Vernacular Agricultural Practices and their Impact and Dependency on Riverine Landscapes: Insights from the Mali Community in India

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Received	Revised	Accepted
31.12.2024	20.05.2025	31.05.2025

https://doi.org/10.61275/ISVSej-2025-12-03-10

Abstract

Rivers and landscapes are crucial in influencing the interactions between people and Nature. Indigenous communities living along these ecosystems develop strong connections stemming from ancestral observations and interactions. Their traditional beliefs, systems, knowledge, and practices help them maintain and shape their livelihoods around seasonal changes and the natural cycle of the landscapes they inhabit. This co-existence fosters sustainable living while maintaining the ecological balance. Indeed, the interactions between vernacular practices and riverine systems result in a dynamic system of adaptation and survival. This paper examines this coexistence, to reveal their indigenous knowledge and vernacular sensibilities to live around these ecosystems. It focuses on the temporal living systems based on the livelihood practices and patterns of the Mali community caused by seasonal changes along the River Banas near Palanpur City, Gujarat, India.

The research employs qualitative and quantitative documentation methods. Fieldwork involved a site survey with community members and photographic documentation. Oral histories were recorded to understand the seasonal changes and community adaptations. Drawings were created based on site observations of settlement patterns, cropping patterns, and water usage. The mix of interviews and direct observations help capture both the concrete and intangible knowledge systems that govern their sustainable practice.

The study concludes that seasonal rhythms of the river Banas' influence the agricultural practices of the Mali community. Their adaptive land use and cropping patterns provide a sustainable and adaptive response to a non-perennial riverine setting, providing insights into resilient, temporal living.

Keywords: Indigenous communities, Riverine landscapes, Vernacular Agricultural practices, temporal living systems, Oral history, non-perennial rivers

Introduction

Temporary River Systems

Temporary river environments are ever-changing and are linked to various types of habitats, both in water and on land. According to Steward (2012), these habitats include flooded channels, riparian zones, floodplains, flowing water, isolated pools, and dry river beds. Out of these habitats, dry river beds are the exposed beds in the river channels where the water table no longer reaches the surface. They are not part of the riparian zone and can be found between patches of surface water, like isolated pools or waterholes.

Dry river beds are often associated with negative connotations as they are present during droughts and do not contain surface water. However, they support a range of important human and ecological values and are utilized for various purposes such as agriculture, recreation, transportation routes, and as habitats for diverse biota (Steward, 2012). Dry river beds can in fact serve as sources of sustenance and water for communities and are recognized around the world in human language and culture, and feature in stories told by indigenous people.' (Steward, 2012). They also provide fertile substrata for agriculture, and supporting practices like intensive farming and greenhouse agriculture. Hence, it is important to examine and document these landscapes. It is particularly so in the Global South, where much of such landscapes and traditions survive through oral traditions, with only limited, incomplete written records. While some academics have addressed these before, many indigenous practices and techniques remain largely unexplored.

Steward (2012) mentions that 'human alterations to the natural landscape have resulted in the increased spatial and temporal prevalence of dry river beds in some places.' One such unexplored area is the connection between vernacular agricultural practices and the dynamic nature of seasonal river systems. Communities living along temporary rivers, like the Mali community in Gujarat, India, develop methods specific to the site and landscape for agriculture and habitation (Premkumar & Nautiyal, 2022; Goswani et al., 2023). These methods frequently adapt to the changes in seasonal cycles, soil fertility, and water availability (TERI, n.d.). These lived experiences influence not just their farming practice, but also deep environmental knowledge based on adaptation and resilience. (Premkumar & Nautiyal, 2022). The adaptive methods of the community are shaped by seasonal land use and cropping patterns, which are influenced by the river's non-perennial character. This link indicates extensive environmental knowledge founded on adaptation and resilience. However, such practices, which are ingrained in local ecologies and cultural life, are not often recorded and rarely integrated into formal discourse (Goswami et al., 2023).

In this context, this study examines the relationship between vernacular farming practices and the riverine landscapes in the Mali community along the Banas River near Palanpur City, Gujarat. It investigates how seasonal changes in the river system affect the livelihood strategies, and how, in turn, the temporal land-use patterns and farming methods of the community respond to these adjustments. The study focuses on the Mali settlement along the River Banas near Palanpur City, Gujarat, specifically in the months of experiencing the dry phase, demonstrating the interdependence of vernacular agricultural techniques with the riverine landscape.

Its aim is to understand how the vernacular agricultural practices depend on and impact the seasonal riverine landscapes through lived, adaptive responses. Its objectives are:

- To document the seasonal rhythms of land use and cropping patterns shaped by the non-perennial nature of the River Banas.
- To analyze the spatial and temporal adaptations made by the Mali community in their agricultural and settlement practices.
- To explore how these practices contribute to sustainability and resilience in the face of ecological uncertainty.

Theoretical Framework

Non-perennial Rivers and Riverine Landscapes

'Rivers and streams that cease to flow at some point in time or space—hereafter referred to as non-perennial—are hydrologically diverse and globally prevalent.' (Busch, Costigan, Fritz et al., 2020). Non-perennial rivers, also known as ephemeral, intermittent, or temporary rivers, have discontinuous flow regimes and frequently dry up for long parts of the year due to climatic and geological factors (Larned et al., 2010). According to Vidal-Abarca et al., 2020), a distinguishing trait of non-perennial rivers is their dry season, which varies in duration and spatial extent. These rivers dominate dry and semi-arid areas, where most precipitations infiltrate rather than contribute to the stream flow or aquifer recharge (Scanlon, et al., 2006). While these systems are sometimes dismissed as lifeless during the dry years, they are ecologically significant, providing intermittent but critical habitats and rich soil for human use (Busch et al., 2020).

Riverine landscapes are the complex and dynamic zones formed by fluvial processes and the natural systems that surround the rivers. They include not only river channels, but also floodplains, riparian zones, and neighboring ecosystems, all of which interact through hydrological and geo-morphological processes (Naiman, Décamps, & McClain, 2005). Due to their relationship between terrestrial and aquatic systems, these landscapes have a high level of ecological connectedness and biodiversity. According to Ward (1998), riverine landscapes are made up of a mosaic of interrelated habitats and environmental variances, which constitute an interconnected system that supports both spatial and temporal ecological functions. These landscapes are fundamentally dynamic, subject to periodic disturbances such as flooding and seasonal drying, and this unpredictability promotes ecological resilience and complexity.

The correlation between non-perennial rivers and riverine landscapes is most visible in the dry and semi-arid regions, where the availability of water varies periodically. Vidal-Abarca et al. (2020) argue that while it might seem that the dry phase is a negative happening, the dry phase of non-perennial rivers is critical to their structure and function, influencing both the hydrology and ecology. Price et al. (2021) also remark that non-perennial rivers are likely to grow in size as a result of human activities and climate change, emphasizing the importance of complete study and management of these systems.

Ingold (1933) defines 'Landscape as a living process', saying that 'the landscape is never complete: neither 'built' nor 'unbuilt', it is perpetually under construction'. This stance aligns with the dynamic connection of the Mali community with the environment, in which agricultural and settlement practices are constantly adjusted in response to the ecological changes. Ingold goes on to say that "a place owes its character to the experiences it affords those who spend time there," emphasizing the importance of lived experiences in defining the character of the environment.

Understanding the interaction between non-perennial rivers and riverine landscapes via the perspective of indigenous knowledge systems might provide important insights into sustainable practices and ecosystem resilience. Documenting and incorporating these vernacular activities into formal discourse can contribute to greater ecological and cultural continuity in transient riverine ecosystems.

Vernacular Agricultural Practices as Expressions of Indigenous Knowledge

Vernacular agricultural practices are regionally evolved cultivation methods that have been shaped over generations of observation, adaptation, and responsiveness to environmental conditions, as noted by Sillitoe (1998). These practices are more than just technical solutions; they are embedded in cultural frameworks that reflect a shared knowledge of place, Nature, and time. Sillitoe (1998) defines indigenous knowledge as "the knowledge held collectively by a population, often embedded in cultural traditions and oral transmission." According to Christie (2007), such knowledge is performative and context-specific, with the emphasis on "something you do" rather than "something you have."

In agrarian communities, this understanding reveals itself in strategies such as flood-recession farming, sediment-based cultivation, and cyclical land usage, all of which are tailored

to non-perennial river systems. For example, communities that practice agriculture along the seasonal rivers rely on detailed knowledge of soil fertility, water timing, and climate variability (Kumar 2003; Agarwal & Narain 1997). These approaches are resilient and adaptive, which is consistent with finding that indigenous knowledge systems are dynamic, context-specific, and frequently merged with changing social and environmental conditions (Briggs,2005).

Rather than imposing stability on dynamic settings, vernacular agricultural systems adapt and understand ecological alterations via lived experience. As Rapoport (1982) notes, vernacular environments reflect both functional adaptability and cultural continuity, allowing communities to preserve livelihoods while reinforcing their relationship with the shifting landscapes.

Indigenous Knowledge – Agricultural Practices

According to Christie (2007), "Indigenous knowledge is what makes possible the 'routine practices of everyday life'. He identifies the characteristics of Indigenous knowledge as performative, something you do rather than has; context-specific, differing from place to place; owned, protected, and accountable as it is governed by laws; collective; responsive; active and constantly renewed and reconfigured." The components of indigenous knowledge that are 'singular, non-transferable, tacit and unable to be expressed in words' (Christie, 2007) are less acknowledged than non-indigenous knowledge.

According to Christie (1990; 2007), understanding the relationships between species, people, ancestors, stories, dances, art, science, politics, economics, power, society, and the universe is the basis for building knowledge in many Indigenous systems where context-specific information is developed through this relationship, as opposed to western knowledge emphasizing separation as the foundation for understanding surroundings. Agrawal (1995) states that the link between power and knowledge needs to be explicit for genuine recognition of the contribution of indigenous knowledge. Why he says that is because fundamental variations in the ways that knowledge is constructed, connection or separation, have a big impact on how power structures are created and how indigenous knowledge gets overlooked when it comes to natural resource decision-making. The pragmatic, utilitarian, and daily necessities of living often shape indigenous knowledge, which can include parts of non-indigenous sciences into an overlapping, mediated, and constantly evolving form (Briggs, 2005).

Review of Literature

Vernacular agricultural practices based on indigenous knowledge have long influenced the evolution and survival of people living close to dynamic landscapes, particularly those shaped by rivers (Berkes 1999; Adams 1993). The reliance of such systems on fluvial processes, particularly nonperennial rivers, is increasingly recognized in modern literature (Costigan et al. 2017; Datry, Larned & Tockner 2014). This study delves into major research from around the world, as well as the Indian context and vernacular settlements like those of the Mali people in Gujarat, India.

Scholars around the world have investigated the relationship between vernacular agricultural knowledge and riverine ecologies. According to Adams (1993), traditional activities in African drylands are strongly rooted in seasonal hydrological rhythms, highlighting the importance of non-perennial streams in farming cycles. According to Powell (1995), in Australia's arid zones, Indigenous land management is based on ephemeral water sources and associated ecological indicators to determine planting and harvesting cycles. These findings highlight the importance of indigenous ecological literacy in adjusting to temporally changing contexts. Furthermore, Berkes (1999) argues that such systems act not just as ecological adaptations, but also as socio-cultural constructs that perpetuate resilience through memory, tradition, and collective experience.

In the context of non-perennial rivers, Costigan et al. (2017) and Datry, Larned, and Tockner (2014) address how the spatial and temporal diversity of these systems challenges modern conservation paradigms while also aligning well with the indigenous and vernacular

sensibilities. Busch, Costigan, Fritz et al. (2020) observe that communities reliant on intermittent flows frequently evolve subtle techniques for sensing water availability, stressing lived, place-based intelligence. These findings imply that vernacular systems are uniquely suited to responding to hydrological uncertainty, which is crucial in the face of growing climatic unpredictability.

Traditional agricultural systems in India have evolved in response to monsoon and river cycles. Agarwal and Narain (1997) describe indigenous water harvesting systems such as Johads and Ahars in semi-arid locations, demonstrating locally adapted strategies for managing non-perennial water sources. Kumar (2003) emphasizes how rural communities have intimate knowledge of riverine ecologies, responding through seasonal movement, rotational agriculture, and temporary dwellings in floodplains and dry river banks. According to Chambers (1980), flood-recession farming along the Yamuna and Brahmaputra rivers is a practice embedded in thriving but temporary post-flood environments.

Rapoport (1982) emphasizes that vernacular dwellings are formed by environmental limitations and functional requirements—insights that are particularly valuable in riverine environments where impermanence and adaptability are essential. Mishra (2000) also observes that riverbank communities in India link their agricultural calendars and spatial organization with seasonal river flows, adjusting crop selection and settlement patterns to varying water availability.

In western India, notably Gujarat, studies on vernacular riverine settlements are sparse. However, Jadeja (2018) investigates how people in the Banas River basin deal with seasonal water scarcity through rotational cropping and reliance on sediment-rich soils in the dry riverbeds. Mali communal settlements, which rely primarily on non-perennial rivers such as the Banas, have traditional methods of land demarcation, water access, and temporal land usage that show an adaptive coexistence with their surroundings. Devi, Vijayalaxmi, and Srikonda (2023) emphasize the importance of spatial configurations, shade, and vegetation in vernacular settings in Visakhapatnam, which, while not riverine, provide insight into the greater ecological intelligence embedded in everyday building.

Despite these significant advances, gaps remain. Most studies are either broadly regional or focused on water management, rather than delving deeply into the architectural and spatial logic of vernacular agriculture in non-perennial river situations. There is little anthropological and architectural data about the Mali people, and even fewer studies connect their agricultural methods to the cultural landscape dynamics of the Banas River. The scarcity of integrated research that looks at the rivers, settlements, and knowledge systems as interrelated components restricts our understanding of how ecological, spatial, and cultural resilience interact in such landscapes.

This study seeks to address this gap by exploring the integration of indigenous knowledge into the agricultural and settlement patterns of the Mali community, thereby adding knowledge to discussions about sustainable rural futures.

Research Methodology

Research Strategy

This study uses a qualitative case study method to investigate the interaction between vernacular farming practices and the seasonal riverine landscape of the River Banas, with a focus on the community of Balundra. A case study method is best suited for capturing the lived, embedded knowledge of the Mali community within their distinct ecological setting (Yin 2009). It enables the analysis of temporally and spatially placed behaviors, particularly where the dynamics of water supply, land use, and community response are inextricably linked (Flyvbjerg 2006).

Case Study Selection

Balundra village, situated on the floodplains of the River Banas in Gujarat, was chosen as the case study based on three criteria as follows.

1. The existence of seasonal, non-perennial water flow,

2. Vernacular agriculture is still practiced, mainly by the Mali population, and
3. It is relatively under documented in mainstream academic discourse.

This purposeful selection is consistent with the study goal of highlighting indigenous and place-based knowledge systems in underrepresented geographies.

Data Collection Techniques

Following qualitative data gathering strategies were used. They were adapted to generate direct observable insights, qualitative patterns, and manual documentation.

- **1. Semi-structured interviews** were conducted to document lived experiences, indigenous knowledge, and socio-spatial activities associated with agriculture and riverine adaptation.
  Participants:
  Nine people of Balundra village, including elderly Mali farmers, women cultivators, temple caretakers, and seasonal workers were. These individuals were chosen as key knowledge-holders based on their active participation in the riverine agricultural cycle.
  Format:
  Interviews were held in Gujarati with open-ended questions to allow for flexible and in-depth storytelling. Initial site visit aided rapport-building, and based on early observations, a basic questionnaire was created to guide interactions with community members for the next site visits.
  Themes Explored:
  Core themes included site selection procedures, crop cycles and crop-specific knowledge, seasonal patterns of residence and mobility, farm and temporary shelter spatial organization.
  Duration:
  Each interview lasted 45 to 90 minutes, depending on participant availability and the amount of discussion.
  Documentation:
  Interviews were audio-recorded (with verbal authorization) and accompanied by handwritten notes and images that captured the geographical context of the conversations.

  2. Participant Observation.
  Participant observation was used to directly observe everyday agricultural and spatial behaviors, with a focus on how these change over seasons.
  Field trips:
  4 visits were made between Jan 2023 and May 2024.
  Duration:
  Each visit lasted 9-10 hours, timed to coincide with agricultural and irrigation activity. Observations include land preparation, irrigation systems and temporary shelter construction. Documentation includes field notes, process sketches, photographic records, and environmental recordings (Bernard 2011).

- **3. Visual and Spatial Documentation.**
  Visual documentation was used to capture spatial configurations and landscape modifications on a systematic basis.
  Tools: Smartphone, drawings (plans and sections)
  Purpose: to document cultures, terrain topographies, temporary habitation typologies, and seasonal vegetation.

- **4. Cartographic Mapping**
  Visual documentation was used to capture spatial configurations and landscape modifications on a systematic basis.
  Tools: Smartphone (limited use due to wind conditions).
  Purpose: to document cultures, terrain topographies, temporary habitation typologies, and seasonal vegetation.
  Output: Informative Images and several minutes of video footage, which were later analyzed for the study

- **5. Remote Sensing-based spatial analysis**
  Historical satellite imagery from Google Earth Pro (2013-2023) was examined to better understand temporal changes in land use and agricultural practices.
  Design: areas of multiple sites in nearby villages along the Banas river to observe the varieties and similarities on site conditions.
  Focus: Each timeline and site, the study recorded settlement pattern, living vicinity, chosen areas for agriculture, shaping of streams, type of crops
  Tools include Google Earth Pro, adding to the interview, and observational data

- **6. Literature and Secondary Data**
  A detailed literature review guided the formulation of field questions and provided support for the analytical approach.
  Sources include peer-reviewed publications, research and relevant literature.
  Themes include non-perennial river systems, vernacular hydrology, seasonal mobility, and indigenous agricultural expertise.
  Purpose: To highlight gaps in current research and frame the Balundra case within larger theoretical disputes (Rigg & Nolintha, 2017).

Data Analysis Techniques

The data analysis was based on on-site participation and direct interactions with the Balundra community. Rather than abstract classification systems, the technique was based on direct interpretation of field notes, images and seasonal observations. Observational data from the site visits were analyzed by time, season, and activity to uncover recurring agricultural and settlement trends. These were manually recorded in diaries and activity sheets to track the sequences and geographical linkages.

The interview transcripts were examined several times, with themes such as water-sharing, crop cycles, and ritual behaviors organized by the frequency and contextual importance. The emphasis was on uniformity among the narrators matching with observable landscape elements.

Historical satellite imagery from Google Earth Pro (2013-2023) was examined to monitor land-use trends and environmental change over time. Annotated maps depicted changes in vegetation, settlement structures and river streams, allowing for temporal comparisons of landscape use. Drawings, plans and sections were made to understand and then analyse the use of space and structures. Field sketches, photographs, and field records were organized chronologically and geographically. This allowed interpretation to arise directly from the lived experience, ecological facts, and the tangible nature of the riverine environment (Ingold 2011).

Ethical Considerations

All research participants were informed about the research and its purpose. Interviews and visual documentation were conducted with the verbal consent of the participants. Personal information was made anonymous when appropriate, and no interference into ritual or private spaces occurred.

Contextual Background of Balundra

Location of Balundra

Research was conducted in the Banaskatha district of the Northeastern part of Gujarat, near the border with the neighboring state, Rajasthan. This region is located between latitudes 23°33' and 24°45' North and longitudes 72°15' and 73°87' East. The area, is defined by semi-arid plains sculpted by the Banas River, which flows intermittently across the district (Mistry & Suryanarayana, 2019). Banas is a seasonal river crucial to agriculture and habitation patterns of the areas, particularly during the dry season (Singh et al., 2024).

After locating the region, moving North of the city of Palanur, towards the river Banas, the village of Balundra—located near Iqbalgad, some 40 kilometers from Palanpur City—was chosen as the principal site for this study. Balundra, located along the Banas River, shows the vernacular agricultural methods of the Mali community and seasonal reliance in a non-perennial riverine environment. While other areas along the river were examined for comparison, this paper concentrates specifically on Balundra due to its representative landscape features and accessibility. The proximity of the settlement to the river, temporal use of land, and evident patterns of adaptation to seasonal water supply make it an excellent case study for investigating the interrelationship between residence, cultivation, and river ecology.

Fig 1: Palanpur city, Gujarat, India. (Area marked in red circle)
Source: Google Earth Pro. (01.20.24). 24°17'59.520"N, 72°27'53.67"E, Eye alt 28.70 Km. http://www.earth.google.com [March 30, 2024]

Fig 2: Highlighted patch, the Site, located on the river Banas' riverbed, and includes the settlement on the riverbed.
Source: Google Earth Pro. (01.20.24). 24°22'10.09"N, 72°32'47.74"E, Eye alt 3.03 Km. http://www.earth.google.com [March 30, 2024]

Topography and Climate

The hot summers and dry, non-rainy seasons of the district are indicative of its hot season, lasting from March to May, following the winters, which last from December to February. The post-monsoon season spans from October to November, while the Southwest monsoon season runs from June to September. There is a range of 214 mm to 1,801 mm of yearly rainfall. The Banaskantha district has 26.97ºC average temperature and a scarcity of rainfall for the last 102 years with its average annual rainfall being low—520 mm (Mistry & Suryanarayana, 2019). The climate of Balundra plays a significant role in supporting the local economy, agricultural practices, and various ecological cycles in the region (Goswami et al., 2023).

Riverine Setting

The Banas River, a non-perennial river that originates in the Aravalli highlands, is crucial to the seasonal ecosystem of Balundra. It only flows during the monsoon and produces nutrient-rich alluvium on the nearby fields, promoting flood-recession agriculture and groundwater recharging (Shah & Kulkarni 2017; Patel & Hirway 2010). For the rest of the year, the riverbed is dry, repurposed for grazing and temporary land usage. Local farmers use ancestral knowledge of the flood patterns of the river to differentiate the land types, such as khadip, based on moisture retention and flood frequency. This understanding influences farming strategies, land classification, and settlement organization (Baviskar, 1995).

Vegetation

The Balundra region in Banaskatha is home to thorny and dry deciduous forests of Banaskantha that modulate the climate of North Gujarat. It includes Neem (Azadirachta indica) which is one of the most prevalent species, being one of the most significant species in the non-forest areas. High quality neem seeds are acquired exclusively from Banaskatha, and planting is encouraged throughout the districts such as Mehsana, Gandhinagar, and Anand (Khanna, Singh et al., 2010).

Other significant and local species are the Israel baval, Arduso, Deshibaval, Ganda baval, Khijado, Bordi, Kanji, Piloo, and Mango (Khanna, Singh et al., 2010). ‘Baval’ also known as gum arabic tree (Acacia nilotica) is found in the semi-arid region, which is a low-growing, prickly plant and shrubs that have adapted to thrive in such circumstances. These bushes are primarily dispersed over the desert regions of Gujarat and Rajasthan. Over the past ten years, farmers in the districts of Mehsana, Sabarkantha, and Banaskantha have begun to raise grafted mangoes (Amba or Mango-*Mangifera indica*) in addition to traditional agricultural products. Potato, great millet (Sorghum), castor, peanut, wheat, mustard, and vegetables are the principal crops farmed in the region (Sharma, Ahmed, Manoj et al., 2018) along with Cotton and Pigeonpea (Pandey, 2023).

The Community

The Mali community, sometimes referred to as Mali samaj, is one of India’s tribal and social group communities. They have historically been connected to gardening, horticulture, and agriculture. They have many subgroups and are extensively distributed over West Bengal, Tripura, Meghalaya, Mizoram, Arunachal Pradesh, Assam, Maharashtra, and Gujarat (Hazarika & Chetia, 2022). The community in and around Rajasthan is composed of two primary sub-castes: the Malis, who engage in agricultural and vegetable production, and the Phool-Mali, who grow flowers for the temples and shrines (Open Book Publishers CIC Ltd., 2013).

Mali people live in the villages across the rivers near Palanpur city and work primarily in agriculture. Vegetable farmers in Mali typically own either a small plot of land or none at all. This causes people to either move to the riverbed for farming purposes or labor on someone else’s farm, when not farming on the riverbed. Many Mali communities have relocated to cities to take advantage of new opportunities, jobs, and enterprises. Their gatherings, customs, and festivals are frequently linked to their main source of income, agriculture, and so are widely

observed holidays like Holi, Diwali, and Navratri. In the past ten years, there has been a change as local youth are choosing professional or higher education paths over conventional agricultural vocations.

Findings: Vernacular Practices and Dwellings

Livelihood Practice of the Mali community near Balundra

The Mali community living along the river Banas is primarily associated with agriculture. Seasonal farming along the riverbed is the foundation of their livelihood and economic activity. During the off-season or when farming circumstances are poor, many community residents supplement their income with supplementary jobs. These include paid work on the adjacent farms, jobs in local businesses, and positions in religious institutions. During an interview, one resident mentioned that his employment at the Vishweshwar Mahadev Temple near the riverfront provided a year-round source of supplementary income for his family.

Fig. 3: Farm along the river Banas with a view of the house in the background
Source: Clicked by author

The Settlement Pattern

Historical satellite imagery and on-site observations demonstrate how over the years, the placement for settlements, area for practicing farming and the locations of the river streams changes, in adaption to the landscape conditions of the time. The Malis choose to shape the streams in accordance with that year's water availability. The fields are deliberately placed along and perpendicular in direction to the flow of the rivers precisely. For the water to easily reach throughout the field, several additional river streams are further separated from the primary one.

The dwellings are consistently chosen and constructed at the highest elevation of the riverbed, and far from the river stream, to save houses and possessions from flooding during unforeseen high water levels or periods of heavy precipitation. These high-altitude sites provide the community with symbolic grounding amongst the flows of the s cycle of the river in addition to providing physical security. Due to the non-perennial Nature and periodic drying of the river, the elevation of the riverbed varies annually, changing both the altitude and the places of setting up homes. Land divides have been preserved through centuries, with ancestral boundaries respected and each household caring to their allocated allotment. While land is managed individually, choices about water consumption and cropping cycles are frequently made together, enhancing communal relationships and adaptive resilience in a changing terrain.

Fig. 4: image chowing settlement pattern of 2014 on river Banas.
Source: Google Earth Pro. (12.03.14). 24°22'12.88"N, 72°33'02.32"E, Eye alt 904 m. http://www.earth.google.com [March 30, 2024]

Fig. 5: Image chowing settlement pattern of 2016 on river Banas
Source: Google Earth pro. (02.07.16). 24°22'12.88"N, 72°33'02.32"E, Eye alt 904 m. http://www.earth.google.com [March 30, 2024]

Fig. 6: Image chowing settlement pattern of 2020 on river Banas.
Source: Google Earth pro. (12.29.20). 24°22'12.88"N, 72°33'02.32"E, Eye alt 904 m. http://www.earth.google.com [March 30, 2024]

Fig. 7: Image chowing settlement pattern of 2024 on river Banas.
Source: Google Earth Pro. (01.20.24). 24°22'12.88"N, 72°33'02.32"E, Eye alt 904 m.
http://www.earth.google.com [March 30, 2024]

Similar instances of placement of river streams, fields, and settlements are seen in the current condition of the riverbed. Field setups are observed in low-elevation beds where water naturally flows toward the crop, as discussed in the section BB. Places for shelter are then decided and constructed at the highest elevation of the riverbed, and far from the river stream.

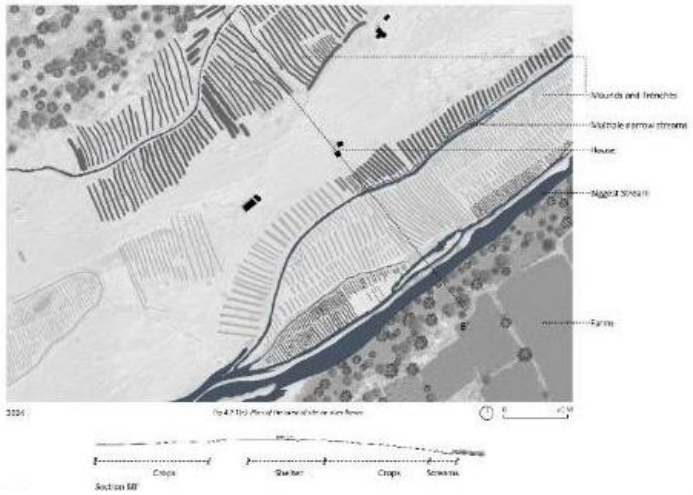

Fig. 8: Image showing settlement and temporal agricultural patterns along the river Banas (2024).
Source: Made by author

Fig. 9: The locations of the field and shelter
Source: Author

Above Figures help understand how the site operates. The river streams flowing along the river bed connect the settlements along the river. The direction and arrangement of the field are arranged perpendicular to the river streams. Numerous river streams run next to one another, providing water for the crops growing next to them, as seen in the Figures.

Territorial Markers

Along the river Banas, the Malis rely on various kinds of territorial markers. These markers are used to identify ownership, acting as animal barriers, and demarcating agricultural boundaries. Despite their temporary housing, these symbols act as a non-verbal means of ownership and space marking.

One of the most common methods involves using 'Gando Bavad', species of a local cacti, placed in consecutive order, to build a wall of prickly plants that serves as a barrier, marking their ownership and providing protection for the area. It serves to keep grazing animals and other wanderers at bay. Furthermore, this serves as a communal marker for defining the limits of common areas or resources. Other types of markers include stones, which are mostly used to mark the boundaries of fields and indicate how the land is divided for different purposes. Farmers and landowners in the area may occasionally use certain unusual trees or rocks as border markers or reference points. Gaps in the cultivation or empty spaces between the fields are also used to indicate boundaries.

Fig. 10 : Territorial marker using the dried structure of a local cacti plant.
Source: Made by author

Dwellings and the Settlement

Rural settings and villages along the river Banas are home to the residents of the Mali community. These houses are based on the availability of the resource, cultural preferences, and economic standing. In addition to living in the villages along the rivers, they reside on the riverbed of the Banas a few months of the year. Typically, the residences in the villages are one-story structures with tiny floor plans, thatched roofs, and mud walls. These houses are suitable for the local climate and designed to endure the elements. However, the study focuses on the temporary dwellings set up on the riverbed, during the months the Malis are on the riverbed.

Whereas, their houses in the village are made using tile or corrugated metal roofs and plastered walls. Pucca residences typically feature multiple rooms and may be furnished with modern conveniences such as electricity, running water, and restrooms. Some of the wealthy Mali community members have constructed more durable and long-lasting dwellings using brick, concrete, and cement in villages.

Fig 11: Traditional House set up with spill-out activities around like stove 'chulha', cots, drying on utensils on a cot, animals, drying rack, etc.
Source: Made by author

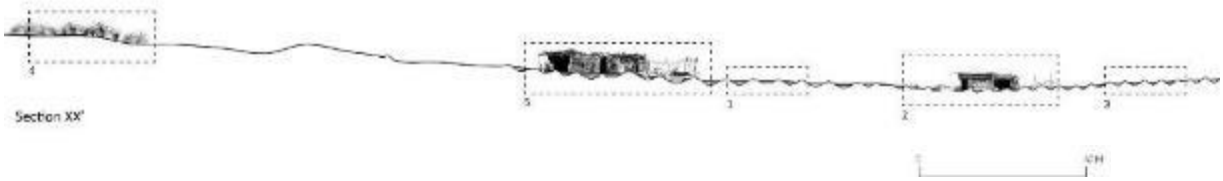

Fig. 12: Responses to topography – relationship between dwellings and the fields
Source: Made by author

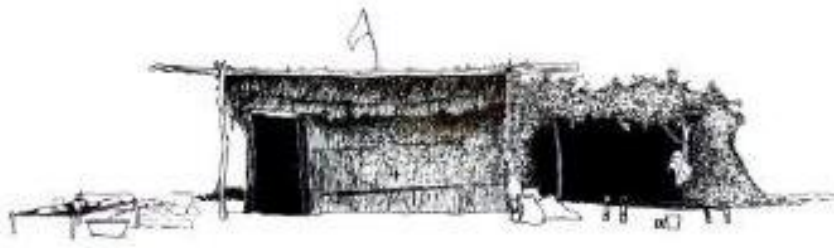

Fig. 13: The Dwellings
Source: Made by author

Fig. 14: Construction of these houses
Source: Author

As the figures 13 show, these houses are built of thatch, straw, clay, and mud found locally, particularly from the leaves and brackets of the locally found "Baru" trees. These dwellings, for about half the year, are set up on the riverbed. Their ability to pursue their principal employment in agriculture has led to their dynamic, temporary lives and mobility. The Fig. 14 shows the construction of these houses, which are traditionally referred to as 'chapru', which is essentially a hut, can take ten to twelve

days, including the time needed to gather the necessary supplies, put them together, and tie them together to form their makeshift shelters for the following six to eight months. They also use plastic covers such as tarps to shield their homes from severe weather and sudden downpours.

Drinking Pod

Getting pure, edible drinking water directly from the source along the Banas River requires drinking pods. They are mainly found near houses and in the gaps between houses and farms for convenience of access. Where they can be located depends on the height that the riverbed, to get to reach the groundwater. Here, the drinking pod was dug near the house with flowers planted along the edge. Malis covers the placed utensil with cloth or sieve to avoid any debris.

Fig. 15: Farm along the river Banas with a view of the house and the landscape.
Source: Author

Process and stages of Vernacular agricultural practices

- **Getting the land ready**

The Mali community begins their agricultural journey around the time of the festival of Navratri, which coincides with the end of winter and the arrival of spring. Depending on how the riverbed is that year, they usually begin the laborious process of preparing it. Assessing the riverbed and utilizing machinery such as JCBs to clear the first layer of rocks on the dried-out riverbed resulting in a much smoother area for farming and construction. When carefully digging the riverbed, several factors are taken into account, such as prior patterns of the locations of streams and water levels, which determine the sites of their homes and agricultural areas.

- **Crop selection**

Vegetables like cauliflower, cabbage, pumpkin, bottle gourd, etc. are grown on site 1. These need wider trenches and mounds due to the larger size of the fruit, whereas vegetables like onions, fenugreek, etc. can be arranged in narrower trenches, housing more crops in less area. Crops needing more water, like onions and methi, are planted near the water streams. The crops selected for the region as a whole are the outcome of decades of knowledge gained through trial and error, taking into account both a favorable climate and high-quality crop soil.

While a variety of crops are grown on site 1, some crops cannot be grown here because they are not suited to the site's environment. Tomatoes are one of them; they can be cultivated on site 2 and will be mentioned in detail in Chapter. Among the others are watermelon and muskmelon, which were cultivated in the past but were abandoned by the farmers ten years ago since the plants were disease-prone and did not yield. They use cow dung or manure for fertilizers, but the manure of a couple of cows is insufficient to for the crops, hence they additionally rely on artificial fertilizers.

Fig. 16: Vegetable crops along banks.
Source: Author

- **Molding river streams**

The next step in the process is equally important as treating the lands: precisely shaping the river streams according to the year's water availability is necessary to support agriculture and enable people to live on the riverbed since these sculpted river streams act as vital irrigation routes during the growing season. They also help to rejuvenate the riverbed from the yield and use of the previous year. In addition, they are utilized for daily activities like washing clothes and bathing. In addition to allowing water to flow through the region, along river Banas, the water streams help with improved water management across the fields. Water streams are sculpted between lines of crops based on the supply to the crops.

Fig. 17: The widest stream with flowers planted along both sides.
Source: Author

Fig. 18: Largest mound acting as a boundary between the farm and the waterbody.
Source: Author

Fig. 19: Multiple small streams along the farm.
Source: Author

Fig. 20: Section XX' representing response of topography – relationship between dwellings and fields
Source: Author

Fig. 21: land used for farming along the river.
Source: Author

Fig. 22: Spreading creepers planted in wider trenches
Source: Author

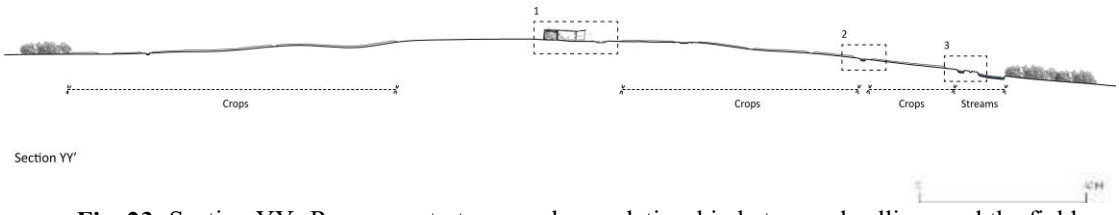

Fig. 23: Section YY- Responses to topography – relationship between dwellings and the fields
Source: Author

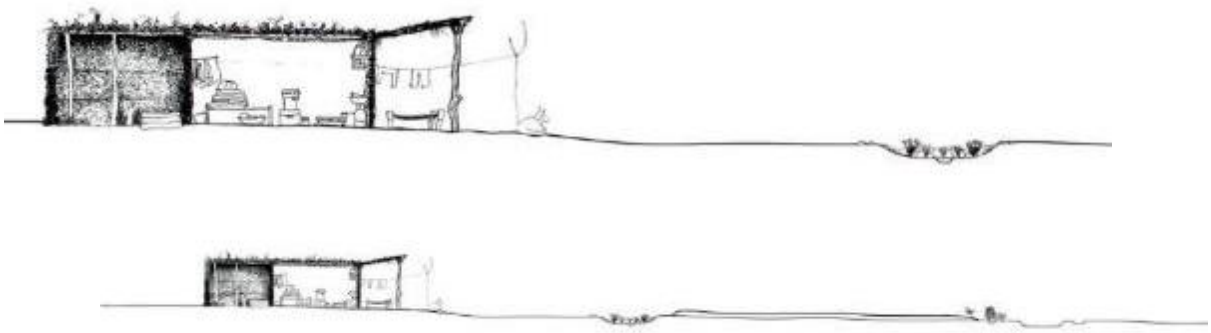

Fig. 24: Relationship with the local environment
Source: Author

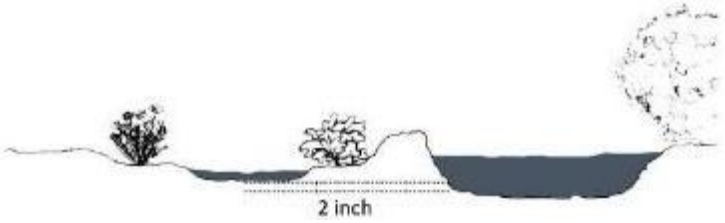

Fig. 25: indigenous techniques for modifying riverbed for farming
Source: Author

Fig. 26: Multiple water streams
Source: Author

The Fig. 21 shows that they use a specific method to arrange the land used for farming along the river. This technique involves creating mounds and trenches; the hill is used to prevent flat terrain, while the trenches are where the crops are planted. The deep trench essentially allows the river's groundwater to reach the roots, relieving them of the need for manual watering. The widths and directions are flexible and can be altered. The Fig. 22 shows that to accommodate a vegetable with a bigger fruit like a pumpkin, a spreading creeper is planted in wider trenches.

The Fig. 24 demonstrates that the building materials for these shelters are ideal for the local environment since they allow all of the riverbeds inside the home to be cool during the day and warm at night because of the trapped heat of the day. The Fig. 26 shows that multiple water streams are molded according to the water availability on the riverbed that year. They carve them to keep the flow of the river stream going while being strategic about watering the crops planted along it.

Fig. 25 shows that one of the indigenous techniques the Malis use, is the modified riverbed for farming and the riverbed levels for the streams. For water to reach the crop and its roots during farming, the riverbed must be excavated to a depth of two inches below the surface of the nearest river stream. The systems established are responsive and effective, but they are also sensitive since if the 2 inches increases to 4 inches, the water will not reach the roots adequately, which would affect the yield.

Discussion

This section analyzes the important findings in relation to the objectives of the study and the theoretical framework, focusing on how the vernacular farming practices of the Mali community reflect adaptive tactics in a non-perennial riverine landscape. The conversation is organized around four primary themes: adaptive land-use, temporality and resilience, indigenous ecological knowledge, and spatial logic of settlement. These together demonstrate how agriculture, water, and habitation are linked in shaping Balundra's local lifeways.

Adaptive land use and seasonal planning

Every year, the Mali tribe carefully alters their landscape, preparing farms and sculpting streams to accommodate projected water levels. These changes reflect extensive ecological understanding and a history of farmer-led innovation (Gupta 1998). Crop pattern, trench depth, and irrigation channels follow a practice-based logic passed down through generations, shaped by lived experience and adaptive responses to seasonal fluctuations, resembling what Oliver (2006) refers to as vernacular systems founded in environmental responsiveness.

Temporality and Resilience

Their habitation and livelihood methods are defined by temporality rather than permanency. Riverbed houses are built seasonally on elevated mounds, demonstrating a purposeful reaction to flood hazards (Sharma & Mehrotra 2010). This nomadic, adaptable way of living the land demonstrates a vernacular resistance to ecological variability (Oliver 2006).

Indigenous knowledge and cultural practice

Indigenous knowledge is embedded in the community's daily behaviors, such as water sharing, agricultural cycles, and construction techniques. These are passed down orally and led by seasonal events such as Navratri, which connect cultural time with natural cycles (Briggs 2005; Agrawal 1995). Hedges and stones serve as territorial markers, encode memory and ownership, and reinforce social order in the absence of legal land titles (Baviskar 2003).

Spatial logic and settlement organization

The spatial layout—fields near streams, houses at higher altitudes, and clever trenching—showcases an intuitive design influenced by experience. These patterns mirror Rapoport's (1982) concept of "environmental determinism," in which constructed form is dictated by function and ecology rather than abstract aesthetics.

The agricultural system of Mali is based on dynamic adaptations rather than unaltered traditions. Their expertise, rooted in practice and place, provides a long-term paradigm for coping with riverine instability. Recognizing such systems is critical to larger ecological and rural resilience discussions.

Conclusion

This study reveals how the vernacular agriculture practices of the Mali community are influenced by and actively shape the non-perennial riverine landscape of Banas. The intimate understanding of natural rhythms, geographical mobility, and material practices produce a complex and resilient agroecological system of the community, developed from generations of living in sync with environmental unpredictability. Rather than opposing the unpredictability of a seasonal river, the Mali community adapts to it through flexible living patterns, strategic land use, and vernacular sensibiltity that incorporates environmental understanding into daily life.

Their interaction with place is defined by temporality, not permanence. Their communities and practices strive to flow with the environment, reconfiguring space each season based on water levels, soil fertility, and climatic patterns (Oliver 2006; Agrawal 1995). Such observations call mainstream development paradigms into question, as they frequently neglect rural communities' sophisticated, place-based solutions. This study advances our understanding

of vernacular landscape-making in dynamic ecosystems by recording and analyzing these activities using empirical fieldwork, visual documentation, and historical satellite imagery.

In an era when global agricultural systems are under increasing strain from climate change and environmental degradation, the Mali community provides crucial insights. Their seasonal, river-integrated living model offers a different perspective on sustainability, one based on lived adaptation rather than technology dominance. Recognizing and learning from these vernacular systems might contribute to broader discussions about rural resilience and regenerative futures (Gupta 1998; Kumar & Singh 2022).

The findings highlight the need to recognize and sustain indigenous methods, particularly when climate change and modern agriculture threaten local systems' survival. This study adds to the limited documentation of similar activities in the Indian semi-arid context. It encourages future academics and planners to view indigenous agricultural knowledge as a dynamic, intelligent system inherent in the landscape and essential to its preservation.

Limitations

This research has the following limitations.

Research duration and origin:

This study is an extension of an architectural dissertation completed during 16 weeks, during which all main data gathering and analysis were accomplished. The study expands on that extensive interaction, but its time frame limits long-term surveillance.

Single Case Focus:

The study focuses just on Balundra village and does not include a comparative analysis of other Mali settlements or riverine communities, perhaps limiting broader generalization.

Seasonal Constraints:

Fieldwork was limited to specified seasonal windows (dry phase), therefore, certain temporal practices, particularly those during the monsoon, could not be documented in person.

Temporal Snapshot:

Although Google Earth historical imagery was used, the on-ground field data only spans one year. Long-term ecological or socioeconomic changes occurred outside the study's era.

Non-standardized Units:

Observational equipment, such as measuring tapes and sketches, was calibrated manually and informally. While suitable for vernacular scale analysis, it may hinder replicability in precision-focused environmental investigations.

Lack of Archival Data:

There is little written or archival data about the historical evolution of agricultural techniques in Balundra. As a result, oral histories were used, which are naturally subjective and memory-dependent.

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