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Chief Editor
Professor B. C. Vaidya

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TRAJECTORIES OF YAK HERDING IN THE WEST SIKKIM HIGHLANDS

Nirjala Rai and Uttam Lal

Abstract

Yak pastoralism in west Sikkim was introduced in the mid-twentieth century by the Tibetan herdsman who had settled in the adjoining border region of Nepal and Sikkim. The earliest Yak herd in Sikkim belonged to the Chogyal, who ruled the independent kingdom till 1975. Yak pastoralism in west Sikkim began to expand, with additional people involved in yak rearing practice following a nomadic lifestyle and accessing the pastures across the border. It was in fact a long-term investment for ensuring livelihood security in the highlands of west Sikkim with environments featuring harsh climatic and environmental conditions. Yak is an integral part of the highland community and plays an important role in the cultural and religious aspects of herders. However, many concerns were expressed regarding unsustainable grazing and its impact on the fragile ecological zone due to overgrazing. The livestock-dependent people and their livelihood changed its course with the policy decision of the state government to ban the practice of open grazing in 1995. This upheaval not only affected the livelihoods of the herders but also threatened the cultural heritage tied to this practice. The loss of traditional grazing lands, once rich in biodiversity and vital for the yak's sustenance, led to a decline in herding communities and their customs. As herders were forced to abandon their way of life, the intimate bond between people and their animals weakened, representing a significant shift in both the ecosystem and the cultural landscape of the region. Nevertheless, few people still hold on to the practice to keep their traditions alive but the system has changed. This paper, thus, seeks to highlight the long-standing herding practice in West Sikkim incorporating the historical background moving towards the current practice and addressing various changes and challenges faced by the yak herding community in West Sikkim following the ban.

Introduction

Sikkim was an independent kingdom under the Namgyal dynasty that ruled until 1975. Yaks, hardy beasts of the highlands, were introduced in the west district

of Sikkim during the reign of the Chogyal dynasty in the seventeenth century but emerged as a livelihood strategy around the mid-twentieth century (Tambe & Rawat 2006). Yak herding followed a transhumance system with vertical movements of a herd on a seasonal basis. Livestock rearing in the highlands of Sikkim, Himalaya, is presumed to have been present during the 8th century AD and followed throughout the reign of Chogyal. The earliest records of animal rearing are presumed to be found in the travelogue of Sir J.D. Hooker, with an innumerable mention of different livestock and the communities rearing them (Tambe, 2007). Sheep, Yak, Yak-cow hybrids, buffaloes, and cows were the main herd compositions herded by different communities, such as Gurungs and the Bhutias, in the alpine highlands of West Sikkim (Tambe and Rawat, 2009). Sheep and Yak herding was mostly confined to the upper reaches of the Greater Himalaya, while the other upland cattle were lately introduced and mostly confined to the lower reaches of the Himalaya (Tambe 2007, Sharma et al., 2016). The local herdsman kept other domesticated bovines in an intermediate ecological zone, where they cross-breed Yak stud with lowland cow to produce cross-breed cow locally called Urang/Dzomo and bull as Dzo. Both the animals are of great economic value, as Urang had a high milk yield in comparison to female Yak, locally called Dri, while Dzo, which is comparatively stronger and amenable than male Yak, was an ideal pack animal in the region and was hired mostly by the tourism sector (Tambe, 2007; Thargyal, 2007). Urang subsequently dominated the highland from 1975 onwards (Tambe, 2007). A native breed of sheep, Banpala, was reared by the semi-nomadic Gurung and Mangar herders mainly for wool and meat. The herders of Dhoopi, Pokhri, Karjee, Rung-Dung, and Sada-Phamtam used to roam the pastures of Kanchendzonga National Park (KNP) and accessed the resources on a seasonal rotation basis. Sheep rearing had a great start before 1975 when the owners owned a maximum of 500 sheep, but the population gradually declined to around 4000 or below at present.

Study Region

This study is based on the Churong Chu watershed in the Gyalsing district of Sikkim. The Churong Chu (river) originates from Rathong Glacier and flows north-south before meeting the Rangit River. The region has prominent ridges and passes such as Khangla (Figure 1) and Boktok that open into Nepal. The watershed is further connected to the adjacent Rimbi Chu watershed by rocky Dapheybhir, extending up to 4,631 meters above mean sea level (AMSL) (Tambe, 2007). Churong Chu has a total area of around 152 km², with Chongri, Sindrabung, and Yuksom as its major villages.

Objectives

The main objectives of the study were (i) to understand the nature of Yak pastoralism in west Sikkim and (ii) To examine the changes and challenges faced by the herding community following the ban on grazing.

Database and Methodology

The data for the study was collected from both primary and secondary sources. Fieldwork was carried out in the year 2019 and 2020 to supplement the secondary information. The household sample was intended to capture a broader picture of Yak rearing practices and to understand the challenges imposed by external interventions upon Yak and how it has endured throughout time and space. The data was collected from sample villages mainly Darap, Yuksom and Chongri. In Chongri, majority of the households are still actively engaged in Yak pastoralism while in Yuksom, it has gradually discontinued after the ban on grazing in 1998, however, the village was considered in order to capture an outlook upon the impact of the ban upon the herding community as well as the animal.

There were altogether 7 active yak rearing households in Chongri and each household was surveyed and the herders were interviewed. The herders from these villages were asked about the present challenges and changes in the herding practices. Further, to understand the impact of the ban and the shift in herders' livelihood strategies, ex-herders who had settled down and opted for new jobs were also interviewed. The historical information about the royal herd keeping was obtained from the two elderly persons who had experience regarding the yak culture, traditions and rotational herding regime during Chogyal reign.

Result and Discussion

Yak pastoralism in west Sikkim was introduced in the mid-twentieth century by the Tibetan herdsmen who had settled in the adjoining border region of Nepal and Sikkim. The earliest Yak herd in Sikkim belonged to the Chogyal, or king, who ruled the independent kingdom till 1975. Around fifty Yaks were mainly kept for Dzong/Szung, a traditional ceremony performed during Pang-lhabsol in the name of the Khangchendzonga guardian deity Dzo-nga protecting the inhabitants of Sikkim. A mountain in the intimate narrative of people is symbolised as God and the custodian of faith, culture, identity, and history and “facilitates nearness to the divine canopy” (Langdon, 2000). Pang means ‘witness’ and Lhabsol means ‘worship’ is celebrated to offer homage to Mount Kanchendzonga. During Pang-lhabsol, the royal family

worshipped the five protector deities of Khangchendzonga, where Dzung, a highly revered ceremony by the royal family, was performed with the help of Buddhist monks. The rituals and prayers were offered to the deities for the good harvest and welfare of the kingdom. As per the field interaction, each year during the celebration the royal family would offer five Yaks (both male and female) to the deity and the sole purpose of keeping the royal herd during the seventeenth century was to make yak available for the offerings. The herd was kept in Dzungri, a trekking destination situated at an elevation of 4,200 meters asl. by an under-recruited caretaker who used to manage and look after it. Further, the Yak were kept at a higher altitude, and their grazing areas were confined to the high-altitude region of the Greater Himalaya. The herd spent the whole season in the alpine pastures of Dzungri and during winter the caretaker would feed the Yak with supplementary feeds to tackle the unavailability of forage in the snow-laden pastures. Yak played an important role in the cultural and religious aspects of the royal family. The certain reaction to the external element decides the fate of the Yak in the herding tradition that still prevails in current practice since the Dzung yak is granted a life and is prohibited from selling or slaughtering, unlike other Yak, whose life and decisions related to it rest in the hands of their owner. The monarchy system came to an end following the merger of Sikkim with India in 1975. The end of the Chogyal era, however, did not stop the tradition, and the Dzung ceremony is still retained and carried out on behalf of Chogyal by the monk from the Pemayangtse monastery, which is the oldest monastery of Sikkim.

The high alpine pasture of west Sikkim gradually evolved as a pastoral landscape in the early to mid-twentieth century as livelihood-orientated Yak herding practices were introduced in the region. The herders were mainly of Tibetan origin and used to graze their Yak in the alpine highlands of eastern Nepal and along with the border areas of west Sikkim. According to the field investigation, the Yak herders from Nepal shared the alpine pasture along with the royal herd in Dzungri. Yak pastoralism began to expand, with additional people involved in it while following a nomadic lifestyle. In the latter half of the twentieth century, the herdsman purchased land in Sikkim and settled down while continuing the tradition of herding Yak and accessing the pastures within the border. The herders utilized the pastures by paying grazing fees, locally referred to as Patta, to the forest department. The patta was a legal permit for pastoralists to graze their livestock and differed with the types of livestock reared. According to the field respondent, initially, Yak herder had to pay fifty paise per Yak later increased to 1.50 rupee,

for which the herders formally requested the department and resumed the previous rate, which continued for several years. The Forest Department had appointed Chaprasi, or the forest guard, to check any illegal activities within the forests, protect them, and check over the patta of the herders. The patta system allowed the graziers to get hold of a particular plot of pastures where they were free to graze their animals and set up their goth while the external encroachment was strictly checked, and the other herdsmen were not allowed to establish their goth inside it although their animals were allowed to graze. The patta system introduced by Chogyal continued even after Sikkim as a state joined India in 1975 and was finally abolished in 1986, and the issue of patta was stoooped after the park was notified. The herders roamed around the alpine and sub-alpine pastures, reaping all the possible benefits from the resources available as well as from their herd, until state policy stepped in and altered both their traditional route and practice.

Government Policy and Its Impact on Yak Herding

The Livestock population escalated rapidly due to the lucrative economy associated with milk and its by-products, in the past, there were more than 300 households of livestock herders alone from Churong Chu. The herders were engaged in small-scale trade with the local market of Nepal, where they traded items like butter, cheese, herbs, and aromatic plants. With the increasing opportunities and profits in the market, the high and mid-altitude ecological regions experienced heavy exploitation by the local herdsmen who accessed the region. Ecologists observed the herdsmen, often collected medicinal and aromatic plants from the alpine zone for trade and indulged in illegal hunting. Further, concerns were expressed regarding unsustainable grazing and its impact on the fragile ecological zone due to overgrazing, altering the plant communities, cutting off trees and branches for cattle shed constructions and as firewood, and soil erosion caused by livestock trampling, etc. (Bhagwat et al., 2012). According to the field account, most of the destructions were linked with the Urang goth and cattle goth, mostly confined in the temperate zone to a sub-alpine zone extending from 3100 meters to 4200 meters because of their habitat requirements. At the same time, the Yak herders often cleared the shrub habitat to increase fodder availability. Further, the herdsmen collected the Juniper from the forest area and supplied it to the local markets. Smudging and burning juniper is a part of the daily prayer of the Buddhist people in Sikkim and has a common belief that it creates a clear atmosphere by cleansing the negative energy. The extraction of juniper and selling it fetched the herdsmen the essential items required for themselves as well as the herd, such as salt and supplementary feed.

However, such negative impacts caused by the grazing pressures together with herders exploiting the wide range of flora and fauna led the state to enact policy that could put an end to the further degradation and avoid biodiversity loss (Tambe and Rawat, 2009). On 26th August 1977, the area of about 850 sq. km stretching right from Lhonak Valley in the north to the historical town of Yuksom in the west was notified as a Khangchendzonga National Park in Sikkim under the provision of the Wildlife (Protection) Act, 1972. The park comprised notified reserve forests that were free from rights and concessions and protected under the Sikkim Forests, Water Courses, and Road Reserve (Protection and Preservation) Act 1988. Other than tourism, other livelihood activities were restricted within the park, and the strict national laws gradually exerted their influence upon pastoralism. In 1995, the state government came up with the policy to ban the practice of open grazing in the reserve forest, around water sources, and plantation areas in the West and South districts of the state. The policy decision was challenged by the herder associations in the Sikkim High Court, but they reaffirmed the notification via its judgment dated 14th May 1999 (Tambe et al., 2005; Tambe, 2007).

Impact After the Ban

The eviction notice was forwarded to the herders from the Divisional Forest Officer (DFO), West Sikkim, stating the removal of their goth along with their herd. The herder association had several meetings with the forest department with the concern of leaving their herd into the wild. They applied to the Chief Minister and other forest dignitaries of the state, stating the formulation of a scheme that ensured the state government would purchase their livestock and provide alternative livelihoods to the herders. However, the main problem lay in accommodating Yak owing to their distinctive adaptability features and the complexity of rearing them. With the concern of their Yak, the herders appealed to the DFO, west Sikkim, for time, and the herders were granted an additional one month by the Conservator of Forestry (CF), but with an instruction to leave the alpine pasture of KNP after one month. Yak herders approached the higher authority seeking to protect their age-old traditional practice and demanded the recognition of yak herding as the traditional system and the tribal people who had been engaged with this practice since ages should be allowed to continue without any hurdles were the primary ones. However, the fight couldn't go any further, and the herders settled down for financial assistance, roofing sheets, and small jobs offered by the government. Soon after the non-success of the case, the herders had a 15-day deadline to evacuate their traditional pastoralist landscape, and their age-old tradition was about to shatter in a few days.

Despite all the hardship and effort by herders to defend their traditional system from the government policies and state interventions, on 14th May, 1999, Sikkim declared a ban on grazing. After the declaration, few goths voluntarily phased off, and some were forcefully evicted using armed force like the SSB, who patrolled and burned down the goths starting from Chewa Bhanjyang, Uttarey, West Sikkim . By 2003, the mass eviction of herds and their herders was completed, irreparably disrupting the age-old yak herding tradition. According to the filed interaction, the recording and settling rights were unfair, and the compensation was not provided to the herders, and the exclusion strictly hampered their livelihood. The herds belonging to the influential people somehow sustained the system and defended the new policy, while the ordinary herders were left with no option other than to sell their yaks to the neighbouring herders of Nepal, some to abandon them in the wild. The herders usually sold off their herds after consultation with the herders from Nepal and also decided a particular date for handing over the yaks to the purchaser from Nepal.

The Yak was sold at the rate of twelve thousand per pair as malla, a pair of one big and one small animal, which was a quite minimal amount for their herd. Similarly, some sold off their Yaks, and some fled with their goth to the other side of the border in Nepal. The perpetual struggle for the rights to carry on their traditional practice, resources, movement, and ultimately livelihood left many herders exhausted and settled down. The herders who fled to Nepal retained their tradition of herding Yak, and within a few years, they again started utilising the conventional pasture in the reserve area of KNP secretly. They often came and stayed at their previous grazing stations; once their animal crossed the border while grazing, the herder would come along with them. The visit turned into a short stay, and their permanent sheds were replaced by tarpaulin tents equipped with the necessities like the herder's rations and salt for their Yak. Since tarpaulin tent (was easier to dismantle and hide whenever they suspected the patrolling of a forest ranger in their locale and fled to their home before getting caught. The process continued for a long and is continuing, although cooperation exists at present between the herders and the rangers, where both equally realise the symbiosis between the herding system and the conservation of biodiversity. After all, it is the healthy and diverse nature that supports sustainable pastoralism, and sustainable pastoralism in return keeps nature alive through its social and cultural expressions. Altogether, the repercussions of the ban were visible in economic and livelihood loss, loss of culture and increased inequality and elite captures (Jain, 2023).

Herding System in West Sikkim: A Current Scenario

The policy on grazing ban on KNP reserve areas impacted the livelihood of the Yak herders in Churong Chu watershed as well as its adjacent places. The restrictive conservation model adopted by the government seemed to favour and facilitate the entry of several interests into these areas while excluding the interests of native stakeholders (Singh et al., 2021). Following the ban, the herders shifted their livelihood to other activities such as tourist guides, porters, taxi- drivers, daily wage earners under MGNREGA, seasonal labour in agricultural fields, and some ex-herders engaged themselves in community-based conservation programs such as Himal Rakshaks and continuing to do so. Himal Rakshaks are the local ex-herders recognised as “the honorary guardians of mountains” by the Forest Department based on their traditional knowledge and experience in the management of high alpine regions (Shrestha et al., 2013; Singh, 2020). They are trained conservators and are given the stewardship of the alpine areas. The repercussions of the ban were visible not only across herders' livelihoods, but the adversity faced by domesticates as well. During field interaction in 2020, it was found that many households gave up the herding practices after the ban, and few left their Yaks in the wild at present have turned into feral animals. Despite the ban, Yak herders have found ways to continue their traditional practices, balancing their cultural heritage with a growing awareness of conservation. They often implement sustainable grazing techniques and maintain the ecological health of their environments. However, the Yak population has declined (Table-1) due to factors such as climate change and herding regime. Many herders are now joining forces with conservation organizations to promote responsible herding methods and advocate for policies that protect both the Yaks and their habitats. This collaboration reflects a commitment to preserving their way of life while addressing the challenges posed by modern pressures. At present, there are seven active households from Churong Chu watershed carrying forward the age-old tradition of Yak rearing, which they locally refer to as Dri goth in the sub-alpine and alpine regions of KNP. the herders practice an agro-pastoral way of life and are associated with herding Yak, or jaat chauri, as they refer to it. The herd is mainly kept for milk, dairy products, wool, and meat while their memory of herding is fabricated in the intimacy of their relations, expressions of movement, routinized activities, and their lived culture.

Table-1: Yak Population in KNP from (1950-2019)

Livestock type	Population								
	1950	1975	1987	2000	2004	2007	2009	2012	2019
Yak	50	200	441	800	779	1142	489	194	94

Source: Compiled from Tambe 2016 and Livestock census, 2007, 2009, 2012, 2019 (Dept. of AHLF&VS, Sikkim)

Yak in the Economy of the Herders

Yak is an important source of income and a significant contributor to the domestic economy of the pastoral household. Every part of Yak contributes to the herders' economy, and not just a part of Yak as a whole fetches them a good amount. Milk is the key product obtained from Dri and is appropriate for butter, curd, and cheese production. The main products obtained from milk are butter and dried and smoked hard cheese locally known as Churpi. Despite its tremendous size, Dri is not a very excellent dairy producer; in fact, a Dri produces around 1 to 3 kg of milk per day. The average milk yield, however, was around 1.6 kg per household, and the total yields depend on total numbers of lactating Dri and also on the seasonal growth of grass and its quality. The milk is not obtained for ten to fifteen days or even a month after a Dri has given birth, and the herder ensures enough availability of colostrum milk for a calf to consume for their better development and gain enough strength in a harsh environment (Li et al., 2011) (Table-2). The quantity of milk is important in the pastoral household because more quantity of milk means larger production of other major derivatives such as butter and Churpi. Milk, rather than selling in the local markets, is primarily used for obtaining its by-products, while a small amount is kept for household consumption. Butter is a primary product and is believed to hold medicinal properties, which make it an important commodity of the pastoral household. It is supplied mostly to the nearby monastery during festivals, the local markets at Jorethang, Geyzing, and also in Nepal. Churpi is yet another major product of pastoral households and contributes to half of the household income. The dehydrated and smoked Churpi is a popular masticator and is found in the village local shops to roadside stalls in west Sikkim. Unlike butter, it has a ready market extending from Darap, Pelling, Geyzing, and Jorethang to Gangtok and Nepal and is usually supplied through intermediary channels. Churpi costs around INR 500–700 per kg, and butter costs around INR 400–600 per kg.

Table-2: Field Details of Yak Herding, West Sikkim

Field Details	Range
The average family size of the herders	05
Total household rearing Yak	07
Total Yaks (Nos.)	395
Total milch Yak holding (Nos.)	145
Average milk yield per lactation (ltr/day)	1.61
Butter (Rs./kg)	600
Average butter production (Kg/day)	1.32
Churpi (Rs./kg)	700
Average Churpi production (Kg/day)	1.36
Yak meat (Rs./kg)	400
Yak wool (Rs/kg)	700
Average household income (Rs.)	1.5 lakh e
Average expenditure on Yak (Rs.)	60,000 e
Male Yak (Rs.)	50,000-65,000
Female Yak/Di (Rs.)	25,000-35,000

Source: Field study, 2019-2020 *(e): Estimated Value.

In the past, around 10–12 herdsman used to supply butter and churpi to Gangtok and Kalimpong Lal Bazaar, an open market where local farmers from around the places congregated to sell their products at the rates of INR 30 and INR 45, respectively. Besides, whatever quantity could be traded, the herders received a fair amount from it, while the unsold quantity was left with their fellow vendors at the rate of INR 20–25 per kg. At present, churpi is supplied a lot during the winter, while butter, due to its perishable characteristic, reaches the market every one to two months. Their hardship to earn a livelihood is expressed in the difficulties of their journey, where, unlike these days, there was no easy access to transportation and the herders had to walk for miles to reach the bus that took them to their destinations, and half of their earnings were consumed by transportation alone. The herders nowadays supply their products through a middleman or a contractor who collects the required product from their respective settlement. Meat is yet another important product and costs around INR 400 per kg, while the rate varies with different parts of the body, such as the head, which costs INR 500 per kg (Fig. 1).

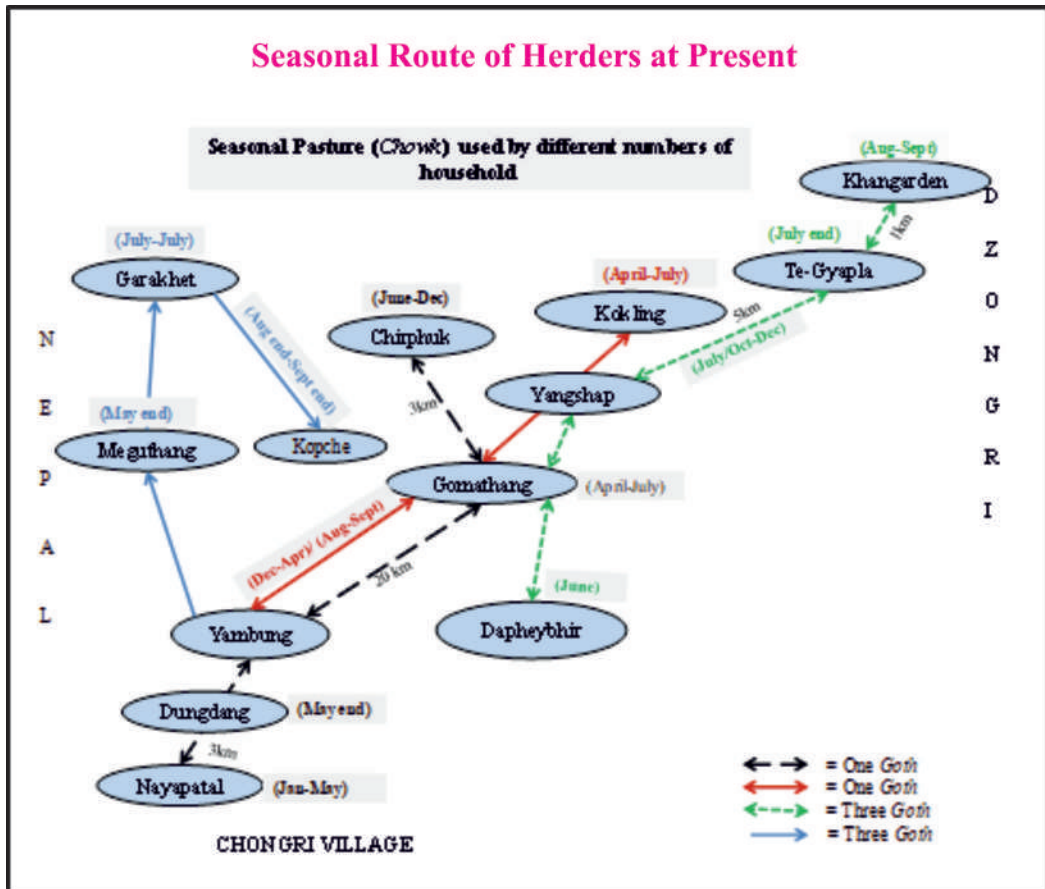


Fig. 1

The meat is mostly consumed during Tibetan Losar, and around 6-7-year-old yak is slaughtered for meat. Apart from meat, wool is also obtained from the Yak and costs around INR 700 per kg. A male Yak costs around INR 50,000-65,000, while a female Yak or Di costs around INR 25,000-35,000 when sold. However, Dri is occasionally sold in comparison to Yak because they are smaller in size in comparison to Yak and because they are used for the production of milk, and reproduction often makes them weak and thin by the time they reach their old age. Dri is crossed with a Tibetan stud bull called Fhulang Goru, and the cross-breed calf is known as Dimzo. Fulang Goru costs around 3 to 3.5 lakh Nepalese rupees (NPR) and is imported from China (Tibet Autonomous Region) with the help of a Nepali dealer. The bull was reared almost in every pastoral household in the past because of its economic importance and returns; however, it required intense care regarding the forage and continuous supervision, which led herders to gradually stop keeping them. As a result, only two households are left that own three Fulang goru at present. The offspring of Fulang goru and female yak is called Dimzo, which is sold in Tibet through Nepal at the rate of Rs. 90,000-1 lakh (NPR) and up to Rs. 56,000 to 62,000 Indian rupees (INR). Dimzo is traded soon after they reach a year old, and more than 100 Dimzo were taken to Tibet via Nepal through Khang La Pass near the Sikkim-Nepal border. However, at present the Dimzo trade has come to a halt because of the COVID-19 pandemic.

Mobility Pattern

In the past, the herders stayed in the high alpiners throughout the year, looking after them and reaping the potential benefits out of them. The Goth had embraced their sense of home, and their sense of belonging still lurks somewhere in the sentiments of ex-herders. As Gomez and Vannini (2017) put it, 'home is not just a place; it is a feeling.' The sense of belonging is visible in the reminiscence about the home they left behind and that they create one in their memories. While relocating, the household moved entirely with their home lashed in the back of Yak, and a sense of home and belonging remained the same even though their territory changed. Their whole life and practice revolved around Yaks, and the way of living and association with Yak rendered them a unique identity that dominated the highland alpiners of KNP till the late 20th century. With the introduction of new policy and increasing new economic opportunities, the herding system gradually came under its influence. The ex-herders who had spent more than 60 years in goth tending their herd of Yak have noticed the changes that have occurred in the practice. The tradition that once incorporated the dual nature of home and their identity is now bare,

as their essence has been stripped off, leaving only a container of risks and uncertainties. The retired herders equate the current Yak herding tradition as 'camping tourism' designated with impermanence, transience, and a couple of household members taking charge of the herd. With the enforcement of various acts and laws related to biodiversity conservation, once-permanent dwellers now foray into their customary land with clear risk. Despite the risk and shrunk spaces, the herders still carry out a seasonal movement to the long-established grazing stations, which they refer to as Chowk or Degh. They move vertically as well as horizontally within a fixed period and season, and their mobility is directed by factors like the availability of grass, water sources, rising temperature, and escaping the midges and leeches. The herders utilise the chowk on a rotational basis, and the distance they cover differs as well as their locations. The practice of pasture utilisation is done in a sustainable manner, such as when a single pasture is not utilised by the entire household; rather, they put up their camps in distant places. Particular chowk is used in three to four herding households, and the same routine is followed every season. Unlike other pastoralist communities, the herders in West Sikkim do not practice annual transhumance; rather, they spend six months looking after the herd, from March to the end of September, and with the approaching winter, yaks are driven to the lower altitude and left in the forests, and the herders descend to their permanent settlement. The Yak forges in the temperate forest throughout the winter, and the herders in between occasionally approach the jungles to feed salt to their yaks.

The herder feeds salt at a regular interval and is fed not only to satisfy their sodium requirements but also to nurture the habit of returning from the pasture. Salt plays a significant role in maintaining the human-Yak relationship, as it can draw Yak near to strangers and enhance the atmosphere of trust and cooperation. Salt feeding, although it may have various intentions behind it, certainly the course of action brings humans and animals in a close tie, convincing Yak to trust humans, and Yak, in turn, cooperates with human intentions. Thus, the 'salt tie' often keeps the herder and Yak in scrutiny with each other, and the occasional visit of herders to their free-ranging Yaks during winter just to feed salt could be one motive to re-establish the salt tie and prevent them from reverting to a semi-wild state (Rhode et al., 2007). The herders further check their yaks and count their numbers, given that the herder loses most of Yak during this time due to the high rate of depredation caused by a wild animal attack. A household loses around 10 to 15 yaks per year during unsupervised grazing. The herders are of the opinion that such depredation is the main reason that the Yak population in the region is not able to flourish properly. The calving period begins from March till July, and the herdsmen

again begin their journey to collect the scattered herd in the temperate forests, and once they are done with the collection, they count the numbers of remaining as well as additional yaks, including calves, and move to their chowk. The herders drive their herds to a different portion of forests, and each herder has their own respective center where all the herders gather their herd, stay for a few days, and start their seasonal journey towards their respective pastures. Each year, the herders follow the same routine before approaching the distant pastures. Besides, long-range pastoralism has now shifted to short-range pastoralism within an area. The herders may shift their occupations, but their identity remains connected to the animal and place they left behind. The impression of herding practice has followed them and their tradition. The herders might have discontinued their practice, but the imprints of their traditions still hold a sacred place in their everyday lives. Yak and the tradition related to it are highly revered by the herders, who now are no longer able to interact on an everyday basis; the herders use each material that once adorned their traditional nomadic practices and experiences in their main ceremonies, such as Dzung. Dzung represents the true form as an animal liberating ceremony, which is significant for animal wellbeing because the Dzung yak is prohibited from causing any harm through selling or slaughtering; the herder can draw milk from it but cannot harvest wool or even harm it. Yaks are a fundamental part of herder's traditional society, and the long-term interaction with it probably makes herders realise its importance in maintaining the highland ecosystem that they are heard proudly saying, "Chauri himal ko gahana ho" (Yaks are the jewels of mountains). Animals serve as useful instruments of culture because they are highly flexible symbols (Arluke, 1996). Yak herders widely honour the objects that have a connection with their Yak and their traditions, and such objects are kept still today as a totem for protecting and safeguarding them.

The objects like a saddle (Gaa), rope (Thakpa), sling (Chumikbuti hurto), yak bell (Mikma) are used during household rituals, and each artifact has spiritual values and significance, especially to protect from negative energy and misfortune in a pastoral household. Further, the herders hold the view that the grassland and the forests have degraded after the ban, as most of them hold onto the positive side of the grazing story. They stated that the trampling accelerated the decomposition of twigs and leaves; their dung provided the manure to the ground, and this process helped in the fertilisation of the soil. In addition, animals know their landscape (Lorimer, 2006) and acquired only what was needed for them as they roamed across the grazing grounds; however, it was humans who knew no bounds of their desire and went on destroying the environment, and the animal was made to bear the brunt

of the damage. The future of yak rearing practice in many places seems uncertain due to various issues such as climate change, predation, blind conservation efforts, and the absence of a successor. These challenges discourage herders from continuing the tradition (Bhusal et al., 2018; Dorji et al., 2020). However, some herders have managed to preserve their age-old tradition by creatively modifying their herding practices (Hellman, 2019).

Conclusion

West Sikkim existed as a pastoral landscape for ages; however, the first known pastoral community in the region is known to be the herders from Nepal who traversed across borderless land with their herd and established Goth in Sikkim. Yak is the most remarkable animal that dominated the alpine and sub-alpine landscape of KNP in west Sikkim. The expanding herd compositions and the increasing number of livestock due to the lucrative economy associated with pastoralism led to a negative impact on biodiversity, which included the intense cutting and logging of trees for shed maintenance, fuelwood, fodder supply, the hunting and poaching of wild ungulates, converting scrub vegetation into pastures, etc. and the negative impacts induced by grazing practices consequently led to the imposition of a ban on grazing in reserve forests and the eviction of graziers from the reserve area. The ban on grazing ripped the Yak herders out of their traditional lands and practices, impacted their livelihood to a great extent, and altered traditional practices as well. However, existing herders are striving to maintain their age-old practices despite facing numerous challenges. Given the potential for collaboration, effective conservation policies can be developed by combining traditional knowledge with scientific insights. This partnership can enhance conservation efforts, ensuring that both cultural heritage and ecological sustainability are prioritized. By working together, herders and scientific agencies can create innovative solutions that respect traditional practices while addressing modern environmental challenges.

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SHIFTING TRENDS IN PEARL MILLET PRODUCTION AND CONSUMPTION: A CASE STUDY OF BANASTHALI GRAM PANCHAYAT, NEWAI, TONK

Lata Gopaliya, Siddh Kunjika Pandey, Dr. Rashmi Sharma

Abstract

The Indian agriculture sector, currently contributing 18.2% to the country's GDP, supports 42.3% of the population and plays a crucial role in the economy. Cereal grains, including millet, one of the oldest known foods, potentially domesticated 10,000 years ago, are a primary food source worldwide. In the tropical, dry, and semiarid regions of Asia, Africa, and Europe, millet is an essential food for millions of inhabitants. Rajasthan, the "pioneer in pearl millet," boasts the country's largest area and highest production, covering 46 lakh hectares with an average output of 28 lakh tons. The gluten-free "grain" is rich in vitamins, minerals, phytochemicals, polyphenols, and proteins, acting as a natural remedy against health-related disorders, making it suitable as food and feed. Over the years, consumer preferences have shifted toward more convenient and tasty diets. Indian farmers' cereal preferences are shifting towards rice and wheat due to a lack of millet cultivation initiatives and the misconception that millet is only for impoverished people. This study examines the evolving patterns of pearl millet production and consumption and highlights the role of government policies in promoting this crop. A multistage random sampling method was used to conduct a survey of 100 farming households in four villages of Banasthali Gram panchayat, Newai tehsil, Tonk district of Rajasthan. The present research employed both primary and secondary data collection methods. Software such as Excel and SPSS have been used for data analysis. India, the fifth largest millet exporter in the world according to 2020 data, is promoting its production and consumption through government programs like the National Food Security Mission, Integrated Cereal Development Programmes, and Rashtriya Krishi Vikas Yojna. In addition, India has promised to launch the International Year of Millets in 2023 as a "People's Movement" and to position itself as the "Global Hub for Millets" because the superfood millets support soil health, human health, and the mitigation of climate change. The celebration focuses on themes of endurance, sustainability,

and cultural legacy. India's millet cultivation and consumption are gaining momentum through promotional campaigns, awareness programs, and training sessions, enhancing food security, public health, and agricultural sustainability.

Introduction

Millet is a sustainable, eco-friendly, and small-seeded annual grass crop commonly grown staple on marginal lands in arid and semi-arid regions (Meena et al., 2021). Millets, with their early maturity, high drought, salinity, and heat tolerance, are highly climate-resistant crops that are adaptable to dry regions, supporting increased resilience to climate change (Gowri & Shivakumar, 2020). Millets are nutrient-rich, gluten-free grains that meet global nutritional and health needs, providing iron, zinc, folate, calcium, low GI, protein, dietary fiber, and antioxidants (Srivastav & Chauhan, 2024). With a well-balanced amino acid profile and higher protein content compared to other grains, they offer superior nutrition (Panjala et al., 2023). In addition, millets are low in fat and exhibit anti-inflammatory and anti-oxidative properties, along with phytochemicals that offer therapeutic benefits. Millets, once cultivated as coarse cereals, are now grown as “super cereals” in India, known for their high nutritional content, making them a global trend in cuisine. Millets are a global priority for achieving food and nutritional security, contributing to sustainable development goals 2 zero hunger, 3 good health and well-being, 12 responsible consumption and production, and 13 climate action. Sorghum, Pearl millet, Finger millet, Foxtail millet, Proso millet, Little millet, Barnyard millet, Brown top millet, and Kodo millet are among the nine generally known traditional millets that are grown in India (NITI Aayog, 2023). The largest millet crop in India is pearl millet, the sixth most important cereal in the world (Pattanashetti et al., 2016). Pearl millet, or bajra, is a popular cereal crop in India, scientifically known as *Pennisetum glaucum*. Due to several supply and demand issues, millets, formerly a staple of Indian cuisine, have been nearly forgotten. Indian farmers are shifting away from millet cultivation, causing the loss of thousands of hectares of millet production land. The poor margins associated with millet production in comparison to other crops were disincentives for millet farmers. The decrease in demand has been caused by the crop's shorter shelf life, shifting consumer preferences and lifestyles, and the absence of ready-to-eat millets. Pearl millet is considered a promising crop for the future of farming because it is a versatile crop, used 70 percent for food, and also in cattle feed, alcohol, poultry, and seed industries. It also requires minimal input to thrive in the arid and semi-arid tropics. In 2022, India led global millet production, with 38.4%, followed by Niger

at 11.85%. China and Nigeria produced 8.75% and 6.29%, respectively. In India, pearl millet leads to millet production at 62%, followed by Jowar at 26%, ragi at 9%, and small millets at 3%. In 2023-24, millet production in India was dominated by Rajasthan (32%), followed by Uttar Pradesh (18%), Karnataka and Maharashtra (11% each). Haryana contributes 8%, Madhya Pradesh 7%, Tamil Nadu 4%, Gujrat and Andhra Pradesh 3% each, other States 2%, and Utrtrkhand 1%. India has become the largest producer of pearl millet, producing 7.3 million tons from 9.1 million hectares of land in the last five years. Despite a decrease of 26% in area under cultivation over the past few decades, total production has increased by 19%. Rajasthan contributes 39.98% of the total pearl millet production in the country, 13.89% of nutria-cereals, and 12.67% of Jowar. The significance of these grains as food staples has decreased over the past 20 years, especially in South Asia. This decline can be attributed to several factors including urbanization, rising incomes, and government initiatives that have increased the production of high-quality cereals like wheat and rice. Millets' decline is attributed to low remuneration, lack of subsidies, a shift in consumer preferences, processing difficulties, low flour shelf life, low social status, and the green revolution's focus on rice and wheat.

Study Region

Niwai is a municipality and tehsil situated in the Tonk district of the eastern part of Rajasthan between east longitudes 75°07' and 76°19' and north latitudes 25°41' and 26°34'. Covering a total area of 980.16 km², including 925.11 km² of rural area and 55.05 km² of urban area. It consists of ridges and valleys, structural hills, sand sheets, and peneplain surfaces with a thick alluvium cover. The tehsil has a semi-arid, dry climate with large variations in temperature and scanty rainfall. The temperature ranges from 5°C to 45°C. The monsoon season extends from June to mid-September. According to 30-year average (1991-2020) statistical data, the district receives an average annual rainfall of 536.96 mm. Highly deficient rainfall was recorded in 2002 and highest during 1996 and 2013 (CGWB, 2022). Rainfall in the tehsil is quite erratic and prone to normal types of droughts. Winters are severe and the temperature sometimes touches freezing point. Saline-alkaline soils with low nutrient status and inadequate irrigation facilities are typically found in the Niwai tehsil. The soil varies from sandy loam to loam in the Niwai tehsil. The tehsil is drained by the perennial Banas River and its tributaries. It is situated in the semi-arid Eastern Plains Agro-Climatic Zone. In this region, crops like pearl millet and sorghum are commonly grown in the Kharif season and wheat, mustard, and gram in the Rabi season. The main crops are sorghum, groundnut, pearl millet,

moong, urad, mustard, wheat, barley, gram, spices, and vegetables. The primary irrigation sources are canals and tube wells. As per the 2011 census, the population of Niwai is 2,45,787 people, out of which 50,600 are urban and 1,95,187 are rural. The population density in the Niwai tehsil is 251 people per square km. The sex ratio is 988 females per 1000 males. In Niwai Tehsil, 55.26% of the population is literate, with 67.27% of the males and 43.1% of the females. The Niwai tehsil's economy mainly depends on agriculture as 67.7% of workers are either cultivators or agricultural workers.

Objectives

- (1) To analyze the changing patterns of production and consumption of pearl millet in the study area
- (2) To identify government policy intervention for millet promotion in the study area

Database and Methodology

The present study is based on both primary and secondary data. A multistage random sampling technique was used to collect primary data. In the first stage, one tehsil (Niwai) out of 7 tehsils has been selected purposively. In the second stage, four villages of Banasthali gram panchayat Haripura, Ramjipura, Karanpura, and Motipura were selected. In the third stage, 25 households from each sample village were randomly selected for the field survey. A total of 100 sampling households were selected for the field survey using the interview schedule method. Focus group discussions, personal interviews, and field observation were conducted for primary data collection. Secondary data were collected from the revenue department Niwai, the district census abstract 2011, and the central groundwater board 2021 reports. For data analysis, Excel, and SPSS software have been used.

Results and Discussion

The present study aims to understand how pearl millet production and consumption patterns have shifted in Banasthali Gram Panchayat. In recent times, a discernible change in dietary preferences has been observed in many rural and semi-urban areas of India, including Banasthali Gram Panchayat in Niwai, Rajasthan. Pearl millet (bajra) has long been a staple grain in these areas because of its high nutritional content, ability to withstand dry conditions, and low input needs. However, a shift towards the consumption of other grains, especially wheat and rice is becoming more prominent.

Table-1: Pearl Millet Production in Rajasthan

Years	Area (Lakh Ha.)	Production (Lakh Tonnes)	Yield (Kg/ Ha.)
2019-20	42.87	46.86	1093
2020-21	43.48	45.61	1049
2021-22	37.36	37.40	1001
2022-23	45.71	51.05	1117
2023-24	42.65	42.81	1004

Source: DA&FW

Pearl millet production in Rajasthan has shown fluctuations over the years. In 2019-20, the state cultivated 42.87 lakh hectares, producing 46.86 lakh metric tons with a yield of 1,093 kg per hectare. The following year, 2020-21, saw a slight increase in area to 43.48 lakh hectares, resulting in a production of 45.61 lakh metric tons and a reduced yield of 1,049 kg per hectare. The 2021-22 season experienced a decline, with 37.36 lakh hectares yielding 37.40 lakh metric tons, and a further decrease in yield to 1,001 kg per hectare. However, production recovered in 2022–23, with 45.71 lakh hectares producing 51.05 lakh metric tons and a higher yield of 1,117 kg per hectare. In 2023-24, the area decreased to 42.65 lakh hectares, resulting in a production of 42.81 lakh tons and a yield of 1,004 kg per hectare (Table 1).

Changing Trends in Rainfall and the Production of Pearl Millet

In India, pearl millet is grown as a one-season crop. The majority of cultivation occurs in unirrigated and marginal areas. The crop is grown in small areas under irrigation in the northwestern states of India, primarily as a food and fodder crop. The pearl millet crop in India is experiencing a consistent decline in production and consumption. The paper studied shifting trends in production and rainfall between 1993 and 2023, as well as the consumption patterns of local people in the study area. Between 1993 and 1994, the rainfall was about 800 mm, and the production of pearl millet was about 1688 kg/h. But there is a slight decline seen in 2003–2004, as the rainfall was 620 mm and production fell to 1266 kg/h. A decadal fall was seen in 2013–14, where the rainfall reached 410 mm and production decreased by about 1150 kg/h. The annual production of pearl millet in Banasthali Gram Panchayat is directly impacted by the variations in rainfall patterns triggered by climate change, global warming, and extreme weather events. But in 2022–23, productivity will be boosted by nearly 1535 kg/hect (Table-2). Due to good rainfall (802 mm),

high-yielding varieties are being developed, awareness among consumers is being promoted, value is being enhanced through industrial participation, and integrated plant nutrient management and production technology are being developed.

Table-2: Changing Trend in Rainfall and Production of Pearl Millet (1993-2022)

Years	Rainfall (mm)	Production (kg/hect.)
1993-94	800	1688
2003-04	620	1266
2013-14	410	1150
2022-23	802	1535

Source: Revenue department, Newai

Millet Crop Production

Before 30 years, almost 88% and 43% of the surveyed rural households grew pearl millet and Jowar millet crops, respectively in the present year, 76% of rural households have grown pearl millet, and 39% of farmers have grown Jowar millet crops on their agricultural land. Before 30 years, wheat, groundnuts, mustard, maize, and other crops were grown alongside millets. In the present year, wheat, mustard, maize, groundnut, and other crops are the most commonly grown.

Purpose of Growing Pearl Millet

The population engaged in agriculture used 42% of pearl millet for subsistence, while 34% of the population grew pearl millet for both subsistence and commercial purposes, and 16% of the population grew pearl millet for only commercial purposes. Most people grew pearl millet for food (61%), both food and fodder (21%). Only 8% of the population grew pearl millet for fodder. Among them, 40% of households used both organic and chemical fertilizers, while only 23% and 33% of farmers used chemical and organic fertilizers, respectively. Only 4% of farmers didn't use any fertilizer in their fields. Nearly 51% of the population grew pearl millet as a poor man's crop, while 49% grew it for its health benefits (Fig. 1).

Reasons for Declining Millet Production

Climate change is perceived to be affecting 97% of the population, causing a decline in millet production. While 81% of people thought that there had been less rainfall, 19% said that there had been more rainfall, which had helped their

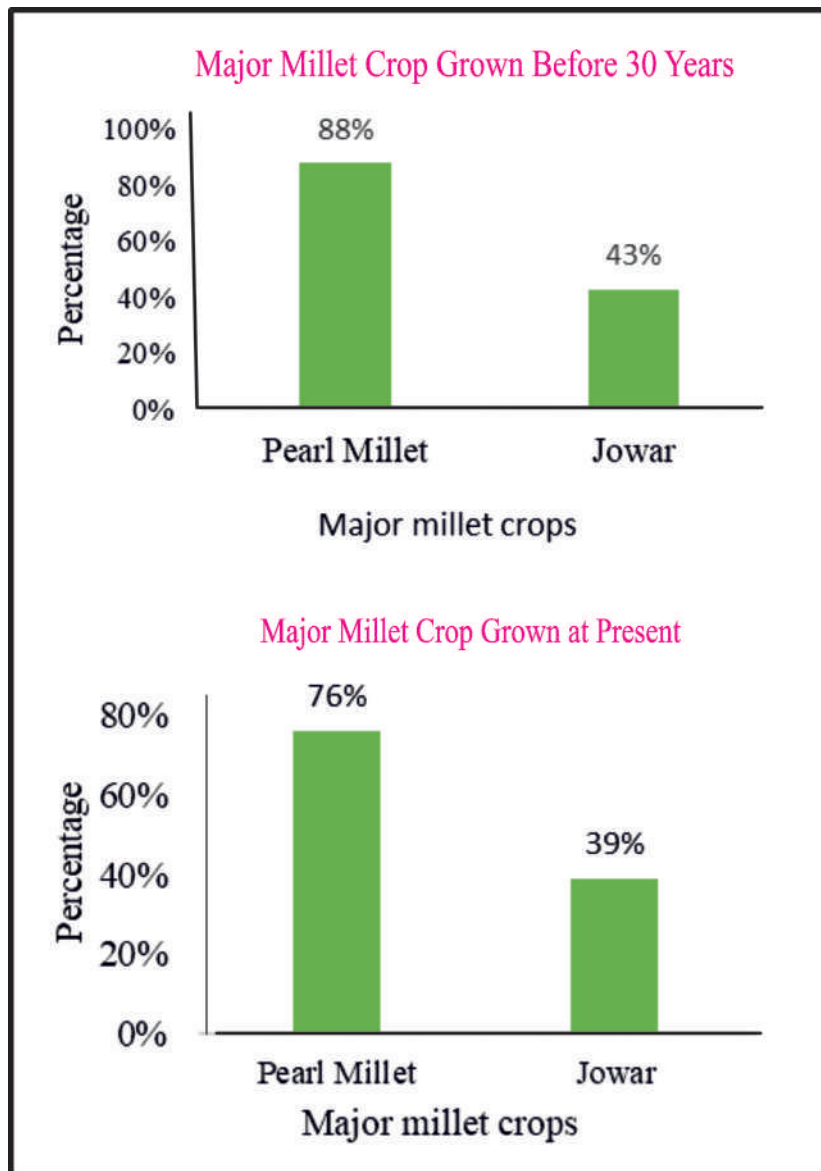


Fig. 1

millet crop. Almost 72% of rural households considered that millet production has decreased within 30 years, and 22% said that it has increased due to the availability of high-quality seeds, etc.

Frequency of Pearl Millet Consumption

Millet is a staple food for over 93% of the surveyed rural household population who consume millet in their diet. Among them, 44% of the population consumes millet daily and 25% weekly. Only 19% of people eat millet once a month and 12% eat millet rarely the food culture of rural Rajasthan has changed as a result of increased migration and the influence of urban lifestyles. Wheat and rice consumption symbolizes modernity and improved socioeconomic status, particularly in pearl millet-dependent regions. Families often serve wheat-based foods at social gatherings as a sign of progress or affluence. In Banasthali Gram Panchayat, Niwai, the dietary preferences of people have changed from pearl millet to wheat and rice. This change reflects broader changes in agricultural practices, government policies, economic accessibility, and cultural influences. While wheat and rice have become more prominent due to factors like availability, subsidies, and shifting consumer preferences, this trend raises concerns about the loss of traditional grains that are more resilient to climate change and nutritionally superior.

Children's Preferences for Food

Before thirty years, the rural household's population, including children, predominantly favored pearl millet over wheat, with 93% of the surveyed population including it in their diet. In the present year, 58% of the population prefers to eat wheat, 32% prefer to eat pearl millet, and 10% of surveyed rural households prefer to eat both wheat and pearl millet. In the study area, 38% of the respondents have common health problems and 62% of people are in good health. The majority of the population sources their food from subsistence farming, with 25% purchasing from the market and 23% from the public distribution system.

Government Policy Intervention for Millet Promotion

In the surveyed households, 18% of the population is aware of the International Millet year, and 82% of the population is not aware of it. The survey indicates that 43% of households benefit from government schemes, while 57% of the population does not receive any benefits from these programs (Fig. 2). There are several reasons behind their exclusion from these initiatives. Rural households often lack knowledge about government schemes, including subsidies, food distribution

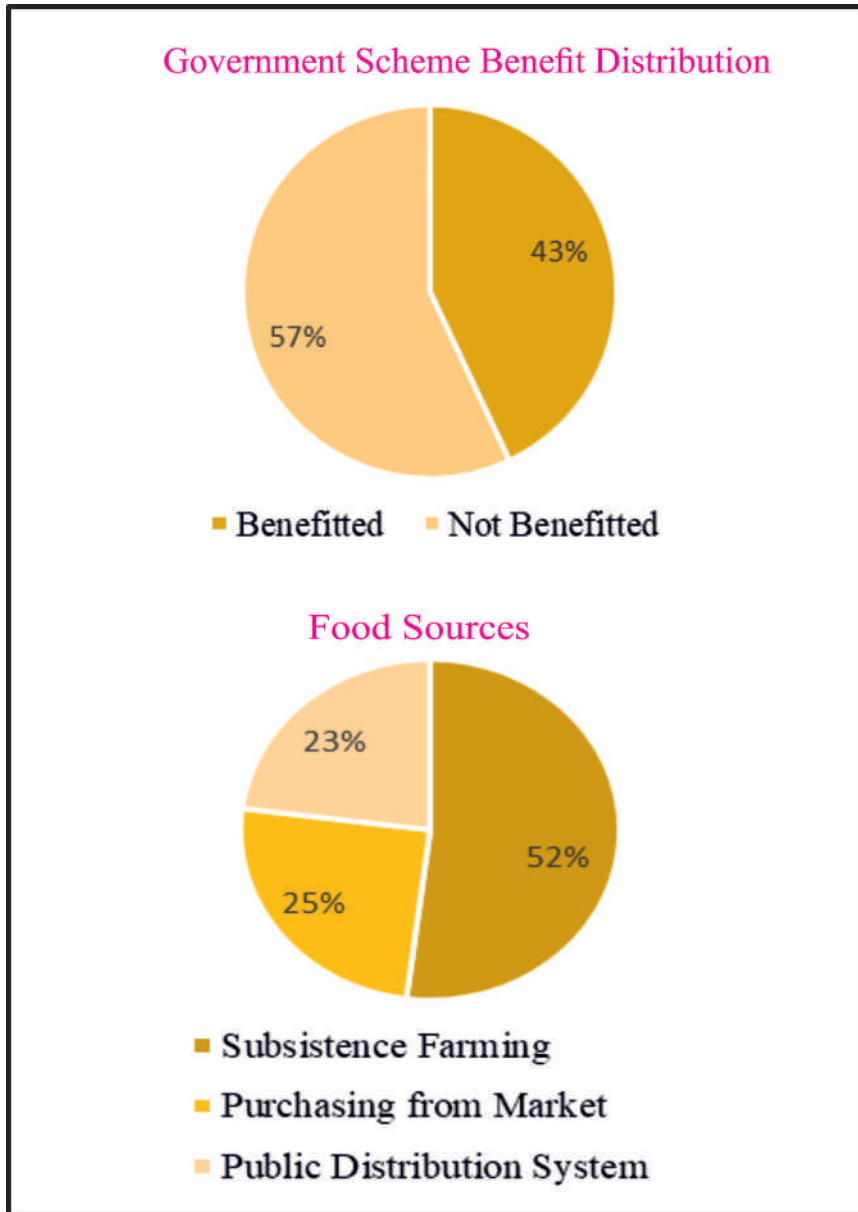


Fig. 2

programs, and social welfare benefits, leading to a lack of access to these resources. The absence of representation in local decision-making bodies significantly restricts the accessibility of government support. Households lacking government support, such as subsidized seeds, fertilizers, and irrigation equipment, often struggle to improve farming practices, leading to lower yields and productivity. The study indicates that households without access to government aid or insurance are more susceptible to crop failure in areas with frequent erratic rainfall and drought. The government and local authorities should enhance the dissemination of information about available schemes, with a particular focus on marginalized communities. Addressing these challenges can increase household benefits from government schemes enhancing agricultural productivity, food security, and overall well-being. Government distribution programs like the Public Distribution System make wheat and rice more accessible and affordable, making them more appealing to households compared to pearl millet. Over time, wheat and rice are increasingly promoted as staple grains in Indian diets due to urbanization and exposure to modern food cultures, offering softer texture and easier cooking and versatility. Pearl millet, a nutritious food source, is often overlooked due to its lack of widespread awareness about its nutritional benefits. Government food security programs such as the PDS and mid-day meal schemes, primarily offer wheat and rice, causing a decline in pearl millet consumption due to increased accessibility and affordability. Although there have been initiatives to promote millets, such as the International Year of Millets 2023 and the National Food Security Mission, these policies are relatively new and have not yet had a widespread impact on reducing the decline in millet consumption.

To maintain a balance between traditional grains and subsidized staples, more robust initiatives supporting millet cultivation, consumption, and awareness are needed. The Rajasthan government is implementing various initiatives to promote millet, including the International Millet Year 2023, a millet startup innovation challenge, and the Rajasthan state promotion mission, Pradhan Mantri Kisan Samman Nidhi (PM-KISAN). They are also investing in pearl millet processing units, PDS, and private seed distribution, and providing subsidies for up to 50% of open rural godowns. The Rajasthan State Seed Production and Certification Agency provides seeds to farmers. Rajasthan Kisan Ayog provides guidance, research, and education in agriculture under ICAR. Nearly 42 Kisan Vigyan Kendras are under ICAR for various activities such as farm testing, soil testing, seed supply, organic techniques, and workshops. Other missions include the Rajasthan organic farming

mission, the Rajasthan crop production mission, etc. A multifaceted strategy that includes initiatives to maintain traditional food cultures, policy support for millet cultivation, and nutritional education will be needed to address these shifts. Rural households receive support through various programs that support agricultural production, increase food security, and provide financial aid. Many rural households are receiving subsidies for fertilizers and improved seed varieties to reduce production costs and increase yields. The government has been promoting crop diversification to tackle sustainability issues and shift production from water-intensive crops to pulses, oilseeds, and nutria-cereals / Shree Anna.

Conclusion

The present study has assessed the changing patterns of production and consumption of pearl millet and identified government policy intervention for millet promotion in the study area. The focus on millet-based production systems and substituting water-intensive crops is crucial for ensuring food and nutritional security in the face of climate change and resource scarcity. Major constraints include adverse environmental conditions, low crop nutrient efficiency, pest damage, limited consumer interest and commercial demands, laborious post-harvest processing, unavailability of high-yielding varieties, and integrated plant nutrient management. The shrinking of land holdings due to fragmentation makes agriculture more challenging, so people are shifting towards intensive agriculture and cash crop cultivation. Low yields in agriculture are attributed to factors such as fragmented land, low farm investment, lack of mechanization, insufficient access to quality inputs, inadequate marketing infrastructure, and short growing seasons. The promotion of production and consumption should be increased for the benefit of both people and the environment. Pearl millet holds immense potential and has deep roots in our history. It is a great option for sustainable agricultural systems with minimal input.

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THE BRASS INDUSTRIAL DETERMINANTS AND ITS IMPACT ON URBANIZATION IN MORADABAD CITY: A GEOGRAPHICAL ANALYSIS

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Abstract

The brass industry in Moradabad, India, is a significant contributor to the city's economic growth and urbanization. This study aims to elucidate the primary factors influencing the progression of the brass manufacturing sector and evaluate its ramifications on urban expansion within Moradabad City. This study explores the industrial determinants of the brass industry in Moradabad City, focusing on its impact on urbanization. Moradabad, located in western Uttar Pradesh, is renowned for its brass craftsmanship, which has evolved over generations. Brass, an alloy composed primarily of copper and zinc, is widely utilized in various applications due to its enhanced properties. The manufacturing sector, including brass production, is acknowledged as a catalyst for socioeconomic growth, providing structural change and productive jobs. Moradabad has gained international recognition for its exceptional brass handicrafts, which are exported to foreign markets. The city's rich tradition of craftsmanship is not only a source of livelihood for many artisans but also a vital part of the cultural identity of the region. The study highlights the importance of preserving traditional craftsmanship while adapting to contemporary market demands. The study employs a descriptive research method, utilizing secondary data sources such as topographic maps, demographic details, and industrial data collected from various government agencies and publications, including the district census handbook and EPCH exports of handicraft, to analyze the socio-economic dynamics of the region. The research employs a descriptive methodology, utilizing secondary data from various sources. The results are represented through diagrams, tables, and maps. The findings suggest that the brass industry not only contributes to the local economy but also plays a crucial role in the urbanization process, shaping the socio-cultural landscape of the city. The study also expected to provide valuable insights into the determinants of the brass industry in Moradabad and its impact on the city's urbanization, contributing to the understanding of the complex interplay between industrial development and urban growth in the region.

Introduction

The term 'brass' is derived from English words 'braes' (old English) or 'bras' (middle English) dating back to around 1200 AD and signifies an alloy with varying meanings across different cultures. Brass is an alloy primarily composed of copper and zinc, with trace amounts of other elements. An alloy is a combination of dissimilar metals that enhances the properties of metals, such as resistance, lightness, and flexibility. Copper, which is abundant, lustrous, and easily molded, is widely utilized in various alloys. The manufacturing sector, encompassing brass production, is acknowledged as a catalyst for socioeconomic growth, providing structural change and productive jobs (Herman, 2016). It also plays a crucial role in achieving steady growth in national wealth indicators and ensuring national security (Klevtsova et al. 2021). In conclusion, the brass industry forms an integral part of the manufacturing sector, contributing to economic growth and development on both national and international levels. It faces challenges that necessitate modernization and adaptation to global economic trends. The industry's success is intertwined with the efficiency of related sectors, such as transport, and its ability to integrate into the global market (Dubrovskaya, 2021). Furthermore, investment in research and development is essential to foster innovation and enhance competitiveness, ensuring that the brass industry can meet evolving consumer demands and environmental standards. Additionally, collaboration between industry stakeholders and government entities can facilitate the creation of policies that support sustainable practices and promote long-term growth. Brass work encompasses a wide range of processes, which may include traditional manufacturing techniques that have endured socio-economic and cultural diversities despite the passage of time (Premarathne et al., 2017). These techniques often involve skilled artisans who blend age-old craftsmanship with modern innovations, ensuring that the final products not only meet contemporary standards but also retain their historical significance. As a result, there is a renewed interest in preserving these artisanal methods while also exploring sustainable practices that can enhance efficiency and reduce environmental impact.

Study Region

Moradabad, also known as the "Brass City," is a significant city in the state of Uttar Pradesh, India. It has gained international recognition for its exceptional brass handicrafts, including brassware, jewelry, trophies, and decorative metal crafts. The geographical boundaries of Moradabad extend between 28°48' N and 28°52' N latitude and 78°45' E and 78°48' E longitude. The city covers an

area of 75 square kilometers, divided into 70 wards and nearly 340 localities. It is strategically located on National Highway 24, providing convenient traffic and transportation links to major cities such as Delhi, Lucknow, Haridwar, Patna, Chandigarh, and others. The metal craft industry in Moradabad exports thousands of crores of products annually, catering to the demands of foreign buyers. In addition to brass, the city also exports aluminum, iron, and steel metalware as per the requirements of international markets. The rich tradition of craftsmanship in Moradabad is not only a source of livelihood for many artisans but also a vital part of the cultural identity of the region. Moradabad is situated on the banks of the Ramganga River, a left bank tributary of the Ganges River. The city is located in the western part of Uttar Pradesh and is one of the state's largest cities. It serves as a vital lifeline for industrial development in the region. The artisans often pass down their skills through generations, ensuring that the intricate techniques and designs remain alive, while also adapting to contemporary trends to appeal to a broader audience. This blend of tradition and innovation not only preserves the rich heritage but also fosters economic growth, attracting both domestic and international markets. Moradabad also has a well developed railway system, with a main railway station and a divisional headquarters of the Northern Railway on the Howrah and Amritsar main lines. The local government has recognized the importance of supporting these artisans by implementing various initiatives aimed at promoting their crafts and providing them with better access to resources and training. These efforts not only help preserve traditional skills but also contribute to the local economy by attracting tourism and fostering a sense of community pride.

Objectives

- (1) To elucidate the primary factors influencing the progression of the brass manufacturing sector in Moradabad.
- (2) To evaluate the ramifications of the brass industry on the phenomenon of urban expansion within Moradabad City.

Database and Methodology

The study utilizes secondary sources of data, which are essential for gathering existing information relevant to the brass industry in Moradabad City. A descriptive research method is employed, allowing for a comprehensive analysis of the data collected. The data required for the study comprises demographic details and industrial data. Data sources include the district census handbook, which provides demographic details crucial for understanding the population dynamics

in Moradabad. Information from Nagar Nigam Moradabad is incorporated to understand the urban governance and its influence on industrial growth. The EPCH exports of handicraft data is utilized to assess the economic impact of the brass industry on local and international markets. The study also references journals, previous research, websites, newspapers, and other research papers to enrich the data pool concerning brass metalware. The methodology emphasizes the integration of various data sources, ensuring a holistic view of the brass industry's impact on urbanization. Data representation is achieved through diagrams and tables, which are created using MS Excel and MS Word, facilitating clear visualization of findings. The historical context of Moradabad is analyzed to understand the evolution of the brass industry, including significant events and changes in demographics. The climate and drainage patterns of the region are also considered, as they influence the industrial activities and accessibility of resources. The relief and topography of Moradabad are examined to assess their impact on transportation and industrial development. The research aims to provide insights into the socioeconomic growth driven by the brass industry, highlighting its role in national and international markets. The study categorizes the determinants of the brass industry into economic and technological factors, which are critical for understanding market dynamics. Overall, the study employs a multifaceted approach to analyze the brass industry, combining quantitative and qualitative data for a comprehensive understanding of its determinants and impacts.

Results and Discussion

Major Determinants of Brass Industry in Moradabad City

The brass manufacturing sector constitutes an amalgamation of numerous interrelated determinants. Fundamentally, these determinants and factors influencing the advancement of brass production can be classified into three overarching categories, which can subsequently be subdivided into additional sub-categories. The classifications are enumerated as follows: 1. Economic Factors: This includes access to capital, market demand, and pricing strategies. 2. Technological Factors: The adoption of modern techniques and machinery plays a crucial role in enhancing productivity. 3. Social and Cultural Factors: Community engagement, skill transfer, and the preservation of heritage significantly impact the industry's sustainability. Additionally, the interplay between these factors often dictates the competitive landscape, influencing both local artisans and larger manufacturing entities in their operational strategies.

Physical Determinants and Factors

The physical and natural characteristics of any specific locale play a crucial role in facilitating the advancement of particular activities or sectors. Brass craftsmanship represents a significant endeavor encompassing various processes, including the creation of gully, the fabrication of patterns, sheet metal work, molding, soldering, scraping, engraving, lacquering, electroplating, and polishing. (Sajid, 1989). The primary physical determinants influencing brass production include topography, hydrology, climatic conditions, and soil composition. These elements not only affect the availability of raw materials but also shape the skill sets required for artisans to thrive in their craft. Additionally, the proximity to markets and trade routes can significantly impact the economic viability of brass craftsmanship, as artisans must navigate both local demand and competition from other regions. Furthermore, the cultural heritage and traditions surrounding brass work play a crucial role in preserving techniques and fostering innovation, ensuring that each piece not only serves a functional purpose but also tells a story reflective of its origins.

The terrain of the Earth is called relief. The terrain shows various differences between elevation and depression, such as mountains, valleys, plains, and plateaus, all of which have different elevations of any particular space and affect the climate vegetation of that area. It plays an important role in the development of any type of industrial activity. Moradabad City has an elevation of 673 feet (204 m) above the mean sea level. The city has a marked slope, from north to south. Moradabad is a part of Indo Gangatic plain, it comes under upper Ganga plain region. It extends from west to east. Geologically, the region belongs to alluvium and dun gravels. Moreover, the city has plain terrain, which helps provide transportation accessibility to other major cities. Thus, city relief plays a major role in the development of brass. The favorable topography, combined with the rich availability of raw materials, has made Moradabad a hub for brass manufacturing and craftsmanship. The skilled artisans of Moradabad have honed their craft over generations, producing intricate designs that are sought after both domestically and internationally. These artisans utilize traditional techniques alongside modern innovations, ensuring that their products not only reflect cultural heritage but also meet contemporary market demands. The geographical location of the city, situated in close proximity to the Himalayas and the tarai swamps, results in elevated temperatures during the summer months and extreme cold during the winter season. The principal components of the climate encompass temperature, precipitation, humidity,

atmospheric pressure, and solar radiation, among others. The brass manufacturing processes are also significantly influenced by climatic variations. The harsh winter conditions not only diminish productivity but also adversely impact the health of the labor force. During the sweltering summer months, the process of gully creation becomes exceedingly challenging and poses health risks. The monsoon season frequently hampers various activities and impedes accessibility (Khalil, L.2008). Consequently, the climatic conditions exert a crucial influence on both production capabilities and the efficiency of the workforce. Moreover, fluctuations in weather patterns can lead to unexpected delays in supply chains, further complicating the operational landscape for manufacturers. These challenges necessitate adaptive strategies, such as investing in climate-resilient infrastructure and implementing flexible work schedules to mitigate the impact of adverse weather on production.

Drainage patterns denote the configuration that a river and its associated tributaries collectively establish. The factors that govern drainage significantly influence the topographical characteristics, gradient, geological composition, hydrological supply, and historical context of the area. The city is traversed by the notable Ramganga River, which serves as a left bank tributary of the Ganga. Additionally, several smaller rivers, such as Gagan and Dhela, are located in proximity to the city. The Ramganga River is of paramount significance to the advancement of brass manufacturing. Numerous activities are contingent upon water resources, and the industry necessitates a substantial volume of water for the processing of production. In the low-lying regions, the availability of water during the pre-monsoon and winter seasons is limited. The Ramganga River is generally navigable by vessels with minimal draught; however, it remains unutilized throughout the year due to considerable fluctuations in its discharge.

Soil of Moradabad is predominantly alluvial, enriched by the sediment deposited by the river over centuries, making it fertile for agriculture and supporting a variety of crops. This agricultural productivity not only sustains local livelihoods but also contributes to the overall economic stability of the region, creating a symbiotic relationship between farming and brass manufacturing.

Natural Resources and Economic Resources

Although, in the city, there is no dense vegetation. Even the agricultural land converting very fast in settlement area. Human encroachment widely responsible for the shaping nature of the city. From the minerals and mining point of view the city and surrounding regions almost zero. There is no natural resource region and it is completely dependent area as point of resources and raw material for production of things.

Historical Determinants

The brass industry that is located in the city of Moradabad is widely regarded as an exemplary representation of a traditional industry, showcasing the rich heritage and craftsmanship that has been passed down through generations. Before the year 1632 AD, the area that we now know as Moradabad was referred to as Chaupala, a name under which it was governed by the ruling authority of Raja Ramsukh Khataria, who played a significant role in the region's early history. In the year 1632, following the directive issued by the Mughal emperor Shahjahan, a notable figure named Rustam Khan arrived in this locality, subsequently renaming Chaupala to Moradabad in honor of Murad Bakhsh, who was one of Shahjahan's sons and held the title of prince. During this transformative period, the Jama Masjid, an important architectural structure, was constructed under the supervision and leadership of Rustam Khan, adding to the cultural and historical significance of the area. Within the confines of the Mughal cantonment area known as Katghar, a community of iron smiths and carpenters took residence, contributing their skills to the local economy and the craftsmanship of the time. At that juncture in history, the production of brass products predominantly took place in the older sections of the city, specifically in neighborhoods such as Faiz Ganj, Lal Bagh, and Mandi Bans, where artisans engaged in their trades. As the 18th century approached, the city of Moradabad underwent significant changes, including the construction of defensive walls marked by prominent gates like Amroha Gate, Sambhali Gate, and Delhi Gate, which defined the city's boundaries and provided a sense of security.

The growth of Moradabad extended beyond these protective walls, spurred by the active participation of artisans who dedicated themselves to the time-honored craft of brass making, thereby fostering a thriving community. Up until that period, the craftsmen were primarily settled in the Katghar area, where they practiced their trades and honed their skills. Between the 19th and the mid-20th century, the city experienced considerable expansion, reaching into various new localities, with Mandi Chowk and Bartan Bazar emerging as vital centers for the trade of brass products that reflected the city's burgeoning industry (Bhardwaj, K. & Bhole, R. P. 2023). During the period of independence, there was a notable shift in the city's demographics and economic activities as residents began to migrate away from the confines of the old city towards the northern side, strategically located along the banks of the Ramganga River. This significant transition heralded a remarkable transformation in the urban landscape of Moradabad, giving rise to the development of new markets and residential areas that were designed to accommodate the

increasing population and meet their diverse needs. As the demand for brass products escalated dramatically, a wave of new workshops began to emerge, drawing skilled artisans from neighboring regions who arrived with an array of innovative techniques and unique designs that enriched the local craft. These talented artisans not only played a crucial role in bolstering the local economy but also contributed to the cultural richness of the city, skillfully blending traditional craftsmanship with contemporary influences that reflected the changing times. The lively atmosphere of these newly established markets quickly transformed them into bustling hubs of trade and social interaction, fostering a strong sense of community and camaraderie among both residents and artisans who shared their passion for the craft.

Socio- economic Determinants

The advancement of brass craftsmanship in the urban center of Moradabad is significantly influenced by various socio-economic determinants. Numerous socio-economic elements contribute to the proliferation of brass work within this city. Among these, several key factors are delineated as follows. These include access to raw materials, the availability of skilled labor, market demand, and the support of local government initiatives aimed at promoting traditional industries.

Availability of Raw Material

The urban area is classified as a region exhibiting neither mining activities nor a deficit in natural resources. The primary constituents of brass are copper and zinc, with the closest production areas for these metals to Moradabad located within the state of Rajasthan. The raw materials are imported from Rajasthan and subsequently distributed within the city by factory exporters to the local populace. Artisans engaged in the production of intricate gully components utilize copper, zinc, nickel, and other materials provided by exporters and manufacturers. These artisans often rely on traditional techniques passed down through generations, ensuring that each piece reflects the rich cultural heritage of the region.

Transport and Communication

The urban area encompasses an expanse of 75 square kilometers and is effectively integrated with the adjacent major urban centers through both railway and roadway infrastructure. A dual railway line exists between the cities of Moradabad and Rampur. Moradabad is situated along National Highway 24, which serves as a vital link connecting Moradabad to New Delhi and Lucknow, the capital of the state. National Highways 509 and 93 facilitate the connection of Moradabad to Agra

through the intermediary towns of Chandausi and Aligarh. The Moradabad railway station is positioned on the Lucknow-Moradabad line, the Delhi-Moradabad line, as well as the Moradabad-Ambala line. It is designated as an interguage station due to its convergence of five railway lines and is classified as an 'A' category station. Furthermore, Moradabad has recently established a domestic airport, which is anticipated to undergo significant development in the near future. This airport is expected to enhance connectivity and boost local tourism, making it easier for visitors to explore the rich cultural heritage and vibrant markets of the region.

Cheap and Skilled Labor

Inexpensive and proficient labor constitutes one of the fundamental elements necessary for any industrial advancement. The brassworking sector is predominantly labor-intensive, necessitating a substantial workforce. During the initial stages of product fabrication, both skilled and unskilled labor are essential for activities such as gully making, pattern creation, sheet processing, molding, polishing, and packaging, among others. The involvement of the female demographic in this industry is notable, as a significant proportion of women actively participate in this labor. At the nascent phase of their development, children often commence learning the craft under the guidance of their parents. (Sajid, M.1989). Both children and adults—men and women alike—contribute to labor in various capacities. As they gain experience, many artisans develop their own unique styles, which not only enhance the quality of the products but also foster a sense of community pride and cultural heritage. This evolution of skills often leads to the establishment of workshops where knowledge is shared, ensuring that traditional techniques are preserved and passed down through generations.

Export Promotion Council

This council plays a crucial role in supporting these artisans by connecting them with broader markets, helping to elevate their craft on an international stage. These efforts not only provide economic opportunities but also encourage the appreciation of local artistry, allowing artisans to thrive while keeping their cultural narratives alive. In addition, initiatives aimed at sustainable practices are increasingly being integrated, ensuring that the materials used are sourced responsibly and that the environmental impact is minimized. These initiatives foster a sense of community among artisans, encouraging collaboration and innovation while reinforcing the importance of ethical craftsmanship.

Moradabad SEZ (Special Economic Zone)

Moradabad SEZ (Special Economic Zone) has emerged as a significant focal point for such initiatives, drawing the attention of both domestic and international investors who acknowledge the capabilities of these adept artisans. Consequently, the SEZ not only enhances the local economic landscape but also exemplifies a paradigm for other regions endeavoring to integrate traditional practices with modern advancements, demonstrating the compatibility of cultural heritage alongside contemporary market exigencies. Established in 2003 at Pakbara (NH 24), Dingarpur Road, it occupies a substantial area of 421,565 acres, extending 8 kilometers on either side, and has been operational since 2007 (Rastogi, S. & Agarwal, S.K. 2018). The governance of the SEZ is managed locally by an Assistant Development Commissioner. It offers exceptional infrastructure, specialized facilities, and ancillary services conducive to the handicraft sector. Furthermore, it provides a robust global telecommunications network, an uninterrupted power supply, and an efficient local transportation system. The SEZ comprises 478 registered plots, among which 137 plots are currently hosting 42 industrial units in active production. Initially conceived as a handicraft-focused SEZ, Moradabad SEZ has evolved into a multi-sectoral economic zone with the potential to establish export-oriented industries. The SEZ framework operates under a single-window system featuring zero-rated transactions of goods and services, provisions for duty-free imports, automatic hundred percent foreign direct investment in most sectors, and deemed port status. This strategic approach not only enhances the ease of doing business but also attracts a diverse range of investors looking to capitalize on the region's unique advantages. Additionally, the SEZ is supported by robust infrastructure, including well-developed transportation networks and utilities, which further facilitate operational efficiency and connectivity for businesses. Moreover, the local government actively promotes skill development programs to ensure a skilled workforce is available to meet the demands of these industries.

Trade Fair Authority of India

The Trade Fair Authority of India facilitates Indian engagement in international exhibitions and trade fairs by showcasing Moradabad handicrafts at various global exhibitions and fairs. The Trade Fair Authority of India is actively contributing to the enhancement of export activities on an international scale. This initiative not only boosts the visibility of local artisans but also fosters partnerships that can lead to increased investment and collaboration in the handicraft sector.

Additionally, the authority organizes workshops and training sessions to equip artisans with modern techniques and marketing strategies, further empowering them to compete in the global market (Sajid, M.1989). These efforts are crucial in preserving traditional craftsmanship while adapting to contemporary consumer demands, ensuring the sustainability of this vital industry. Moreover, the integration of digital platforms has opened new avenues for artisans to reach a wider audience, allowing them to showcase their unique creations online and connect with potential buyers worldwide.

Scenario of Urbanization in Moradabad City

Moradabad, one of the most populous cities of Uttar Pradesh. Moradabad city is the administrative headquarter of Moradabad district. According to 2011 census the population of Moradabad city is 887871 and it is growing very fast. Basically, the haphazard growth of city playing a major role to emerging many problems like destruction of agricultural land and wild life, discharge of polluted water in streams and large water bodies and lack of sanitization. It gives birth to socio economic problems like housing shortage, unemployment, traffic congestion and also increase in crime. According to 1951 census the city had the population 154018 while in 2011 the population was 8,87,871. It is also increasing continuously with a rapid rate in present. Moradabad is an oldest township in north India due to the existence of several small, medium and large industries. The industrial composition in this area provides a wide scope for labors work and it is the main cause of city’s unplanned expansion (Table-1).

Table-1: Decadal Population Growth and Density Scenario in Moradabad City

Years	Population	Decadal Change	Growth Rate	Area in km	Density	Decadal density growth
1951	154018	-	-	51.75	3127.614	-
1961	180100	26082	16.93	56	3216.071	88.45
1971	258590	78490	43.58	61.2	4225.326	1009.255
1981	330051	71461	27.63	65.45	5042.492	817.66
1991	429214	99163	30.04	69	6220.492	1177.572
2001	641583	212369	49.48	75	8554.44	2333.948
2011	887871	246288	38.39	75	11838.28	3283.81

Source: Census Handbook of Moradabad (2001 and 2011)

Decadal Population Growth in Moradabad City

The table lists the years from 1951 to 2011. It shows the total population of Moradabad in each of these years. The "Decadal Change" column tells us how many more people lived in the city compared to the previous decade. For example, from 1951 to 1961, the population increased by 26,082 people. The "Growth Rate" column shows the percentage increase in population for each decade. For instance, from 1961 to 1971, the population grew by 43.58%, which means the population increased significantly during that time. In 1951, the population was 154,018. By 2011, the population had grown to 887,871, showing a steady increase over the years. The highest growth rate recorded was 49.48% from 1991 to 2001, indicating a rapid increase in the number of people living in Moradabad during that decade.

Decadal Density Scenario

The table provides information about the area of Moradabad in square kilometers (km) and how many people live in that area, which is called "density." The "Decadal density growth" column shows how much the density increased from one decade to the next. For instance, from 1971 to 1981, the density grew by 817.66 people per square kilometer. In 1951, the area of Moradabad was 51.75 km², and the density was relatively low. By 2011, the area had increased to 75 km², but the density had risen dramatically to 11,838.28 people per km², indicating that even though the area got larger, more people were living in it, making it more crowded.

Growth of Metalware Industry of Moradabad

Brass plays a vital role in Moradabad's economic landscape and has a significant influence on the livelihoods of its residents. Moradabad's brass manufacturers specialize in producing decorative items, utensils, and household products, with the majority of exports heading to European, North American, Middle Eastern, and Central Asian countries. In recent years, there has been a notable increase in demand for brass, particularly in the manufacturing and construction industries, resulting in a rise in imports. This growing demand has prompted some countries to shift their focus towards importing more brass rather than relying on domestic production. The brass industry is a labor-intensive sector that offers substantial employment opportunities to socially and economically disadvantaged individuals in Moradabad city and surrounding regions. Nearly one-third of the total population in Moradabad relies on direct employment in brass establishments (Table-2). The brass industry holds significant importance at both national and international levels.

Internationally, brass products have garnered a reputation for fulfilling consumer needs and changing preferences. As a specific segment of the manufacturing sector, the brass industry contributes to national economies by generating employment, fostering industrial development, and facilitating trade.

Table-2: Scenario of the Growth of Export Metalware Industry in Moradabad

Year	Export of metalware (in INR crore)	Year	Export of metalware (in INR crore)
1950-51	1.6	1985-86	88.80
1955-56	1.8	1990-91	127.08
1960-61	1.9	1995-96	246.94
1965-66	2.13	2000-01	794.66
1970-71	6.5	2005-06	1094.69
1975-76	15.7	2010-11	910.13
1980-81	51.67	2014-15	1681.99

Source: Katyay, S. (2018) & EPCH (<http://www.epch.in/moredetails.htm>)

Explanation of Metalware Exports

The table shows the export of metalware from a Moradabad over several years. The values are presented in Indian Rupees (INR) and are measured in crores. One crore is equal to ten million, so when we say "1.6 crore," it means 16 million rupees. The table lists data from the years 1950-51 to 2014-15. Each year represents a specific time period, starting from 1950-51, which is the first year in the table, and ending with 2014-15, which is the last year shown. The export values start very low in the early years. For example, in 1950-51, the export was only 1.6 crore. As we move through the years, we can see a significant increase in the export values. By 2014-15, the export had risen to 1681.99 crore. This shows a clear trend of growth in the metalware industry over time. Notable jumps in export values can be seen in certain years. From 1970-71 to 1975-76, the export increased from 6.5 crore to 15.7 crore. A major leap occurs between 1995-96 and 2000-01, where the export skyrockets from 246.94 crore to 794.66 crore. The highest value recorded is in 2014-15, which indicates that the metalware industry was thriving at that time. This could suggest that the demand for metalware products was growing, or that the production capabilities of the region improved.

Impact of Brass Industrial Growth on Urbanization

Industrialization represents a significant epoch of socio-economic metamorphosis within human society, wherein a community transitions from a predominantly agrarian framework to an industrialized paradigm. This phenomenon constitutes a systematic reconfiguration of the economy towards manufacturing processes. The industrial advancement in Moradabad city, particularly with regard to the brassware sector, facilitated enhanced employment prospects; consequently, a substantial influx of individuals migrated to the town, thereby accelerating the urbanization trajectory. The factors influencing the brass industry in Moradabad city catalyzed the regional industrial progression, resulting in the emergence of diverse industries both within Moradabad city and its adjacent locales. As industrialization progressed in Moradabad city, individuals relocated in pursuit of superior employment prospects and improved living conditions, leading to their permanent settlement in the city; this phenomenon significantly contributed to the urbanization of Moradabad city. Economic growth and urbanization exhibit a positive correlation. Urbanization is frequently regarded as a pivotal indicator of a nation's comprehensive development. Analyzing historical contexts, urbanization has been intrinsically associated with economic advancement. Similarly, the economic evolution of Moradabad city plays a crucial role in fostering urban growth.

Conclusion

The study indicates that Moradabad has experienced substantial population growth and increasing density over the decades. The growth in population and density can be linked to various factors, such as economic opportunities, migration, and urbanization, which means more people moving to cities for jobs and better living conditions. It shows that the city has become more populated and crowded, which can have both positive and negative effects on living conditions, infrastructure, and resources available to the residents. Understanding these trends is important for planning and managing the city's growth in the future. Economic Factors include access to capital, market demand, and effective pricing strategies, which are essential for the industry's viability and growth. Community engagement, skill transfer, and the preservation of traditional craftsmanship significantly impact the sustainability of the brass industry, affecting both local artisans and larger manufacturing entities. The data shows a significant growth in export values over the years, indicating the increasing importance of Moradabad's metalware industry on both local and global scales. Understanding the trends in population growth and

the determinants of the brass industry is essential for effective urban planning and management. This knowledge can help address challenges related to infrastructure, resources, and living conditions as the city continues to grow. In conclusion, the significant growth in export values indicates that Moradabad's metalware industry has become increasingly important, both locally and potentially on a global scale. The results of the study also underscore the critical role of the brass industry in shaping the urban landscape of Moradabad, highlighting the need for continued support and strategic planning to ensure its growth and sustainability in the future.

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NDVI: VEGETATION CHANGE DETECTION USING REMOTE SENSING AND GIS TECHNIQUE IN BARA TEHSIL, PRAYAGRAJ DISTRICT, UTTAR PRADESH

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Abstract

There are 2 development blocks and 19 Nyaya Panchayats in Bara Tehsil of Prayagraj district. Due to various social, economic and physical factors Land use/ Land cover changed over the year in the study area Bara Tehsil. The main objective of this paper is to find out the changes in vegetation cover which have taken place in study area. Remote Sensing and GIS technique is used for the vegetation change detection. Satellite data of Landsat 7 ETM+ (2001) and Landsat 8 (2021) has been used for the study. Vegetation change dynamics were analyzed in between year of 2001 to 2021. Arc GIS 10.8 software has been used for Satellite image processing. There has been an increase of 9.43 percent in the lower vegetation category in last 20 years, which is not a good sign. The medium vegetation category, which mainly belongs to the cropped area, has declined 4 percent due to increased use of land for non-agricultural purposes. There has been a 1.47 percent decrease in the dense vegetation category in the last 20 years, which belongs to forest and tree cover.

Introduction

The Normalized difference vegetation index (NDVI) is a widely-used metric for the estimation of vegetation cover using satellite's imagery. NDVI index shows health and density of vegetation coverage in an area. NDVI value lies between -1 to +1, which is divided into different classes like waterbody, builtup area, scrub and grassland, sparse vegetation and dense vegetation. As the NDVI value increases towards +1, vegetation health and density also increases. So, NDVI is a standardized way to estimate healthy vegetation. When you have high NDVI values, you have healthier vegetation and vice versa (GIS Geography). Nowadays NDVI is a widely used technique to detect vegetation changes occurring in a particular area. As socio-economic condition of any area changes, land use keeps on changing (Rayamane et .al, 2002). Due to various social, economic and physical factors Landuse/

Landcover changes over the year in any area, as a result vegetation health and coverage also changes. Change in vegetation affects wildlife habitats, climate, air quality and other resource values. Since NDVI data provides a measurement of crop health, it can be effectively implemented in crop health monitoring systems in the agricultural sector.

The modern Geo-spatial technique of Remote Sensing (RS) coupled with Geographic Information System (GIS) is very helpful in monitoring natural resources and environmental changes and also helps to analyze the information of other environmental variables (Marble et al. 1983). Remote sensing provides information based on radiation reflected or emitted from objects located on the Earth's surface (Read & Torrado, 2009). Currently, remote sensing techniques are being used by various researchers and geographers to estimate the changes in vegetation over the year. For the first time NDVI calculation was used in the Great Plains study in 1973 by Rouse et al. (1973). However, before this in 1969 Kriegler et al. formulated a normalized difference spectral index. The NDVI value varies according to the amount of chlorophyll in the plants. High levels of chlorophyll indicate healthy vegetation. Bid, Sumant (2016) analyzed vegetation cover changes using NDVI Technique on catchment Area of the Panchet hill dam, India. Pantho, Md Jubair et. al. (2022) detected vegetation changes using NDVI technique in Barishal city, Bangladesh. Gandhi, G.M. et. al. (2015) estimated NDVI change detection in Vellore district using geospatial technique. Rahman, S. et. al. (2011) detected temporal change in vegetation coverage of Dhaka with the help of remote sensing technique. NDVI is very useful in monitoring of vegetation dynamics (Beck et al., 2006). This index shows positive correlation with high chlorofill content in plants, biomass, dense vegetation cover and Leaf Area Index (LAI) (Schmidt et al., 2000).

Study Region

Prayagraj is divided into 7 tehsils (Soraon, Phulpur, Handia, Meja, Karchana, Koraon, Bara) and one urban area Sadar. Study area Bara tehsil has two development blocks - Jasra and Shankargarh. Jasra block covers 36.4% of the tehsil area and Shankargarh block covers the remaining area. The total area of Bara tehsil is 744 km², out of which 735.852 km is rural area and the remaining 8.36 km² is urban area. There are about 325 villages in Bara tehsil, out of which 114 villages are located in Jasra block and 211 villages in Shankargarh block. There are a total of 19 Nyaya Panchayats, out of which 9 are in Jasra and 11 in Shankargarh block. Bara tehsil is located in the transition zone between Yamuna and Tons rivers in the

southwest of Prayagraj district. The latitudinal extension of Bara tehsil is between 250 2' 30" to 250 22' 30" north latitude and longitudinal extension is between 810 31' to 810 50' east latitude and its area is about 744 km². The length of the study area is 33.82 km from east to west and width is 33.77 km from north to south. Bara tehsil is connected to Prayagraj city in the north, Karchana tehsil in the east, Meja and Koraon tehsils in the south-east. Rewa region of Madhya Pradesh state is situated to the south of Bara tehsil, Chitrakoot in the south-west and Kaushambi district in the west. According to Census 2011, the total population of Bara tehsil is 365605, out of which 192517 are males and 173088 are females. There is a lot of disparity in the rock structure of Bara tehsil. Jasra block is plain and has a lot of alluvial soil while Shankargarh block's most part is rocky wasteland.

Objectives

- (1) To identify the changing pattern of different land cover classes in the study area.
- (2) To detect the changes which have taken place in vegetation coverage in study area.

Data Sources and Methodology

In this study, Landsat 7 ETM+ (Enhanced Thematic Mapper Plus) data (Band-7,6,5,4,3,2,1; Resolution-30m), Date: 12th April, 2001, path 143, row 043 and Landsat 8 data (Band -7,6,5,4,3,2,1; Resolution- 30m), Date: 16th April, 2021, path 143, row 043 were used (Table-1). The satellite data covering study area were obtained from USGS Earth Explorer. As reference and base map preparation, Survey of India topographical sheets on 1:50000 scale numbered G44P11, G44P12, G44P15 and G44P16 were used. These data sets were imported in Arc GIS 10.8 software for Satellite image processing to create a False Colour Composite (FCC). Vegetation change dynamics were analyzed in between year of 2001 to 2021.

Table-1: Characteristics of Satellite Data

Date of Data retrieved	Satellite	Sensor	Path	Row	Projection	Datum	UTM Zone	Spatial Resolution
12 April, 2001	Landsat 7	ETM+	143	043	UTM	WGS 1984	44N	30 m
16 April, 2021	Landsat 8	OLI/TIRS	143	043	UTM	WGS 1984	44N	30 m

Source: Authors

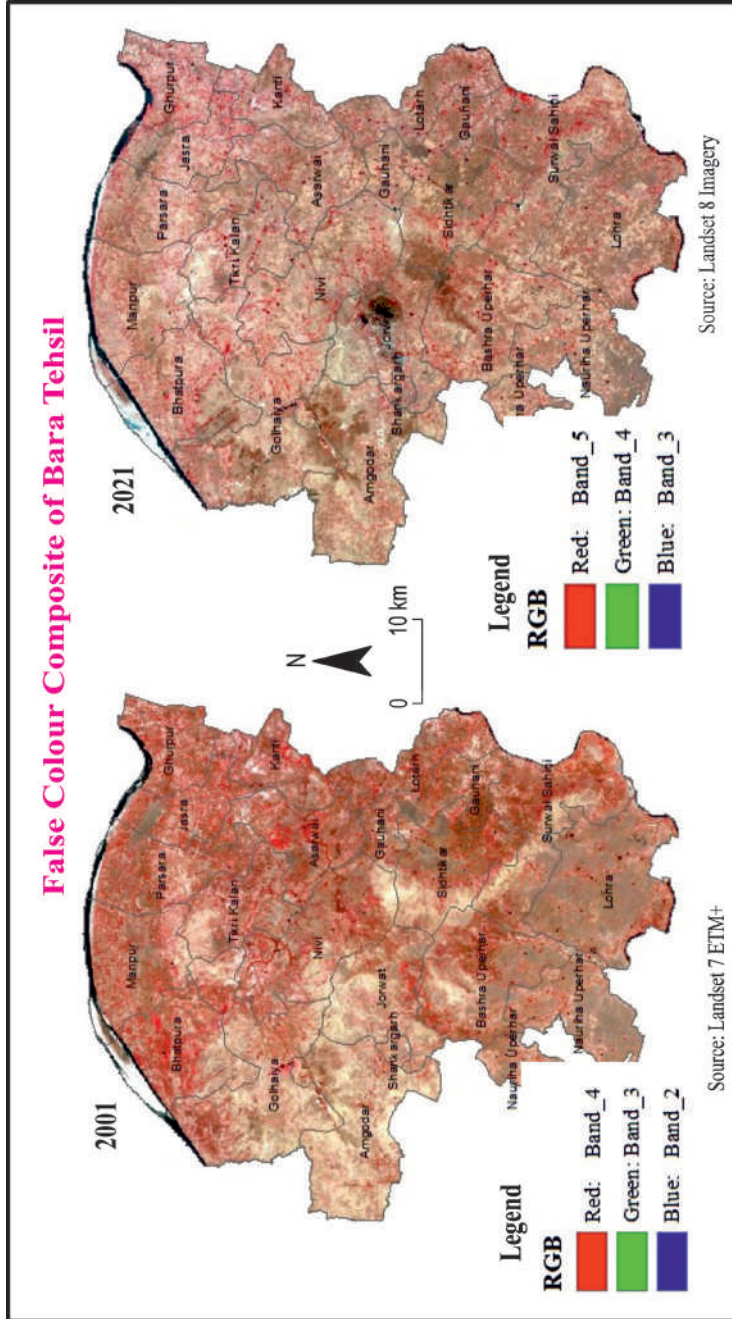


Fig. 1

NDVI Calculation Processing

Satellite Imagery retrieved from USGS Earth Explorer of the study area is used for the determination of NDVI. The NDVI map are generated using Near Infrared (NIR) and Red channels because near infrared light is strongly reflected by vegetation and red light is absorbed by the vegetation. NDVI calculation method for Landsat 7 and Landsat 8 is given below –

For Landsat 7

In Landsat 7 satellite data Band 4 as Near Infrared and Band 3 is used as Red channels. So the NDVI calculation formulae will be –

$$\text{NDVI} = (\text{NIR} - \text{RED}) / (\text{NIR} + \text{RED}) = (\text{Band 4} - \text{Band 3}) / (\text{Band 4} + \text{Band 3})$$

For Landsat 8

In Landsat 8 satellite data Band 5 as Near Infrared and Band 4 is used as Red channel. So the NDVI calculation formulae will be –

$$\text{NDVI} = (\text{NIR} - \text{RED}) / (\text{NIR} + \text{RED}) = (\text{Band 5} - \text{Band 4}) / (\text{Band 5} + \text{Band 4})$$

Results and Discussion

NDVI is very important technique for measuring land use land cover (LULC) pattern, especially in detecting changes in vegetation. Land use classification is the systematic arrangement of lands based on certain common characteristics, the main purpose of which is to identify and understand their fundamental utilities intelligently and effectively (Kumar and Tiwari, 2017). The study of changes in the vegetation of an area is of great importance in sustainable land use planning of that area. For this purpose, the land cover data for the years 2000-01 (base year) and 2020-21 (the closing year of the study period) have been considered and changes in vegetation over a period of 20 years have been calculated (Table-2 and Fig. 1 and 2).

As we know that NDVI value ranges from -1 to +1 and in this high NDVI value indicates high vegetation density, while low NDVI value indicates low vegetation density. Waterbody appears light blue to dark blue and in black colour in standard FCC map. In Bara tehsil, waterbody of the total reported area was 1599 hectares (2.15%) in the year 2001, which decreased to 1477 hectares (1.98%) in the year 2021, means there has been a decrease of 0.17 percent in the waterbody of Bara tehsil. Built up area appears light blue to bluish green tone in FCC map while Rocky and stony wastelands appears light brown to dark brown and white tone in FCC map. In Bara tehsil, in this category area of the total reported area was 22573

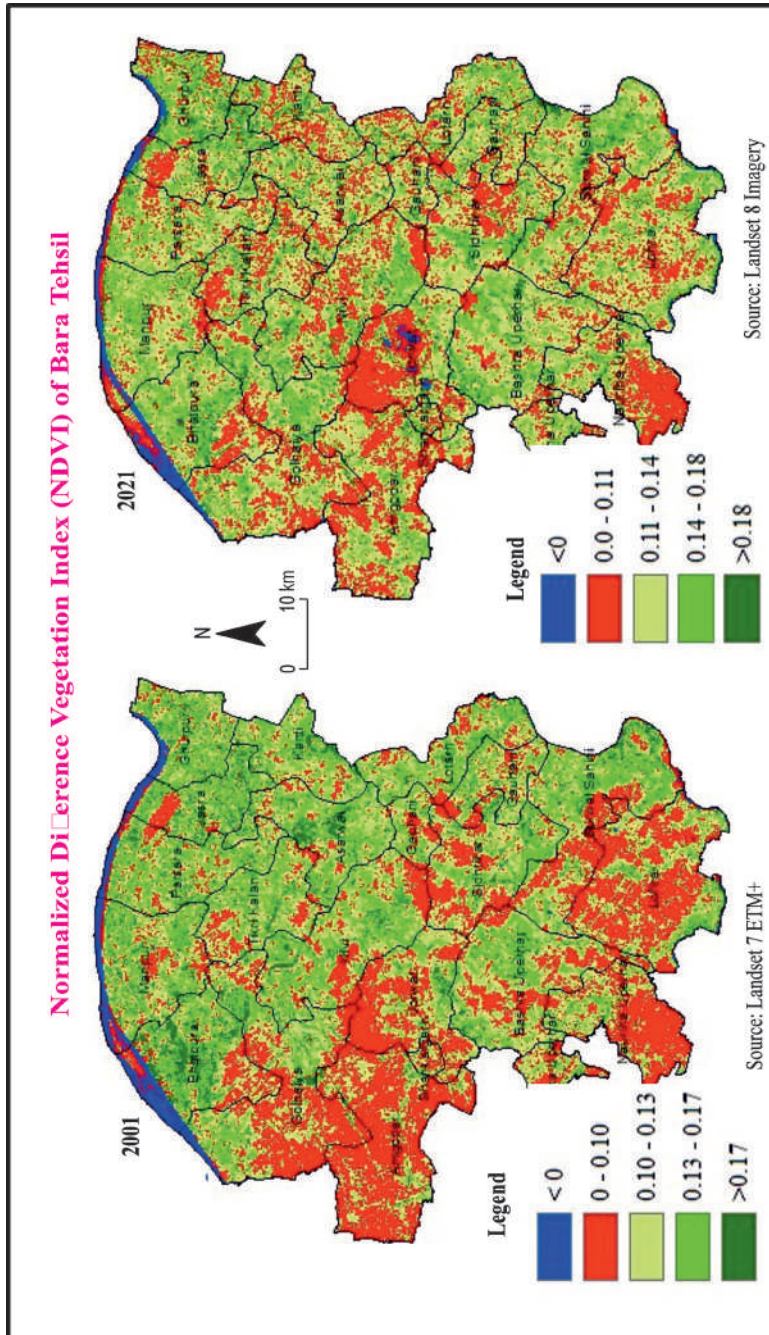


Fig. 2

Table-2: Changes in Vegetation of Bara Tehsil (2001 to 2021)

Class Name	NDVI Value 2001		Area, Year 2001		NDVI Value 2021		Area, Year 2021		Change	
	<0	0 – 0.10	in Hectare	in percentage	<0	0 – 0.11	in Hectare	in percentage	in Hectare	in percentage
Waterbody			1599	2.15			1477	1.98	-122	-0.17
Bair Soil, Built up Land			22573	30.36			19748	26.56	-2825	-3.80
Low Vegetation	0.10-0.13		27868	37.49	0.11-0.14		34882	46.92	7014	9.43
Medium Vegetation	0.13-0.17		17533	23.58	0.14-0.18		14561	19.58	-2972	- 4
Dense Vegetation	>0.17		4760	6.40	>0.18		3667	4.93	-1093	-1.47
Total			74333	100			74335	100		

Source: Authors

hectares (30.36%) in the year 2001, which decreased to 19748 hectares (26.56%) in the year 2021, means there has been a decrease of 3.80 percent in this category. Land resources which is used for nonagricultural work like – settlement, factories, roads, railways, buildings etc. comes in builtup area category.

This has divided vegetation into three categories on the basis of vegetation density as – Low, Medium and Dense vegetation in the Bara Tehsil. The lower vegetation category includes shrub, grasslands and some cropland area. It appears light brown to red patches tone in FCC map. In Bara tehsil, the total reported area under lower vegetation category was 27868 hectares (37.49%) in the year 2001, which increased to 34882 hectares (46.92%) in the year 2021, i.e. there has been an increase of 9.43 percent in this vegetation category. The medium vegetation category mainly includes areas under various types of sown crops. It appears pink to bright red tone in FCC map. In Bara tehsil, the total reported area under medium vegetation category was 17533 hectares (23.58%) in the year 2001, which decreased to 14561 hectares (19.58%) in the year 2021, i.e. there has been a decrease of 4 percent in this vegetation category. The dense vegetation category mainly includes forests and areas covered with various types of trees. It appears bright red to dark red tone in FCC map. In Bara tehsil, the total reported area under dense vegetation category was 4760 hectares (6.40%) in the year 2001, which decreased to 3667 hectares (4.93 %) in the year 2021, i.e. there has been a decrease of 1.47 percent in this vegetation category.

Conclusion

The present paper provides a comprehensive view of changing vegetation pattern of Bara Tehsil using Remote Sensing and GIS technique. It shows how social, economical factors and increasing population pressure on land affect vegetation density in any particular area. As the socio-economic status of people changes, change in the nature of land use pattern is also inevitable. There has been an increase of 9.43 percent in the lower vegetation category in last 20 years, which is not a good sign. We can reduce the area under this category and can increase healthy vegetation with the help of various land use reform programmes and methods like- soil health card, use of gypsam, Dhaincha, organic manure, better water drainage system etc. There has been a 4 percent decrease in the medium vegetation category in the last 20 years and the main reason for this is the increase in population, settlements, urbanization, construction of new roads, railways etc. There has been a 1.47 percent decrease in the dense vegetation category in the last 20 years which belongs to forest and tree cover. Deforestation is the main reason

for this. There is a need of proper planning for forest conservation and awareness programmes like – Agroforestry, social forestry to increase forest and tree cover. There is a need of sustainable land use planning so that resources are protected for the present generation as well as for future generations. I hope this NDVI analysis will be very useful for policy makers and planners in decision making.

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LOCAL FOOD PRODUCTION FOR TOURIST CONSUMPTION IN THE WESTERN HIMALAYAS: AN APPROACH TOWARDS SUSTAINABLE TOURISM DEVELOPMENT

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Abstract

This paper aims to investigate the relationship between tourism and sustainability, focusing on the economic and environmental consequences due to import of food products in order to fulfill the tourist demand rather than producing within the geographical or the territorial jurisdiction of the tourist destination. The study uses secondary data from the District Statistical Handbook to analyze the production of various food items in the Western Himalayan region. It employs the Import Dependency Ratio to quantify the reliance on imported foods to fulfill tourists need and also calculate the carbon footprints due to transport, logistics and procurement, which impacts on the economy and environment of the region. The findings reveal a significant reliance on imported food products to meet the demands of tourists in the Western Himalayas. The transportation of these imported foods contributes to a substantial carbon footprint, posing challenges to the destination's sustainability. This underscores the need for strategies to enhance local food production and integrate the agriculture sector into the tourism industry to promote sustainability.

The research highlights the importance of promoting local food production to reduce dependency on imported foods and mitigate the environmental impact of food transportation in tourist destinations. Policymakers can utilize these findings to develop strategies for enhancing local food production and fostering sustainable tourism practices. This paper contributes to the literature by examining the specific context of food import dependency in the Western Himalayas thereby impacting the economy, its impact on the environment due to carbon footprints and its implications for sustainable tourism development. It offers insights into the potential role of local food production in promoting Environmental and Economic sustainability within tourist destinations.

Introduction

Tourism is acknowledged as a major player in the global economy, standing as one of the major economic sectors globally. Given the economic significance of the industry and its rapid expansion, it is not unexpected that numerous literatures have explained various consequences of tourism across numerous levels (Baloch et al., 2020). However, Tourism has the potential to influence various aspects of sustainability, encompassing economic growth, employment and alleviation of poverty (Manzoor et al., 2019). In order to maintain our current level of comfort without endangering the capacity of future generations to experience the natural world, it is imperative that we discover sustainable practices. Sustainable tourism encompasses various perspectives, but according to the UNWTO, it is characterized as achieving a harmonious equilibrium between the economic interests of the industry and the overall welfare of local people and the environment (Batool et al., 2023). Tourism sustainability, as Butler (1999) put in that it aims to facilitate the enduring coexistence of natural beauty and human communities by reducing the human footprint on the Earth's natural resources. The increasing necessity for the establishment of sustainable tourism is driven by numerous economic, social, and cultural challenges that pose threats to the industry's expansion (Wani et al., 2022). Against the backdrop of the growing emphasis on sustainability in the tourism industry's growth, researchers have progressively directed their attention toward investigating the viability of food as a resource that can be sustained over time (Seraphin and Gowreesunkar, 2021). Roughly 33% percent of the money spent by visitors at a destination goes towards food (Giritlioglu and Ipar, 2016). According to many scholars, the use of locally produced products is accentuated because the types of foods that are given to tourists do certainly have huge bearing on the overall benefit that the hosts and the guests enjoy through economic, sociocultural and environmental sustainability of tourism destinations (Batool et al., 2021). This underscores the importance of incorporating local cuisines into sustainable tourism is crucial.

In places like Majorca, Spain, where three-quarters of food for tourists is imported, the resulting carbon footprint from sourcing and logistics threatens sustainability (Filimonau et al., 2011). Therefore, Importing food for tourist consumption not only depletes the limited foreign exchange reserves earmarked for development in the Caribbean but also deprives agriculture of potential employment opportunities and income generation (Bélisle, 1984). The growing need for food

due to tourism drives the expansion of food production and service offerings in a tourist place (Mak et al., 2012a). While sustainability in tourism and local food consumption have gained attention, the specific impact of consuming local food on sustainability requires further exploration. In this context, 'local food' refers to products sourced or produced within a specific region, including local delicacies or regionally themed brands (Wani, Dada and Shah, 2022). Prior research has addressed the influence of regional cuisine on the economic development of local communities (Rossi et al., 2017). Few researches have also recognized the correlation between tourist preferences and local food (Baah et al., 2020). However, there is a dearth of studies examining the impact of production of local food on the economic, social and environment sustainability, because as the tourism industry expands so do the accompanying environmental challenges (Wani, Dada and Shah, 2023). To address this gap in the literature, this study investigate the following objectives.

Study Region

Kargil district was carved out of erstwhile district Ladakh. Kargil came into being as a separate district in July 1979. A considerable number of tourists, trekkers, and mountaineers started visiting Kargil when the area was opened for tourists in the year 1974 with other parts of Ladakh. The place again came into limelight after the infamous 1999 Kargil conflict, and it certainly became the identity of the region for quite some time till people realized its pristine beauty. However, for one or the other reasons, these features attract tourists from the whole world. In the year 2008, a total number of 17191 tourists visited Kargil, which increased to 109558 in the year 2018, and it is expected to increase in the coming years. So this is an opportunity for the tourism industry to develop and promote tourist attraction sites of Kargil, which are bestowed with immense tourism potential (Tourism vision Ladakh, 2021). Besides tourism the economy of Kargil district relies on agriculture, with primary crops including barley, wheat, pulses, potatoes and apricots alongside livestock activities, fostering a self-sufficient lifestyle (Fig. 1).

Objectives

- (1) To investigate how many quantities of food are imported in order to fulfill the tourist demand during the peak tourist season.
- (2) To calculate how these imports of food items have impacted the environmental sustainability of the region by calculating the carbon emissions due to transportation.

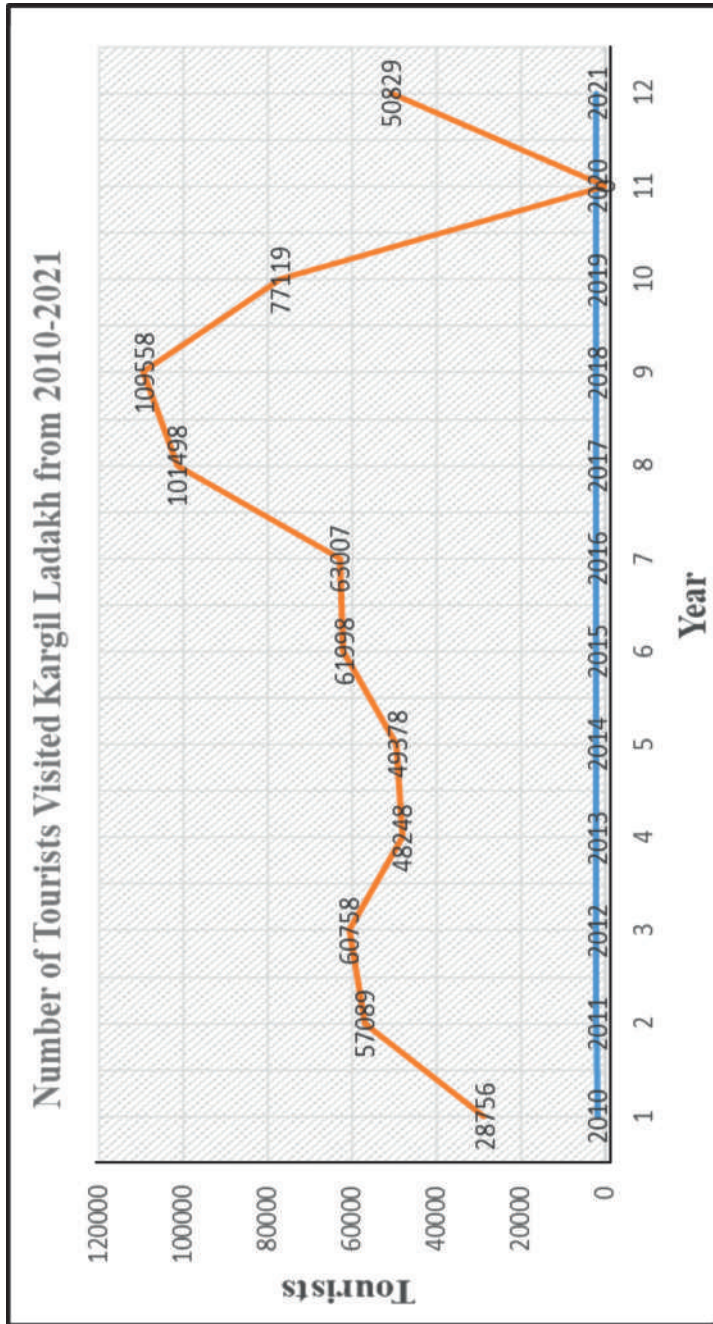


Fig. 1

Database and Methodology

It is noted that only those food items are assumed which is produced in the region as registered in the district statistical handbook (DSH) of Kargil. A crucial element in assessing the food dynamics of a country, region, or district (comprising the food system, food security, and food self-sufficiency) involves understanding the proportion of food sourced from external imports compared to that from local production within the area. As noted by (Pelliciardi, 2021), According to FAO (Food and Agriculture organization), “the Import Dependency Ratio (IDR), described in percentage, which answers this question, is defined as”:

$$\text{IDR} = \frac{\text{Imports (in mass)}}{(\text{Local production} + \text{Imports} - \text{Exports})(\text{in mass})} \times 100 \quad (\text{formula 1})$$

Assumptions made in the analysis include: quantities are measured and expressed in quintals [q] instead of tons (the SI unit), as this aligns with the unit used in the District statistical handbook and other stakeholders. Additionally, the quantity of food-grain exported from Kargil District is assumed to be 0.0 [q]. Imports of food items are considered as the minimum quantity required to fill the deficit in food items, which is calculated as the difference between the required (R) and the available produced quantities (AP). This determines the minimal quantity that must be imported to meet the needs of tourists (the numerator of formula 1). Therefore, the simplified formula for the study is.

$$\text{IDR} = \frac{\text{Imports (in mass)}}{(\text{required})(\text{in mass})} \times 100 \quad (\text{formula 2})$$

The remainder of this ratio up to 100 would signify the portion of the local food supply that originates within the country. Nevertheless, it's important to note that these ratios are valid only if imports primarily serve domestic consumption and are not re-exported. The study relies on secondary data collected from the Statistical Handbook of District Kargil UT Ladakh, Journals and Research Papers. The average number of tourists (both domestic and foreign) visited Kargil from 2010 to 2021 as recorded in the Tourism vision hand book and Statistical Handbook of District Kargil Ladakh are 59089.83 approximately 60,000.

Results and Discussion

The diagram presented illustrates the tourist influx to Kargil from 2010 to 2021. It indicates a notable surge in visitors starting from 2011, peaking in 2012.

However, there was a decline in tourist numbers in 2013, continuing into 2014 before rebounding in 2015 and 2016 (Table-1). The years 2017 and 2018 marked the highest number of tourist arrivals, followed by a downturn in 2019. The onset of the COVID-19 Pandemic in 2020 severely impacted the tourism sector, resulting in a complete absence of tourists in Kargil during the same year. In 2021, immediately after the outbreak, only 50829 tourists visited, indicating a gradual recovery. Now as tourism grows, it becomes increasingly crucial for local regions that supply food for domestic consumption to enhance their food production capacity. This underscores the importance of aligning local food production with the demands of the tourism sector. Table-1 reveals the quantity of food products produced in the region.

Local Food Production in Kargil

Table-1: Local Food Production in Kargil

Barley/ grain (in quintals)	Wheat (in quintals)	Other cereals and millets (in quintals)	Pulses (in quintals)	Vegetables including potato (in quintals)	Milk and milk products (in quintals)	Meat, egg and fish (in quintals)	Total (in quintals)
107726.0	37323	49	7573.6	86580.0	72.50	7020	246343.6

Source: District Statistical Handbook

Required Quantity of Food-grain

Consuming a variety of food and beverages ensures the daily average energy intake required for a normal lifestyle. According to (Dyson and Hanchate, 2000) in India the consumption of pulses, vegetables, milk and milk products, (meat, egg & fish) and cereals in terms of quantity are 0.62 kg, 9.95kg, 13.13kg, 0.20kg and 12kg per month respectively. In the present analysis the amount of food items required (R) for tourist consumption over a five months period has been determined by multiplying required per capita (R/pc) by the average number of visitors in the given year. The age and gender differentiations were not considered owing to insufficient data, the resultant outcome serves as the denominator of the formula 2. The table 2 below reveals the different items of food, Monthly per capita consumption (Kg), Per capita consumption for a period of 5 months (Kg), Per capita consumption for a period of 5 months (in Quintals), $Req = R_{pc} [q/pc] \times$ Tourist population in the current year (Quintals), Local Production in the current year 2021-2022 as per the DSH in (Quintals), Current (local) production minus the required amount in Quintals, (i.e. Imports) and then the IDR (Import Dependency ratio) has been calculated.

Table-2: Import Dependency Ratio (IDR)

Items	Monthly per capita consumption (Kg)	Per capita consumption for a period of 5 months (Kg)	Per capita consumption for a period of 5 months (In Quintals)	Req = Rpc [q/pc] x Tourist population in the current year (Quintals)	Local Production in the current year 2021-2022 as per the DSH in (Quintals)	Current (local) production minus the required amount in (Quintals)	IDR (Import Dependency ratio)
Pulses	0.62	3.1	0.031	1860 (q)	7573.6	5713.6	24.56%
Vegetables	9.95	49.75	0.4975	29850 (q)	86580	56730	12.98%
Milk and milk products	13.13	65.65	0.6565	39390 (q)	72.50	-39317.5	99.9%
Meat, Egg, Fish	0.24	1.2	0.012	720 (q)	7020	6300	Nil
Cereals	12	60	0.6	36000 (q)	145098	109098	75.189%
Total (in Quintal)				107820	246344.1	1385241.1	48.92%

Source: Computed by Researcher

Import Dependency ratio (IDR)

Therefore IDR (this study) = $175639.1/359000 \times 100 = 48.92\%$

Whereas,

IDR of 0% indicates totally import dependent.

IDR of 100% indicates self-sufficiency.

Based on these calculations, it can be concluded that around 12.98% of the domestic supply of vegetables, 99.9% of milk and milk products come from import. In aggregate Kargil imports 48.92% of the food items consumed by tourists. Now when around 50% of the food items are imported from outside of the destination, it results in an amplified carbon footprint associated with the destination's food sourcing and logistical operations, due to emissions from the transports thus undermining the sustainability of the destination. In the backdrop of these results, it is important to minimize the gap between the local production and imported food products to satisfy the needs of the tourist by enhancing the local production of food items in order to become self-sufficiency. Since the production and consumption of Local food significantly and positively impacts the socioeconomic and environment of the destination sustainably. In order to get a better understanding of the interrelationships among tourist food demand and local food production in the study area, we calculated the data for the per capita consumption of food by tourists.

Required Amount of Different Food Items in Quintals

The per capita food consumption of different food items has been calculated by using the monthly per capita consumption extracted from the paper “India's demographic and food prospects: state-level analysis” (Dyson & Hanchate, 2000). The table 4 below reveals the food items consumed by tourists in quintals. Since the agriculture production is barely for the sustenance of the local population. Therefore, most of the food products consumed by tourists are sourced from different parts of the country like Punjab, Haryana and Jammu and Kashmir etc. which may lead to excessive carbon footprint of this destination's food sourcing and logistics, thus compromising its sustainability (Table-3).

Impact of Foods Imported

Now in order to fulfill the demand of food for the tourist, the amount of energy used to transport the food and the intensity of carbon footprint of this destination's

Table-3: Required Amount of Different Food Items in Quintals

Items	Monthly per capita consumption (Kg)	Monthly per capita consumption (grams)	Per day per capita consumption (grams)	Average stay i.e. 4 days multiplied by per day per capita consumptions (grams)	Average no of visitors' visit Kargil Ladakh is 60000. Therefore food items consumed by tourist in kilograms	Required amount of different food items in Quintals
Pulses	0.62	620	20.6	$20.6 \times 4 = 82.4$	$2.50 \times 82.4 = 20600$	206
Vegetables	9.95	9950	331.6	$331.6 \times 4 = 1326.4$	$2.50 \times 1326.4 = 331600$	3316
Milk and milk products	13.13	13130	437	$437 \times 4 = 1748$	$2.50 \times 1748 = 437000$	4370
Meat, egg, fish	0.20	200	183	$183 \times 4 = 732$	$2.50 \times 732 = 183000$	1830
Cereals	12	12000	400	$400 \times 4 = 1600$	$2.50 \times 1600 = 400000$	4000
Total (in Quintal)				107820	246344.1	1385241.1

Source: Computed by Researcher

food procurement and logistics due to emissions from the transports are calculated below in the table 5. The average fuel consumption of a 4*2 axle goods vehicle is 14.9 liter of diesel per 100 km. therefore for every 1 kilometer it consumes $100/14.9 = 6.71$ km/liters. It is assumed that every vehicle carries 180 quintal of food items.

Calculation of Co² Emission

Table-4: Calculation of Co² Emission

Food Items	Required amount of different food items (Quintals)	No of vehicles (Trucks) required	Quantity of Fuel required to import. (Per 1000 kms).	Amount of CO ₂ produced by burning 1 liter of diesel is 2640gms (i.e. 2.64 kg/ltr)
Pulses	206	1	149 liters	0.393 Co ₂ kg/km
Vegetables	3316	19	2831 liters	7.473 Co ₂ kg/km
Milk and milk products	4370	24	3576 liters	9.843 Co ₂ kg/km
Meat, egg, fish	1830	10	1490 liters	4.326 Co ₂ kg/km
Cereals	4000	23	3427 liters	9.047 Co ₂ kg/km
Total	13722	77	11771	31.075 Co ₂ kg/km

Source: Computed by Researcher.

Diesel Truck CO² Emissions per Km: Truck CO₂ Emissions per Km Calculator

The Table-4 reveals the amount of Co₂ produced by importing the food items measured in Kg/Km or Kg per Kilometer. To calculate CO₂ emissions per kilometer for diesel trucks, a straightforward method has been utilized. Initially, it's established that 1 liter of diesel equates to 835 grams and comprises 86.2% carbon, resulting in 720 grams of CO₂ per liter. The combustion process of carbon into CO₂ necessitates 1920 grams of oxygen. Therefore, the calculation can be expressed as follows: $720 + 1920 = 2640$ grams of CO₂ per liter of diesel. For instance, if the consumption is 5 liters per 100 kilometers, the calculation becomes: $5 \text{ liters} \times 2640 \text{ grams per liter} / 100 \text{ (per kilometer)} = 132$ grams of CO₂ per kilometer (<https://8billiontrees.com/carbon-offsets-credits/carbon-ecological-footprint-calculators/truck-co2-emissions-per-km-calculator/#ref-8>) (Table-3). Similarly the amount of Co₂ produced by burning the required quantity of diesel to import different food items has been calculated using the above formula. It is also assumed that the

foods are imported from regions which are approximately 1000 kilometers away from the destination.

Conclusion and Policy Implications

The present study analyses the impact of imported food on the environment by calculating the emission by vehicles during the process. The study sheds light on the intricate relationship between local food production, tourist consumption patterns, and sustainability in the region. Through a meticulous analysis of secondary data and calculations, several key findings have emerged. First of all, the analysis makes it clear that there is a big difference between the amount of food produced locally and the demand that visitors create. This difference results in heavy dependence on imported food products amounting to about half of the overall consumption by the visitors. This heavy dependence on imports has broad consequences. Firstly, it draws attention to the negative environmental effects of obtaining food from outside the region leads to increase in carbon emissions which could results in environmental deterioration. Furthermore, the economic ramifications which include higher expenses and a decrease in self-sufficiency which necessitates how significant action need to be taken in order to decrease the gap between supply and demand. The study suggests improving local food production in response to these findings. Prioritizing food production in the area allows other stakeholders like farmers to get indirect benefits from tourism. Secondly, the reduction in transportation related carbon emissions, strengthen the local economy and encourage sustainable development.

The report also emphasizes the importance of local food systems and to support its production in order to promote environmental and social sustainability. Investing in local agriculture has the potential to improve food security, sustain livelihoods, and protect cultural heritage in addition to catering to the requirements of tourists. Considering the mutually beneficial connections among sustainable development, tourism and boosting local production becomes a crucial approach. Destinations such as Kargil may both increase their economic resilience and lessen the environmental impact of large-scale imports by supporting local agriculture and creating a healthy food ecosystem. The report is a stark reminder that coordinated efforts are needed to restructure the food supply chains in popular tourist locations like Kargil. Through prioritizing local production, reducing reliance on imports and reducing carbon emissions, stakeholders may improve economic status of the locals and promote sustainable development that benefits locals and visitors alike. A more

prosperous and sustainable future for the region can be attained by implementing regional food systems which can reduce dependence on imports, mitigate carbon emissions and promote economic resilience. The limitations of the study lie in its assumptions that the peak tourism season lasts for a mere four months, which is in contrast with the time period of 7 to 8 months food production in the study area. Furthermore, the analysis predicted that the food products are imported from outside the region using 4x2 Excel trucks only which in contrast to the other kind of goods carrier used also for transportation. Furthermore, it makes the assumption that the food produced is only meant for consumption by tourists, potentially ignoring other demographic groups.

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SOCIO-ECONOMIC PROFILE, KNOWLEDGE AND ADOPTION LEVEL OF SOIL HEALTH CARD BASED FERTILIZER APPLICATION BY FARMERS IN CHHINDWARA DISTRICT OF MADHYA PRADESH

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Abstract

Soil health card is an important tool for helping the farmer to improve soil health based on recommendations and enables the farmer to use the soil and crop specific fertilizers doses. In this view the present study aimed to assess the knowledge and adoption level of soil health card based fertilizer application by farmers in Bichhua block of Chhindwara District during 2020-21 because most of the soil health card has been completed and distributed to farmers by Agriculture department. Purposively, ten villages were selected randomly from Bichhua blocks and from each village, five beneficiaries of soil health card were considered. Accordingly total of fifty beneficiaries of soil health card considered as respondent for the present study. A pre-tested interview schedule was prepared and the data was collected. The study revealed that, the variable namely farmers education, land type, land holding, communication source, irrigation source, major crops and availability of resource may influence the adoption of soil health card based fertilizer application. More than half of respondent were having high level of awareness and knowledge about soil health card based fertilizer application. The awareness and knowledge of this technology made significant contribution to its adoption by farmers. It was perceived from study, majority of farmers showed high adoption (67.00%) of soil health card based fertilizer application.

Introduction

Naturally, soils contain many nutrients, among these the major elements of prime importance are nitrogen, phosphorus, calcium and potassium. Such nutrients are important for the growth and development of plants (Kibblewhite et al., 2007 and Stevens, 2018). The better soil health plays a vital role to ensure sustainable agricultural production. To Popularizing Soil Test based Fertilizer usages, soil

health card (SHC) is an essential step. SHC is a tool to help the farmer to monitor and improve soil health based on recommendations and enables the farmer to use the soil and crop specific fertilizers. A SHC is meant to give each farmer soil nutrient status of his holding and advise him on the dosage of fertilizers and micronutrient and also the needed soil amendments that he should apply to maintain soil health in the long run. The scheme is considered as a holistic measure for soil health and farm economy. A soil health card carries crop wise recommendation of nutrients and fertilizer required for the individual farms to help farmers to improve productivity through judicious use of inputs (Patel et al., 2017). Neufeld et al., (2006) stated that soil testing is the only necessary and available tool for determining the amount of soil nutrients. To avoid deterioration of soil in long run and peruse the importance of balance nutrient in crop production, government commence soil health card programme. The soil health card (SHC) provides soil health data to get appropriate guidance to the farmers for the efficient use of fertilizer to cultivate crops based on soil health analysis.

Deteriorating soil health leads to sub optimal utilization of farming inputs, injudicious application of fertilizers, low addition of organic matter and non replacement of depleted micro and secondary nutrients over the years, has resulted in nutrient deficiencies and decrease in the soil fertility in many parts of the nation. However, till recent past, the fertilizer recommendation for different crops was made on the basis of agronomic practices and not on the basis of soil tests. Fertility maps prepared using soil analysis, in general, are not able to provide specific information for the farm of each and every farmer. In order to enhance the soil health and increase the productivity it has become necessary to nurture the soil. It was in this context, the Government of India has launched the soil health card programme. This is aimed at the promotion of soil test based recommendation of fertilizer use which not only increases the crop production but will also help to maintain the soil productivity in a sustainable manner. This investigation is of great significance in creating data based understanding of the factors responsible for knowledge, adoption and the extent of use of soil health cards and also the course of action to be taken in the future.

Study Region

The study was carried out in the Chhindwara district of Madhya Pradesh during the year 2020-21. Administratively district comprises of 12 blocks namely, Amarwada, Chhindwara, Harrai, Jamai, Mukhed, Tamia, Umreth, Chourai, Parasia, Bichhua, Sausar, and Pandurna. Among 12 blocks Bichhua block was selected

purposely, which lies between the latitude range 210370 to 210520 N and longitude range 780590 to 790150 E. The block has 147 villages which, are mostly covered by Deccan Trap basaltic rock. According to 2011 census of India, total population of Bichhua is 87,691 of which 44,463 are male and 43,228 are female. Literacy percentage is 60.98 percent, out of these 34.81 percent is male literates and 26.17 percent is female literates. The total Agriculture farmer's percentage is 67.34 percent in Bichhua. Soil is mainly Laterite in origin though sandy, alluvial and forest soils are also seen in certain belts. Sandy soil, which is deficient in almost all plant nutrients. Forest soil is confined to some parts of Bichhua block. Alluvial soil which is rich in organic matter is generally found in the low lying areas of Block. The climate of Bichhua block is subtropical climate bordering tropical wet and dry climate. The study regions has a hot, dry summer (April-June) followed by monsoon rains (July-September) and a cool and relatively dry winter. Average annual rainfall is 1183 mm. Minimum temperature during winter is 40 to 60 C while maximum temperature during summer is 380 to 420C.

Objectives

- (1) To assess the socio-economic profile of the farmers in study area.
- (2) To assess the knowledge of farmers about application of soil health card based fertilizers.
- (3) To assess the adoption of soil health card based fertilizer recommendation by the farmers.

Database and Methodology

The present study aimed to assess the knowledge and adoption level of soil health card based fertilizer application by farmers in Bichhua block because most of the soil health card has been completed and distributed to farmers by Agriculture department. During the study, 10 villages were selected of Bichhua block based on simple random sampling. Based on proportionate random sampling method, 05 respondents were selected from the each village that formed the sample of the study. The information were collected by individual contact with the respondent, discussion on importance and content of soil health card and motivated them for applying fertilizer based soil health card. The interview schedule has prepared by keeping in view the objectives of the study and the collected data were passed through classification, tabulation, analyzing, interpretation and drawing meaningful conclusion. The following independent and dependent variables were finally selected for detailed investigation in the present study. Independent variables i.e.,

age chronologically, gender (male and female), caste, education, occupation and monthly income by modified G. Trevedi scale (1963), Size of Family, Type of house Land, Size of land holding, Source of Irrigation, Major Crops, Availability of Agricultural implements, Source of communication available, Availability of resource, Knowledge level was measured by schedule prepared and Dependent variable i.e., adoption level were measured by adoption Index followed by Chowdary and Thiodore (2016)

Results and Discussion

Socio-economic Profile of the Farmers

Distribution of respondent based on their socio-economic profile of the farmers in relation to adoption of soil health card based fertilizer application were shown in Table 1. A detailed and careful perusal of results revealed that, the majority of respondent belongs to old aged (48.00%) as compared to middle and young aged (28.00% and 24.00%). It was also revealed that, 84.00% of the respondents were male whereas 16.00% were female. Out of 50 respondents, majority of respondent had acquired intermediate (40.00%), followed by undergraduate (28.00%), illiterate (18.00%) and 14.00% respondents were postgraduate. In case of monthly income of the respondents, half of respondents monthly income was medium (50.00%) followed by high (38.00%) and low (12.00%) respectively. It was evident from the results that, majority of the respondents 60.00% were having medium family size, which was followed by large 22.00% and only 18.00% of the respondents to small family (Table-1). The findings are supported by Rawat et al., (2019) and Bhatt et al., (2010), Marenya and Baret (2007) had reported that education level as one of the variable influencing adoption of soil health card based fertilizer application.

Table-1: Respondents Based on their Socio-economic Profile of Farmers

S. No.	Particular	Category	Frequency	Percentage (%)	Rank
1.	Age (Year)	Young age (≤ 25)	12	24.00	II
		Middle age (26-45)	14	28.00	I
		Old age (≥ 45)	24	48.00	II
2.	Gender	Male	42	84.00	II
		Female	08	16.00	I

Contd...

3.	Education	Illiterate	09	18.00	III
		Intermediate	20	40.00	I
		Under graduate	14	28.00	II
		Post graduate	07	14.00	IV
4.	Monthly income	Below 5,000 (Low)	06	12.00	III
		5,001 - 7,500 (Medium)	25	50.00	I
		7,501 & above (High)	19	38.00	II
5.	Family Size	Small (≤ 5)	09	18.00	III
		Medium (5 - 10)	30	60.00	I
		Large (> 10)	11	22.00	II
6.	Land Type	Irrigated	34	68.00	I
		Unirrigated	15	30.00	II
		Fallow	01	02.00	IV
7.	Land holding	Marginal farmers	08	16.00	III
		Small farmers	23	46.00	I
		Medium farmers	15	30.00	II
		Large farmers	04	08.00	IV

Source: Computed by Authors

It was perceived results that, the majority of the respondents (68.00%) having irrigated land followed by unirrigated land (30.00%) and fellow land (2.00%). It was also revealed that, 46.00% of the farmers having small land holding, 30.00% medium size of land holding (Table-1 and Fig. 1). 16.00% have marginal and 08.00% were having large size of holding in Bichhua block of Chhindwara district. In case of the source of irrigation, majority of the participant SHC users had tube well 26.00% followed by 24.00% having well, 20.00% having canal, 20.00% having Rainfed and only 2.00% were having pond/tank. The major crops of study area, majority of respondent (86.00%) were grown maize followed by soybean (42 %) and rice (34 %) during the Kharif season. whereas, maximum number of respondent (82 %) were grown wheat crop followed by chickpea (78 %), mustard (38 %) and other crops (26 %) during the Rabi season. Major crop means the most common plant species that are important for economic



Fig. 1

development and need to be closely managed in the study area. Majority of respondents (80 %) were used television as source of communication followed by mobile (76.00%), radio (58.00%), newspaper (8.00%), computer (02.00%) and magazine or newspapers (4.00%). On the basis of availability of resource 68.00% farmers having toilet, 64.00% LPG, 56.00% animal shed, 16.00% biogas, 12.00% vermicompost pit and only 2.00% were having soak pit (Table-2 and Fig. 2).

Table-2: Respondents Based on their Socio-economic Profile of Farmers

S. No.	Particular	Category	Frequency	Percentage (%)	Rank
1.	Source of Irrigation	Canal	10	20.00	III
		Well	12	24.00	II
		Rainfed	10	20.00	III
		Pond/Tank	01	02.00	IV
		Tube well	13	26.00	I
2.	Major Crops	Maize	43	86.00	I
		Soybean	21	42.00	IV
		Rice	17	34.00	VI
		Mustard	19	38.00	V
		Chickpea	39	78.00	III
		Wheat	41	82.00	II
		Other (Vegetables)	13	26.00	VII
3.	Source of Communication available	Mobile	38	76.00	II
		Radio	29	58.00	III
		TV	40	80.00	I
		Computer	01	02.00	VI
		Newspaper	04	08.00	IV
		Magazine	02	04.00	VI
4.	Availability of Resource	Biogas	08	16.00	IV
		Vermi compost	06	12.00	V
		Animal Shed	28	56.00	III
		Toilet	34	68.00	I
		Soak Pit	01	02.00	VI

Source: Computed by Authors

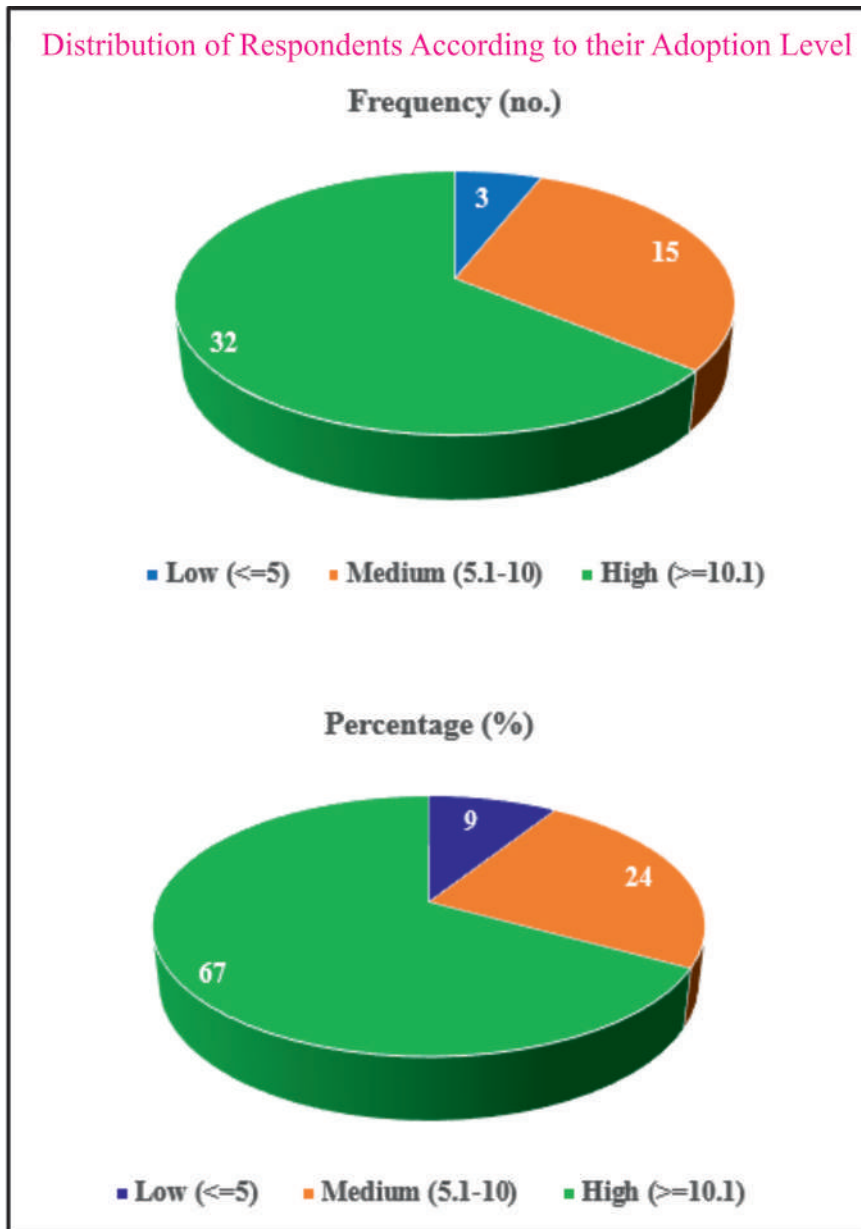


Fig. 2

Awareness Level of SHC Based Recommendation

The awareness score of the respondents/farmers regarding soil health card scheme was quantified using an interview schedule during the present study. It was envisaged from the study that, awareness level of the farmers for soil health card based fertilizer application were high (52.00%) followed by medium (41.00%) and low (7.00%) in study area (Fig 1). These findings are in agreement with Patel and Chauhan (2012), Naruka et al., (2018) and Rawat et al., (2020). The state government has always given their advisement in time interval to enhance balance and efficient use of fertilizers based on soil testing and soil health cards by different programmes. Patel et al., (2017), Mukati et al., (2018) and Manimekalai et al., (2021) reported that the SHC holders obtained high level of awareness on the utility of SHCs.

Knowledge Level of SHC Based Recommendation

It was perceived from the present study, the knowledge level of the respondents/farmers for soil health card based fertilizer application were high (58.00%) followed by medium (25.00%) and low (17.00%) in Bichhua block of Chhindwara (Fig 2). From these findings, it may state that the farmer's knowledge of technology made contribution to its adoption. The overall knowledge level of farmers was medium to high which indicates the reason behind high adoption rate of soil health card in selected study area. Moreover, land holding, cropping intensity and productivity had maximum influence over the knowledge level of Soil health card holders. The findings are supported by Srivastava and Pandey (1999), Yadav et al., (2005), Bhatt et al., (2010), Pagaria (2011), Rawat et al., (2019), and Ravikishore et al., (2021) findings. They found the technology satisfactory and important with respect to lower the input cost, benefit of soil analyse and use of soil health card in their farming operation. Agbamu's (1993) findings stated that farmer's knowledge of technology made contribution to its adoption. They found the technology satisfactory and important in respect to lower the input cost, benefit of soil testing and use of soil health card in their farming operation. Choudhary and Theodore (2016) also reported that more than two third (67%) of the respondents had high level of satisfaction on soil health card based recommendations.

Extent of Adoption Level of SHC Based Recommendation

Extent of adoption of SHC based recommendations was operationalized as the degree to which a respondent actually adopted the SHC based recommendations in soil health management. It was observed from the study that, adoption level of

the farmers for soil health card based fertilizer application were high (67.00%) followed by medium (24.00%) and low (09.00%) in Bichhua block of Chhindwara (Fig 3). These type of variations might be attributed due to farmers had high level of perception on soil health card based recommendations, the impeding constraint like lack of knowledge on soil sampling procedure, lack of comprehending ability of SHC report and Socio-economics factor forced the farming community to go for imbalance usage of fertilizer Rather than adopting soil health card based recommendations. The finding was inconformity with results of Choudhary et al., (2018), who planned a study on awareness, knowledge and attitude of farmers toward soil health card scheme in Tamilnadu. Same study was also conducted by Archana and Balasubramanian (2019) on awareness, knowledge and attitude of farmers towards soil health card scheme in Tamilnadu.

Conclusion

The present study revealed that, the adoption level of soil health card based fertilizer recommendation was not only influenced by basic characteristics of the farmer but also by the level of awareness and knowledge. More than half of respondent were having high level of awareness and knowledge about soil health card based fertilizer application. The awareness and knowledge of this technology made significant contribution to its adoption by farmers. The farmers found the technology satisfactory and important with respect to lower the input cost, benefit of soil testing and use of soil health card in their farming operation. The major impeding factor in adopting the soil health card based fertilizer recommendations may be difficulty in understanding the information given in the soil health card and calculating fertilizer dose on the basis of nutrient status of soil, unscientific method of collecting soil samples. The variable namely education, land type, land holding, communication source, irrigation source, major crops and availability of resource may influence the adoption of soil health card based fertilizer application by farmers.

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IDENTIFICATION OF HERITAGE TOURISM SITES IN THE EMERGING PUNE METRO INFLUENCE ZONE USING QGIS

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Abstract

The paper tries to identify the concentration of heritage tourism sites within the Metro Influence Zone by utilising Quantum GIS and a comprehensive heritage inventory. It also attempts to classify the heritage sites based on their antiquity, significance, and type, revealing a diverse range of cultural resources. It highlights the potential for heritage tourism development in the region, emphasising the role of heritage sites in attracting visitors and stimulating economic growth. The study is interdisciplinary and involves spatio-historical methodology. It is descriptive and interpretive in nature and extensively uses geospatial technologies such as Buffer Analysis with Global Positioning System integration for precise results. The analysis revealed a substantial concentration of heritage sites within a 150-metre radius of the Pune metro corridors, highlighting the potential for easy accessibility and integration with urban transportation. It shows that by focusing on religious tourism, industrial heritage, and heritage homes, the Pune Metro Influence Zone can become a thriving heritage tourism destination.

Introduction

Pune city is also known as the 'Queen of Deccan' and is situated in the west-central part of Maharashtra state of India (Diddee & Gupta, 2000). It is also considered the cultural and educational capital of Maharashtra. Pune has been declared one of the best livable cities in India. It has officially received the top rank among the 111 cities of the country under the 'Ease of Living Index' released by the Union Government of India (Jadhav, 2018). With a rapidly growing population, Pune also faces several urban development challenges. The Government of Maharashtra and the civic bodies are taking all necessary steps to match the pace of urban infrastructure development with population growth. As a result, the Government of India has granted Pune the status of 'Smart City' (PIB, 2015). Public mobility improvement is a key pillar of the smart city mission. Funds have been allocated for constructing the Pune Metro

Rail Project. Throughout the world, the Mass Rapid Transport System has brought revolutionary changes in the mobility of the population. At the same time, it has managed to transform the city's character in several senses (Fouracre et al., 2003). The Pune Metropolitan region has witnessed population growth in the last few years. The high growth rate of the population may be attributed to factors such as natural growth, the concentration of economic activities such as Information Technology and Manufacturing, the popularity of Pune as an international educational hub, and migration from the hinterland of Maharashtra and other parts of the country. Such an unprecedented rise in population has put immense pressure on the infrastructural facilities of the Pune Metropolitan Region. The population has exceeded the actual carrying capacity of the city. The population in PMC and PCMC areas is expected to reach 7549,765 by 2031 (PMC, 2009). The Pune Municipal Corporation (PMC) Environment Status Report (ESR) since 1997-98 shows that there is ten-fold growth (895%) in the number of four-wheelers, five-fold growth in the number of two-wheelers (400%) and just 2.6 fold growth (162%) in the civic bus fleet (Khairnar, 2018). It is essential for a country like India, with a growing urban population and vehicular traffic, to shift from a private mode of transport to a public one. While evaluating different mass transit options for Indian cities, metro systems are often given preference due to the belief that road-based bus systems cannot cater to the capacity requirements of Metro systems.

Proponents of the metro system often claim that the significant benefit of the metro is reduced congestion, pollution, and road accidents (NBMCW, 2023). The pace of developing a Mass Rapid Transport System (MRTS) remained slow in India since the Kolkata metro started working 25 years ago. Delhi, Bengaluru, Mumbai, Chennai, and Hyderabad are other successfully operational metro systems. Similar metro rail projects are being planned and in/or under construction in Ahmedabad, Bhopal, Indore, Chandigarh, Ludhiana, Jaipur, Kochi, and Pune. It is known that the construction of the Metro Rail Project involves alteration in landuse and hydrology of the area. Elevated corridors, new stations, and other concrete structures also change the urban landscape. Historical and cultural heritage sites are integral to Pune's urban landscape due to their strategic location and association with the Marathas, Peshwas, Mahars, and the British. Pune has been an important centre during the struggle for Indian independence as well. The Pune Metropolitan region is dotted with many such sites of historical and cultural significance. It has been observed worldwide that the construction of Metro projects such as the Pune Metro has resulted in increased footfall or tourist inflow to the historical and cultural heritage sites. It develops a renewed interest in heritage, especially the

neglected ones. However, it may have some adverse influences as well. Therefore, conducting a heritage impact assessment of the proposed project is essential, which is a humongous task. The starting point of any such assessment is to develop an inventory of all major and minor sites near the metro project and to trace the antiquity and significance of such places.

Study Region

The Pune Metropolitan region mainly lies in the Western Ghats and Deccan Plateau. It is underlain by basaltic lava and shallow alluvium near major rivers. The region is drained from west to east by River Mula and Mutha. Mula River, which comes from the western side of Pune city, meets the Mutha River near Sangamwadi, and then the combined river flows towards the eastern side. Pune has a Bsh (semi-arid) type of climate bordering tropical wet (Aw). The average temperature of the study area ranges from 20-28° Celcius. The average annual rainfall is 722 mm, falling between June and September. As per the 2011 census, the total population of Pune Metropolitan region was 49 lakhs. The Pune Metro north-south corridor starts at 18.6° N and 73.8° E at Pimpri Chinchwad Metro Station. It ends at 18.4° N, 73.8° at Swargate station, with an average altitude varying from 542 to 580 metres along the corridor. The east-west alignment starts at 18.5° N and 73.9° E at Vanaz station. It ends at 18.5°N and 73.9° E at Ramwadi, and elevation varies from 542 to 605 metres along the corridor (Pune Metro, 2018).

Objectives

The paper aims to develop an inventory of historical and cultural heritage tourism sites in the emerging Pune Metro Rail Ecosystem. It also intends to present a classification and trace the antiquity of heritage sites in the selected region.

Database and Methodology

The study is interdisciplinary and involves spatio-historical methodology. The study extensively used geospatial technologies along with descriptive and interpretive methodology. The first step of the research process was to develop an inventory of heritage sites inside the emerging Pune Metro Ecosystem. The major international conventions protecting heritage emphasise the determination of inventories of heritage sites (Ndoro, 2008). A methodical and detailed inventory of cultural resources such as heritage sites enables researchers to evaluate their size, value, and uniqueness (Simou et al., 2022). Moreover, inventory plays a crucial role in developing criteria and approaches for future action and facilitating the enactment

of policies to conserve and enhance cultural heritage (Simou et al., 2022). Also, creating an inventory of heritage sites is so important that any conservation process of heritage sites commences with documentation and inventory (Rajangam & Rajani, 2017). A comprehensive secondary research was carried out to prepare a list of major heritage sites existing within the limits of the Pune Metropolitan Region. The gathered information was then authenticated with the help of data collected from the Pune Municipal Corporation. The data set contained 199 heritage sites along with their coordinate's information. Similarly, a list of sites with heritage and tourism value in Pimpri Chinchwad was also collected from the internet. The total number of heritage sites reached 221 after clubbing PMC and PCMC regions. Subsequently, the Pune Metro route map was obtained from the Environmental Impact Assessment (EIA) and the Environmental Mitigation Plan (EMP) report for both metro corridors prepared by the Maharashtra Metro Rail Corporation Limited. The route map raw image was then entered into a GIS environment using QGIS software. QGIS or Quantum GIS, a standalone open-source GIS software, receives regular updates from a highly active global community of users and developers. Accordingly, the route map was digitised on QGIS, and a geodatabase was configured to provide a georeferenced inventory of locations, i.e. points in the form of the upcoming metro stations and lines as the metro route. The most important determinant of area of influence is proximity. To ascertain the area of influence or the proximity factor, Buffer Analysis was done on the QGIS. It also involved a comprehensive GPS survey for the purpose of getting precise location of the heritage sites located within the Pune Metro Influence Zone.

Result and Discussion

The most important aspect of the Buffer Analysis is distance or limit of the influence of a site or location. For a site to be considered part of the Pune Metro Influence Zone, it was essential for that site (heritage tourism in this case) to be located in close proximity to the stations of the Metro lines. Therefore, three buffers of 150 metres each to a maximum distance of 450 metres were created. The tourist may easily walk half a kilometre to reach any heritage site. Taking private or public transport by a tourist to reach any heritage tourist site within a radius of 450 metres would be affordable. Studies have indicated that tourist behaviour is also influenced by proximity or distance to travel to a particular destination. Tourists always prefer to travel short distances for leisure purposes. The Distance Decay Effect theory of geography also explains this behaviour (Wu & Cai, 2006). The demand for tourism is believed to be inversely correlated with distance; the more distant a location is

from a tourist, the less probable the tourist will make the trip. (Xue & Zhang, 2020). The buffer analysis provided a map with three categories of the area of influence also called the Pune Metro Influence Zone.

- (1) 0 - 150 metres (High Influence)
- (2) 150 - 300 metres (Moderate Influence)
- (3) 300 - 450 metres (Low Influence)

It also involved a comprehensive GPS survey to identify and map heritage sites along the Pune Metro route. This survey provided precise point locations for each site. The collected GPS data was then integrated into the QGIS software, a geographic information system (GIS) platform) By overlaying the GPS points on the base map of the Pune Metropolitan region and the Pune Metro route maps enabled to visualise the spatial distribution of heritage sites in relation to the Pune Metro Influence Zone. It has come out from the study that the maximum number 54 % (55) of the historical and cultural heritage sites are located within 0-150 metres, while a good number 28% (29) of sites are located in the 150-300 metres zone. Only 18 % (19) of such sites are located in the 300-450 metres distance from the metro corridors. To document these sites, photographs were taken and stored for reference. Additionally, secondary sources were consulted to gather information about each heritage site, including its history, significance, and current condition. In cases where information was lacking, interviews were conducted with caretakers of the sites and monuments to fill the gaps. This process allowed for a more accurate and in-depth understanding of the heritage resources in the area. The collected data was then used to classify the heritage sites based on their antiquity, significance, and other relevant factors. This classification system provides a valuable framework for promoting heritage tourism and prioritising heritage conservation efforts and ensuring that the rich cultural heritage of Pune is preserved for future generations.

Tracing Antiquity and Significance of the Sites Identified

Information regarding antiquity and significance has been collected through authentic online and offline sources. However, details about some of the sites have been traced through primary surveys. The figure above shows that the maximum number (56%) of historical and cultural heritage tourism sites in the metro influence zone belongs to the British era. It is followed by the medieval period (24%). It also shows that 5 percent of sites were from the early medieval period which included caves and prominent temples. 15 percent of the sites were from the post-independence period for which the pre-decided cut-off year was 1965.

Classification of Heritage Sites Located under MIZ

Table-1: Classification of Sites Located in Metro Influence Zone (MIZ)

(A) Places of Worship

(1) All Saints Church (2) Amruteshwar Temple (3) Ashtabhuja Temple (4) Belbaug Temple (5) Bhangya Maruti Temple (6) Bhausahab Rangari Ganpati (7) Church of Holy Name (8) Dagadusheth Ganpati Temple (9) Dagdusheth Datta Temple (10) Gundacha Ganpati Temple (11) Gupchup Ganpati Temple (12) Jangli Maharaj Samadhi Temple (13) Jilbya Maruti Temple (14) Joshi Shriram Temple (15) Junakal Bhairavnath Temple (16) Kali Jogeshwari Temple (17) Kasba Ganpati Temple (18) Lakdi Pul Vitthal Temple (19) Limbraj Maharaj Vitthal Temple (20) Mandai Ganpati Temple (21) Markandey Temple (22) Misgar Mosque (23) Old Tofkhana Mosque (24) Omkareshwar Temple (25) Pasodya Vithoba Temple (26) Peshawe Ganpati Temple (27) Pimpleshwar Temple (28) Ram Mandir Pappasheth Khanna (29) Rameshwar Vishnu Khasgat Devsthan (30) Shanipar Temple (31) Shankarsheth Shiva Temple (32) Tambdi Jogeshwari Temple (33) Trishund Ganpati Temple (34) Tulshibaug Ganpati Temple (35) Tulsi Baug Ram Temple (36) Vruddheshwar Temple

(B) Heritage Homes

(1) Anandashram- Hari Narayan Apte (2) Bhausahab Rangari Bhavan (3) Bhide Wada (4) Biniwale Wada (5) Godbole Bhavan (6) Mujumdar Wada (7) Nagarkar Wada (8) Parasnis Wada (9) Parnakuti Bungalow (10) Puranik Wada (11) Renuse Wada (12) Sardar Shitole Wada

(C) Industrial Units

(1) ICC-Indian Card Clothing (2) Hindustan Antibiotics (3) Haffkine Institute (4) Sandvik Asia (5) Atlas Copco (6) Alfa Laval (7) Forbes/Simmonds Marshall (8) KSB pumps (9) Finolex cables (10) Dai-ichi (11) Dinshaw shapoorji & co.

(D) Educational Institutes

(1) NEST (2) AISSMS (3) De Nobili College (4) N.M.V school Boys (5) Wadia College (6) St. Crispin Home (7) Modern High School (8) Chinchechi Talim

(E) Gastronomy

(1) Cafe Paradise (2) Vaidya Upahar Gruha (3) Café Goodluck (4) Ganesh Udupi hotel, khadki (5) Karachi Cold Drink House (6) Shiv Kailash Dairy

Contd...

(F) Entertainment
(1) Kibe Laxmi/Prabhat theatre (2) Alka Talkies
(G) Hospitality
(1) Regal Hotel (2) Poona Guest House (3) Seth Morarjee Gokuldas Sanatorium
(H) Institutions
(1) Pune Nagar Vachan Mandir (2) Pune Court (3) All India Radio-Akashvani (4) Shimla Office-IMD (5) Pune Municipal Corporation (6) Pune City Post office (7) Pune Railway Station
(I) Monuments
(1) Historic tower , N.T. Wadi (2) Aga Khan Palace (3) Bank Of Maharashtra -Bajirao Road (4) Kesari Wada (5) Nana Wada (6) Shaniwarwada (7) Vishrambaug Wada (8) Lal Mahal
(J) Old Bridges
(1) Harris Bridge (2) Sangam Bridge (3) Sambhaji Bridge (4) Shivaji Bridge
(K) Market Place
(1) Mahatma Phule Mandai
(L) Shops
(1) Janardan Shilpkala bhuvan (2) Naro Aappaji Godbole (3) V K Samak aani company (4) Gore and Mandali Shawl house
(M) Archaeological Site
(1) Pataleshwar Caves
Total: 103 (Heritage Sites)

Table-1 shows that the maximum number (35 %) of sites located in the Metro Influence zone are places of worship. It is followed by Heritage Homes/Bungalows (11%). It is also dotted by a good number of old industries/factories (10 %). The area also consists of reputed educational institutions (8%) and monuments (8%). It also has old and famous eating joints (8%). There is a good number of old public institutions (7%), bridges (4%), shops (4%) and hotels/guest houses (1%). The Metro Influence Zone also contains heritage places of entertainment (2%) and one important archaeological site i.e. Pataleshwar caves and one market place i.e. Jyotiba Phule Mandai (Fig. 1). The Pune Metro's influence zone presents a promising opportunity to revitalise three significant heritage and cultural tourism attractions. Religious tourism can be enhanced by focusing on the city's ancient and

well-known temples, which often hold deep religious significance. Industrial heritage tourism can be promoted by highlighting the city's industrial past through preserved factories, machinery, and historical sites. Heritage homes (wadas), traditional residences with rich architectural and cultural heritage, can be transformed into tourist attractions, offering glimpses into Pune's historical lifestyle. By leveraging the accessibility provided by the metro, these attractions can be more easily reached by visitors, contributing to the city's economic growth and cultural preservation (Fig. 2 and 3)

Cultural and Religious Heritage Corridor of Central Pune

The Pune metro corridor, stretching from Shivaji Nagar to Mandai metro station and Deccan Gymkhana to Mangalwar Peth metro station, is adorned with a rich tapestry of significant religious places. These include Hindu temples such as the Amruteshwar, a shrine dedicated to Lord Shiva, a testament to the devotion of Veer Babuji Naik, who built it in 1749 (Ghanekar, 2015). The Ashtabhuja temple, a relic from the 1700s, the Belbag temple in Budhwar Chowk, a creation of Nana Phadnis, the revered Bhangya Maruti, and the majestic Dagdusheth Ganpati temple, completed in 1893, all stand as living testaments to the city's rich religious history (Ghanekar, 2015). Gupchup Ganpati temple, which is around 132 years old, was built in 1892 by Shri Ramchandra Vishnu Gupchup. In the same area lies Jangali Maharaj Samadhi temple, situated next to Pataleshwar caves over a hillock under the Banyan tree, where Jangali Maharaj's body is buried. Another important temple in the corridor is Kasba Ganpati, which is also called "Manache Ganpati" and is referred to as the "God of the City," i.e., Pune (Ghanekar, 2015). The Omkareshwar temple was built by Shivram Bhat, the spiritual Guru of the Peshwas, and is also located within the metro influence zone. The corridor also has some heritage mosques like Misgar masjid, which is around 300 years old and situated in Guruwar Peth. Similarly, the old Topkhana masjid (Circa 1718) is situated near Kamgar Putala Vasahat. The name "Topkahana" comes from the fact that the Peshwas would store their cannon and cannon balls in the area. All these places of cultural and religious significance can be easily accessed from the Metro stations.

Wadas (Heritage Homes): Metro Journey to the Past

The next major attraction along the Pune metro corridor, between Shivaji Nagar to Mandai metro station and Deccan Gymkhana to Mangalwar Peth metro station, are the "Wadas". These traditional Marathi homes, found in Pune and other parts of Maharashtra, are not just buildings but living testaments to the city's rich cultural

heritage. With their large, multi-story courtyards and unique architectural features, the Wadas offer a fascinating glimpse into the city's history and the lifestyle of its people, making them a must-see for any cultural enthusiast. A few prominent Wadas include Mujumdar Wada, which is the oldest after the Shaniwar Wada and was built in 1770 (Pune Mirror, 2018). Nagarkar Wada is around 220 years old and was constructed by Sardar Nagarkar. Nana Wada was built in 1780 and is almost entirely constructed from timber. The Parasnis Wada was built before Peshwai by poet Nirranjan Madhav in 1723. The Puranik Wada was built in 1845. It was washed away by the Panchet floods but rebuilt later. Renuse Wada is located in Shaniwar Peth. Its owner was Balwant Somajirao Renuse (Khandge, 2015). The Sardar Shitole Wada belongs to Sisodiya Rajput of Udaipur, who migrated to Pune in the 15th century. Biniwale Wada was built in 1870 and was the house of Visaji Krushna. He got the title Biniwale (means a person at the front) in his career as a military General (Khandge, 2015). Another very important Wada in the area is Bhide Wada, also known as India's first school for girls, set up in 1848. It was the courageous initiative of Krantijyoti Savitribai Phule and her associate Fatima Shaikh (Medium, 2018). The Gaikwads built Kesari Wada, located in Narayan Peth. Lokmanya Bal Gangadhar Tilak used to run two newspapers, the Kesari in Marathi and Maratha in English from Kesari Wada. The Pune metro can give a new lease of life to some of the old Wadas, which are in dilapidated condition, and help create awareness of the preservation and conservation of these heritage buildings.

Industrial Heritage Circuit of Pune

Industrial heritage explores the history of industrial sites, preserving and interpreting their significance. It involves factory tours, museums and interactive exhibits. It has come out from this research that a number of old industrial units exist in a linear fashion between Phugewadi and PCMC metro station. For example, Finolex Cables was established in 1956 by P.P. Chhabria and K.P. Chhabria, who came to Pune from Karachi. They manufactured PVC-insulated cables for the automobile industry. Another old industrial unit that can also be opened for heritage tourism purposes is ICC-Indian Card Clothing, which was established in 1955 as a joint venture between Carlo Engineering Group and English Card Clothing. Similarly, Hindustan Antibiotics Limited was set up in cooperation with the WHO and UNICEF with the social objective of providing affordable drugs throughout India. It was inaugurated by India's first Prime Minister, Pandit Jawaharlal Nehru. These industrial units represent India's post-independence industrial revolution. Sections of these industrial units can be developed as industrial heritage tourism

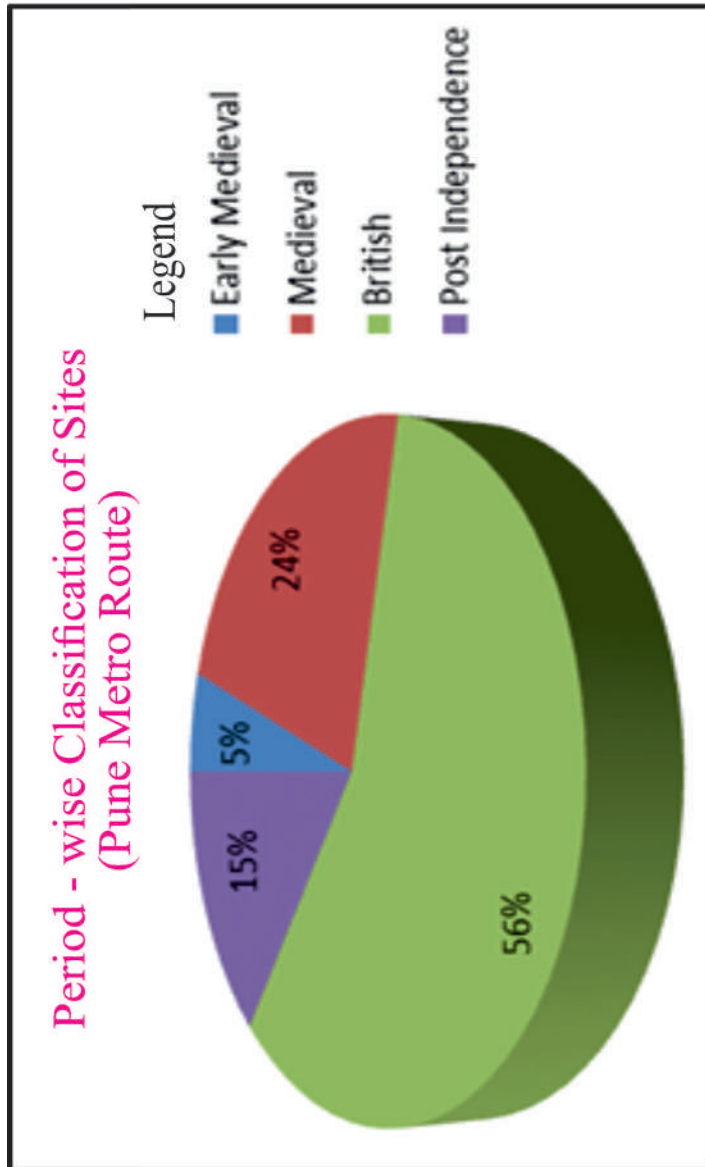


Fig. 3

sites along with museums and exhibits. School visits to industrial heritage sites can inspire young minds to become entrepreneurs. Witnessing the history and progress of industries can ignite a passion for innovation and entrepreneurship. This can contribute to the "Make in India" initiative and India's vision of becoming a developed nation (Viksit Bharat).

Conclusion

The study conducted on the Pune Metro Influence Zone effectively identified and mapped significant historical and cultural heritage tourism sites. The analysis revealed a substantial concentration of heritage sites within a 150-metre radius of the Pune metro corridors, highlighting the potential for easy accessibility and integration with urban transportation. The classification of heritage sites based on antiquity, significance, and type offered a comprehensive understanding of the diverse heritage resources available within the Pune metro influence zone. Places of worship, heritage homes, industrial units, and educational institutions emerged as prominent categories, each presenting unique opportunities for heritage tourism. The study highlighted the potential of heritage tourism to revitalise the Pune Metro Influence Zone. By focusing on religious tourism, industrial heritage, and heritage homes, the area can attract visitors, stimulate economic growth, and preserve its cultural heritage.

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THE EVOLUTION OF THE INDO-PACIFIC IN THE PARADIGMS SHIFTS OF GEOPOLITICS: A CHRONOLOGICAL OUTLINE

Ravi Dass and Muraree Lal Meena

Abstract

The emergence of the Indo-Pacific idea is a major shift in the global context in the series of geopolitical shifts of the 21st century, at the core which lies global politics and economic gravity. It was initially in the form of a mental map, but now the regions were coming closer to a realistic geographical setting. Indo-Pacific primarily addresses the global balance arising from the connectivity of the Indian and Pacific oceans. Over time, integrating economic and geopolitical dimensions has made it appear like a spotlight. This region has become an essential break-in-bulk point for global geopolitics and economy. This paper discusses the chronology of the emergence of the Indo-Pacific idea and the reasons behind it. The initial emergence of the Indo-Pacific, prominent among which was the Indopazifischen Raum idea of Karl Haushofer. After this, a chronological description of Japan's diplomatic policies was described, giving the main basis for the Indo-Pacific idea. It also examines the geographical specificity of the region and the convergence of national interests of the countries. The present study analyzes those facts from a bird's perspective, which establishes the rational logic for why the regional and extent powers are giving importance to the Indo-Pacific in their foreign policy. Subsequently, the trans-Atlantic policy of the USA regarding the Indo-Pacific and the development of this idea in the governmental documents of India and Australia are also included for analysis.

Introduction

The Indo-Pacific region has emerged as the center of power politics in the 21st century due to its geopolitical and geo-strategic significance. The Indo-Pacific is so broad that it can be understood in terms of geolocality as an interconnected space between the Indian and the Pacific Oceans. Given the contemporary changing geopolitical outlook, the region's significance is continuously increasing due to the rise of India and China as two major economic and political actors in regional and

global politics. The basis for the emergence of this region is the ‘mental mapping’ (Gould & White, 1974) in which there are systems like ‘global strategic balance’. The Indo-Pacific Region has been established as a region serving essential national interests. Today’s Indo-Pacific, formerly known as ‘Asia-Pacific’, emerged in the 1980s to promote relations between Southeast Asia and emerging economies on the periphery of the Pacific region (Brown, 2021). In the present scenario, the fundamental national interest in the rise of the Indo-Pacific region has been based on the concept of a ‘functional approach’, which gives priority to economic connectivity, energy security, and maintaining the integrity of sea lines between the Indian Ocean and the Pacific Ocean. But with time, in the changing geopolitics, the ‘balance of power approach’ was added to the above approach. This approach can include the effects arising from the rise of China. China’s extraordinary economic expansion, increasing dependence on the resources of the Middle East and Africa, sovereignty-based disputes in the South and East China Sea, and attempts to polarize Asia can be included in this vision. Through the Indo-Pacific, countries located on the rim of the Indian and Pacific Oceans felt the need for a grouping that could accommodate a balance of power perspectives. Gilpin (1987) believes that powerful states enable the emergence of regionalism as a by-product of pursuing their economic and geopolitical interests. Countries located on the rim of Asia and the Pacific resorted to this regionalism in the creation of the Indo-Pacific.

In the late 1800s, American naval officer Alfred Thayer Mahan (1890) explained the influence of sea powers on history, saying that national power was directly tied to the oceans. Therefore, having control over the open oceans was a major strategic advantage. In today’s Indo-Pacific, the colonial British Empire had largely kept the region’s geopolitics in bondage to ‘fulfill its economic interests’ by controlling important spaces in the sea. The term Indo-Pacific in a geopolitical context was initially used by the German Major General and geographer Karl Ernst Haushofer in the 1920s. Later, after World War II, the strategic importance of this region became widely recognized. Japan initially adopted and promoted it to provide a secure economic interest. But with time, nations like the United States of America are joining it and working to transform it into an ‘architecture of collective security’. The Indo-Pacific region holds great geo-economic graveness in addition to its strategic significance. There are 38 countries located in this region, which are fully committed to the Indo-Pacific idea (Basker, 2021). These countries, share 44% of the total global area and 65% of the world population and account for 62 percent of the global GDP (Rahman, 2020). Indo-Pacific, a symbol of the balance

of power in global swap geopolitical changes, has gone through mainly two main phases from its initial formation till the present. First is the making of a 'Mental Map' and the second is 'trying to establish it geographically'. Both the above phases have been influenced by the policies and diplomacy of many nations located on the rim of the Indian and Pacific Oceans. The Indo-Pacific region is far from a geographical demarcation that evolves in the light of changing geopolitical and economic conditions. (Beeson & Wilson, 2018). The mental mapping of the Indo-Pacific greatly influenced the policies of countries located on the rim of the Asia Pacific, helping to shape the region's institutional nomenclature and its architecture (Medcalf, 2013). This paper describes the cruise of the Indo-Pacific from the stage of 'mental mapping' to a mature geopolitical path.

Objectives

- (1) To study the chronological order of the formation of the Indo-Pacific idea.
- (2) To study the different aspects involved in the formation of the Indo-Pacific region.
- (3) To study the basis that led national interests to converge against the context of the Indo-Pacific geopolitical Milieu.

Study Region

The Indo-Pacific region encompasses the tropical areas of the Indian Ocean region (IOR), East Asia, South East Asia, and the Western Pacific region. The geographical characteristics of this zone exhibit a variety of climatic patterns, ranging from tropical to temperate climate zones. With India and China being the most populous nations worldwide, the Indo-Pacific region is home to 4.3 billion individuals, which accounts for 60 percent of the global population. The sea routes of the Indian Ocean are among the most strategically important in the world. More than 80 percent of the world's maritime trade in oil and energy resources transits the Indian Ocean and its critical chokepoints. Among these chokepoints, the Straits of Hormuz, Malacca, and Bab al-Mandab are prominent. The Indian Ocean is a geopolitical platform where the world's major powers converge. The largest ocean in the world is the Pacific Ocean, whose surface area is 165,250,000 km². Its northern edge is connected to the Arctic Sea by the Bering Strait.

Several important seas along the irregular western margin of the Pacific Ocean make it important to the Indo-Pacific paradigm. East China, the Philippines, South China, and the Yellow Sea play an important role in present-day geopolitics. The Indo-Pacific mainly includes the rimlands of Asia and the eastern Pacific Ocean.

Database and Methodology

This study examines the various phases of the Indo-Pacific idea using analytical and descriptive approaches. The descriptive method describes the characteristics of the major events of the Indo-Pacific formation. This method has helped in finding the answers to the fundamental question regarding the Indo-Pacific idea, such as ‘What is this idea? The analytical approach helped in observing various views about the Indo-Pacific, after which a holistic understanding of the Indo-Pacific idea could be molded into the formation of the paper.

Indo-Pacific’s Geopolitical Rostrum: Inauguration on Geopolitical Landscape

Through the concept of ‘Indopazifischen Raum’, Karl Haushofer first described the geography and history of the Indo-Pacific region in the context of global geopolitics. His work titled ‘Geopolitics des Pazifischen Ozeans’ (Geopolitics of the Pacific Ocean, 1924) attempted to integrate the history and geography of the Indo-Pacific region. The works of Karl Haushofer are central to achieving a comprehensive and detailed understanding of the conceptual evolution of the Indo-Pacific region. Karl Haushofer worked to promote the Indian and Pacific Oceans as an integral organized geographical constituent. However, he envisioned the Indo-Pacific as an organized geographical constituent against colonialist tendencies (Li, 2021). During his travels from February 1909, he saw the diverse political, social, and economic situations of the East, like India, Japan, Singapore, etc. He tried to give a comprehensive understanding of this region as a ‘strategic region’ in global geopolitics. His main objective in this effort was the political revival of this strategic region so that Western colonial influence could end. However, Karl Haushofer’s ideological understanding was influenced by German nationalism, and he wanted to establish the region as an ‘alternative space’ to landlocked Germany. However, their ideological works reveal many geopolitical possibilities regarding the integrated nature of the Indo-Pacific. Karl Haushofer defined the Indo-Pacific region as an Ökumene (life realm), distinguishing it from an anökumene (no-life realm) (Li, 2021). In his works, Haushofer attempted to describe the geopolitics of the Indo-Pacific region in the context of its antiquity. Highlighting the importance of the ‘Sunda Strait’ in the Indo-Pacific, he said that this strait is the crossroads of convergence of the Indo-Pacific and the gateway to the South China Sea. He also recognized Manila and Malacca as ‘two pivotal spaces’ in the Indo-Pacific region. In this way, he probably made the first diplomatic effort to politicize the Indo-Pacific region. They established the region as a ‘counter space’ and ‘security architecture’ against ‘colonialist tendencies’ including ‘Atlantic’ and ‘Euro America’.

USA influence in the present form of the Indo-Pacific can also be understood from Haushofer's study. He sees the US as an 'Atlantic-Pacific player' in the oceanic politics of the region, as its 'geolocality' near the Pacific designates it as a 'key player' (Li, 2021). The initial emergence of the Indo-Pacific can also be understood in terms of voyages made for commercial purposes in the region. The arrival of merchant travelers to the southern African coast and the Polynesian islands contributed to highlighting the region's geopolitical potential on the global stage. (Hertz, 1922). However, intellectual and monetary interests in the Indian and Pacific Oceans remained at the forefront of the initial discourse. In the 1920–1930s, Haushofer's idea of the Indo-Pacific was established as a 'germinating ground of strategic interests' for German interests, the main objective of which was to streamline Germany's geography and geopolitics. Haushofer also presented much intellectual evidence to establish India and China's strategic position and regional power in the Indo-Pacific. Karl Haushofer attempted to establish the strategic and geopolitical position of East Asia as the 'core consciousness' for the Indo-Pacific. For this, he took the help of Otto France (1863-1946)'s 'New Formations of East Asia' (1911) and 'Great Powers in East Asia' (1923). These studies attempted to foresee Asia's future geopolitics. (Sarkar & Benoy, 1918)

Indo-Pacific Frame Formation through Japanese Arc of Freedom (2000-2007)

Emerging from the 1997 Asian economic crisis, a new globalization-based geo-economic setup emerged in the Indo-Pacific region (Dittmer, 1999), resulting in the 'convergence' of inter-regional interdependence and shared 'geopolitical way-styles'. This marked unprecedented structural changes in the politics, security, and economy of Asia. Japan began to explore its economic and security interests in these changes and tried to present new dimensions of its diplomacy to the world (Okano, 2012). One of these dimensions was to define our diplomacy in the context of the Asia-Pacific region as an Arc of Freedom. Under this policy, Japan encourages steps such as building stable international relations, resolving disputes through diplomatic channels, and building the US-Japan security alliance. This is the strategic direction in which Japan tries to strengthen the East Asia Summit (EAS), Japan-ASEAN relations, and Japan-US relations for the 'geopolitical establishment acceptance' of 'Indo-Pacific Architecture'. The geography of Japan has been a catalytic factor in stimulating innovation in the Japanese economy (Koshino, 2022). Maintaining the economy is a 'national necessity' for the nation. The economy of this nation with immense natural 'adversities' depends on 'optimized flows of trade' and secure sea lines of communication (SLOC). Security of Sea Lines of Communication (SLOC)

is today a motivating factor for establishing military posts in the maritime domain (Khurana, 2007). In the Early mode, Given the importance of SLOC and the growing terrorism threats, the state started realizing the need for cooperative and collective geopolitical in the Indo-Pacific region. In November 1999, the Japanese Ship Alondra Rainbow (given the pseudonym of Mega Ram) was hijacked by pirates and was chased on the High Seas and rescued by India (Kumar, 2019). This incident forced Japan to consider changing the entire scenario of fulfilling its commercial interests through sea routes. India's efforts for the Alondra Rainbow laid the groundwork for Japan's future 'Maritime force convergence' in the Indian Pacific Ocean, with Japan recognizing the Indian Navy's capabilities for its regional commercial security. During his visit to India in January 2003, the Japanese Foreign Minister talked about the 'new strategic environment' that was being created to fill the void left by the policy of neutrality during the Cold War (Kawaguchi, 2003). It explained the implications of the relationship between India, the USA, Japan, and other major countries for the establishment of peace and stability in Asia. At this time, Japan presented itself to the world as an alliance between India and the United States as a tool to promote stability and prosperity in the Asia Pacific region. Central to the development of this presentation was the creation of a 'Cooperative Security Architecture' to protect the sea lanes across the Indian and Pacific Oceans and the Strait of Malacca (Bradford, 2011). The 2004 tsunami demonstrated the potential of the Indo-Pacific region (Cannon, 2022) with the United States, Japan, India, and Australia coming 'together to act'. This was a new type of diplomacy that created a new alliance in the face of an emerging challenge (Benjamin, 2020). Principles like Maritime Security and Cooperation remained the main driving goals during the visit of the Prime Minister of Japan to India in 2005 (Cherian, 2007). In December 2005, a major institutional development in the Asia-Pacific region occurred with the establishment of the East Asia Summit (2005) with 16 founding countries. In which 10 ASEAN countries were also included. EAS plays an important role in the transition from Asia Pacific to Indo-Pacific.

This institutional development towards an Indo-Pacific 'multilateral architecture' reflects the geopolitical capabilities of the region. Later over time, the Indo-Pacific concept began to be prominently reflected in the official documents of the founding member states of the EAS (Ao, 2020). The establishment of the EAS heralded the 'distinct geopolitical and economic' landscape of the Indo-Pacific geographical region. The member countries of this group represent 50 percent of the global population and about 58 percent of the global GDP. (Chauhan, 2020).

In 2005, the famous New Zealand analyst Peter Cozen successfully tried to make the Indo-Pacific terminology the center of the global discussion through his paper ‘60 Years of Maritime Development in the Indo-Pacific Region’ (Khurana, 2019). In May 2006, India and Japan expressed their commitment to achieve the common goal of addressing regional and global security challenges. In subsequent years, Japan’s foreign policy, taking a QUAD-based approach, made several strategic expansions, with the Indo-Pacific being a major consideration. In November 2006, the new diplomatic dimensions in Japan’s foreign policy were officially spelled out by the Foreign Minister of Japan, speaking on the topic “Ark of Freedom and Prosperity: Japan’s Expanding Diplomatic Horizons”. He placed Japan’s perspective in the context of new discourses such as “value-oriented diplomacy” (Akimoto, 2022) and “the arc of freedom and prosperity”. Japan, focusing its foreign policy on the outer edges of Eurasia (Asian Rimland), presented the idea to the world that this region (which can be called the Belt) has undergone major changes after the end of the Cold War. As disputes between East and West are ending, this belt should be developed as an ‘Arc of Freedom and Prosperity’. With this policy, Japan saw itself becoming stronger by accepting USA and European influence in the Pacific region. In December 2006, the ‘Arc of Freedom’ was recognized as a new pillar under Japan’s expanded diplomacy (Gursel, 2008).

In which an attempt was made to create a ‘Mental Map’ to create a prosperous and stable region based on universal values around the outer edge of the Eurasian continent. Efforts were made to recognize the convergence of Japan’s strategic interests with those of the United States, Australia, and India in the region. This ‘mental commitment’ (Grey, 2012) was later transformed into the ‘Indo-Pacific Mental Map’ (Medcalf, 2019). During the visit of the Indian Prime Minister to Japan in December 2006, a joint statement titled ‘India-Japan Partnership in a New Asian Era: Strategic Orientation of the India-Japan Global Partnership’ (2006) was issued. An attempt was made to identify ‘areas of convergence of strategic and global partnerships’ between India and Japan in Asia (Ministry of External Affairs, India, 15 December 2006). At this time, both India and Japan agreed to work strongly together in the East Asia Summit (EAS) and ASEAN was accepted as a driving force in the process of creating a new regional architecture. In March 2007, the Foreign Minister of Japan, while speaking on the topic ‘Arc of Freedom and Prosperity’ at the 20th anniversary of the ‘Japan Forum on International Relations’ (Aso, 2007) discussed the geographical aspects of this Arc. He said that this Arc is a new pillar in diplomacy, which Japan is adopting. In this statement,

he attempted to envision a new bridge across the Atlantic Ocean as an ‘alternative method’ of contact with the United States, Canada, and Europe. The fourteenth SAARC Summit was held in New Delhi on April 03, 2007, in which Japan participated as an observer nation. At this conference, Japan tried to officially give shape to its ‘Arc of Freedom and Prosperity mental concept’. In this arc, Japan recognized South Asia as a central pillar, a region of development with greater stability than ever before, and committed to universal values. On the one hand, institutional development in the direction of geographical ‘establishment-acceptance’ (Newman, 2021) of the Indo-Pacific has been the establishment of QUAD. Convergence in the Indo-Pacific region was signaled by the convening of the first meeting of QUAD during the ASEAN Regional Forum meeting held in Manila in May 2007. During this time, China’s attitude appears to be undemocratic. Such as demonstrating reluctance to establish the interstate river water system we agreed upon during the visit of the Chinese President to India in November 2006, building dams on rivers without sharing information, rejecting the principles of the 2005 agreement, etc.

Realistic Recognizability of Indo-Pacific: Region Confluence of Two Seas

The biggest milestone in the geopolitical establishment of the Indo-Pacific took place in the Shabhgaar of the Indian Parliament in August 2007. On 22 August 2007, the Prime Minister of Japan (Abe, 2007) delivered a speech titled ‘Confluence of the Two Seas’ in the Parliament of the Republic of India. He made a successful attempt to coin Indo-Pacific terminology as a form of geo-logical mental mapping while expanding his ‘Arc of Freedom’. In fact, in this speech, Japan attempted to portray its past diplomatic efforts as a ‘mental map’ (in the form of Indo-Pacific) of the common interests of the Indian Ocean and the Pacific Ocean. In August 2016, the Prime Minister of Japan (Abe, 2016) presented Japan’s official vision of the Indo-Pacific while giving a speech in Kenya on the “Free and Open Indo-Pacific” (Cuesta, 2020). In which he underlines the potential growth of two continents (Asia and Africa) and two oceans (India and the Pacific). Here he introduces the concept of ‘Free and Open Indo-Pacific’ (FOIP) and mentions its four important pillars - principles for peace and rules for prosperity; tackling challenges in an Indo-Pacific way; establishing multi-layered connectivity; and expanding efforts for security and safe navigation and communications (Fig. 1). In September 2018, Japan called the Free and Open Indo-Pacific a Vision instead of a Strategy. Vision addresses an idealistic drive that outlines the architecture of a long-term future, while ‘strategy’ is directly based on a mission (Haaf, 2020). In strategy, the work’s direction and

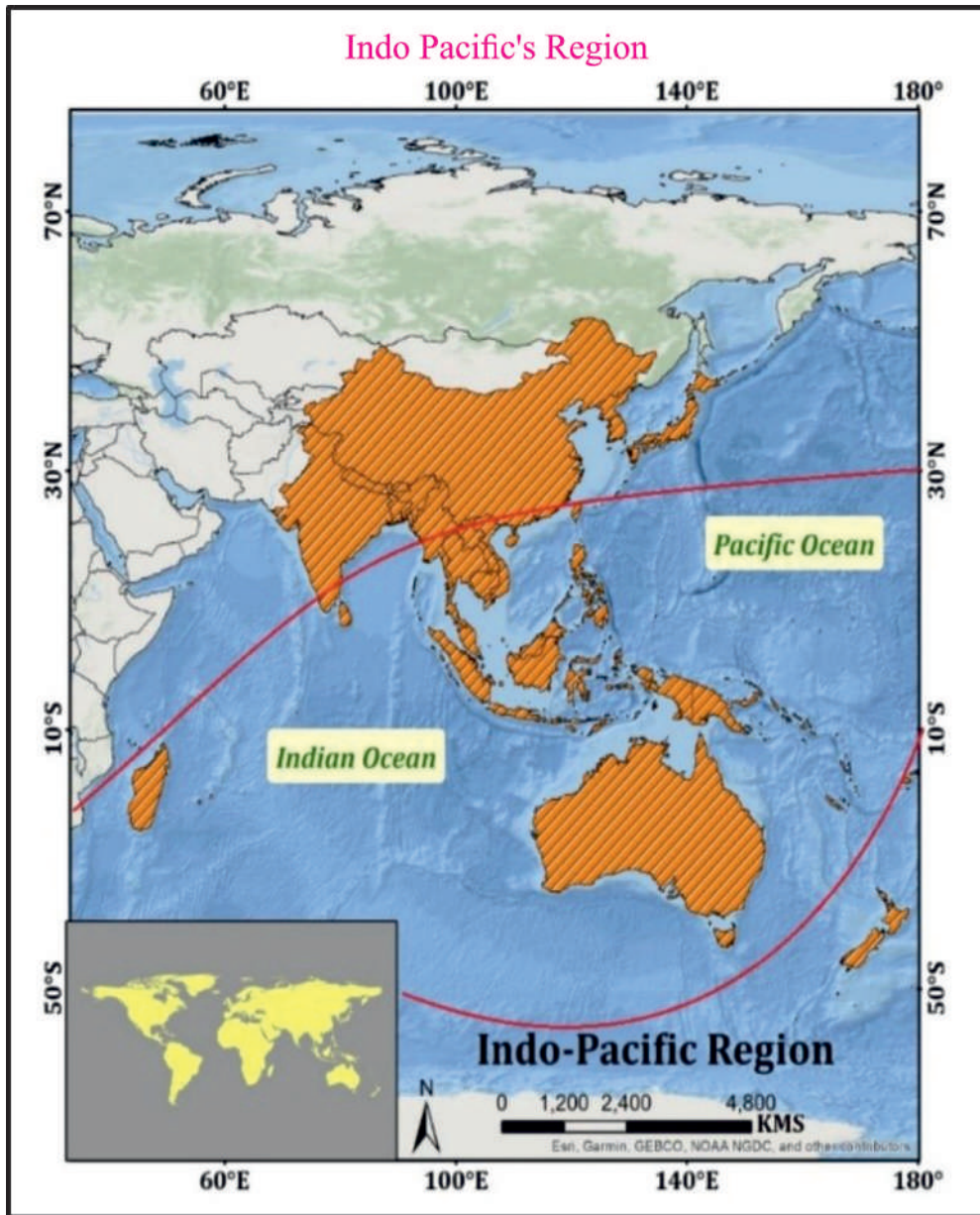


Fig. 1

result and its impact are assessed in advance. Strategies act like realistic mirrors. It can be argued behind this idealistic construction that to distance itself from the practice of the concept of ‘direct competition’ in the Indo-Pacific between the USA and China (which would have been established as a strategy), it was more appropriate to call it a vision.

Mental Map to Realistic Establishment: USA’s Trans-Pacific System

Geographically, the United States faces an East and West-based geopolitical prism (Salmon 2024), but for decades, its foreign policy has been mostly directed toward Europe. Washington’s foreign policy post-2011 witnessed a paradigm shift in which it wanted to create a trans-Pacific system in the Asian region that would provide it with significant dividends and strategic advantages in the future. Since 2011, the US has tried transforming the Asia-Pacific region into a ‘zone of strategic and economic gravity’ to suit its interests. At this time, the USA tried to strengthen its trade and energy routes from the Indian Ocean to the Strait of Malacca and then extended to the Pacific Ocean. Here the US appears to be identifying key allies for Washington beyond its ‘Partners of First Resort’ mental strategy. Along with trade interests and security architecture, it also promotes alliance-based regional integration in Asia. In a November 2011 statement titled ‘America’s Pacific Century and the Pivot to Asia’, the USA’s Secretary of State (Clinton, 2011) acknowledged that the United States must be more vigilant in maintaining its leadership and securing its interests.

This statement attempted to define American statecraft in the context of the Asia-Pacific region. However, the terminology Indo-Pacific had not yet been made a part of official papers, the above mental concept was coined for the Indo-Pacific only. Over time (2011), the US attempts to officially promote that it will expand its existing role in the Asia Pacific region. Which he addresses as ‘rebalancing in Asia’ (Daggett, 2012). In the changing strategic era after the Second World War, the ‘pace of geopolitical dynamics’ of today’s Indo-Pacific region appears to be the center. The presence of the USA and European countries in this region further intensified the pace of this movement. The wars in Korea and Vietnam made the USA realize the ‘urgency’ of the region. The Strategic Shift to ‘Rebalance to Asia’ included several efforts to meet the USA’s interests in the region, including cooperation with the Philippines and Taiwan, and the deployment of troops in Australia. In February 2017, the US directly mentioned China in its national security strategy, saying that China is trying to fulfill its ambitions in this region. Due to this Chinese dominance, the sovereignty of many states in the Indo-Pacific region is at risk.

In this way, the concept of the ‘dialectical presence’ of ‘America-China’ came to the fore in the architecture of the Indo-Pacific region. In this 2017 strategy, the US prominently coined the US-led ‘collective response’ for the Indo-Pacific region. At the APEC summit in November 2017, the US President (Trump, 2017) reiterated the US commitment to promoting a free and open Indo-Pacific. At this time, the US declared the Indo-Pacific as the ‘focal point’ of the ‘US Asia Policy’, which was a major step in recognizing Western interests in the Indo-Pacific region. After December 2017, the frequency of use of the word Indo-Pacific increased significantly in the Strategy Papers of the USA. At the same time, the USA gave an important space to Indo-Pacific in its National Security Strategy (2017). Also, in November 2017, the official QUAD meeting held in Manila sought to showcase the Indo-Pacific as a region of long-term interests; - immense potential for shared prosperity and inclusive growth. In this meeting, India accepted the ‘Act East Policy’ as the ‘cornerstone’ of its participation in the Indo-Pacific. In May 2018, an important change came in the order of giving official recognition to ‘The Indo-Pacific’, in which the United States decided to change the name of its Pacific Command to ‘Indo-Pacific Command’ (USINDOPACOM). USINDOPACOM is one of six geographic combatant commands defined under the U.S. Department of Defense’s Unified Command Plan (UCF), which unifies military forces within an area of responsibility (AOR) to serve U.S. national interests. USINDOPACOM is the command responsible for U.S. military activities throughout the Pacific, underpinning the U.S. security strategy at all critical junctures from the coasts of East Africa to California’s coasts.

Geographical Establishment of Indo-Pacific: Documentation through White Papers

In October 2012, the term Indo-Pacific was ‘first officially’ introduced by Australia in a white paper titled ‘Australia in the Asian Century’ (Henry, 2016). This white paper said that there is now a wave of change in the direction of the world’s busiest trade corridor because the Indian Ocean is becoming more important in many ways than the Atlantic and Pacific Oceans (Cameron, 2012). Coining the term ‘Indo-Pacific’ instead of ‘Asia Pacific’, this white paper enumerated the ‘benefits of geolocality’ of the Indian and Pacific Oceanic region. This paper showed the applied benefits of mapping the Indo-Pacific over East Asia and Asia Pacific for Australia. Australia in its 2012 official white paper embraced the Indo-Pacific geographically and strategically and said that the US would emerge as a ‘powerful strategic actor’ in the region. In 2016, Australia again issued a white paper talking about a stable

and 'Rules-based Indo-Pacific'. It also includes some competitive concerns in the region, in which 'geopolitical regional competitive tendencies' between China and the US are also mentioned. At the same time, terminology like 'strategic balance' (Sharma, 2017) also comes into use in the context of the Indo-Pacific region.

Maritime Security and Indian Effects: Geostrategic Balance and Indo-Pacific

In January 2007, Captain Khurana (2007) of the Indian Navy, wrote 'Security of Sea Lines: Prospects for India-Japan Cooperation', defining the need for the Indo-Pacific domain. Khurana (2007) is credited with coining the term Indo-Pacific in a 'strategic sense'. In the following years, the term Indo-Pacific became an integral part of the Indian maritime domain and diplomatic strategy. In 2015, India released its New Maritime Strategy titled 'Ensuring Secure Seas: Indian Maritime Security Strategy' (2015). Using the terminology 'Indo-Pacific' in this strategy, it was told that the 21st century will be of the seas, with India having a high degree of 'Locational strategic advantages' (Singh, 2015). This strategic document highlighted regional geostrategic changes. One of the important changes is the shift of the balance of power from the 'Euro-Atlantic' to the 'Indo-Pacific'. In this strategic document, the Indian Navy called for a national approach towards the sea and the maritime domain and mentioned activism in the Indian Ocean region (Baruah, 2015). In June 2018, the Indian Prime Minister (Modi, 2018) presented India's vision for the Indo-Pacific at the 'Shangri La Dialogue' (2018) in the presence of the Prime Minister of Singapore (Lee, 2018). Some excerpts from the statement given in this dialogue are as follows: -

"..The human-kind now looks to the Rising East, with the hope to see the promise that this 21st century beholds for the whole world because the destiny of the world will be deeply influenced by the course of developments in the Indo-Pacific region...." (Prime Minister of India Speech in 'Shangri La Dialogue', 2018, New Delhi)

Intuitional Actions against the Salami Slicing: China's Strategy in Indo-Pacific

China had already publicly referred to Indo-Pacific construction as an 'attention-grabbing idea' (Khurana, 2023), an idea that 'will dissipate like ocean foam' (Gray, 2020). In 2004, US analysts came up with a hypothesis called 'String of Pearl Policy' addressing the presence of Chinese military bases and a network of sea communication lines in the Indian and Eastern Pacific Oceans (Marantidou, 2021). Since the 2010s, these 'Hypotheses' started becoming more pragmatic in the Indian and Eastern Pacific Oceans. China's Salami Slicing Strategy (a strategy that

combines a series of small steps into a big profit) is becoming increasingly visible in today's Indian Pacific Ocean (Chellaney, 2020). In 2013, China launched the 'Belt and Road Initiative' to build global infrastructure. In diplomatic terms, BRI is a form of 'Melanistic diplomacy' in which China can play a more leadership role in global affairs by increasing its power and position (Stephen, 2021). This diplomacy has given rise to sovereignty-based border disputes with neighboring countries. In this direction, China has direct disputes with India and Japan. China's confrontation with the United States' interests at sea has led to new strategic changes in the Asian and East Pacific regions. As a result, the United States calls for building a free and inclusive Indo-Pacific while addressing goals such as freedom of navigation and the rule of law (Poker, Ches and Go, 2016). The USA has been in constant dispute with China since the period of 2018 due to bilateral trade and diplomatic consequences. Questions were raised about India-China relations after the violent clash in Galwan Valley in June 2020. In the second QUAD meeting of the Foreign Ministers of Japan, USA, India, and Australia in October 2020, the partner countries emphasized increasing coordination in the region for a free and open Indo-Pacific, which can curb China's expansionist attitude. (Jash, 2021) In this meeting, the United States of America talked about establishing 'Intuitional Actions' in this region. (Park, 2020) This institutional action was synonymous with the creation of a security structure. QUAD's activism (Kapoor, 2023) in the era of COVID-19 and its focus on the Indo-Pacific reflect new changes in geopolitics. This change presents the Indo-Pacific as a 'security architecture' (Kumar, 2014).

Conclusion

The development of ideas such as the Indo-Pacific has significantly influenced how nations perceive the world, shaping new perspectives over an extended period. This evolution results from the collaboration of politicians, think tanks, and academia spanning many years and decades, responding to the demands of the geopolitical landscape. In short, it can be said that the Indo-Pacific is a collection of strategies of states that define the geography of this region. With time, European interests in this region have also been added to the changing geopolitical system. The first European effort was made by Germany, and later, in May 2018 France made the Indo-Pacific Strategy the basis of its foreign policy. The Indo-Pacific perhaps now appears to be closer to its geographical establishment, as the pace of convergence of strategic interests in the region is very high. But till now, there is no unity in the strategies of different states regarding its geographical extent. In this way, the Indo-Pacific again goes into its 'Mental Map' phase. The goal of shared prosperity can be achieved

through infrastructure development, resolution of geopolitical disputes, and free navigation in the region. A joint statement on the Indo-Pacific was issued during the QUAD summit in Hiroshima, Japan, in May 2023, emphasized the development of the region's infrastructure. At this conference, it was said that the global strategic and economic environment is changing rapidly, which is having a direct impact on the countries located in the Indo-Pacific region. In the EAS meeting itself in September 2023, the Master Plan for ASEAN Connectivity (MPC) was encouraged for the development of sustainable infrastructure in strategic areas, which will establish a structural system in the Indo-Pacific region. In the end, it can be said that the Indo-Pacific can become a constructive platform on which the principle of coexistence can be included in global geopolitics. However, geopolitical changes and a polarization-based approach have presented it as a defense wall, which will be useful in curbing the expansionist attitude of nations like China. After trying to understand the process of emergence of this region, it can be said that in the coming era, the Indo-Pacific will create such a geo-political global setup, which will help establish global balance. From the state of the mental map to the political acceptance of geographical establishment, the Indo-Pacific is a unique example of a paradigm shift in geopolitics.

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RAINFALL VARIABILITY IN MANAS RIVER BASIN IN ASSAM

Parbin Nahar Begum and Eahya Al Huda

Abstract

Hydrological and water quality models rely heavily on precipitation data since it affects the rate and magnitude of flow and mass transfer. Analysing the rainfall patterns of a watershed, river catchment, or drainage basin can help with water management and water efficiency. The potential of crop production, farming systems, and patterns of agricultural productivity can all be determined through an understanding of the nature and characteristics of rainfall, this is then used in reservoir planning, flood control engineering, drainage system design, soil and water conservation, and other similar fields of study and practice. Understanding the features of rain in relation to its temporal variation is crucial for long-term sustainability. The industrialization has altered global and regional climate, which in turn alters hydrologic conditions and the responses of runoff in watersheds. Given its significance to local economies, it's vital to study rainfall variability at the regional level. The rainfall trends of the Manas River basin have been outlined in this research. From 2005 through 2018; the yearly rainfall trend of the Manas River basin before, during, and after the monsoon has been studied.

Introduction

The increased temperature and precipitation variability that characterize the global climate changes have a significant impact on interconnected earth systems, particularly hydrology and water resources (Fu et al., 2007). The hydrological cycle in a watershed and on a regional scale is altered by climatic factors, such as total precipitation, rainfall, and temperature, which have an impact on every aspect of hydrology and water resources, changes the hydrological series in the Manas River Basin (陈伏龙 et al. 2019; Li et al., 2020). The primary cause of its sudden shift is the variability displayed by hydrological and climatic variables (Chen et al., 2015; Ling et al., 2011). Vegetation cover in a watershed area has a direct or indirect impact on rainfall because it absorbs and stores some of the precipitation that falls on its surface during the early stages of a storm, before letting the rest of it

evaporate or run off (Jiayi Huo et al., 2020). Net precipitation is determined by the sum of the water lost through evaporation and water lost via transpiration, both of which vary over a period of 78 days (Shahin, 2002). It's not easy to put a number on a rainfall event because it might have many different characteristics (how much rain fell, what kinds of rain fell, how long it rained, how hard it rained, and so on) and these characteristics change over time (Lan et al., 2005). It is emphasized that long-term daily rainfall data is crucial since it allows for statistical analysis at daily, weekly, and seasonal scales of time (Aris et al., 2010). For flood study in a specific location, the daily unit of rainfall observation is a crucial temporal unit for revealing seasonal and spatial-temporal variability and uneven distribution of rainfall (Chu et al., 2010). Intricate climatic events rely heavily on precipitation (Narkhedkar et al., 2010). Therefore, in order to comprehend the nature of variable rainfall, experts from various fields, such as meteorologists, hydrologists, soil scientists, agronomists, geographers, etc., describe rainfall differently. Air pressure, temperature, and humidity all play a role in determining rainfall patterns, all of which have knock-on effects on the river catchment's evaporation, precipitation, soil moisture, surface and sub-surface flow, and discharge (Al Huda and Singh, 2016).

However, orography and terrain features exert substantial control over rainfall totals, intensities, and occurrences (Starkel, 1972a; Starkel, 1972b; Starkel, 2002). As a result, elevation and surface slope are two of the most important determinants of precipitation (Singh, & Syiemlieh, 2010). In general, it is true that the Indian subcontinent receives more than 80% of its annual rainfall between June and September due to the summer monsoon rains (Kripalani et al., 2004). The hydrological system in the north-eastern parts of India relies heavily on the summer season rainfall, as this is when the majority of the year's precipitation falls. This is because the average annual rainfall in these regions is significantly lower than the amount of rain that falls during the summer (May-August) (Goswami et al., 2010). The river basins in north-east India are prone to flooding at this time of year. Changes in river basin water level and discharge are amplified by heavier downpours. Heavy monsoon rainfall (Jamir et al., 2008), insufficient river bank ability to contain high flow, erosion, silting of riverbeds, landslides, and inadequate drainage facilities in flood-prone areas are the primary causes of flooding (Mohapatra et al., 2003). The hydrology of rivers and the diversity of ecosystems in protected areas are both directly impacted by climate change (McManamay, 2022). Because of climate change, the global hydrological cycle is expected to become more intense, which will have a significant effect on local water supplies (Amell, 1999).

Surface and subsurface water balances are significantly impacted by the shifting geographical and temporal patterns of precipitation brought on by global climate change (Kunstmann et al., 2004). Therefore, scientists, environmentalists, planners, policymakers, and others will pay close attention to the extent of climate change and its implications in order to maintain ecological equilibrium in the long run. The hydrology of a river can be significantly impacted by climatic, land-use, and human-use variations (Singh, 2020). Rainfall is a key component of climate and has been characterized in a variety of ways by experts from various fields, including meteorologists, hydrologists, soil scientists, agronomists, and geographers (Arora et al, 2005,). It fundamentally affects the hydrological cycle and modifies the nature and properties of hydrographs. The key factors affecting the hydro-tropes of the catchment landscape are the extreme rainfall circumstances, which have an impact on the evapotranspiration regimes, soil moisture and sub-surface flow, surface runoff, and trends of base flow. On the other hand, the macro-regional atmospheric conditions and the micro-regional orographic impacts of the Indian monsoon climate govern the amount, intensity, and frequency of precipitation (Starkel, 1970; Starkel, 1972a). The Inter Tropical Convergence Zone (ITCZ) shift is an atmospheric factor that affects the monsoon climate and causes irregularities in the seasonal distribution of rainfall. Thus, this paper discusses the study of variations of rainfall patter of the Manas River basin.

Study Region

Eastern Bhutan and northeast India are drained by the 41,350 square kilometres watershed that is the Manas River, a major tributary of the Brahmaputra River. Out of its total length of 376 kilometres, 272 kilometres flow through Bhutan and the remaining 104 kilometres run through Assam to the point where the river meets the mighty Brahmaputra at Jogighopa. A total of 18,300 km² of Bhutanese territory is drained, between the coordinates of 26°10" to 26°50"N Latitudes and 90°00" to 91°00"E Longitudes, while a total of 23,000 km² of Assam, India is drained. Some of the river's main stem originates in southern Tibet and flows into India over the Bumla pass in Arunachal Pradesh's north-western region. The Manas River travels from the southwest via Bhutan and into the south-central foothills of the Himalayas in India's Assam. This route follows the river's original course as it was carved out by glaciers. The Aie River begins its journey into India at the village of Agrong in the Goalpara district of Assam after flowing roughly 29 kilometers south-westward through Bhutan. The next 75 kilometers or so of its winding path take it to the Brahmaputra, not far from Jogigopa. The Black Mountains provide the source of

the 110-kilometer-long Aie River, which begins at an elevation of around 4,915 meters near the village of Bangpari; the Manas is 376 kilometers long along the course of its longest tributary, the Kur, of which roughly 104 kilometers are located in the Indian state of Assam.

When it exits the western side of Manas National Park, it divides into the Beki and the Bholkaduba. The Manas National Park is located on a vast low-lying alluvial terrace below the foothills of the outer Himalaya, and is traversed by the Manas River as well as five other smaller rivers. Besides serving as a natural boundary between India and Bhutan, the river is also a recognized international boundary. There is not a single flat area within the watershed's 140-kilometer radius; the catchment rises from an elevation of 100 meters near the Indian border to the Great Himalayan peaks at over 7,500 meters along the major Himalayan range bordering Bhutan and Tibet. It is one of the world's most biodiversity regions because of the convergence of several different types of ecosystems, including the Sub-Himalayan Bhabar Terai formation and the riverine succession that continues up to the Sub-Himalayan Mountain Forest. It gets as low as around 150 C and as high as about 370 C. May through September sees the heaviest rains, with an average of 333 cm (13 feet) every year.

Objectives

- (1) In the northern regions, Sub-Himalayan Light Alluvial Semi-Evergreen woods
- (2) Mixed moist and dry deciduous woods in the East Himalayas (the most common type)
- (3) Woodland on a low-lying savanna, and
- (4) Nearly 50 percent of Manas National Park is made up of Assam Valley Semi-Evergreen Alluvial Grasslands.

Materials and Methods

The following database and statistical methods, which will serve as the basis for the entire project, will be needed to perform the research.

- (a) Daily rainfall data is gathered from the CWC office at Adabari, Guwahati and CWC office in Shillong for the 14-year period (2005-2018).
- (b) The temporal variations of rainfall in Manas River Basin were categorised into Annual variations, seasonal variations, and storm variations for the 14 years period (2005-2018) and have been calculated with the help of various

statistical techniques like Mean, standard deviation, Coefficient of variation and Z score.

- (c) The toposheets of the research area has been used in the mapping, which is done at a scale of R.F.1/50,000, from Survey of India.

Results and Discussion

The Manas basin receives rainfall from both the boreal winter and summer monsoon circulations since the area is impacted by both monsoonal and mid-latitude weather systems. The land-sea temperature difference and its associated thermal circulations have previously been thought to be responsible for monsoon circulation. The main precipitation sources in the area during the winter and early spring are synoptic weather systems that originate in the Mediterranean and migrate eastward toward South Asia. One important hydro-meteorological factor that helps control the hydrological response in a river watershed is rainfall. The meteorological, atmospheric, geo-hydrological, and land surface factors all have an impact on the rainfall-runoff interaction. In order to determine which model is appropriate for such humid conditions of the land surface and relatively large seasonal rainfall intensities, the present chapter focuses on two key methodological aspects: generation of data of hydrological parameters and its spatio-temporal variations and, secondly, the establishment of rainfall-runoff relationship in Dikrong river catchment (Al Huda, 2013). In general, the greatest, most fundamental and most immediate threat to the local population in a region is the unpredictable variability of rainfall – the dimensions of which can only be appreciated by understanding the historical record on various time scales (Maria et al, 2021). While most of the rainy days have low intensity, but most of the annual rainfall total is contributed by the fewer, high intensity events majorly associated with deep convection into the troposphere. Here we have discussed the various parameters that contribute for the overall study of rainfall variability in the Manas river catchment.

Annual Variations

Annual variation in rainfall occurs mainly due to the changes in precipitation, evaporation and transpiration, soil moisture and ground water levels (G. Singh & S.K. Singh, 2023). In India the variability of annual rainfall is affected mainly by monsoon winds, topography, ocean currents, etc. Here we can observe that the annual variations of rainfall for the years 2005 to 2018. The total amount of rainfall received during each year, indicating fluctuations in annual rainfall amounts over time (Fig. 1). For instance, the highest total rainfall was observed in 2017 (3247.00 mm),

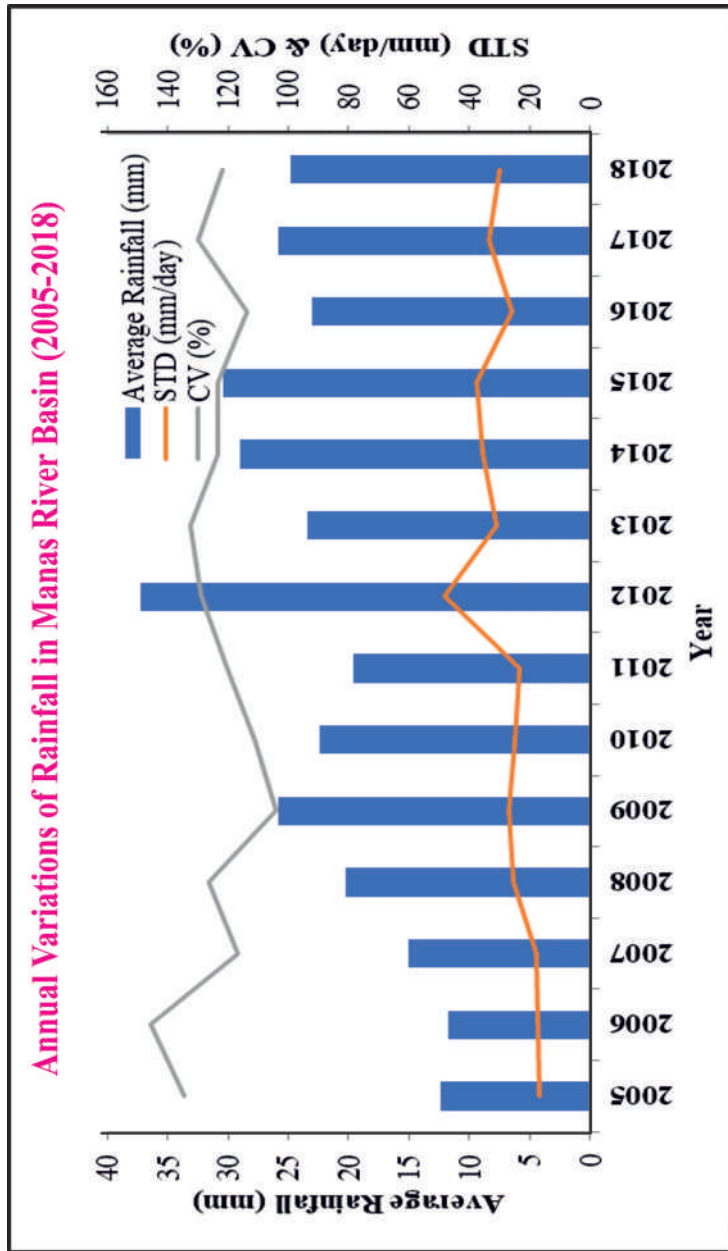


Fig. 1

while the lowest was recorded in 2006 with 1376.52 mm. Years with higher standard deviation, like 2012 (48.05 mm/day), experienced more variable rainfall patterns compared to others. The year 2005 had a Coefficient of Variation of 134.57%, indicating a high degree of variability in rainfall relative to the mean for that year. Thus we can say that the study provides valuable insights into the annual fluctuations, average patterns, and variability of rainfall, aiding in the understanding of rainfall patterns and trends in the specified region over the studied period (Table-1).

Table-1: Annual Variations of Rainfall in Manas River Basin (2005-2018)

Year	Total Rainfall (mm)	Average Rainfall (mm)	STD (mm/day)	CV (%)	No of Rainy Days	Rainfall Intensity (mm/day)
2005	1401.80	12.41	16.69	134.57	80	17.52
2006	1376.52	11.77	17.13	145.58	78	17.65
2007	1882.65	15.06	17.57	116.64	91	20.69
2008	2767.50	20.20	25.48	126.13	121	22.87
2009	2709.00	25.80	26.82	103.94	97	27.93
2010	2527.40	22.37	24.88	111.22	101	25.02
2011	1493.20	19.65	23.65	120.36	59	25.31
2012	3013.80	37.21	48.05	129.14	80	37.67
2013	1618.20	23.45	31.04	132.36	67	24.15
2014	2699.60	29.03	35.76	123.21	83	32.53
2015	2978.50	30.39	37.52	123.44	97	30.71
2016	2142.40	23.04	26.18	113.66	75	28.57
2017	3247.00	25.77	33.48	129.91	106	30.63
2018	3031.50	24.85	30.21	121.57	106	28.60

Source: Computed by Authors

Note: The day which has more than 2.5 mm of rain from 8.00 am has been counted as a rainy day as per the definition given by the Indian Meteorological department, Pune.

Rainfall intensity is the ratio of the total amount of rain (Rainfall Depth) falling during a given period to the duration of the period (Otuaga, 2015). It is expressed in depth units per unit time, usually as mm per hour (mm/hr). The "Number of Rainy Days" indicates the count of rainy days for each occurrence.

For the specific study area, the first occurrence had 80 rainy days; the second had 78, and so on. On the other hand, the "Rainfall Intensity (mm/day)" reveals the amount of rainfall experienced per day during the rainy days. The values for rainfall intensity vary across the occurrences, indicating fluctuations in the amount of rainfall per day during different rainy periods. The highest rainfall intensity was observed during 2012, with a value of 37.67 mm/day, while the lowest was recorded during the 2006, with 17.65 mm/day. Analyzing this data provides valuable insights into the patterns and characteristics of rainfall in the specified region or time frame. Occurrences with a higher number of rainy days may indicate prolonged rainy seasons, while those with high rainfall intensity suggest intense and heavy rainfall in shorter periods. Overall, understanding the distribution of rainy days and the corresponding rainfall intensity is essential for various applications, including water resource management, agricultural planning, and environmental studies (Rai & Dimri, 2020). This data contributes to a better comprehension of the region's rainfall patterns and variability, aiding in decision-making and planning for activities that are influenced by weather and precipitation.

Seasonal Variation of Rainfall (2005-2018)

The study area has a warm, humid climate with up to 76% relative humidity. The majority of the rain falls between June and September during the monsoon season, flooding the western side of the park, and it rains from mid-March to October. The smaller rivers dry up from November to February, and the Manas River's water level declines during this time. The average high temperature in the summer is 37 °C, and the average low temperature in the winter is 5°C. Based on variations in rainfall, temperature, and wind, this region's climate can be split into four separate seasons. Winter (December–February), pre-monsoon (March–May), monsoon (June–September), and retreating monsoon are these (October–November). Climate change and human meddling pose serious threats to the park's sustainability and environmental safety. Over the past century, this region's rainfall has been noticeably declining at a rate of about 5 mm each decade (Bora, 2018).

It's been observed that the forest environment, especially the marsh, and grassland, along the Manas River's banks and across the park are undergoing change. The environment, which is characterized by factors like temperature, soil moisture, and humidity, could be severely impacted by this (Fig. 2). There is no doubt that the hydrology of the Manas River and the local flora and fauna have been affected by these alterations. Variations in water output and environmental changes in the upper section of the river affect the sediment load on the river flow,

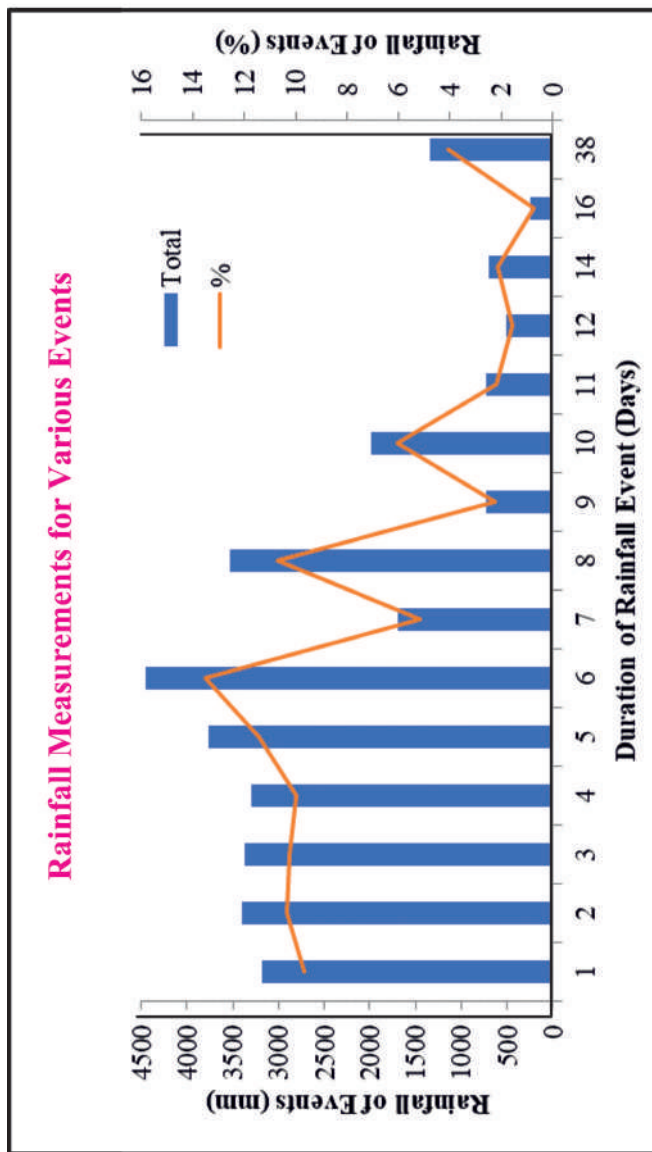


Fig. 2

which in turn affects downstream environments (Rolls, 2017). Sedimentation in the Manas River rises in tandem with the melting of the ice caps that fed it. Countless wild animals perished in the river's flash floods, which also caused substantial damage to the park's vegetation and infrastructure. Usually the trend of daily rainfall in Manas river catchment follows the same as general trend of monsoon climate. The winters are dry, the stormy rain summers have thunderstorms and sudden rain i.e. April, setting monsoon has continuous rain and then occasional rains in the last phase of monsoon, probably in October with occasional storms, 10-days moving average also shows high fluctuation of rainfall during the continuous heavy rain period. During this period, the intensity of rainfall varies significantly and makes more fluctuations in the rainfall pattern. This may be one of the main causes of flash floods in these areas of foot-hill topography. As far as temporal variation in daily rainfall pattern is concerned, in spite of such higher rainfall intensity during the post-monsoon period, the degree of its fluctuation is marginally lesser (CV=29%) than the pre-monsoon period (CV=19.10%) as there are more numbers of occasional rains that fluctuate the rainfall trends. But the intensive rains for shorter period recharge the soil and sub-surface stratum in this areas of deep loamy and sandy soils. However, such fluctuating nature of rainfall intensity is also seen in post-monsoon season of retreating monsoon when there are cases of flash floods due to soil-water discharge conditions (Table-2).

Table-2: Seasonal Variations of Rainfall in Manas River Basin

Seasons	Total Rainfall (mm)	Mean Rainfall (mm)	STD (mm/day)	CV (%)	No of Rainy Days	Rainfall Intensity (mm/day)
Pre-Monsoon	2980.27	15.13	17.09	112.96	156	19.10
Monsoon	27675.65	23.72	30.28	127.68	964	28.71
Post Monsoon	2233.15	21.47	36.83	171.54	77	29.00

Source: Computed by Authors

Identification of Stormy Days

Storm intensity is classified into different categories based on the Z value, representing the amount of rainfall (Yin. H, 2023). Extremely low storms, with a Z value below 0, recorded a total rainfall of 8079.62 mm, with an average of 8.02 mm.

Slightly more rainfall was observed in very low storms (Z value: 0-0.5), with a total of 5467.10 mm and an average of 29.24 mm. Low storms (Z value: 0.5-1.5) exhibited even higher rainfall, reaching 8788.55 mm in total, with an average of 49.37 mm. Moving up the intensity scale, moderate storms (Z value: 1.5-2.5) had a total rainfall of 3678.10 mm, averaging 78.26 mm. High storms (Z value: 2.5-3.5) was further increases in rainfall of 2077.80 mm, and an average of 109.36 mm. Very high storms (Z value: 3.5-4.5) experienced significantly high rainfall, amounting to 2497.60 mm on the whole, with an average of 138.76 mm. Finally, the most intense category, extremely high storms (Z value: Above 4.5), witnessed the highest amount of rainfall, with a total of 2470.90 mm and an average of 190.07 mm. In that particular study area we can observe a consistent trend of rising rainfall levels with increasing storm intensity, highlighting the importance of understanding these variations for climate monitoring and disaster preparedness in storm-prone regions.

Table-3: Characteristics of Different Rainstorm Events in Manas River Basin during 2005-2018

Storms	Z Value	Total Rainfall (mm)	Mean Rainfall (mm)	STD (mm/day)	CV (%)	No of rainy Days	Rainfall Intensity (mm/day)
Extremely Low	Below 0	8079.62	8.02	6.34	78.96	736	10.98
Very Low	0-0.5	5467.10	29.24	4.22	14.45	187	29.24
Low	0.5-1.5	8788.55	49.37	8.50	17.21	178	49.37
Moderate	1.5-2.5	3678.10	78.26	7.92	10.12	47	78.26
High	2.5-3.5	2077.80	109.36	9.58	8.76	19	109.36
Very High	3.5-4.5	2497.60	138.76	8.40	6.05	18	138.76
Extremely High	Above 4.5	2470.90	190.07	18.88	9.93	13	190.07

Source: Computed by Authors

Over the observed period, there were 736 rainy days with a relatively low rainfall intensity of approximately 10.98 mm per day. Moving up the intensity scale, there were 187 rainy days with a moderate rainfall intensity of around 29.24 mm per day, and 178 rainy days experienced a higher intensity of about 49.37 mm per day. As we further ascend, 47 rainy days had a significant rainfall intensity of approximately 78.26 mm per day. More infrequent but impactful,

there were 19 rainy days with an intense rainfall of about 109.36 mm per day. Additionally, 18 rainy days experienced even higher intensity, with approximately 138.76 mm of rainfall per day. At the top of the scale, there were 13 rainy days with the most substantial intensity, reaching approximately 190.07 mm per day (Table-3). The data indicates that higher rainfall intensities are less frequent but can result in significant volumes of rainfall within a single day. This information is essential for understanding local hydrology, managing water resources, and preparing for potential impacts on infrastructure and agriculture, allowing for more effective planning and response to extreme weather events.

Storm Duration

A rainfall event is the basic unit used for infiltration, runoff, and soil erosion (Alavina. M et al 2019). It is defined as a specific rainfall depth distributed in time according to a specific temporal rainfall distribution. This particular study provides an insight into the duration and frequency of rainfall events. The majority of events are of shorter duration, with one-day events being the most prevalent, constituting 44.26% of the occurrences, followed by two-day events at 18.64%. As the duration increases, the frequency of rainfall events gradually decreases. Longer events, such as 9 day and 14 day events, are comparatively rare, each representing only 4 days and 2 days of occurrence (Table-4). This information is crucial for effective planning and preparation against weather-related impacts, such as flooding and droughts, and for ensuring the resilience of communities and infrastructure to varying rainfall patterns. Understanding the distribution of rainfall event durations aids in implementing appropriate strategies to manage water resources and mitigate potential risks associated with extreme weather conditions. This information offers valuable insights into the duration and frequency of rainfall events in the observed period. Understanding the distribution of rainfall event durations is essential for various sectors, including agriculture, water resource management, and urban planning, as it can help prepare for potential flooding, droughts, and other weather-related impacts (Praveen. B et al, 2020). By recognizing the prevalence of shorter-duration events and the rarity of longer-duration events, authorities can develop appropriate strategies for mitigating risks associated with rainfall patterns and ensuring the resilience of communities and infrastructure to weather fluctuations.

The highest recorded rainfall is 4453.30 mm, making up 13.52% of occurrences in 6 days rainfall event. There are other significant events around 3761.05 mm, 3529.90 mm, and 3401.10 mm, each accounting for over 10% of the overall rainfall recorded. Moderate to lower rainfall events are also present,

Table-4: Total Number, Total Stormy Rainfall and Average Rainfall Depth Per Storm in Different Duration during 2005-2018

Duration of Rainfall Event (Days)	No of Event		Rainfall of Events (mm)		Mean Rainfall (mm)	STD (mm/day)	CV (%)	No of Rainy Days	Rainfall Intensity (mm/day)	Average Rainfall Depth (mm/event)
	Total	%	Total	%						
1	235	44.26	3182.10	9.66	13.54	20.04	148.00	159	20.01	13.54
2	99	18.64	3401.10	10.33	17.18	19.56	113.87	165	20.61	34.35
3	57	10.73	3374.82	10.25	19.74	26.84	135.99	133	25.37	59.21
4	44	8.29	3293.80	10.00	18.71	25.50	136.25	147	22.41	74.86
5	33	6.21	3761.05	11.42	22.79	28.33	124.29	139	27.06	113.97
6	23	4.33	4453.30	13.52	32.27	38.98	120.79	177	25.16	193.62
7	9	1.69	1694.90	5.15	26.90	31.97	118.84	50	33.90	188.32
8	12	2.26	3529.90	10.72	36.77	42.99	116.92	87	40.57	294.16
9	4	0.75	734.10	2.23	20.39	20.52	100.64	32	22.94	183.52
10	7	1.32	1981.10	6.02	28.30	39.31	138.90	63	31.45	283.01
11	3	0.56	729.40	2.21	22.10	23.94	108.33	29	25.15	243.13
12	1	0.19	513.80	1.56	42.82	42.64	99.59	10	51.38	513.80
14	2	0.38	700.20	2.13	25.01	20.53	82.10	26	26.93	350.10
16	1	0.19	243.60	0.74	15.23	23.42	153.81	11	22.15	243.60
38	1	0.19	1337.80	4.06	35.21	37.23	105.77	35	38.22	1337.80

Source: Computed by Authors

ranging from 1981.10 mm to 243.60 mm, representing 6.02% to 0.74% of the total rainfall. The observation indicates that extreme rainfall events with values above 3000 mm are more common, collectively accounting for approximately 51.47% of the total recorded rainfall, while moderate to low rainfall events make up the rest. Understanding the distribution of rainfall amounts is vital for various sectors, including agriculture, water resource management, and disaster preparedness. By recognizing the prevalence of different rainfall intensities, authorities can develop appropriate strategies to manage water resources efficiently, prepare for potential flooding or droughts, and ensure the resilience of communities and infrastructure to varying weather conditions (Pal et al 2021). Therefore we receive information on mean rainfall (in mm), standard deviation (STD) in mm/day, and the coefficient of variation (CV) as a percentage for various rainfall observations. Analyzing the data, we observe varying patterns in rainfall characteristics across the recorded instances.

The mean rainfall ranges from 13.54 mm to 42.82 mm, indicating different average rainfall amounts for each observation. The standard deviation, which measures the dispersion or variability of the data, shows variations from 19.56 mm/day to 42.99 mm/day. This indicates that some instances have higher variability in rainfall compared to others. The coefficient of variation (CV) expresses the standard deviation as a percentage of the mean, offering insights into the relative variability of each dataset. The Coefficient of Variation values range from 82.10% to 153.81%, (Table-4) indicating diverse levels of relative variability in rainfall patterns. Notably, some instances have high Coefficient of Variation values, suggesting substantial fluctuations in rainfall compared to their mean values. On the other hand, instances with lower Coefficient of Variation values have relatively more stable and consistent rainfall patterns around their respective means. Higher value Coefficient of Variations may indicate the potential for extreme weather events, leading to floods or droughts, whereas lower values Coefficient of Variation suggest more predictable rainfall patterns (Bianca & Wile, 2021). Such information is essential for water resource management, agriculture, and disaster preparedness, helping authorities make informed decisions and prepare for weather-related impacts effectively. The presented research provides a comprehensive analysis of rainfall patterns in the Manas River basin over a 14-year period, from 2005 to 2018. The study explores various meteorological aspects, including the annual variations of rainfall, storm intensity, distribution of rainy days, and characteristics of rainfall events. The data reveals valuable insights into the region's climate and precipitation trends, which have significant implications for water resource management,

agriculture, and environmental conservation. The analysis of annual variations in rainfall indicates fluctuations in total rainfall amounts and average rainfall patterns over the studied years. These variations can have implications for water availability, agricultural productivity, and flood risks in the region. The standard deviation and coefficient of variation demonstrate the variability of rainfall data, with some years experiencing more erratic patterns compared to others. Understanding such variations is crucial for preparing communities and infrastructure for extreme weather events, such as heavy rainfall and droughts. The classification of storm intensity based on the Z value provides a comprehensive overview of different rainfall scenarios during storms (Bruegel et al., 2020). The data highlights the prevalence of low to moderate-intensity storms, with higher intensity storms being less frequent but potentially more impactful. Identifying such patterns is essential for disaster preparedness and response planning, as intense storms can lead to flooding, landslides, and other natural hazards. The distribution of rainy days and corresponding rainfall intensity gives valuable insights into the nature of rainfall events in the region. The majority of rainy days exhibit lower rainfall intensity, while fewer rainy days experience intense rainfall. This information is crucial for managing water resources, agricultural planning, and infrastructure development to cope with varying rainfall patterns. The characteristics of rainfall events, including their duration and corresponding rainfall amounts, provide a comprehensive understanding of the variability in rainfall occurrences (King et al, 2022). The data highlights the prevalence of shorter-duration events, with one-day events being the most common. However, extreme rainfall events with values above 3000 mm are also relatively common, indicating the potential for heavy precipitation and flooding in the region.

Conclusion

The research on rainfall patterns in the Manas River basin provides essential information for water resource management, agriculture, and environmental conservation in the region. The analysis of annual variations in rainfall indicates fluctuations in total and average rainfall amounts, emphasizing the need for adaptive water management strategies to cope with changing precipitation patterns. The classification of storm intensity helps identify potential risks associated with heavy rainfall and extreme weather events. Understanding storm intensity patterns is critical for disaster preparedness and mitigation measures to safeguard communities and infrastructure. The distribution of rainy days and rainfall intensity assists in planning agricultural activities and managing water resources effectively.

By recognizing the prevalence of lower-intensity rainy days, farmers can optimize irrigation practices and enhance water use efficiency. The characteristics of rainfall events, such as duration and rainfall amounts, provide valuable insights into the variability of precipitation in the region. This information is crucial for designing resilient infrastructure and disaster response strategies to mitigate the impacts of extreme weather events. In conclusion, the study on rainfall patterns in the Manas River basin is essential for long-term water resource planning, flood control engineering, agricultural productivity, and climate change adaptation. The findings presented here serve as a valuable point of reference for policymakers, water managers, and researchers in making informed decisions and developing sustainable strategies for the region's water management and environmental conservation.

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ANALYSIS OF LANDUSE AND LANDCOVER CHANGES IN BHARATPUR BIRD SANCTUARY, RAJASTHAN

Vipin Chandra Lal

Abstract

The Bharatpur Bird Sanctuary, also known as Keoladeo National Park, is a globally significant wetland habitat recognized for its rich biodiversity and vital role as a breeding and wintering ground for numerous avian species. This study investigates the patterns and dynamics of Land Use and Land Cover (LULC) changes in the sanctuary over recent decades, highlighting the ecological implications and underlying factors driving these transformations. Using multi-temporal remote sensing data and Geographic Information System (GIS) techniques, changes in key land cover categories such as wetlands, grasslands, forests, and agricultural areas were analyzed. The findings indicate significant shifts, with a notable reduction in wetland areas, agricultural land expansion, and vegetation cover alterations. These changes are attributed to both anthropogenic activities, such as encroachment and land conversion, and natural factors like climatic variations and hydrological modifications. The study emphasizes that the decreasing wetland area poses a threat to the sanctuary's ecological health, impacting bird species that depend on these habitats. The encroachment of agricultural activities around the sanctuary's periphery has also led to habitat fragmentation, reducing the connectivity between different habitat patches. Furthermore, variations in rainfall patterns and water management practices have affected the hydrological regime, altering the park's availability and quality of habitats. To address these challenges, the study recommends the implementation of a comprehensive LULC management strategy that integrates the needs of local communities while ensuring the conservation of critical habitats. Regular monitoring using remote sensing technologies, coupled with community engagement and adaptive management approaches, is essential for safeguarding the biodiversity of Bharatpur Bird Sanctuary. This research provides valuable insights for policymakers and conservationists, facilitating informed decision-making for sustainable management of the sanctuary.

Introduction

Land use and land cover (LULC) change is a major issue of global environmental change. The scientific research community called for a fundamental study of land use changes for the duration of the 1972 Stockholm Conference on the Human Environment, and again 20 years later, at the 1992 United Nations Conference on Environment and Development (UNCED). Simultaneously, the International Geosphere and Biosphere Programme (IGBP) and International Human Dimension Programme (IHDP) co-organized a working group to set up a research agenda and promote research activity for LULC changes (Xiubin, 1996). Land use/ land cover mapping is an essential component wherein other parameters are integrated on a requirement basis to drive various developmental indexes for land and water resources. Bharatpur Bird Sanctuary is a UNESCO World Heritage Site located in the state of Rajasthan, India. This wetland reserve, covering an area of approximately 29 square kilometres, is renowned for its diverse avian population, attracting both resident and migratory bird species from across the globe. The sanctuary plays a critical role in maintaining the ecological balance of the region, serving as a vital breeding and feeding ground for birds and supporting various other flora and fauna. However, in recent decades, the sanctuary has witnessed significant changes in its Land Use and Land Cover (LULC), which have raised concerns about the sustainability of its ecological health and biodiversity. Land Use and Land Cover changes refer to alterations in the natural landscape, often driven by human activities and environmental factors. These changes can have profound impacts on biodiversity, hydrology, and the overall functioning of ecosystems. In the context of Bharatpur Bird Sanctuary, LULC changes are primarily associated with factors such as agricultural expansion, urbanization, water management practices, and climate variability. These changes not only threaten the integrity of the wetland ecosystem but also affect the availability of suitable habitats for various bird species, leading to shifts in species composition and population dynamics.

Study Region

Bharatpur Bird Sanctuary also known as Keoladeo National Park (27°7'6" N – 27° 12'2" N and 77° 29'5" E – 77° 33'9" E) is a 29 km² area located on the fringe portion of the western edge of the Gangetic basin that was once a convergence of Rivers Gambhir and Banganga in Bharatpur district in the State of Rajasthan. Bharatpur Bird Sanctuary has an exceptional variety of ecosystem that include swamps, forests, scrub and grasslands that support an incredible diversity of both plant and animal species. Bharatpur Bird Sanctuary flora contains over 380 species

of angiosperms of which 95 species are wetland species. The fauna covers more than 355 species of birds which include 39 species of raptors and 10 species of owls, 15 species of reptiles, 8 species of amphibians, 30 species of creatures 60 species of fishes and 75 species of butterflies, more than 35 species of dragonflies and more than 32 species of spiders inhabit the park. Due to the plenty of birds, Bharatpur Bird Sanctuary is every so often cited as 'Bird Paradise'. The sole variety of habitations comprises different types of plantation, forest, scrub forest, savanna wood, low plains with dispersed trees and shrubs, plantations and swamp. Plantations, mostly in the northeast of the sanctuary, are conquered by Jamun, babul and Kadam etc. The rich variety of habitations supports the main flock of water birds in the region and is also home to many terrestrial and indigenous migratory birds. The swamplands of the sanctuary are host to the most remarkable heronry of the region. 20 species of birds nest here founding an wide heronry from the month of July to September. Vegetation and bushes usually found in savanna in certain wetland areas are bordered with this kind of vegetation. Bharatpur Bird Sanctuary had been the only wintering ground for the endangered Siberian Crane. It has a long and exclusive past as it was once part of the former state of Bharatpur and had been accomplished as a duck shooting reserve.

Objectives

To analyze the spatial and temporal patterns of Land Use and Land Cover (LULC) changes in Bharatpur Bird Sanctuary over a defined period using multi-temporal satellite imagery and Geographic Information System (GIS) techniques.

Database and Methodology

In the present study Image processing and visual interpretation, the technique is employed to carry out Land use / Land cover classification using digital data. The Level-II classification is adopted to prepare land use and land cover map. Land use/land cover maps of Bharatpur Bird Sanctuary for the years 2000, 2008 and 2017 are prepared by the data of Landsat 5, Landsat 7, and Landsat 8 respectively with the Image processing, classification and visual interpretation technique. Land use/land cover maps of Bharatpur Bird Sanctuary for the years 2000, 2008 and 2017 have been prepared by using Landsat 5, Landsat 7, and Landsat 8 images respectively acquired from USGS.

Radiometric and Geometric Corrections: Apply radiometric corrections to normalize the satellite images for differences in illumination and atmospheric conditions. Perform geometric corrections to align images with a common

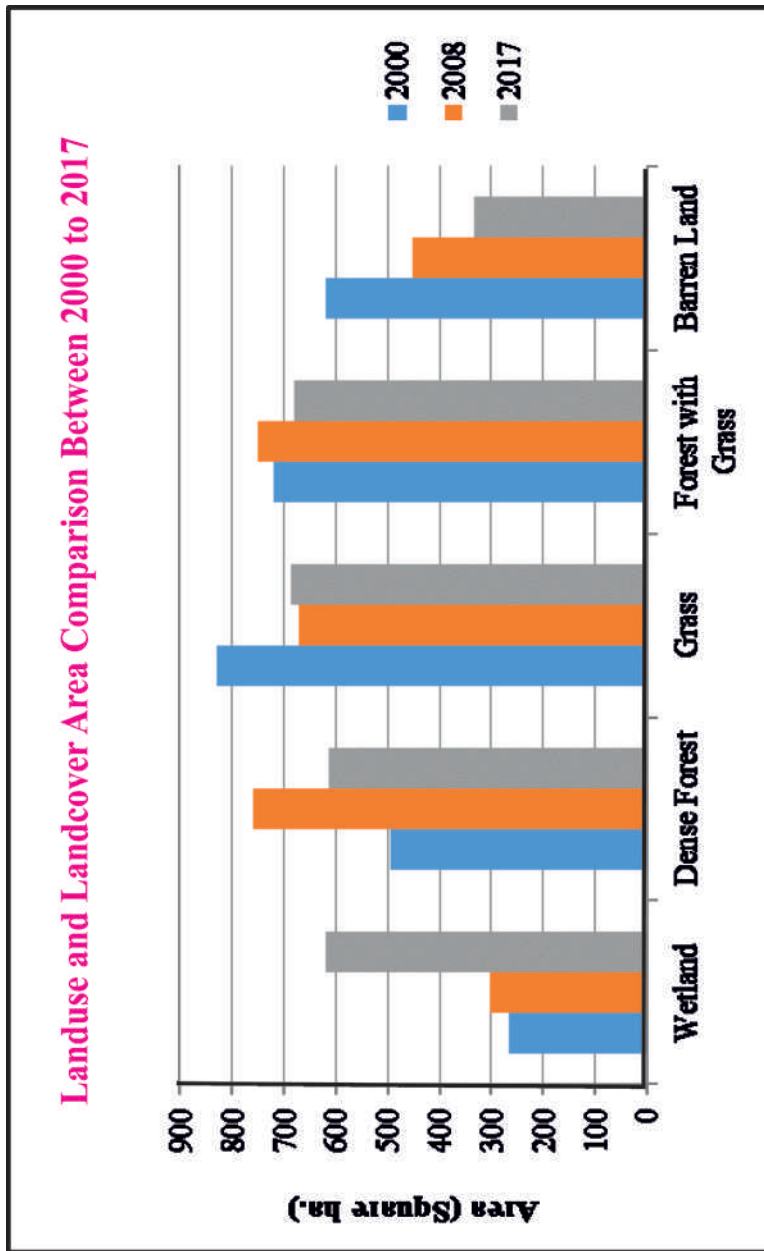


Fig. 1

spatial reference system. Image Enhancement: Use techniques such as contrast stretching and histogram equalization to improve the visual quality of images for better classification and interpretation. Image Classification: Utilize supervised and unsupervised classification techniques, such as Maximum Likelihood Classification (MLC) or Support Vector Machine (SVM), to classify the satellite images into distinct LULC categories (e.g., wetlands, forests, grasslands, water bodies, agricultural areas). Change Detection Techniques: Apply change detection methods such as post-classification comparison, image differencing, and normalized difference indices (e.g., NDVI) to detect and map LULC transformations. Trend Analysis: Assess the trends and patterns of LULC changes over the selected time period, focusing on the spatial distribution and intensity of changes.

Result and Discussion

The major landuse and landcover types shown by the maps of 2000, 2008, and 2017 include Barren Land, Wet Land, Dense Forest, and Forest with Grass and Grassland. As indicated in the Figures below that the greatest share of land use and land cover from all classes is grassland, which covers an area of 830.43 Square ha, and contributes (28.31 %) of the total area (Table-1).

Table-1: Change in Area (Hectares) from 2000 to 2017

Class	2000-2008	2008-2017	2000-2017
Wetland	36.59	316.26	352.85
Dense Forest	262.8	143.64	119.16
Grass	160.29	16.74	143.55
Forest with Grass	29.97	70.92	40.95
Barren Land	169.07	118.44	287.51

Source: Prepared by Author based on USGS data

Forest with Grass and Barren Land covers an area of 721.53 Square ha (24.60 %) and 620.51 ha (21.15 %) respectively. Dense Forest and Wetland cover an area of 495.45 square ha (16.90 %) and 265.27 square ha (9.04 %) of the total area of the Bharatpur Bird Sanctuary. This shows that 57 % of the total area of the study area covered by Vegetation (Forest, Forest with Grass and Grassland) in 2008. As indicated in the figure and table below the area of wetland has increased. The Dense Forest land has also increased but the grassland, forest with grassland and Barren land reduced in Bharatpur bird sanctuary (Fig. 1 and 2). The wetland area was reduced slightly in the years 2000–2008, 2008-2017 and 2000-2017.

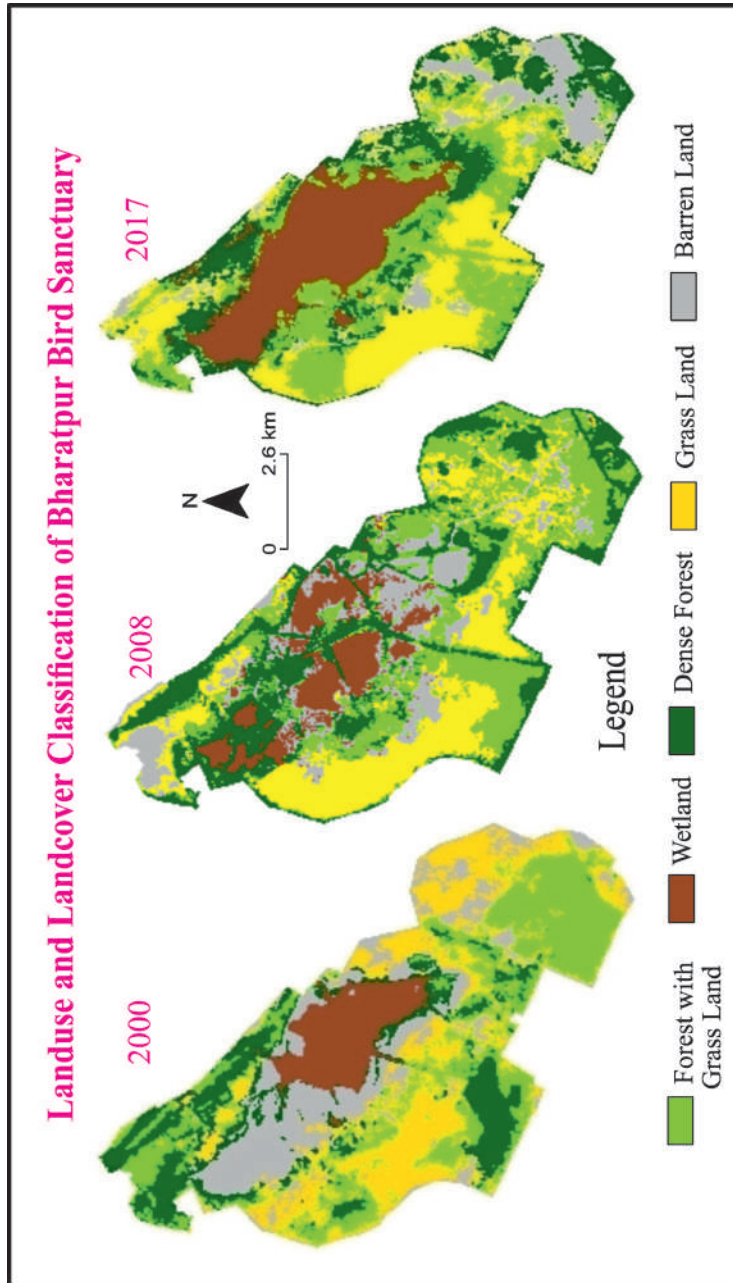


Fig. 2

While the Dense Forest area was first reduced in 2000-2008 but slightly increased in 2008-2017. But overall in 2000-2017, dense forest areas are reduced. Similarly, Grassland increased in 2000-2008 but decreased in 2008-2017 and overall increased in 2000-2017. On the other hand, Forest with grass decreased in 2000-2008 but increased in 2008-2017 and overall, all increased in 2000-2017. Whereas, Barren Land increased in 2000-2008 and 2008-2017.

Conclusion

This study shows land use and land cover changes that have occurred in Bharatpur Bird Sanctuary in the last 17 years and considers as well as relates to different components responsible for the change with the implications on increase in biodiversity loss, and inappropriate land management. The methods developed as an outcome of this study have been employed for their capability to assess the spatial and temporal changes in land use and land cover at a landscape scale and to subsequently determine an effective means to measure landscape stability over large assessment areas such as Sanctuary and its surrounding area. Specifically, Remote Sensing integrated into a GIS environment provides an ability to characterize large assessment areas and establish reference conditions. Generally, the situations of land use and land cover dynamics have a depressing effect on the local scale as well as beyond that because its consequences do not have clear boundaries. There is, therefore, a need for local land use planning and design with conservation practices of the study area. As far as the LULC is concerned, wetland have continuously increased between 2000 to 2017 and other categories under LULC observed a decrease but not very high. An increase in annual rainfall led to an increase in area under grassland but the decrease in forest area will impact the bird's migration due to loss of their habitat.

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WATER QUALITY INDEX- BASED GROUNDWATER APPRAISAL OF JHAJJAR DISTRICT OF HARYANA: A SPATIAL ANALYSIS

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Abstract

A quality index-based study of the groundwater is very important due to its dependency ratio for the drinking water being relatively higher as compared with other sources of drinking water, particularly for the rural areas. The present study is confined to Jhajjar district, where the majority of the groundwater in the rural areas is far from satisfactory. However, the majority of the villages that belonged to five blocks are suffering from the excessive concentration of various salts and minerals, which are quite beyond the permissible limits as prescribed by the WHO/BIS. The study is based on a secondary source of information, groundwater cell Jhajjar. In order to work out the WQI, the collected data of various qualitative parameters have been worked out for the 71 sample villages of the five blocks of the Jhajjar district, which are aimed at making the appraisal of the quality of the groundwater. The findings of the study show that the index-based quality of the groundwater indicates a significant regional disparity in accordance with the prevailing socio-economic and physiographic conditions of the groundwater problematic areas. Water Quality Index' based on 9 different qualitative parameters like (1) pH value (6.5-8.5), (2) Electric-conductivity (1500mg/L max), (3) Alkalinity (200mg/L max), (4) Fluoride (1mg/L max), (5) Chloride (250mg/L max), (6) Sulphate (200mg/L max), (7) Total hardness (300mg/L max), (8) Ca H(200mg/L max), (9) Total Dissolve Solid (TDS) (300-600) etc.

Introduction

The quality index-based study of the groundwater is very significant to measure the qualitative aspects of the drinkable water. In most of the states, particularly the arid and sub-arid states of the country, the majority of the groundwater in the rural areas is far from satisfactory. Water, a prime natural resource and precious national asset, forms the chief constituent of an ecosystem (Gupta, 2022). Water sources may be mainly in the form of rivers, lakes, glaciers, rainwater, groundwater, etc.

Besides the need for water for drinking, water resources play a vital role in various sectors of the economy, such as agriculture, livestock production, forestry, industrial activities, hydropower generation, fisheries, and other creative activities. The availability and quality of water, either surface or ground, have been deteriorated due to some important factors like increasing population, industrialization, urbanization, etc. The water quality of any type source or area can be assessed by applying the qualitative parameters (Tyagi, Sharma, Singh, & Dobbal, 2013). Therefore, the suitability of the drinkable water sources for the inhabitants has been discussed in terms of the Water Quality Index (WQI). The Water Quality Index is one of the most effective measures to work out the quality of the drinkable water. Thus, it was realized that the application of the individual water qualitative parameters to evaluate the qualitative aspects of the groundwater for the people is not so easy to understand. Therefore, the WQI has paved the way for reducing the ample information into a single composite value by expressing the data in a logical and simplified way (Ahmad and Singh, 2023). There are numerous studies on the groundwater relating quality indices that have been applied to make the appraisal of the groundwater quality, which provides their mathematical structure. Sets of the qualitative parameters worked out with their merits and demerits have been applied widely to work out such types of problematic areas of the groundwater in terms of spatio-temporal changes in the depth of the groundwater of the Hisar district of Haryana by applying the 'Inverse Distance Weightage (IDW) interpolation technique in Arc GIS (Rani, Reeta, and Chaudhary B.S. (2016) Earlier, by applying the Water Quality Index (WQI), based on 12 qualitative water quality indexes (WQI) for the groundwater of Tumkur taluk of Karnataka state (Ramakrishnaiah et al., 2008). Subsequently, Aher, K.R., & Salve, P.L. (2020) have examined the groundwater in terms of WQI by making a composite index of the several qualitative parameters in the Aurangabad district of Maharashtra.

The study is based on the Water Quality Index; the study shows a significant regional variability in the good qualitative water in the study area of Aurangabad district of Maharashtra. Further, this study was supported by the authors like Nadikatla & Mushini, S.K., and Subarao (2018), who have evaluated the groundwater quality in terms of the Water Quality Index of the Palakonda Mandal, located in the Shrikakulam district of Andhra Pradesh. Further, the study shows a significant variability in the quality of the groundwater, which indicates a significant deviation in accordance with the BIS standard. Further, the study has justified the multivariate correlation values among various qualitative parameters taken for the study.

Ahmad, S., & Singh, R. (2023) reviewed the growing alarming situation of the groundwater contamination across the country. The study shows that the quality of the groundwater in the Serghati block of the Gaya district of the Bihar state has led to a drinking water problem, particularly in the population segment, which solely depends upon the groundwater. The Water Quality Index (WQI) shows that the groundwater quality was examined. Further, the findings of the study show that there were three sites that have a WQI value over 100, which shows a critical situation of the groundwater that is not suitable for drinking purposes. Further, the study was supported by Gopinath, R. Venkashv, and Govindan (2023), who have examined the groundwater quality through hydrochemical analysis and highlighted its long-term implications for drinking water. Similarly, by applying the Water Quality Index, scholars like Siddiki, N. (2022), who has examined the groundwater quality situation of the groundwater of the Yamuna Nagar district of Haryana, take some of the qualitative parameters. Further, based on WQI, on the groundwater of this study area, the study shows that there is excessive concentration of chloride, TDX, total hardness, fluoride, and magnesium that are beyond the permissible limit of the Bureau of Indian Standard (BIS). Further, the study by the scholars Rao, G., and Kumari, P. (2022) shows that the situation of the groundwater of some of the towns in the coastal areas of Andhra Pradesh is far from satisfactory. However, the WQI-based study shows that there is considerable deviation of the qualitative parameters from the permissible limits, as mentioned in the BIS (Bureau of Indian Standard). All these excessive quantities of these minerals and salts tend to affect human health adversely. Further, this study was supported by Gobindrraju, P. et. al. (2022), who have carried out a study by assessing the groundwater in terms of the Water Quality Index of the Chikmaglure district of the Karnataka state.

Study Region

Jhajjar district in Haryana has been chosen for a groundwater quality study. It is bordered by Rohtak district to the north, the Union Territory of Delhi to the northeast (touching Nazafgarh and Badli), and the Charkhi Dadri district to the east. Its southern border touches Mehendergarh, Rewari, and Gurugram districts. The location of the Jhajjar district of Haryana lies between 28° 22' to 28° 49' North Latitudes and 76° 18' to 76° 59' Eastern longitudes. It covers an area of 1834.2 square kilometers, which shares 3.777% of the total area of the Haryana state (District Handbook of Jhajjar district, 2021). As per the 2011 census, the district had a population of 956,907, with 514,303 males and 442,604 females' inhabitants.

The rural population constituted 74.60 percent of the total population, with a population density of 522 people per square kilometer. Top of Form Jhajjar district boasts a well-developed road network and railway connectivity with other parts of the state, fulfilling a long-standing demand of its residents. However, realizing this potential requires a focus on developing quality water infrastructure for irrigation and drinking purposes. Therefore, prioritizing water management initiatives is essential for addressing groundwater-related issues (District Handbook, 2020). The WQI is one of the significant index that is meant to measure the quality of the water in terms of its physical, biological, and chemical attributes in a single value that ranges from 0 to 100. The index, which includes the selection of parameters; transformation of the raw data into a common scale; providing the weightage in accordance with its importance; and aggregation of the subindex value that has been taken for the study. The Water Quality Index more scientific so that it may provide precise results of each and every quality parameter to measure the quality of the water.

Objectives

- (1) The study is aimed at working out the ‘Water Quality Index’ for the groundwater across the Jhajjar district.
- (2) The study is aimed at showing the regional disparity across the Jhajjar district.

Database and Methodology

The water quality index method classified the water quality in accordance with the degree of purity by using the most commonly measured water variables. The identified villages of the district, which have already been selected by the Central Groundwater Board (CGWB) of India for physiochemical analyses. The CGWB has collected samples from these villages, and various physiochemical parameters have been identified based on their concentration. These parameters are compared to the permissible limits prescribed by the Bureau of Indian Standards (BIS) to determine the Water Quality Index (WQI) of the district.

Thus, working out the WQI is by applying the equation, which is as follows:

$$WQI = \{(Q_i)W_i/W_i\}$$

The quality rating scale (Q_i) for each parameter is calculated by using this expression:

$$Q_i = 100[(V_i - V_o)/(S_i - V_o)]$$

Whereas;

V_i is estimated concentration of i th parameter in the analyzed water

V_o is the ideal value of this parameter in pure water

$V_o = 0$ (except pH=7.0 and DO=14.6mg/l)

S_i is recommended standard value of i th parameter

The unit weight (W_i) for each 'water quality parameter' is worked out by applying the formula; as follows:

$$W_i = K/S_i$$

Whereas;

K = is constant and worked out as follows:

$$K = 1/i/S$$

The Rating Process of the Water Quality in Accordance with the WQI

The water quality rating is in accordance with the weight-arithmetic Water Quality Index Method. The ranges of the Water Quality Index are formed in accordance with different grading hierarchies of the quality of the groundwater is based on WQI, Water Quality Index, which is a composite form; it represents a composite picture of worked-out values of different qualitative parameters like (1) pH value (6.5-8.5), (2) electric conductivity (1500 mg/L max), (3) alkalinity (200 mg/L max), (4) fluoride (1 mg/L max), (5) chloride (250 mg/L max), (6) sulfate (200 mg/L max), (7) total hardness (300 mg/L max), (8) Ca H (200 mg/L max), (9) total dissolve solid (TDS) (300-600), etc.

Results and Discussion

Block-wise Distribution of WQI of Jhajjar District

According to Table-1, which shows the quality of the groundwater based on WQI, it divides the groundwater into five categories with their specific range of intensity. However, the first quality of the groundwater is excellent, with < 50 WQI, followed by good quality, which ranges within 50.1-100. The 3rd groundwater category of the poor quality ranges from 100.1 to 200 WQI. The very poor range is within 200.1 to 300; it's WQI. Lastly, <300.1 and above WQI, which shows that the groundwater is not fit for drinking purposes. Based on WQI, the block-wise distribution is worked out (Table-1).

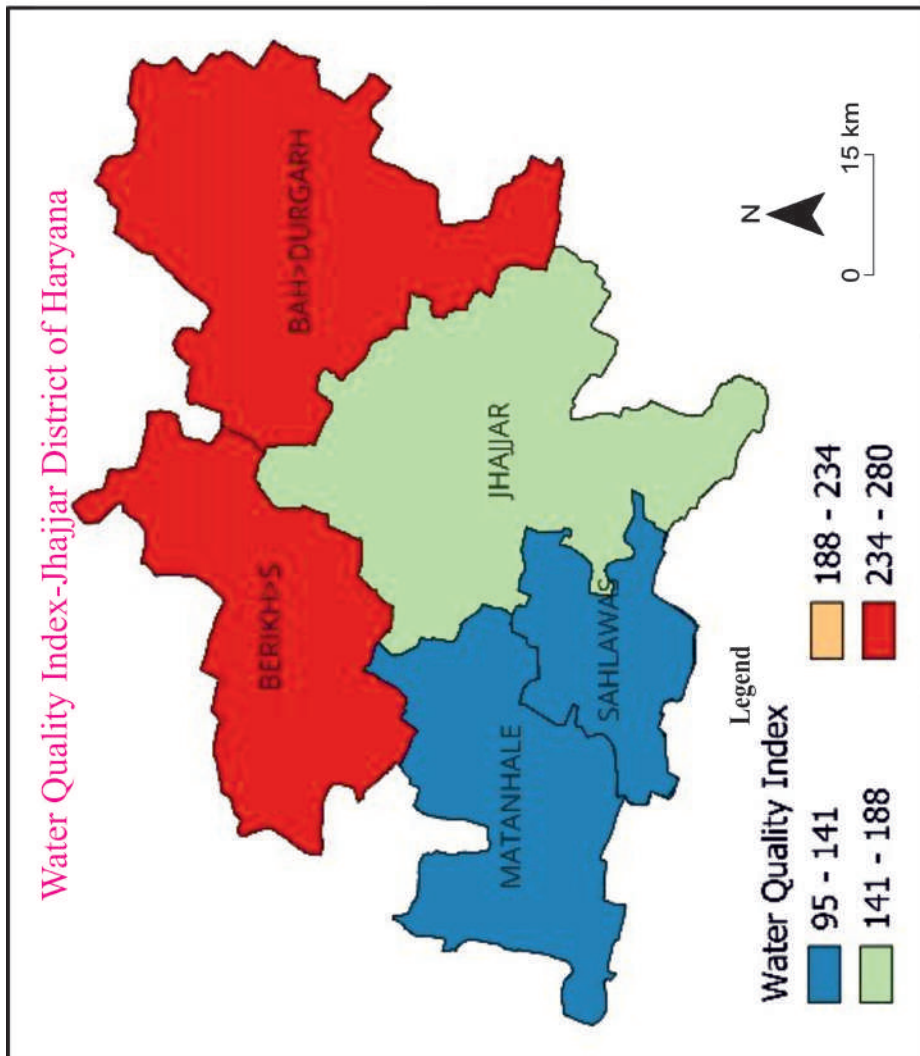


Fig. 1

Table-1: Village/ Blockwise Distribution of WQI of Jhajjar District, Haryana, 2020-21

Sr. No	Jhajjar	Bahadurgarh	Beri	Matanhail	Sahlawas
1	12.83	60.58	40.18	52.55	103.29
2	44.12	125.94	221.08	333.32	62.11
3	241.07	351.12	341.75	142.65	100.71
4	342.37	141.36	410.19	142.25	95.13
5	63.91	256.97	392.67	449.09	95.26
6	148.35	119.61	91.65	60.66	89.16
7	112.25	348.35	178.40	95.82	78.65
8	93.70	361.36	191.52	84.90	100.87
9	192.34	97.12	454.06	88.92	98.02
10	342.92	396.25	256.06	79.99	102.32
11	189.52	712.72	164.74	103.55	92.27
12	89.03	165.77	111.58	86.06	129.85
13	79.51	502.35	126.22	86.10	93.07
14	--	277.84	984.60	--	--
15	--	199.75	333.99	--	--
16	--	188.87	379.57	--	--
Average value of WQI	150.15	256.89	279.89	127.94	95.44

Source: Computed by Researcher

Keeping in view the block-wise average value of the Water Quality Index and the scale of the groundwater quality index is shown.

Table-2: Block-wise Distribution of WQI Based Quality of Groundwater of Jhajjar, Haryana, 2020-21

Sr. No	WQI Range	Type of Water	No of Block	Name of block & Average value of WQI
1	< 50	Excellent	Nil	Nil
2	50.1 -100	Good	1	Sahlawas (95.44)

Contd...

3	100.1 -200	Poor	2	Jhajjar (150.15) and Matanhail (127.94)
4	200.1 – 300	Very poor	2	Bahadurgarh(256.89) and Beri (279.89)
5	<300.1 & above	Unfit for drinking water	Nil	Nil

Source: Computed by Researcher

Keeping in view the block-wise re-distribution of the Jhajjar district, it is quite clear from the worked-out figures of all the five blocks, which shows that the excellent category groundwater is found in none of the blocks. It is, therefore, clear that there is only one block, which is Sahlawas, which has good-quality groundwater within <50 WQI. The villages belonged to Sahlawas, which is the least industrialized block and also the least chemically derived agricultural inputs, which are practiced by the farmers. In case of poor quality of groundwater, with 50.1 to 100 WQI, which shows that there are two villages that belonged to, namely Jhajjar block, indicates poor level of groundwater quality. Lastly, the very poor category; within the range 200.1-300 WQI indicated by the two blocks, Bahadurgarh and the Beri blocks. The block-wise distribution of groundwater quality, based on WQI, is shown in Fig. 1.

All these affecting factors have led to the groundwater being in very poor condition, which adversely affects the agriculture and the human health of the inhabitants of the villages, which belonged to these blocks. Lastly, the worked-out value of the WQI of the blocks shows that there is none of the village that has the groundwater, which is characterized by the groundwater that is not fit for drinking purposes. Hence, it is obvious that the study shows that the majority of the groundwater of the villages that belonged to Jhajjar district is characterized by poor and very poor types of groundwater, which is a matter of serious thinking. It is therefore imperative to have a periodic review of the groundwater policy and its implementations in accordance with prevailing local conditions so that every inhabitant of the Jhajjar district may get poor drinking water within their residential areas.

Conclusion

A quality index-based study on the groundwater is a very significant study. It is because the dependency of the rural population for the drinking water is higher

as compared with other sources of drinking water. The present study is confined to the Jhajjar district, where the majority of the groundwater in the rural areas is far from satisfactory. However, the majority of the rural population of the five blocks of the Jhajjar is one of the most problematic districts of Haryana, where there is limited access to the fresh drinking water, particularly the groundwater. It is due to excessive concentrations of various salts and minerals, which are quite beyond the permissible limits as prescribed by the WHO/Bureau of Indian Standard (BIS). This study is based on a secondary source of information made available by the groundwater cell, Jhajjar. In order to work out the WQI, which was quantified by collecting the data of various qualitative parameters, we have worked out the 71 sample villages, which belonged to five blocks of the Jhajjar district. The study is aimed at making an appraisal of the quality of the groundwater. The findings of the study show that the index-based quality of the groundwater indicates a considerable regional disparity in accordance with prevailing socioeconomic and physiographic conditions. Though the majority of the water supply is regulated by the public health department of the state government.

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Reports

Groundwater Cell report of Jhajjar district, 2021

Manual of Bureau of Indian Standard, 2021 (BIS)

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ANALYSIS OF THE IMPACT OF LAND USE/LAND COVER CHANGE ON LAND SURFACE TEMPERATURE WITH GEOSPATIAL TECHNIQUES IN BARA TEHSIL, PRAYAGRAJ DISTRICT, UTTAR PRADESH

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Abstract

The main objective of this paper is to find out the changes which have taken place in land use/Land cover pattern and its effect on land surface temperature in study area. Due to various social, economic and physical factors Land use/ Land cover changed over the year in the study area Bara Tehsil. Remote Sensing and GIS technique is used for the study of LULC pattern and LST. This Geospatial technique is very useful in generating data on natural resources like - land, forest and also helps in decision making for proper planning. Satellite data of Landsat 7 ETM+ (2001) and Landsat 8 (2021) has been used for the land use land cover (LULC) and LST calculation. Land use/land cover and LST dynamics were analyzed in between year of 2001 to 2021. Arc GIS 10.8 software has been used for Satellite image processing. In Arc GIS software ISO clustered unsupervised classification was used for making LULC classes. Land surface temperature has been calculated by processing of thermal bands. The land use land cover analysis reveals that the area under built-up and water bodies are increasing and area under cropland and wasteland is decreasing. There has been a decrease in waste land, which is a good sign. Cropland has been decreased due to increasing use of land in non-agricultural work. Likewise, the land surface temperature calculation showed increased temperature for all classes from 2001 to 2021. Maximum temperature has been observed in builtup land area and minimum in waterbodies.

Introduction

Land surface temperature may be defined as the temperature of any location felt when touching the land surface. From a satellite's point of view, the "surface" is whatever it sees through the atmosphere to the ground. It could be ice, grass, builtup land, cropland, barren land, waterbodies and hilly areas etc. Thus, land surface temperature is not the same as the air temperature that is included in the

daily weather report (NEO). Due to various social, economic and physical factors Land use/ Land cover changes over the year. This also influences LST of that area. Due to Change in LST value, the local climate of the area also changes. Increase in LST also affects the climatic condition of that area leading to unpredictable rainfall. This will definitely affect the vegetation of that area too. It means there is definitely a correlation between land use pattern and land surface temperature. LST is influenced by land surface characteristics, type of land use-land cover, and surface imperviousness (Khandelwal et al., 2018). The environmental changes due to LULC and LST dynamics can be traced easily using Geospatial techniques, which reduces the human effort in calculations (Akyürek et al., 2018). So LST is an important phenomenon to be investigated. Nowadays it is very easy to calculate LST for any particular area with the help of Geospatial techniques. Therefore, many researchers have estimated LST using various algorithms and techniques. The modern Geo-spatial technique of Remote Sensing (RS) coupled with Geographic Information System (GIS) is very useful in monitoring natural resources and environmental changes and also helps to analyze the information of other environment variables (Marble et al. 1983). At present, Remote sensing technology is being used by various scholars and geographers to study land use change and land surface temperature. Evapo-transpiration also controls the surface temperature through reducing of incoming energy in latent and sensible heat (Stisen, 2007). Kumar, M., Tripathi, D. K., et.al. (2017) analyzed Impact of urbanisation on land surface temperature in Nagpur, Maharashtra using geospatial technique. Khan, F., Das, B et.al. (2021) analyzed land use land cover changes with land surface temperature using supervised classification for LULC and Sobrino, 2004 LST calculation process for Nagpur city, Maharashtra. A., Rajeshwari, N. D. Mani (2014) estimated land surface temperature of Dindigul district using split window algorithm. Hussain, A., Bhalla, P. et al. (2014) analyzed role of the land use/land cover in surface temperature changes in Ajmer District, Rajasthan. Joshi, Janak P., and Bindu Bhatt (2012) estimated temporal land surface temperature using remote sensing of Vadodara urban area, Gujarat. The remote sensing technique due to its extensive view, multi-resolution, multi-spectral and frequent monitoring capabilities make its very useful for analyzing land surface temperature and their dynamics for any particular areas.

Study Region

Prayagraj is divided into 7 tehsils (Soraon, Phulpur, Handia, Meja, Karchana, Koraon, Bara) and one urban area Sadar. Study area Bara tehsil has two development

blocks- Jasra and Shankargarh. Jasra block covers 36.4% of the tehsil area and Shankargarh block covers the remaining area. The total area of Bara tehsil is 744 km², out of which 735.852 km is rural area and the remaining 8.36 km² is urban area. There are about 325 villages in Bara tehsil, out of which 114 villages are located in Jasra block and 211 villages in Shankargarh block. Bara tehsil is located in the transition zone between Yamuna and Tons rivers in the southwest of Prayagraj district. The latitudinal extension of Bara tehsil is between 25° 2' 30" to 25° 22' 30" north latitude and longitudinal extension is between 81° 31' to 81° 50' east latitude and its area is about 744 km². The length of the study area is 33.82 km from east to west and width is 33.77 km from north to south. Bara tehsil is connected to Prayagraj city in the north, Karchana tehsil in the east, Meja and Koraon tehsils in the south-east. Rewa region of Madhya Pradesh state is situated to the south of Bara tehsil, Chitrakoot in the south-west and Kaushambi district in the west. According to Census 2011, the total population of Bara tehsil is 365605, out of which 192517 are males and 173088 are females. There is a lot of disparity in the rock structure in Bara tehsil.

Objectives

- (1) To determine LULC pattern and changes in the study area.
- (2) To generate LST from thermal bands of satellite imageries for 2001 and 2021.
- (3) To find out the relationship between LULC and LST in the study area Bara Tehsil.

Data Sources and Methodology

Landsat 7 ETM+ (Enhanced Thematic Mapper Plus) data (Band 6; Resolution-30m), Date: 12 April, 2001, path 143, row 043 and Landsat 8 data (Band- 10,5,4 ; Resolution-30m), Date: 16 April, 2021, path 143, row 043 have been used for Land Surface Temperature calculation of year 2001, 2021. The satellite data covering study area were obtained from USGS Earth Explorer. As reference and base map preparation, Survey of India topographical sheets on 1:50000 scale numbered G44P11, G44P12, G44P15 and G44P16 were used. These data sets were imported in Arc GIS 10.8 software for Satellite image processing to create Land surface temperature map. Land surface temperature dynamics were analyzed in between year of 2001 to 2021. Land use/Land cover map of year 2001 and 2021 has been created in Arc GIS software using ISO clustered unsupervised classification method.

LST Calculation

Satellite Imagery extracted from USGS Earth Explorer of the study area is then used for the determination of LST. The LST map is generated using thermal band 6 for Landsat 7 and band 10, 5, 4 for Landsat 8.

Landsat 7 LST Measurement

The first step is to convert DN value to Radiance using formulae given below –

$$L\lambda = (LMAX\lambda - LMIN\lambda / QCALMAX - QCALMIN) * (QCAL - QCALMIN) + LMIN\lambda$$

Where,

$L\lambda$ = Spectral radiance, QCAL= Quantized calibrated pixel value in DN

LMAX λ = Spectral radiance scaled to QCALMAX in (Watts/ (m² *sr * μ m))

LMIN λ = Spectral radiance scaled to QCALMIN in (Watts/ (m² *sr * μ m))

QCALMIN=Minimum Quantized calibrated pixel value in DN

QCALMAX= Maximum Quantized calibrated pixel value in DN

Now we derive atmospheric brightness temperature from radiance –

$BT = K_2 / \ln(K_1 / L\lambda + 1)$, where T is the atmospheric brightness temperature in Kelvin

K_2 = Calibration constant 2, K_1 = Calibration constant 1

Now converted Degree Kelvin into Degree Celsius –

$$C = K - 273.15$$

Landsat 8 LST Measurement

The first step is to convert DN value to Radiance using formulae given below

$$L\lambda = ML * Qcal + AL - Oi$$

Where $L\lambda$ is spectral radiance in Watts/ (m² *sr * μ m), ML is the radiance multiplicative scaling factor for the band, Qcal is the level 1 pixel value in DN, and AL is an additive scaling factor for a band. Oi is the Correction value for Landsat 8 TIRS band 10. The Oi value is 0.29 which is used in the study for calibration of Landsat image band 10 (USGS, 2017). Then, atmospheric brightness temperature is calculated from radiance –

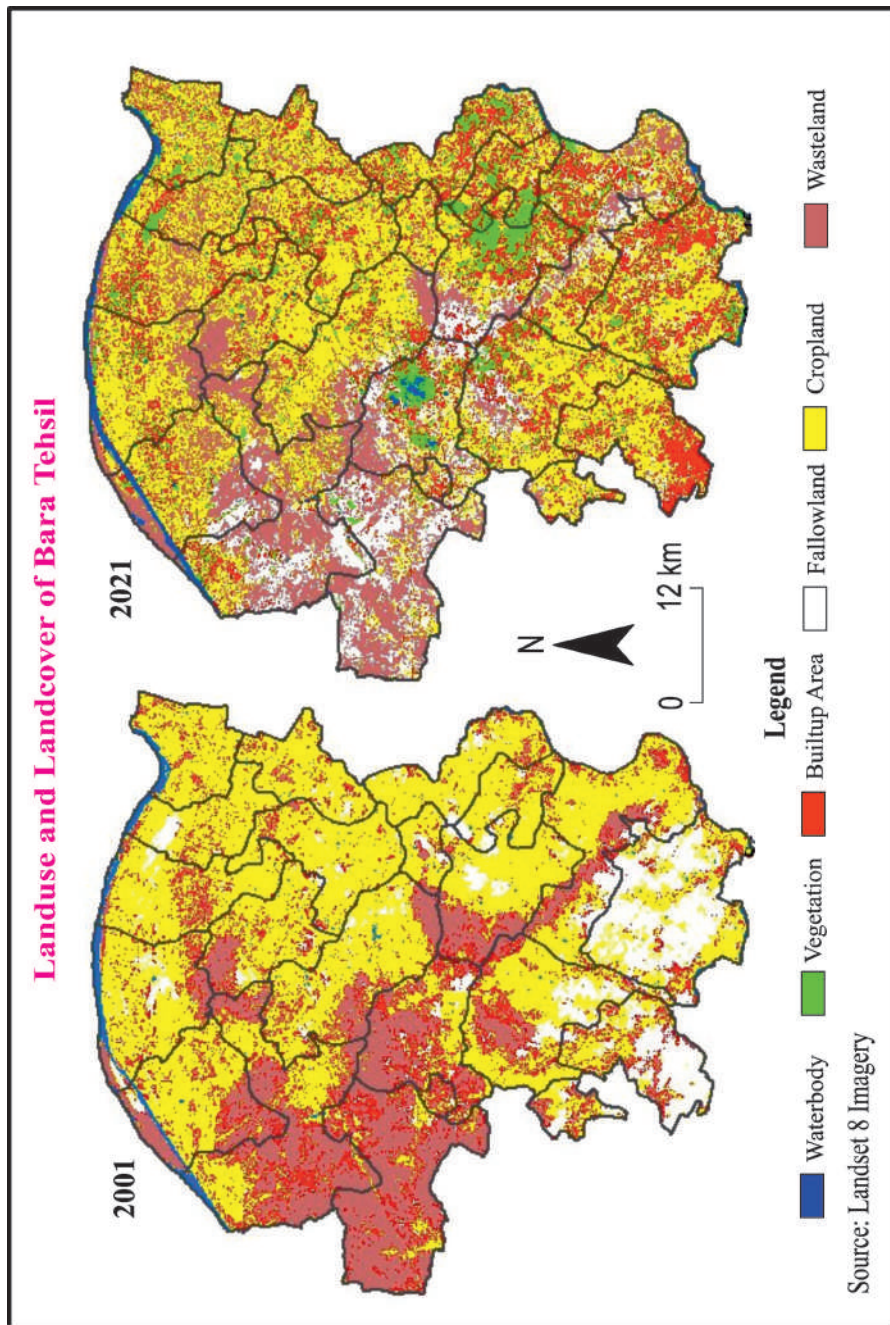


Fig. 1

$$BT \text{ (in } ^\circ\text{C)} = K_2 / \text{Ln} (K_1 / L\lambda + 1) - 273.15$$

The next step in calculating LST requires the calculation of normalised difference vegetation index (NDVI) –

$$NDVI = (\text{Band 5} - \text{Band 4}) / (\text{Band 5} + \text{Band 4})$$

Next the proportion of vegetation (PV) is calculated using the values obtained from NDVI calculation, maximum and minimum NDVI is used to calculate PV using below equation-

$$PV = ((NDVI - NDVI_{min}) / (NDVI_{max} - NDVI_{min}))^2$$

The Land surface emissivity (E) is calculated based on the value of PV using below equation, where the value of m is taken as 0.004 and n value as 0.986 (Sobrino et al., 2004)-

$$E = mPv + n$$

From all of the above calculation LST is calculated using below equation, where λ (wavelength of emitted radiance) is 10.8 μ m for Band 10 and $c_2 = h * c / s = 14388 \mu\text{mk}$ –

$$LST = (BT / (1 + (\lambda * BT / c_2) * \text{Ln}(E)))$$

Results and Discussion

Landuse /Landcover Analysis

From the analysis of different Landsat imageries, the land use/land cover classification is performed. LULC class mainly divided in four categories (1) Waterbodies (2) Cropland, Vegetation (3) Fallow land, Wasteland (4) Built-up area.

The LULC images are shown in Fig. 2. Area under different LULC classes and changes is shown in Table-1.

Table-1: Changes in LULC Classes of Bara Tehsil (2001 to 2021)

LULC Class	Area, Year 2001		Area, Year 2021		Change in Area	
	In hectare	In percentage	In hectare	In percentage	In hectare	In percentage
Waterbody	1319	1.80	1453	1.95	134	0.15
Cropland, Vegetation	38395	52.43	37370	50.27	-1025	-2.16

Contd...

Fallow land, Wasteland	22701	31	20969	28.20	-1732	-2.8
Builtup Area	10806	14.75	14542	19.56	3736	4.81
Total	73221	100	74334	100		

Source: Authors

LST Analysis

The characteristics of the thermal signature for each LULC class has been analyzed to understand the transition impact of LULC on radiant surface temperature. The LST map of Bara Tehsil Year 2001 and 2021 is shown in Fig. 2 with different classes of the land surface temperature. The mean temperature change has been calculated for different LULC classes shown in Table 2.

Table-2: Changes in Mean LST, Year 2001 to 2021

LULC Class	Mean LST(in 0C)		Change in Temperature
	Year 2001	Year 2021	
Water	30.5	32.10	+1.6
Fallow land, Wasteland	42.55	43.58	+1.03
Cropland, Vegetation	40.1	41.5	+1.4
Builtup Area	43.8	45.5	+1.7

Discussion

Landuse Landcover

Analysis shows that In Bara tehsil, waterbody of the total reported area was 1319 hectares (1.80%) in the year 2001, which increased to 1453 hectares (1.95%) in the year 2021, means there has been an increase of 0.15 percent in the waterbody of Bara tehsil. Builtup area of the total reported area was 10806 hectares (14.75%) in the year 2001, which increased to 14542 hectares (19.56%) in the year 2021, means there has been an increase of 4.81 percent in the builtup land .Fallow land of the total reported area was 22701 hectares (31%) in the year 2001, which decreased to 20969 hectares (28.20%) in the year 2021, means there has been a decrease of -2.8 percent in the fallow land which is a good sign for future (Fig. 1). Cropland is a major part in LULC which cover 38395 hectares (52.43%) of the total reported area in the year 2001, which decreased to 37370 hectares (50.27%) in the year 2021, means there has been decrease of about -2.16 percent in the cropland of Bara tehsil.

LST

The LST shows the waste land and built-up land both have the highest temperature in the study area, barren has 42.55 °C in 2001, and 43.58 °C in 2021, the built-up area shows a temperature of 43.80°C in 2001 and 45.5 °C in 2021. Analysis shows that both these classes of land use contribute to the rising temperature in study area Bara Tehsil. It means that by replacing natural vegetation with non-evaporating, non-transpiring surfaces like stone, metal, and concrete, urban construction increases surface radiant temperature (Forsake et al., 2019; Yuan & Bauer, 2007) (Fig. 2). The temperature for cropland area is 40.1°C in 2001 and 41.5°C in 2021. The lowest surface temperature is observed for the water bodies, which is 30.5°C in 2001 and 32.10 °C in 2021. The change in LST from the year 2001 to 2021, wasteland's temperature is increased by 1.03°C, for built-up/urban it is increased by 1.7°C, for the cropland covered area it is increased by 1.4°C, and for water bodies, the surface temperature is increased by 1.6°C. Builtup land area have a major role in increasing land surface temperature in study area. LST of built-up area is having max and min. temperature is 33.1°C and 46°C respectively, in the year 2001, while the max and min. temperature increases to 34.3°C to 48.9°C respectively, in the year 2021 which is noticeable. From the above analysis we can say that due to increment in built up land, land surface temperature also increases.

Conclusion

The present paper provides a comprehensive view of changing land use pattern and its effect on LST in Bara Tehsil using Remote Sensing and GIS technique. The objective of the study is to determine qualitative and quantitative results for LULC and LST. The study is performed for a period of twenty years, from 2001 to 2021. The study shows that the rapid changes in land use affects the temperature, which is a critical issue. Cropland decreased 2.16 percent and builtup land has increased 4.81 percent in last 20 years and the main reason is increasing of population, settlements, urbanization, construction of new roads, railways etc.. Due to population pressure and urbanization, land used in non-agricultural work is increasing day by day and due to increment in built up land, land surface temperature is also increasing. The study suggests that there is a need of proper land use planning so that we can prohibit the land change issue in the study area. There is a need of sustainable land use planning so that resources and environment are protected for the present generation as well as for future generations.

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DEVELOPMENT AND FUTURE PROSPECTS OF ADVENTURE TOURISM IN PITHORAGARH DISTRICT

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Abstract

Adventure tourism is a growing component of the worldwide tourist business that combines thrills with nature. Pithoragarh, a district in Uttarakhand, India, is known for its diversified terrain, making it suitable for hiking, paragliding, river rafting, and climbing. Tourism is a major revenue generator for many nations. The 1980 Manila Declaration on World Tourism called it "important to countries because of its direct repercussions on social, cultural, educational, and economic sectors and international relations. International tourism affects a country's balance of payments both in and out. The current research examines tourism in Pithoragarh and finds potential for expansion. Study area has natural beauty, adventure sites, various tourist aspects, historical and tribal culture perspective, renowned spiritual places, and more. Their tourist potential is enormous, yet their tourism location is undeveloped and unconnected by road, communication, etc.

Introduction

Adventure tourism is a growing worldwide industry that combines physical, cultural, and natural activities. Adventure tourism is tourism to unknown, uncharted, or unexplored, unfamiliar, exotic, and possibly even dangerous territories where tourists seek thrills and excitement through an engagement with the natural environment and the physical challenges of travelling to get there. It didn't take thousands of people this year to climb skyscraper-high mountains, ride white-water rivers in inflatable rafts, hike across vast wilderness and SCUBA-dive in coral gardens and 'black waters' of limestone grottoes and caves. One hundred and eighty-three individuals climbed Mount Everest in 2001. This was the biggest number of successful climbs in a year, reaching 1,114. Adventure Tourism links all of the aforementioned activities and participants (Tiwari, 2021). India has many natural P and ecotourism resources, giving it a good geography index. From India's searing heights to its thick woods, a transformation driven by adventure and

discovery is underway. Adventure tourism is a growing trend that attracts travellers worldwide (Pathania, 2022). Adventure tourism involves visiting or participating in adventurous activities in new places. Mountain climbing, hiking, skiing, white-water rafting, bungee jumping, zip-lining, and other adventure tourist activities are included (Buckley, 2012). It spices up the traditional idea of travel by encouraging individuals to try something new. It seeks pleasures and self-realization (Melkani, 2021). Because people want to experience nature and culture rather than just view it, this category is expected to develop globally. The worldwide adventure tourism industry will grow over 10% to USD 882 billion by 2028 (Patar, 2016). India's diversified landscapes, from the Himalayas to the Western Ghats and Thar Desert, position it to capitalise on this trend (McKay, 2013).

Study Region

Pithoragarh district in Uttarakhand, India, is strategically located near Nepal and Tibet, offering potential for adventure tourism. The district, spanning 7,100 square kilometers, is surrounded by high altitude mountain ranges, rivers, and glaciers, making it suitable for various activities like trekking, mountaineering, paragliding, river rafting, and camping. The district is also close to religious and cultural heritage sites, such as the Kailash Mansarovar Yatra, which attracts pilgrims. However, the district faces challenges in developing adventure tourism, including limited connectivity, poor road conditions, and inadequate tourism infrastructure. The district government is working to develop infrastructure, promote eco-friendly tourism, and unlock the true potential of Pithoragarh as a major adventure tourism destination. Despite its limited development, Pithoragarh's unique nature and history make it a relevant area for further tourism development.

Study Area: Pithoragarh District

In Uttarakhand, India, Pithoragarh district hosted the research. The region is becoming an adventure tourism destination in India due to its gorgeous landscapes, difficult geography, and tourist attractions including hiking, paragliding, and river rafting. The research focused on large-scale adventure activities in key tourist locations.

Objectives

- (1) To assess the current state of adventure tourism in Pithoragarh district.
- (2) To the study of development and future of adventure tourism in Pithoragarh district.

- (3) To the study of growth and challenges of adventure tourism.
- (4) To explore the future prospects for adventure tourism in Pithoragarh and propose strategies for its sustainable development.

Database and Methodology

Adventure tourism in Pithoragarh is examined using a descriptive research approach to evaluate its existing state, potential, and significant challenges. Data was collected and analysed using qualitative and quantitative methodologies. The purposively chosen key informants were interviewed for qualitative data, while tour operators, other visitors, and local inhabitants provided quantitative data. The research uses primary and secondary data to acquire topic-related information. Primary data was collected from travellers, schoolchildren, tourism stakeholders, hotels, tour operators, and government officials using questionnaires and semi-structured interviews. Survey objectives were, namely, Tourist demographics, preferences, and satisfaction levels, Perceptions of local residents regarding tourism development, Challenges faced by adventure tour operators and Government initiatives in promoting adventure tourism. The Secondary data was collected from various sources, including: Tourism department reports, Government publications and statistics, previous research papers and case studies, Websites and promotional materials of adventure tourism operators in the region. Out of 200 responders, 120 are tourists, 50 are locals, and 30 are tour providers. Additionally, 10 local government and tourist representatives were given scripted questions and volleys. This was done using purposive and convenience sampling. Key informants including tour operators and government officials were identified via purposeful sampling, whereas visitors and locals were sampled using convenience sampling because the researchers had easy access to them. We analysed the data using qualitative and quantitative methods. The survey answers were statistically analysed using frequency distribution, percentage analysis, and cross tabulation. This helped identify trends, client preferences, and visitor satisfaction. Transcribed interviews and topics were analysed to assess Pithoragarh adventure tourism potential and policy concerns.

Result and Discussion

Analysis of Adventure Tourism Potential

Indian adventure tourism has profited from its geographical variety, cultural richness, and climate. Uttarakhand, especially Pithoragarh, is one of India's best adventure tourism destinations. The last tehsil of Kumaon, Pithoragarh, has a stunning mountain charm that can only be compared to the crowded Himalayas,

forests and valleys of Kumaon hills, and deep crystal-clear rivers, making it a paradise for trekking, paragliding, mountaineering, river rafting, and more. Southeast Asia's adventure tourism potential has yet to be fully realised owing to its unique location. A geological, ecological, cultural, and economic study of Pithoragarh and its adventure tourism potential. Consider the present opportunities and dangers to better understand how adventure tourism may grow and be promoted in the area.

Geographical and Natural Features

Adventure tourism in Pithoragarh is explained by many geographical factors. One of the most picturesque places, the area is renowned as 'Mini Kashmir' for its snowy mountains, meadows, and other scenes. Its proximity to Nepal and Tibet makes it an ideal tourist destination in Uttarakhand. The height ranges from 1,514m to over 6,000m, providing varied terrains for adventure activities.

- **Trekking and Mountaineering:** Pithoragarh offers numerous famous treks, including Milam Glacier Trek, Darma Valley Trek, and Kailash Mansarovar Yatra route, with famous peaks like Panchachuli, Nanda Devi, and Nanda Kot, making it a prestigious site for trekking and mountaineering tourism.
- **Paragliding and Adventure Air Sports:** Pithoragarh, a popular tourist destination with long valleys and ridge systems, offers an ideal environment for adventurous flying sports, with alternative wind conditions and a relatively cloudless climate, making it a potential top paragliding center like Bir-Billing in Himachal Pradesh.
- **River Rafting and Kayaking:** Pithoragarh, a city in India, is attracting a growing number of tourists for its white-water rafting and kayaking activities. Major rivers like Kali, Saryu, and Gori offer thrilling experiences, while the Kali River, running along Nepal's border, presents potential for cross-border river rafting tourism.
- **Rock Climbing and Bouldering:** The district's cliffs and rocky outcrops offer opportunities for rock climbing and bouldering, suitable for adventure tourists. With proper training infrastructure and certified programs, it could attract novice rock climbers.

Ecological and Environmental Factors

Pithoragarh is located in the Kumaon division of the state of Uttarakhand which is rich in bio diversity and has very conducive environment. It is blessed with comparable ranges of forest land and alpine pastures and flora and fauna, including

quite a few endangered species. Ecotourism and feasible sustainable adventure tourism practices can take advantage of this endowment while at the same time maintaining the beauty of this region and the surrounding ecosystem.

- **Biodiversity Hotspots:** Eco-tourism, a conservation approach, can be implemented in protected areas like Askot Wildlife Sanctuary, promoting wildlife treks and nature photography. However, challenges and risks need to be addressed for environmental preservation.
- **Environmental Concerns and Sustainability:** The advancement of adventure tourism in Pithoragarh faces environmental concerns, potentially leading to habitat degradation, pollution, and increased carbon footprints. Sustainable tourism practices should include eco-friendly facilities, reduced plastic use, restricted trekking groups, and waste management. Campaigns should inform tourists and locals to preserve ecosystems.

Socio-Cultural Considerations

Cultural tourism forms an important part of Pithoragarh's profile and enhances the flavor of adventure tourism. The region is inhabited by several ethnic groups of people who includes; the bhotiya tribes that add more spice to the tourists as they show them round their cultural practices. Culture-based activities that could complement adventure tourism include, accommodation with host families, tourism related to cultural events and fairs, food tourism. It also diversifies the range of tourist attractions while guaranteeing that the people of a particular destination reap the monetary rewards of the industry.

- **Homestays and Community-Based Tourism:** Community-based tourism in Uttarakhand can increase adventure tourism without compromising socio-economic welfare by encouraging homestays and guided tours by local indigenous people. This model has been successful in Sarmoli village, providing accommodations for nature enthusiasts.
- **Cultural Festivals and Adventure Tourism:** Pithoragarh's local festivals like Harella and Kumaon Holi can be integrated into adventure tourism plans, providing cultural experiences during high tourist periods, extending stay, and benefiting artisans and business ventures.

Economic Opportunities

The emergence of adventure tourism in Pithoragarh is one of the best chances to boost the region's economy. Adventure tourism is specialised tourism; earning high

revenues at relatively low numbers of arrivals thus is a sustainable form of tourism. Thirdly, adventure tourism mostly targets those tourists who are willing to spend more money hence acting as an extra bonus to the economies of the affected nations.

- **Employment Generation:** Adventure tourism provides employment opportunities for locals and related areas, including tour guides, hospitality staff, and transport service providers. Skill development in mountaineering, paragliding, and survival courses empowers youth and creates specialized forces.
- **Local Entrepreneurship:** Adventure tourism can boost entrepreneurship in the region by creating a favorable environment for renting equipment, organic food, and handicrafts industries. Government subsidies or microcredits can encourage local businesses, making the area economically sustainable and preventing job migration.

Infrastructure Development

Pithoragarh has a large scope for adventure tourism but the present facilities are constrained to accommodate mass tourism. There is lots of room to improve the roads that connects remote areas/regions, accommodations, and medical facilities to cater for adrenalin seeking tourists. Several talks have been made regarding the enhancement of transportation facilities to this region particularly from Dehradun and Delhi shall ensure the attraction of both local and foreign tourists.

- **Road and Transport Connectivity:** The region faces challenges in transportation due to its physical characteristics, especially during rainy seasons. Improvements in road construction, maintenance, and aerial transport, along with improved signs and safety measures, could boost adventure tourism.
- **Medical and Emergency Services:** Adventurous tourism in Pithoragarh faces risks due to inadequate health facilities, including hospitals and ambulance services, necessitating the development of emergency healthcare and rescue services.

Pithoragarh holds significant potential for adventure tourism and ecotourism due to its natural, cultural, and ecological endowments. However, infrastructure support, ecotourism initiatives, and local participation are needed for its potential to become a leading destination.

Tourist Preferences, Satisfaction Levels

This section showcases the findings of the collect primary data of questionnaires that were distributed and administered to the tourists who visited the Pithoragarh

district to visit the adventure tourism related destinations. Primary data was used in the study and this was obtained through structured questionnaires administered on the respondents who were selected randomly. The target population for this study was all the 200 tourists that were whether domestic or international tourists. The main concerns involved the Likelihood of the tourists, the level of satisfaction and possible areas of discontent. The next sections give a breakdown of the data as discussed in this study.

- **Tourist Preferences:** Pithoragarh district is popular for adventure tourism, with activities like trekking, paragliding, rock climbing, river rafting, and camping being preferred. The mountains' natural environment and physically demanding tracks are preferred by 45% of respondents. Leisure tourism activities like paragliding and rock climbing receive 30% and 15% of tourists, respectively. 58% prefer high-risk, high-reward adventures, while 42% prefer low-risk activities.
- **Tourist Satisfaction Levels:** Tourist satisfaction in Pithoragarh is moderate to high, with 35 out of 50 respondents rating it 4 or 5 out of 5. However, 30% reported dissatisfaction due to infrastructure and access issues.

Table 1: A Breakdown of Satisfaction Levels Across Key Parameters

Parameter	Very Satisfied (5)	Satisfied (4)	Neutral (3)	Dissatisfied (2)	Very Dissatisfied (1)
Infrastructure	10%	30%	40%	15%	5%
Safety Measures	25%	35%	25%	10%	5%
Cost-Effectiveness	20%	40%	20%	15%	5%
Environmental Conservation	35%	30%	25%	5%	5%
Overall Experience	40%	30%	20%	7%	3%

The survey revealed that 40% of respondents were satisfied with the infrastructure in Pithoragarh, with 20% expressing dissatisfaction. Issues raised included poor roads, lack of signage, and poor amenities at base camps (Table-1 and Fig. 1). While 60% of tourists were satisfied with the safety and unpredictable nature of adventure tourism, 15% suggested improvements in supervisors and emergency measures.

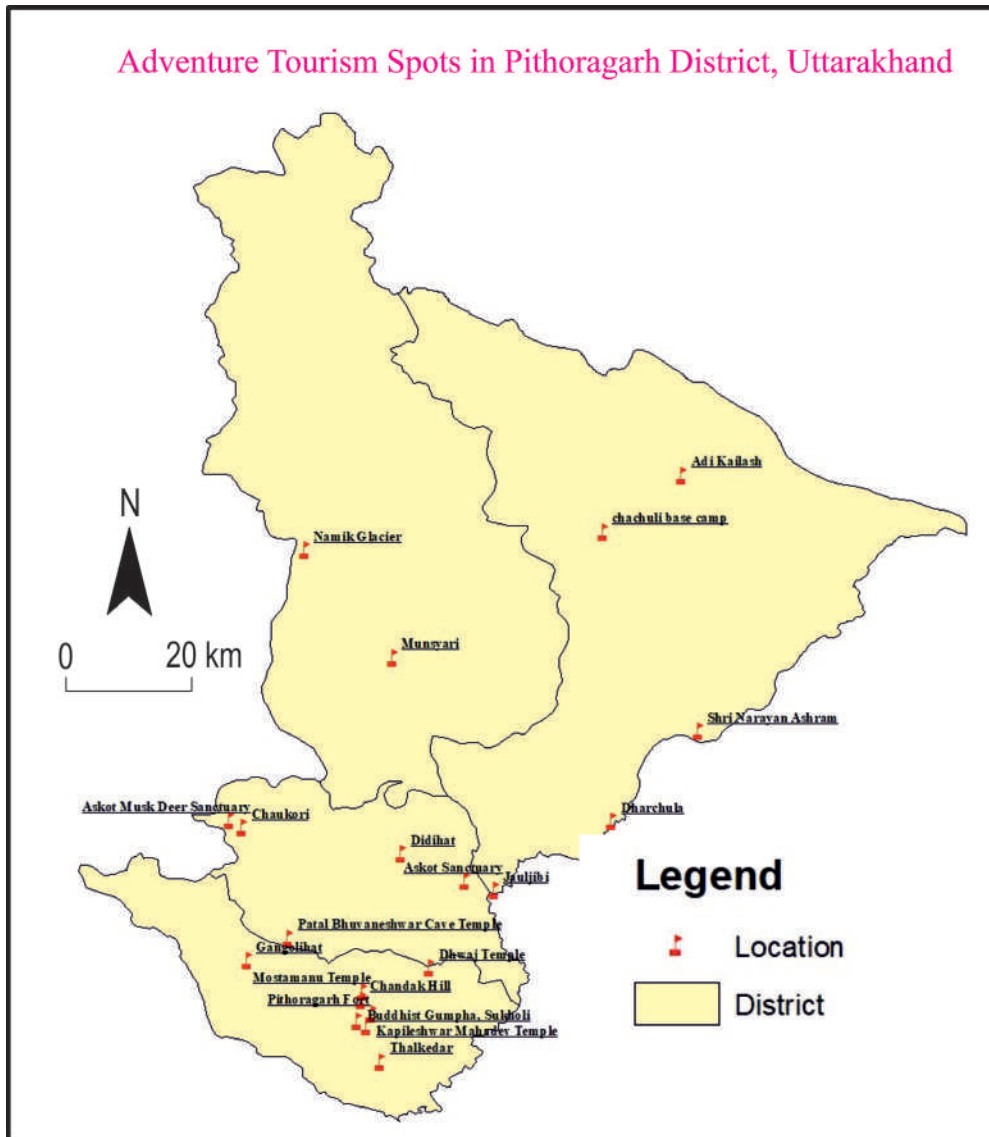


Fig. 1

The majority of tourists found the activities fairly priced, but some felt they could be more affordable compared to other markets in Uttarakhand and Himachal Pradesh. 65% of tourists were satisfied with the district's environmental conservation efforts, but 10% were concerned about litter and waste disposal. Overall, 70% of tourists had a highly satisfying adventure tourism experience, with some complaints about accommodation and transport.

SWOT Analysis of Adventure Tourism in Pithoragarh

While conducting SWOT analysis, one is able to establish the Strengths, Weaknesses, Opportunities, and Threats that concerns adventure tourism in Pithoragarh. It proffers an understanding of the state of the sector and what has been its performance in the past up to the amount of growth that can be expected in the future. Pithoragarh, a region with vast natural and cultural attractions, has the potential to grow adventure tourism if properly exploited. However, existing weaknesses in infrastructure and marketing need to be addressed. Changes to roads, transport, lodges, houses, and medical facilities are crucial for growth. Ineffective promotion and a global attitude towards adventure tourism are also needed. By targeting these trends and engaging local societies, Pithoragarh can create a desirable location for adventure tourists. However, significant hazards such as climatic change and natural calamities could threaten the survival of adventure tourism.

Conclusion

This study critically evaluates Pithoragarh District adventure tourism development and potential. Pithoragarh's hospitable topography and abundant natural resources make it a good destination for adventure tourism, according to studies. Trekking, paragliding, and river rafting are untapped potentials in the area. Major findings showed that Pithoragarh has enormous adventure tourism potential but faces several obstacles, including insufficient access and lodging, environmental limits, and little marketing. This report suggests investing in infrastructure and improving sustainable tourism marketing and practice to address obstacles. The results imply that Pithoragarh might become a significant adventure tourist destination with effective planning and coordination of government and non-government entities and local and private sector engagement. If this research's conclusions are implemented, Pithoragarh's adventure tourism growth would boost the district's economy.

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ADAPTIVE RESPONSES IN THE HIMALAYAN MOUNTAIN ECOSYSTEM AMID CLIMATE CHANGE: ENHANCING LIVELIHOOD POSSIBILITIES IN CHAMOLI DISTRICT OF UTTARAKHAND

Roosen Kumar and Bindhy Wasini Pandey

Abstract

Climate change is directly linked to mountain vulnerability. The impact of climate change has been significantly greater in the Himalayan Mountain Ecosystem putting the high-altitude at risk. The socio-economic growth face unprecedented challenges because of climate change. These changes have a negative impact on the mountain biodiversity, ecological services, and on local livelihood of the region. Therefore, this threat will be more prevalent and develop more rapidly, limiting local resilience and adaptability. This study examines the complicated interconnections of climate change and livelihood changes associated with it in the Chamoli district. The study has used satellite imagery and remote sensing techniques to find out land surface temperatures and vegetation changes. Further, the 40-year analysis of climatic data showed variable pattern of temperature and precipitation trends. As a result, there has been changes in local vegetation density in the region. Thus, this confirms ongoing climate variability in the region. As a result, it affects local population and livelihood in numerous ways. The primary survey focused on documenting the perception of the locals with respect to these changes. Purposive random sampling, interviews and FGD's were used to collect locals' perception. The local community has observed specific changes in the environmental system, such as temperature increases, changes or inconsistencies in rainfall and snowfall patterns, and the occurrence of extreme weather events. The study also documents local perception of the changes and the way they adapt to these changing scenarios. This work focuses largely on the adaptive tasks to respond to climatic and environmental change which is useful in improving livelihood prospect in the region.

Introduction

Climate change has had a significant impact on mountain communities and their livelihoods in India. Extreme weather events and environmental hazards are

becoming more frequent and prolonged in the Himalayan region. According to the International Centre for Integrated Mountain Development (ICIMOD), climate change is causing a decrease in agricultural productivity, with changes in rainfall patterns and increased incidence of floods and landslides damaging crops and leading to food insecurity. Livestock rearing, another important source of income for mountain communities, is also being impacted by climate change, with the availability of pasture lands and water decreasing, leading to a decrease in livestock productivity and income. In addition, forestry is being affected by climate change, with changes in forest composition and distribution leading to a decrease in the availability of forest products and income. The impact of climate change on water resources is also significant. The mountainous region is characterized by poverty and vulnerability, and therefore the impact of climate change is high at higher altitudes. It is a great source of a wide range of goods and services for the local inhabitants of the mountain. It also maintains the regional climate and promotes livelihood options within the region (Mukherji et. al., 2019). The projected impact of global warming is estimated to exceed 2.5 degrees by the end of the 21st century (IPCC, 2014). It is also estimated that there is the likelihood of a consistent increase in occurrences of extreme events like floods, Glacial Lake Outburst Flood (GLOF) when coupled with increased human pressure on the indigenous resources and change in land use pattern may have catastrophic consequences on the environment (Dimri et al., 2021). Mountains contribute multiple services to society. But the visible impact of climate change on the IHR is threatening the natural system of the IHR. Several mitigation measures are taken by different actors of the mountains, but, these measures face limitations in adoption due to rough terrain, low adaptive capacities, lack of knowledge, and high uncertainty about the future risks (Rasul and Malden, 2019). This requires further research to understand the underlying factors influencing the adaptation actions and policy options which can tackle existing barriers (Golam Rasul, 2019). Climate change is anticipated to influence the lifestyle of most of the poor, particularly by affecting agriculture, on which the vulnerable rely for a living. People's ability to deal with the effects of climate change is often limited at high altitude. Therefore, it is important to find out the ways in which local people mitigate through the challenges posed by climate change.

Study Region

The present study is based on the Chamoli district of Uttarakhand. The Chamoli district is located in Uttarakhand's northeastern region. The district's geographical

area is 7820 km². According to the 2011 census, the district is divided into six tehsils, nine development blocks, and 1244 villages. It has a total population of 391,605 (2011). The region is rich in biodiversity, which forms the base for social and economic activities for locals. The region is characterized by harsh climatic conditions and inhospitable terrain making the large tract of land nearly inaccessible. Local communities have developed a distinct pattern of their lifestyle with co-harmonious nature based on prevailing climatic conditions. The regions lack prospects in terms of various social and economic development facilities. Women bear most of the responsibilities in rural families and the local Communities rely heavily on primary activities for living.

Objectives

This study examines the complicated interconnections of climate change and associated livelihood. It focuses largely on the adaptive practices to respond to climatic and environmental change in Chamoli district of Uttarakhand.

Database and Methodology

The study is primarily based on primary data collected from 25 different villages from different blocks in Chamoli district through field survey. The stratified random sampling has been used for the identification of the population, sample size (n=200). For the primary study, a questionnaire survey, focus group discussion (FGDs) and interview have been used to cover the dimensions of the study. Analysis of climate data and its impact on agricultural activities and livestock production were seen in the study areas using perception of the locals. Secondary source such as satellite imagery and climatic data has been used to find out temporal changes. The historical temperature and precipitation data were accessed from ERA5-Land at intervals of two years from 1980 to 2022. A randomization process to collect random points in the Chamoli district and derive temperature and precipitation values based on these extracted random points. The Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) of select locations were calculated for the period 1980-2020 to understand the trend using the ARC GIS software. To calculate NDVI and LST, several different locations in the district were selected based on altitude and they were categorized into five different categories (variations (683-2052 m, 2052-3053 m, 3053-4149 m, 4149-5152m and 5152-7801 m). Based on the altitudinal classification of the data, the NDVI and LST were correlated to find the nature of the relationship.

Results and Discussion

Climatic Variability in the Region

Analysis of the meteorological data over the 40 years period (1981-2020) has shown significant insights into the temperature and precipitation patterns in the study area. The results show a high degree of unpredictability in both temperature and precipitation, with significant variations occurring during the last four decades. The provided graphs (figure 1, a. and b.) reveals significant variability in both temperature and precipitation patterns in the Chamoli district over the past few decades. A clear and alarming pattern of rising temperatures in the study region is revealed by the examination of temperature records. The average temperature has increased by around 1 to 1.50 degrees. This increase in temperature is consistent with worldwide patterns linked to climate change. Such a steady temperature rise has the potential to have significant effects on many facets of the environment, such as changed ecosystems. Precipitation data analysis has revealed a lot of variation in rainfall totals during the past 40 years. This shows that while precipitation may have reduced in some locations, it may have increased in certain areas. Both, the temperature and precipitation in Chamoli are not only experiencing long-term changes but are also becoming more variable.

The nature and pattern of precipitation have changed over time, in addition to the variations in rainfall amounts. Growing erraticness and unpredictable rainfall have been seen in the study area. The land surface temperature based on altitude was examined, and it has been observed that the land surface temperature of the identified locations had increased in the recent few decades (Fig. 1 and 2). To have a better analysis of the climatic variability, the data were categorized into five different categories depending on altitudinal variations (683-2052 m, 2052-3053 m, 3053-4149 m, 4149-5152m and 5152-7801 m). Over the given period, LST values have generally increased from 1990 to 2020. The highest LST values are observed in 2020, indicating warmer trends in land surface temperatures during that decade. The lowest LST values are seen in 1990, indicating slightly lower land surface temperatures compared to the other years. The altitudinal study of the data demonstrates that higher altitudes (above 3000 m) have experienced more fluctuation in surface temperature than sites located at a lower altitude. In contrast to temperature variations, the LST across the same sites has demonstrated an increase in temperature with increasing altitude. This indicates that the land surface temperature rises at higher elevations on average and that temperature variability is more pronounced at higher altitudes. Understanding the effects of

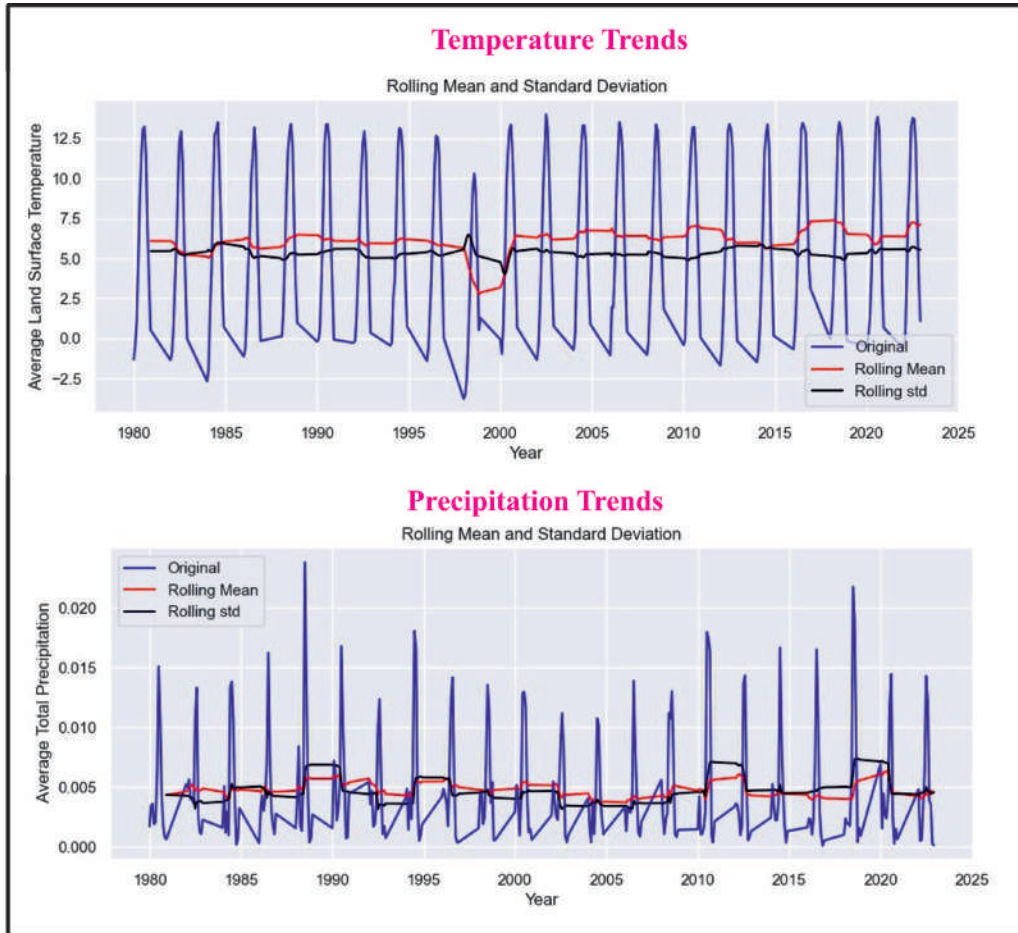


Fig. 1

altitude on different ecological processes depends on understanding these patterns. The Normalized Difference Vegetative Index (NDVI) was derived to better understand the variability and its influence on the local ecotone (figure 3). From 1990 to 2020, there seems to be a fluctuating pattern in NDVI. The highest NDVI values were observed in the years 2000, 2010, and 2020, indicating a potential increase in vegetation density during those periods. The lowest NDVI values was observed in 1990, which suggests relatively sparse vegetation at that time. The fluctuating pattern observed of the NDVI highlights the dynamic nature of the local ecotone. It indicates that the area has experienced changes in vegetation cover and density, which could have significant implications for ecosystem functioning, biodiversity, and ecosystem services. The various variations in temperature and precipitation have had a direct impact on the area's vegetation. LST and NDVI have a substantial link that shows that LST and NDVI have a negative correlation, which indicates that if LST increases, NDVI or vegetation decreases, and vice versa, as evident in Chamoli. The variations in NDVI over time in the Chamoli district from 1990 to 2020 illustrate changes in vegetation. From the above analysis of changing trend of land surface temperature, precipitation and changes in vegetation density, it is clear that the region is experiencing climatic variability. The changes in temperature and precipitation induces changes in vegetation of the region as it is highly reliant on it (Fig. 3). These changes do not only affect local ecology and landscape but also affects local socio-economic conditions by having an impact on the dependent population in the region. Climate change poses both an opportunity and threat to the local people that severely affect the socio-economic fabric of the region. People who live in mountainous areas are especially exposed to slight changes in environmental anomalies. Therefore, it is important to document how the local population perceives those changes and how they have been mitigating with the risks associated.

Local Perception on Changing Environment of Agriculture

The surveyed villages in Chamoli district mainly depend on agriculture and livestock for livelihood. Due to the limited availability of land that is appropriate for agriculture, the scarce availability of resources is putting more pressure. Most of the villages of the district rely heavily on the subsistence type of agriculture with a dependency on rainfall for irrigational purposes. Agriculture is a subsistence type of agriculture and is mainly dependent on rainfall. Agriculture is mostly rain-fed with little capability for irrigation. Overall seasonal precipitation determines productivity, but stress and dry spells affect productivity largely. During the survey,

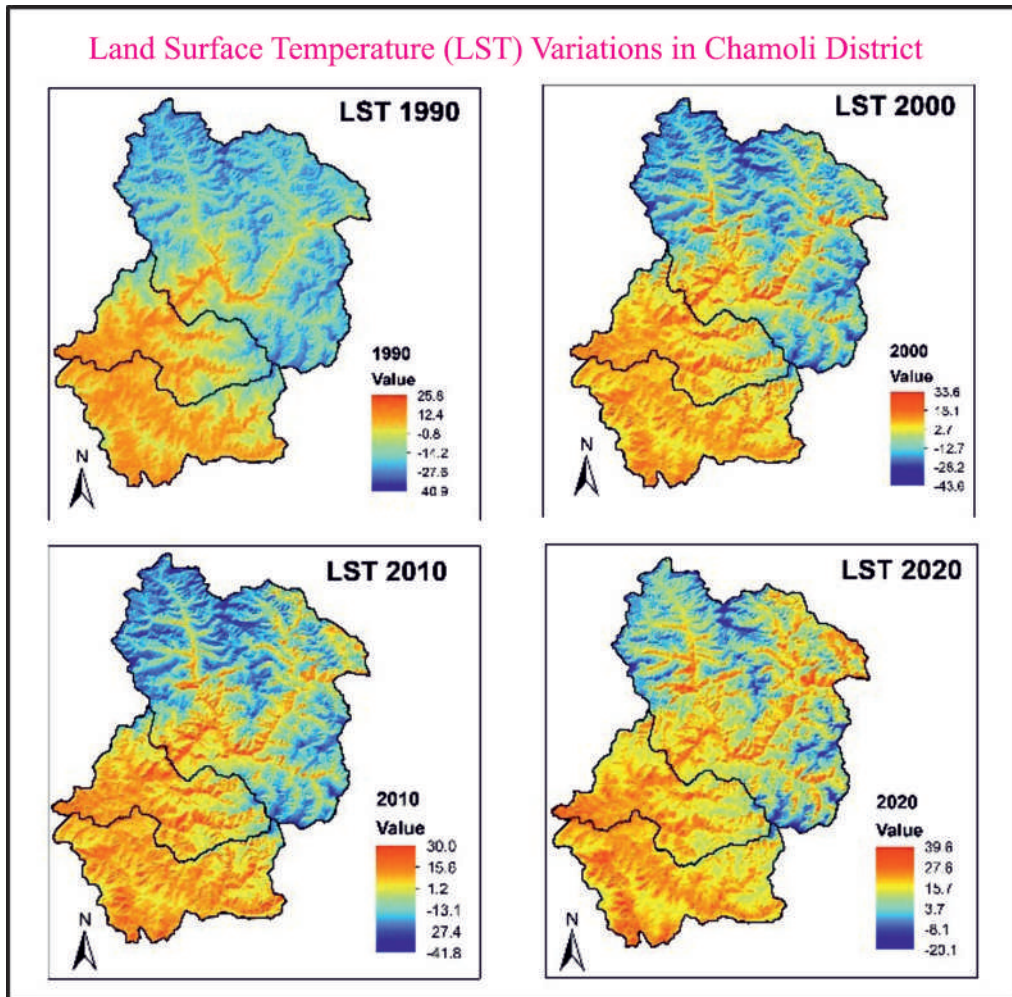


Fig. 2

it was found that the climate change has negative impacts on highland agriculture due to limited adaptability and low resilience options among local population. Due to variability in temperature, there is a shortening of the maturation period, crop deterioration, and irregularities in rainfall and snowfall ultimately affecting the crop productivity and its growing season. These incidents have contributed to crop failure, an increase in the threat of food insecurity, decreased accessibility to water, and increased financial instability. The growth and production of basic crops are hampered by erratic weather patterns. The problem of irrigation becomes acute with an increase in altitude due to less availability of water. Most of the villages do not have proper irrigation channels. These conditions have weakened the socio-economic fabric of the region. Due to a lack of an effective irrigation infrastructure and labor shortages during the crucial cropping seasons, most of the agricultural land remains fallow. Numerous areas are experiencing water stress because of the unusually rapid drying up of streams and springs in recent years. One of the most prevalent factors that affect crop production in this area is found to be the crop disease. Around 60 percent of the surveyed respondents claimed that they are facing the problem of crop disease and it has increased in last few decades. These concerns are forcing the people to leave their fields that do not help them earn income and therefore, they look for alternative livelihoods that can provide them social security. There is growing concern for crops as the frequency of disease and pest attacks has increased many folds. Many farmers stopped growing indigenous crops and prefer to grow crops that can tolerate varying climatic conditions that are not attacked by pests easily. The cultivation of cash crops instead of indigenous crops in response to climatic variability led to a decrease in the area under traditional crops. Horticulture has been affected the most resulting in low productivity, yield has reduced in most of the sites.

The sowing and harvesting season of vegetables has also altered in the past few years. Due to unpredictable rain and other factors, agricultural output (which is essential for subsistence based livelihoods) has been becoming more uncertain (Semwal et. al., 2004; Tuladhar et. al., 2021). Farmers mostly grow alternative food crops during times of water scarcity. In addition, farmers have begun growing vegetables in plastic tunnels (mini greenhouses). They use small-diameter LDPE tanks to transport the collected water to the tunnels via gravity. The area has witnessed growth in organic products. Organic-based farming with sustainable techniques is being adopted by the people. There has been an increase in the horticulture sector. People are concerned about diversifying their income through farmlands but,

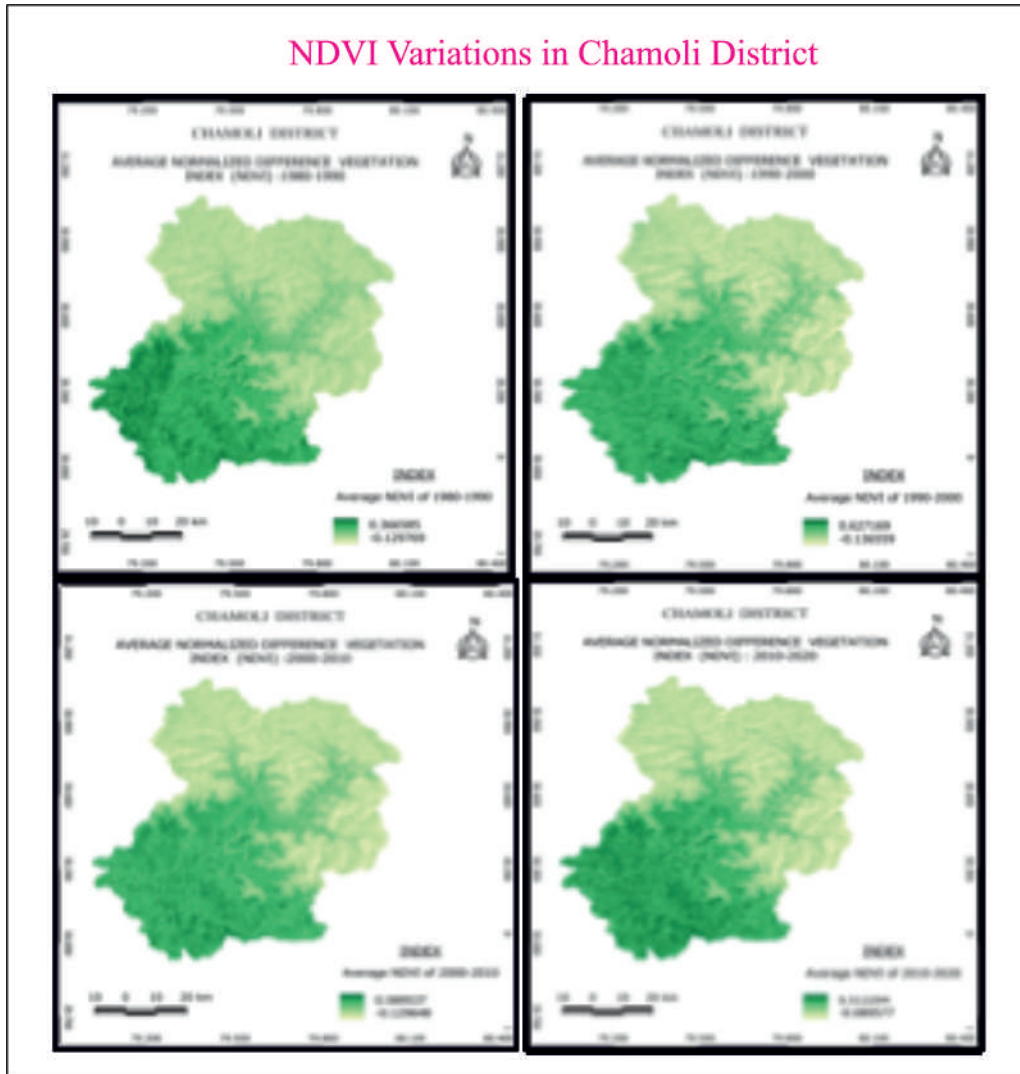


Fig. 3

the required services needed to extend agriculture (channels for the irrigation of fields, better quality of seeds, modern agricultural equipment and technology, and marketing services) are some key concerns. Therefore, the constraints forces people to move away from the area in search of better livelihood and income opportunities leaving their land behind. However, to provide people with more diverse sources of income, local NGOs are playing a key role.

Changing Perceptions on Livestock Production

The economy of local people is also dependent on livestock. The livestock consists mostly of native milch, goats, and sheep, as well as draught animals. Many households rely on livestock for livelihood. However, people's reliance on animals for a living is dwindling. Livestock assets are exceedingly becoming scarce, even among those who were formerly completely reliant on them. In comparison to the past, rural households keep fewer animals. People also feel that keeping animals is costly and did not provide them with the necessary income. During the survey, it was found that the domestication of the livestock has decreased dramatically. People are willingly abandoning this because of societal and economic developments. The pattern illustrates that people's reliance on livestock does not provide them with a better income. Another important issue that has been highlighted by the people is a lack of fodder. Fodder scarcity is a serious issue for most households due to restricted land and limited grazing lands available in the area (Mirzabaev et. al., 2016; Tiwari et. al., 2016). Few respondents stated that the women usually traverse for 3 to 5 kilometers in search of fodder, which was not the case in the past. In addition, the amount of time they spend to collect fodder has increased with time. Previously, fodder was collected in the surrounding areas, but as time passed, the situation has changed. People have been deterred from raising animals for a living due to a lack of fodder and difficulties in sourcing feed. Agriculture and cattle have always been key sources of income for the locals. Except for a few, animal husbandry in such areas is quite backward. Extreme weather events with a progressive decline in fodder and other sources in the recent years has resulted in feed and water shortages, causing livestock deaths. Therefore, local population see other sectors more benefitting in terms of livelihood and show less dependency on them.

Local Resilience and Mitigation against Climatic Variability

The livelihood of the mountainous people is fundamentally dependent on the local climate and seasonal rainfall. Any change in it has a significant impact on the crop yield and food supply of the region. There is a decline in the income of

farmers due to low production and productivity of crops. This has created a vicious cycle of poverty and compelled them to look for alternative sources of livelihood apart from agriculture and livestock-related livelihoods. With the drastic change in weather and climate, the local community has developed adaptation strategies undertaking the consideration of indigenous culture, knowledge, and belief to cope with climate change. In the survey, the evidence of good sustainable farming practices, horticulture development, dairy development, and fishery production were found prevalent. The wastelands in the region were used to generate fodder as there is much dependence on the primary sector. The majority of farmers are marginal and have fragmented lands. This issue can be resolved by appropriate use of land and with proper management. There is a lack of better-quality seeds, irrigation facilities, and organic manures. Most of the places irrigate through local ghuls and gadheris (local water sources). The local NGOs are working to empower the locals and assist them by providing better quality seeds and creating irrigation facilities. There has been a drastic reduction in the herbal and medicinal plants that were a source of livelihood for many small communities. People recognize the social and economic value of these herbal plants, and they are being encouraged to take them as a part of their livelihood. If the constraints faced by the locals are improved then the productivity can be increased in all sectors. The collection of NTFPs, one of the key sources of money for low-income households, is dropping year after year. This also shows a change in the people's livelihood. Since all regions do not acquire similar characteristics, therefore, some alternative ways for livelihood are to be developed. The fishery department of Uttarakhand has been helping villagers to find livelihood in this sector. The department trains people to earn income by pisciculture. The fishery-related schemes are promoted by NGOs to make people aware of this. The schemes related to fish farming aim to empower the locals socially and economically. Due to environmental concerns, agriculture is increasingly seen as a non-profitable and unstable industry. Youth are also gravitating toward industries other than agriculture.

The locals had realized the risk associated with agriculture and livestock rearing often changing with changing socio-economic and environmental conditions. The youths of the village have been influenced a lot by urban development around and therefore, this is one of the reasons that they do not want to continue with their traditional source of livelihood (Mamgain et. al., 2015). Locals want to switch from agriculture to horticulture if they are provided with proper training and facilities. Majority of people stated that the out migration is due to lack of basic facilities.

Thus, Income generation sources and employment opportunities will enhance people to return back who have already migrated to the lower regions (Sharma et. al., 2019). Chamoli district has several tourist destinations. The arrival of tourists in the state has experienced rapid growth over the years. The tourism sector has created immense backward and forward linkages in the district. The tourism sector has lot of potential for the generation of livelihood. It is emerging as a tourist destination as the district has huge prospects to expand its spiritual tourism, rural and eco-tourism, etc. The youths of the district see huge scope in employment if the tourism industry is expanded properly. With an increase in the number of tourists in rural villages, the village has experienced an upsurge in the number of demands for accommodation, catering, tourist guides, transport, and other associated services. Rural tourism has also seen an increase over the years. This can be seen as a direct economic benefit to the locals. Tourism as an occupation has been accelerated in the last few decades. The diagram below (figure 4) demonstrates how climate change makes local people more sensitive to shifting conditions by posing persistent obstacles to their living. The figure represents how climate change shape the local landscape and in turn how it affects the socio-economic conditions of locals.

Conclusion

There is a significant variability in the climatic conditions of the study area and the challenges posed by it become more evident in the fragile and sensitive environment. To overcome the challenges posed by climatic variability, some strategies are undertaken, such as diversification of high-value crops instead of water-intensive ones, extension of agricultural services, development of farmland and access to markets, rural tourism development and etc. The focus should also be given to a generation of employment opportunities and more sustainable off farm livelihood options that will significantly improve the quality of life. The district is having a high potential for tourism activities (especially religious and spiritual tourism). The district also has potential for expansion of horticulture sector. The major concern is to diversify the livelihood in these regions. There has been an effort to improve social and economic conditions and several schemes are working in this area. These schemes have successfully improved farm productivity, food security, and accessibility to markets for rural households. Understanding and predicting the effects of climate change on mountainous landscapes as well as the values they offer to people is crucial to attempt to create and execute effective mitigation management and adaptation policies.

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SPATIAL ANALYSIS OF THE AIR POLLUTION IN CHENNAI CITY

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and Usha Rani

Abstract

Climate change and the environment are intimately related to the difficulties caused by air pollution. The primary goal of the research is to evaluate Chennai's air quality. The study's goals are to examine the city's air quality between 2013 and 2020, identify the root causes of the pollution, and assess how the weather affects the city's air quality. The Central Pollution Control Board, the Tamil Nadu Control Pollution Control Board, and several literature reviews provided the secondary data, while field visits to different parts of the city provided the primary data. Several statistical methods and the GIS software were used to analyze the data. The study's primary conclusions are that Chennai is situated in the Bay of Bengal's coastline zone. Sea breezes and land breezes flow horizontally, dispersing and eliminating contaminants. Chennai City is less affected by air pollution as a result of these regions. Nevertheless, even with this element taken into account, the city's air quality is still not very adequate due to the rise in emissions from automobiles, factories, homes, and building sites, among other sources. The northern industrial area of Manali and the city's most congested area have higher air quality indices. The year-round purity of the air is maintained, with minor fluctuations around the Diwali and Pongal festival seasons.

Introduction

Any atmospheric state where specific compounds are present in such amounts that they can have unfavorable impacts on humans and their surroundings is referred to as air pollution (Rajamanickam and Nagan, 2018). Air pollution is the term used to describe any chemical, physical, or biological factor that tampers with the natural properties of the atmosphere to contaminate the indoor or outdoor environment. According to Pinner and Langton (2016), air pollution is the result of dangerous or toxic compounds existing in the atmosphere. The combustion of domestic appliances, automobile and industrial emissions, and forest fire smoke are the main causes of air pollution. Particulate matter, ozone, nitrogen dioxide,

sulphur dioxide, and carbon monoxide are among the pollutants that pose a serious threat to public health. The World Health Organization released the air quality guidelines in order to establish a relationship between concentration level and health risk (Doll, 2009). The lesser the size of particulate matter the more dangerous threat it poses to human health because smaller particulate matter can be directly inhaled to lungs without any obstruction (Basumatary, et, al, 2023). Air pollution from both outdoor and indoor sources can induce respiratory conditions as well as other illnesses, which can result in a high death and morbidity rate. Nearly 99 percent of people worldwide breathe air that is polluted and has high levels of air pollutants, according to data from the World Health Organisation. The developed nations with lower and moderate incomes suffer more from high levels of air pollution exposure than do the higher income countries. The World Health Organisation estimates that air pollution caused seven million deaths globally in 2012, making it the leading environmental risk factor (Greenstone et al., 2015). Particulate matter-related air pollution has become a major global concern since the London fog of 1952, which was followed by the Meuse fog of 1930 and the Donora fog of 1948 (Grunig, et al, 2014). Because of the rapid population growth and little public participation, programmes aimed at preventing and combating air pollution are ineffective (Imam and Banerjee, 2016).

The daily air quality is reported using the air quality index (AQI). It indicates if the air is clean or polluted as well as any potential health risks. The AQI focuses on potential health impacts that a person may have hours or days after breathing in contaminated air. India is one of the biggest emerging nations, and in recent decades, it has had some of the fastest economic growth in global history. The usage of fossil fuels and vehicle emissions rise with such economic progress. These toxins have an impact on human health and lead to numerous illnesses (Thilagaraj, et al, 2014). India is home to 21 of the 30 most polluted cities in the world. Chennai is one of the top six cities on the list. According to reports, Delhi's air quality is worse than Beijing's. However, India's city seems to have given up the struggle for clean air, while China's capital seems to be gradually reversing the clock on pollution. In India, occupation and environmental risk factors account for over 40% of the country's overall disease burden. One of the main risk factors is air pollution (Balakrishnan et al., 2011). Over the past 20 years, India has been especially sensitive to air pollution because of factors like population expansion, an increase in the number of vehicles on the road, fuel consumption, ineffective transit systems, improper land use patterns, industrialisation, and lax environmental legislation (Chatterji, 2020).

Study Region

One of the most important cities in South India, Chennai, is situated on the country's Coromandel Coast and faces the Bay of Bengal. The climate of the city is tropical, humid and dry. The city is shielded from the extreme variance because it is located in a coastal and tropical region. The most of the time, the city has hot, muggy weather. With temperatures between 38 and 42 °C, May's end and the beginning of the city see the highest temperatures. December and January bring the city's lowest temperatures, which hover around 18–20 °C. The city receives roughly 1300 mm of rain annually. The city experienced the majority of its rainfall and sporadic cyclones between mid-October and mid-December. Chennai, the capital of Tamil Nadu, is the sixth most populated city in India. The provisional findings of the 2011 census showed that there were 4.68 million people living in the city. The city is the fourth most populated metropolitan area in India and the 31st largest urban hub on Earth. The city's economy is heavily reliant on the automotive, technology, computer hardware, and healthcare industries. In terms of business process outsourcing services and information technology, the city was the second-largest exporter in the country in 2012. The city's greatest contribution to the automotive industry has earned it the moniker "Detroit of India." Dust particles, particulate matter from the road, building sites, vehicle and industrial emissions, etc. are the main sources of air pollution in the city (Tamil Nadu Pollution Control Board, 2021). Four general regions make up the city: North, South, Central, and West. The northern section of the city is home to the industrial area. The residential and business areas in the city's southwest and south are fast transforming, with an increasing number of finance, IT, and call centre industries taking their place.

According to the District Statistical Hand Book of Chennai District (2017), Chennai City is currently growing quickly towards the Grand Southern Trunk Road, the old Mahabalipuram Road, and in the west, towards Koyambedu, Sriperumbdur, and Ambattur. The entire coast length that the city share is 19 km, as stated in the former corporation boundary. Currently, the coast length has increased due to the company limit expansion. Since Chennai is one of the few cities worldwide that have a national park, the city is unique in and of itself. The 4.5 percent of the city's green space is protected by the Guindy National Park. The Adyar and Cooum Rivers as well as the Buckingham Canal are the city's most notable waterways (Verma, et al, 1999). Chennai has performed better in terms of air quality index and has exhibited progress since 2017 when it reported a concentration of 39.8 of PM_{2.5}, according to the 2021 World Air Quality

report by the Swiss organisation IQ Air. It was recorded as 25.2 in 2021. The city exceeds the optimal mark by five times, as per the WHO criteria. Chennai benefits from being a coastal city, and the winds there help to lower the amount of suspended particulate matter. The city is able to control the ambient air quality thanks to the sea breeze.

Objectives

- (1) Spatially identify the concentrations of air pollutant's different locations of the Chennai City.
- (2) To analysis the spatio-temporal changes of Air pollution in the Chennai City
- (3) To access the causes of air pollution in the Chennai City
- (4) To access the impact of meteorology in air quality of the Chennai City

Database and Methodology

For the objective of the study, both primary and secondary data are collected. The Central Pollution Control Board, the Tamil Nadu Pollution Control Board, and a number of publications and journals are the sources of the secondary data. A comprehensive field survey was carried out inside the city of Chennai in order to gather primary data. Three methods were employed to gather primary data from the field: group discussions, interviews, and observation methods. Arc GIS and statistical techniques were used in the analysis of the gathered data. Particulate matter (PM10 and PM2.5), sulphur dioxide (SO₂), nitrogen oxides (NO_x), carbon monoxide (CO) (measured in mg/m³), ozone (O₃), and ammonia (NH₃) are among the many pollutants that contribute to air pollution. The Chennai city's Air Quality Index is computed using four pollutants: SO₂, NO_x, PM10, and PM2.5, for the period from 2013 to 2020. The CPCB provided the calculator that was used to determine the AQI. At least three pollutants are needed to calculate the Air Quality Index, with PM10 or PM2.5 constituting one of those pollutants. From 2013 to 2020, the following Chennai city locations had their AQI and different contaminants analysed: Kathivakkam, Manali, Thiruvottiyur, Madras Medical College, Taramani, Adiyar, Kilpauk, Thiyagaraya Nagar, and Anna Nagar. The government created the Air Quality Index in order to effectively apply rules and provide the public with a straightforward numerical value that represents the quality of the air. The AQI is categorised into six groups with distinct colours and names based on its numerical value and how it affects human health. Air pollution has little effect on a rating between 0 and 50 (Good); for those who are sensitive, a value between 51 and 100 (Satisfactory) may cause slight respiratory discomfort. People with lung or heart illness,

as well as older adults and children, may experience breathing difficulties if the reading falls between 101 and 200 (Moderate). People will experience respiratory difficulties after extended exposure if the value falls between 201-300 (Poor). People will experience respiratory illnesses after extended contact if the result is between 301 and 400 (Very Poor). In the event that the value surpasses 401 (Severe), respiratory illnesses will impact even those in good health.

Result and Discussion

Pollutant readings of SO₂, NO_x, PM₁₀, and PM_{2.5} were taken from Kathivakkam, Manali, Thiruvottiyur, Madras Medical College, Taramani, Adiyar, Kilpauk, Thiyagaraya Nagar, and Anna Nagar in order to identify the spatiotemporal changes in Chennai's air quality between 2013 and 2020. It has been discovered that the variations in Chennai's air quality between 2013 and 2020 do not conform to any specific patterns; instead, they exhibit fluctuations and an up-and-down curve. The majority of city areas indicate a minor improvement in air quality between 2013 and 2015. The quality of the air declined in 2016, showed a little increase in 2017, then declined once again in 2018 and 2019. The year 2020 demonstrated a notable increase in the city's overall air quality across all sites (Fig. 1). Support vector machine (SVM) is a machine learning technique that may be used to perform predictions on the data (Gladence et al., 2019). The city's air quality index number varies from 28 to 113 between 2013 and 2020. Chennai is a city facing the Bay of Bengal on the Coromandel Coast. The city's western and southern sections are significant areas for commerce and residential development, while the eastern portion of the city faces the Bay of Bengal Sea. The three categories of venues used for data collecting are Industrial, Commercial, and Residential. Thiruvottiyur, Manali, and Kathivakkam are the city's industrial areas. Smoke and unburned hydrocarbons from industrial emissions are the main pollutants causing air pollution in those areas. There aren't many notable changes in the industrial regions' air quality between 2013 and 2020. The industrial regions of Kathivakkam, Manali, and Thiruvottiyur have average AQIs of 52.75, 53.25, and 52 from 2013 to 2020, respectively.

This demonstrates that the city's industrial area has acceptable air quality, however those with sensitive health issues may experience some respiratory irritation. It was discovered during a field investigation that residents close to enterprises have skin rashes and eye irritation as a result of industrial effluent discharge. The city benefits from its location near the coast. The contaminants in the atmosphere were removed by the daily movement of land and sea breezes. It is discovered during the field survey that industrial gas releases occur around

midnight or early in the morning. From 2013 to 2020, the overall average changing pattern in Chennai's air quality index was computed. The impoverished and emerging countries are more affected by air pollution than are the developed countries. China, a recently industrialised nation, is able to control the air quality index by following stringent regulations and tactics. In comparison to other industrialised nations, India passed the air quality legislation pertaining to and providing information about the air quality index rather recently. Actually, the nation has only just come to realise how detrimental air pollution is to both the environment and human health. Between 2013 and 2020, Chennai's overall air quality fluctuated and was not consistently good. The value of the air quality index fell between 2013 and 2015, then increased in 2016 and 2017 before declining once again in 2018 and 2019. 2020 saw the lowest and best levels of air pollution in the city as a result of a complete shutdown of all industrial, transportation, and construction activity. When the COVID-19 lockdown opened and events began, the city's air quality began to deteriorate. Between 2013 and 2020, there was a notable shift in Chennai's SO₂ concentration in different areas. Not every part of the city experiences the same pattern of change. Between 2013 and 2020, there was a notable shift in Chennai's SO₂ concentration in different areas. Not every part of the city experiences the same pattern of change the amount of sulphur in the fuel directly correlates with the amount of sulphur dioxide emitted. The primary source of the gas in the atmosphere is the burning of coal; the gas is acidic by nature and produces acid rain when it combines with atmospheric water. The health of people is impacted by the presence of gas in the ambient air, especially those who are ill and suffer from asthma, chronic obstructive pulmonary disease, weak lungs, children, and old people.

The city discovered that there were no noticeable changes from 2013 to 2020 in northern industrial locations including Kathivakkam, Manali, and Thiruvottiyur. In Kathivakkam in 2013, the SO₂ concentration was 15 µg/m³, and it was also the same in Manali and Thiruvottiyur. By the end of 2020, Kathivakkam, Manali, and Thiruvottiyur had concentrations of 13 µg/m³, 14 µg/m³, and 13 µg/m³, respectively (Fig. 1). The amount of pollution in the city is rising due to the worryingly high number of cars and industrial activity, which could have a serious negative influence on public health (Jayanthi and Krishnamoorthy, 2006). The concentrations of SO₂ have significantly decreased in the remaining residential and commercial areas of the city, including Taramani, Adiyar, Kilpauk, Thiyagaraya Nagar, and Anna Nagar, as well as Madras Medical College. The switch to renewable energy, restrictions on car emissions, and increased public awareness of the damaging

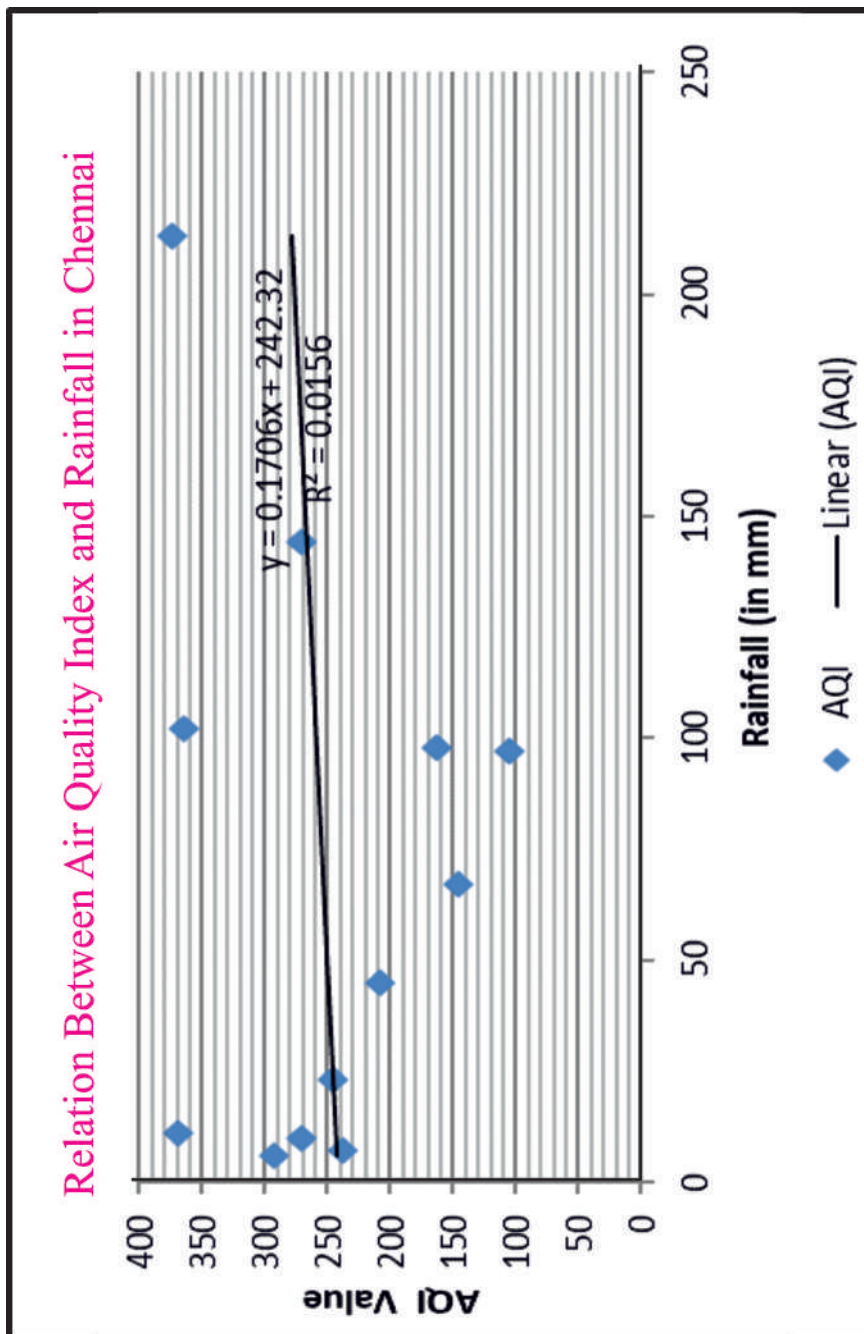


Fig. 1

impacts of air pollution on both humans and the ecosystem are to blame for the changes. From 2013 to 2020, the pattern of variation in Chennai's NO₂ air pollution concentrations was examined from several city areas. During those times, there were notable changes. The oxidation of nitrogen at high temperatures brought on by air combustion forms the oxides of nitrogen. Nitrogen dioxide (NO₂) and nitric oxide (NO), together referred to as NO_x, are the two most common forms of oxide of nitrogen. The main source of NO is emissions from driving on the roads. Road traffic accounts for 32% of NO emissions in the USA and 49% in Europe. Both petrol and diesel-powered cars release petrol into the air. There were notable changes in every site in the city during those times. Residential and commercial areas saw alterations that were more akin to those in Kathivakkam, Manali, and Thiruvottiyur's northern industrial area. In 2013, the concentrations in those locations were 18 µg/m³, while in Kathivakkam, Manali, and Thiruvottiyur, they decreased to 16 µg/m³, 16 µg/m³, and 15 µg/m³, respectively. Although there were only minor alterations, the NO₂ emissions from the remaining residential and business locations were significantly reduced. Because of different government programmes, awareness of air pollution, and effective management of road traffic emission standards for petrol and diesel engines, there has been a significant drop in NO₂. A dual fuel low temperature combustion (LTC) technique called reactivity-controlled compression ignition (RCCI) produces almost zero NO_x and particulate matter emissions (Pandian and Krishnasamy, 2019). From 2013 to 2020, the variations in the PM₁₀ particulate matter pattern at various Chennai locations were examined.

Its concentration fluctuated, with some years seeing high concentrations and others seeing low concentrations; the variations did not follow any specific pattern. PM₁₀ is the term for particulate matter with a diameter of up to 10 µm. Due to its toxicity and minute size, this particulate matter can be inhaled and immediately enters the lungs, severely damaging lung tissue and increasing the risk of asthma, chronic obstructive pulmonary disease (COPD), and bronchitis. As per the Central Pollution Control Board, Ministry of Environment and Forest (2012), the particulate matter is quite small in size and can linger in the atmosphere for almost two days. The rise in AQI value reading in urban areas is caused by particulate matter. Policymakers are primarily concerned on its reduction (Fig. 2). The primary sources of particulate matter are not limited to one area; they originate from a variety of places, including industries, brick kilns, traffic routes, building sites, and smoke from burning materials and firecrackers. With the exception of Taramani,

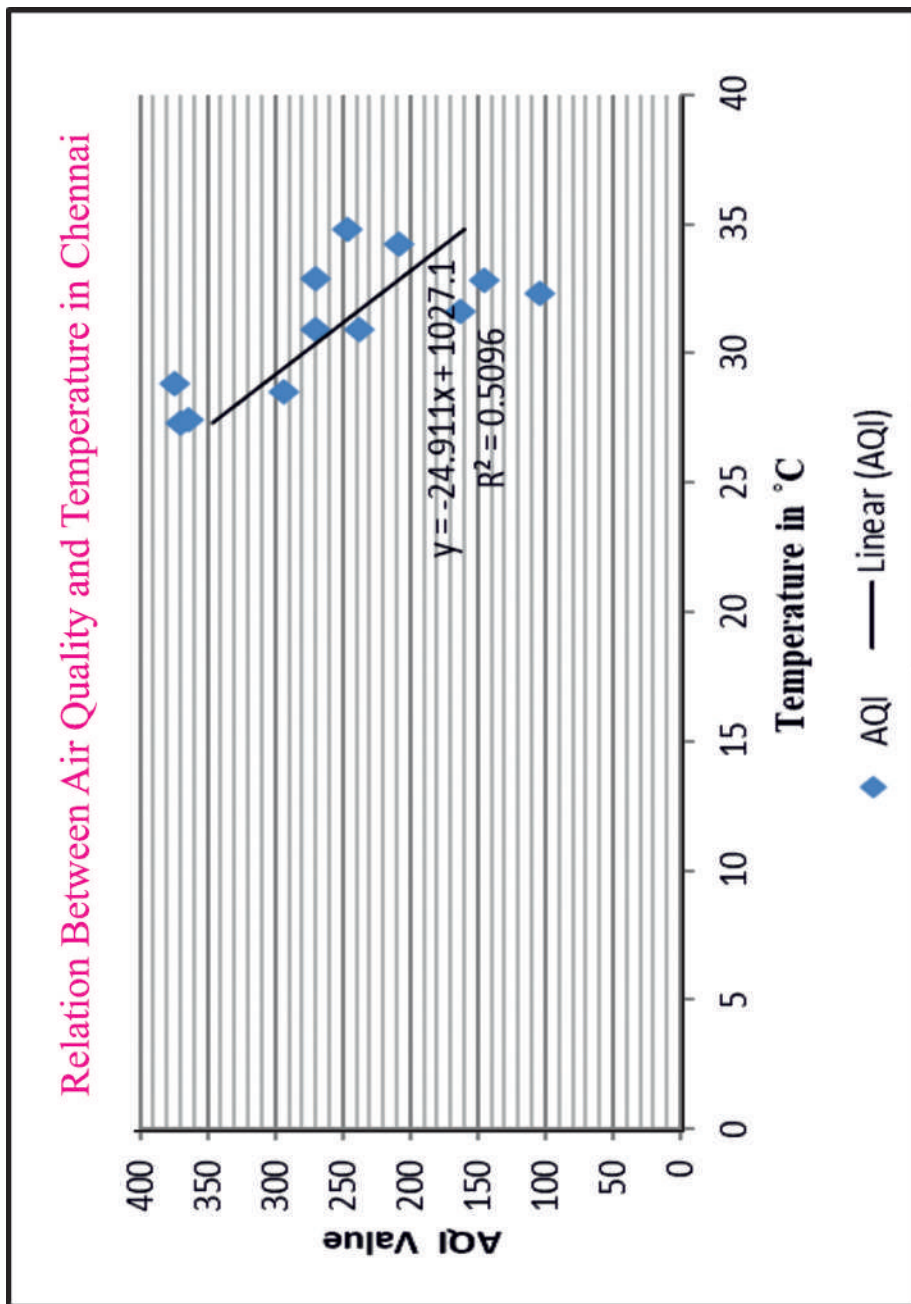


Fig. 2

all nine areas in Chennai City showed a decrease in PM10 concentration in 2015. In 2016, the concentration of pollutants was observed to have increased across all areas, with the exception of Anna Nagar. In 2017, the concentration decreased in most of the areas once more. The amount of air pollution in the city increased in both 2018 and 2019. The city's numerous operations were completely shut down owing to COVID, which resulted in a considerable decrease in PM10 concentrations in the atmosphere in 2020. The large-scale circulation of urban heat islands, mountain and valley winds, and the concentration and diffusion of air pollutants are related (Xu, 2002). The major factor influencing the region's air pollution control is meteorology. Chennai benefits from being located near the coast as opposed to being a landlocked metropolis. The pollutants are washed away by the land and sea breezes, which also keep them from standing still for an extended amount of time. The relative importance of the various meteorological elements—rainfall, wind, and temperature—varies. There is very little relationship between the air quality index and annual rainfall in Chennai. Rainfall is brought to the city twice a year by both the North East and South West Monsoon Winds. Nonetheless, November and December bring the lion's share of rainfall to the city as the North East Monsoon withdraws. The air contaminants in the atmosphere are brought to the ground by rainfall. As a result, whenever it rains, the air gets clean and the inhabitants' health is not greatly affected. Since Chennai is located in a tropical location where rainfall is unpredictable, there is no discernible pattern or correlation between the amount of rain and the AQI reading. In Chennai, the relationship between wind speed and air quality was examined. Chennai experiences year-round wind flow because to its location in a tropical coastal zone. Throughout the year, the diurnal land and sea breezes regularly wash away the air contaminants. Throughout the year, there is not much of a correlation in the city between the AQI and wind speed. City's air quality index changes with the seasons and the months. The winter months of November, December, and January had the highest air quality score; during those months, the wind speed is marginally slower than it is during the other months. The city also receives rainfall from the northeast monsoon when it retreats during the winter. From April through August, the quality of the air begins to improve. August is the month with the best air quality in the city. The beginning of the south-west monsoon brings rain to the city in the months of May, June, and July. Beginning towards the end of August, the city's air quality steadily starts to decline.

In Chennai, the relationships between temperature and air quality are examined. There is a fifty percent link between the city's air quality index and temperature. Summer months have good air quality, whereas the winter months have a modest decline in the same quality. May and June, when the average high temperature reaches up to 32°C, are the hottest months in the city. December and January have the lowest average temperature, which only reaches 22°C. The city's air quality index reading decreases with rising temperatures and precipitation. In the winter, as the temperature drops and there is less rainfall, the city's air quality index rises. When inversion and quiet, cool weather trap and increase everyday pollution, winter presents a unique difficulty (Roychowdhury and Somvanshi, 2021). In Chennai the annual average AQI is more or less constant since 2013 to 2020. Its value is lowest in 2020 with 50.63 which is slight 0.63 greater than good category (0-50) (Basumatary, et al, 2022). Petrol or liquid fuel is used by all of the major industries. As a result, the industries' portion of the pollution has significantly decreased. Reducing the sulphur level of fuel supplied to automobiles resulted in a decrease in sulphur particle emissions from the vehicles. Permission for construction projects should be granted subject to the requirement that they take all reasonable precautions to prevent dust emissions while under development.

Conclusion

This study examines the concentration of air pollutants in Chennai City between the years of 2023 and 2020. Four pollutants' concentrations were used to construct the city's air quality index: PM10, PM2.5, NO2, and SO2. The city's high air quality index number is entirely the result of particle matter. The contaminants are gathered from eight distinct city locations. The city regions were categorised into three main areas: commercial, residential, and industrial. The city is divided into three sections: industrial in the north, residential and commercial in the south, and facing the Bay of Bengal in the east. Significant concentrations of SO2 and NO2 are seen in industrial areas. Everywhere in the city is visible because to the particle matter. It makes it abundantly evident that while climatic factors like rainfall are important in controlling the city's air quality, so are wind speed and temperature. These are not the only natural elements that influence the city's air pollution. Both man-made and natural causes contribute to the concentration of air pollution. The main human endeavours include the transportation, industrial, and building sectors as well as the automotive, commercial, and residential sectors' emissions and particulate matter. It's critical

to monitor and control those operations in order to reduce air pollution. Planting plenty of trees is the easiest, most effective natural technique to reduce air pollution.

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MEASURING AND MONITORING URBAN SPRAWL IN KATHUA CITY OF JAMMU AND KASHMIR USING GEOSPATIAL TECHNIQUES

Shruti Gupta, Meetu Sharma, Yog Raj Singh and Dr. Inder jeet Singh

Abstract

The rapid urbanization of Kathua city, fuelled by rapid industrialization and migration, necessitates thorough monitoring and analysis for sustainable development planning. This study focuses on tracking the evolution of urban sprawl in Kathua city over the past two decades, leveraging temporal remote sensing data from Landsat TM and Landsat-8. A structured methodology is employed. The synergy of remote sensing and Geographic Information Systems (GIS) techniques facilitates the mapping and quantification of Kathua city's urban sprawl across different timeframes. This research conducts a detailed quantitative analysis to illustrate spatial changes vividly. Furthermore, it undertakes spatio-temporal analysis while extensively utilizing spatial and temporal changes to identify the driving forces behind Kathua city's urban sprawl. The findings of this research contribute to a deeper understanding of the urbanization process in Kathua city, offering a comprehensive analysis of the physical drivers of urban sprawl.

Introduction

Urbanization refers to the spatial and demographic growth of towns and cities, driven by large-scale migration from rural areas to urban centers. According to European Environmental Agency “The spatial phenomenon of urban sprawl entails the outward expansion of large urban regions into surrounding agricultural zones under market dynamics. This expansion occurs without significant planning oversight, resulting in a dispersed and irregular development pattern characterized by patchy, scattered, and discontinuous growth, often leaving pockets of agricultural land interspersed within the urban fabric” [2]. It results in changes in population composition and transformations in social, economic, environmental, and cultural dimensions [3,4]. Urban sprawl, characterized by outward expansion into agricultural zones, often occurs without adequate planning [5]. This low-density, fragmented development, typically along city fringes, negatively impacts the environment,

increasing infrastructure costs, inequality, and habitat destruction [6]. Indicators of sprawl include single-use developments, strip commercial areas, and leapfrog land use patterns [7]. As a consequence of sprawl, cities rely heavily on private vehicles, exacerbating traffic congestion, pollution, and greenhouse gas emissions [8]. Urban sprawl often outpaces population growth, leading to unsustainable land consumption [9]. In India, researchers have highlighted urban sprawl as a significant barrier to sustainable urbanization [10,11]. Remote sensing and GIS studies of cities like Srinagar have shown rapid expansion in land use, further straining infrastructure, biodiversity, and ecological systems [12]. The expansion of low-cost housing on city outskirts promotes reliance on private vehicles, increasing air pollution, and creating urban heat islands [13]. This study focuses on Kathua city's rapid sprawl, exploring whether its growth follows an urban model or is driven by other factors.

Study Region

Kathua city is the headquarter of district Kathua and Municipal council in the Jammu division of Jammu & Kashmir. The study area is situated at the foothills of Shiwaliks and is bordered by Syar khad in the west, Magar khad in the east, Kandi Shiwaliks in the north, and Andher plains in the south. Kathua town is located between 32° 21' to 32° 24' North latitude and 75° 30' to 75° 33' East longitude, with an elevation of 393 metres. It covers an area of 16 sq. km, has a Municipal Council with 21 wards [14]. The combined population of the Municipal Council and its surrounding outgrowth areas stands at 59,688 individuals, comprising 31,717 males and 28,149 females. In total, there are 12,061 households within the Municipal Council and its outgrowth regions [15]. The city offers excellent market and transportation facilities to the nearby areas. Additionally, the area is a significant industrial hub, providing employment opportunities for both local residents and people from neighbouring states.

Objectives

- (1) To identify the land use and land cover changes of Kathua city during the study period.
- (2) To measure and monitor the urban sprawl in Kathua city and to highlight the associated factors.

Database and Methodology

The study utilized multiple data sources for analysis. Recent Survey of India (SOI) toposheets were used to generate map boundaries. Landsat 7 imagery from

2000 and 2011, and Landsat 8 data from 2021, were employed for land cover analysis and change detection. Data from the Kathua Municipal Council provided city boundaries and population information. Population data from the 2011 Census of India supplemented the analysis, offering insights into demographic trends and urban growth in Kathua. Apart from these, official publications of the State Government, Journals, Magazines, reports submitted by Scholars, Economists, published works of research institutions and universities were also collected. Secondary data for this study are also obtained from other numerous published and unpublished literatures. The data covered population, economics, housing and social issues pertaining to Kathua city.

Result and Discussion

To assess the growth of an area, examining land use and land cover changes is crucial. In Kathua city, a comparison between 2001 and 2021 reveals significant shifts: vegetation cover has drastically decreased, while settlement areas have expanded considerably. This urban sprawl has led to the conversion of agricultural land into built-up areas, confining agriculture to a few remaining sections of the city. These changes highlight the impact of urbanization on the local environment and land use patterns, emphasizing the need for sustainable development strategies. This diagram illustrates the dynamic changes in land use patterns in Kathua city over the span of two decades, from 2001 to 2021. Three primary categories of land use are outlined: Vegetation, Agriculture/Fallow land, and Built-Up areas. Between 2001 and 2021, there was a notable decrease in Vegetation from 12.20 percent to 5.7 percent, indicating a potential reversal or decline in these efforts, possibly due to urban expansion or land conversion for other purposes. Agricultural/Fallow land witnessed a substantial decline from 30.71 percent in 2001 to 2.2 percent in 2021, suggesting a shift away from traditional agricultural practices or potentially increased urbanization. Also, signalling a significant reduction in agricultural land or fallow areas, possibly due to urban sprawl or intensive land development. The most striking trend is observed in Built-Up areas, which surged from 57.08 percent in 2001 to 92 percent in 2021, indicating rapid urbanization and expansion of infrastructure within Kathua city (Fig. 1). This represents extensive urban sprawl and intense development activities, potentially at the expense of natural habitats or agricultural lands. Also, in 2021 Land use map, agricultural land seems to have completely vanished, replaced by built-up and rocky terrain (map 2). There is notable development around Kathua's industrial area and J&K Small Scale Industries Development Limited (SICOP), primarily in the form of built-up areas.

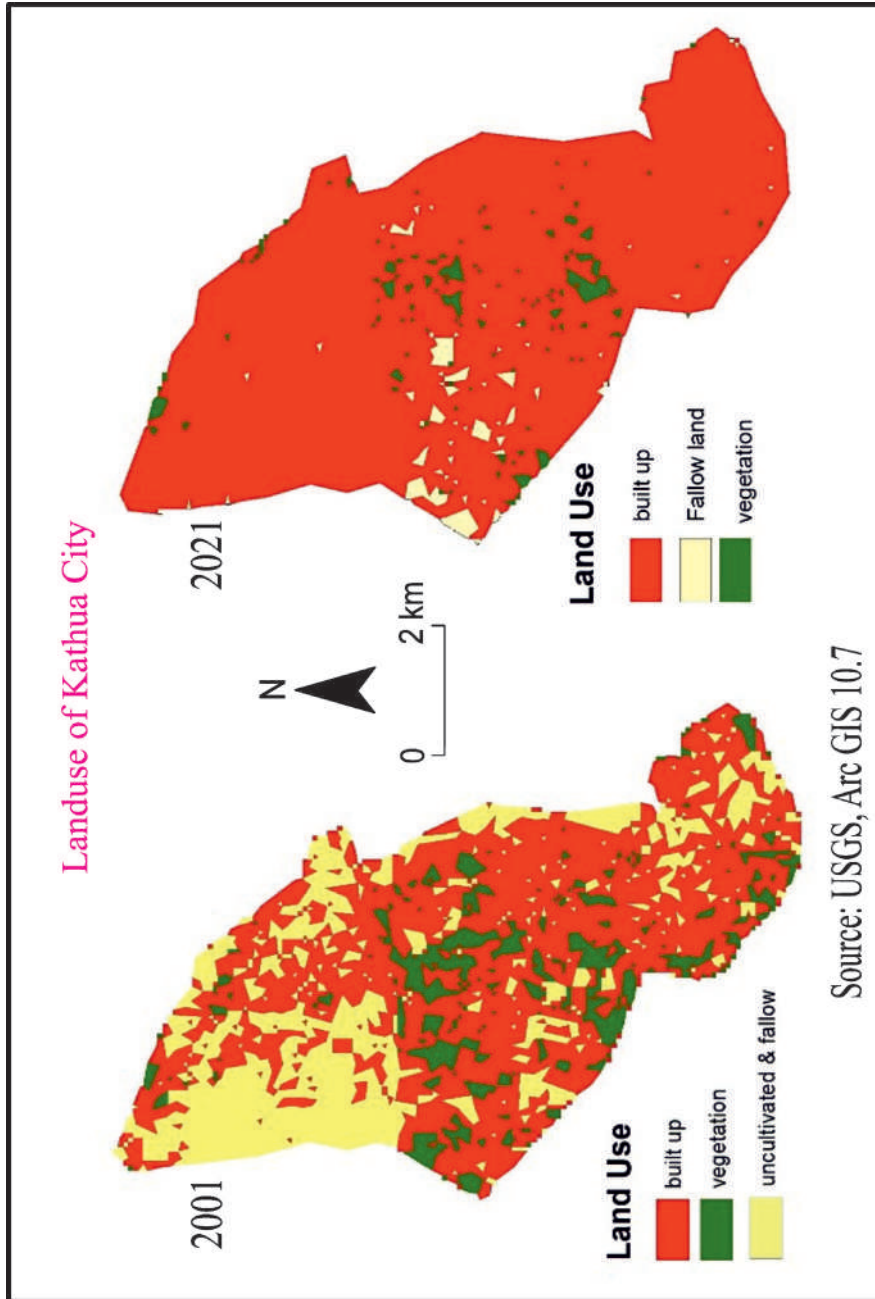


Fig. 1

Forest area is still prevalent in patchy form. Also, Waste land area is converting into forest patches. This indicates that urban sprawl has significantly expanded around Kathua city from 2001 to 2021.

In 2001 imagery (Plate 1), we can see that most of the built-up area was situated within the city of Kathua. There was a significant amount of agricultural land, especially to the south of the city. On the south-west side inside the city, there are agricultural land, and we can observe large patches of forested areas. To the east and west of the city, there were wastelands referred to as "Khad". The industrial area, located to the east of the city, has limited expansion, and there were agricultural patches nearby. Looking at the transition from 2001 to 2021 (Plate 2), we observed a decline in agricultural land, a considerable increase in settlements surrounding the industrial zone, and some encroachment onto previously unused land in northeast of Kathua city. Urbanization seems sporadic, particularly in former agricultural zones. By 2021, agricultural land appears to have been entirely replaced by urban and rocky landscapes. This data underscores the urgent need for sustainable urban planning and land management strategies in Kathua city to mitigate the adverse effects of urban sprawl, preserve green spaces, and ensure food security amidst rapid urbanization. Additionally, it highlights the importance of further research to understand the underlying factors driving these changes and to formulate effective policies for balanced and inclusive urban development.

Reasons for Urban Sprawl

Population Growth

The population of Kathua city has experienced significant growth over the past two decades. If we refer to the 2001 census data, the population of Kathua was 51,034, and by 2011, it had increased to 59,866. This means that there was a 17 percent increase in population from 2001 to 2011. According to the predictions for the 2021 census, the population of Kathua city is estimated to be 77,000, which represents a 28% percent increase over the previous decade. With the increasing population, there's a rising demand for housing. In Kathua city, people are converting nearby agricultural areas into residential zones to meet this demand. This transformation is not only about housing but also leads to the development of shops and other amenities in these areas to support the growing population. Thus, leads to urban settlement growing in the outskirts of the city (Fig. 2).

Infrastructure Facilities

Kathua city functions as a central business unit within the district, acting as its headquarter. This central role ensures that various essential facilities such as quality education, markets, employment opportunities, medical services, and more are readily available. This accessibility makes Kathua a focal point for nearby rural and fringe areas, as residents rely on the city for their day-to-day activities and needs.

Transport and Connectivity

The development of many roads, bridges, and connecting lanes has significantly contributed to the growth of fringe areas. This infrastructural development has enhanced connectivity between the city outskirts and rural areas, surpassing the connectivity to the city center. For example, the Keerian Gandial Bridge has connected the Keerian area to Kathua city, reducing the distance from 45 kilometers to just 8.4 kilometers. Similarly, due to the construction of a paved road in Nagri village, there has been substantial development, leading to the establishment of various market areas. Apart from this, Kathua's Fringe area (Lakhanpur) is the Gateway of Jammu & Kashmir, connecting Punjab and Jammu.

Employment Opportunities

Table-1: Kathua City: Distribution of Workers

S. No.	Indicator	2001	2011
1	Total Workers	15542	17977
2	Primary Sector	999	787
3	Secondary Sector	170	185
4	Other Workers	14373	17005

Source: Census of India, 2001 and 2011

Employment opportunities fuel urban sprawl as people seek jobs and housing in thriving areas. Commuters' preferences also play a role, with individuals favouring accessible workplaces. As job opportunities and industries grew in the urban areas of Kathua, there is a rising need for housing close to these job centres (Table-1). This demand for housing in proximity to work led to the urban areas expanding outward, encroaching into the previously undeveloped fringe regions surrounding the city.

Additionally, it's not just the local population that benefits from these job centres. People from outer states and fringe areas are also drawn to the city centre because of the employment opportunities it offers. This influx of workers from surrounding regions seeking jobs in the city further emphasizes the importance of urban centres as employment hubs and contributes to the overall urban sprawl phenomenon.

Industrial Units

Industrial growth in the outskirts of Kathua city is driven by the accessibility and affordability of land in these areas. This results in the establishment of commercial and industrial zones, subsequently drawing in both workers and residents to these regions. A thriving industrial estate, SICOP (State Industrial Cooperation), is home to various enterprises, including the Chenab Textile Mill (CTM), a unit of the Birla Group, which was founded in the 1970s. These industries have played a significant role in fostering employment opportunities and fostering the development of Kathua. Additionally, the area hosts several other factories engaged in the production of cement, iron, and food products (Table-2 and 3).

Table-2: Kathua City: Distribution of Workers in Industrial Units

S. No.	Industrial Sector	Total Workers
1.	Chenab Textiles Kathua	5000
2.	Shiva Steel Rolling Mills	47
3.	Aman Paper Mills	34
4.	Asian Cements Ltd	50
5.	Vickson Sports Industries	11
6.	Varun Roller Mills	50
7.	Chenab Agro-Chem Ltd	37
8.	Sri Ram Foundary	14
9.	Rana Enterprises	36
10	J&K Cement Corporation	45
11	Bharat Small Arms Pvt Ltd	25

Source: <https://kathua.nic.in/industries>

Migration

Table-3: Kathua City: State of Origin of Migrant Workforce

State	Population	%age
Chhattisgarh	2192	80.59
M.P.	200	7.35
Odisha	150	5.51
West Bengal	80	2.94
Punjab	50	1.84
U.P.	48	1.76
Total	2720	100

Source: <https://www.jiarm.com/June2014/paper15182.pdf>

With the development of the industrial sector in Kathua and the presence of the Chenab Textile Mill, people from other states like U.P, Odisha, Chhattisgarh etc. began migrating to this city. Simultaneously, residents of other rural areas such as Billawar, Bani, and Basholi also migrated to the city's fringe areas in search of better opportunities, including education, employment, and improved living standards. Additionally, the construction of the Ranjit Sagar Dam led to the resettlement of people from the Basholi area, who settled in Kathua city (areas like Hatlimorh and Rajbagh) and its outer regions.

Effects of Urban Sprawl

Urban sprawl in Kathua city has resulted in several issues impacting daily life, the environment, and infrastructure. The uncontrolled expansion has led to severe traffic congestion, especially on key routes like the city centre to Hatli Morh, increasing commute times and causing frequent gridlocks. Additionally, air quality has significantly deteriorated, with PM2.5 levels exceeding World Health Organization guidelines by 7.4 times, posing serious health risks. Water pollution is another concern, with bodies like the Magar Khad contaminated by industrial effluents and untreated sewage. The rapid urbanization has also led to the conversion of agricultural land into residential and commercial spaces, reducing the region's green cover and threatening food security. This encroachment disrupts the local

ecosystem, causing soil degradation and loss of biodiversity. Public transportation infrastructure remains inadequate, forcing residents to rely on private vehicles, further contributing to traffic congestion and pollution. This lack of accessible transport options disproportionately affects marginalized groups, limiting their access to essential services. Addressing these issues requires a more sustainable urban planning approach and enhanced infrastructure.

Suggestions

In pursuit of smart growth, it is imperative to prioritize compact, mixed-use development and walkable neighbourhoods, thereby optimizing land use and diminishing reliance on long commutes and car dependency. A key aspect involves fostering affordable housing options within urban cores, catering to low-income workers and curbing the necessity for extended travels. Expansion and enhancement of public transportation systems, including buses, subways, and commuter trains, offer sustainable alternatives to driving, effectively easing traffic congestion and environmental strain. Green spaces and parks like Dream Park and K.K Birla Park play a crucial role in elevating urban living standards while combatting environmental degradation. Strengthening environmental regulations ensures the preservation of natural habitats and fosters sustainable developmental practices. Encouragement of alternative transportation modes, such as biking and pedestrian-friendly infrastructure, not only reduces automobile reliance but also promotes healthier lifestyle choices. The promotion of telecommuting and flexible work arrangements presents a viable solution to reduce daily commutes, subsequently mitigating traffic congestion and carbon emissions. Additionally, initiatives focused on historic preservation safeguard the cultural richness of urban areas. By offering incentives to developers and businesses committed to revitalizing urban cores and embracing sustainable strategies, we can foster a resilient and vibrant urban landscape, enriching the lives of inhabitants and ensuring a sustainable future for generations to come.

Conclusion

In conclusion, urban sprawl in Kathua city is a complex phenomenon that has unfolded over the years, driven by factors such as population growth, economic development, and rural-to-urban migration. While it has brought about certain benefits, such as economic opportunities and improved infrastructure, it has also given rise to a host of challenges. The expansion of the city has led to the depletion

of agricultural land, forest, impacting food security and livelihoods. Environmental concerns, including deforestation and habitat loss, have emerged as significant issues, affecting the region's biodiversity. The strain on infrastructure and services has resulted in inefficiencies and disparities in access to basic amenities. Addressing the problems associated with urban sprawl in Kathua city necessitates a well-planned and sustainable approach that balances development with environmental preservation and social equity. It is crucial for local authorities, urban planners, and the community to collaborate effectively to manage and mitigate the adverse impacts of sprawl. By doing so, Kathua can strive for a more inclusive, environmentally friendly, and prosperous urban future while preserving its unique cultural and natural heritage.

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CONSUMER PERCEPTION ON POPULARITY AND SOCIO-CULTURAL INFLUENCES OF NORTH-EAST INDIAN CUISINES IN GUWAHATI CITY, ASSAM

Jyotishma Bordoloi and Prof. Madhushree Das

Abstract

Northeast India, comprising the states of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura, is well recognised for its abundant ecological and cultural diversity and rich culinary heritage. The study examines the consumer's perspective on the popularity of Northeast Indian ethnic cuisines in Guwahati, focusing on factors contributing to the widespread acceptance and cultural values shaping the tastes and preferences for food within the city. A descriptive survey design is adopted to gather data from 300 residents of the city through structured and semi-structured questionnaires, in-depth interviews and focus group discussions. Statistical tools such as descriptive statistics and inferential statistics are employed to identify patterns in consumer behaviour. The findings reveal that the consumers are highly aware and knowledgeable about these cuisines, with Assamese cuisine being the most favored, followed by Naga and Manipuri cuisines. The key factors driving popularity among consumers include taste, cultural heritage, and health benefits, while family and social networks significantly influence food choices. The study reveals the most preferred consumption location and frequency of consumption of the cuisines in the city by the consumers. The study colludes towards indigenous dishes of the region in the city. Consumers and media, particularly social media and food blogs play a crucial role in promoting these cuisines. The study highlights the importance of leveraging cultural preservation, social connections, and media representation to enhance the acceptance and enjoyment of Northeast Indian culinary traditions in Guwahati.

Introduction

Northeast India with its special distinct topography of culture is a trove of indigenous knowledge systems on agriculture, food, medicine and natural resource management. Made up of the Seven Sister states of India, Arunachal Pradesh,

Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura; along with a brother state Sikkim, it accounts for about 8% of India's total geographical area, with a population of about 40 million, comprising about 3.1% of the total Indian population (Mao and Hynniewta, 2000).

Northeast India consists of seven Northeast India consists of seven sister states of India, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura; along with a brother state Sikkim. The region accounts for about 8% of India's total geographical area, with a population of about 40 million, comprising about 3.1% of the total Indian Population (Mao and Hynniewta, 2000). This region's ethnic cuisines intertwine with the local cultural practices, geography and history providing a unique gastronomic experience that represents the native heritage. The cuisine of Northeast India is characterized by simple cooking techniques using local ingredients and distinct flavoring styles. The food is typically less oily and spicy compared to other Indian cuisines. They use fermented products, bamboo shoots, and a variety of herbs and greens (Devi 2014). Guwahati, being the largest city in Assam, and gateway to the Northeast serves as an intersecting point for cultures across the Northeast. This cultural amalgamation has led to the widespread acceptance and popularity of Northeast Indian cuisines in the city. According to the Theory of Reasoned Action (TRA), consumer preferences are influenced by attitudes towards taste, cultural importance, perceived health benefits, along with social influences such as recommendations (Roseman, Kim, & Zhang, 2013). The ethnic cuisines of Northeast India are not just about sustenance; they symbolize cultural identities and communities. The traditional methods of preparation and the use of indigenous ingredients not only preserve the cultural heritage but also contribute to the maintenance of biodiversity and ecological balance (Tamang & Tamang, 2009). Media influence, particularly through social media as well as food blogs has become increasingly significant in determining consumer food choices. This is because family members or friends often recommend new culinary practices (Nakayama & Wan, 2019; Middleton & Evans, 2013). The main aim of this paper is to study the contribution of consumer preferences to the popularity of ethnic cuisines of Northeast India in Guwahati city. It focuses on the factors that contribute to their widespread acceptance and the cultural influences that shape culinary preferences in the city.

Study Region

Guwahati, the largest city in Assam and one of India's fastest-growing urban centers, is geographically positioned at $26^{\circ} 11' 0''$ N latitude and $91^{\circ} 44' 0''$ E longitude, covering an area of 216 square kilometers (Census of India 2011). According to the 2011 Census of India, Guwahati had a population of 963,429, with 502,255 males and 461,174 females. The city boasts a high literacy rate of 91.11%, with male literacy at 92.89% and female literacy at 89.16%. Of the total literate population, 426,401 are males, and 372,325 are females. These statistics highlight Guwahati's significant role as a key educational and cultural hub in North-East India.

Objectives

- (1) To assess, identify and determine the levels of awareness, popularity, frequency of consumption and preferences of N.E Indian cuisines among consumers of Guwahati.
- (2) To explore how cultural identity, social networks, and media influence the popularity and acceptance of the cuisines in Guwahati.

Database and Methodology

The research design adopted for the study is a descriptive survey to collect consumer data on Northeast Indian cuisines. The target population for this study was the consumers of Guwahati. A total of 300 residents were selected to participate in the study. Stratified random sampling was adopted in this study to ensure that the sample represented the population. The population was divided into strata based on key demographic variables such as age, gender, education, and occupation. The samples were then randomly drawn from each stratum. For data collection, structured and semi structured questionnaire was developed. Online survey (using tools like Google Forms) and physical distribution of questionnaires in selected areas, in depth interviews and focus group discussions were adopted for data collection. The discussions helped to identify common themes and patterns in consumer behaviour. Statistical tools like descriptive statistics, such as mean, percentage and frequency distributions are calculated to summarize the demographic profile, awareness levels and consumption patterns of the respondents. Inferential statistics, including correlation analysis, are employed to examine the relationships between various factors influencing the popularity of cuisines.

Results and Discussion

Key Demographics

The demographic profile is crucial for understanding the factors contributing to the popularity of these cuisines in Guwahati. The average age of the respondents is 35 years. The gender distribution among the respondents is evenly split, with 50% male and 50% female participants. A significant portion of the respondents hold a graduate degree (40%), postgraduates (30%) and another 30% in other educational categories. A large proportion of the respondents are working professionals (40%), followed by students (30%), with a smaller percentage engaged in business (20%) and other occupations (10%).

- (1) **General Awareness:** A significant majority (85%) of the respondents have heard of Northeast Indian ethnic cuisines. This high level of awareness indicates that these cuisines are well-known among the residents of Guwahati.
- (2) **Specific Knowledge:** 70% of the respondents can name at least one Northeast Indian ethnic dish. This shows a relatively high level of specific knowledge, suggesting that these cuisines are not only recognized but also familiar to many residents. The ability to name specific dishes reflects a deeper understanding and appreciation of these cuisines.
- (3) **Consumption Locations:** Restaurants (51%) and Home (25%) are the primary places where these cuisines are consumed. Festivals (21%) and Social Gatherings (17%) are also notable venues for enjoying these foods. Restaurants are a popular choice for consuming due to convenience without the need for extensive preparation at home. Eating at home provides ability to customize dishes according to own dietary preferences while festivals and social gatherings provide spaces for communal sharing of meals.
- (4) **Sources of Information:** Family (34%) and Friends (32%) are the top sources of information about these cuisines. Media (25%) and Restaurants (20%) also contribute significantly. Travel (15%) and other sources (5%) have a limited influence, but still contribute to expanding culinary knowledge.
- (5) **Popularity Factors:** Taste is the most significant factor (75%) driving the popularity of Northeast Indian cuisines. Cultural Heritage (60%) and Health Benefits (49%) are also significant drivers, reflecting a deeper connection to well-being. Availability (40%) and recommendation (45%) influence interest, while Media Influence (31%) and other factors (10%) have lesser impact in shaping preferences (Table-1 and Fig. 1).

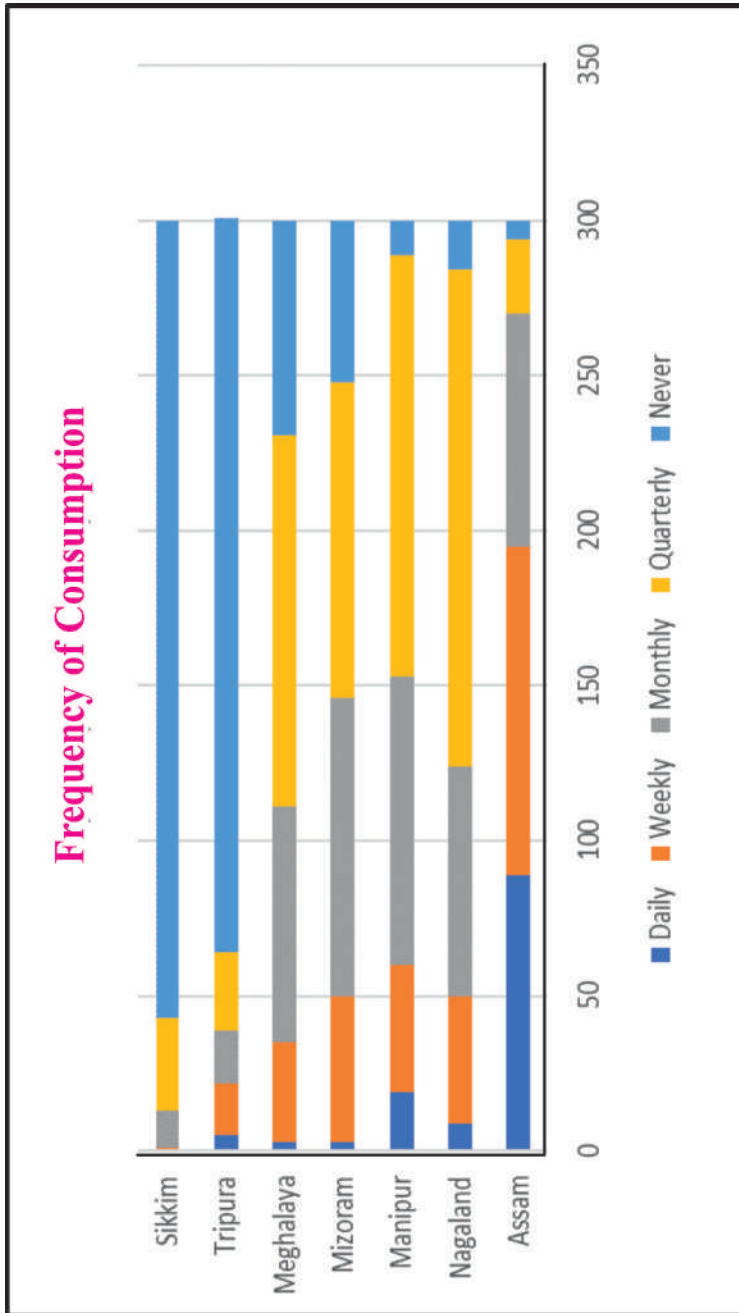


Fig. 1

Table-1: Key Demographics and Factors Influencing Northeast Indian Cuisine Consumption in Guwahati City

Category	Sub Category	No. of Respondents	Percentages
Demographic Profile	Age (Mean)	35	
	Gender (Male)	150	50%
	Gender (Female)	150	50%
	Education (Graduate)	120	40%
	Education (Postgraduate)	98	30%
	Education (Others)	82	30%
	Occupation (Students)	90	30%
	Occupation (Professionals)	120	40%
	Occupation (Business)	61	20%
	Occupation (Others)	29	10%
Awareness Levels	Heard of NE Indian cuisines	255	85%
	Can name at least one dish	210	70%
Consumption Locations	Home	75	25%
	Restaurants	152	51%
	Festivals	63	21%
	Social Gatherings	50	17%
Sources of Information	Family	102	34%
	Friends	95	32%
	Media	75	25%
	Restaurants	60	20%
	Travel	45	15%
	Others	15	5%

Contd...

Popularity Factors	Taste	225	75%
	Health Benefits	150	49%
	Cultural Heritage	180	60%
	Availability	120	40%
	Recommendations	135	44%
	Media Influence	90	31%
	Others	30	10%

Source: Primary Survey, 2024

The graph illustrates the varying levels of popularity and frequency of consumption of the different cuisines among the residents of Guwahati. Assamese cuisine is highly consumed regularly, indicating strong cultural integration and preference. Very few people consume it less frequently or not at all, showcasing its popularity. Cuisine of Nagaland shows moderate regular consumption, with a significant number consuming it monthly. A large number consume it quarterly, suggesting that while it is appreciated, it might be less integrated into daily routines. Manipuri cuisine shows moderate regular consumption, higher than Nagaland in daily and monthly categories. High quarterly consumption, indicating interest but less frequent integration into regular diets. The cuisine of Mizoram shows limited daily consumption, with better representation in weekly and monthly categories. It also shows significant quarterly consumption, but also a notable number who never consume it, indicating mixed reception. Cuisine of Meghalaya shows low daily and weekly consumption, with some presence in the monthly category. High quarterly consumption and never consumption, suggest lower popularity and occasional interest. Tripuri cuisine shows minimal regular consumption, indicating very low popularity or awareness. Sikkimese cuisine show extremely low regular consumption and it is predominantly never consumed, indicating very low popularity or awareness.

Positive Correlations: Taste and recommendations (0.135) show moderate positive relationship, taste and cultural heritage (0.094) and health benefits and availability (0.122) show slight positive relationship, taste and media influence show minor positive relationship (0.076).

Negative Correlations: Health benefits and cultural heritage (-0.068) shows minor negative relationship. Many factors show weak or negligible correlations, indicating independent contributions. The strongest positive correlation between taste and recommendation indicates that taste significantly influences recommendations.

Consumer Preferences on Popular Authentic Cuisines

Table-2: Consumers Cuisine Rank based on Preferences

Sl. No	Cuisine	Mean Rank	Rank	Inferential Statistics
1	Assam	1.7	1	N=300
2	Nagaland	1.5	2	df=6
3	Manipur	2.9	3	df=6
4	Mizoram	4.5	4	p=0.000 **p<0.01, significant at 1% level
5	Meghalaya	4.7	5	
6	Tripura	5.8	6	
7	Sikkim	7	7	

p=0.000 **p<0.01, significant at 1% level

Source: Primary Survey, 2024

Assamese cuisine with mean rank of 1.7 is the most preferred among the residents of Guwahati followed by Naga (1.5), Manipuri (2.9), Mizo (4.5), Khasi (4.7), Tripuri (5.7) and lastly Sikkimese (7) being the least popular dish. Based on the qualitative study conducted among the consumers, the study reveals a variety of authentic Northeast Indian cuisines popular in Guwahati (Table-2). Assamese cuisine, celebrated for its simplicity and health benefits, includes signature dishes Khar (sundried feather-back banana), Pitika (mashed potato/ eggplant, pumpkin) and OuKhatta (sweet and sour chutney, made from elephant apple and jaggery). The non-vegetarian dishes include Masor Tenga (fish curry made with gourd and tomatoes), Patot Diya Maas (marinated fish wrapped in banana leaves and steamed), Lai Xaak Gahori (pork prepared with mustard greens) and Baanhgajor Lagot Kukura (chicken and bamboo preparation) and Paror Mangxo (curry made with pigeon meat). From Nagaland, dishes like Smoked Chicken with Akhuni (smoked chicken boiled with fermented beans and naga garlic) and Smoked Pork Dry Bamboo Shoots (smoked pork cooked with bamboo shoots, ginger, and naga garlic) are particularly favored. The traditional Akhuni Chutney, made from fermented beans, green chili, and tomato paste, is also popular among consumers. Additionally, local fish cooked in Naga style with Naga herbs, local chicken Naga curry (local chicken cooked with mashed tomato and potato curry) and Smoked Pork Anishi (pork with dried yam leaves curry) further add to the delicacy of Naga cuisine in the city. Jadoh, a dish where red rice prepared with pork meat is a local favorite. In Tripura, Mui Borok, smoked fish and vegetables dish has gained popularity. Mizoram's famous food

includes Sanpiau (snack prepared with rice porridge served with chicken or pork) and Bai (meat with bamboo shoot with vegetables). Manipur's most celebrated dishes in Guwahati include Eromba (a chutney made of boiled vegetables and fish), Fish Atoiba (fish in spicy curry), and Singju, a refreshing Manipuri salad and Kangshoi, a vegetable stew. The black rice pudding known as Chak Hao Kheer also reflects the distinct culinary heritage of Manipur. The cuisines of Sikkim are relatively unknown in the city with its ethnic dishes yet to gain popularity in the city. The important observation made is that rice is a dominant ingredient in all states' foods. Rice is a staple in North East India hence consumed by its people in various forms (Longvah & V.S.S 2020). Overall, the survey provides valuable insights consumer preferences of indigenous dishes, highlighting the dominance of Assamese cuisine and the growing interest in Naga and Manipuri foods based on consumer preferences. The less familiar cuisines from Meghalaya, Mizoram, Tripura, and Sikkim present increased exploration opportunities.

Influence of cultural identity, social networks, and media on North East Indian cuisines

Cultural Identity

- (1) Connection to Heritage: The concept of cultural capital of Pierre Bourdieu explains how cultural knowledge and practices function as a form of capital that one uses to maintain cultural heritage (Bourdieu, 1986). Cultural capital is deeply embedded in traditional dishes, which serve as a means to preserve and celebrate one's heritage.
 - (a) Example: Assamese participants highlighted the importance of dishes like Khar and Masor Tenga in their daily lives and during festivals like Bihu they focus on traditional food items.
 - (b) Quote: "I consider eating Assamese food my way of connecting to my roots. Sira, doi, cream, hurting along with luci torkari is the perfect combination for my taste buds during Bihu. It goes beyond taste; it's about upholding our traditions." (Fig. 2)
 - (c) Observation: During Bihu, traditional dishes are prepared and shared among community members, strengthening cultural bonds.
- (2) Influence of Festivals: Clifford Geertz's interpretive theory of culture posits that cultural practices, are acts of symbolic communication that reinforce community bonds and cultural identity (Geertz, 1973). These acts serve as

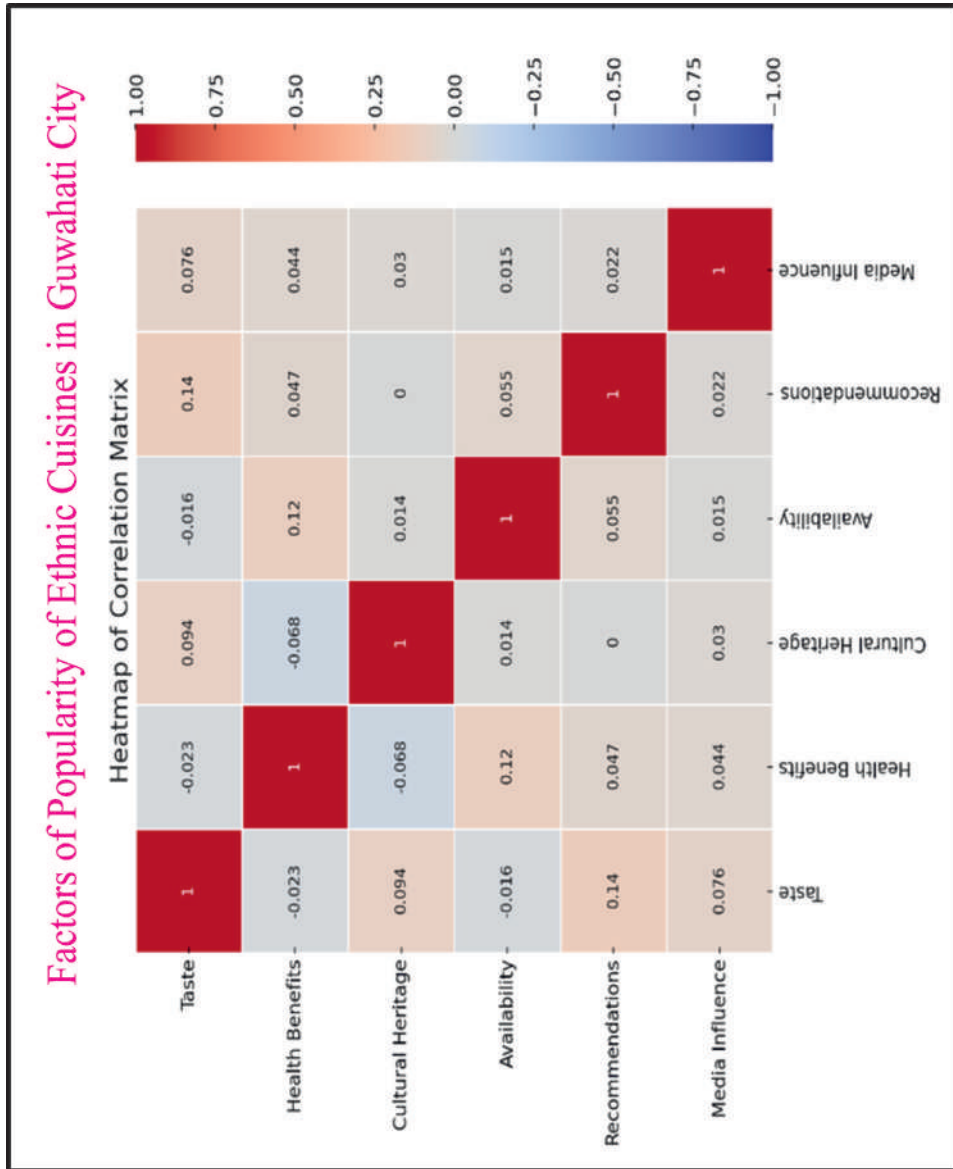


Fig. 2

a collective representation of a community's values and traditions. Cultural festivals are mentioned as key occasions where traditional foods are prepared and consumed, reinforcing cultural practices.

- (a) Example: Consumers from Nagaland highlighted that dishes like Smoked Pork with Anishi are central to their cultural celebrations.
- (b) Quote: “Smoked pork together with bamboo shoots is something we cannot miss during our tribal festivals because it reminds me home. My Assamese friend loved akhuni when I served him with rice!”
- (c) Observation: The preparation of traditional dishes during festivals serves as a cultural reminder and a way to pass traditions to younger generations.
- (d) Insight: The city has seen a rise in the trend of ethnic fairs and festivals being celebrated. Food festivals such as Rongali Bihu Mela and Mongolian Food Festival showcase food from across North East India.

Media Influence

- (1) Social media: Agenda-setting theory, developed by Maxwell McCombs and Donald Shaw, explains how media, by highlighting certain issues and topics, influences public perception and priorities (McCombs & Shaw, 1972). Social media platforms like Instagram, Facebook and YouTube are highly responsible for peoples’ choice of food. These recipes are visually attractive and easily accessible thus encouraging people to try new dishes.
 - (a) Example: Consumers often mentioned following food bloggers and influencers who have Northeast Indian cuisines.
 - (b) Quote: “I follow many food bloggers who write about cooking Northeast Indian dishes. Their reviews and pictures make me want to try these dishes. I have learned many Assamese cuisines from Hiranya Jyoti Das @foodiehiranya foodblog on Instagram.”
 - (c) Observation: High-quality images and detailed reviews on social media platforms make unfamiliar cuisines more approachable and desirable.
- (2) Television and Food Blogs: Albert Bandura’s social learning theory explains how people learn new behaviors and skills by observing others, particularly through media (Bandura, 1977). Cooking shows and food blogs have played a significant role in the introduction of new cuisines. They come with recipes, cultural context and cooking methods that enable beginners to start experimenting meals of different kind.

- (a) Example: One consumer explained how they learned how to cook Eromba from a popular show on cooking.
- (b) Quote: “A cooking show taught me how to make Eromba. It’s one of my favorite foods now. Cuisine Show- Just a Taste is an amazing entertainment platform I follow on Youtube”
- (c) Observation: Media content that includes cultural context alongside cooking tips makes it easier for viewers to appreciate new dishes.

Social Networks

- (1) Family Influence: Social network theory examines how social structures and relationships influence behaviors and attitudes (Granovetter, 1973). The primary influence on food choices was identified as family. Several participants first tasted Northeast Indian cuisines at family events, which created a sense of familiarity and acceptance.
 - (a) Example: A person from Assam narrated how he discovered Naga cuisine through his family friend.
 - (b) Quote: “We love smoked pork in my family, especially during our family dinners. Naga Kitchen, one of the authentic restaurants is my children’s favourite”
 - (c) Observation: Family gatherings are avenues for cultural exchange and introducing new foods and recipes to each other.
- (2) Peer Recommendations: Mark Granovetter’s theory of the strength of weak ties highlights how acquaintances and casual social interactions can introduce individuals to new ideas and practices, including food preferences (Granovetter, 1973). Friends and social gatherings also play a crucial role in trying new cuisines. Example: A respondent mentioned that they had their first taste of Jadoh when they visited their friend’s house in Shillong.
 - (a) Quote: “I remember having my first taste of Jadoh at my friend’s place; it was so different. There are many small food outlets on the roadside on my way to Cherrapunjee where I tasted Jadoh and I loved it”
 - (b) Observation: Social settings provide a conducive atmosphere where individuals can explore and embrace new culinary encounters as well as have them accepted by society. Cultural heritage and festivals reinforce

traditional food preferences while recommendations from friends and families encourage to try out such new delicacies. Media, particularly social media, and food blogs, significantly impact food choices by providing exposure to various recipes that are easily available.

Conclusion

This research demonstrates the high awareness and knowledge of Northeast Indian ethnic cuisines among Guwahati residents, with the highest preference for Assamese cuisine, followed by Naga and Manipuri cuisines. The popularity of these foods is driven by taste, cultural heritage, and health benefits while family and social networks play crucial roles in introducing and promoting these foods. Cultural identity can be traced to traditional food items prepared during festivals and family gatherings which helps to strengthen the bond in the community. Media influence, particularly through social media, cooking shows, and food blogs, significantly impacts dietary selections by providing exposure and making unfamiliar dishes more accessible and desirable. Further research could be carried out to examine the economic consequences of Northeast Indian cuisines on local businesses and also how culinary tourism plays a crucial role in promoting Northeast Indian cuisines.

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CHALLENGES OF WOMEN ENTREPRENEURS IN FLORICULTURE OF PURBA MEDINIPUR DISTRICT IN WEST BENGAL, INDIA

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Abstract

Floriculture industry is considered as one of the most significant flourishing industries in India. The role of women is particularly effective in producing flowers and adding value to floriculture products. The rapid development of floriculture in India has opened up a great opportunity specially for peri-urban and rural women to become successful entrepreneurs as it is highly profitable. In this context, an attempt has been made in this paper to analyse the challenges of women entrepreneurs in floriculture in Purba Medinipur district, West Bengal. Primarily, based on the concentration index of flowers (Bhatia, 1965), Purba Medinipur district has been divided into high, moderate and low flower concentration zones. A total of 180 women entrepreneurs involved in floriculture have been surveyed from the high concentration zone of flowers. The 5-point Likert scale (Likert, 1932) has been used to collect perceptions of women entrepreneurs about the major challenges of entrepreneurship in floriculture. Consensus measure (Tastle & Wierman, 2007) and Consensus strength (Tastle et al., 2005; Tastle & Tastle, 2006) have been used to determine the degree of agreements about the major challenges of women entrepreneurs in floriculture. Out of the 25 challenges of women entrepreneurs, the highest consensus strength of women entrepreneurs has been found in high fluctuations in demand and price of floricultural products followed by lack of access to organized flower markets, high interest rates of credit for informal sources, lack of storage facilities and increase in pests and diseases outbreaks. The lowest consensus strength of women entrepreneurs has been observed in remote location of flower markets followed by adverse effects of fog and hailstorm on floriculture and high transportation cost.

Introduction

The demand of flowers is increasing rapidly in the domestic and foreign markets. There is an immense potential for development of entrepreneurship in

floriculture in India. There are many opportunities available in entrepreneurship such as generation of employment and income, value addition of flowers and scope for development of flori-tourism. Women have a special role in planting, nurturing and picking flowers as well as in value addition and marketing. Entrepreneurship in floriculture has the immense potential to women to secure their lives and livelihoods. The successful inclusion of women in entrepreneurship in floriculture will lead to their empowerment, which will ultimately reduce gender inequality in the society. Naturally, entrepreneurship in floriculture has brought great opportunities to peri-urban and rural women in India. Some studies have been done in various aspects on women entrepreneurship in floriculture at national and international levels. In Sri Lanka, studies on the current status and future prospects of floriculture industry (Padmini and Kodagoda 2017), drivers and barriers of women entrepreneurs in floriculture (Dayarathne et al., 2017) and in Bangladesh, challenges and prospects of floriculture industry (Rakibuzzaman et al., 2018) are mentioned. Floriculture and livelihoods of rural women in Gujarat (Agoramoorthy and Hsu, 2012), the status, limitations and future prospects of floriculture (Chawla et al. 2016), economic empowerment of women through floriculture entrepreneurship (Janakiram et al. 2018), entrepreneurial behaviour of nursery owners in Andhra Pradesh (Bhaska et al. 2019) and current status and export potential of floriculture (Anumala and Kumar, 2021) are some of the key aspects of research of this theme in Indian context. There is still a lacuna at micro-level research on the perspectives of all the possibilities of women entrepreneurship in floriculture. Therefore, an in-depth study of the challenges faced by women entrepreneurs in floriculture is needed, especially to understand how to achieve real success for women in this entrepreneurship and how to ensure their involvement to a greater extent. In this context, the major challenges of women entrepreneurs in floriculture in Purba Medinipur district in West Bengal have been analysed in this paper.

Study Region

Purba Medinipur district lies in the southern part of West Bengal is considered as the study area. The district lies in the Lower Gangetic Plain of West Bengal and surrounded by Bay of Bengal in the south. Topographically, the district is divided into a) Flat plains located in the north, east and western parts and b) Contai Coastal plain situated in the southern part of the district (Census of India, 2011). The development of floriculture is particularly noticeable in the northern plain of the district. The district covers an area of 4,713 sq. km. with total population of 50,95,875 persons (Census of India, 2011). Extensive alluvial plains,

tropical monsoon climate, fertile soils and available irrigated water are favourable for the production of large varieties of good quality flowers. Along with these, farmers have a long tradition of being involved in floriculture in this district. The flower growers in this district claim that they were the first to start commercial flower cultivation at large scale in West Bengal. The principal flowers in this district are marigold, tuberose, rose, chrysanthemum, gladiolus and jasmine. In 2021-22, in both the terms of area and production of flowers, Purba Medinipur district ranked second in West Bengal (GoWB, 2022a). In 2021-22, area under flowers in Purba Medinipur district has been recorded as 5965 hectares accounting for 19.86 % of the total flower producing area in West Bengal (GoWB, 2022a). Loose flowers production in Purba Medinipur district has been reported as 15299 metric tonnes accounting for 20.41 % of the total loose flowers production in West Bengal in 2021-22 (GoWB, 2022a). Cut flowers production in Purba Medinipur district has been recorded as 68.372 crore sticks accounting for 22.28 % of the total cut flowers production in West Bengal in 2021-22 (GoWB, 2022a). Out of the total 25 Community Development (C.D.) Blocks in Purba Medinipur district, flowers are cultivated mainly in eight C.D. Blocks. Among these, only three C.D. Blocks i.e. Panskura, Kolaghat and Sahid Matangini account for 95.54 % of the total flowers producing area in Purba Medinipur district in 2021-22 (GoWB, 2022b). In this study, women entrepreneurs in floriculture have been surveyed from Panskura, Kolaghat and Sahid Matangini C.D. Blocks.

Objective

This paper has attempted to analyse the major challenges of women entrepreneurs in floriculture in Purba Medinipur district.

Database and Methodology

Secondary data have been collected from District Horticulture Office, Purba Medinipur district, Directorate of Horticulture, Government of West Bengal and Directorate of Horticulture, Department of Food Processing Industries & Horticulture, Government of West Bengal.

Flower concentration zones in the study area have been delineated following the method of crop concentration index (Bhatia, 1965).

Concentration index of flowers

$$\text{Concentration index of flowers} = \frac{\text{Area of flowers in a C.D.Block}}{\text{Area of all crops in a C.D.Block}} \div \frac{\text{Area of flowers in the entire district}}{\text{Area of all crops in the entire district}}$$

Based on literature review and pilot survey in the study area, 25 major challenges of women entrepreneurs in floriculture have been identified. 60 women entrepreneurs involved in floriculture from each C.D. Block in the high flower concentration zone (Panskura, Kolaghat and Sahid Matangini C.D. Blocks), i.e. altogether 180 women entrepreneurs have been surveyed in this study. Snowball sampling method has been used to select women entrepreneurs as the total population is unknown and it is quite difficult to identify and access women entrepreneurs in floriculture. Perceptions of women entrepreneurs in floriculture about the major challenges have been collected with the following 5-point Likert scale (Likert, 1932).

SD (Strongly Disagree) = 1; D (Disagree) =2; N (Neutral) =3; A (Agree) =4 and SA (Strongly Agree) = 5

Measure of consensus (Cns) has been applied to assess the degree of agreement about the challenges of women entrepreneurs in floriculture with the following method (Wierman & Tastle, 2005, p.76; Tastle & Wierman, 2007, p.538).

$$Cns(X) = 1 + \sum_{i=1}^n p_i \log_2 \left(1 - \frac{X_i - \mu_x}{d_x} \right)$$

Whereas:

p_i = Probability or frequency of each challenge (in Likert scale); X_i , ranges from 1 (SD) to 5 (SA); μ_x = Mean of X; d_x = Width of X ($d_x = X_{\max} - X_{\min}$), here, $d_x = 5 - 1 = 4$

Consensus values range from 0 (complete disagreement) to 1 (complete agreement).

The strength of consensus or consensus strength (sCns) has also been measured to assess the strength of association of each challenge of women entrepreneurs with the following method (Tastle et al., 2005; Tastle & Tastle, 2006, p.4).

$$Cns(X) = 1 + \sum_{i=1}^n p_i \log_2 \left(1 - \frac{X_i - 1}{2d_x} \right)$$

‘System width’ has been changed from d_x to $2d_x$ and μ_x is always taken as 1 and ‘the strength of consensus is based on the presumption that the mean value is “Strongly Agree,” and hence has a numerical value of 1’ (Tastle & Tastle, 2006, p.5).

Results and Discussion

Flower Concentration Zones in Purba Medinipur District (2021-22)

Of the total 25 C.D. Blocks in Purba Medinipur district, flower cultivation is concentrated in eight C.D. Blocks (Table-1 and Fig. 1). In the remaining 17 C.D. Blocks, floriculture is either nil or negligible. Based on the C.D. Block wise concentration index of flowers in 2021-22, the entire Purba Medinipur district has been divided into three flower concentration zones i.e. high, moderate and low.

- (i) High Flower Concentration Zone: Three C.D. Blocks namely Sahid Matangini, Panskura and Kolaghat have fallen into the high flower concentration zones with an index value more than 5.0. The highest concentration index of flowers has been observed as 8.792 in Kolaghat C.D. Block and the lowest concentration index of flowers as 5.649 in Panskura C.D. Block in this zone. These three C.D. Blocks account for 95.54% of the total flowers producing area in the district, for 100% of the total loose flowers and for 94.80% of the total cut flowers production in the district.
- (ii) Moderate Flower Concentration Zone: Only Tamluk C.D. Block has made the moderate flower concentration zone with concentration index value of 1.068.
- (iii) Low Flower Concentration Zone: Four C.D. Blocks namely Nandakumar, Mahisadal, Nandigram-I and Kanthi-III have fallen into the low flower concentration zone with concentration index value less than 1.0.

Challenges of Women Entrepreneurs in Floriculture

Out of 25 major challenges of women entrepreneurs in floriculture, the highest consensus score has been found for high fluctuations in demand and price of floricultural product (Cns=0.80) followed by high interest rates of credit for informal sources (Cns=0.78), high cost of inputs (0.75) and lack of access to organized flower markets (Cns=0.73). The lowest consensus score has been observed for remote location of flower markets (Cns=0.48) followed by high transportation cost (Cns=0.49) and negative effects of floods on floriculture (Cns=0.51) (Table-2). 25 challenges of women entrepreneurs in floriculture in terms of strength of consensus or consensus strength (sCns) have been analysed into the following four categories (Table-2). A. Challenges related to financial and production levels. Out of nine challenges related to financial and production levels of women entrepreneurs in floriculture, the highest consensus strength has been found for high fluctuations in demand and price of floricultural products (sCns=92.39%) followed by high

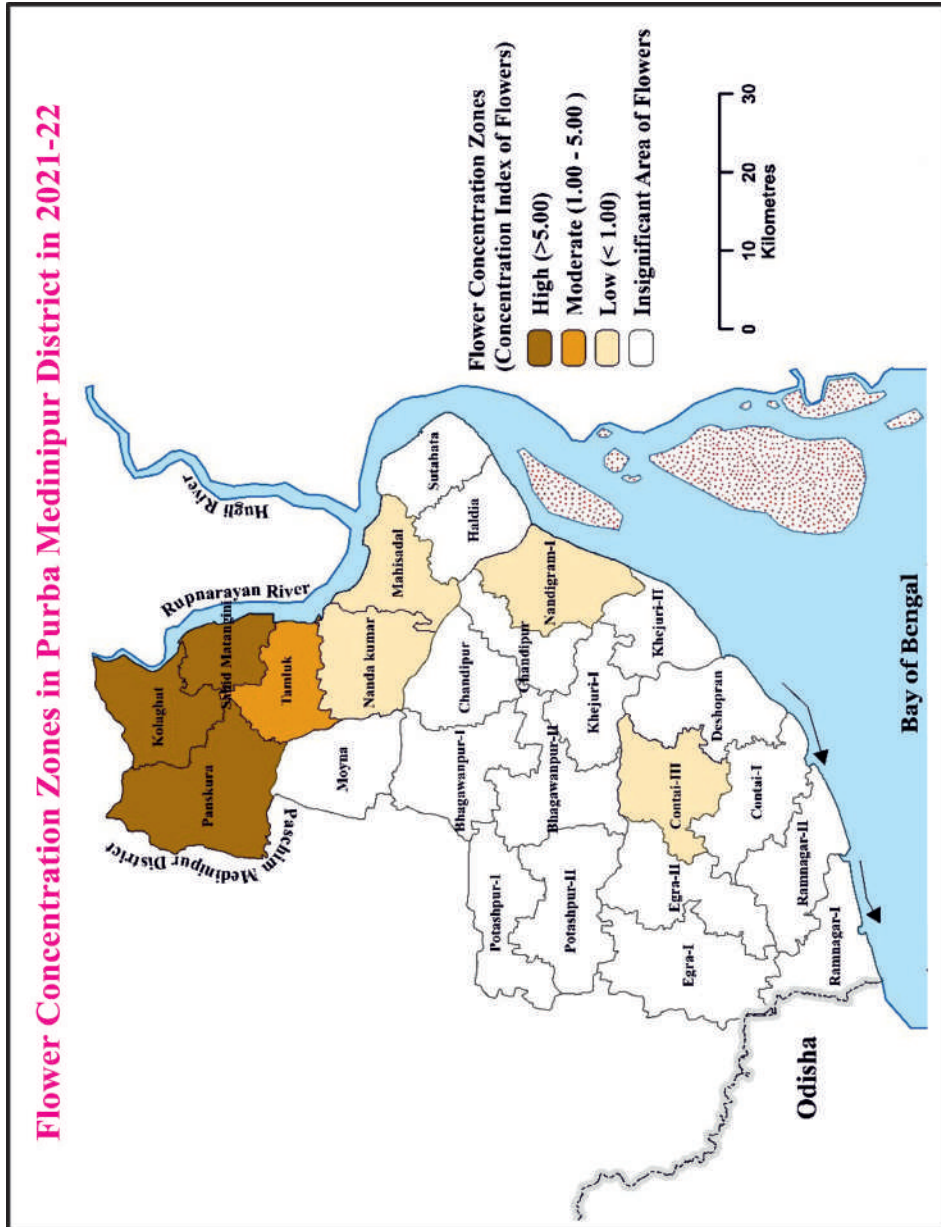


Fig. 1

Table-1: Area, Production and Concentration Index of Flowers in Purba Medinipur District (2021-22)

Sl. No.	C.D. Blocks	Gross Cropped Area (Hectares)	Area under Flowers (Hectares)	Production of Cut flowers (Crore Sticks)	Production of Loose flowers (MT)	Concentration Index of Flowers (Bhatia, 1965)
1	Tamluk	13505	165	0	506	1.068
2	Sahid Matangini	10374	996	3.416	3010	8.389
3	Panskura	40280	2604	40.797	5450	5.649
4	Kolaghat	20860	2099	24.159	6134	8.792
5	Nandakumar	14904	44	0	126	0.258
6	Mahisadal	21668	31	0	93	0.125
7	Nandigram-I	16932	13	0	38	0.067
8	Kanathi-III	20732	13	0	38	0.055
District Total		521186	5965	68.372	15395	1.000

Source: District Horticulture Office, Directorate of Horticulture, Government of West Bengal, Purba Medinipur district, West Bengal, India, 2022.

interest rates of credit for informal sources (sCns=89.75%), increase in pests and diseases outbreaks (sCns=88.73%) and high cost of inputs (sCns=87.51%). The lowest consensus strength under this category has been found for lack of access to credit facility (sCns = 72.22%) followed by non-availability of good quality seeds and saplings (sCns = 75.13%) and lack of extension services (sCns = 76.22%). Fluctuations in both the demand and price of floricultural products are considered as one of the biggest challenges to women entrepreneurs in floriculture. Seasonal variations in production of flowers in terms of quantity and quality differ widely with respect to demand. Although large quantity and high quality of flowers are produced in this district in winter season, sometimes the price of flowers goes down due to large volume of production. If flower production is too high during the festival season when the demand for flowers is high, the price of floricultural products may also decrease. In this district, there are barriers for women entrepreneurs in floriculture to access credit, especially from formal sources. As a result, in many cases, women entrepreneurs rely on the informal sources of credit at high interest rates. Pests and diseases outbreaks in floriculture are increasing due to climate change and climate variability and poor management of pests and diseases. Increasing incidence and outbreaks of pests and diseases in floriculture not only reduce flower production but also degrade flower quality. Flower producers often use excessive and powerful chemical pesticides and insecticides to protect flowers from disease and pest attacks. These agro-chemicals often remain in the flowers and these flowers fail to meet the quality standards set for sale in the international markets.

Challenges related to Climate Change, Climate Variability and Natural Calamities

Among the five challenges related to natural calamities, the highest consensus strength has been observed for negative effects of climate change and climate variability on floriculture (sCns=81.34%) followed by negative effects of floods on floriculture (sCns=78.37%) and adverse effects of waterlogging on floriculture (sCns=75.01%). The lowest consensus strength under this category has been found for adverse effects of fog and hailstorm on floriculture (sCns = 65.06%) followed by adverse effects of cyclones/ nor'wester on floriculture (sCns = 71.86%). Flowers cultivation is highly sensitive to climate change and climate variability. Variations in seasonality of temperature, rainfall and humidity significantly affect the flower productivity and flower quality. Climate change and climate variability largely control the extent of pest and disease outbreaks in flowers fields. Purba Medinipur district is considered as one of the most flood prone districts in West Bengal.

Table-2: Measures of Consensus (Cns) and Consensus Strength (sCns) on Major Challenges of Women Entrepreneurs in Floriculture in Purba Medinipur District (N=180 Women Entrepreneurs)

Major Constraints	SD (%)	D (%)	N (%)	A (%)	SA (%)	Cns(X)	sCns (X) (%)
A. Challenges related to financial and production levels							
1. Lack of access to credit facility	5.00	10.56	17.78	42.78	23.89	0.60	72.22
2. Lack of access to formal credit facility	2.22	6.67	15.00	26.67	49.44	0.62	81.89
3. High interest rates of credit for informal sources	0.00	1.11	2.78	43.33	52.78	0.78	89.75
4. High cost of inputs	0.00	1.11	9.44	40.56	48.89	0.75	87.51
5. Non availability of good quality seeds and saplings	5.00	11.67	13.33	33.33	36.67	0.56	75.13
6. Lack of skilled labourers	5.00	9.44	11.67	29.44	44.44	0.57	78.08
7. Increase in pests and diseases outbreaks	0.00	3.89	9.44	24.44	62.22	0.71	88.73
8. High fluctuations in demand and price of floricultural products	0.00	0.00	3.89	31.11	65.00	0.80	92.39
9. Lack of extension services	5.00	9.44	16.67	28.33	40.56	0.56	76.22
B. Challenges related to climate change, climate variability and natural calamities							
10. Negative effects of climate change and climate variability on floriculture	3.89	7.78	10.00	27.78	50.56	0.59	81.34
11. Negative effects of floods on floriculture	6.11	11.11	9.44	21.11	52.22	0.51	78.37

Contd...

12. Adverse effects of cyclones/nor'wester on floriculture	5.00	10.00	21.11	39.44	24.44	0.60	71.86
13. Adverse effects of waterlogging on floriculture	6.11	10.56	12.78	33.33	37.22	0.55	75.01
14. Adverse effects of fog and hailstorm on floriculture	7.78	15.00	20.56	43.89	12.78	0.58	65.06
C. Challenges related to infrastructure (market, storage and transport)							
15. Remote location of flower markets	11.11	19.44	22.22	25.56	21.67	0.48	61.56
16. Lack of access to organized flower markets	1.11	2.22	4.44	28.89	63.33	0.73	89.97
17. Exploitation by intermediaries	3.33	2.78	8.33	24.44	61.11	0.64	86.62
18. Lack of cold storage facilities	1.67	1.67	4.44	30.56	61.67	0.72	89.47
19. High transportation cost	7.78	11.67	20.56	24.44	35.56	0.49	71.07
D. Challenges related to family and society							
20. Overburden of household responsibility	3.89	8.89	11.11	15.00	61.11	0.54	82.58
21. Lack of access and control over resources	2.78	4.44	9.44	31.67	51.67	0.64	84.19
22. Male dominance in floriculture entrepreneurship	2.22	4.44	12.78	33.33	47.22	0.66	83.04
23. Gender discrimination in the society	2.78	6.67	11.67	36.11	42.78	0.64	80.90
24. Limited mobility of women	5.00	7.78	11.11	34.44	41.67	0.60	78.48
25. Lack of digital knowledge	4.44	7.78	13.33	31.67	42.78	0.60	78.65

Source: Calculated based on field survey data, August-December, 2023

The Kangsabati (also known as the Kasai or Cossye) and Keleghai rivers are mainly responsible for devastating floods in this district. In addition, the Rupnarayan and Rasulpur rivers are also cause floods in this district. In many parts of the study area, flower production is particularly hampered by waterlogging. During rainy season, waterlogging is a common occurrence in this region due to the high amount of clay in soil (Census of India, 2011). Being a coastal district, the catastrophic effects of cyclones are also noticeable in this region. Severe cyclonic storm Aila (2009), extremely severe cyclonic storm Fani (2019), super cyclonic storm Amphan (2020) and very severe cyclonic storm Yaas (2021) are the most devastating cyclones that had extensive damaging effects in this district.

Challenges related to Infrastructure (Market, Storage and Transport)

Among the total five challenges related to infrastructure, the highest consensus strength has been recorded for lack of access to organized flower markets (sCns=89.97%) followed by lack of cold storage facilities (sCns=89.47%) and exploitation by intermediaries (sCns=86.62%). The lowest consensus strength under this category has been reported for remote location of flower markets (sCns=61.56%) followed by high transportation cost (sCns=71.07%). Kolaghat flower market and Deulia flower market are the two main flower markets in Purba Medinipur district. Apart from these, there are many small flower markets in this district. All these flower markets are unorganized. Flowers collected in Kolaghat and Deulia flower markets are sent to Malik Ghat Flower Market, Kolkata, one of the largest flower markets in the Asia. Floricultural products are also sent from Kolaghat and Deulia flower markets to the different metro cities in India such as Mumbai, Delhi, Bangalore, Hyderabad, Ahmedabad and Pune. Flowers and floricultural products of this district are also exported abroad specially to the Middle East, South East and European countries. As there is no organized market in this district, women entrepreneurs are exploited through intermediaries. Due to the lack of cold storage for flowers, many times women entrepreneurs are forced to sell their flowers even if the market price is very low. In many cases, if the demand of flowers in the market is very low, the unsold flowers are thrown away due to the lack of cold storage facilities.

Challenges related to Family and Society

Among the total five challenges related to family and society, the highest consensus strength has been recorded for lack of access and control over resources (sCns=84.19%) followed by male dominance in floriculture entrepreneurship

(sCns=83.04%) and overburden of household responsibility (sCns=82.58%). The lowest consensus strength under this category has been found for limited mobility of women (sCns=78.48%) followed by lack of digital knowledge (sCns=78.65%) and gender discrimination in the society ((sCns=80.90%). More than 97% women entrepreneurs are jointly involved with male members in their family entrepreneurship in floriculture. As male dominance is more in the family, women have no control over land, inputs or financial resources. Women are also neglected in making decisions at various stages of entrepreneurship in floriculture. It is very stressful for women to give time to entrepreneurship after taking care of domestic works and child rearing. Gender inequality that exists in the society has a negative impact on women's entrepreneurship in floriculture.

Conclusion

Purba Medinipur district has huge potential for expansion of women entrepreneurs in floriculture. Due to the long tradition of floriculture and conducive agro-ecological conditions, Purba Medinipur district produces good quality flowers which are in great demand at national and international markets. All kinds of challenges need to be solved to bring more success in women's entrepreneurship in floriculture, to involve more women in this venture and to empower rural women through the success of their entrepreneurship. Adequate arrangement of credit from formal sources to women entrepreneurs, establishment of organised flower markets and cold storages, adoption of climate resilient floriculture and precision floriculture will be more effective to promote successful women entrepreneurship in floriculture. Supply of good quality seeds and saplings, seed money and appropriate use of advanced technology must be ensured. Women will be more successful in entrepreneurship if their skilled orientation and capacity building trainings are ensured. An integrated policy is needed through which decision-making power, innovativeness, leadership ability and adaptability of women can be properly applied in their entrepreneurship.

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ANALYTICAL STUDY OF LANDUSE AND LANDCOVER CHANGES IN BALIA RIVER CATCHMENT, KUMAUN LESSER HIMALAYA

Vaseem Ahmad, Poonam Shah Gangola and Virender

Abstract

Land use and land cover (LULC) study is vital to investigating land use patterns and changes in any specific region, which helps forecast future sustainable land use management. The present study was carried - out in the Balia catchment of Kumaun Lesser Himalaya, which is a tectonically unstable, ecologically vulnerable, and densely populated area. This study analyzes the land use dynamics over the past three decades between 1990 and 2021, using remote sensing satellite imagery data from Landsat-5 and Landsat-8 and the Geographic Information System (GIS) tool. The present study reveals significant transformations, including urban expansion, agricultural intensification, and forest cover alterations, driven by increasing population pressures, shifting economic activities, and climate change. In the past three decades, significant changes have been identified in forest cover, which increased by 22.56%, and a sharp reduction in barren land by 45.99%, a decline in agriculture by 12.59% and water bodies by 32%, along with a slight expansion in built-up area. This research contributes to an understanding of anthropogenic influences on Himalayan ecosystems and serves as a basis for policy formulation aimed at sustainable land use in fragile mountainous regions.

Introduction

The Himalayan Mountain ecosystem is one of the most densely populated, tectonically alive, economically underdeveloped, and most fragile and vulnerable mountain ecosystems which is susceptible to global environmental change on planet Earth (ICIMOD, 2010; Joshi and Tiwari, 2014). Term land use refers to the human activities associated with a specific piece of land on the earth's surface (Legg, 1987). Land use refers to the modification of natural land cover by humans for a particular purpose. It encompasses a wide range of human activities. However, land cover refers to the physical and biological material on the Earth's surface. It describes what is present in a given area, providing insight into the natural and human-altered environment. LULC reflects human activities such as industrial zones,

residential zones, agricultural fields, grazing, logging, and mining (Zubair, 2006). LULC patterns are vital in shaping a region's environmental and socioeconomic landscape. The changes in land use are now one of the major driving factors transforming the natural landscape and affecting ecosystem services in the mountainous region (Ives, 1989; Haigh, 2002; Tiwari et al., 2018). Therefore, the investigation of land use has more significance for development planning, and conservation and management of natural resources (Nand, 2023). Land use and land cover changes are the result of both anthropogenic and natural factors that may trigger deep threats to water resource availability, food security, and agriculture sustainability. Understanding how land is utilized and changes over time provides essential insights into the sustainability of ecosystems, agricultural productivity, urban expansion, and environmental health. These dynamics are especially critical in ecologically sensitive regions such as the Kumaun Lesser Himalaya, where the interaction between natural forces and human activities has profound implications for the landscape. Over the past few decades, the region has experienced considerable land use changes, such shifts have led to a complex interplay between forest cover, agricultural land, barren land, and water resources. Climate change is expected to exacerbate current stresses on water resources resulting from population growth, economic factors, and land use change, including urbanization (Raneesh 2014). The significance of this study lies in its potential to inform policymakers and local communities about the critical need for balanced land use planning. Unplanned urbanization and the depletion of water resources and agricultural land threaten the fragile ecosystem of the Himalayas. Investigating the land use changes highlights the need for land use management approaches that address both environmental conservation and the livelihood needs of the local people.

Study Region

The Balia River Catchment, located in the Kumaun Lesser Himalaya region, serves as the geographical focus of this study. It extends between 29°17'11.98" and 29°24'12.24" north latitude to 79°26'28.45" and 79°32'22.32" east longitude, encompassing a total area of 80.23 km². Administratively, Balia River Catchment is situated in the district Nainital, within the newly formed Himalayan state of Uttarakhand, India. As per the 2001 and 2011 censuses, the total population of the Balia Catchment was 11,778 and 15,275, which shows a fast-growing population in the region. Balia Catchment represents the most densely populated tracts of the Himalayas. The population density of the Balia Catchment has been calculated to be 190persons/km². The catchment is an integral part of the Gaula River Basin,

characterized by an elongated shape, and it hosts the Balia River, locally known as Balia Nala which is a principal river of the catchment that originates from the world-famous Nainital Lake. The catchment is bordered by the Shipragad watershed in the east, the Bhakra and Banihal rivers in the west, the Naina Mountain range to the north, and the Gaula River to the south. Geologically, the Balia Catchment shows its complex structure is composed of rocks from the Krol, Balani, Nagthat, and Shiwalik formations, reflecting the complex tectonic structure of the region. Balia catchment is a tectonically alive and sensitive zone in the Himalayan region because this zone is a junction of the Lesser and Shiwalik Himalayan ranges from where the main boundary thrust (MBT) passes. Moreover, this region encompasses diverse terrain with varying elevation and climate; the catchment is a significant hydrological unit, marked by its unique land use patterns, and Maximum area under the moderate (10 to 20) and steep (20 to 30) degree slopes. The altitude in the catchment ranges from 566 to 2324 meters above mean sea level, contributing to its diverse topographic features.

Objectives

The present paper has attempted to analyze the dynamics of land use and land cover (LULC) over the past three decades from 1990 to 2021 assessing the factors driving land use changes and emphasizing sustainable land use management.

Database and Methodology

The study was conducted over the Balia River catchment, mainly based on secondary data. Detection of land use land cover (LULC) Change by using data generated from satellite images is the central aspect of the present study. The present study analyzes the dynamics of LULC over the past 31 years between 1990 and 2021, using remote sensing satellite imagery data from United States Geological Survey (USGS) Landsat-5 and Landsat-8 and Geographic Information System (GIS) technologies. This study employs a combination of remote sensing data, GIS by using ERDAS IMAGINE 2016 for LULC classification, and Arc GIS 10.8 (crack version) for map preparation with ground truthing during field survey to analyze the changes in land use and land cover patterns, verify land use categories, and ensure the accuracy of the satellite-based classification. The present study used a well-established supervised classification method. The supervised classification method helps to create groups of land use land cover sensed from satellite imageries. The Landsat satellite images have been classified into five LULC groups; Settlements, agriculture, barren land, forests, and water bodies.

Results and Discussion

Land Use and Land Cover Distribution in 1990

Table-1 shows that in 1990 Land Use pattern in the region was dominated by forest cover. The broad land use classes include forests (vegetation cover), cultivated land (agriculture land), built-up areas, barren land, and water bodies (Table-1). Forest cover area emerged as the principal land use category in the region as out of the total geographical area of the region, as much as 53.98% is under vegetation cover, whereas the area under barren land accounts for 20.38% of the total area of the study region. Out of the total geographical area of the catchment, 17.91%, 5.86 and 1.87% are under cultivated land (agricultural land), settlements, and water bodies respectively.

Table-1: Land Use Distribution of Balia Catchment in 1990

S. No.	Land Use Category	Area (in Km)	Area (in Percentage)
1.	Forest	43.31	53.98 %
2.	Barren Land	16.35	20.38 %
3.	Agriculture	14.37	17.91 %
4.	Settlements	4.7	5.86 %
5.	Water Bodies	1.50	1.87 %
	Total	80.23	100 %

Source: Based on Satellite data Landsat -5

Landuse and Landcover Distribution in 2021

Table-2 reveals that as per the data of 2021, the maximum part of the land use pattern of the study region was dominated by forest cover (Fig. 1). Forest cover area emerged as the chief land use category in the region as out of the total geographical part of the region as much as 66.16% is under vegetation cover whereas, the area under cultivated land (agricultural land) accounts for 15.66% of the total area of the study region. Out of the total area of the catchment, 11%, 5.91%, and 1.27% are under barren land, settlements, and water bodies respectively.

Landuse and Landcover (LULC) Change Detection from 1990 to 2021

Table-3 and Fig. 1 show that forest cover area increased by 9.77 km² which accounts for 22.56%, during the last three decades from 1990 to 2021 (Table-2). Cultivated and barren land turned into forest cover due to less cultivation and

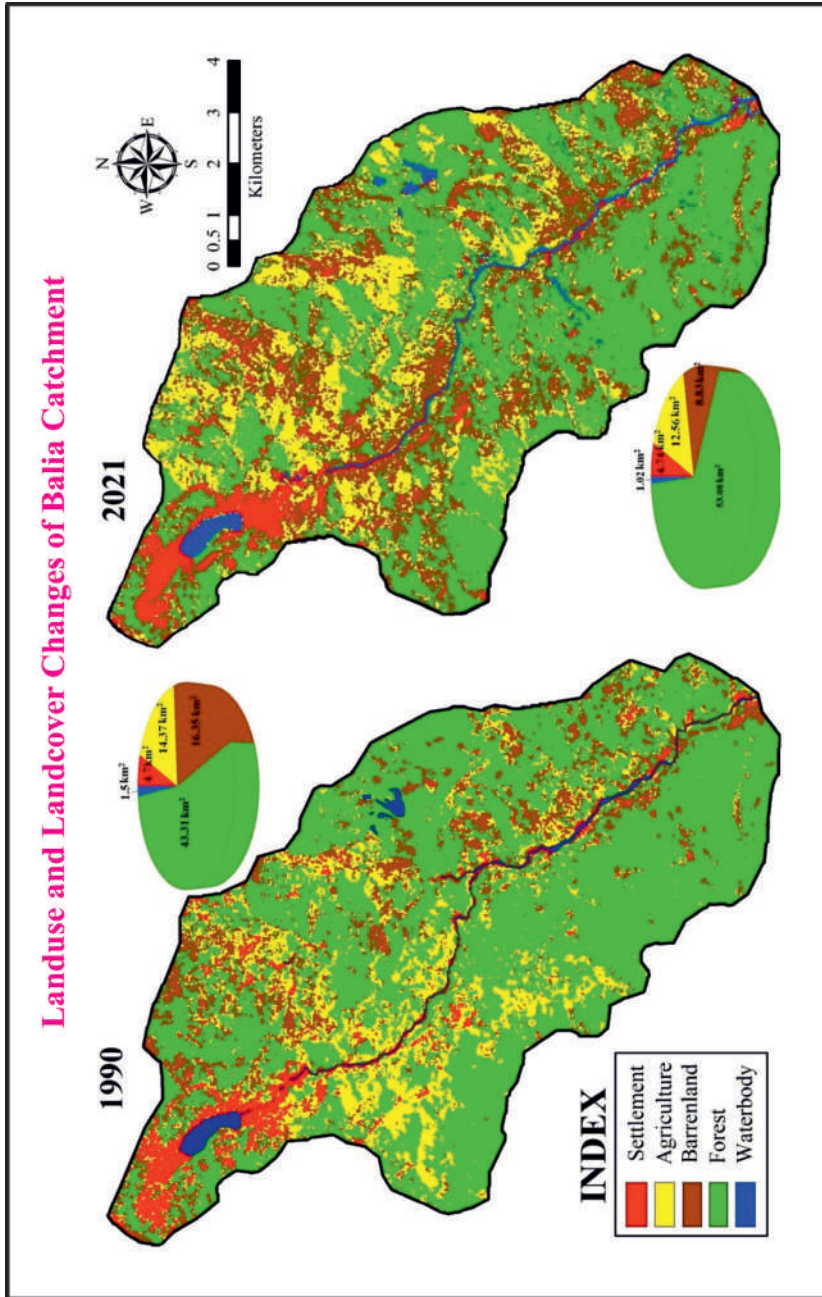


Fig. 1

Table-2: Landuse Landcover Distribution of Balia Catchment in 2021

S. No.	Land Use Category	Area (in Km)	Area (in Percentage)
1.	Forest	53.08	66.16%
2.	Agriculture	12.56	15.66%
3.	Barren Land	8.83	11.00%
4.	Settlements	4.74	5.91%
5.	Water Bodies	1.02	1.27%
Total		80.23	100 %

Source: Based on Satellite Data Landsat - 8

afforestation efforts by the government, especially the forest department and the local community with the help of local governance and natural forest regeneration. The increase in forest cover was mainly in the mid-elevation ranges, where barren and cultivated land was converted into forest. It is clear from Table-3 Fig. 1 that there is a sharp decline in barren land. The most significant reduction in barren land was observed in low-altitude areas. Barren land was mostly converted into forest and built-up areas. In the last three decades, 7.52 km², or 45.99%, of barren land decreased. Due to population growth, the newly added population needs more space to fulfill their basic needs. To achieve their needs, they encroached on land. In this exercise, the barren land was transformed into hotels, resorts, and other activities. Table-3 and Fig. 1 demonstrate the change in cultivated (Agricultural) land, which decreased by about 1.81 km², or 12.6%, in the last three decades. The decreasing rate of cultivated land is quite alarming for the food and livelihood security in the study region. The reason behind this conversion can be urbanization, and horticulture, as the changing environmental conditions and increasing rate of climate change, which is responsible for declining agricultural production and rising crop diseases, have pushed the local population into horticulture activities, and landslide incidents also reason for the decline in agriculture land.

A slight change that has occurred in this study area is the settlement or buildup area, which is shown in Table 3. It has increased by about 0.04 km² or 0.85%. An increase in settlement or buildup area has occurred due to population growth in the study region. As per the 2001 and 2011 census, the total population of the Balia Catchment was 11,778 and 15,275, which shows a fast-growing population in the catchment. Balia Catchment represents the most densely populated tracts of the Himalayas.

Table-3: Landuse Landcover Changes in Last Three Decades (1990 to 2021)

S. No.	Land Use Category	Area in 1990 (in km ²)	Area in 2021 (in km ²)	Changes Area (in km ²)	Changes Area (in %)
1.	Forest	43.31	53.08	+9.77	+22.55%
2.	Barren Land	16.35	8.83	-7.52	-45.99%
3.	Agriculture	14.37	12.56	-1.81	-12.59%
4.	Settlements	4.70	4.74	+0.04	+0.85%
5.	Water Bodies	1.50	1.02	-0.48	-32.00%

Source: Changes computed by researcher

The changes in water bodies are shown in Table-3 and Fig. 1. It has been calculated that the water bodies have shrunk by 0.48 km² or 32%. A sharp decline in water bodies indicates potential water scarcity or depletion of local water resources over time. The decline in water bodies was more evident in the central and southern parts of the catchment area. Decreasing water bodies due to human encroachment, settlement, tourism development, global climate change, more particularly erratic and irregular rainfall, shrinking wetlands, a lack of conservation of water sources, and landslide activities.

Conclusion

The study of land use and land cover (LULC) changes in the Balia River Catchment over the last three decades between 1990 and 2021 reveals significant changes that reflect the complex interplay between natural and human forces shaping the landscape. The depletion of water bodies signals an urgent need for improved water resource management practices. This is critical for maintaining agricultural productivity, ensuring water security for local communities, and sustaining ecological balance in the catchment. These changes have important implications for the region's environmental sustainability, agricultural productivity, and socio-economic conditions. The reduction in agricultural land poses a serious threat to food security and livelihoods of the local community. It concluded that essential steps to develop strategies in the Himalayan region that promote sustainable land use management while preserving the area's natural heritage.

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POLITICAL PARTICIPATION AND WOMEN EMPOWERMENT IN INDIA

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Abstract

This paper explores recent trends in women's participation in formal politics in India, highlighting two key developments. First, since the 1990s, there has been a notable increase in female voter turnout, peaking during the 2014 Lok Sabha elections with the highest recorded participation. Second, the 2014 general elections saw a rise in women's involvement in prominent election campaigns. Despite these advances in voter-driven feminization of electoral politics, women remain significantly underrepresented in legislative bodies and within political party structures. A historical overview of women's electoral participation in India is provided, followed by a time series analysis of voting patterns, revealing that political parties have limited efforts to mobilize female voters around gender-specific issues at the national and state levels. Gender-related promises in party manifestos are often rigid and neglected post-election. Implementing the Women's Reservation Bill exemplifies the lack of genuine political commitment to addressing women's growing political engagement. The study is based on qualitative research methods, and it identifies economic, religious, social, and cultural factors as critical contributors to the continued underrepresentation of women in Indian politics.

Introduction

Women's empowerment has become essential to global social, economic, and political progress, and India is no exception. Despite a history of socio-cultural barriers, women in India increasingly engage in formal politics at various levels—from local governance to national representation. This growing participation is critical not only for fostering gender equality but also for strengthening the democratic fabric of the nation. Women's political empowerment is integral to creating a more inclusive society where diverse voices contribute to policy-making and governance. Empowering women to participate actively in politics enables

them to influence decisions affecting their lives and communities, making political empowerment an essential element of broader social development (Singhal, 2016). Women's political participation in India has its roots in the social reform movements of the 19th century. Reformers such as Raja Ram Mohan Roy and Ishwar Chandra Vidyasagar championed women's rights, especially in education and social justice. Their efforts laid the foundation for the eventual inclusion of women in the political sphere. The Indian freedom struggle, led by Mahatma Gandhi, further elevated women's political role, mobilizing thousands of women nationwide to participate in civil disobedience and non-cooperation movements. Figures like Sarojini Naidu, Kasturba Gandhi, and Kamaladevi Chattopadhyay became iconic symbols of women's active political participation (Saryal, 2014). The post-independence period saw the inclusion of gender equality as a constitutional guarantee. The Indian Constitution, through its Preamble, Fundamental Rights, and Directive Principles, ensures equality for women and prohibits discrimination based on gender. Article 15(3) empowers the state to make special provisions for women and children, and several legal frameworks have since been introduced to promote women's rights. However, these progressive provisions have not always translated into increased political participation for women. Historically, women have been underrepresented in political offices, legislative bodies, and political parties.

The challenge has been allowing women to vote and contest elections and ensuring equitable representation and participation in decision-making bodies (Sewa, 2019). One of the most significant legal interventions to promote women's political participation in India came through the 73rd Constitutional Amendment Act of 1992, which institutionalized the Panchayati Raj System. This Amendment aimed at decentralizing governance and marked a significant step towards democratic decentralization. It introduced reserved quotas for women and marginalized communities in local governance institutions, ensuring that women occupy at least one-third of all seats in Panchayats. The Act has provided women with opportunities to engage in governance at the grassroots level, enabling them to participate in decision-making and policy formulation that directly impacts their communities (Sharma, 2020). The Panchayati Raj system has played a critical role in fostering political empowerment for women, especially in rural areas. By making it mandatory for women to hold leadership positions, this legislative reform has helped to break the traditional male dominance in politics (Baker, 2017). Women elected through this system have been able to influence decisions related to local infrastructure, health, education, and development. While legally guaranteed,

women's representation in Panchayats only sometimes translates into effective participation in decision-making. Socio-cultural norms, patriarchal structures, and lack of political training often prevent women from exercising real power within these institutions. Several barriers continue to hinder the full political empowerment of women in India. These include entrenched gender stereotypes, socio-cultural practices, economic dependence, limited access to education and healthcare, and discriminatory laws (Ahmed, 2020). These factors have historically marginalized women from political spheres, limiting their opportunities to take on leadership roles. Moreover, the patriarchal structure of Indian politics, with its male-dominated power hierarchies, further restricts women's participation (Adhikari & Saha, 2021). Political parties at the national and regional levels often discriminate against women in candidate selection and seat allocation. Women are frequently sidelined in internal party structures, reducing their influence in policy-making processes (Chandrashekhar, 2016). The marginalization of women within political parties remains a significant factor contributing to their underrepresentation in legislative bodies. While there have been prominent female leaders, such as Indira Gandhi, India's first woman Prime Minister, and more recently, figures like Sonia Gandhi and Mamata Banerjee, women have historically been relegated to secondary roles in political parties. Even when elected to legislative bodies, they often face exclusion from key ministerial positions, particularly in portfolios traditionally dominated by men, such as finance, defense, or foreign affairs. However, under the Modi government, Nirmala Sitharaman has broken this pattern by holding a pivotal role as Finance Minister. Across the world, countries have adopted various legislative measures to improve the political participation of women. For example, neighboring countries like Nepal, Bangladesh, and Pakistan have taken the legislative route to ensure better representation for women in their parliaments.

In Pakistan, 17% of the seats in the National Assembly are reserved for women, while Bangladesh has reserved 50 out of 350 seats in its Jatiya Sangsad (Das & Chattopadhyay 2020). Nepal, meanwhile, has reserved 33% of the total seats in its legislature for women. In these countries, the percentage of women legislators has often exceeded the number of seats reserved, indicating a positive trend towards gender inclusivity in politics. The issue of women's political empowerment is not unique to India. India, by contrast, has lagged in achieving similar levels of representation. Although women's representation in the Lok Sabha has increased from 5% in the first Lok Sabha to 15% in the current Lok Sabha and the Rajya Sabha from 7.2% to 13%, these figures remain significantly lower than global standards.

India currently ranks 148th out of 193 countries regarding women's parliamentary participation, 31st among 47 Asian countries, and 5th among 8 SAARC nations (Harnsamut & Maluleem, 2020). These rankings highlight the need for targeted measures to accelerate women's political empowerment in India. One of the most widely debated legislative measures aimed at improving women's political representation in India is the Women's Reservation Bill. This Bill seeks to reserve 33% of seats in the Lok Sabha and state legislative assemblies for women (Dehalwar & Sharma, 2024). Despite broad support from various political parties, it has encountered repeated delays and opposition in Parliament. Even after both houses pass the Bill, its practical implementation will be crucial in addressing women's underrepresentation. The passage of the Women's Reservation Bill holds the potential for transformative change, promoting gender equality by creating more equitable opportunities for women to engage in decision-making processes at every level of government.

The Bill's potential impact on Indian politics cannot be overstated. Increasing the number of women in legislative bodies would create a more gender-balanced political environment, encouraging more women to take on leadership roles. Furthermore, the presence of women in these bodies could shift the focus of policy-making towards issues that disproportionately affect women, such as healthcare, education, and social welfare. Research suggests that women leaders prioritize these issues more than their male counterparts, leading to more inclusive and responsive governance. One way to address these challenges is by providing women with political training and capacity-building programs. Such programs would equip women with the skills and knowledge needed to navigate the political landscape, enabling them to be more effective in their roles. Additionally, efforts must be made to change the patriarchal attitudes within political parties and institutions, creating a more inclusive environment where women's voices are heard and valued. Another critical factor in improving women's political participation is the role of civil society organizations. NGOs and women's rights groups can be essential in advocating gender equality in politics and holding political parties accountable for their promises. By raising awareness about the importance of women's political participation and mobilizing support for legislative reforms like the Women's Reservation Bill, civil society can help accelerate the pace of change (Prodip, 2022). The political empowerment of women is not only a matter of gender equality but also a crucial factor in the development of a stable and democratic society (Majumder, 2020).

Women's political participation strengthens democratic processes, enhances governance, and ensures that policies are more inclusive and representative of the entire population. While India has made significant strides in promoting women's political participation, much work remains. The persistent underrepresentation of women in legislative bodies, political parties, and executive positions highlights the need for targeted legislative reforms, capacity-building initiatives, and cultural shifts to create a more inclusive political environment. The passage of the Women's Reservation Bill and the continued implementation of legal provisions like the 73rd Constitutional Amendment Act are essential steps toward achieving gender parity in politics (Parvin & Sarkar, 2021). However, addressing the socio-cultural barriers that limit women's participation will require sustained efforts from the government, civil society, and political institutions. Empowering women politically is about increasing their numbers in legislative bodies and ensuring they have the influence and power to shape policies and decisions affecting their lives and communities.

Study Region

India, with a population exceeding 1.4 billion, is a vibrant democracy marked by rich cultural diversity. Despite its socio-political advancements, women's political participation and empowerment remain significant challenges. Historically, Indian women played crucial roles in the freedom movement and post-independence political activities and actively participated in voting, with a turnout of 65.63% in parliamentary elections, slightly lower than men at 67.09%. Despite this, India ranks 20th in terms of women's representation in Parliament, with only 10.9% of female representatives. However, women have held significant roles, including President and Prime Minister. The Indian Constitution guarantees universal suffrage since 1950, granting equal voting rights to women. Women's voter turnout has significantly increased over the decades, narrowing the gap with men. State elections have seen even higher participation among women, exceeding men in states like Uttar Pradesh, West Bengal, Goa, and Kerala. Reservations for women in local governance, introduced through the 73rd and 74th amendments, reserve 33% of seats, with some states raising this to 50%. These reservations have substantially increased women's political participation, especially in Panchayati Raj Institutions. Major political parties like BJP and INC have introduced quotas to increase women's participation, with the Women's Reservation Bill (33%) still pending.

Objectives

- (1) To examine the evolution of women's political participation in India during pre- and post-independence periods.
- (2) To explore the challenges and opportunities for women's empowerment in contemporary India.

Parameters for Evaluating Women's Political Participation in India

- (1) **Women as Voters:** The 2024 Lok Sabha elections marked a significant achievement in gender equality in politics, with women's voter turnout nearly matching men's. This development has been hailed as a "silent revolution of self-empowerment." The rise in female voter participation, mainly since the 1990s, can be attributed to various factors, including increasing political awareness, social changes, and efforts to mobilize women voters.
- (2) **Women as Candidates:** Although the number of women candidates in parliamentary elections has gradually increased, their proportion remains disproportionately low compared to male candidates. In the 2024 Lok Sabha elections, women comprised less than 9% of the 8,049 candidates, reflecting the ongoing gender disparity in political representation.
- (3) **Women's Representation in Parliament:** Despite the significant growth in women's participation as voters, their representation in both the Lok Sabha and Rajya Sabha remains relatively low. While progress has been made, the number of women in Parliament still lags far behind that of men, highlighting the need for more focused efforts to promote gender equality in political leadership.

Historical Perspective on Women's Political Participation in India

"The emotional, sexual, and psychological stereotyping of females begins when the doctor says, 'It's a girl.'" – Shirley Chisholm. This quote reflects the entrenched nature of gender inequality. To fully grasp the dynamics of women's political participation in India, it is essential to examine its historical evolution nationally and globally. Today's advancements result from past struggles and efforts, forming the foundation for ongoing progress.

Global Context of Women's Political Participation

Globally, the fight for women's political rights has been long and hard. In ancient Greece, Republican Rome, and other early European democracies, women were excluded from political processes, including voting rights. The suffrage

movement in the United States marked one of women's earliest and most notable efforts to claim their right to vote. The 19th Amendment to the U.S. Constitution in 1920 was a significant milestone, granting American women the right to vote. Meanwhile, in Europe, the right to vote for women came later, with many nations not allowing women full voting rights until the mid-20th century.

Pre-Independence India: Struggles and Contributions

Women in India have historically faced systemic oppression, exploitation, and marginalization, deeply entrenched within patriarchal societal structures. Before India's independence, women suffered from various forms of physical and mental discrimination, both within their households and in the larger societal framework (Priebe, 2017). This unequal treatment created an imbalance in social, political, and economic realms, leaving women with limited opportunities to participate in public life. However, despite these challenges, Indian women played a pivotal role in the freedom movement, demonstrating resilience and leadership in adversity. The Panchayati Raj system, which existed since ancient times, included local self-governance through village councils known as panchas. Although traditionally male-dominated, these systems laid the foundation for future political involvement. During the Indian freedom struggle, women emerged as influential leaders, contributing significantly to the cause. For instance, the Swadeshi Movement of 1905-08 saw women organizing protests, mobilizing resources, and leading political demonstrations. Prominent women leaders like Rani Lakshmi Bai, Sarojini Naidu, Annie Besant, Aruna Asif Ali, and Kasturba Gandhi played critical roles. Sarojini Naidu, in particular, championed women's rights, leading a delegation of Indian women to the British Parliament in 1917 to demand voting rights (Mahammad, 2021). The Reforms Act of 1921 partially granted women the right to vote, although with property ownership and education restrictions. However, the Government of India Act of 1935 expanded voting rights to all women without any conditions. These legal milestones were crucial in the long journey towards full political participation.

Post-Independence Era: Women's Rights in the Constitution

After India gained independence in 1947, the Indian Constitution guaranteed equal rights for all citizens, including women. The Constitution provided women with equal political, social, and economic status, ensuring their participation in the democratic process. Part III of the Constitution enshrined fundamental rights. At the same time, the Directive Principles of State Policy advocated for equal

pay for equal work, humane working conditions, and maternity relief, all aimed at empowering women economically and socially (Fadia 2014). Including these provisions in the Constitution marked a turning point for women in India, granting them the right to participate in the political process as voters, candidates, and office-bearers'. Women's political representation gradually improved, though the road to equality remained challenging.

Women's Political Participation Post-Independence

In the years following independence, women in India held significant political and administrative roles. They served as governors, chief ministers, judges, and cabinet ministers, occupying important state and national positions. Despite these advancements, the representation of women in Indian politics remained disproportionately low compared to their male counterparts. The 73rd and 74th Constitutional Amendments, passed in 1992, were landmark reforms aimed at increasing women's political participation at the local level. These amendments reserved 33% of seats for women in Panchayati Raj Institutions and urban local bodies, providing millions of women with opportunities to engage in governance. As a result, women's participation in local politics soared, with over 1.5 million women holding positions in local self-governance bodies, representing 36.8% of all seats (Kundu & Chakraborty, 2012).

However, at the national level, the representation of women in the Lok Sabha (lower house) and Rajya Sabha (upper house) has remained limited. Despite making up nearly half of India's population and 47.5% of the registered voting population, women currently hold only about 11% of seats in the Lok Sabha and 10.6% in the Rajya Sabha. In 2024, women held just 9.8% of all ministerial positions in India, highlighting the continued marginalization of women in political leadership roles (Luka, 2011).

Women's Political Leadership: Key Figures

India has produced several prominent women leaders who have left an indelible mark on the country's political landscape. Indira Gandhi, the country's first female Prime Minister, symbolized women's leadership on the global stage. Other notable women include Mayawati, who became the Chief Minister of Uttar Pradesh, Jayalalitha in Tamil Nadu, and Mamata Banerjee, the current Chief Minister of West Bengal. These leaders influenced National and regional politics and played significant roles in shaping national policies (Das, 2015).

The Indian National Congress (INC) has historically supported women's political participation. In 1917, Annie Besant became the first female president of the INC, followed by Sarojini Naidu in 1925. In recent years, Sonia Gandhi served as the president of the INC from 1998 to 2017, with a brief reappointment from 2019 to 2022. Other political parties have also contributed to women's leadership. Under Mayawati and Mamata Banerjee, the Bahujan Samaj Party (BSP) and the All-India Trinamool Congress (TMC), respectively, have seen women rise to top leadership positions. The Bharatiya Janata Party (BJP) has also promoted women's leadership, established women's leadership programs, and reserved 33% of party leadership positions for women. The historical evolution of women's political participation in India reflects a broader struggle for gender equality. While significant progress has been made since independence, especially at the local level, women's representation in national politics remains limited. Addressing the barriers to women's political empowerment will require continued efforts, including legal reforms, socio-cultural changes, and the active promotion of women leaders at all levels of governance. Women's political participation is crucial for building an inclusive and democratic society where men and women can contribute equally to the nation's progress.

Challenges to Women's Political Participation in India

Despite constitutional promises and various reforms to increase women's representation in Indian politics, significant barriers continue to hinder their participation. These multifaceted challenges range from institutional inaccessibility to deeply ingrained socio-cultural norms.

Inaccessibility of Political Institutions

Despite pledges by political parties to promote women's representation, women continue to face significant challenges in accessing political institutions. Election records show that political parties often allocate fewer tickets to women candidates than to men. Furthermore, studies reveal that women who do receive party nominations frequently have political family connections or belong to dynastic political families, highlighting the limited pathways for women to enter politics through traditional channels. Without systemic changes, the inaccessibility of political institutions will continue to restrict women's participation in the political process.

Perceptions of Women's Electability

A prevailing belief within political circles is that women are less likely to win elections than their male counterparts. This perception makes political parties reluctant to nominate women, limiting their chances of standing for elections. The notion of women being “unelectable” leads to fewer tickets being allocated to female candidates, perpetuating a cycle of underrepresentation.

Challenging Structural Conditions

The demands of Indian election campaigns are another significant barrier for women politicians. Campaigning is a time-consuming and physically exhausting process that often extends over months. Women frequently bear the additional burden of family commitments and childcare responsibilities and find it challenging to dedicate the time required for effective campaigning. These structural conditions make it difficult for women to fully participate in electoral processes, limiting their visibility and effectiveness in campaigns.

High Vulnerability to Abuse and Violence

Women politicians in India often face severe challenges, including humiliation, inappropriate comments, and threats of violence. These experiences are not uncommon, with many female politicians reporting frequent abuse both online and offline. This high level of vulnerability creates substantial obstacles, as the constant threat of violence or harassment can deter women from engaging in political contests or diminish their ability to campaign effectively.

Costly Electoral System

The financial aspect of elections presents a formidable barrier for women aspiring to enter politics. Parliamentary elections in India are relatively inexpensive, with candidates needing substantial financial resources to mount competitive campaigns. The high costs disproportionately affect women, who often depend on family finances. Many women cannot fund their campaigns without adequate financial backing from political parties or independent means. This economic barrier is one of the most significant deterrents for women seeking political office.

Internalized Patriarchy

Internalized patriarchy further complicates the situation for women. Many women have been socialized to prioritize family and household responsibilities over their political or career aspirations. As a result, they often view their primary

obligation as being to their families, limiting their political engagement. This phenomenon reinforces the traditional gender roles that keep women out of public life, even when opportunities for participation exist.

Socio-Cultural Barriers

Patriarchal norms and gender stereotypes continue to pose significant obstacles to women's political participation. Socio-cultural expectations often dictate that women should prioritize domestic responsibilities over public roles. In addition, many women lack family support to pursue political careers, particularly in rural areas with limited educational and economic opportunities. These factors collectively restrict women's ability to engage in politics, as they are often seen as less capable or appropriate for leadership roles.

Political Party Dynamics

Political party dynamics are another major hurdle for women. Many political parties in India are male-dominated and resistant to nominating women candidates. When women are nominated, they are often assigned to "safe" or "unwinnable" seats, where their chances of success are slim. The lack of internal quotas or affirmative action policies within parties further diminishes women's opportunities to rise as candidates. This exclusionary practice prevents women from gaining the political experience necessary to contest in more competitive seats.

Institutional and Legal Barriers

Institutional and legal challenges have also played a role in limiting women's political participation. For instance, the delayed implementation of the 73rd and 74th Constitutional Amendments, which stipulate a one-third reservation for women in local governance bodies, has hindered the development of a pipeline of female political leaders. These amendments were intended to create opportunities for women at the grassroots level, but their postponement has impeded establishing a robust system that nurtures women's political ambitions. As a result, fewer women can transition from local governance roles to state or national-level politics.

While India has significantly increased women's political representation, various challenges prevent women from fully participating in the political process. From institutional inaccessibility and financial constraints to socio-cultural norms and internalized patriarchy, the barriers are complex and deeply entrenched. Addressing these issues requires reforms within political parties and institutions and a broader societal shift in how women's roles in public life are perceived and valued.

Without tackling these systemic obstacles, women's political participation in India will remain limited, undermining the goal of achieving true gender equality in governance.

Strategies for Enhancing Women's Empowerment in India

(a) Enhancing Women's Political Representation

The underrepresentation of women in political institutions is a significant barrier to achieving gender equality and fostering inclusive governance. Despite progress in women's electoral participation in India, their representation in Parliament remains far below the global average. Women constitute about 25% of parliamentary representatives globally, while India lags with a significantly lower proportion. Implementing a 33% reservation for women in the Indian Parliament would address this disparity and create a pathway for more gender-inclusive legislative processes. This policy measure is essential not only for promoting gender parity but also for enhancing the overall inclusivity of democratic governance. Women's increased participation in law-making would ensure their voices and concerns are represented more effectively, creating more balanced and comprehensive policies.

(b) Promoting Gender Equality and Inclusive Governance

Women in India face numerous barriers to political participation, stemming from entrenched socio-cultural norms, economic disadvantages, and systemic political challenges. These barriers include patriarchal expectations, limited access to financial resources, and the prevalence of gender-based violence. Overcoming these obstacles is critical for promoting gender equality and achieving inclusive governance. Reservation policies could be a powerful tool to dismantle these entrenched barriers and give women greater access to political institutions. It would help to address the gender gap in political representation and create more inclusive governance structures.

(c) Strengthening Democratic Participation

Allocating one-third of parliamentary seats to women would significantly empower their involvement in the political process. By increasing women's representation, India could strengthen its democratic practices and ensure that governance reflects the needs and perspectives of the entire population, including women and children. Women's active participation in politics would also foster the development of policies more attuned to gender-specific issues such as healthcare,

education, and social welfare. This shift would contribute to broader human development goals by addressing inequalities in representation and ensuring more equitable decision-making in governance.

(d) Women's Contribution to Policy and Governance

Including women in politics facilitates the representation of women's specific interests in state policy. Women are more likely to advocate for policies related to gender equality, healthcare, education, and social welfare, which are critical for human development. Moreover, research shows that women legislators perform better in terms of economic development indicators in their constituencies compared to male legislators. Women are also less likely to engage in criminal activities or corruption, making them highly effective leaders. Introducing a 33% reservation for women in the Indian Parliament would be crucial to achieving gender parity in political representation. Women's increased participation in governance would not only promote gender equality but also strengthen democratic practices and improve the quality of policy-making. By addressing the structural, financial, and socio-cultural barriers that hinder women's political engagement, India can move closer to realizing a truly inclusive and representative democracy.

Conclusion

Women's political participation is crucial not only for achieving gender equality but also for strengthening democracy and fostering more inclusive governance. The marginalization of women from decision-making processes in India, as well as in other parts of the developing world, represents a major democratic deficit. Women's underrepresentation in legislative bodies and decision-making forums has led to policies that fail to reflect the needs, values, and priorities of half the population. Addressing this imbalance is not merely a matter of numbers but of realizing women's full rights to political participation, which is essential for their status as equal citizens and for creating policies more responsive to societal needs. Efforts such as reservations and quotas at both the Panchayati Raj and legislative levels have shown promise in empowering women and enhancing their role in governance. Yet, additional steps are required to overcome structural, societal, and cultural barriers that prevent women from fully engaging in politics. Training programs, mentorship, institutional support, and electoral reforms, such as the Women's Reservation Bill, must ensure women have equal opportunities to run for office and succeed in leadership roles. Including women in politics brings

unique perspectives that enrich policy debates, especially in gender equality, social justice, healthcare, and education. Women leaders have proven to be instrumental in addressing critical social issues, from child marriage to maternal health, and ensuring that governance structures address the needs of the broader population. Women's participation also leads to more collaborative and empathetic decision-making processes, fostering more inclusive and effective governance.

Breaking down systemic barriers and promoting gender diversity in political institutions is essential for building stronger, more equitable societies. Women's political empowerment creates a virtuous cycle, advancing social justice, human rights, and sustainable development. Governments, political parties, and civil society must work together to promote and facilitate women's full participation in politics, ensuring a truly representative democracy where the voices of all, regardless of gender, are heard and valued. Ultimately, achieving gender parity in political participation is a goal for women and society. By ensuring that women have equal power and representation, we move closer to a democratic system that serves the needs of everyone, promotes social justice, and fosters sustainable development for future generations. Women's political empowerment is not only a human right but a necessity for the well-being and advancement of all.

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ASSESSING THE IMPACTS OF THE PRADHAN MANTRI UJJWALA YOJANA ON TRADITIONAL FUEL RESOURCES AND WOMEN'S HEALTH IN PRAYAGRAJ DISTRICT

Sangam Lal Saroj and Dr. Sunil Kumar Singh

Abstract

The Pradhan Mantri Ujjwala Yojana (PMUY) is a key initiative by the Indian government. PMUY aims to alleviate poverty in women's households by supplying clean cooking fuel. This research examines PMUY's effects on women's health and fuel resource usage in Prayagraj district. An integrative methodology was employed to assess PMUY's impact on 190 selected households. In rural India, traditional resources like firewood remain significant for cooking. In Prayagraj, local energy resources are utilized for various domestic tasks. A comprehensive study was conducted to explore PMUY's influence on socio-economic conditions and resident health. The assertion that India's essence lies in its villages holds merit. This is attributed to the enduring happiness of the Indian populace. They have consistently adapted their resource use to sustain their living standards. Energy resources have been pivotal in this process. Findings indicate that PMUY has lessened reliance on traditional fuels, yet challenges in adopting clean cooking fuels persist. Primary challenges include inducing behavioural changes towards clean cooking and ensuring accessible and affordable LPG refills. This study emphasizes the necessity for targeted actions to mitigate health issues linked to indoor air pollution by investigating the correlation between clean fuel adoption and enhancements in women's health. Furthermore, the research provides insights into the effectiveness of PMUY in promoting clean cooking practices and alleviating women's health issues in the Prayagraj district.

Introduction

In the context of Indian cultural practices, it is frequently observed that women undertake various vital domestic responsibilities in addition to the task of food preparation. As a fundamental source of energy, materials derived from arboreal sources, including timber, foliage, and grass, have been utilized.

In the contemporary landscape, efforts have been directed towards enhancing these energy sources through a thorough comprehension of their implications, which includes an investigation into the ramifications on the health of women residing in the rural regions of Prayagraj district. It has been noted that in the rural locales of Prayagraj district, a significant proportion of the population, due to economic constraints, resorts to the use of firewood, animal dung, and agricultural byproducts as cooking fuel. Given that these energy sources are economically viable and readily accessible, they concomitantly incur the detrimental cost of Indoor Air Pollution (IAP), which is responsible for approximately 1.04 million premature fatalities annually in India (WHO, 2018). This issue is particularly pertinent for women, as they bear the predominant responsibility for culinary activities and face considerable health risks attributable to prolonged exposure to IAP, which is associated with respiratory ailments, cardiovascular disorders, and even lung carcinoma (Chaturvedi et al., 2019). In response to the hazards linked with IAP concerning health and energy security, the Government of India instituted the Pradhan Mantri Ujjwala Yojana (PMUY). PMUY was inaugurated on May 1, 2016, with the objective of providing 8 crore LPG connections to Below Poverty Line (BPL) households by March 31, 2020 (Ministry of Petroleum and Natural Gas, 2016). The initiative has achieved a significant milestone by April 1, 2021, as it enhanced LPG coverage from 62 to 99.8 percent (Press Information Bureau, 2021). Building upon this success, the Union Budget for 2021-22 introduced PMUY 2.0, which sought to extend an additional 1 crore LPG connections to households by March 31, 2022 (Ministry of Finance, 2021). This objective was successfully met in January 2022 (Press Information Bureau, 2022). In recognition of the persistent necessity for clean cooking alternatives, the Union ministry has prolonged the PMUY timeline from the fiscal year 2023-24 to 2025-26. Upon accomplishing this target, the cumulative number of PMUY beneficiaries is anticipated to reach 10.35 Crore. This research paper critically evaluates the outcomes of PMUY in relation to the reliance on conventional fuel resources and the health implications for women.

Study Region

Prayagraj district of Uttar Pradesh has been selected for study area. It has been called by many names throughout its illustrious history. The name of the Prayagraj area has changed many times since the Vedic times. In October 2018, the name of Allahabad was again changed to Prayagraj. Prayagraj district is located in the southeastern part of the state of Uttar Pradesh. It lies between the parallels of

24° 47' N latitude to 25° 43' N latitude and between 81° 31' E longitude and 82° 21' E. The total geographical area of Prayagraj is 5482 km² from north to south, the breadth of Prayagraj is 109 km and from east to west the length is 117 km. The city is not solely significant in a historical, religious, and cultural context, but it also serves as a crucial destination for countless pilgrims. The sanctity of this site has been established due to the Triveni Sangam. The district is additionally distinguished by its prominent architectural and cultural monuments, including the Allahabad Fort, Anand Bhavan, and the Allahabad Museum. From an economic perspective, Prayagraj has developed into a vibrant urban center characterized by active sectors such as agriculture, textiles, and education. It functions as a pivotal educational hub, housing one of India's most venerable institutions, the University of Allahabad. Furthermore, its role as a nexus for numerous essential transportation networks, encompassing both road and rail infrastructure, considerably amplifies its significance in trade and logistics. The city has evolved into a contemporary urban area while simultaneously maintaining its rich cultural heritage.

Objectives

This research work was started with basically following objectives:

- (1) To assess the dependency of rural households on traditional fuel resources and the impact of PMUY, and
- (2) To study the impact of PMUY on Women's health.

Data and Methodology

This study has been conducted based on primary data collection through a survey conducted with 190 women of Below Poverty Line (BPL) Households in the Prayagraj district. To determine the sample size, Taro Yamane's sample size technique and random sampling method have been applied using following formula.

$$n = \frac{N}{[1 + N(e)^2]}$$

Where, n = sample size, N = population under study, e = margin of error

Secondary data has played an incredibly pivotal role in the advancement and enhancement of this research endeavour, contributing significantly to the overall findings and conclusions drawn throughout the study (Fig. 1). The comprehensive array of potential sources, including but not limited to official documents such

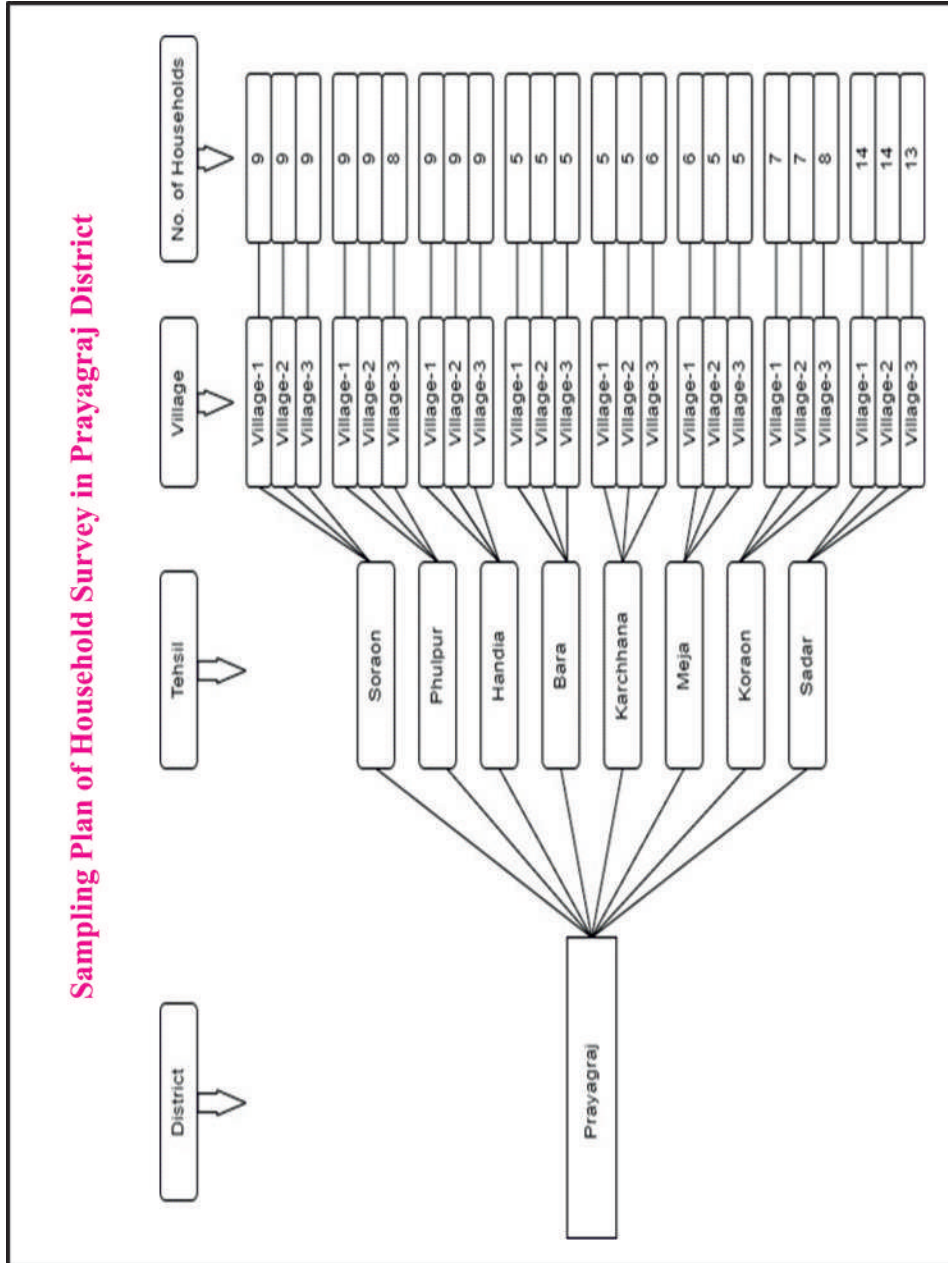


Fig. 1

as the reports generated by the Comptroller and Auditor General (CAG), various newspaper articles, and a multitude of other pertinent publications, collectively furnish an in-depth understanding of the historical context, prevailing challenges, and the resultant outcomes associated with the PMUY. The incorporation of secondary data not only enriches the analytical depth of the research but also facilitates the introduction of a broader observational perspective that enhances the overall investigative framework. To obtain primary data, an interview schedule was meticulously crafted and implemented, employing a closed-ended question format within the questionnaire to ensure structured responses. Additionally, the inclusion of open-ended questions serves to enrich the research with qualitative insights, thereby allowing respondents the opportunity to express their complex and nuanced perspectives as well as their personal experiences related to the subject matter at hand. Following the systematic collection of primary data, the gathered information was subsequently organized into tabulated formats and subjected to thorough analysis using both tables and graphical representations, thereby providing a clearer visual interpretation of the data trends and patterns identified during the study.

Results and Discussion

According to the CAG report of 2019, the LPG coverage in India increased drastically after the induction of PMUY. Fig. 2 suggests that the LPG coverage reached up to 94 percent in 2019, which was only 56 percent before the introduction of PMUY. In Prayagraj district till 2017 total LPG connections were 495231 and from 2017 to 2024, 96759 LPG connections were distributed and till 2024 total LPG connections was 591990 (Prayagraj Supply Department). It shows that many LPG connections were increased in the district after the PMUY was launched. We surveyed 190 households in the Prayagraj district and asked some questions about the use of traditional fuel resources and women's health after the implementation of the Pradhan Mantri Ujjwala Yojana.

Table-1 summarizes socio-demographic data and other relevant information about 190 households participating in the survey. The data is organized into different categories such as age group, social category, education, energy resources used, and the impact of the Pradhan Mantri Ujjwala Yojana (PMUY) on these households. In the survey, respondents of different age groups were selected so that the impact of PMUY on different age groups could be understood.

Table-1: The Details and Results of the Household Survey

Sr. No.	Socio-demographic Variables	Households	
		No. of respondents	Percentage of respondents
1	Age Group		
	20-30	21	11.05
	30-40	47	24.73
	40-50	58	30.52
	>50	64	33.68
2	Category		
	General	38	20
	OBC	51	26.84
	SC	94	49.47
	ST	7	3.68
3	Education		
	Illiterate	61	32.10
	Below Primary	27	14.21
	Above Primary	18	17.36
	Highschool	15	13.15
	Intermediate	11	9.47
	Graduation	33	7.89
	Post-Graduation	25	5.78
4	Using of energy resources in cooking		
	Firewood	156	82.10
	Cow dung	146	76.84
	Agricultural residue	129	67.89
	Other	32	16.84
5	When received the LPG connection under PMUY		
	1/2 Years before	5	2.63
	2/4 Years before	48	25.26

Contd...

	4/6 Years before	97	51.05
	>6 Years before	40	21.05
6	How many gas cylinders are received in one year		
	2 to 3	49	25.78
	3 to 4	139	73.157
	4 to 5	2	1.05
7	Whether Receiving gas cylinder on time		
	Yes, on-time	147	77.36
	Not on time	43	22.63
8.	Demand for LPG after PMUY		
	Increased	173	91.05
	Decreased	0	
	Do not know	17	8.94

Source: Computed based on Primary Survey

The table shows that more than 50 percent of respondents are between the age group 30 to 40, and more than 30 percent of households have been selected who are more than 50 years old so that they can share their experience more effectively with PMUY. Caste-wise social groups like General, OBC, SC, and ST have been selected. Around 50 percent of respondents belong to the SC community because most of the PMUY beneficiaries are SC in the study area followed by OBC, General, and ST. The education level of the respondents is less than the average of the district, 32.10 percent of the respondents are illiterate, about 15 percent have an education less than below primary level, and about 17 percent have an educational of above primary level, around 14 percent have the education of Highschool level, about 10 percent have intermediate level, about 8 percent graduation level and around 6 percent have education of postgraduation level. As per respondents, apart from LPG, the other fuels being used in cooking are firewood, cow dung, and agricultural residue. The respondents are using firewood more than any other energy resource, which is about 82 percent followed by cow dung and agricultural residue. Most of the respondents received LPG connections under PMUY around 4 to 6 years ago; about 73 percent of respondents refilled gas cylinders 3 to 4 times in one year. About 77 percent of respondents receive gas cylinders on time, though 40 percent of respondents are not satisfied with PMUY (Table-2). Around 88 percent

of respondents agreed that PMUY has reduced the dependence on other energy resources that were being used in cooking. The 69 percent of households do not use LPG cylinders regularly, while 31 percent use LPG regularly. It is clear from this chart that most households are still dependent on traditional fuel resources Table 2 shows that 83.16 percent of households replied that dependence on traditional fuel resources is decreased after the PMUY has been launched. 4.7 percent of respondents replied that no dependence decreased on traditional fuel resources while about 12 percent were unable to say anything regarding the scheme. In the survey caste wise participation was 48.95 percent SC followed by 26.84 percent OBC, 20.53 percent General, and 3.68 percent ST households. Where 18.95 percent out of 20.53 percent General, 21.05 percent out of 26.84 percent OBC, 40.53 percent out of 48.95 percent SC and 2.63 percent out of 3.68 percent ST households replied that PMUY has decreased dependence on traditional fuel resources, 0.53 percent General, 2.10 percent OBC and 2.10 percent SC households replied that PMUY has not decreased the dependence on traditional fuel resources while 1.05 percent General, 3.68 percent OBC, 6.31 percent SC and 1.05 percent ST households were unable to say regarding the scheme. This table shows that most of the respondents agree that PMUY has played a major role in decreasing the utilization of traditional fuel resources.

Table-2: The Perception of Dependence on Traditional Fuel Resources

Social group	Dependence on traditional fuel resources after PMUY						Grand total	Total %
	Decreased	Percentage	Not decreased	Percentage	Do not know	Percentage		
General	36	18.95	1	0.53	2	1.05	39	20.53
OBC	40	21.05	4	2.10	7	3.68	51	26.84
SC	77	40.53	4	2.10	12	6.31	93	48.95
ST	5	2.63	-	-	2	1.05	7	3.68
Total	158	83.16	9	4.74	23	12.10	190	100

Source: Computed based on Primary Survey)

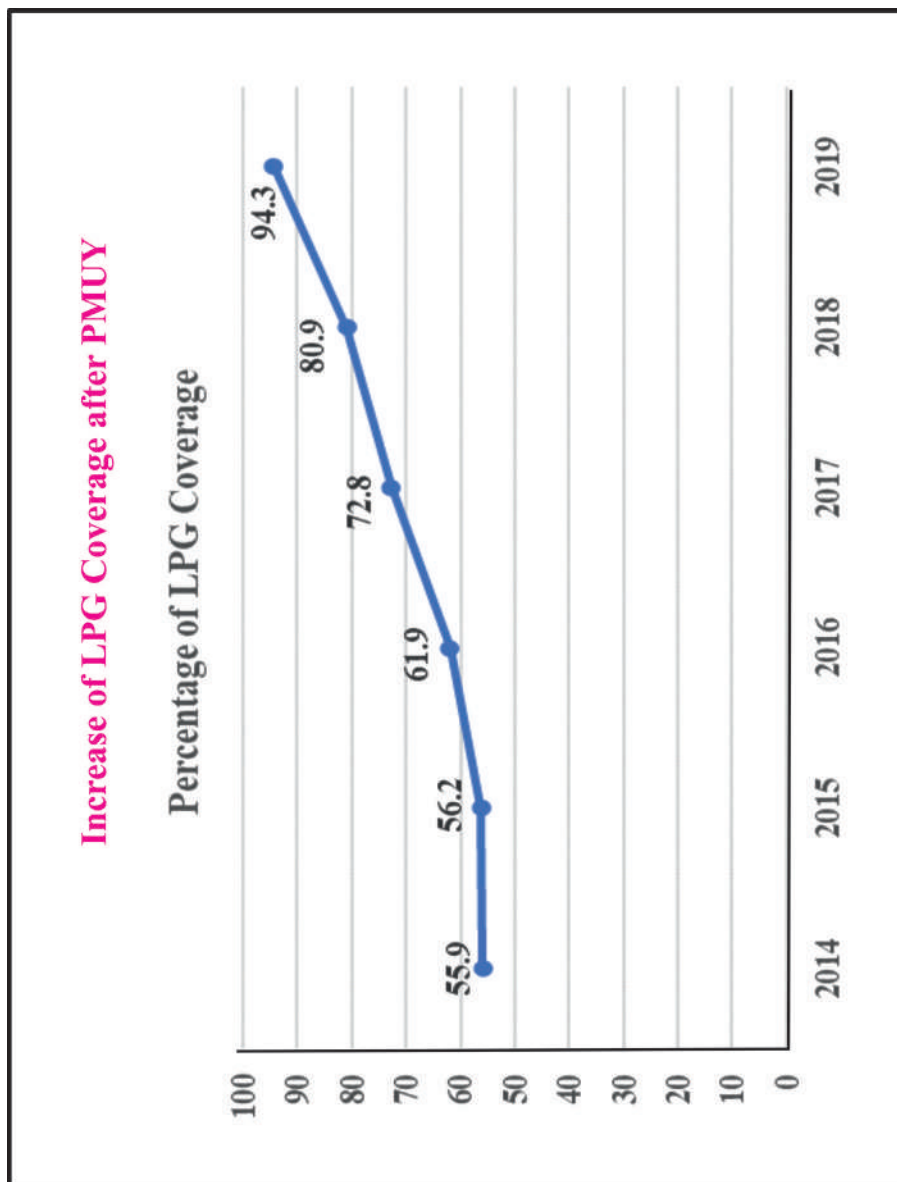


Fig. 2

Table-3 shows that more than 50 percent of households feel that their health improved after they started using the LPG cylinders, which they received in the PMUY scheme. About 33 percent of households do not feel that PMUY improves their health, and about 14 percent do not know the health implications of PMUY (Fig. 2). 17.89 percent from 20.53 percent General, 13.16 percent out of 26.84 percent OBC, 17.89 percent out of 48.95 percent SC, and 2.63 percent out of 3.68 percent ST households agreed that their health has been improved due to adoption of clean cooking while 2.63 percent from General, 8.95 from OBC, 21.05 from SC and 1.05 percent from ST households did not feel the health improvement. 4.73 percent of OBC and 10 percent of SC households were unable to understand the health implications of PMUY. During the survey, when we interacted with households, we found that about 70 percent of the respondents used traditional fuel resources occasionally (Table-3). When we asked them about the main barriers to using LPG cylinders, most of them answered that the high cost of cylinders and delayed subsidies are the main barriers that compel them to use traditional fuel resources. Firewood, cow dung, and agricultural residue are the main traditional fuel resources that are frequently used by households. Most of them get 3 to 4 cylinders in one year. Some respondents are yet facing the problem of using LPG cylinders.

Table-3: The Perception of Women's Health after PMUY

Social group	Women's Health after PMUY						Total	Total %
	Improved	%	Not Improved	%	Do not know	%		
General	34	17.89	5	2.63	-	-	39	20.53
OBC	25	13.16	17	8.95	9	4.73	51	26.84
SC	34	17.89	40	21.05	19	10	93	48.95
ST	5	2.63	2	1.05	-	-	7	3.68
Total	98	51.58	64	33.68	28	14.74	190	100

Source: Computed based on Primary Survey

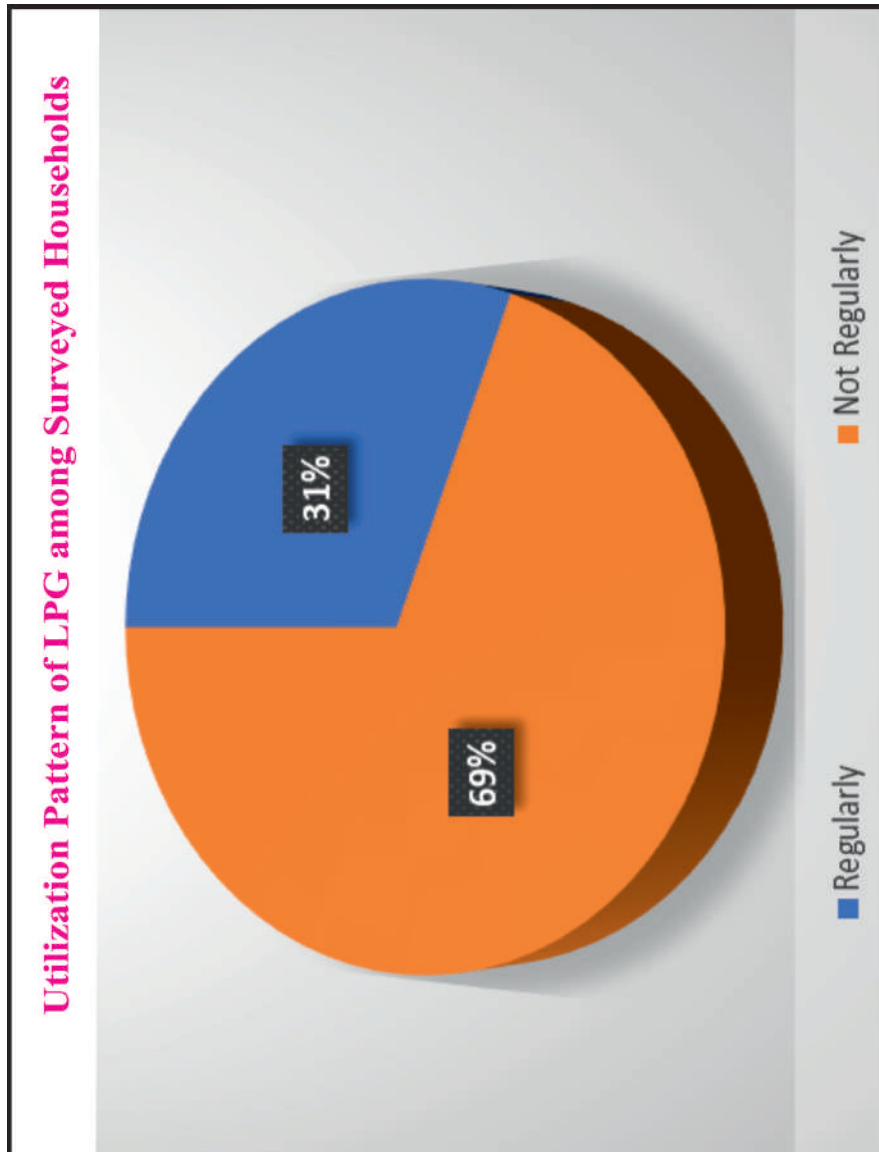


Fig. 3

Eye irritation, headache, and respiratory diseases are the main problems that have been reduced due to the adoption of clean cooking. More than 60 percent of households agree that their health problem has been reduced now (Fig. 3). There are fewer visiting doctors than earlier. They are now participating more actively in their economic and social activities because their health has improved compared to earlier.

Conclusion

The PMUY has significantly impacted the rural households of the Prayagraj district. In this respect, PMUY is playing a considerable role in improving the health and well-being of the women who are the primary beneficiaries of the scheme because of their key role in cooking activities. The research shows that over 80 percent of households use traditional fuel resources only sometimes in a year while they use LPG cylinders the rest of the time. Over 50 percent of the households agreed to fewer health problems due to the adoption of LPG, thus showing that the scheme effectively provides a smoke-free and clean environment. Although this effectiveness exists, many challenges still restrict people in the study area. Only 31 percent of households use LPG regularly; 69 percent of households occasionally use the traditional fuel resource; hence, further intervention is needed to ensure a complete transition to LPG eventually. Establish a monitoring system for monitoring the usage of LPG, and support households who may be facing problems in utilization of LPG. The feedback mechanism should be established by which the beneficiaries can give feedback and able to share their valuable opinion. By addressing these problems PMUY may be more effective.

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ASSESSMENT OF TRANSITIONS IN LANDUSE TRENDS OF JODHPUR CITY, RAJASTHAN

Priyansha Singh and Dr. Lalit Singh Jhala

Abstract

Land is the primary place for mankind and the magnitude of land use land cover changes over the period of time are intense. How it is used by the people is implied as land utilisation which varies with the purposes it serves, it ranges from agricultural purpose to water bodies to residential purpose, from recreation, extraction and processing of materials, and the bio-physical characteristics of land itself. This paper aims to present a four decadal analysis of how the patterns of Land use of Jodhpur which is the second largest city in the state of Rajasthan have changed from 1980 to 2020. Jodhpur has made a transitional journey of urbanisation owing to several factors, which has had impacts on land use as well, so various dimensions have been studied majorly via remote sensing technology, census of India and suitable allied documents, and their patterns have been presented through maps, charts, tables and graphs. Landsat images of resolution 30m have been taken and after processing in ARCGIS are classified by maximum likelihood method. Further change has been studied under individual classes and overall and potential causes for the said change have been stated. Population and Land Use are highly co related variables and affect each other drastically. Continuous increase has been seen in built up area in the city and share of agricultural land.

Introduction

Land cover is defined as assemblage of biotic and abiotic components on earth's surface (Turner et al 1994). Land use is how the of land is intended to be managed on the land cover by human agents to exploit the land cover and reflects human activities such as industrial zones, residential zones, agricultural fields, grazing, logging and mining among others (Zubair, 2006). Growth in population, lifestyle changes and rapid urbanization is impacting the land use pattern around the globe very highly (Hubacek and Vazquez, 2002). Therefore, given the multifold rise in population, the study of land use of a region is utmost crucial.

The development of LULC pattern of any region results from various natural, human and socio-economic factors. A large section of Jodhpur falls under Thar Desert, has undergone various changes over the years. It has been the biggest district of western Rajasthan and second biggest city of Rajasthan after capital Jaipur. Despite being situated in the desert ecosystem, it has seen rapid urbanisation, population growth, urban expansion, in migration etc. which has ultimately impacted the objectives of land use for the residents of this city. In 1981 the population of district was 1,66,7791 which increased to 36,87,165 in 2011 and on the same growth rate it is expected to be very high in next census. Rise in activities of building & construction of both residential and commercial infrastructure has happened due to this population growth. It includes housing and colonies, schools, institutes, organisations etc. No significant research had been done till yet to find changes in land use so this study aims to present an analysis of land utilisation of Jodhpur using geospatial techniques. Jodhpur city has a varied profile of conducted activities from industrial to stone mining, with that large sections being barren at a point have now been seen utilised under different areas, population has also seen continuous spike, all these factors make it necessary to study the patterns of its land use. Remote Sensing and GIS are the latest and very accurate techniques to study LULC, therefore satellite imagery from years 1980-2020 have been processed to be used for the purpose of study, giving us category wise data for LULC.

Objectives

- (1) To examine the four decadal land use land cover scenario of Jodhpur city.
- (2) To see the decade wise growth of major LULC categories, analyse the structure of growth, and reflect on potential contributory factors.

Study Region

Jodhpur district is located at 26°18' N Latitude and 73°1' E Longitude in western Rajasthan. The large part of city is semi-arid with some being entirely arid. The district is approximately 197 kilometres long from north to south and 208 kilometres long from east to west. The district is shaped like an irregular rectangle. Sand dunes are commonly seen in the arid region. The district's hills range in height from 284 metres in the north to 450 metres in the east. Total area of the district is 22564 sq. kms. The terrain has a general westward slope. Jodhpur is home to a diverse range of flora and fauna, despite its arid climate. The district's soil is predominantly sandy and loamy. The desert city has extremes of heat in the summer and cold in the winter. The temperature ranges from 49 °C in the summer to 1 °C in the winter.

The average annual rainfall is 302 millimetres. Although there is no perennial river, Luni and Mithri rivers are main rivers in the district. For the precision of research, study region for this paper has been delimited to the area under Jodhpur Developmental Authority, the autonomous body of government of Rajasthan responsible for urban development of the region.

Database and Methodology

In this study cloud free satellite imagery from USGS LANDSAT 3 (Path160/ Row 42), LANDSAT 5 (Path 160/Row 42), LANDSAT 7 (Path160/ Row 42), LANDSAT 8(Path160/ Row 42) of spatial resolution 40m and 30m were used for years 1980 to 2020. Dates for images were 29/11/1980, 11/11/1990, 29/10/2000, 21/10/2010 and 06/11/2020. Images from the post monsoonal months were obtained to develop decadal thematic maps of study area. Followed by making GIS database. Along this, SOI Toposheets no. 45/F/02 45/F/03 45/F/04 on scale 1:50000 were referred for further better understanding and confirming the directions of growth. ArcGIS and ERDAS Imagine were used as preprocessing, processing, classification, calculation and computing softwares. Firstly, the satellite images were obtained and subsets were created from them. Then, first the unsupervised classification was done, then using ground truth information actual sets were created. Then on the basis of generation of signature files, Maximum Likelihood Method was applied and final six categories of LULC were generated. These categories are Agriculture, built up, mining, soil and barren land, vegetation and water bodies. Further Post Classification change was identified for maps and results were obtained for changes between 1980 and 2020 land use. Change Percentages have been calculated using formula:

$$\text{Change Percentage (\%)} = \frac{\text{Present LULC area} - \text{Previous LULC area}}{\text{Previous LULC area}} \times 100$$

For the analysis of area increase and decrease secondary data from various reports including census data, agriculture vital statistics, master development plans of the city, weather data reports were studied for necessary observations and have been co related in accordance.

Results and Discussion

Landuse pattern in Jodhpur city in 1990 and 2000

(A) Agriculture: Agricultural land is area under agricultural crop lands. Here, significant change can be seen in this category, the growth rate has differed

but it has continuously increased from just 84 kms in 1980 to 1413 kms 2020. Percentage wise from 1.92% to 32.05 % has been seen, showing exponential growth rate of 30.13% in 40 years with maximum growth between 1980 to 1990. Agricultural Vital Statistics published by Government of Rajasthan give us a better clarity to understand the reasons to this rise in area. Statistics show constant increase in net sown area of the district (Fig. 1). This change owes its cause to the better irrigation facilities, government schemes, evolution of technology, hybrid seeds, insurance facilities, training of farmers and increase of general awareness.

(B) Soil and Barren Land: These areas are defined as vegetation less vacant vast lands. Waste and degraded land is also included in this category. This category had the highest area given the city is located in desert but as the years followed from 1980, the idle area here has been put to other uses and hence the overall area drastically decreased from 3555.97 kms to 2157.16 kms. The reduction in area was most between years 2000 to 2010 which was 636.66 kms. Even after reducing from 80.63% in 1980 to 48.69 % in 2020, it still occupied maximum share in total area through all decades.

(C) Water Bodies: No major water bodies let alone any perennial river have been present in this region, except a few seasonal water streams, ponds and reservoirs. This category has always had least area under it because of scanty rainfall and arid ecosystem. More importantly since the images were post monsoonal, it is safe to presume that most area under this head could be temporary water bodies, which eventually dry up. As far as area is concerned, it has showed irregular pattern with overall increase from 39.3 kms in 1980 to being as low as just to 1.71 kms in 2000 to rising 30.81 kms in 2010 to again being 50.14 kms in 2020. These lows and highs in the area of water bodies have been in consistency with amount of rainfall for the years as observed from data by IMD, Pune. For 1980, it was 250.2 mm, 821 mm in 1990, 273 mm in 2000, 511 mm in 2010 and finally 444.1 mm in 2020.

Table-1: Area Under Different LULC Categories

Class Name	(Area in kms)					Percentage Share in total area		
	1980	1990	2000	2010	2020	1980	2020	Change
Agriculture	84.92	494.74	655.67	1004.02	1413.94	1.92 %	32.05 %	+30.13 %
Soil & Barren Land	3555.97	3103.72	3382.71	2746.05	2157.16	80.63 %	48.90 %	-39.73%
Water Bodies	39.3	7.70	1.71	30.81	50.14	0.89 %	1.14 %	+ 0.25%

Contd...

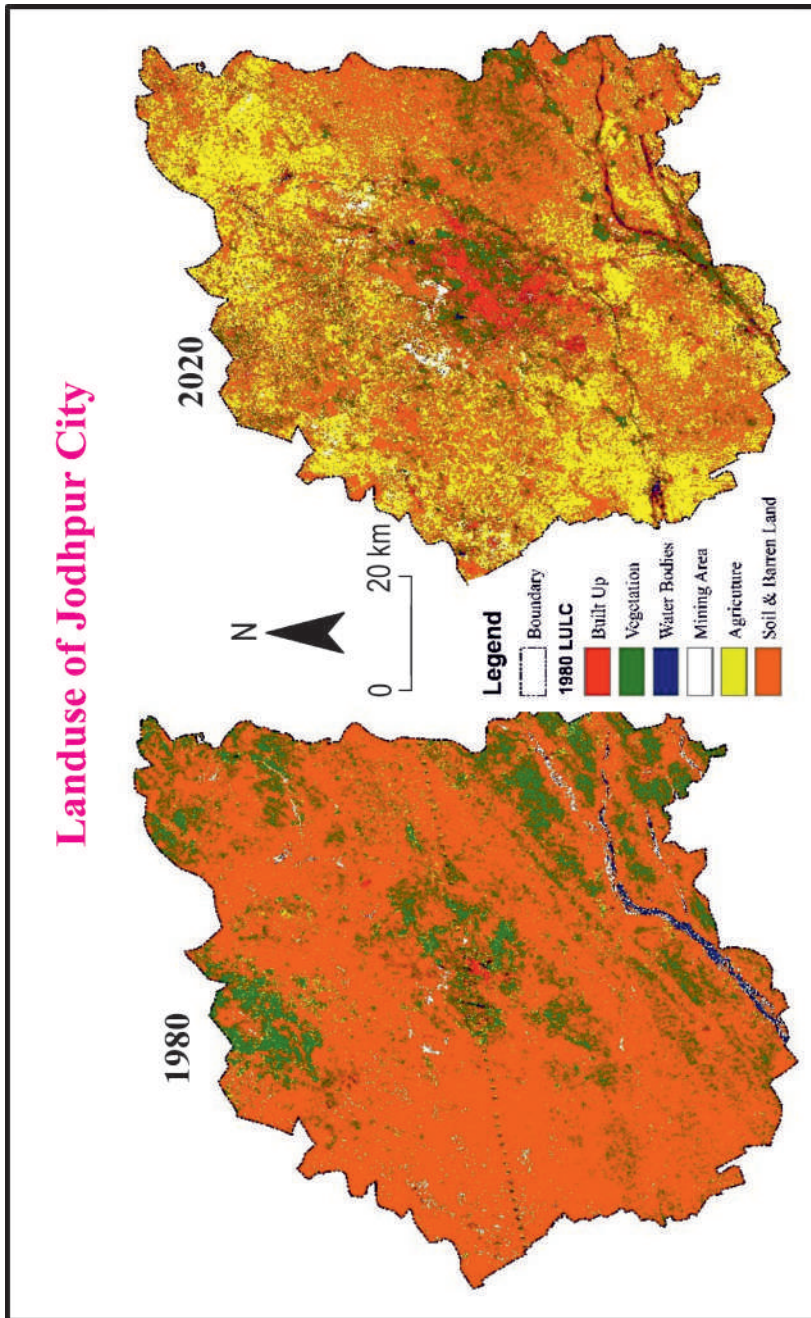


Fig. 1

Built Up	11.68	36.19	93.05	176.56	264.11	0.26 %	5.98 %	+5.72%
Mining Area	63.87	18.54	98.5	78.12	106.79	1.45 %	2.43 %	+0.98%
Vegetation	658.16	753.16	182.42	379.05	422.95	14.93 %	9.53 %	-5%
Total	4410	4411	4411	4413	4412	100	100	

Source: Computed by Authors

Table-2: Period wise Area Change

Land use Category	Area Change (in kms)				Percentage Increase/Decrease (%)			
	1980-1990	1990-2000	2000-2010	2010-2020	1980-1990	1990-2000	2000-2010	2010-2020
Agriculture	+409.82	+160.93	+348.33	+409.92	+482.56%	+32.53%	+53.15%	+40.82%
Soil & Barren Land	-452.25	+278.99	-636.66	-588.89	-12.72%	+8.98%	-18.82%	-21.44%
Water Bodies	-31.6	-6	+29.1	+19.33	-80.40%	-77.93%	+1701%	+62.74%
Built Up	+24.51	+56.86	+83.51	+87.55%	+209.85%	+157.16%	+89.744%	+49.58%
Mining Area	-45.33	+79.96	-18.4	+28.67%	-70.97%	+431.29%	-18.68%	+36.69%
Vegetation	+95	-570.74	+197.74	+42.35%	+14.44%	-75.77%	+108.34%	+11.18%

Source: Computed by Authors

(D) Built Up: Built up area is land under non-agricultural use by humans and is the direct reflection of population growth and urbanisation, therefore the continuous and intensive increase in this category tells us about the city expanse, sprawl and the concentration centres. From just 11 kms in 234 kms in 2020, the city of Jodhpur has shown constant built-up development more inclined towards south and east in comparison to north and west. Maximum growth rate was seen in between 1980 to 1990 and overall share of built up was 0.26 % in 1980 to 5.98 % in 2020. Also, in 1980 where the built up was largely concentrated in centre, eventually the diverse concentration centres lead to irregular shape and pattern of growth with varying urbanisation levels (Fig. 2).

(E) Mining Area: The sandstone of Jodhpur is famous globally for its beauty and strength and hence it is a mining hub. The mining work is done in the city since pre independence times. This category has also seen overall increase with slight decrease in the decade of 1990 from 63.87 kms to 18.54 kms. The area under mining increased from 63.87 kms to 106.78 kms. Overall growth rate

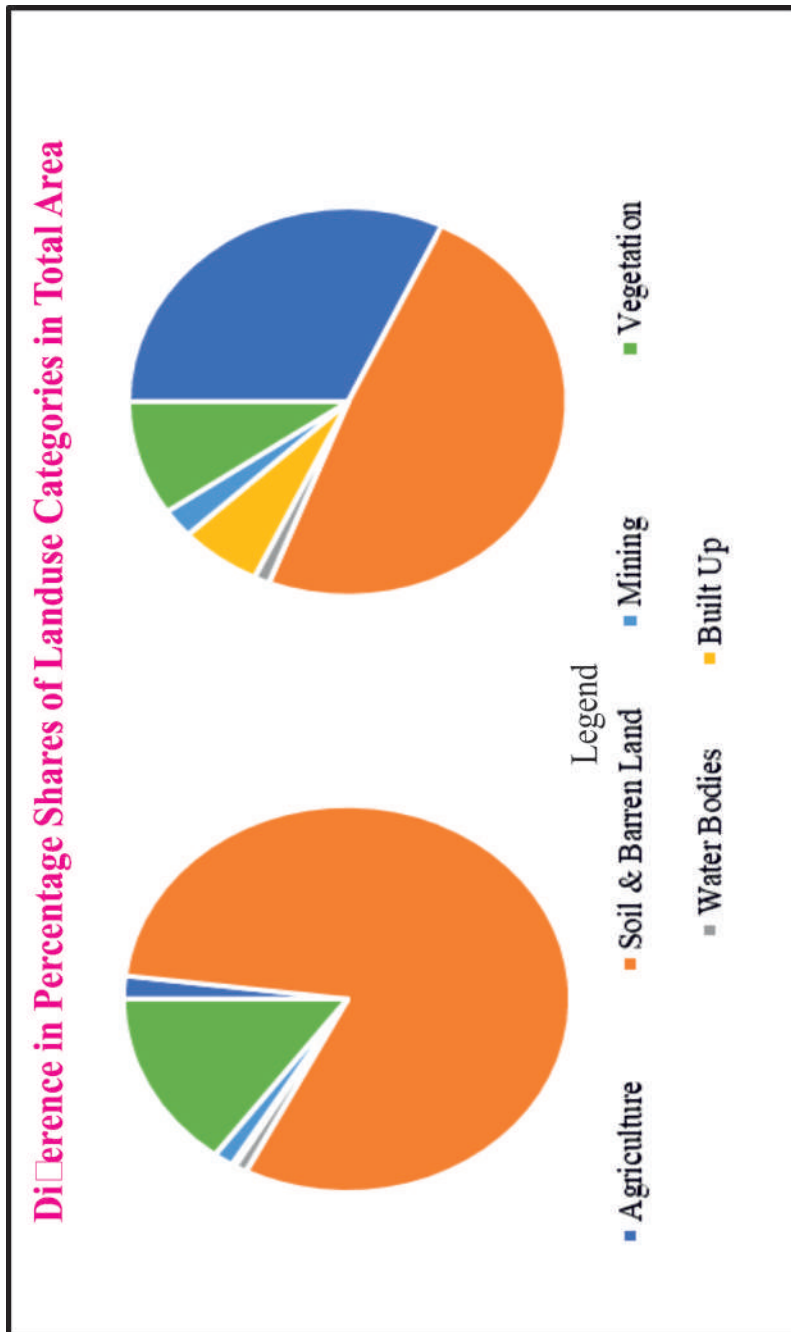


Fig. 2

has been +0.98%. Most mines are located in the north and northwest direction. This change is particularly alarming because it has resulted in huge cliffs in the mining area where eventually water fills up apart from health issues like silicosis in the working labourers.

(F) Vegetation: Vegetation cover has largely remained very scattered and scarce with slight increase and decrease here and there with overall decrease. There is no dense vegetation cover in entire region, only shrubs and trees that grow well in aridity can be seen along with some pockets of green cover from parks and gardens in the city spaces. The area under vegetation category has gone down from 658.16 kms and share of 14.93% to 422.95 kms and share of 9.53 %. The reasons have been similar to the category of water bodies, extreme temperatures of arid ecosystem and scanty rainfall. The pattern observed is that the temperatures in summer season go as high as 48°C leading to loss of maximum shrubs and minor vegetation except big trees, followed by drastic increase in temporary pasture and grass lands after the rainy season which eventually deplete later.

Conclusion

This paper has made an attempt to see the changes in Land use trends and patterns of Jodhpur city from 1980 to 2020 and found that land use of Jodhpur has shown major change in two-way manner, decrease in area under soil and barren land and increase in area under agriculture and built-up area. Water Bodies and Vegetation appear to have least impact with overall increase in water bodies and decrease in already scarce vegetation. More efforts can be made to increase the share of green cover in the city. Residential and Commercial built up needs to be in coordination with overall development. More concentrated expansion in two directions indicate irregular pattern so it needs to be checked and properly planned development needs to occur.

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ASSESSMENT OF BACKYARD POULTRY REARING FOR POTENTIAL FOOD SECURITY AND ECONOMIC EMPOWERMENT IN RURAL INDIA

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Abstract

Backyard poultry farming is pivotal in enhancing food security and promoting economic empowerment in rural India. This practice offers a sustainable and accessible source of high-quality protein, particularly benefiting landless and smallholder farmers, thus helping to address widespread nutritional deficiencies. Integrating indigenous poultry breeds strengthens resilience, enabling rural households to rear poultry with minimal capital investment. This study examines the multifaceted contributions of backyard poultry farming, emphasizing its socio-economic benefits, particularly in poverty alleviation and combating malnutrition. The findings underscore the substantial impact of backyard poultry farming on local food security and economic empowerment while identifying key challenges such as disease outbreaks and low productivity. The study concludes with recommendations to improve poultry farming practices and advance rural development initiatives, maximizing its potential to contribute to India's food security objectives.

Introduction

Backyard poultry farming has emerged as a pivotal practice in India, significantly enhancing food security and fostering economic empowerment among rural communities. This approach to poultry rearing offers a sustainable source of high-quality protein, essential for addressing nutritional deficiencies in rural diets (Mahapatra & Johnson, 2019). By allowing families to rear birds with minimal investment, backyard poultry is a crucial livelihood strategy, particularly for landless and smallholder farmers facing economic challenges (Kumar et al., 2019). Integrating indigenous poultry breeds in backyard systems is especially beneficial, as these breeds are well-adapted to local conditions and can thrive on low-input resources (Gupta et al., 2021). This traditional practice helps meet

household protein needs and generates supplementary income through the sale of eggs and meat (Ahuja et al., 2008). Moreover, research highlights the potential of improved poultry breeds to enhance income levels and nutritional quality within rural households (Kumar et al., 2021).

As India grapples with increasing urbanization and shifting dietary preferences, the demand for poultry products is rising (Chen, 2022). However, rural communities often struggle to access these resources, underscoring the need for self-reliant poultry production systems to ensure local food security (Khandait et al., 2011). Studies indicate that backyard poultry farming can significantly contribute to the supply of eggs and chicken meat, improving food availability in rural areas (Rajkumar et al., 2021). Furthermore, this practice has been shown to empower women by providing them with income-generating opportunities and enhancing their roles in household nutrition (Singh et al., 2022). The socio-economic benefits of backyard poultry are profound, particularly in alleviating poverty and malnutrition among vulnerable populations, including women and children (Yadava et al., 2017). Additionally, backyard poultry farming is an environmentally sustainable practice, as it contributes organic manure for agricultural use and aids in pest control within farming systems (Selvam, 2004). With the Indian poultry sector experiencing substantial growth—evidenced by an 8% annual increase in meat production and a 7.45% rise in egg production from 2014-15 to 2021-22 (BAHS, 2022)—backyard poultry is poised to play a critical role in rural economic development and food security initiatives across the country. This assessment aims to explore the multifaceted contributions of backyard poultry rearing to food security and economic empowerment, highlighting its importance in rural India's socio-economic landscape.

Study Region

Rural India reflects significant diversity in backyard poultry farming, with indigenous breeds well-suited to varied climates and traditional farming methods, ensuring sustainability and resilience. The diverse climate and terrain across rural regions enable the rearing of different indigenous breeds, each adapted to local environmental conditions, further enhancing their productivity. It supports approximately 68% of rural households, contributing 17% to national egg production and 33% to poultry meat. Households typically rear 5-15 birds, generating an extra income of ₹5,000 to ₹10,000 annually. Women play a crucial role, managing around 70% of poultry operations, thus fostering economic empowerment. With maintenance costs of ₹300-₹500 per bird, and improved nutrition from eggs and meat, backyard poultry remains essential to rural livelihoods in India.

Objectives

- (1) To analyze the contribution of backyard poultry rearing to food security in rural India
- (2) To evaluate the role of backyard poultry farming in the economic empowerment of rural areas.
- (3) To provide policy recommendations for enhancing backyard poultry rearing as a tool for food security and economic empowerment

Database and Methodology

The study utilizes data collected from various primary and secondary sources, including government reports, livestock census data, and published research papers. Key data sets were drawn from the Basic Animal Husbandry Statistics (2022) and state-level reports on poultry farming, focusing on backyard poultry population, egg production, and growth rates across different Indian states. The primary data collection method involved a systematic review of available literature, including reports from the Ministry of Animal Husbandry, Dairying, and Fisheries and various state animal husbandry departments. Data analysis employed descriptive statistical methods to interpret growth rates and production trends and inferential statistics to assess the relationship between backyard poultry farming and rural livelihoods, food security, and economic empowerment. This mixed-method approach provided a comprehensive understanding of the role of backyard poultry farming in rural India.

Results and Discussion

Backyard Poultry in Indian Context

Backyard poultry farming is crucial in India's agricultural sector, particularly in rural and semi-urban areas. It provides essential support in terms of income, nutrition, and employment. The use of indigenous breeds like Aseel, Kadaknath, Giriraja, and Vanaraja, which are well-adapted to local conditions, is common. This form of poultry farming is low-cost and high-yield, with minimal investment needed for feed and infrastructure as birds often scavenge for their food. Eggs and meat produced from these birds boost household food security and offer additional income, especially for women, who typically manage the operations. Recent statistics show the growing prominence of backyard poultry across various states in India. For instance, Odisha has a backyard poultry population of 22.95 million birds, with an impressive growth rate of 54.16%, producing 1,230 million eggs annually,

with egg production growth at 56.80%. West Bengal, with 24.10 million birds, also shows rapid expansion, growing by 57.83% in population and producing 1,305 million eggs, increasing by 58.60%. Assam, with 22.15 million birds, has the highest growth rate in egg production at 61.75%, producing 1,110 million eggs. Other states, such as Chhattisgarh and Jharkhand, contribute significantly to backyard poultry, growing by 51.07% and 65.35%, respectively (Table-1). Table 1 further highlights states like Tamil Nadu, Uttar Pradesh, and Andhra Pradesh, which have notable growth rates in this sector. Andhra Pradesh, with a population of 9.91 million backyard birds, has a growth rate of 43.85% and contributes 1,120 million eggs annually. Bihar has a population of 13.47 million backyard birds, while Madhya Pradesh holds 9.84 million, contributing significantly to egg production.

Table-1: Backyard Poultry Population, Egg Production and Growth

States	Backyard Poultry Population (In millions)	Growth Rate in Population (%)	Egg Production (In million eggs)	Growth Rate in Egg Production (%)
Odisha	22.95	54.16	1,230	56.80
West Bengal	24.10	57.83	1,305	58.60
Assam	22.15	59.35	1,110	61.75
Chhattisgarh	15.77	51.07	855	53.90
Jharkhand	14.92	65.35	725	67.10
Bihar	13.47	58.07	680	59.45
Tamil Nadu	8.25	58.16	950	61.25
Uttar Pradesh	7.42	55.23	690	57.80
Andhra Pradesh	9.91	43.85	1,120	45.25
Madhya Pradesh	9.84	51.00	580	52.40
Rajasthan	7.11	55.92	435	57.15
Karnataka	7.97	55.10	840	58.00
Maharashtra	6.78	65.37	510	68.25
Kerala	5.43	57.39	600	59.80
Punjab	3.26	55.98	250	57.50

Sources: Animal Husbandry Statistics, 2022; Government of India (GOI), 2020

India's poultry population has seen substantial growth between 2012 and 2019. The number of backyard poultry increased from 217.49 million to 317.07 million, reflecting a growth of 45.79%. In comparison, the commercial poultry sector showed a modest increase of 4.5%, from 511.72 million to 534.74 million.

The overall poultry population in India grew from 729.21 million in 2012 to 851.81 million in 2019, marking a 16.81% rise, with backyard poultry being a major contributor to this growth. The notable rise in backyard poultry farming, especially compared to the commercial poultry sector, highlights the growing importance of this low-cost, resource-efficient system. Several factors contribute to this trend, including increasing awareness of the nutritional benefits of eggs and poultry meat and support from government programs like the Rashtriya Krishi Vikas Yojana (RKVY) and the Poultry Venture Capital Fund. The resilience of indigenous breeds to local environmental conditions and diseases also makes backyard poultry an ideal option for resource-poor communities, further driving the sector's expansion.

The data illustrates that backyard poultry farming is vital in rural economies, offering nutritional and financial benefits. Women, in particular, benefit from the income generated through these activities. With continued population and egg production growth, backyard poultry is positioned to be a key driver in the country's agricultural and rural development strategies.

Contribution of Backyard Poultry Rearing to Food Security in Rural India

Backyard poultry farming plays a significant role in enhancing food security, particularly in rural and low-income areas. It provides a consistent source of high-quality protein through eggs and meat, with a single hen producing between 150 and 300 eggs annually. This availability contributes to better nutrition and food accessibility. Poultry meat is an excellent source of lean protein, crucial for body growth, muscle development, and tissue repair, with a 100-gram serving of cooked chicken breast offering approximately 31 grams of protein. Furthermore, poultry meat contains all nine essential amino acids the human body requires, making it a complete protein source. Its combination of high-quality protein, essential vitamins, and minerals makes poultry a key dietary component in improving nutrition, especially in low-income and developing regions where access to other animal protein sources may be limited.

Regional Contributions of Backyard Poultry Rearing to Food Security in Rural India

Backyard poultry rearing has emerged as a crucial component of rural livelihoods in India, significantly enhancing food security across various regions. This practice addresses the specific nutritional and economic needs of local communities in a country where millions face malnutrition, particularly in rural areas. With minimal resources, smallholder farmers, often including women,

manage flocks of indigenous or semi-scavenging breeds, providing a sustainable source of high-quality protein through eggs and meat. A comprehensive overview of the contribution of backyard poultry farming to food security across various Indian states underscores its vital role in enhancing rural livelihoods by providing protein, income, and nutritional security. In Eastern India, West Bengal stands out with 40 million birds, contributing 30% to the protein intake and generating annual earnings ranging from ₹5,000-10,000. The high average egg consumption of 64 per capita indicates significant reliance on poultry for protein. Moreover, West Bengal's poultry farming addresses nutritional needs and plays a pivotal role in local economic dynamics, with numerous small-scale farmers engaged in this practice. Odisha and Assam also demonstrate considerable contributions, with 14.8 million and 8 million birds, respectively. These states enhance protein intake and income, particularly for tribal communities, with Odisha supporting sustainable livelihoods through traditional poultry farming practices. In Northern India, Uttar Pradesh leads with 38 million birds, contributing 40% to protein intake for rural households and serving as a crucial income source for 20% of the rural population.

The state's extensive network of backyard poultry farmers has established a vital supply chain that contributes to local markets and food systems. With 20 million birds, Bihar plays a significant role in bridging food security gaps, enhancing local nutrition, and supporting diverse agricultural practices. In comparison, Haryana (6 million birds) bolsters local economies through poultry sales, which also help maintain regional culinary traditions. Southern India showcases strong contributions from Andhra Pradesh and Tamil Nadu, with annual earnings of ₹7,000-10,000 and ₹6,000-9,000, respectively. In Andhra Pradesh, women's empowerment through income-generating opportunities from poultry farming contributes to household incomes and enhances women's social status within their communities. The government has implemented various programs to promote backyard poultry farming as a sustainable livelihood option, thereby improving overall family nutrition. Telangana and Tamil Nadu also emphasize nutritional enhancement, with backyard poultry providing essential protein sources that help combat malnutrition and stunting in children. In Western India, Maharashtra (17 million birds) and Gujarat (10 million birds) highlight the economic importance of backyard poultry farming in drought-prone regions. These states have developed supportive policies to assist smallholder farmers, ensuring food security and a stable income for rural households facing economic challenges. The poultry sector in Maharashtra is crucial for maintaining household food security, particularly in times of climate variability.

In contrast, Gujarat's efforts to integrate poultry farming with local agrarian practices have helped sustain livelihoods amidst economic fluctuations. In North-Eastern India, states like Nagaland and Manipur show the highest protein contributions, with 60% and 50%, respectively, indicating a critical reliance on backyard poultry for nutritional needs. This reliance is underscored by cultural practices that incorporate poultry into traditional diets, and these states demonstrate the effectiveness of community-based poultry initiatives that strengthen local food systems. Moreover, the diversity of poultry breeds in these regions, adapted to local conditions, enhances resilience and food security for rural families.

In Central India, Madhya Pradesh and Chhattisgarh address chronic malnutrition issues, with 30% and 25% protein contributions, respectively. Both states have recognized the importance of poultry farming in improving food security and reducing anemia and stunting rates, particularly among vulnerable populations. Government initiatives in these states focus on training and providing resources for smallholder farmers, facilitating the growth of sustainable poultry farming practices. Overall, the data underscores the pivotal role of backyard poultry farming in improving food security across India, with significant variations by state reflecting local socio-economic conditions, cultural practices, and agricultural policies (Table-2). This sector supports nutrition and income generation and fosters empowerment, especially among women and marginalized communities, making it a vital area for policy focus and development initiatives. Further investment in this sector, including access to veterinary services, improved feed supply, and training programs, could significantly strengthen food security, improve livelihoods, and foster sustainable rural development, ultimately contributing to India's more resilient agricultural system. Backyard poultry, largely dependent on scavenging for feed, has lower productivity than commercial systems. Indigenous breeds produce fewer eggs (around 60-100 per year), and meat yield is also low, limiting the nutritional benefits of protein, vitamins, and minerals for rural households (Mehta et al., 2003; FAO, 2013). This impacts the potential for backyard poultry to contribute to daily protein intake, especially in areas with malnutrition. According to a FAO report, rural poultry farmers consume only 2-3 eggs per week, far below the recommended levels (FAO, 2020). Promoting improved dual-purpose poultry breeds and better feed management could help boost productivity and increase the availability of animal-sourced foods (Kumar et al., 2022). Scavenging-based feeding systems provide insufficient nutrients, affecting growth and egg production. Chickens in these systems often lack essential nutrients, producing only about 50-60 eggs and

Table-2: Contribution of Backyard Poultry Farming to Food Security in Indian States

Region	State	Backyard Poultry Birds (in millions)	Protein Contribution (% of intake)	Annual Earnings (₹)	Average Egg Consumption (per capita)
Eastern India	West Bengal	40	30%	5,000-10,000	64
	Odisha	14.8	25%	6,000-8,000	40
	Assam	8.0	30%	5,000-7,000	40
	Jharkhand	5.5	20%	4,000-6,000	35
Northern India	Uttar Pradesh	38	40%	3,000-7,000	40
	Bihar	20	25%	2,000-5,000	40
	Haryana	6.0	30%	5,000-8,000	45
Southern India	Andhra Pradesh	24	25% of total egg consumption	7,000-10,000	56
	Telangana	14	20%	5,000-7,000	35
	Tamil Nadu	15	30%	6,000-9,000	50
Western India	Maharashtra	17	25-30% of household income	4,000-6,000	50
	Gujarat	10	35%	4,000-6,000	40
North-Eastern India	Nagaland	3.6	60%	4,000-6,000	50
	Manipur	2	50%	4,000-6,000	45
	Tripura	1.5	40%	3,000-5,000	30
Central India	Madhya Pradesh	12.6	30%	5,000-8,000	30
	Chhattisgarh	9.2	25%	5,000-8,000	40
Western India	Rajasthan	8.0	20%	3,500-6,500	35

Sources: Govt. of West Bengal, 2021; ICAR, 2022; Assam Animal Husbandry & Veterinary Dept., 2021; Jharkhand Animal Husbandry Dept., 2022; Dept. of Animal Husbandry & Dairying, GOI, 2019; Bihar Agricultural Univ., 2020; Haryana Animal Husbandry Dept., 2021; Andhra Pradesh Animal Husbandry Dept., 2022; Telangana State Agricultural Univ., 2022; Tamil Nadu Animal Husbandry Dept., 2021; Maharashtra Animal Husbandry Dept., 2021; Gujarat Animal Husbandry Dept., 2022; Nagaland Animal Husbandry & Veterinary Services, 2021; Manipur Animal Husbandry Dept., 2020; Tripura Animal Husbandry Dept., 2021; Madhya Pradesh Animal Husbandry Dept., 2021; Chhattisgarh Animal Husbandry Dept., 2020; Rajasthan Animal Husbandry Dept., 2022.

1.5 kg of meat per bird annually, contributing less than 10% to household protein intake (FAO, 2020). Formulated supplementary feeds and high-protein forage crops can improve poultry growth and product quality (Mehta et al., 2003). Disease outbreaks, like Newcastle disease, lead to high mortality rates, further reducing egg and meat availability. Strengthening veterinary infrastructure and vaccination campaigns can help mitigate these losses (FAO, 2013; Kumar et al., 2022).

Contribution of Backyard Poultry Rearing to Economic Empowerment in Rural India

Backyard poultry rearing plays a significant role in the economic empowerment of rural households in India, particularly for small and marginal farmers and women. This practice requires minimal investment while providing a substantial source of supplemental income, essential for households with limited financial resources. According to the Food and Agriculture Organization (FAO), rural families in India earn approximately INR 5,000 to INR 10,000 annually from backyard poultry activities, mainly selling eggs and live birds. This income is particularly valuable in regions with seasonal or inconsistent agricultural income due to climatic factors like drought or low crop yield (FAO, 2013; MANAGE, 2021). Research by Kumar et al. (2016) indicates that rural farmers engaged in poultry farming can experience an increase in household income by up to 20-30%. Such financial stability is crucial in areas with scarce alternative income sources, directly contributing to food security and poverty alleviation. In addition to income generation, backyard poultry rearing offers a steady income stream even during lean periods, helping stabilize household finances. The Ministry of Animal Husbandry, Dairying, and Fisheries (2021) estimates that the poultry sector in India employs around 15 million people, with a significant proportion of these jobs embedded in rural backyard poultry systems. This includes poultry rearing and ancillary services such as feed supply, veterinary care, and local poultry marketing (Ministry of Animal Husbandry, 2021). The International Livestock Research Institute (ILRI) emphasizes that backyard poultry contributes to the livelihoods of smallholders and landless laborers, employing individuals lacking access to agricultural land. For every 10 birds raised, at least one additional person is employed in support services, such as feeding, healthcare, or transporting products to local markets (ILRI, 2021). It makes backyard poultry a vital source of employment, particularly for marginalized communities and women. Women's economic empowerment is another crucial aspect of backyard poultry rearing, as women are typically the primary caretakers in this sector. In many regions, social norms restrict women's access to formal employment; however,

backyard poultry provides them with opportunities to generate personal income. A study by the International Food Policy Research Institute (IFPRI, 2021) found that over 75% of rural women involved in poultry rearing use their earnings to enhance household welfare, including improved nutrition and education for children. Furthermore, women's self-help groups (SHGs) engaged in poultry farming have reported income increases of up to 40%, as noted by the National Bank for Agriculture and Rural Development (NABARD, 2022). This financial independence improves women's decision-making power within households and enhances their access to credit, enabling them to expand their poultry operations and achieve greater financial security. Backyard poultry rearing is not merely an economic activity but a vital tool for empowering women and fostering social inclusion in rural India. It significantly contributes to the economic well-being of households, enhances food security, and provides sustainable employment opportunities, particularly in marginalized communities. Through targeted support and initiatives, backyard poultry can continue to be essential in promoting rural development and poverty alleviation across India (Ahuja et al., 2008).

Backyard poultry farming is economically significant in rural India, enhancing food security and providing supplemental income for households. West Bengal leads with 3.8 million households involved, producing 800 million eggs annually. Odisha follows with 70% of rural households engaged, supported by initiatives like the Mukhyamantri Krushi Udyoga Yojana. Rajasthan focuses on traditional breeds, while Kerala and Punjab generate the highest incomes due to modern practices and demand for organic products. This sector empowers marginalized communities, particularly women in self-help groups (SHGs), fostering gender equity and financial independence, especially in Tamil Nadu and West Bengal, thereby contributing to overall community development. Indigenous breeds like Kadaknath in Madhya Pradesh and Rajasthan have opened new market opportunities for organic poultry, boosting rural incomes. However, challenges persist in states like Assam, where disease outbreaks and limited veterinary services threaten sustainability. High mortality rates due to inadequate biosecurity measures affect productivity. Government interventions, such as improved veterinary services and training, are essential to building resilience. Backyard poultry continues to play a vital role in rural development and food security, but targeted support is necessary to address regional challenges.

Conclusion

Backyard poultry farming offers significant potential to contribute to food security, economic empowerment, and rural development in India, particularly in resource-limited regions. It provides a sustainable source of protein, addressing nutritional deficiencies and creating economic opportunities for smallholder farmers. By integrating backyard poultry farming into rural development policies, India can advance food security and improve the socio-economic conditions of its rural communities. States like Kerala, Punjab, and West Bengal have demonstrated how government support, access to improved poultry breeds, and better infrastructure can lead to gains in productivity and income. These examples highlight how targeted policy interventions can maximize the benefits of backyard poultry farming. However, challenges remain in states like Assam and Odisha, where issues related to infrastructure, veterinary care, and market access hinder progress. Addressing these region-specific barriers through focused policies is essential. Key recommendations for driving the growth of backyard poultry farming include improving access to high-yielding poultry breeds, which will enhance productivity and improve rural household nutrition. Comprehensive training programs on poultry management and biosecurity, particularly for women, are crucial for promoting financial independence and reducing flock losses.

Ensuring affordable veterinary care and vaccinations is essential to prevent disease outbreaks, a major challenge in rural poultry farming. Mobile veterinary units and partnerships with veterinary institutions can provide much-needed healthcare services. Additionally, improving access to quality feed by encouraging local cultivation of forage crops or providing subsidies for feed procurement can enhance productivity and product quality. Strengthening market linkages is equally important for increasing profitability. Supporting cooperative models, local markets, and direct connections between producers and consumers will help rural communities secure stable incomes and contribute to the availability of affordable protein sources. Integrating backyard poultry farming into broader rural development policies is key to ensuring sustainability and maximizing its impact on food security and rural livelihoods. Through strategic interventions and community-based initiatives, backyard poultry farming can play a transformative role in India's rural economy.

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SPORTS, SPACE AND MOBILITY OF CRICKET IN DELHI

Arnav Anshuman and Dr. Kiran Bhairannavar

Abstract

Sports are a medium for social interaction and bring together people from diverse backgrounds. In the Indian context, cricket has emerged as the most popular sport, encapsulating public imagination. The fandom for cricket is ubiquitous and the game is celebrated as a religion in the country. The overwhelming presence of cricket as a sport and as well as a social device in the public spaces of India makes it an interesting case study to understand how mobilities are enabled through sports. Drawing on the data generated through an ethnographic study of cricket in Delhi, the paper aims to highlight the relationship between sports, space and mobility. The paper reports four findings, as to how sporting mobilities are enabled at the local, city and regional scales as well as in the realm of ideas and sporting practices that transcend these scales. The paper enables a dialogue between mobilities and sports studies by dwelling into the nuances of socio-spatial production of cricket in Delhi.

Introduction

Sports is a rich site of movement, communications and governance analysis (Newman and Falcous 2012). The sports scene in India harbors a variety of sporting activities - anchored at the intersection of social, political, economic and geographic dimensions. However, cricket has emerged as the most dominant sport rising out of historical context, social acceptability and economic transformations. Hence, cricket becomes the essential conjuncture to understand sports-space relationship in the Indian context. The paper aims to bring out a dialogue between mobilities and sports studies by taking the case study of cricket in Delhi- the way the game is played and experienced in the city and how mobility underpins the geographies of this popular sport. Firstly, we look into the scholarly development of sports geography as a sub-discipline and underscore the emergence of the mobility paradigm. Secondly, we contextualize the mobilities paradigm with reference to cricket. There has been a resurgence of interest in sports and fitness within geography in recent years. Activities like cycling, running, calisthenics and jogging which involve sensory

corporeality and physical movements (Newman and Falcous 2012) have come to the fore in context of the everyday life of people. Participation in physical activities is linked with socio-spatial processes that circumscribe the locale, city, or regional landscape. The recent developments have added a fresh layer of insights and depth to the academic knowledge and place-making in the city. However, sports geography has a long and complex history. Earlier works in the discipline followed a positivistic spatial science approach which incorporated locational analysis and explanatory methods to explore field trends, location, performance and attendance related to varied sporting activities (Andrews 2016). Post 1970s, the political economy and welfare perspective underscored the economic and social impacts of sports. Since the turn of the century, the discipline saw a break from the spatial science approach. The vanguard of modern sports geography (Gaffney 2014), John Bale, introduced place sensitive, social constructivist and post-structuralist theories to re-image sports in terms of space and self-identities at the local, regional and national scales (Andrews 2016). Furthermore, the humanistic trends in sports geography inspired emergence of critical feminist lens which argued that sports and gender are mutually constituted. Foucauldian scholars brought the idea of body, mobility, ethnicity and power (Cole et al., 2004) within the fold of nature of places and stadiums related to sports. At the same time, stadiums, education, human-animal relationship, sports venues and mega-events emerged as popular avenues for sports studies. In the recent past, mobility paradigm has emphasized the significance of movement, migration, and circulation of people, ideas, and goods in shaping social dynamics.

However, mobility scholars have often overlooked sports as a cultural formation that encapsulates the logics of mobility (Newman and Falcous 2012). The few works which co-relate sports and mobility bring about new epistemological and ontological approaches involving relationship between geography and sport (Andrews 2016). These include sports labor migration, stadiums as global sportscapes, constituents of micro and macro level urban environments, non-representational theories implications on rhythm analysis and kinesthetic. Scholars have looked into the 'Paradox of Mobility' (Newman and Falcous 2012) where the dynamics of neoliberal globalization shape and constrain the movement of sporting bodies across various social, cultural, and economic landscapes. Colley (2012) presents a critique for static view of sporting landscapes that are transfixed at a particular scale – individual, local, macro, that produce spatio-temporal fixity

and called for employing non-representational theories and a ‘new mobilities paradigm’ (Newman and Falcous 2012) to understand sports in relation to urban infrastructure, resource flows, and environmental challenges (Sheller and Urry 2006). Looking at sports-space relationships through the mobilities lens, geographers are well-placed to research how cities can be made enchanting, inclusive and playful places to live (Latham and Layton 2019). Cook (2023) illustrates the connections between materiality, bodily movements and rhythms in the context of everyday mobility by arguing that running is a polyrhythmic exercise that connects the body, corporality, public spaces and the city. Latham and Layton (2019) propound that the topographies and materiality of urban infrastructure can be put to innovative use to make cities more kinesthetic. Thus, plurality of practices within the city facilitates a social infrastructure that can lead to professional, spectacular and charismatic world of sports and fitness practices. Looking through the non-representational approach and emphasizing on practice, performance, senses and sensation can shape the future of sports geography (Andrews 2016). Lastly, scholars have highlighted the dynamic relationship between sports and mobility with ‘a taken for granted’ presence of urban infrastructure that facilitate sports and fitness practices (Latham and Layton 2019), synergy between sports and urban environment (Koch 2023), universally accessible social infrastructure (Klinenberg 2018) and a post-human approach to the city (Amin and Thrift 2017). This paper extends the conversation of sports-space relationship and mobility studies by taking the case study of a developing country like India which lacks public infrastructure for sports and people bring about multiple usage of public space to embody, experience and enact cricket at particular space and time. Through this study, the authors express the need to realize the inherent potential of sports to define new socio-spatial relationship in terms of urban environment, identities, nationalism, geo-politics and everyday spaces – that circumscribe cricket, the most celebrated sport of India and the city of Delhi.

Study Region

Delhi has a rich cultural heritage. The city's spatial dynamics are a mixture of Mughal architecture, colonial legacy, and modern urbanization. The landscape of New Delhi in itself caters to mobility in sports and otherwise. Delhi as India's capital city provides a huge migrant population from all over the country. International cricket stadiums, open public parks and grounds, and a general interest in sports ensure that the city of Delhi enables mobility through cricket in its unique way.

Objectives

- (1) To understand how cricket enables mobilities within the community of strangers at the local level.
- (2) To explore how knowledge about the urban infrastructure is produced as the sporting bodies move around the city.
- (3) To understand how sporting landscape of Delhi enables inter-regional mobilities. Fourth, to examine mobility of ideas and practices across sporting landscapes. The paper contributes to the discipline of geography and mobility studies by discussing the case study of a developing country like India where spatial studies on sports and space are still meagre.

Database and Methodology

The data is drawn from the first author's doctoral research field work which aimed to study the sports-space relationship in Delhi, conducted from May 2022 to May 2023. The ethnographic work employed semi-structured interviews, participant observation, focus group discussions and play-along-ethnography as key methods for generating data from field sites spread across the city. An 'irrealis' style of ethnography focusing on non-representational approach (Thrift 2008) was followed to bring out the mosaic of experiences, senses and corporeality with reference to understand the lived experience of cricket in their everyday life. As such the study makes a methodological contribution by unfolding the dynamics of sports-space relationship while the game of cricket is in play. The data drawn for this paper was coded and analyzed using the three-step coding (Saldana, 2011). Additionally, content and discourse analyses were also undertaken to analyse data generated from online discussion forums and social media handles to have a broader understanding of the game.

Results and Discussion

The findings of the study are discussed under four sub-headings reflecting distinct spatial scales underscored by mobilities, namely, mobilities at the level of the neighbourhood, the city, between regions and ideas that move across space. The findings reflect the multi-scalar potential of sports to induce mobilities.

Neighborhood level Mobilities

Scholars have mentioned how sports create a sense of belonging (Spaaij 2011) and a 'plurality of practice' (Latham and Layton 2019) within the urban spaces. This sub-section report findings on sports-enabled mobility in the immediate

neighborhood as well as mobilities that extend beyond the field as participants create new experiences of the city.

Blachnicka-Ciacek and Trąbka (2022) highlight the significance of sports as a tool for social integration, emphasizing how participation in football activities can contribute to migrants' sense of belonging and facilitate their inclusion within the host society. Cricket serves a similar purpose in context of Delhi. The capital city of India attracts people from different backgrounds and regions who share the same space. At the local level, cricket serves as the medium for navigating social barriers and fostering social cohesion. This is evident from the interview of Santu, a migrant living in the city of Delhi.

When I moved to Delhi in 2017, initially, I did not know anyone here but I met a few people who played on the streets in my neighborhood, and things progressed from there.... Absolutely, connections and friendships developed gradually... I made friends on the field and started playing together occasionally. Over time, we formed a close-knit group that played regularly... I noticed an improvement in my game, especially in a limited space with fewer players, which reminded me of my childhood cricketing experiences and once again I felt like home when I played with people in my neighborhood (Shantu, 31, Migrant)

The interview excerpt sheds light on the experience of migrant population in Delhi who find cricket as a means for social interaction. According to Shantu, cricket provides a greater sense of belonging and acceptance within the local community. The site of play becomes the nodal point of mobility for the community of practitioners who were primarily strangers to begin with. Hence, mundane activities related to sports in the everyday spaces underscore transformative power of sports as a means to bridge divides, build relationships, and create a sense of community among individuals from varied cultural backgrounds. Following a non-representational approach, Latham and Layton (2019), mention the emergence of acquaintances and friends from strangers who participate in the activity of sports and fitness in the urban environment. Similarly, the connections that are developed through cricket give 'a sense of plurality of practice' (Latham and Layton 2019) and help in re-imagining of the city. The first author's account of engaging with a community of practitioners highlight the dynamic role sports plays in extending social conviviality and the experiencing the city. My interactions with fellow players was not just limited to sports. We started having lunch together and often met for tea breaks. All of us planned to visit several locations in the city which included historical sites such as India Gate and food joints in Jama Masjid.

When one of the players got infected with dengue, it was his fellow players who admitted him to the hospital and donated blood for quick recovery. (Field Notes, 22 April 2022). The site of cricket fosters social cohesion which then percolates to different aspects of everyday life. It helps create new experiences through new urban knowledges as they move around residential, market and other functional spaces within the city. These practices reverberate with Cresswell's (2010) idea of mobility that revolves around individuals' experiences and interactions within different spaces and cultures.

City Level Mobilities

Sport in urban areas is a complex phenomenon that intersects with urban landscapes, and can act as a catalyst for movement. The sporting spaces provide the necessary connections between people to develop social conviviality, following which, players are 'on the move' to look for better avenues at different places in the city. Such practice leads to mobility of sporting practices, knowledges about urban infrastructure and a 'ground' for meeting of people from different parts of the city. This is evident from the ethnographic engagement with Gaurav Dispensary, a resident of Delhi, who talks about the shared experience of city spaces through playing cricket. First Author (FA) – Why do people call you 'Gaurav Dispensary'... Which all places in Delhi have you played cricket in? Gaurav Dispensary (GD) – I used to work at a Tuberculosis eradication center as a data entry operator. Whatever time I could manage, I would come play cricket in the ground. I met people who liked the way I played and wanted to befriend me. They asked about my whereabouts and someone saved my name as 'Gaurav Dispensary' on their phones as Gaurav is a very common Indian name, the suffix was used for identification which later got circulated among their [player] circles... now everyone connected to me through cricket calls me Gaurav Dispensary... I am a wanderer when it comes to cricket. Because I have developed some connections, people always call me from all around the city. I often go to Jahangirpuri to play where you would find people coming from as far as Chandini Chowk to play. From the interview excerpt we can deduce that in a developing country like India, players tend to move to longer distances to access suitable sporting facilities of their choice. In case of Delhi, as seen above, people travelled from Chandini Chowk (Central Delhi) to Jahangirpuri (North-West Delhi), a distance of almost 17 kms to play the game. Thus, the urban public places, such as the open grounds, serve as a nodal point for sporting mobilities in the city. These sites serve as important nodes for leisure, recreation and the intermingling of people which lead to the social production of sportsapes in the city.

Inter-regional Mobilities

Giulianotti et al. (2015) highlighted the case of London Olympic 2012 to comprehend the dynamic nature of mobility that encompasses sports mega-events. They shed light on how mega-events not only impact physical movements and logistics but also influence communication, imagination, and virtual interactions. Cricket has a huge fan following in the region which is reflected in the way people associate themselves with the game. Looking through the lens of mobility, cricket mega-events in India bring similar social, economic and political implications. The stadiums become a spectacle of mobile bodies (Newman and Falcous 2012) with the incoming of local well as national and international tourists who visit the city to witness the game. Participant observation at the Arun Jaitley Stadium in Delhi during the Indian Premiere League (IPL) reflects similar prospects of mobility with respect to sports. I have come from Darbhanga just to watch Virat Kohli... We don't have a Bihar Team in IPL... so I had to travel to Delhi to watch him... I try my best to watch him on TV every time he plays but today, I will get a chance to watch him live for the first time... I am really excited to see him. (Field Notes, 30th April 2023, 6:00pm). Delhi functions as an important node in the landscape of cricket in the country with an IPL team, representation of players from the region in the nation cricket team and prevalence of the game in the open public spaces. From the observation mentioned above, it is evident that the mobile nature of followers of the game crisscross regional boundaries and produce distinct spatial knowledges as they travel. Similarly, the presence of international audience at the stadiums transforms it as a mobility space, intensifying global sportscape in Delhi.

Adding to this, players move to Delhi for improved infrastructure and coaching facilities. Sanjay Bharadwaj, the head coach of L B Shashtri Cricket Academy, in an interview talks about the accommodation facilities in his academy that caters to people who come from distant locations. A lot of players come from areas apart from Delhi. We understand the issues that they have to face and hence we have provided for residential quarters in our academy. The selection criteria are same for everyone, we select people on the basis of performance in the trails and coach them to improve their game. We also give scholarships to talented players if we see the spark in them. Our academy has people from all across India and from different backgrounds which adds to the facilities that we provide (Sanjay Bharadwaj, Head Coach). As seen above, Delhi becomes a crucial conjuncture for local, regional and global mobility of players, tourists and everyday participants. This section looked into how cricketing sites facilitate inclusion of migrant community,

enhance neighbourhood mobility, initiate nexus of flows of players from across the city and movement of national and international fans to witness the game. In the next section, we understand how mobilities are in-effect even beyond the fields where the game of cricket is played.

The Kohli Effect

Apart from the mobility of people, ideas and practices move across cultural landscapes. The site of sports is reflective of transmission as it sets the discourse for political movement, developmental agenda and societal change (Coakley 2011). In the context of cricket, there are innumerable instances of spatial subjectivities and cultural intersections. One such example is the “Dhoni Effect” which rendered transformative changes in the landscape of the town of Ranchi (Dhoni is the former Indian captain hailing from Ranchi – a Tier 2 city in India). This phenomenon has been extended to the understanding of the smaller growing towns of India that take the center stage as a result of increased awareness due to media penetration, improved physical connectivity, and significant changes in consumption patterns. Following this approach through the mobilities paradigm, the case study of Virat Kohli, the Indian national cricket player from Delhi, in an exceptional example to study the movement of ideas and practice from the site of sport to the society at large. Analysis of cricket commentaries and media platforms highlight the mobilities induced by Virat Kohli. His exponential growth from a humble background to immaculate stardom reflects the aspirations of youth in India. Because of these reasons, he has huge fan-following and everyone wants to become like him. Women love him and come to the stadiums just to watch him, even though they might not know much about cricket. (Diksha, Student). Let’s be honest 90 percent of people who follow cricket in India follow it because of Kohli, they are not cricket, India or RCB [Royal Challengers Bengaluru] fans they are just Kohli fans, though its huge for Kohli and his fans this kind of following, how good is this to the actual game you have to wonder... (Posted on Reddit on 30th April 2024, Accessed on 15th May 2024).

Everyone wants to be like Kohli... you can see parents asking the coaches to make their children like Kohli... We keep giving his examples to players on how to play and work on their fitness to improve the game... There is not a batsman in Delhi who does not want to replicate him... Every bowler wants to get him out to show their prowess (Cricket Administrator from?). Kohli has re-ignited Indian minds towards test cricket... He wears confidence on his sleeves and wants to dictate terms every time he plays... He is an Indian with an Australian Blood...

India needed a player like him to bring the best out of players and fans alike. (Who? Former Indian Coach). Kohli has brought about a paradigm shift in Indian cricket with reference to fitness and provided a blue-print for players to follow. People have internalized the idea of it in their everyday life. Sites of cricket training tend to pursue his corporeality and training regimen. The larger public shares an emotional bond with the player and he is seen as an icon for representing India at the global stage. Kohli's humble beginning connects him to the masses who tend to embody the idea of the player in their everyday life. Thus, Kohli's persona gets reflected as an idea moving across society, entertainment, media and everyday life transcending local regional and national geographies.

Conclusion

Through an ethnographic approach of cricket in the city of Delhi, we have made an attempt to contextualize sports-space-mobility triad in a developing country like India. We contend that extending the mobility paradigm towards cricket in India would invite renewed perspective to view sports-space relationships. The paper had 4 arguments. At first, we looked into how cricket enables social mobility among the migrant population in Delhi at the local scale further leading to the creation of new experiences in the city. Second, people move within the city for better sporting infrastructure which unfortunately is limited given the population. Third, sports induce inter-regional movement of fans and aspiring cricketers towards Delhi which is a hub for cricket related activities. And Fourth, sporting mobilities are not just limited to the movement of people but also ideas and practices that shape training regimens, body and culture of sports in the country. The paper explores the possibilities of the mobility approach and non-representational theory to unpack the sports-space relationship. Analyzing regional sports and mobility; and sporting women's mobility could be possible directions to take insights of this study in future.

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BIHAR, THE HEARTLAND OF INDIAN POLITICAL LANDSCAPE: A GEOGRAPHIC REVIEW

Dr. Shashi Bhushan

Abstract

Bihar's strategic geographic position has profoundly influenced India's political landscape throughout history. Geographically located at the transitional junction between diverse terrains—the northern Himalayan ranges, the southern Peninsular plateau, the eastern Gangetic delta, and the eastern Middle Gangetic plain—Bihar has served as a centre for cultural and political development. Its extensive network of perennial rivers, particularly the Ganges and its tributaries, has historically enhanced Bihar's connectivity and political significance. This research paper offers a geographic review of Bihar, exploring how its unique location facilitated the spread of Jainism and Buddhism and its pivotal role in historical movements such as Gandhiji's Champaran Satyagraha and the Quit India Movement. Additionally, this study examines Bihar's significant influence on the Indian political landscape, highlighting its historical, geographical, and cultural impacts. Following India's independence, Bihar made notable contributions to the Constituent Assembly, providing 36 members and producing prominent leaders like Dr. Rajendra Prasad, the first President of India. The state's representation in the Interim Government further solidified its political stature. Through a comprehensive analysis of Lok Sabha elections' results, this paper underscores Bihar's critical contributions to various government formations and political shifts, including the rise and fall of the Indian National Congress and the emergence of regional parties. Key political events, such as the Bihar Movement led by Jayaprakash Narayan, illustrate the state's ability to galvanize national movements and influence political discourse. Ultimately, this paper argues that Bihar's unique political narrative, rooted in its geographical location, historical significance and social dynamics, continues to shape the national political framework, establishing it as the heartland of Indian political landscape and making it an essential subject for understanding contemporary Indian political dynamics.

Introduction

Bihar, located in the middle Ganga plain, holds a significant position in India's history and politics (Singh & Singh, 1971, p. 189). It is known for its ancient

civilization, being the birthplace of prominent figures like Videha Janak, Sita, and rulers like Jarasandh and Karna, and as the land where Lord Buddha and Mahavira attained enlightenment. Bihar was home to India's first empire, Magadha, and the world's first republic, Vaishali. Even during the medieval era, figures like Sher Shah Suri highlighted Bihar's national relevance. The state's contribution to India's independence is profound, with heroes like Babu Kunwar Singh leading the 1857 revolt, and revolutionaries such as Amar Shaheed Khudi Ram Bose and Shaheed-e-Azam Baikunth Shukla making significant sacrifices. Mohandas Karamchand Gandhi, a barrister who returned from South Africa, gained global recognition as a harbinger of peace and was honored with the title of Mahatma through his work in Champaran, Bihar. This event also solidified Bihar's role in shaping the freedom struggle. After independence, Bihar was the first state to abolish the Zamindari system, setting a precedent for the nation. Governance in Bihar was also exemplary during that period. The then Prime Minister Jawaharlal Nehru had invited Professor Paul H. Appleby, an American expert on public administration, to assess the quality of administration across different states in India in 1954. Appleby acknowledged Bihar as one of the best-administered states in the country, setting an example for others (Appleby, 1953, pp. 16-17). This important position of Bihar highlights that it has not only pioneered political and governance systems in ancient, medieval and modern periods but has also significantly influenced Indian national politics in the post-independence era. The impact of Bihar's political scenario, decisions and election results on national politics has been reviewed in this paper.

Study Region

The study region, i.e., the state of Bihar, is one of the major states of the Indian Union; which is bounded on the north by Nepal, on the east by West Bengal, on the west by Uttar Pradesh and on the south by Jharkhand (India, 2022, P. 1159). It spans over an area of 94,163 square kilometres stretching between the latitudes of 24°20'10" and 27°31'15" and the longitudes of 83°19'50" and 88°17'40". Being situated in the eastern part of the Union of India, the land has an average altitude of 173 feet above mean sea level. It holds historical significance, deriving its name from the Sanskrit word 'Vihara', meaning abode. Bihar, or ancient Magadha, has been a cradle of Indian civilization, home to figures like Aryabhatta, and the birthplace of great empires, such as the Mauryan Empire, and religions like Buddhism and Jainism. It housed renowned ancient universities like Nalanda and Vikramshila. Its administrative boundaries evolved during British rule, with Bihar and Orissa forming a single province in 1912, later separated in 1936 (Ahmad, 1965, P. 6).

Jharkhand was carved out from Bihar in 2000. The capital, Patna, historically known as Pataliputra, was significant during the Mauryan and Gupta periods (Spate & Learmonth, 1967, P. 569). Geographically, the region is a segment of the great Indo-Ganga trough; however, it has some marginal portions of the other two major formations, that is, the Siwaliks in the northern part of Champaran district and the fringes and projections of the Peninsular Block in the south (Singh & Singh, 1971, P. 189). The Bihar plain is divided into two unequal halves by the river Ganga which flows through the middle from west to east. It experiences three seasons; a hot season from March to May, a rainy season beginning with the onset of the south-west monsoon from June to September and a cold season from November to February, heralded by the retreat of the monsoon in the months of October-November. Five types of soil (1. Foothill's or Bhabar Soil, 2. Tarai Soil, 3. Bangar Soil or Older Alluvium, 4. Newer Alluvium and 5. Balsundari Soil) in North Bihar and four types (1. Older Alluvium, 2. Tal Soil, 3. Sandy Soil and 4. Diara or Riparian Soil) in South Bihar. Moist Deciduous and Dry Deciduous are the two types of forests, which are found in the state, are separated by 120 centimetres of Isohyet. As of 2011, Bihar's population is over 104 million, with the highest population density among Indian states. Politically, Bihar has a deep-rooted democratic tradition, with a bicameral legislature and regular elections. Its political structure reflects both historical evolution and its integral role in India's democratic system.

Objectives

- (1) To assess Bihar's importance in national politics through Lok Sabha elections' results and role in government formations;
- (2) To investigate instances where Bihar's political decisions have influenced national political discourse and events;
- (3) To analyze how Bihar's unique geographical position has historically shaped its political significance and cultural development; and
- (4) To assess the geographical factors which contribute to Bihar being recognized as the heartland of the Indian political landscape.

Database and Methodology

The reports published by the Election Commission of India regarding the current context of the research form the primary database for this study. Additionally, several articles and reports by reputable field researchers and election reporters, published in recognized journals, newspapers, and periodicals, have been thoroughly reviewed. Information and data on voting trends, patterns, and voter behavior in the study

area were collected through personal interviews and discussions with numerous field observers and experts in electoral behavior. The researcher also conducted personal interviews with several political veterans and researchers who have closely studied the factors influencing voting patterns across different segments of Bihar. The methodology employed in this study can be summarized as follows:

- (a) Collection of information, data, and other relevant materials from various written sources;
- (b) Gathering information through personal interviews and detailed discussions with field observers, political veterans, researchers, and experts on electoral behavior in the area;
- (c) Classification of the collected materials according to their nature and function;
- (d) Tabulation of the collected data and information;
- (e) Cartographic representation of data and information; and
- (f) Drawing conclusions based on these findings and interpretations.

Constituent Assembly of India and Bihar's Stature

Following the Mountbatten Plan and the Indian Independence Act of 1947, Bihar contributed 36 members, representing 11.11% of the Constituent Assembly, highlighting its significant influence in Indian national politics. Dr. Sachchidanand Sinha, a veteran and prolific social worker from Bihar, was nominated as the first provisional President of the Constituent Assembly (Roy Chaudhury, 1974, p. 79). Subsequently, Dr. Rajendra Prasad was elected as the permanent President of the same historic Constituent Assembly, which framed the Constitution for Independent India. These examples reflect the nationwide recognition of Bihar's political leadership. Thus, Bihar has continued to influence all-India politics in modern times as well. Two Bihari leaders, Dr. Rajendra Prasad and Acharya J. B. Kripalani, chaired five (31.25%) of the sixteen key committees of the Assembly. After the Constitution was finalized, Dr. Rajendra Prasad was unanimously elected the first President of India on January 24, 1950. This highlights the significant influence and stature of Bihar's representatives in the Constituent Assembly.

Importance of Bihar in the Interim Government

On September 2, 1946, when the 12-member Interim Government of India, led by Pt. Jawaharlal Nehru, was formed, two ministers from Bihar, Dr. Rajendra Prasad (Ministry of Food and Agriculture) and Babu Jagjivan Ram (Ministry of Labour), were included. This gave Bihar a 16.66% share in the Council of Ministers, significantly higher than its national share in terms of area (4.11%),

population (6.76%) and representation in the Constituent Assembly (11.11%) (Prasad, 2017, pp. 893-904).

Lok Sabha Elections' Results and Formation of Union Governments: Key Role of Bihar

The journey of Bihar in the Lok Sabha elections reflects its crucial role in shaping the national political landscape. The present analysis traces Bihar's political significance through the general elections to the Lok Sabha, highlighting the phase of the Indian National Congress (INC)'s dominance, the impact of political shifts and the emergence of new power structures. In the inaugural 1951-52 elections to the Lok Sabha, the Indian National Congress (INC) secured a massive victory, winning 364 of 489 seats in the Lok Sabha, a 74.44% majority. Bihar contributed significantly, with the INC winning 45 out of 55 seats, accounting for 12.36% of the party's total seats (ECI). The 1957 LS elections saw the INC consolidate its power, winning 371 of 494 seats (75.10%). In Bihar, the party won 41 out of 53 seats, making up 11.05% of its total Lok Sabha representation (ECI). The 1962 LS elections resulted in a slight decline for the INC, which won 361 of 494 seats (73.08%). In Bihar, the party won 39 out of 53 seats, contributing 10.80% to its national tally, reflecting a marginal loss in influence both statewide and nationally (ECI). In the 1967 LS elections, the INC's dominance waned as it secured 283 out of 520 seats (54.42%). Bihar echoed this trend, with the party winning 34 out of 53 seats, accounting for 12.01% of its Lok Sabha seats, indicating a significant decline in both state and national levels (ECI). The 1969 Presidential election catalyzed a major split within the INC.

Prime Minister Indira Gandhi's defiance of the party's official candidate led to her expulsion and the creation of two factions: INC(R) under Indira Gandhi and INC(O) under the Syndicate (Singh, 1981, p. 104). In Bihar five CPI MPs and three Independent MPs supported Indira Government during this phase of deep political divisions (Chandra et al., 2008, pp. 298-299). The 1971 LS election, precipitated by political instability, saw the INC(R) under Indira Gandhi achieve a resounding victory, winning 352 out of 518 seats. In Bihar, the party secured 39 out of 53 seats, contributing 11.08% to the national tally, underlining Bihar's importance in Gandhi's triumph (ECI) (Fig. 1). The 1977 LS elections marked a historic defeat for the INC, which won only 154 out of 542 seats, driven largely by backlash against the Emergency. Bihar played a pivotal role, with the INC losing all 54 seats in the state (ECI). The Janata Party, formed in response to the Emergency, won 330 seats with allies, signifying the first non-Congress union government in India

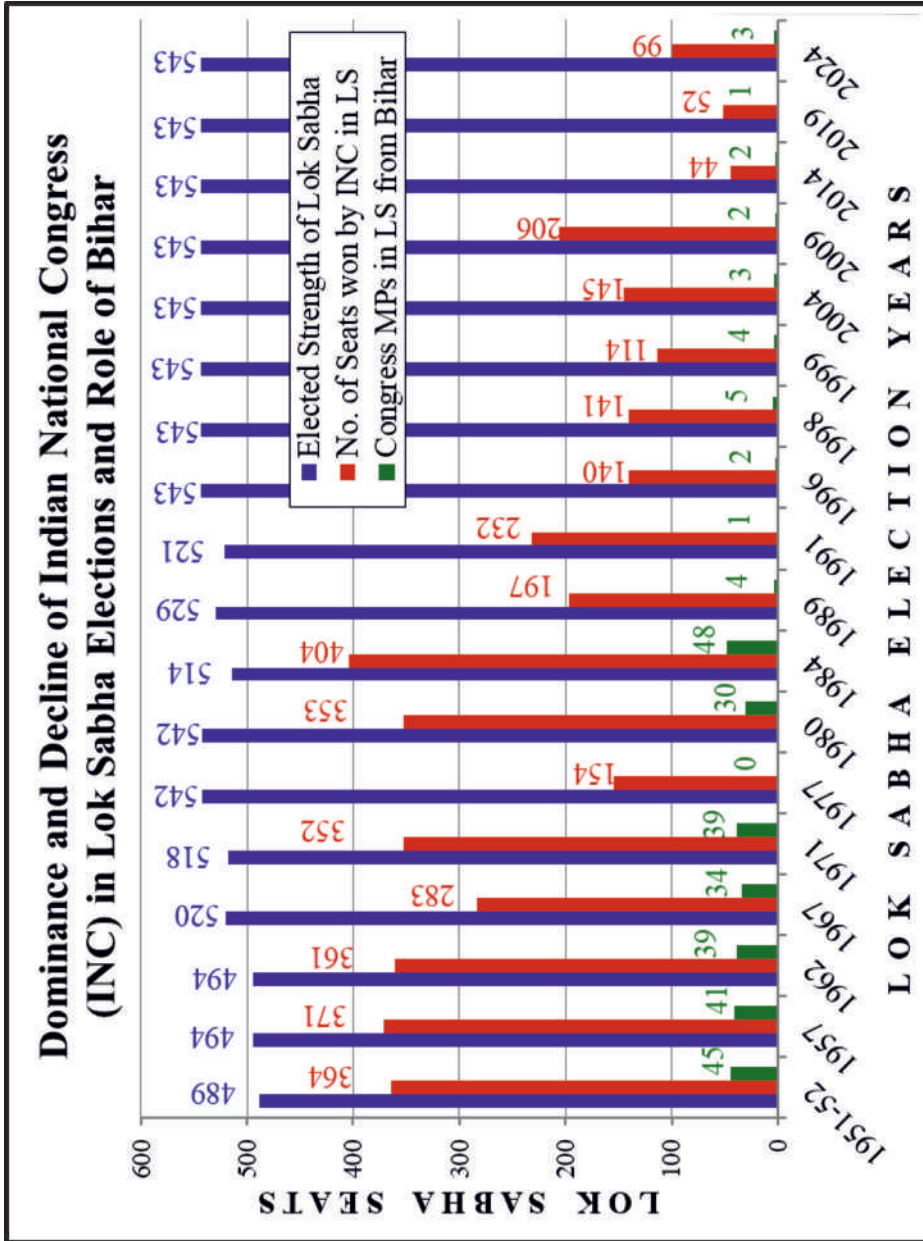


Fig. 1

(Jalan, 2015, p. 168). The roots of the 1977 political upheaval can be traced to Bihar, where the Bihar Movement, led by Jaya Prakash Narayan (JP), demanded 'Sampoorna Kranti' or total revolution. This movement, originating from student protests, became a national force against the Emergency imposed by Indira Gandhi, significantly contributing to Congress's 1977 defeat (Modi, 2014, pp. 22-26). The 1980 LS elections saw the INC(I) return to power, winning 353 out of 542 seats. Bihar's contribution was significant, with 30 out of 54 seats going to the party. This victory ended a 34-month hiatus for Indira Gandhi, demonstrating Bihar's critical role in her political comeback (ECI). The assassination of Indira Gandhi in 1984 triggered a massive sympathy wave, leading the INC to a landslide victory with 404 out of 514 seats in LS elections. Bihar played a key role, contributing 48 out of 54 seats to the INC's total. This result underscored the state's influence in shaping the national political landscape during a period of national mourning (ECI). The 1989 LS elections saw Bihar become a focal point in national politics.

The INC won only four out of 54 seats in Bihar, reflecting its national decline (ECI). Conversely, the National Front, led by V.P. Singh, achieved a majority, supported by non-Congress parties, with Bihar's 50 non-Congress MPs playing a crucial role in the formation of the Janata Dal government. The 1991 LS elections resulted in a reduced majority for the INC, which won 232 out of 521 seats (ECI). In Bihar, the party won only one seat, reflecting its weakened national standing. Bihar's MPs were instrumental in supporting or abstaining during the Confidence Motion, impacting the stability of Prime Minister P.V. Narasimha Rao's government (Pawar, 2017, p. 132). In the 1996 elections, the Lok Sabha was hung, with BJP as the largest party but without a majority. Atal Bihari Vajpayee briefly served as Prime Minister before resigning due to a lack of support. H. D. Deve Gowda then became Prime Minister with significant support from Bihar. Lalu Prasad Yadav, Bihar's Chief Minister, played a key role in this transition, leveraging his 22 Janata Dal MPs to influence the new government and ensure the appointment of five Bihari MPs as Union ministers (ECI). In April 1997, H.D. Deve Gowda resigned as Prime Minister and I. K. Gujral took office with crucial support from Bihari leaders, Lalu Prasad Yadav and Ram Vilas Paswan. Bihar's influence continued as these leaders supported Gujral, though his government was short-lived, leading to mid-term elections in 1998. In the 1998 LS elections, the NDA, with 38 seats from Bihar, achieved a majority with external support. Bihar's seats were crucial for Atal Bihari Vajpayee's government formation (ECI). The 1999 LS elections resulted in another hung Lok Sabha. The BJP-led NDA secured 269 seats, forming the government with 41 seats from Bihar (ECI). The inclusion of numerous Bihari MPs in the cabinet

highlighted Bihar's crucial role in stabilizing Vajpayee's third term. The alliance with George Fernandes's Samata Party helped the BJP mitigate its Hindutva image and gain further credibility (Ramagundam, 2022, pp. xiii-xv). The 2004 elections marked the return of the INC under the UPA, led by Dr. Manmohan Singh. Bihar contributed 29 seats to the UPA, including 22 from Lalu Prasad's RJD. Despite the reduction in Bihar's Lok Sabha seats due to the creation of Jharkhand, the state's MPs were crucial in supporting the formation of the UPA government. The 2009 elections saw the UPA II government return with a decisive majority, but Bihar's influence diminished, with the RJD and INC securing only six seats collectively. This marked a significant political shift, with no Bihari MP included in the Union Council of Ministers for the first time, although Meira Kumar was appointed as the first female Speaker of the Lok Sabha. In the 2014 LS elections, the BJP-led NDA won a majority, with the BJP securing 282 seats. Bihar contributed 31 seats to the NDA's tally, playing a significant role in the formation of the government under Narendra Modi's leadership. In the 2019 LS elections, the NDA secured 353 seats, with the BJP alone winning 303. Bihar was instrumental in this victory, as the NDA won 39 out of 40 seats (BJP 17, JD(U) 16, LJP 6). This significant support was reflected in the inclusion of six Bihari MPs in the Union Council of Ministers. In the 2024 LS elections, the NDA secured 293 seats, with the BJP winning 240. Bihar again played a key role, contributing 30 out of 40 seats (BJP 12, JD(U) 12, LJP (R) 5, HAM(S) 1). This support was further emphasized by the inclusion of eight Bihari MPs in the Union Council of Ministers. The foregoing discussion clarifies that Bihar elections have always influenced Indian national politics. The physical, historical, social and political conditions of the state are responsible for such an important and decisive position of Bihar in the national political landscape. That is, the entire geographical personality of Bihar in its totality provides the ability to delineate the national political discourse, which is being further discussed in this paper.

Bihar, the Heartland of Indian Political Landscape

Bihar is rightly positioned as the heartland of India. It is the birthplace of Jainism and Buddhism, both of which spread across the globe. The roots of many uprisings before the Indian independence movement are also found in Bihar (Fig. 2). It was in Champaran, Bihar, that Gandhi was transformed into the 'Mahatma'. He began his successful experiment of Satyagraha in Champaran, which marked his emergence as 'Mahatma' and 'Bapu'. This movement propelled him to dominate the national stage of Indian politics until his last breath and beyond. Bihar also gave India the Lok Nayak, Jayaprakash Narayan. It was Lalu Prasad of Bihar who had the courage

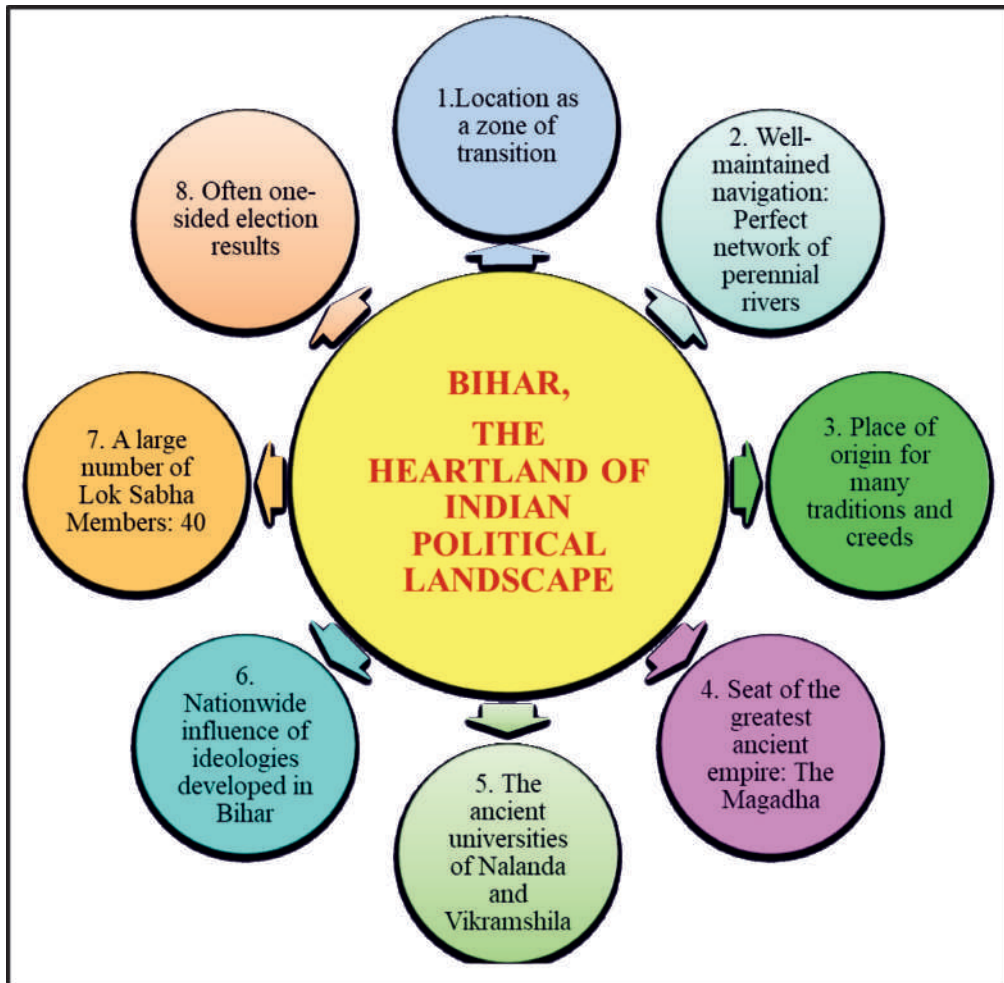


Fig. 2

to halt L.K. Advani's Ram Rath Yatra, which began in Somnath (Gujarat) and was heading to Ayodhya (Uttar Pradesh). This event marked a turning point in Indian politics in the post-independence era, altering the entire political narrative. It led to a significant political upheaval across the country, including the downfall of Prime Minister V.P. Singh's government. Before his resignation, V.P. Singh had announced the implementation of the reservation policy for Other Backward Classes (OBCs), based on the recommendations of the B.P. Mandal Report. Mandal, a former Chief Minister of Bihar and Chairman of the 'Socially and Educationally Backward Classes Commission' (constituted by the Janata Government in 1979), had submitted the report in 1980. However, the policy was not implemented until V.P. Singh's announcement, which subsequently divided national politics into pro-Mandal (reservation supporters) and pro-Kamandal (Ram Temple supporters) camps. As a result, the Congress party weakened over time, while the BJP and various regional and individualist parties grew stronger (Guha, 2017, pp. 601-627). Given these facts, the question arises: why is Bihar the heartland of national politics and why do social, cultural and political sparks from this region ignite waves and flames across the country? To answer this, we must delve into Bihar's glorious past and examine the geographical factors that have shaped its influence. The following points will be reviewed to explore these aspects:

Location as a Zone of Transition

Bihar is actually located as a zone of transition between the northern Himalayan Mountain ranges, the southern peninsular plateau, the eastern wet Gangetic delta and the western arid Upper Gangetic plain. Himalayan mountain ranges, Valleys, Terai, Bhabar in its north, while down the southern slopes of the Himalayan mountain's widespread presence of alluvial cones and alluvial feathers can be amply recognized. Prof. Enayat Ahmad (1965, pp. 21-22) had even said that the plain of North Bihar is in fact the result of the merger of many similar alluvial feathers and cones over a long period of time.

Similarly, southern segment of the South Bihar Plain actually represents the specific features of the northern frontier of the Chhotanagpur Plateau. Monadnock, a peculiar feature of the Chhotanagpur Peneplain, can be identified in the form of hills and hillocks in Gaya, Rajgir, Nawada, Sheikhpura, Jamui, Kharagpur and Munger. From here the hills are surrounded by alluvial deposits which portray the Inlier Patterns. The northern segment of this Plain is actually the deltaic region of the rivers flowing from the Chhotanagpur plateau to the north, reaching where the rivers split into many small streams. Their flow becomes very slow and form many

meanders. Large flooded squares can also be recognised here. Here in the lower valleys and paths of these rivers, sand deposits are found sometimes up to a depth of several hundreds of meters. These prove that here the rivers have deposited on a very large scale. On the contrary, North-Eastern Bihar actually appears to be a western extension of the lower Gangetic plain or the Delta region of Bengal. It is also called the western gate of Bengal. 'Darbhanga' situated in this region is truly the aberration of Duara Banga or Dar-i-Bangal which means gateway to Bengal (O'Malley, 1907, p. 1). It is because of rivers, abundance of water bodies, etc. along with the salient features of Bengali civilization and culture can be recognized here similar to the deltaic region of Bengal. The western segment of Bihar has many similarities including aridity of the Upper Gangetic Plain. Various types of common geographical features are found here including the civilisation, culture and economy, etc. In the central part of the area under review, i.e., the state of Bihar, there is presence of a basin shaped landscape from west to east direction, through which river Ganga and its tributaries flows with water of their drainage area and later on merges into the Bay of Bengal. About a quarter (25 percent) of the total amount of Indian surface drainage passes through this basin and creates the ecosystem of this region. Thus, we see that the landscape of Himalayan region in the northern part, the peninsular plateau in the southern part, the Gangetic delta in the eastern part, the semi-arid in the western part and the Gangetic ecology exist in the central belt. Their effects have manifested not only on the surface features, but also on all other geographical factors including physical, economic, social and cultural in the forms of drainage, soil system, flora and fauna.

Availability of Well-maintained Navigation through a Perfect Network of Perennial Rivers

After entering into the plain at Haridwar, also known as Gangadwar, Mayapuri, Haridwara by Vaishnavas and Haradwara by Saivites; flowing through entire Uttar Pradesh, when the Ganges reaches the threshold of the land of Bihar, it becomes very gigantic by encompassing a network of several dozens of large rivers (like Ramganga, Yamuna and Gomti) along with innumerable small rivers. Even after entering Bihar, rivers coming from north, viz., Ghaghra, Gandak, Burhi Gandak, Bagmati, Kosi and Mahananda, etc. (Sahridaya, 2003, pp. 1-118); whereas the rivers coming from south viz., Karmanasha, Durgavati, Gangotri, Son and Punpun join the Ganges. All of these are perennial rivers. Apart from these, rain-fed rivers coming from the south like Falgu, Kiul, Harohar and Chan join the Ganges. After absorbing the water of all these rivers, it assumes the shape of a sea while leaving

the border of Bihar. Such the Ganga River system is spread over a large area of the country. Its territorial extent can be estimated from the fact that a quarter (one-fourth) of total Indian surface drainage is controlled by the Ganges River system alone. Therefore, through the Ganges River system, every part of North India has remained accessible by the river route since time immemorial. By reaching the Bay of Bengal from the Ganges River path, it can be reached in any part of the world by maritime routes. Emperor Ashoka of Magadha had sent his son Prince Mahendra and daughter Princess Sanghamitra to Sri Lanka by maritime route to promote Buddhism from the present Mahendru Ghat situated on the Ganges river in Patna, the present capital of the State of Bihar. They were able to reach Sri Lanka by reaching the Bay of Bengal via the Ganges. That is, through the river routes of the Ganges, it could be reached anywhere in north India. Due to such excellent navigational facilities, the thoughts of the sages as well as the empires of the emperors of Bihar became continental.

Place of Origin for Many Traditions and Creeds

Bihar, often referred to as the cradle of civilization, holds a profound place in the history of global religious and cultural traditions. As the birthplace of Jainism and Buddhism, two of the world's major religions, Bihar's influence transcended regional boundaries and spread across vast geographical areas, leaving an indelible mark on world history.

Jainism, founded by Lord Mahavira in the 6th century BCE, took root in Bihar. Similarly, Buddhism was born in Bihar when Prince Siddhartha attained enlightenment under the Bodhi tree in Bodh Gaya, transforming into Lord Buddha. The teachings of Buddha, which emphasized the Middle Path and the Four Noble Truths, resonated deeply within the region and soon spread beyond the boundaries of India. Bihar's geographical advantages further facilitated the spread of these religions. The network of perennial rivers, like the Ganges, provided efficient transportation and communication routes within India. Moreover, these rivers connected Bihar to maritime routes, enabling the spread of its religious and cultural influences to other parts of the world. This strategic location not only supported the expansion of Jainism and Buddhism but also allowed Bihar to become a melting pot of diverse traditions, creeds and ideas, shaping the spiritual landscape of the world.

Seat of the Greatest Ancient Empire: The Magadha

Ashoka, one of India's greatest emperors, played a pivotal role in the dissemination of Buddhism, transforming it from a local sect into a world religion.

After his conquest of Kalinga in 260 BC, Ashoka publicly converted to Buddhism and adopted a policy of ‘conquest through righteousness’ or *dhammavijaya*. He dedicated his reign to the propagation of Buddhist ideals, sending missionaries across Asia and establishing stupas and monasteries, which became centres of learning and pilgrimage (O'Malley & James, 1924). Wells (1920, pp. 432-33) remarks, “Amidst the tens of thousands of names of monarchs that crowd the columns of history... the name of Asoka shines and shines almost alone, a star. From the Volga to Japan his name is still honoured”. From Magadha arose India’s first greatest empire, the Mauryan Empire, as well as one of the world’s greatest pacifist religions, Buddhism. It is the land of Ashoka the Great, the only military monarch on record to have abandoned warfare after victory.

The Ancient Universities of Nalanda and Vikramshila: a testament to Bihar's Rich Educational Heritage

The ancient universities of Nalanda and Vikramshila, located in Bihar, were not only centres of learning for India but also held significant global influence, attracting scholars across Asia and beyond. Established during the Gupta and Pala dynasties, these institutions embodied the intellectual and cultural zenith of ancient India. Nalanda, in particular, was renowned for its vast library and diverse curriculum, covering subjects such as theology, philosophy, astronomy, mathematics and medicine. It attracted students and scholars from regions as far as China, Korea, Japan, Tibet and Southeast Asia, making it a vibrant hub of cross-cultural exchange (India, 2022, p. 1159). The impact of these universities extended far beyond their geographical location. They played a crucial role in the spread of Buddhist philosophy and other Indian sciences, significantly influencing educational and religious practices in Asia. Chinese pilgrims like Xuanzang and Yijing travelled to Nalanda, documented their experiences and carried back knowledge that would shape the intellectual and religious landscape of East Asia. The legacy of these universities persisted even after their decline, as they laid the foundations for modern educational systems and intellectual traditions in Asia. Their worldwide influence remains a testament to Bihar's rich educational heritage.

Nationwide Influence of Ideologies Developed in Bihar

Bihar has long been a crucible of influential political ideologies that have shaped the broader Indian political landscape. The state's historical significance as a centre for major social and political movements has allowed it to play a pivotal role in influencing national politics. The ideologies that emerge from Bihar often

resonate with the larger populace, particularly in North India, due to the state's unique social and political dynamics. Movements such as those led by Mahatma Gandhi and Loknayak Jayaprakash Narayan, which had their roots in Bihar, sparked nationwide waves of change. These movements not only influenced the course of Indian history but also set precedents for political activism and governance across the country. As a result, political incidents in Bihar frequently have a ripple effect, influencing election results and political sentiments far beyond its borders. The electoral mandates in Bihar often mirror the broader political trends in North India, highlighting the state's enduring impact on national politics.

A large Number of Lok Sabha Members

The number of Lok Sabha members from Bihar has been relatively high. Till the 15th of November 2000, 54 members or 9.908 percent to the total strength of the Lok Sabha were elected from the State. Even after the separation of Jharkhand from Bihar, 40 or 7.34 percent of Lok Sabha MPs are elected from here alone. After Uttar Pradesh (80 seats), Maharashtra (48 seats) and West Bengal (42 seats), it is the fourth ranking state of Indian Union so far as the number of Lok Sabha seats are concerned. It is because of the large share of seats in Lok Sabha that the elections in Bihar affect the Indian national politics.

Often One-sided Election Results

Elections are the lifeblood of democracy. It has been observed that the results of Bihar elections are often one-sided. Hence the number of Lok Sabha MPs winning from Bihar has often been in decisive due to high number of seats. That is why elections in Bihar boldly impact the Indian national politics. Thus, the state under review has the ability to impose deep imprints on the national political landscape and its roots lie in the geographical conditions of Bihar.

Conclusion

To cut the story short, Bihar's unique geographical positioning as a transition zone between diverse terrains and its extensive network of perennial rivers has profoundly influenced its political landscape. This strategic location has made Bihar a cradle for major religious and ideological movements, such as Jainism and Buddhism, which have spread globally. The state's historical and political significance is further highlighted by its pivotal role in shaping national politics through landmark events and influential leaders. With a substantial representation in the Lok Sabha and frequent one-sided election results, Bihar's political dynamics

continue to impact India's national scenario. Thus, Bihar's geographical and political prominence underscores its central role in the Indian political arena.

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DELINEATION OF URBAN PRIMARY HEALTHCARE SERVICES IN MYSURU CITY – A SPATIAL ANALYSIS

Dr. Chandrashekara. Y.P and Dr. Divya. S

Abstract

Primary care is widely regarded as the most critical component of healthcare for maintaining population health, as it is cost-effective, easier to deliver compared to specialty and inpatient care, and, when properly distributed, highly effective in preventing the progression of diseases on a large scale. Recent advancements in health geography have significantly enhanced our understanding of how the geographical distribution of health services influences population health. However, much of this research has focused on hospitals, specialty services, and rural healthcare. This study focuses on the distribution of Urban Primary Health Centers (UPHCs) in Mysuru city, Karnataka, utilizing spatial analysis techniques such as Euclidean buffer and Thiessen polygon methods. The analysis is based on population projections for 2021, which estimate Mysuru's population at 1,119,828, with only 21 operational UPHCs, although 37 centers are required. Data from the District Health Office and Statistical Department, along with GIS-based tools, reveal spatial inequalities in access to healthcare. The study first uses Euclidean buffers to identify service gaps, but the inability of this method to account for population distribution led to the application of Thiessen polygons to define service areas more accurately. This approach provides a more detailed understanding of healthcare coverage by considering both geographic and population factors. The results highlight the importance of strategic planning and resource allocation to improve healthcare accessibility, especially in densely populated and underserved areas of Mysuru.

Introduction

Urban Primary Health Centres (UPHCs) play a crucial role in India's healthcare system, particularly for urban slum populations and vulnerable groups. Under the National Urban Health Mission (NUHM), UPHCs are strategically placed in densely populated areas with limited access to healthcare services. They offer a wide range of services, including preventive care, curative treatment, maternal

and child health services, family planning, and disease control, all tailored to the specific needs of the urban poor. This approach ensures that essential healthcare is affordable and accessible, reducing the strain on larger hospitals. The services provided by Urban Primary Health Centres (UPHCs) are designed to enhance both individual and community health outcomes. Preventive care, such as immunizations and health education, aims to curb the spread of preventable diseases. Maternal and child health services ensure that women and children receive appropriate care throughout pregnancy, childbirth, and the postnatal period. Family planning services support urban families in managing their reproductive health, while disease control programs focus on tackling communicable diseases like tuberculosis and malaria, helping to mitigate public health risks in overcrowded urban areas. UPHCs also play a key role in connecting communities with the broader healthcare system through referrals and integration with national health programs. As the initial point of contact, they direct patients with more complex health needs to higher-level facilities, ensuring a seamless continuum of care. This integration with national initiatives, such as the Reproductive, Maternal, Newborn, Child, and Adolescent Health (RMNCH+A) program, reinforces India's overall public health infrastructure. Beyond clinical services, UPHCs promote healthy behaviors through public health campaigns focusing on hygiene, nutrition, and environmental health. By providing both preventive and curative care, UPHCs play a crucial role in reducing the disease burden in rapidly growing urban areas, ensuring that even the most vulnerable populations have access to vital healthcare services.

Study Region

Mysuru is located in the southern part of the Deccan Plateau, making it the southernmost district of Karnataka, India. The city is positioned between 76°39' to 76°65' east longitude and 12°18' to 12°30' north latitude, with an average elevation of 770 meters above sea level. Spanning an area of 128.422 square kilometers, Mysuru had a population of approximately 887,446 as per the 2011 census, with an almost equal split between males (443,813) and females (443,633). The city's literacy rate is 83.8%, notably higher than Karnataka's state average of 76%. The gender ratio is 967 females for every 1,000 males, and the population density is 6,223.55 people per square kilometer.

Objectives

This main objective of the study is the distribution of Urban Primary Health Centers (UPHCs) in Mysuru city, Karnataka and delineation of health

service areas utilizing spatial analysis techniques such as Euclidean buffer and Thiessen polygon methods.

Database and Methodology

This study focuses on the ward-wise distribution of Urban Primary Health Centers (UPHCs) in Mysuru. Data on population and healthcare facilities were collected from the District Health Office and Statistical Department. As the 2021 Census was not conducted, population projections were used to estimate the current demographics of Mysuru City. The study area's shapefile was downloaded from the official KGIS website, and the collected data were analyzed using GIS tools to illustrate the spatial distribution of healthcare centers. Initial efforts to map accessibility used simple Euclidean buffers to identify areas with insufficient health services. While these results were informative, they revealed limitations that prompted the exploration of alternative methods. After considering several options, the Thiessen polygon method was applied to assess healthcare availability. Thiessen polygons were used to delineate the service areas of UPHCs in Mysuru, offering a more detailed analysis of healthcare coverage.

Results and Discussion

The location of healthcare centers is influenced by factors such as population, regional climate, transportation and communication systems, overall health status, and cleanliness. Healthcare services are generally not distributed equally, largely due to geographical and economic factors. The use of healthcare services varies locally, reflecting disparities between rural and urban areas. The study of regional differences in the distribution of social services, such as healthcare, has attracted the interest of geographers, planners, and scientists due to their focus on spatial variations across the Earth's surface. Healthcare encompasses a range of services provided to individuals, families, and communities, with the goal of promoting, maintaining, and restoring health. Medical professionals and health service providers are dedicated to delivering these services. Healthcare includes medical care directly provided by physicians or by paramedical staff. As a public right, it is the responsibility of governments to ensure equal access to healthcare for all people (John Spencer and Gustavo Angeles, 2007). Healthcare centers function based on institutional size, workload, and the range of services offered. Healthcare services are structured at three levels: Primary, Secondary, and Tertiary. These institutions are organized hierarchically to optimize resource use, providing services at various levels according to patient needs. The administration of each level is interconnected,

with higher-order institutions like District Hospitals offering advanced services and greater administrative responsibilities, while Primary Health Units (PHUs) provide lower-order services with simpler administrative duties. Healthcare services in a region are delivered through public or private medical institutions, including District Hospitals, Community Health Centers (CHCs), and Urban Primary Health Centers (UPHCs). These facilities are established based on economic feasibility and community needs. Public healthcare centers aim to promote good health for all, but access to these centers varies by location. In Mysuru City, public healthcare facilities include one District Hospital, two Community Health Centers, 21 Primary Health Centers, and five public maternity health centers (including two CHCs) (Fig. 1 and Table-1).

(a) Population and Health Services:

Mysuru is divided into 65 wards. Since the 2021 Census was not conducted, population projections for the city were calculated to estimate its current demographics. These projections are essential for urban planning, infrastructure development, and policy-making. The estimates are based on the decadal growth rate observed between previous censuses, such as from 2001 to 2011. By applying this growth rate to the 2011 population, the estimated population for 2021 is determined. To calculate the projected population for 2021 based on a 26.62% decadal growth rate and a 2011 population of 884,242, we can use the same method. Formula for the calculation of projected population is Projected Population (2021) = 2011 Population X (1 + Growth Rate). The projected population for Mysuru in 2021, based on a decadal growth rate of 26.62%, would be approximately 1,119,828 people.

Table-1: Projected Population and Health Personal of UPHC Mysore City

Sl. No.	UPHC	Wards comes under UPHC	Projected Population 2021	Doctor	Med Staff	Other Staff	Total Staff
1	Kumbara Koppalu	3,4,5,6	53032	1	4	5	10
2	Bannimantap	7,8,17,18	53342	2	8	4	14
3	Rajendra Nagar	9,10,15,16	62876	1	8	5	14
4	Shanthi Nagar	11,12,33,34	57575	2	8	4	14
5	Krishnamurthy Puram	46,48,57	49325	1	8	5	14

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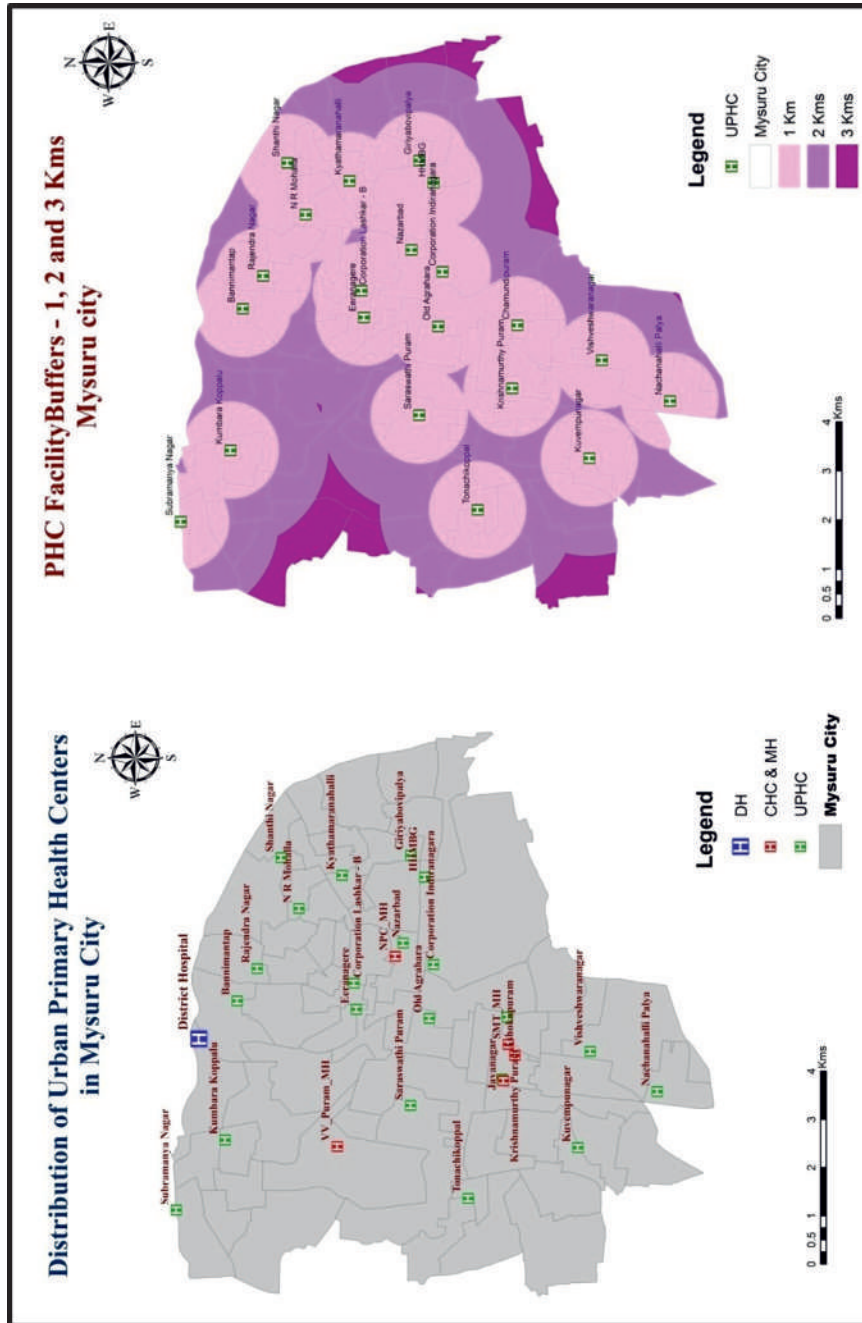


Fig. 1

6	Corporation Lashkar - B	27,28,29,39	60763	1	7	4	12
7	HHMBG	53,36	46053	1	8	5	14
8	Eeranagere	24,25,26	55168	1	7	5	13
9	Chamundipuram	49,55,56	55349	1	8	6	15
10	Nazarbad	40,41	47045	1	8	6	15
11	Saraswathi Puram	21,42,47	46428	1	7	5	13
12	Old Agrahara	22,23,50	52230	1	7	4	12
13	Vishveshwaranagar	54,60,61	51402	1	8	5	14
14	N R Mohalla	13,14	48907	1	7	5	13
15	Giriyabovipalya	35,37,38	54816	1	8	5	14
16	Tonachikoppal	19,43,44,45	54857	1	8	4	13
17	Kyathamaranahalli	30,31,32	35445	2	10	4	16
18	Corporation Indiranagara	51,52	53506	1	8	4	13
19	Nachanahalli Palya	62,63	43509	1	10	5	16
20	Kuvempunagar	58,59,64,65	78936	0	8	4	12
21	Subramanya Nagar	1,2,20,	59264	0	5	4	9
Total		1119828	22	160	98	280	

Source: DHO, Mysuru and Projected Population for 2021

Table-1 presents the projected 2021 population for various wards in Mysuru city and estimates the number of Urban Primary Health Centers (UPHCs) required serving these populations. According to the total projected population across all wards is 1,119,828, and it is estimated that 22 UPHCs are needed to meet the city's healthcare demands. Currently, only 21 UPHCs are operational, revealing a significant gap in healthcare provision. Some areas, such as Kuvempunagar, which has the largest population (78,936), followed by Rajendra Nagar (62876) and Corporation Lashkar-B (60763) require more UPHCs compared to smaller wards like Kyathamaranahalli and Nachanahalli Palya, where the population is lower, and fewer centers are needed. This data underscores the urgent need to increase the number of UPHCs to meet the growing healthcare needs of Mysuru's population. The table 1 also highlights the staffing levels and population coverage of the 21 Urban Primary Health Centers (UPHCs) in Mysuru, which together serve over 1 million residents. These centers are critical in delivering healthcare services to densely

populated and vulnerable urban areas. The table provides a detailed overview of staffing across the centers, listing the number of doctors, PHCOs (Primary Health Care Officers), staff nurses, pharmacists, and other personnel at each location. The number of employees at each center ranges from 9 to 16. Notable variations are seen across centers, with locations like Kuvempunagar and Subramanya Nagar having fewer doctors, while centers such as Kyathamarahalli and Nachanahalli Palya have more PHCOs and support staff. Across all centers, there are a total of 22 doctors, 93 PHCOs, 46 staff nurses, 21 pharmacists, and 98 other personnel, making up 280 staff members in total. UPHCs are a key component of Mysuru's urban healthcare system, providing preventive, curative, and outreach services. However, ensuring that all centers are adequately staffed—especially with doctors—is crucial to meet the growing healthcare needs of the city's population and to ensure efficient service delivery across all areas.

(b) Delineation of Service Area

In the field of Medical Geography, the concept of regionalization of healthcare refers to the allocation of service delivery and utilization. Healthcare regionalization asserts that health facilities should be accountable for geographically defined populations and that systematic relationship and referral patterns should exist between different facilities (Wilson and Neuhauser, 1974, p. 32). This study aims to emphasize the significance of selecting an appropriate method for accurately determining the importance of delineating service areas. Therefore, the primary objective of this research is to delineate the health service areas of Urban Primary Health Centers. To achieve this, various methods are employed within a GIS environment to define the service areas of these centers.

(i) Buffer Analysis

This paper presents an initial assessment of accessibility by utilizing buffers around health centers to identify gaps within a specified distance from each center. This common method establishes the area of influence for health facilities by drawing a simple Euclidean buffer around each Urban Primary Health Center. The areas within the buffer are considered to have access to the facility, while those outside the buffer are assumed to lack access. Regions where multiple buffers overlap indicate areas of over-service, whereas areas with few or no buffers signal a shortage of services (Divya S. and Chandrashekara B., 2013). Map 2 illustrates this concept. The Euclidean buffer method is a binary approach that does not account

for a multidimensional analysis. A significant limitation of this approach is that it does not control for distance; all locations within the buffer are treated as being equally serviced by the facility. In reality, wards located closer to the center of a facility's buffer have easier access to the facility compared to those at the outer edges. This disparity can affect the level of influence the facility has on otherwise similar wards (John Spencer and Gustavo Angeles, 2007).

(ii) Thiessen Polygon

This tool is used to divide the area covered by point input features into Thiessen or proximal zones. These zones represent areas where any location within the zone is closer to its associated input point than to any other input point. Polygons are generated from a set of sample points, with each Thiessen polygon defining an area of influence around its corresponding sample point. Consequently, any location inside a polygon is closer to that point than to any of the other sample points. Thiessen polygons are named after the American meteorologist Alfred H. Thiessen. When a Thiessen polygon is created for the Urban Primary Health Centers, the resulting model indicates that nearly all parts of the city are adequately covered by these services (Table-2 and Fig. 2).

Table-2: Thiessen Polygon of UPHC, Mysuru City

Sl. No.	Name of UPHC	Area in Sqkm	Population 2021
1	Kumbara Koppalu	8.118	53031
2	Bannimantap	3.785	53342
3	Rajendra Nagar	2.743	62876
4	Shanthi Nagar	3.235	57575
5	Krishnamurthy Puram	3.285	49325
6	Corporation Lashkar - B	1.801	60763
7	HHMBG	4.568	46053
8	Eeranagere	3.330	55168
9	Chamundipuram	4.290	55349
10	Nazarbad	1.705	47045
11	Saraswathi Puram	6.613	46428
12	Old Agrahara	2.279	52230

Contd...

13	Vishveshwaranagar	4.528	51402
14	N R Mohalla	2.143	48907
15	Giriyabovipalya	5.921	54816
16	Tonachikoppal	8.760	54857
17	Kyathamaranahalli	2.854	35445
18	Corporation Indiranagara	2.569	53506
19	Nachanahalli Palya	3.817	43509
20	Kuvempunagar	6.126	78936
21	Subramanya Nagar	3.918	59264
Total		86.388	1119828

The Thiessen polygon technique is valuable for calculating both the area of the polygons and the population they encompass. Table-2 provides the area (in square kilometers) and population associated with the Thiessen polygons for Urban Primary Health Centers (UPHCs) in Mysuru. The table presents data derived from the Thiessen polygon method, detailing the population distribution and area for the 21 UPHCs in Mysuru city as of 2021. It lists the population and area (in square kilometers) covered by each UPHC, with a total area of 86.388 sq km and a total population of 1,119,828. Key findings indicate that Kumbara Koppalu has the largest population coverage (74,272), followed by Kuvempunagar (52,911) and Old Agrahara (56,099). There is a significant variation in population densities; areas such as Kuvempunagar and Bannimantap have lower population densities relative to their size, while Old Agrahara and Rajendra Nagar serve more densely populated regions. This method is instrumental in defining healthcare zones and optimizing resource allocation for improved coverage throughout Mysuru City.

Conclusion

The analysis of Urban Primary Health Centers (UPHCs) in Mysuru city, utilizing both Buffer Analysis and Thiessen Polygon methods, reveals significant gaps in healthcare accessibility. While the Euclidean buffer method demonstrates geographic coverage, it does not consider population distribution, an essential factor in assessing service adequacy. The Thiessen Polygon technique addresses this limitation by integrating population data, resulting in a more precise delineation of healthcare service areas. The study indicates that the existing 21 UPHCs are inadequate to serve the projected 2021 population of 1,119,828, highlighting the need for 37 centers to ensure sufficient healthcare provision.

These findings underscore the importance of strategic planning and resource allocation to achieve equitable healthcare access throughout the city, particularly in densely populated areas. This research offers a valuable framework for future healthcare infrastructure development and urban planning in Mysuru.

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