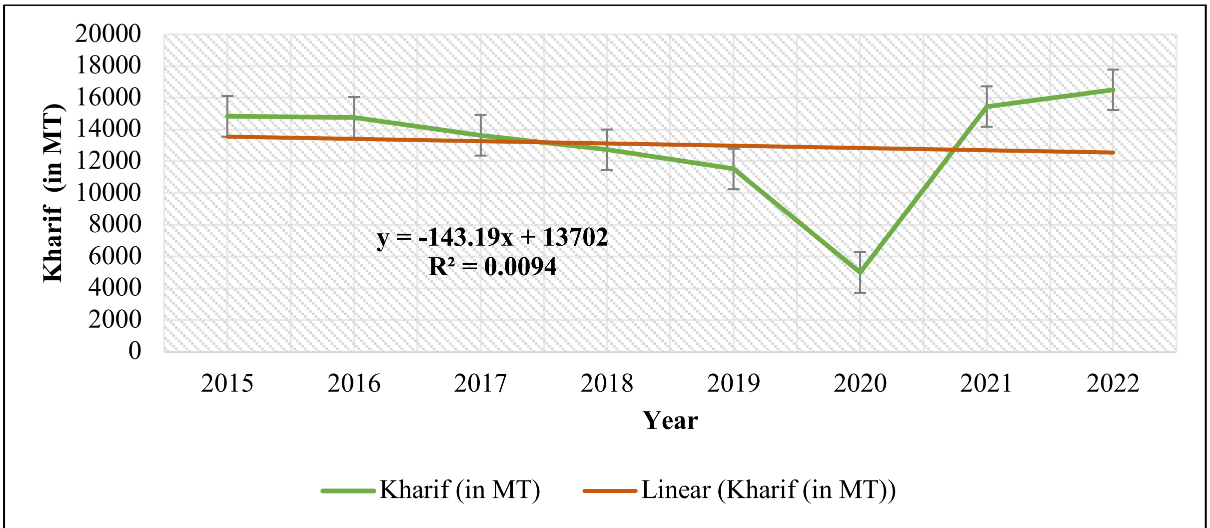

Figure 1.2. Production and trend of Kharif crops (2015-2022)

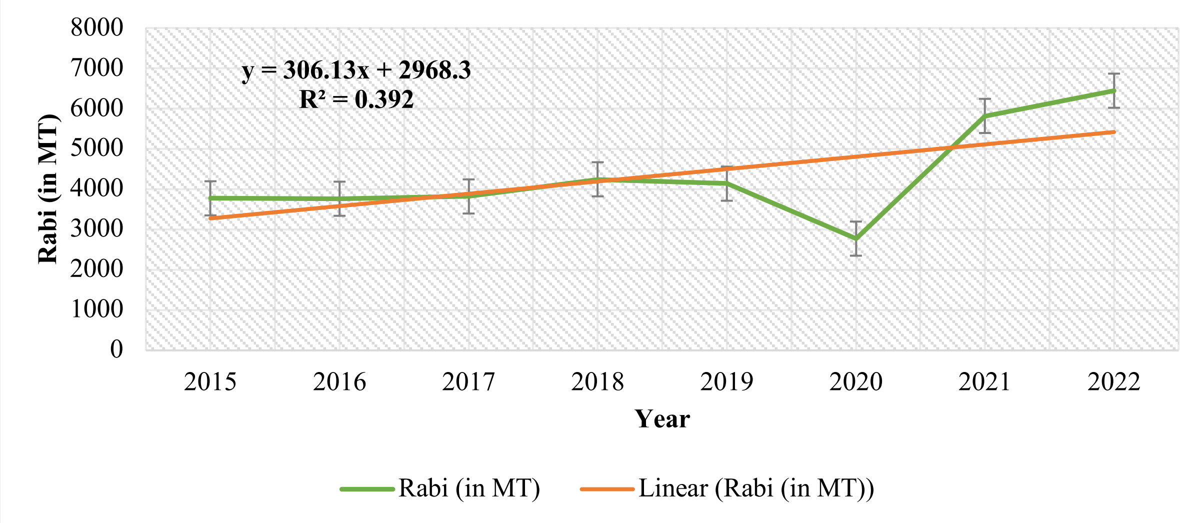

Figure 1.3. Production and trend of Rabi crops (2015-2022)

The results of the F-statistics reveal a significant production trend of the principal crops over the last eight years. The P-value of the statistics shows strong significance of 0.0047, which is under the standard P-value of the F-statistics (Table 1.6).

Table 1.6. F-Test Two-Sample for Variances of Kharif and Rabi production (2015-2022)

	Kharif (in MT)	Rabi (in MT)
Mean	13057.40875	4345.85
Variance	13048623.74	1434303.835
Observations	8	8
df	7	7
F	9.097531097	
P(F<=f) one-tail	0.004662591	
F Critical one-tailed	3.78704354	

*Alpha=<0.05

To understand the growth rate of the principal crops over the last eight years, a Compound Annual Growth Rate (CAGR) was calculated, and the statistics also reveal significant growth over the years (Table 1.7).

Table 1.7. Compound annual growth rate (CAGR) analysis of Kharif and Rabi crops

Kharif (in MT)		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	Case Sequence	.975	.062	.850	15.845	.000
	(Constant)	14263.244	5363.346		2.659	.038
Rabi (in MT)	Case Sequence	1.061	.040	1.719	26.845	.000
	(Constant)	3047.715	676.421		4.506	.004

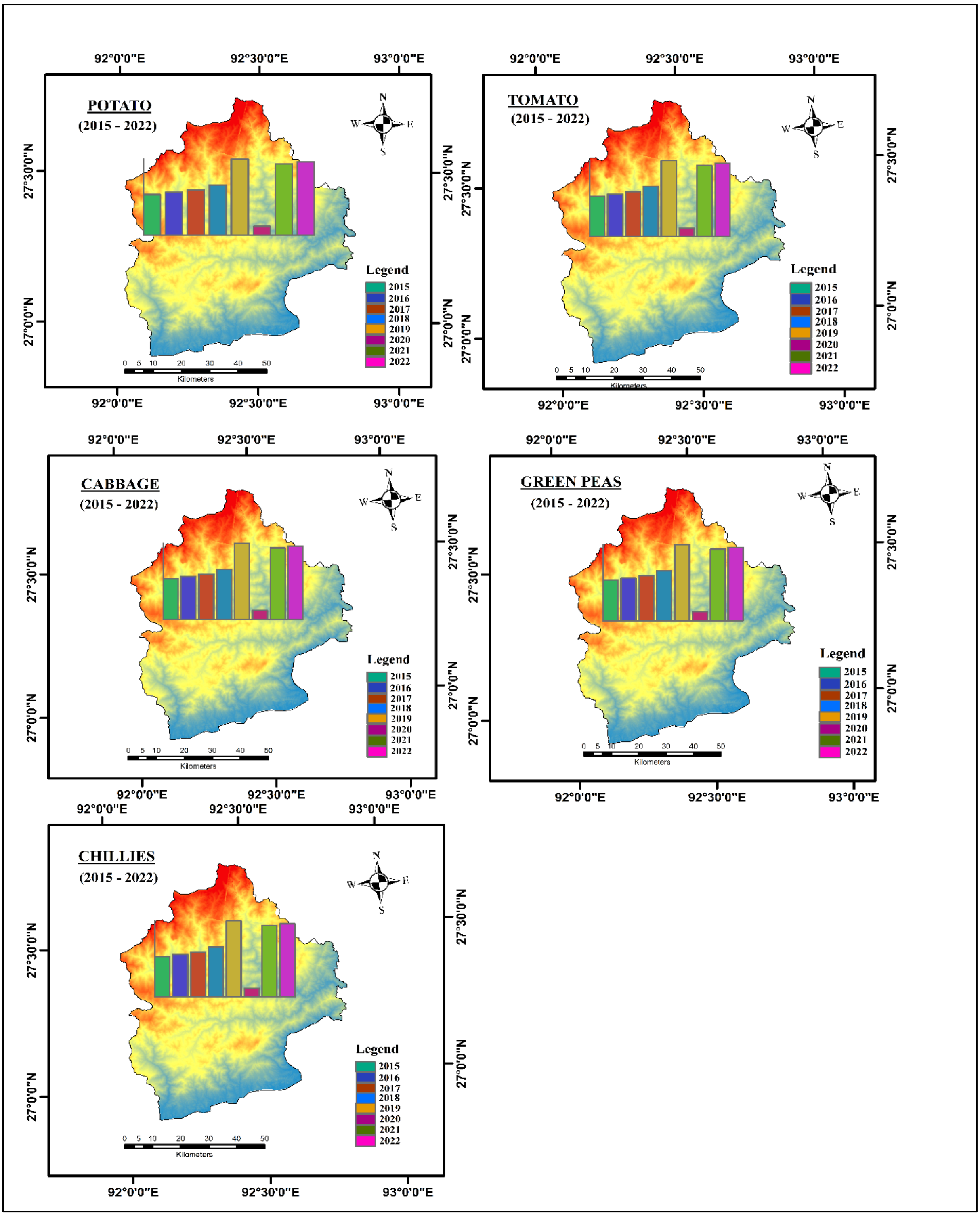

Fig. 1.4. Thematic map showing the temporal variation of crop production (2015-2022)

Factors Affecting the Change in Farming Patterns

The study identified various principal socio-economic factors affecting the changing patterns of crops and their practices in the study area.

Declining Demand and Economic Value of the Traditional Crops

In the past, the farming systems were fully subsistence; the crops produced were used for their consumption rather than for commercial purposes. However, over the years, various commercial crops were introduced, having huge demand, economic value, and most importantly, market accessibility. The farmers replaced the traditional crops (mostly cereals) due to declining demand, economic value, lower yield capacity, and being fragile to climate variability. Therefore, such crops were substituted with newly introduced commercial crops like tomato, cabbage, potato, chilies, capsicums, and green beans. The practice of commercial crops, which are genetically modified crops (GMs), has high potential for productivity and yield, and they are also climate resilient, which can endure climate variability. Above all, the introduction of commercial crops has significantly improved the farmers' socio-economic status in the region.

Short-term Impact of Climate Change

Climate change is a serious issue in the present context. Climate variability has a grave impact, particularly on farming practices. It has both positive and negative impacts on the farming systems, such as crop choice, production, and yield. It negatively affects when there is a sudden change in temperature, humidity, and rainfall patterns, particularly for traditional crops, which are not climate resilient. They are highly susceptible to abrupt changes in the underlying climate patterns over a region.

However, climate change also has a positive impact on the farming patterns, like crop choice, production, and yield. Crops that are highly resistant to harsh climatic conditions and variability are being introduced and adopted by the farmers on a large scale in the region. Such crops are genetically modified crops, also known as GM seeds. They have the potential for high productivity, yield, and, most importantly, are highly resistant and adaptable to climate change, unlike traditional crops. Therefore, climate change is having a short-term positive impact on the agricultural production in the region.

Introduction of Fresh Crops

Traditional crops have low production and yield potential. On the other hand, genetically modified crops (GMs) have the capacity for high production and yield. Due to this, various GM crops like cabbage, potato, tomato, chilies, and green beans are being freshly introduced in the region. And farmers are adopting these crops on a large scale, as these crops are also having high demand in the market, revenue generation, and good market feasibility, making these crops the first-choice crops over traditional crops, resulting in the abandonment of the practice of traditional crops in the region.

High Demand and Economic Value of Commercial Crops

There is an inverse relationship between the traditional crops and the commercial crops. The demand and economic value of the traditional crops are decreasing, whereas commercial crops are increasing. There is a high demand for commercial crops, increasing their economic value in the market also. On the other hand, the demand and economic value of the traditional crops are decreasing in the market in the region. Due to these factors, the region experienced a change in crop choice, resulting in a shift in the farming patterns in the region from traditional to modern farming practices over the years.

Changing People’s Perspective

Farmers once valued traditional crops for self-reliance, low inputs, and cultural continuity, viewing innovations (including GM) with scepticism over risks, dependency, and long-term unknowns. Erratic weather exposed traditional crops' vulnerability, reframing

GM/resilient varieties as essential tools for survival and yield stability amid changing conditions. Rising demand, better prices, and visible revenue gains from commercial crops have shifted views toward agriculture as a business for prosperity, education, and household improvement, making traditional practices seem outdated and unprofitable. Many now see modern/GM adoption as a rational, short-term positive adaptation for better livelihoods.

Discussion

Farming systems and patterns are highly dynamic. Various geographical factors, including both physical and socio-economic elements, greatly influence the spatio-temporal variation. Physical factors like temperature, rainfall, humidity, and soil significantly determine the growth, production, and yield of its crops; on the other hand, socio-economic aspects like market demand, supply, and economic value of crops critically drive the crop choice and intensity of farming, as well as production. With the rising demand for commercial crops, the gap between commercial and traditional crops is lengthening over time. Therefore, the study encompasses the changing patterns of farming systems and their implications on the livelihood of the marginal farmers. The present study is associated with a study conducted by Mondal (2008); Valbuena et al. (2015); Kangalawe et al. (2017); Bhandari & Paudel (2021). Numerous studies have been conducted covering the aspects of changing farming patterns due to various external and internal factors, such as climate, population change, demand and supply and market availability. Over the years, the region has also experienced a shift in climate patterns, which has significantly contributed to changes in farming practices and crop choices. Therefore, local communities and mainly farmers have adjusted their cropping calendar and changed crops and varieties to adapt to the changing climate and climatic variability (Paudel, 2014). A steady increase in mean maximum temperature affects the natural systems, influencing the phenological processes in vegetation and increasing evapotranspiration rates, and increasing risks of crop pests and disease outbreaks of traditional crops. Therefore, among the local adaptation options have been the shift to more drought-tolerant and disease-resistant crop varieties and occasional migration to areas with better agricultural potential (Kangalawe et al., 2017). Moreover, the land is used for different productive purposes in a single year. These changes in land use affect employment and income, thereby altering the livelihoods of small farmers (Mondal, 2008). The characteristics of a particular farming system are largely determined by the past dynamics and interactions between drivers like vital factors, such as climate, local institutions, population dynamics and markets. Agroecosystems are social-ecological systems managed by humans to provide goods and services, particularly food, feed, and fibre for human needs (Conway 1987; Becker and Jahn 2001; Zimmerer 2007, 2013; Raut et al. 2011).

Conventionally, agriculture and allied sectors have been the primary sources of livelihood for people living in rural India. Additionally, over the years, the agriculture sector in India has been experiencing remarkable shifts with respect to area under cultivation, cropping pattern, productivity, use of fertilisers and pesticides, use of high-yielding varieties of seeds, market demand and accessibility (Majhi & Kumar 2018). Concerning the adoption of improved agricultural practices for doubling the income of farm families, the farmers are sensitive to the financial benefits of certain practices of the selected crops. The higher the benefit obtained from the introduced enterprise combinations of different commercial crops, the easier it is to persuade the farmers to adopt them on their farms (Ponnusamy & Devi, 2017). The potential impacts of genetically modified (GM) crops on income. On average, farmers benefit from GM, having higher effective yields and sizeable income gains. Furthermore, GM crops could contribute to rural income increases, which is particularly relevant for poverty reduction in developing countries (Qaim, 2010). Farming practice is particularly prevalent in developing countries, where almost all crops are grown for revenue. Also, food crop production has been marketed, depending on the extent (small-scale farmers produce a surplus for which they find demand and revenue (Achterbosch et al., 2014).

The production and yields of newly introduced or commercial crops are increasing. In addition, the statistical results, like the F-test, reveal a significant change and variations in the crop production of different years. However, the CAGR statistics show slight changes and variations in crop production over the years. The shifts have been strongly witnessed in both kharif and rabi crops; the production data from 2014 to 2022 reveal that after 2016 and during the year 2017-2018, crops consisted mainly of cereals, and aromatics have disappeared. Kharif crops like ginger, garlic, and millet, and rabi crops, particularly barley, have been abandoned. During the period 2019-2020, the cultivation of kharif crops consisting of other vegetables, maize, and paddy, and rabi crops, particularly mustard have been stopped. In addition, during the year, fresh commercial crops like cauliflower were introduced, replacing the paddy and maize. On the other hand, the cropping patterns and crop choice concerning both kharif and rabi crops were seen as unchanged in the year 2021-2022, with a noticeable increase in production over the years. Therefore, the findings of the study validate that cropping patterns, mainly crop choice, have been drastically changed over the years due to socio-economic factors like declining economic conditions and demand for traditional crops, increasing demand and economic value of commercial crops in the market, climate variability, and changes in cropping patterns and the changing perspective of the farmers in the region.

Conclusions

The present study can be concluded that over the last eight years, the cropping patterns in the region have been strongly shifted from traditional to commercial due to various socio-economic and environmental factors. Adaptation and practice of commercial crops over traditional crops have largely influenced the farmers, concerning their standard of living, through the generation of higher revenues and economic viability of the commercial crops. However, most of the commercial crops are GM seeds, which require intense supplements like chemical fertilisers and other substances for growth and yield enhancement. This disintegrates the organic compounds of the soil by turning it acidic and polluting the environment as a whole. Therefore, the study also envisages balanced economic and environmental sustainability through coherent and sustainable farming practices.

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