

## Drivers of changing cropping patterns in Nepal: A review

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### Abstract

*This paper reviews various aspects of drivers of changing cropping patterns in Nepal based on secondary data sources. Data were acquired from Google Scholar and Research Gate database 32 relevant professional journal articles in between 2000-2022 were intensively reviewed. The drivers of changing cropping patterns are complex and interrelated in the farming system. Spatial analysis of cropping patterns of different geographical scales shows that cropping pattern is an integral part of a behavioral focus to reflect the space relation of the community people. The drivers of changing cropping patterns are numerous and intricately linked. It is challenging to gauge the relative significance of the effects ascribed to each scale of the driver or the interactions between them at any particular geographic region. The study revealed that there are several types of drivers for changing cropping patterns. Among these various types of drivers, the theme of technological advancement/inputs, climate change, infrastructural development, road connectivity, and market demand play prominent roles in changing cropping patterns however other drivers such as off-farm employment, agriculture service extension/training, government policies, population growth/change/migration (rural to urban; international.), are also remarkable in this studies. In the Nepalese context, this study indicates that the more prominent role playing drivers of changing cropping patterns are technological advancement /inputs, infrastructural development and road connectivity, and market demand and climate change however land degradation and government policies also play a role to shifting cropping patterns. These all drivers interact and link with each other, leading to changing cropping patterns in Nepal.*

*Keywords: Drivers of changing, cropping pattern, farming system, market demand, climate change*

## **Introduction**

Spatial analysis of cropping patterns of different geographical scales shows that cropping pattern is an integral part of a behavioral focus to reflect the space relation of the community and people. It comprises the yearly progression and spatial arrangement of crops and fallow in a particular area. It is controlled primarily by physical (rainfall, climate, temperature, soil type, etc.), sociocultural, and technical elements and evolves across time and space to satisfy needs. The change in cropping patterns over a specific period demonstrates the changes in agricultural growth and development (Satnami & Surendra, 2019).

Cropping pattern is part of the behavioral approach in geographical study because it reflects the performance of the farmer for various crops sown in an agricultural field. A cropping pattern is a fluid idea that shifts through time and space. As changes in associated factors, cropping patterns in any geographical region fluctuate throughout time (Akhtar & Acharya, 2015). The study of cropping patterns is an important concept in analyzing the spatial arrangement of crops within the farming system. Moreover, it analyzed the selection, sequence, and arrangement of different crops in a particular geographical area over a specific period involved in the cropping pattern. However agro-climatic factors such as soil, temperature and rainfall distribution, and topography of the geographical region determine the overall physical conditions under which crops are grown, whereas farmers are increasingly influenced by changes in economic, technological, institutional, and policy-induced factors of any region (Gulati and Kelley, 1999 cited in Rao, D., & Parwez, S., 2005). Therefore the choice of cropping pattern depends on various factors such as physical factors (like climate, soil type, water availability), and Socioeconomic factors (government policies, market demand, farmer's preferences, and available resources).

It is indicative that the selection, sequence, and arrangement of different crops in cropping patterns in a particular area are influenced by several factors. These factors can vary depending on the geographical region, climatic conditions, market demand, and farmers' preferences. Thus the drivers of changing cropping patterns are complex and interrelated. It is observed that the drivers are varied and can differ depending on the geographical region and specific crop. Understanding these drivers of changing cropping patterns is important for developing sustainable and resilient agricultural systems that can adapt to changing conditions and meet

the needs of an increasing population. In this context, systematic analysis of drivers of changes in the local farming system has been examined through the analysis of different events that have been taking place at different levels i.e. local, regional, national, and beyond (Ghimire, et al., 2022).

Agriculture is one of the major occupations in Nepal and it plays a vital role in shaping the economic condition of the farmers as well as the whole country. So the agricultural sector is a still major source of livelihood for people in Nepal. It is estimated that the contribution of the agriculture sector to the Gross Domestic Product (GDP) of the country is about 23.9 Percent in 2078/79B.S. (MoF, 2079). Likewise, the agriculture sector provides food to the people, green fodder for livestock, and supplies raw materials to various agro-based industries. Therefore, systematic, scientific, and proper cropping patterns and their drivers are the most important aspects for better output in agriculture.

Overall, the drivers of changing cropping patterns are numerous and intricately linked. It is challenging to gauge the relative significance of the effects ascribed to each scale of the driver or to the interactions between them in any geographic region. In this context, this study aims to comprehensively review various aspects of drivers of changing cropping patterns in Nepal.

## **Method and materials**

This paper reviews various aspects of drivers of changing cropping patterns in Nepal based on secondary data. Google Scholar and Research Gate as a database were used for the study. The related professional journal articles in between 2000-2022 were intensively reviewed. In the relevant studies focused on the drivers of changing cropping patterns, terms such as drivers of changing cropping patterns/system/cropping practices were interchangeably used. Thus, these terms were included in our search strategy as: (*“cropping pattern” OR “cropping practice” OR “cropping system” OR “multiple cropping”*). Around 50 research articles were identified, among them 32 articles have been found relevant to the focus of this study.

## Discussion

### Nepalese farming systems

Agriculture has a diverse agriculture practice with a wide range of farming systems depending on altitude, climatic conditions, and socioeconomic conditions of different regions. Understanding the intersection between biophysical conditions and socio-cultural characteristics is more important for sustainable agricultural development. Similarly, it is necessary to recognize and integrate the local knowledge systems with scientific insights to create both environmentally viable and culturally sensitive farming systems. This integration allows for the development of agricultural practices that are well-suited to local conditions while respecting and leveraging the cultural heritage of farming communities.

Nepal has diverse agro-ecological zones, each with its own biophysical characteristics such as altitude, soil types, and climatic conditions. These zones influence the type of crops that can be cultivated. Similarly, socio-cultural factors, including traditional knowledge and indigenous practices, historically determined which crops were suitable and preferred in different regions. It is clearly observed that rice cultivation in the lowlands, wheat and barley in the mid-hills, and millets in the highlands are determined by both biophysical factors and cultural preferences. Upland and non-irrigated land primarily in the hills remain barren. Together with livestock rearing, the high hills also have a distinctive farming system that includes upland and rainfed agriculture of potato, maize, buckwheat, barley, and other minor millets.

The unique integrated hill farming system is characteristic of the mid-hills of Nepal. It is predominantly arranged in terrace farming. Around 40 percent of the cultivated land, 31 percent of the grazing land, and 50 percent of the forest land of the country are located in the mid-hills of Nepal (Paudel et al., 2011).

The mid-hill region of Nepal ranges between 300 and 2,000 meters above sea level. It has a climate that varies between subtropical to warm temperate. Crops are grown in upland terraces and irrigated fertile lands in river basins and valleys (*'khet land*). Paddy and wheat are common in the *khet land* whereas Maize, millet, grams, mustard potato, ginger, cardamom, and temperate fruits, particularly citrus, are the main crops grown in *bari land*. Dairy and commercial vegetable production

is rapidly growing in places nearby market centers in this zone (Paudel, et al. (2017). Bari land is cultivated unbounded upland on non-irrigated valley bottoms whereas the *khet land* is usually bonded for flooding, under various irrigation systems (Shrestha, 2009). Many varieties of crops can be cultivated depending on the local climate. The Tarai region’s primary crops are rice, wheat, legumes, and oilseeds, whereas the hilly region’s primary crops are rice, maize, wheat, pulses, and oilseeds. According to this, the main suited crops of the mountain regions are potatoes, barley, and buckwheat. Likewise, potatoes and vegetables can be grown in every ecological zone. The common cropping patterns in Nepal are shown in the table 1:

**Table 1: Characteristics of the common cropping pattern in Nepal**

Ecological Region	Characteristics of agricultural land		
	Irrigated Lowland	Unirrigated Lowland	Upland
Tarai (Plains)	Rice-Wheat-Maize	Rice - Wheat – Fallow	Maize - Mustard
	Rice-Potato-Vegetables	Rice - Mustard/Peas – Fallow	
	Rice-Peas-Rice	Rice - Lentils – Fallow	
	Rice-Lentil-Vegetables	Sugar cane	
	Rice - Mustard/Peas – Vegetables		
Hills	Rice - Wheat – Maize		Maize + Millet - Black gram – Fallow
	Rice - Potato – Maize		Maize - Millet – Vegetables
	Rice - Wheat – Vegetable		Maize + Legumes - Potato – Fallow
	Rice - Lentils – Vegetables		Maize + Ghaiya - Vegetables – Fallow
	Rice - Vegetables - Rice		Ghaiya - Legumes - Fallow
Mountains			Maize - Vegetable - Fallow
			Potato - Potato - Fallow
			Maize - Wheat - Fallow
			Niger - Potato - Fallow
			Maize - Fallow – Fallow

Source; Subedi, (1990).

It is observed from the table 1 that rice is the topmost important crop in rainfed low land where as maize is the second most important food crop in the hills. Thus there are mainly two types of cropping patterns, namely rice-based cropping patterns in the lowlands and maize-based cropping patterns in the uplands (Sharma, 2001).

In this regard, the drivers of changing cropping patterns are complex and interrelated. It is observed that the drivers are varied and can differ depending on the geographical region and specific crop. Understanding these drivers is important for developing sustainable and resilient agricultural systems that can adapt to changing conditions and meet the needs of an increasing world population. In this context, this study aims to comprehensively review the drivers of changing cropping patterns in Nepal.

### **Thematic categorization of drivers of cropping patterns**

Of the total 32 selected articles, four were published in 2022 and 2011, three in 2021, 2020, and 2017, two in 2019, 2015 and 2012, and one in the each of remaining years. Spatially, among the total of 32 articles 11 articles are related to Nepal, and others belong to abroad countries. Similarly, only 15 articles belong to the mountain /hilly region.

The drivers of changing cropping patterns are identified and these are thematically categorized into nine themes. Table 2 shows the drivers of changing cropping patterns explored in the study.

**Table 2: Summary of the drivers of changing cropping patterns explored from the review of the total 32 selected articles (multiple responses) related to Nepal and abroad.**

<b>S.N.</b>	<b>Themes</b>	<b>Number of articles</b>
1	climate change	11
2	Infrastructural development and road connectivity	12
3	Off-farm employment	5
4	Agriculture service extension/training	9
5	Market Demand	10
6	Technological advancements	17
7	Government policies	8
8	Population growth/change/migration (rural to urban; international, etc.)	6
9	Others (Low production, low prices, land ownership, traditional farming system, land-use change, etc.).	7

There are different types of drivers of changing cropping patterns of the different geographical regions such as lowland, upland land, irrigated land, and non-irrigated land. These various types of drivers are grouped into nine thematic categories namely climate change, infrastructural development and road connectivity, off-farm employment, agriculture service extension/training, and market demand. Technological advancements demand for new varieties of crops, Government policies, Population growth/change/migration (rural to urban; international, etc.), others (low production, land ownership, farming system, land use change, land degradation, etc).

Table 2 shows that among the 32 articles, the greatest number of the articles (17), have mentioned the theme of technological advancement /inputs as a major driver of changing cropping patterns. Technological advancement has had a significant impact on cropping patterns in the farming system. It leads to more efficient and sustainable agriculture practices. However, there is a need to balance the benefits of technology with its potential environmental and social impacts. Technological advancements include such as improved seed varieties, irrigation systems, biotechnology, mechanization, use of chemical fertilizers and pesticides have enabled farmers to grow new crops and improve their yields. Thus these factors play a vital role to increase crop production and crop intensity as well as cropping patterns changes (Shrestha,2006; Hazell& Wood, 2008; Shrestha, 2009; Bhatta & Doppler, 2010; Raut et a.,2011; Ghosh,2011; Singh, 2012; Mbonile, Sokoni & Misana,2012; Sharma & Chauhan,2013; Duche, et al.,2015; Pradhan and Sharma,2017; Vaidya, Bhardwaj, & Sood, 2017; Singh & Singh,2018; Rahman, 2020; Ghosh, 2021; Chapagain et al.2022; Mahlayeye, Darvishzadeh, & Nelson, 2022; Paria, Mishra, & Behera, 2022).

Similarly, 12 articles emphasized the theme of infrastructural development and road connectivity. Infrastructural development and road connectivity can have significant impacts on cropping patterns. The development of better infrastructure and road connectivity has improved access to markets, access to information, and increased access to modern inputs( Pujara & Khanal,2002; Shrestha, 2006; Hazell& Wood, 2008; Bhatta & Doppler, 2010; Raut et a.,2011; Mbonile, Sokoni & Misana,2012; Sharma & Chauhan,2013;Rahman, 2020; Ghosh,2021; Chapagain et al. 2022; Mahlayeye, Darvishzadeh, & Nelson, 2022; Paria, Mishra, & Behera, 2022).

Similarly, the third most recurring theme is climate change which is mentioned in 11 articles. Climate change has significant impacts on cropping patterns, and these impacts vary by region and crop type. Climate change includes; changes in temperature and rainfall patterns, increased frequency and intensity of extreme weather events, and their resultants such as floods, droughts, reduced water availability, and heat waves. These events can cause significant damage to crops, leading to changes in cropping patterns as farmers seek to adapt to the changing conditions. ( Rao & Parwez, 2005; Hazell& Wood, 2008; Manandhar et. al. 2011; Sharma & Chauhan,2013; Yohannes, 2016; Sati & Vangchhia, 2017; Batool et al. 2019; Sanodiya et al.,2019 ; Xue, Huo, & Kisekka, 2021; Ghimire et al.2022; Meier, Pohle, & Griebinger,2022; Paria, Mishra, & Behera, 2022)

Market demand is the next important driver of changing cropping patterns which are mentioned in ten articles. The market can have a significant impact on changing cropping patterns. The market demands for certain crops, driven by consumer preferences or changes in local national, and global markets, can lead farmers to switch from growing one crop to another. If there is an increase in demand for a particular crop, farmers may be motivated to grow that crop to take advantage of higher prices and profits. The growing market demand for certain crops has led to a shift from traditional subsistence crops to more commercial crops (Pujara &Khanal,2002; Rao & Parwez, 2005; Hazell& Wood, 2008; Shrestha,2009; Bhatta & Doppler, 2010; Raut et a.,2011; Sharma & Chauhan,2013; Yohannes,2016.Sati & Vangchhia, 2017; Chapagain et al.2022; Paria, Mishra, & Behera, 2022).

Likewise, agriculture service extension/training and government policies are also important themes explored in 9 and 8 articles respectively whereas other themes are less emphasized.

Agricultural extension services are organizations that provide information, advice, and technical support to farmers and rural communities to improve agricultural productivity. These services are provided by government agencies, non-governmental organizations, and private companies.

Similarly, government policies (trade policy tax policy, price policy, and other economic policies) and programs aimed at promoting certain crops, providing subsidies and other incentives, have also led to changes in cropping patterns in the

region( Hazell& Wood, 2008; Ghosh,2011; Singh, 2012. Akhtar, & Acharya, 2015; Sati & Vangchhia, 2017; Pradhan and Sharma; 2017; Yadav, 2021). Likewise, population growth/change/migration (rural to urban; international.) is a remarkable factor in changing cropping patterns and other drivers of cropping patterns include; low production in the traditional farming system, low prices, land ownership, land-use change, water, and land endowment( Shrestha, 2009; Singh, 2012; Mbonile, Sokoni & Misana,2012; Sharma & Chauhan,2013; Sati & Vangchhia, 2017; Singh & Singh,2 018; Chouchane, Krol & Hoekstra, 2020; Yadav,2021; Ghimire et al. 2022).

### **Thematic categorization of drivers of changing cropping pattern with reference to Nepal**

In Nepal, several factors contribute to changing cropping patterns, which involve shifts in the types of crops cultivated and their spatial distribution. In this study, 11 articles have explored the drivers of changing cropping patterns in Nepal. Table 3 shows the theme -based scenario of drivers of changing the cropping pattern.

**Table 3: Summary of the drivers of changing cropping patterns explored from the review of the 11 selected articles related to Nepal (multiple responses)**

S.N	Themes	Number of articles
1	Climate change	3
2	Infrastructural development and road connectivity	6
3	Off-farm employment	2
4	Agriculture service extension/training	2
5	Market demand	5
6	Technological advancements	7
7	Government policies	2
8	Population growth/change/migration (rural to urban; international, etc.):	2
9	Others (Low production, low prices, land ownership, farming system, land use change, land degradation, etc.)	2

There are several drivers of changing cropping patterns in Nepal. Among them, this study highlighted the following major drivers are described as follows:

## **Technological advancements**

There is a close relationship between the use of new agricultural inputs and socio-economic factors concerning changing cropping patterns (Wagle, 2020). The availability of new farming technologies, such as improved seed varieties, irrigation systems, and farming practices, has enabled farmers to grow new crops and improve their yields (Shrestha, 2009). Technological advancements play a significant role in shaping cropping patterns and farming practices in several ways such as high yielding crop varieties, improved farming techniques, machinery and automated equipment, irrigation and water management, biotechnology, and genetic engineering, climate-smart agriculture, access to information and knowledge on farming practices, etc. Overall, technological advancements play a significant role in cropping patterns in Nepal by enhancing productivity, diversification, sustainability, and market orientation in the agricultural sector. However, the adoption of these technologies might vary among different ecological regions and communities within Nepal due to factors such as accessibility, affordability, and farming awareness.

## **Infrastructural development and road connectivity**

Infrastructure and road connectivity facilities have been developing in both urban and rural areas in Nepal. Its' impact on cropping patterns is becoming increasingly evident. Infrastructural development and road connectivity play prominent roles in influencing the cropping pattern in Nepal. Infrastructure development road connectivity has significantly influenced the cropping patterns in Nepal. Road connectivity has enabled farmers in remote areas to access markets more easily. Due to better access to markets for farmers along the road side farmers have shifted from traditional cereal crops to cultivating high-value cash crops like vegetables, fruits, and flowers. Therefore the construction of roads in any area has facilitated better transportation of agricultural produce. This has encouraged farmers to switch from subsistence farming to more market-oriented cultivation. Similarly, infrastructure development and road connectivity have enabled farmers to diversify their cropping patterns. In hilly and mountainous regions of Nepal, where certain areas were previously inaccessible, farmers can now cultivate different crops due to better transportation networks. For instance, areas like some mountain areas of Nepal have seen the introduction of new crops like apples, kiwi, and medicinal herbs, which were not feasible to grow before due to lack of transportation facilities. Overall, infrastructure development road connectivity has

played a crucial role in changing cropping patterns by enabling farmers to shift towards more profitable, market-oriented, and diverse agricultural practices. However, there are some challenges such as ensuring sustainable farming practices, equitable distribution of benefits, and addressing environmental concerns concerning to positive impact of road connectivity on cropping patterns in Nepal.

### **Market demand**

The growing market demand for certain crops has led to a shift from traditional subsistence crops to more commercial crops. Market demand plays a significant role in shaping cropping patterns in the farming system. Fluctuations in market demand for agricultural products, exports and imports of agriculture products, tourism activities industrial and service sectors, government policies climate change, and natural disasters are the major factors of market demand. These all factors of market demand play a crucial role in shaping cropping patterns in Nepal and it leads to influence farmers' decisions related to crop choices, production quantities, and resource allocation.

### **Population growth/change/migration (rural to urban; international)**

Nepal has experienced significant population growth over the years. The total population of Nepal reached 26.4 million in 2011 with a 1.35 percent growth rate whereas it increased by 0.93 percent inter-census growth rate and reached 29.1 million in the 2021 census (NSO, 2023). Thus increasing population demands more resource use such as land, forest water, etc. Therefore, it is observed that there is an imbalance between population and resources. Similarly, there is an increasing demand for food, which has led to a shift towards crops that yield higher production and income. Thus farmers might shift from traditional crops to more intensive or high-value crops due to reduced arable land.

Concerning internal migration within Nepal, a significant number of the population migrated from rural to urban areas. After reallocating the population of the 2011 census according to the federal structure, the population in urban and rural municipalities were 63.19 percent and 36.81 percent respectively whereas, the population in urban municipalities reached 66.17 percent, while the population in rural municipalities reached 33.83 percent in the 2021 census (NSO, 2023). As the population grows in urban areas, due to increased pressure on land for housing, infrastructure, and urban land, agricultural land might be converted into residential or commercial areas. This migration leads to changes in the types of crops

cultivated, adoption of different agricultural practices, or even abandonment of land. Overall, changes in population dynamics greatly influence how land is used, what crops are grown, and the agricultural practices adopted.

### **Climate change**

Nepal has been significantly impacted by climate change, experiencing various effects such as changes in weather patterns, glacial melting, increased frequency of extreme weather events, and threats to biodiversity and ecosystems. Impacts of climate on agriculture lead to changes in planting and harvesting seasons, choice of crops, and overall crop productivity.

There is significant spatial and temporal (inter-annual) variation in Nepal, with increases in annual precipitation of 0.7 mm/ year and temperature increases of 0.04°C/year and 0.01°C/ year for maximum and minimum temperature, respectively. Likewise, high precipitation increases were registered at higher altitudes (up to 6.6 mm/year), while decreases were experienced in mid-hills regions (-2.3 mm/year) (DHM, 2016). In Nepal, climate change has significantly impacted agricultural practices and cropping patterns. Irregular rainfall patterns and altered temperatures have affected traditional cropping calendars. Changes in the onset and duration of seasons have forced farmers to adapt planting and harvesting times. Similarly, extreme rainfall and melting glaciers have affected water availability, impacting irrigation systems crucial for agriculture. Likewise, droughts and water scarcity have forced to changes in crop selection and irrigation practices. Similarly, most farmers perceive climate change acutely and respond to it, based on their indigenous knowledge and experiences, through agriculture at an individual level (Manandhar, et. al., 2011). It also leads to changes in planting and harvesting seasons, choice of crops, and overall crop productivity which are related to changing cropping patterns.

The government of Nepal has been implementing various strategies to mitigate the impacts of climate change on changing cropping patterns. These strategies aim to enhance sustainable farming practices, enhance resilience, and reduce vulnerability to climate-related risks. Overall, the government of Nepal seeks to enhance food security, improve the livelihoods of farmers, and build resilience in the agricultural sector amid climate uncertainties by adopting climate-resilient agricultural practices and implementing sustainable approaches.

## **Land degradation**

Overgrazing directly affects soil fertility, vegetation cover, and land productivity. So overgrazing, deforestation and other forms of land degradation have led to soil erosion, which has reduced the fertility of the land. It forces farmers to adopt new cropping patterns. Therefore addressing overgrazing is an important issue for maintaining the ecological balance, maintaining soil fertility, and ensuring sustainable farming practices in Nepal.

## **Government policies**

Government policies and programs aimed at promoting certain crops, providing subsidies and other incentives, have also led to changes in cropping patterns in the region. Similarly, government policies play a vital role in influencing and shaping cropping patterns in Nepal. Nepal's government has initiated different policies to help farmers to cultivate new crop varieties and improve their livelihood. (Upadhyaya, 2000 as cited in Ghimire, 2022) These policies are formulated to address various agricultural challenges, promote sustainable practices, and support farmers in adopting new cropping patterns. Likewise, government policies and initiatives play an important role in helping farmers adapt to changing climatic conditions, providing support in the form of technology, information, and financial assistance for transitioning to more climate-resilient agricultural practices. It leads also to shaping the cropping pattern in the farming system. Similarly, government agencies can also encourage farmers to adopt proper crops exclusively rather than traditional crops by providing subsidies. It also plays an important role in to change in the cropping patterns (Wagley, 2020).

## **Conclusions**

This study reveals that the drivers of changing cropping patterns are complex and interrelated issues in the farming system. Based on a review of previous studies, it is clearly shown that there are several types of drivers for changing cropping patterns. Among these various types of drivers, the theme of technological advancement/inputs, climate change, infrastructural development, road connectivity, and market demand most influencing factors that play vital roles in changing cropping patterns however other drivers such as off-farm employment, agriculture service extension/training, government policies, population

growth/change/migration (rural to urban; international.), are also remarkable to shifting cropping patterns. In the Nepalese context, this study reveals that the more emphasized themes of the drivers of changing cropping patterns are technological advancement /inputs, infrastructural development and road connectivity, market demand, and climate change however land degradation and government policies also play a role in changing cropping patterns. These all drivers interact and influence each other, leading to dynamic shifts in cropping patterns in Nepal. The combination of these factors shapes the farming system, enabling farmers to adapt and modify their cultivation practices over space and time.

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