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SPATIAL ORGANISATION OF PREHISTORIC ARCHAEOLOGICAL SITES IN KOSĪ VALLEY, ALMORĀ DISTRICT

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Abstract: *The paper aims to identify environmental determinants of settlement organisation in a montane Himālayan context through a systematic spatial analysis of 8 prehistoric archaeological sites within the Kosī Valley, Almorā district, Uttarākhand. It also aims to examine the relationship between site distribution and key environmental variable including elevation, hydrological proximity, lithology, soil type, and slope by employing Geographic Information System technology within the landscape archaeology framework. A detailed analysis of the valley reveals a structured, non-random pattern of site placement best characterised as vertically differentiated, multi-zonal settlement system. The study finds a positive correlation (r= 0.755) between elevation and distance to river. The slope analysis has indicated a possible broad preference for moderate gradients across all elevation categories, functioning as a contextual constraint rather than a primary determinant. Spring has shown no discernible influence on site placement at this scale. Lithological variation across the valley has remained limited restricting inferences regarding raw material selectivity. Interpreting within the logistical mobility and site catchment frameworks, these findings are consistent with a pattern of functionally differentiated use of the landscape that prehistoric communities in the Kosī valley, engaged in purposeful, functionally differentiated use of the landscape across all environmental gradients.*

Keywords: *Himalayan archaeology, Uttarakhand, landscape archaeology, prehistory, spatial distribution*

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Introduction

The Kosī valley constitutes a geographically distinctive riverine corridor that has variety of small ecotones. The valley is defined by the Kosī River (Kauśiki), a right- bank tributary of river Ramganga, which drains a catchment encompassing varied altitudinal zones ranging from subtropical foothills to temperate mid-montane slopes (Valdiya, 1998). This ecological heterogeneity, characterised by diverse edaphic conditions, perennial water availability, and abundance of quartzite and chert, rendered the valley a particularly favourable environment for communities dependent upon hunting, foraging and early agropastoral subsistence strategies (Pande, 1935; Joshi, 1966). The interplay between these environmental variables and human behavioural adaptation is central to understanding why the Kosī valley has recently given us the evidence of prehistoric occupational residues.

The documented, if uneven, scholarly history of archaeological research in the Almorā district and the larger Kumāon Himalayan zone dates to the early twentieth century. Megalithic and cup-mark site occurrences throughout the Kumāon Hills were first methodically recorded by pioneering surveys conducted by Pande (1935), creating an initial distributional framework. The Archaeological Survey of India and Joshi (1966) later contributed to the corpus of known sites by locating Chalcolithic and early historic assemblages throughout the area. Recent systematic studies conducted since 1990's has significantly improved the cultural sequence, which have also started to address issues of intra-site spatial patterning (Khatri & Agrawal, 1995; Ota, 2000; Sharma, 2007). However, it is important to note that the literature has evidently lacked a thorough settlement-level analysis including spatial organisation, and inter-site distributional patterns throughout the Kosī valley. The earlier attempts have been to document maximum of sites. This represents a major gap in the prehistoric archaeology of the Kumāon Himalayas.

The current study's theoretical framework is based on the application of spatial analysis and landscape archaeology to prehistoric settlement systems. The study views prehistoric sites as functionally distinct nodes within an integrated land-use system rather than as isolated centres of activity, building on Binford's (1982) groundbreaking forager–collector mobility framework and the site catchment analysis methodology proposed by Vita-Finzi and Higgs (1970). The patterned distribution of sites throughout the landscape, the internal organization of activity areas within individual sites, and the resource-exploitation territories suggested by site placement in relation to lithic sources, water bodies, arable land, and ecotonal zones are all included in this analytical sense of spatial organization (Kvamme, 1990; Wheatley & Gillings, 2002). The application of Geographic Information System (GIS) methodology along with typological analysis has made the reconstruction of prehistoric decision-making landscape with an empirical rigor achievable in Himalayan prehistoric research. This integrated methodological approach is crucial in an area as physio-graphically diverse as the Kosī valley for understanding the intricate symbiotic relationship between topography, resource distribution, and human spatial behaviour.

The current study fills the knowledge gap by methodologically examining the spatial organisation of prehistoric archaeological sites within the Kosī valley. The study focuses on identifying physiographical patterns of site distribution, site-type variability and the environmental factors that influenced the settlement choices. It is guided by 4 main research goals:

(i) To perform a thorough survey & documentation of all identifiable prehistoric site localities within the study area.

(ii) To categorize sites based on their morphological characteristics, and functional inferences.

(iii) To analyse spatial relationships among sites with respect to topographic position, hydrological proximity, soil types, and raw material availability.

These objectives collectively address broader theoretical questions pertaining to the adaptive strategies of prehistoric communities operating within montane South Asian environments, for which the empirical dataset remains substantially underdeveloped in comparison with peninsular and Indo-Gangetic plain contexts (Korisettar & Petraglia, 1993; Paddayya, 1995).

Study Area

The study area is in the Almorā district, falling within Uttarakhand's Kumāon division. With an estimated area of around 3,082 km^{2,} is located at latitude 29.6°N and longitude 79.6°E (Government of India, 2018; Census of India, 2011). Almorā is surrounded by 4 districts with Piṭhorāgaṛh to the east, Chamoli to the west, Jāgeśwar to the north and Nainitāl to the south. The district falls within the Lesser Himalayan Zone, which give it a mountainous terrrain, with terraced slopes, steep ridges, deep river valleys, and dense forests. The main watercourse in the study area is the Kosī river (also Koshi or Kauśikī) draining a substantial portion of the central Almorā district. Before joining the Ramganga system, the river flows southward across significant tectonic boundaries from its source in the upper reaches of the Kumāon Himalaya.

Geographically, the district's elevations range from about 750 meters in the lower river valleys to more than 2,000 meters along its higher ridges, with some forested summits rising above 2,500 meters (Government of Uttarakhand, 2018). At the southern edge of the Kumāon Hills, the town of Almorā is situated on a horse-saddle-shaped ridge at an average elevation of 1,604 meters above mean sea level. The Kosī and Suyal rivers flow along the flanks of this ridge before converging in the lower valley.

Geology and Tectonic Framework

The Main Central Thrust (MCT) in the north and the Main Boundary Thrust (MBT) in the south define the geologically complex Kumāon Lesser Himalaya, which includes the Kosī Valley (Valdiya, 1980). The Almorā Nappe (AN), the Inner Krol Nappe, and the Outer Krol Nappe are the three primary tectonic units that comprise most of the region's rocks (Bhattacharya & Ahmad, 1990). The Almorā Nappe is a large synclinal folded thrust sheet whose basal contact with the underlying Lesser Himalayan metasedimentary is defined by the North Almorā Thrust. It is composed of low- to medium-grade metamorphic rocks, such as slates, phyllites, quartzites, and crystalline schists (Kothyari et al., 2017).

Major rock groups include the younger Ramgarh and Jaunsār Groups of the Inner Lesser Himalaya and the Almorā Group (which includes the Saryu Formation, dated at about 1,800 ± 100 Ma), which forms the NAT's hanging wall (Luirei et al., 2015). The intricate folding and faulting of these metasedimentary sequences have greatly impacted the valley's drainage patterns and landform development. Morphotectonic analyses revealed different neo-tectonic activity along the NAT, SAT, Ramgarh Thrust, and HFT which includes, V- Shaped valley, strath terraces, incised meanders, fault scarps, and paleolake deposits. The entire Kosī River basin is located within a seismically active zone (Pant & Singh, 2017; Kothyari et al., 2017). The Quaternary record has preserved multiple levels of fluvial terraces, debris fans, and fluviolacustrine deposits. The upper catchment of this Quaternary record reached close to North Almorā Thrust and the Rasiyari Fault. The aggregational landform record periods of

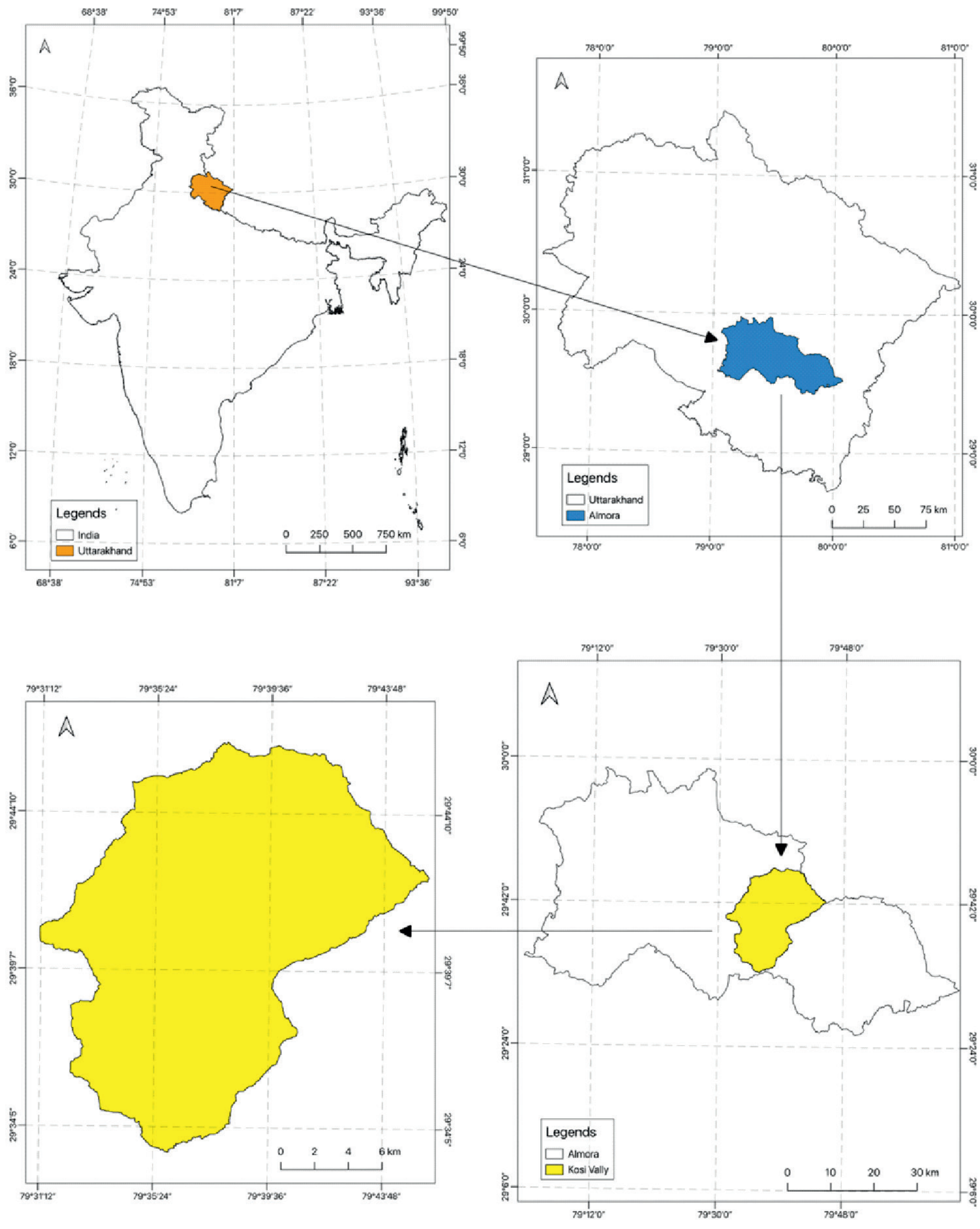

Figure 1: Source: Author, Geographical setting of the study area: from India to Uttarakhand, Almorā district, and the Kosī Valley

tectonic activity and climatic forcing during the Late Pleistocene and Holocene, as determined by optical luminescence techniques (Kothyari et al., 2017). These landforms may also preserve buried occupation surfaces or function as topographic templates for ancient settlement, thus, making them important for prehistoric archaeological research.

Climate and Vegetation

The study area's mid-Himalayan elevation and the southwest monsoon's impact control its climate.

Conditions vary from temperate and sub-alpine on higher ridges and summits to subtropical in the lower valley floors (below about 1,000 m). Higher altitudes in the Almorā district have a cold temperate climate with warm summers and chilly, sometimes snowy winters, whereas the valley bottoms have a more subtropical seasonal pattern (Government of Uttarakhand, 2018). Elevation and aspect have a significant impact on mean annual rainfall, which typically rises from valley floors to higher ridges. Most of the yearly precipitation occurs during the monsoon season (June–September), with dry winter conditions predominating from October to April.

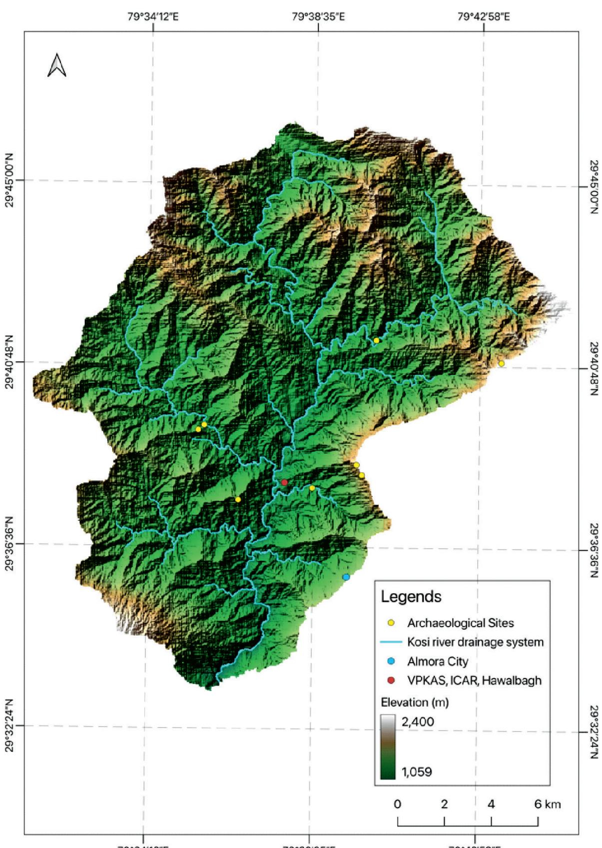

Figure 2: Source: Author, Elevation map of the Kosī Valley illustrating terrain variation, Kosī river drainage, and spatial distribution of archaeological sites

This altitudinal zonation is reflected in the district's vegetation. While mid-elevation slopes (1,200–2,000 m) change into mixed broadleaf forest dominated by bānj oak (Quercus leucotrichophora), rhododendron (Rhododendron arboreum), and deodar cedar (Cedrus deodara), lower valley floors, and slopes (600–1,200 m) are home to subtropical scrub and chir pine (Pinus roxburghii). The valley's extensive agricultural terracing is a result of centuries of human alteration of the Himalayan slopes. Historically, irrigated cultivation of paddy, wheat, barley, maize, and pulses has been supported by the fertile valley floors known locally as sera. (Government of Uttarakhand, 2018).

Historical Background

One of the Central Himalaya's most historically complex areas is the Kosī Valley and the larger Almorā district. The Skanda Purāṇa refers to the area as Mānaskhaṇḍa, and epigraphic and literary sources indicate that human settlement in the hills surrounding modern-day Almorā dates back at least to the time of the Hindu epic Mahābhārata (Sharma, 2022). The Kols, Kirātas, Khāsas, and Indo-Scythians were among the successive waves of early peoples in Kumāon that Atkinson (1882) documented in his seminal survey of Himalayan history. The Katyūrī kings (7th – 11th centuries CE), ruled from their capital at Kārtikeyapura (present – day Baijnath, Bāgeśwar). Their copper plates grants attest to administrative activity throughout the valley system as evidenced by the construction of Katārmal Sun temple by Katarmallā of Katyūrī. The Kumāon region was split up into multiple smaller principalities after the Katyuri polity broke up in the eleventh and twelfth centuries CE. Following their consolidation of power, the Chand dynasty established the town of Almorā in 1568 CE under King Kalyan Chand, who moved the dynasty's capital from Champawat to this new settlement on a strategically located ridge (Government of Uttarakhand, 2018). After the Gorkha forces were defeated in the Anglo-Gorkha War and the Treaty of Sugauli in 1816, Almorā became the headquarters of the newly established Kumaun district under British rule starting in 1815

CE. A series of administrative reorganisation of has shaped the current boundaries of the Almorā district. The most recent of which was in the 1997 division of Bāgeśwar district (Sharma, 2022). The hilly areas of Almorā district have also been identified as one of the likely source areas for copper raw materials linked to the Copper Hoard culture of the Indo-Gangetic plains (Agrawal, 1971). Although, the assumption needs more mineralogical confirmation, this highlights the probable connection between the Himālayan foothills and the larger protohistoric exchange networks of northern India.

Overview of Prehistoric Research in Kumāon

The archaeological research of the Kumāon Himālaya has brought to light a continuous series of human activities from Palaeolithic to early historic. The region is located at the intersection of three cultural zones, namely trans-Himalayan, Gangetic, and Tibetan. Due to this position, the region constituted a corridor for the flow of peoples, ideas, and material culture through deep time. This systematic archaeological survey of hills of Kumāon officially began with the work of Dr. M.P. Joshi in the mid-twentieth century. M.P. Joshi is credited with the discovery and documentation of the rock shelter paintings at Lakhudyār. The following decades brought explorations under the ASI and university departments that gradually unveiled the density and diversity of prehistoric remains in the district.

The prehistoric sites of Almorā district represent a succession of culture: Shelters of rock containing Mesolithic and later pictographs; open-air sites with lithic assemblages; and protohistoric settlements attributed to the use of copper/early iron. The Kosī Valley itself, with its extensive system of terraces, sheltered river-bank exposures and varied ecological niches, offered early human groups a range of habitable microenvironments, an observation that is a basis of the spatial analytical approach of present study of Kosī valley.

Palaeolithic Evidence

Direct evidence for Lower and Middle Palaeolithic occupation in the Kosī Valley is absent as noted in field surveys. The limited extent of the systematic survey is the other reason for this scarcity. In several areas of the Kumāon Himalayan zone, there is evidence of the early manufacture of stone tools. Earlier, Kothyari et al. (2017) documented the Kosī River terrace sequence which preserves sedimentary contexts with the potential for in situ early lithic assemblages. Pleistocene hominins were able to arrive in the region as comparable Palaeolithic records from the sub-Himalayan zone immediately to the south including foothills of Kumāon and the Siwalik piedmont.

Mesolithic Rock Art: Lakhudyār and Associated Sites

The Mesolithic rock paintings are the most widely documented prehistoric cultural evidence from the study area. Of these, Lakhudyār, in Almorā district, is the most significant site in the whole Kumāon region. The village of Barechhīna is located on the right bank of the Suyal River and is roughly 19 km away from Almorā town on the Almorā–Serāghat road. The site has been documented by Dr. M.P. Joshi and studied in a more comprehensive way by historian Dr. Yashwant Singh Katoch. The site is now protected under the ASI. (Lakhudyār Rock Paintings, 2025). The site consists of two main panels of rock shelter formed from natural overhanging cliffs which are about 50 m high. The shelters are about 8 m long and 2 m wide. The Lakhudyār Rock Paintings were probably made in three colour phases with natural pigments: the first layer, black (charcoal); the second layer, red ochre (haematite); and the last layer, white (probably limestone, mixed with water and animal grease) (Mathpal, 1995). The images can be placed into three broad categories:

anthropomorphic figures, zoomorphic forms, and geometric-abstract motifs. The figures seem to play stick-like forms and depict a group activity with group dances with rows of linked human figures. These scenes are interpreted by experts as representations of ritual communal dance (Nautiyal & Rawat, 2015). The long-snouted animal, possibly a fox, along with reptiles, and other animals, probably deer and bovid forms, are included in zoomorphic designs. Elements of geometries include wavy lines, designs filled with rectangles, groups of dots and tectiforms, which is something found in Palaeolithic cave art all over Eurasia and interpreted to be an iconic sign of a dwelling or shelter.

The rock paintings of Lakhudyār have stylistic similarities with the Mesolithic pictorial traditions recorded at major sites in the Indian sub-continent Bhimbetka in Madhya Pradesh, and sites in Mirzapur district, Uttar Pradesh. The paintings at Lakhudyār display stylistic elements ranging from the Old Stone Age to the Chalcolithic, with the earliest layers generally dated to the terminal Pleistocene–early Holocene (c. 10,000–8,000 BCE) and the later phases extending into the first millennium BCE (Lakhudyār Rock Paintings, 2025). The discovery of several more rock shelter sites with prehistoric paintings around Lakhudyār has substantially enhanced the Mesolithic evidence density in the district. Various important species are present in the forests of the study area, or Lwethāp. In the Himalayan region of India, Lakhudyār Rock Paintings, 2025. These sites form a cluster roughly within a 15 km radius of Lakhudyār and are described as the richest concentration of prehistoric rock art in India. In recent years, extra rock paintings were uncovered near Patharkot, a village situated on the Almorā–Daulāghat highway, thus extending the know range of prehistoric art in the district (The Statesman, 2020). The presence of spatial clustering along the rock outcrops at the riverbank particularly Suyal and Kosī drainages suggests that these watercourses became important focal axes in the settlement network and mobility of the Mesolithic people in the region.

Neolithic and Chalcolithic Period

Proof of Neolithic and Chalcolithic habitation in the Kosī Valley and more widely across the Almorā district is less systematically recorded as the rock art tradition. This is mainly due to the slightly nature of preservation in a montane context and the limited degree of excavation. Stone axes and ground stone tools, perhaps pottery, attributed to the Neolithic–Chalcolithic transition have been reported from different localities in the Kumāon hills. Their stratigraphic and absolute dates have yet to be published in full. During this time the wider distribution of Neolithic cultures across northern India provides more context for Kumāon prehistory. This period is marked by the emergence of ground and polished stone tools, handmade and wheel-made pottery, and increased sedentism (Chakrabarti, 2006).

The hilly tracts of the Almorā region are associated with copper metallurgy which is essential to understanding the Chalcolithic age of the region. The Khetri copper belt in Rajasthan and the Almorā hills in Uttarakhand may have been the source regions for the metal objects of the Copper Hoard culture of the Gangetic plains, generally dated to the first half of the second millennium BCE and associated with the Ochre Coloured Pottery (OCP) cultural complex (Agrawal, 1971). No copper hoard objects that are comparable with secure contextual associations from within the Kosī Valley itself have yet been reported. Thus, based on this identification, it may be inferred that the district was to have served as a resource extraction and distribution zone during the protohistoric period, connecting the Himalayan foothills with the wider chalcolithic circuitry of northern India (Lal 1951). Rock art at Lakhudyār and the adjacent areas itself contains data associated with the Chalcolithic period. The uppermost (white pigment) layer of paintings at Lakhudyār shows domesticated animals, horseback riders, bow and arrow wielding men, musical instruments, and sophisticated geometric patterns, the iconographical features of the subsequent prehistoric groups in the area (Mathpal, 1995).

Megalithic and Early Iron Age Evidence

Stone megalithic monuments including cist graves and cairn burials have been recorded from several localities in the wider Kumāon Himalayan region though systematic survey materials specific to the Kosī Valley are not very extensive. The link between the megalithic cultures and the rock art sites of the district still must be established. The early historic period of the Kumāon hills is to some extent known from copper-plate inscriptions and early temple building of the Katyuri period of the first millennium CE, which marks the starting point of the transition from the pre-historic to the proto-historic sequences of the region (Atkinson, 1882).

Methodology

In this research a spatial analytical and landscape-based methodology was used to analyse the spatial pattern of eight prehistoric sites in Kosī valley Almorā through geographical information system (QGIS). The GIS environment on environmental factors such as elevation (digital elevation model, DEM), slope, aspect, hydrology (river and springs), lithology, and soils were used. For each dataset a common projection (UTM Zone 44N) was applied, the attributes such as elevation, slope, distances to water sources at each site were extracted. Although artefactual assemblages are currently unavailable, sites can be provisionally classified based on observable surface characteristics into rock art locations, cup-mark occurrences, and open-air sites. The analysis is based on the detection of structured associations between the site locations and the environmental features, by classifying the continuous variables into ordinal classes (for instance, elevation classes and distance classes) and the use of the pivot tables of Excel to explore the associations between variables, mainly elevation and proximity to water. Due to the limited sample size (n = 8) and the preliminary scope of the study no sophisticated statistical procedures, e.g. nearest neighbour analysis, were used as they are not expected to provide any statistically sound or meaningful results and run the risk of over-interpretation. The dataset reflects the **current state of archaeological discovery**, not the total prehistoric settlement system. This study is explicitly non-chronological and treats the recorded sites as a spatial dataset without assuming contemporaneity. Kernel density estimation was applied to visualise spatial intensity patterns using a bandwidth of 1500 m and a raster cell size of 100 m. Kernel density is used only as a visual heuristic and not as a statistically robust estimator due to small sample size. The research, however, uses a descriptive and relational analytical approach, putting a premium on pattern recognition and coherency of results across variables, with results cross-verified through GIS visualisation. For small samples the use of this method is methodologically sound, and a systematic interpretation of spatial patterns based on the environmental context is possible instead of statistically weak conclusions.

Spatial Analysis of Settlement Distribution

Generally, the distribution of sites over the Kosī Valley does not show tight clustering around one environmental feature. Rather the data set presents a mixed distribution of sites, some relatively close to the river and some quite far from it, indicating that association with water was not the only settlement constraint and that there had been a broader interaction with the valley.

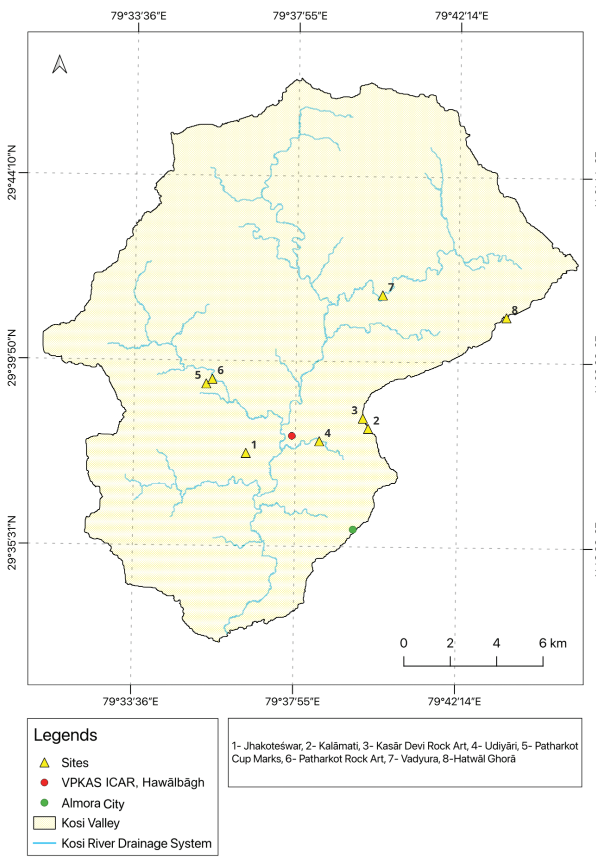

Figure 3: Source: Author, Map illustrating the location of archaeological sites within the Kosī Valley and their proximity to the Kosī River drainage network.

When examined spatially, the sites appear to follow a loosely linear arrangement along the valley corridor, while simultaneously extending into adjacent upland zones. This pattern reflects a valley-oriented but vertically extended settlement system, rather than a strictly riverine concentration. Such configurations are typical of Himalayan contexts, where movement and land use are structured along both the horizontal (valley axis) and vertical gradients.

To further examine the spatial intensity of site distribution, kernel density estimation (bandwidth = 1500 m; cell size = 100 m) was applied. A noticeable concentration of sites in the central valley region has been observed forming a primary density core. Western sector has an evidence secondary cluster, while additional sites occur as low-density, spatially isolated points in

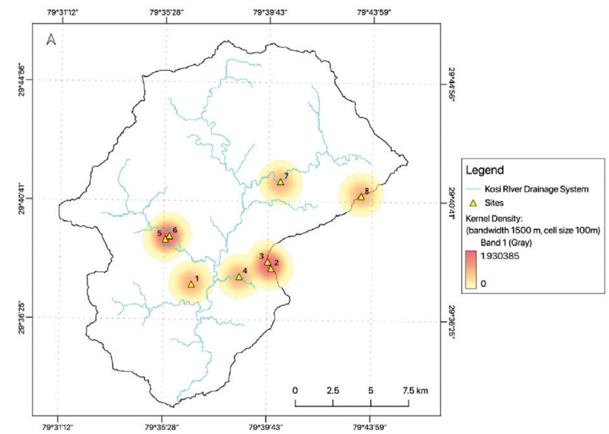

Figure 4: Source: Author, Kernel density estimation of archaeological site distribution in the Kosī Valley (bandwidth = 1500 m; cell size = 100 m).

the eastern and up-land areas.

Table 1 presents the environmental attributes of eight prehistoric archaeological sites recorded within the Kosī Valley, Almorā district. For each site, the following variables are recorded: elevation above mean sea level (metres), straight-line distance to the Kosī River (metres), distance to the nearest spring (metres), aspect (degrees), and slope (classified on a scale of 1–4, corresponding to gradient ranges of 0–15°, 15–30°, 30–45°, and 45–60° respectively). All eight sites fall within slope class 2–3, indicating gentle to moderately inclined terrain. FAO soil classification is uniform across all sites (Bd29-3c), a dystric cambisol typical of the metamorphic hill terrain of the Lesser Himalaya. Lithology is recorded using two codes: Mt (metamorphic rock, including slates, phyllites, quartzites, and schists of the Almora Nappe), which characterises seven of the eight sites, and pa (acidic plutonic rock, i.e. granite or granodiorite), recorded at Hatwal Ghora. Derived ordinal classes elevation class (Low: <1400 m; Mid: 1400–1800 m; High: >1800 m), river class (Near: <200 m; Moderate: 200–800 m; Far: >800 m), spring class (Near: <300 m; Moderate: 300–800 m; Far: >800 m), and slope class (Gentle: slope ≤ 5; Moderate-Steep: slope > 5) were computed from the continuous values to facilitate categorical spatial analysis in QGIS.

Table 1: Environmental and spatial attributes of documented archaeological sites, including elevation, distance measures, slope, aspect, soil, and lithology

S. No	*Name*	*Elevation (m)*	*Distance to Kosī (m)*	*Distance to Springs (m)*	*Aspect*	*Slope*	*FAO Soil*	*Lithology*	*River class*	*Elevation class*	*Spring class*	*Slope class*
1	Jhakoteśwar	1555	1087.8	986.7	158.50	3	Bd29-3c	Mt	Far	Mid	Far	Gentle
2	Kalamati	1873	1625.7	227.0	237.53	4.0	Bd29-3c	Mt	Far	High	Near	Gentle
3	Kasār Devi Rock Art	1933	1745.9	549.3	117.30	3.0	Bd29-3c	MT	Far	High	Moderate	Gentle
4	Udiyāri	1205	22.8	1951.9	110.46	3.0	Bd29-3c	Mt	Near	Low	Far	Gentle
5	Patharkot Cup Marks	1383	403.8	918.4	37.00	3.0	Bd29-3c	Mt	Moderate	Low	Far	Gentle
6	Patharkot Rock Art	1252	84.6	1250.7	7.02	3.0	Bd29-3c	Mt	Near	Low	Far	Gentle
7	Vadyura Cup Marks	1280	48.3	477.5	167.83	2.0	Bd29-3c	Mt	Near	Low	Moderate	Gentle
8	Hatwal Ghora	1456	2226.1	2278.8	178.90	2.0	Bd29-3c	pa	Far	Mid	Far	Gentle

Low-elevation sites exhibit a mean river distance of 139.9 m (SD = 177.8 m), whereas mid- and high-elevation sites show a substantially greater mean distance of 1671.4 m (SD = 467.6 m). This implies that higher-elevation sites occur at greater distances and display increased variability, while low-elevation sites are generally located closer to the river with relatively limited dispersion. The higher-elevation sites tend to occur at greater distance from the river is indicated by a positive correlation ($r = 0.755$, $r^2 = \sim 0.57$) observed between elevation and distance to river. The correlation coefficient is treated as descriptive and not statistically inferential due to the small sample size

The pattern signify that river proximity is conditional rather than universal, becoming significant only within lower altitudinal zones. Low- elevation sites likely represent areas of more sustained or repeated activity, potentially associated with habitation or water dependent task. In contrast, an upland activity area is suggested by the high-elevation sites consistently distant from the river, which may reflect seasonal mobility, resource, procurement, or task specific occupation. This resulting configuration can be elucidated as a multi-zonal settlement system comprising of a riverine zone (low level, near water), an upland zone (higher elevation, distant from water). This vertical structuring of settlement is a key feature of the spatial organisation in the Kosī Valley.

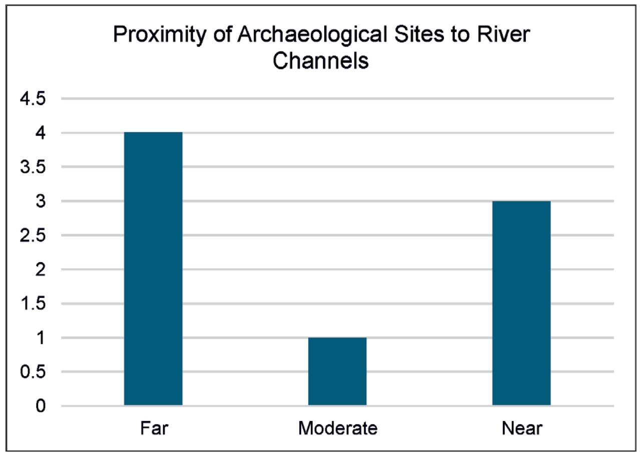

Figure 5: Source: Author, Distribution of archaeological sites according to their distance from river channels (far, moderate, near).

The Slope analysis reflects that most sites are located on moderate to moderately steep gradients with only limited representation on flat terrain. Importantly this pattern is consistent across all elevation categories, suggesting that slope does not structure site placement independently.

Instead, slope appears to function as a background constraint, within which site selection occurs. A balance between accessibility and terrain stability is observed through the preference for moderate gradients, rather than an avoidance of sloping environments. This indicates

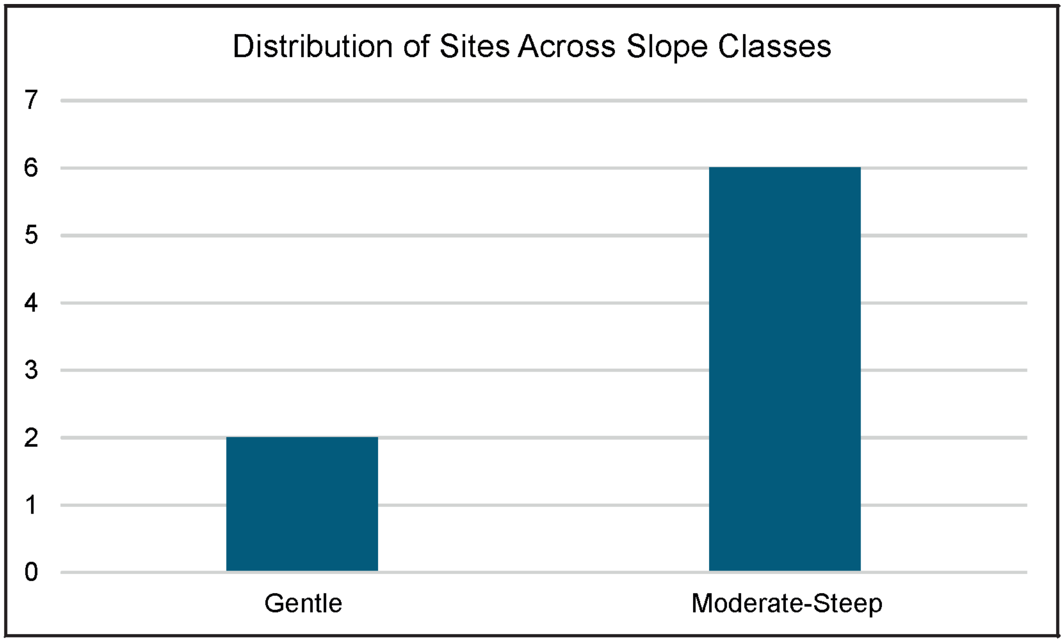

Figure 6: Source: Author, Bar chart showing the distribution of archaeological sites across slope categories (gentle and moderate–steep)

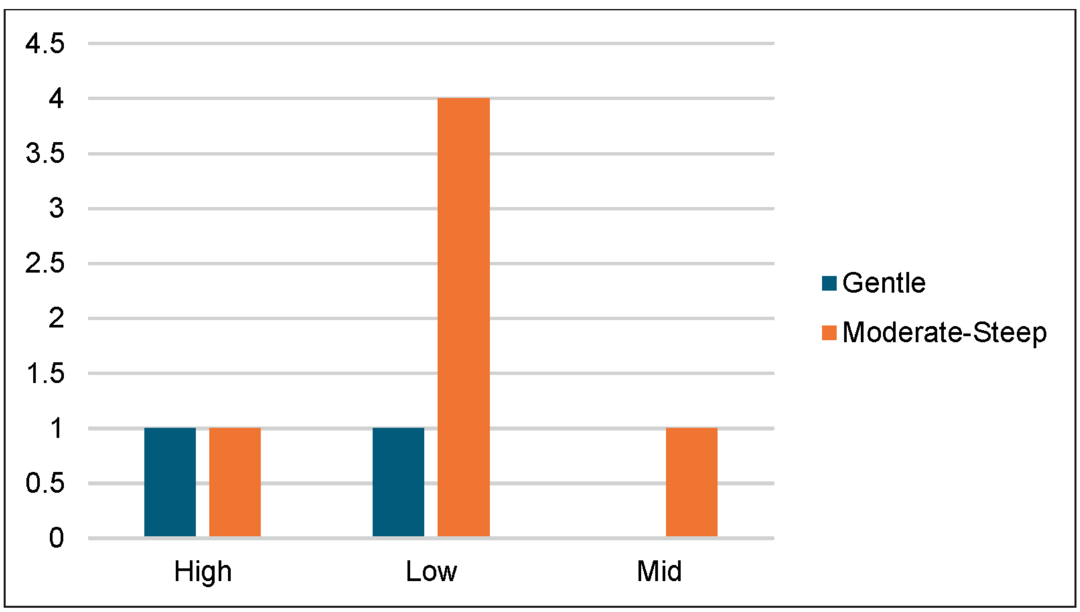

Figure 7: Source: Author, Comparative distribution of sites by elevation (high, mid, low) and slope categories (gentle and moderate–steep)

adaptive strategies in mountainous landscapes, where completely flat terrain is limited and not necessarily optimal. The analysis of spring proximity reveals no consistent pattern. Most sites are located far from springs, and no meaningful relationship is observed between spring distance and elevation or slope.

Figure 8, demonstrates that springs did not place a significant role in structuring site placement at this scale. In contrast, the river emerges as the only hydrological feature with a discernible influence, and even this influence is mediated by elevation. This distinction is important, as it demonstrates that not all water

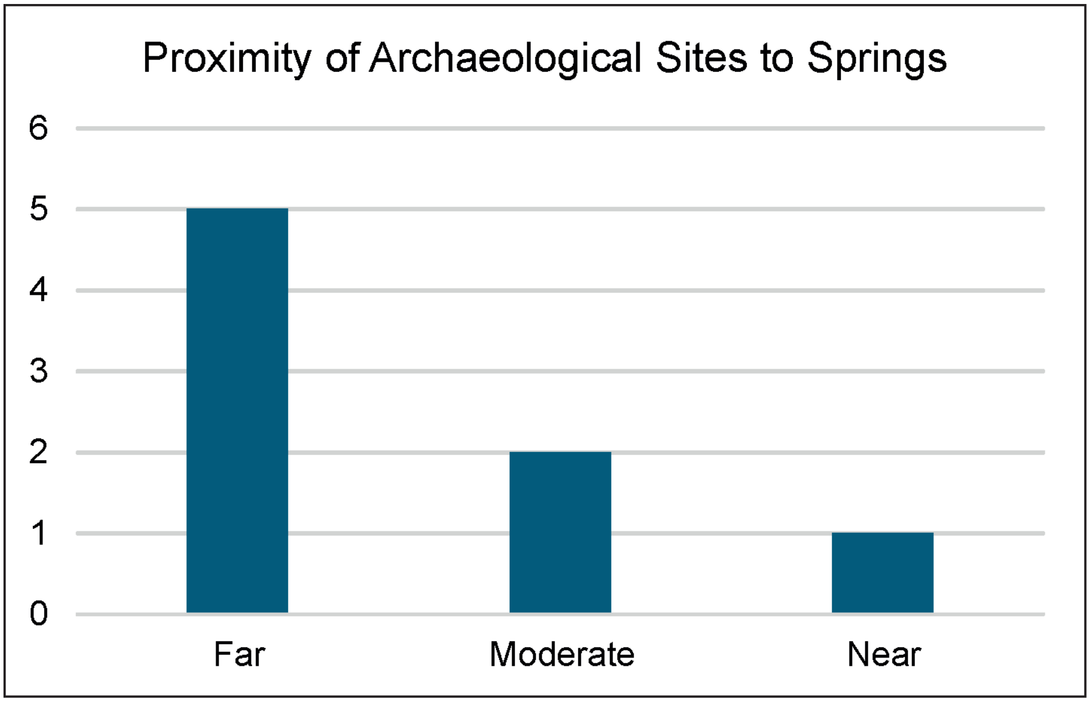

Figure 8: Source: Author, Distribution of archaeological sites across spring distance categories, indicating predominance in farther zones

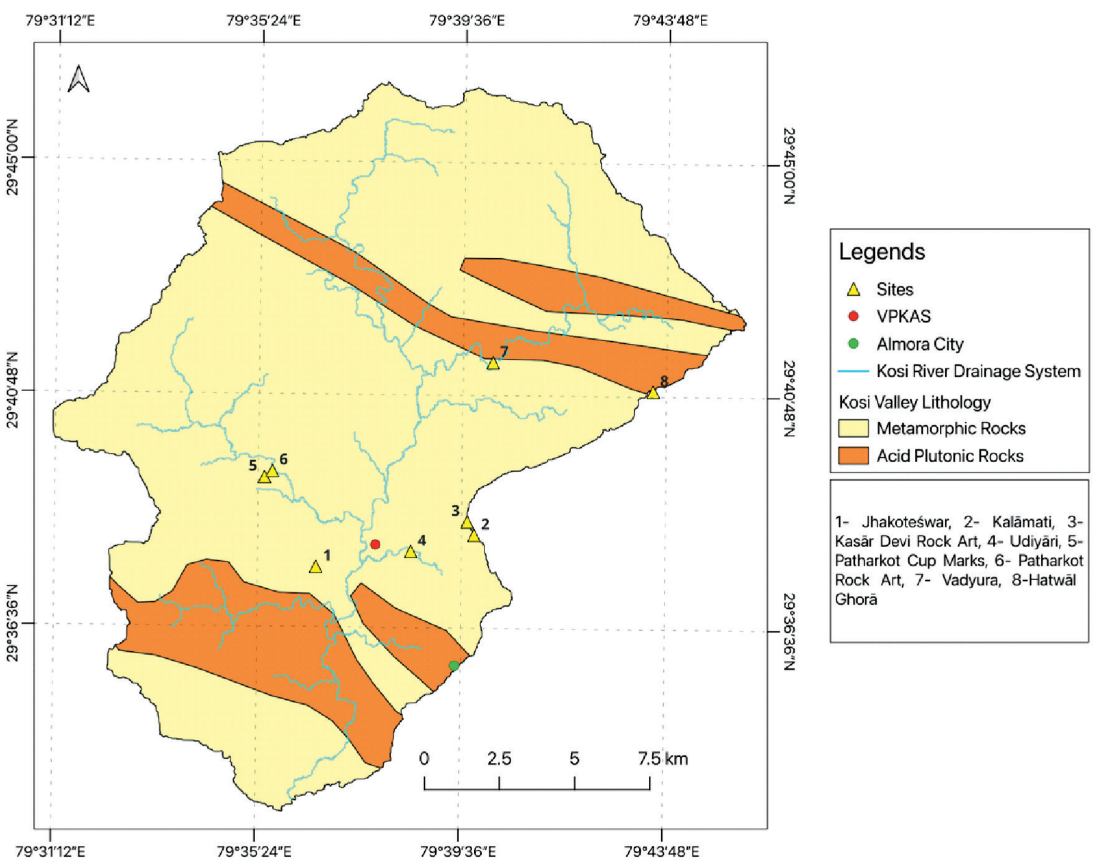

Figure 9: Source: Author, Map showing archaeological sites overlaid on lithological formations, including metamorphic and acidic plutonic rocks.

sources are equally significant in settlement organisation in prehistoric configuration.

Lithological and soil data show limited variability across the study area, with sites occurring predominantly within broadly defined metamorphic and metasedimentary contexts. The regional geological framework of the Kumāon Himalaya limits the ability to identify specific raw material preferences.

Thus, lithology function fundamentally as a contextual backdrop rather than a primary determinant in site placement. The importance of topographic and hydrological variables in structuring settlement patterns is reinforced by the absence of strong lithological differentiation

Discussion and Conclusion

The dataset used in this study reflects the current state of archaeological discovery rather the totality of past scenarios, limiting the number of documented prehistoric sites within the Kosī valley to n=8, thus survey history, accessibility, and surface visibility factors the distribution of these sites. Densley forested or geomorphologically stable upland zone remain underrepresented whereas riverine terraces and exposed slopes more likely yields identifiable material due to erosion and exposure. Therefore, the observed spatial patterns should not be construed as a complete reconstruction of a prehistorical settlement system, but as an indicative model deduced from the available evidence. Through future systematic survey and excavation, the provisional trends identified through the relationship between elevation and river proximity.

Non-random organisation, largely shaped by the relationship between elevation and hydrological proximity, was recognised through spatial analysis of 8 prehistoric sites in Kosī valley. Terrain and spring distribution have less of an impact. The sites show a multi-zonal pattern of landscape use rather than uniform placement, which is consistent with more general principles of settlement ecology and landscape archaeology (e.g., Karl W. Butzer; Grahame Clark). A distinct pattern becomes apparent when considering river proximity, 4 of the 8 locations are "far" from the river, 3 are "close", and one is "moderately far". The site placement was not exclusively dependent on river is indicated by this distribution which is antithetical to the oversimplified models of prehistoric settlement that concentrated only on water access.

More organised pattern emerges when elevation is taken into consideration. Sites closer to river with Low elevation generally display relatively limited dispersion, whereas mid and high elevation sites occur at greater distances and with increased variability. With distance to the river becoming significantly primarily within the lower altitudinal zones, the trend suggests that the organisation might be systematically elevation – dependent. Rather than being occupied uniformly, the valley was structured into discrete functional zones is confirmed by this evident altitudinal differentiation. This pattern is often observed in mountainous environments. In the absence of excavated assemblages or stratified artefactual data, functional attribution of sites remains hypothetical and cannot be independently verified. Areas of more sustained or repeated activity is represented by the low -elevation sites located nearer to the river. Low elevation sites may tentatively correspond to zones of more sustained activity, although this cannot be confirmed. Antithetically, upland activity zone, with high elevation and consistently positioned away from the river could reflect seasonal mobility, resource procurement, or a task-specific occupations. Prevalence of variability indicates that additional factors, such as functional differences or mobility strategies may have influenced site placement.

This interpretation is further refined by slope analysis. Most sites are found on moderate to moderately steep slopes, with only a small percentage of sites are found on gentle terrain.

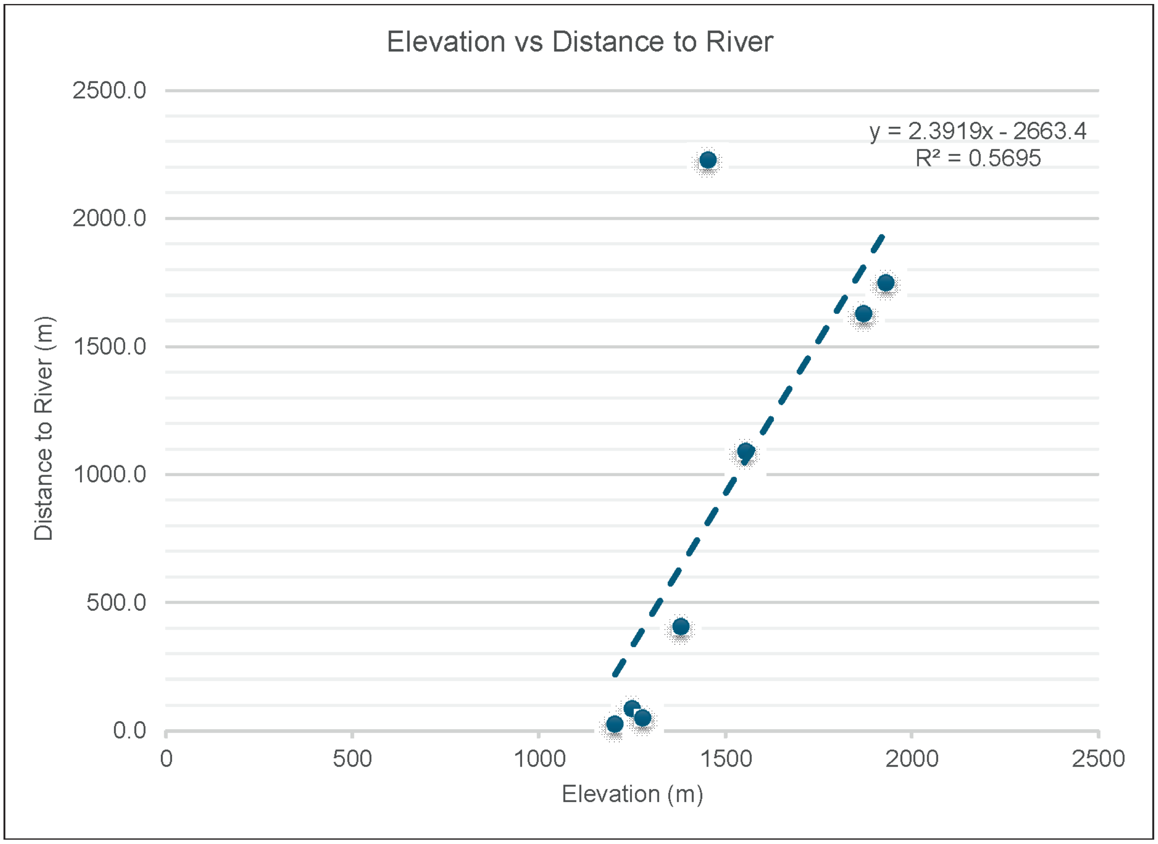

Figure 10: Relationship between elevation and distance to river showing a positive trend ($R^2 = 0.57$), indicating that sites at higher elevations tend to occur farther from the river, with some variability

The slope does not systematically change with elevation or river proximity, suggested by the pattern held true for all elevation classification. It seems to serve as a background constraint where site placement takes place. The prehistoric settlers in the area may have chosen gradients that were manageable, probably striking a balance between visibility, stability, and accessibility instead of avoiding sloping terrain, as in the case of the sites of Udiyāri. Such behaviour seems consistent with findings from Himālayan archaeology (as in the case of Lakhudyār and Lwethāp), which indicates that steep terrain is negotiated rather than avoided. No discernible pattern in the distribution of sites in relation to springs. Most sites are located far from spring sources. Springs did not significantly influence site placement is suggested by the scale of analysis taken into consideration. Rather, the river seems to be the only hydrological feature that has a noticeable spatial influence, and even this influence depends on elevation. Despite being part of the analysis, lithological and soil data show slight variation between sites. The Kumāon Himalaya's regional geological context is reflected in the predominance of broadly defined metamorphic and metasedimentary units, which restricts the ability to deduce fine-grained raw material selection. Lithology primarily serves as a contextual variable instead of being a deciding factor in spatial organisation.

These patterns depicts that the prehistoric sites of Kosī valley are best understood as a vertically structured system where several landscape elements were used in diverse ways. The correlation between low elevations and river proximity and higher elevation and river distance suggest a purposeful structuring of activities across environmental gradients. The model of task-specific site use and logistical mobility aligns with this interpretation in which distinct locations within a landscape are used for different purposed instead of functioning as homogeneous habitation zones. However, not every site in the low elevation category is directly next to the river suggests that this system was not inflexible. Alternatively, it provided flexibility, which probably reflected variation in function, length of employment, or seasonal use. This variability characterises the small-scale prehistoric settlement systems, where environmental limitation interacts intricately with cultural practices. It is also important to acknowledge that the small samples size limits the scope of inference. Consequently, these patterns here should only be construed as indicative of trends in the available dataset. Nevertheless, the consistency of correlation across several variables, especially elevation and river proximity provides a solid foundation for interpreting the spatial organisation of sites within the valley.

In conclusion, the Kosī valley reflects an organised interaction with the landscape, evidenced by the findings. These sites are arranged along hydrological and vertical gradients, instead of being random of consistently resource driven. This accentuate hoe fundamental it is to incorporate topographic and environmental factors when searching prehistoric patterns, especially in mountainous areas where elevation has a significant impact on how people behave.

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