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THE MORPHOLOGY OF TULA GORGE, KALTUNGO LOCAL GOVERNMENT AREA, GOMBE STATE, NIGERIA

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Abstract:

Landscape morphology plays a vital role in determining the activities of Man on the land surface. The paper attempts to examined the morphology of Tula Gorge; using field observations, measurements, remote sensing and geospatial techniques. The results revealed that Tula Gorge has an elevation of 321 meters above sea level, the morphometric of geomorphosites features indicated that 25.17sq.km (40.16%) of the total area were covered by flatland, Shoulder covered 16.04 sq.km (25.60%), Footslope coverved 12.34sq.km (19.69%), Slope coverved 6.52sq.km (10.41%), Ridge covered 0.77sq.km (1.23%), Hollow occupies 0.43sq.km (0.64%), Valley accounted for 1.26sq.km (2.01%), while Spur and Depressions were 0.11 & 0.002 sq km, or (0.18% & 0.0004%) of the total area, respectively. The 3D map depicted the gorge as the greatest valley found on the Tula plateau with a depth of 160 meters. However, continuous erosion and human activity, such as cultivation and careless felling of trees for firewood were found to be the factors causing morphological adjustment of the gorge, consequently, causing increase in runoff and drying up of the gorge. Thus, the Authors recommends that human activities in and around the gorge should be well controlled by the local authority so as to ensure sustainable use of Gorge.

Keywords: Morphology, landforms, Gorges, formation, Tula plateau. Gombe state

1. Introduction

Understanding the shape and genesis of landforms is crucial for interpreting and forecasting the environmental elements that contribute to the alteration of their landscapes (Abdullahi, Odihi, & Wanah, 2015). A gorge is a deep valley situated between hills or mountains that has high, rocky walls. Gorges are predominantly fluvial landforms formed by several geomorphic processes. The most frequent is erosion brought on by rivers or streams. Streams erode or fracture the hard rock layers they cut through. The worn-away rock's sediment is then moved downstream. The steep walls of a gorge will eventually be formed by this erosion. Deeper and broader gorges are formed when streams or rivers flood, accelerating and intensifying the erosion process (Hudson 2012, Hayman 2014, Cole 2015).

A number of geomorphological and geological processes, including erosion, weathering and tectonic movements like vertical uplift and cavern collapse, interact to build the Tula Gorge (Mabin, 2000). As rivers or streams flow across this uplifted surface, gorges and amphitheatrically valley heads are form. Over time, the power of the waterfall erodes the softer rock layers underneath, causing the original river bed to collapse and create a gorge (Niland 2018).

Gorges frequently reveal thousands of years-old rock layers, which has led to several geomorphological discoveries at gorges. Particularly in the case of geomorphological discoveries at gorges, a fundamental understanding of the overall arrangement of landforms, the surface processes, and environmental elements involved in their alteration is required (Clayton et al. 2016). This kind of knowledge will be useful in the endeavor to forecast, preserve, and enhance the sustainability of the physical environment and lessen the influence of current earth surface processes that result in natural disasters.

The Tula Gorge has changed as a result of numerous human activities, including cultivation and the use of water for household needs. Nevertheless, no research that is currently known has examined the morphology of Tula Gorge. Because of the anthropological activities going on, the study aimed to perform a morphological analysis of the Tula Gorge. In order to aid in decision-making on the accessibility and utilization of the gorge natural resources, the study examined the morphology of Tula Gorge.

2. Study Area

Tula Gorge is located at Latitude 9^{o}49'00"N to 9^{o}54'00"N and Longitude 11^{o}27'30"E to 11^{o}33'30"E in Tula Plateau, Kaltungo Local Government Area which is about 16km from the Kaltungo – Yola road. It is a dissected plateau with deep valley and flat top where the Tola tribe settled (Figure 1). Tula experiences a tropical savanna climate, characterized by distinct wet and dry seasons. The wet season typically extends from April to October, with the peak rainfall occurring between June and August. During this period, Tula receives substantial rainfall, averaging between 800mm to 1,200mm annually (Abashiya *et al.,* 2017). This abundant rainfall supports the cultivation of various crops and contributes to the lush vegetation seen during the wet months. The dry season, from November to March, is marked by lower humidity and cooler temperatures, particularly in the evenings and early mornings. During this period, temperatures can range from 15°C (59°F) at night to around 30°C (86°F) during the day. In contrast, during the wet season, temperatures typically range from 20°C (68°F) to 35°C (95°F) (Abashiya, et al., 2019). The elevation of the Tula Plateau contributes to these cooler temperatures, providing a relatively pleasant climate compared to the hotter lowland areas surrounding it (Mayomi et al. 2016). The town and its environs have a moderate population density, with communities spread across the hills and valleys, often in small, clustered settlements. Agriculture is the mainstay of the local economy, with most inhabitants engaged in farming activities such as the cultivation of maize, millet, groundnuts, and sorghum. Livestock farming is also prevalent, with goats, sheep, and cattle being commonly raised. The social structure of Tula is traditionally organized, with community leaders, known as "Mai Tula," playing crucial roles in local governance, dispute resolution, and the preservation of cultural practices. Traditional festivals, dances, and ceremonies are an integral part of community life, reflecting the deep-rooted cultural values of the Tula people (Musa, Sule, & Abashiya, 2019).

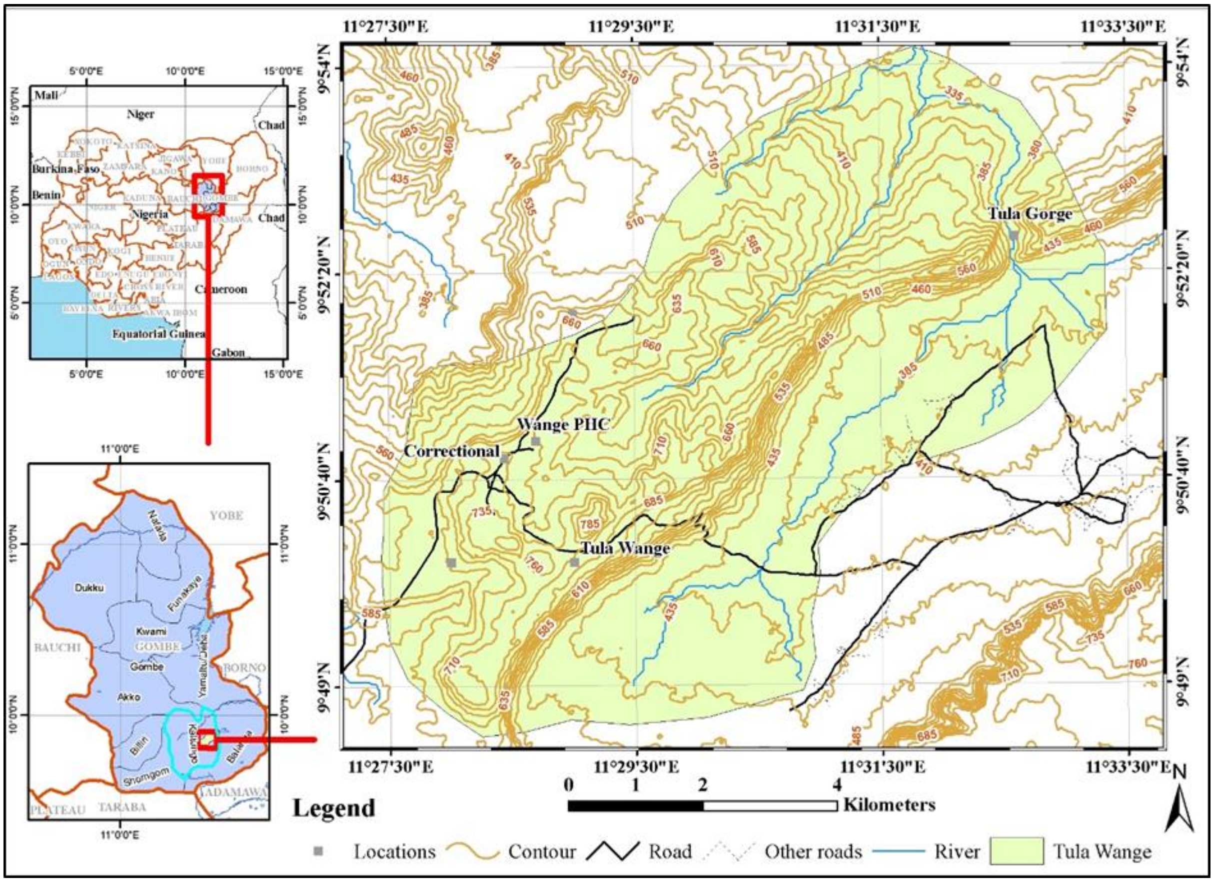

Figure 1: The study area

3. Materials and Methods

In this research, both primary and secondary sources of data were used. The primary data were collected through the use of GPS to sampled points along the gorge for profiling. Secondary sources of data included the Tula topographic map and earlier studies among others. The following materials were gathered to aid in this research: The digital elevation dataset, which has a 90-meter spatial resolution, is derived from the Shuttle Radar Topographical Mission (SRTM). The data was acquired through the use of ArcGIS 9.3 software, Gombe State Thematic Maps, the GPS Germin 76, and a 2021 Niger-sat picture from the National Space Research and Development Agency (NASRDA) located in Abuja, Nigeria. Using the Digital Elevation Dataset from SRTM that could be acquired online, the DEM construction module of ArcGIS software was used to create the Gombe digital elevation modelling (DEM) (Figure 2). The conversion and symbology classification modules of ArcGIS 9.3 were utilized to polygonize and categorize the raster DEM into distinct classes that include: Flat, Summit, Ridge, Shoulder, Spur, Slope, Hollow, Foot slope, Valley and Depression. The ArcGIS 9.3 software's extraction and area calculation modules were used to determine the areas in square kilometers for each of the classes.

4. Results and Discussion

The Tula gorge, has an elevation of 321 meters above sea level, whereas the plateau areas have the highest elevation, which is about 760 meters above sea level, according to the DEM image in Figure 2. These results corroborated the findings of Mayomi et al. (2016), who discovered that the maximum height in Gombe state is found in the highland zones, at 1184 meters above sea level, while the Gongola basin has the lowest elevation, at 184 meters above sea level.

The Tula Gorge, situated in the northeastern region of the plateau, is depicted in deep blue color on the DEM map. The rivers that are represented by the blue areas are between 320 and 350 meters above sea level. The red patches represent the highest elevations, which are situated between 750 and 800 meters above sea level in the southwest portion of the plateau. A closer examination of the slope dimension model in Figure 3 provides a more comprehensive understanding of the gorge's anatomy. The gorge's steepness was assessed using the slope graph that was created, which has an R^2 value of 0.88.

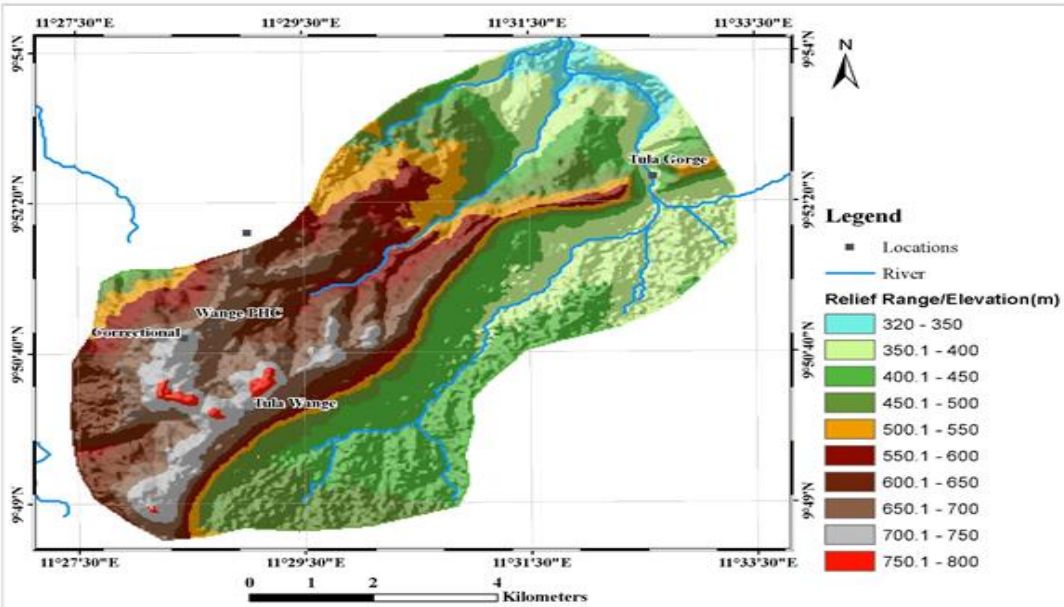

Figure 2: DEM image showing Tula Plateau
Source: GIS Analysis (2022)

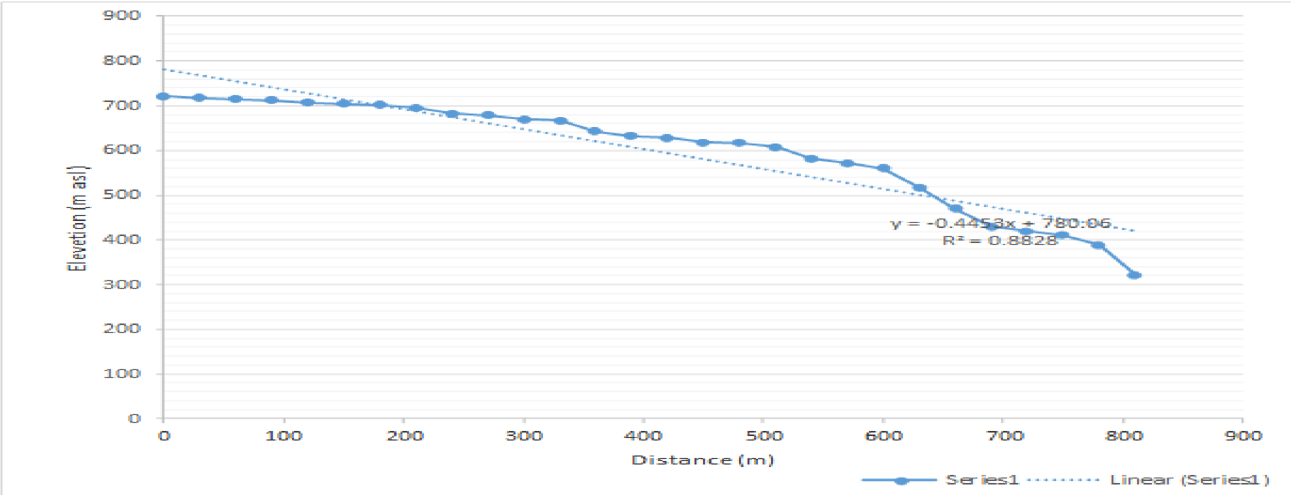

Figure 3: Slope dimension of Tula Gorge
Source: GIS Analysis (2022)

The slope map, created from the DEM, had a 25-meter contour interval that made it easy to distinguish between the plains and the slope. The plains and slopes were marked by wide and near contour lines, respectively. Thus, the slope ranges from the northeastern to the southwest regions where the contour lines were prominently clustered. Nonetheless, certain geomorphic features, such as spurs, valleys, hollows, ridges, footslope slopes, flatlands, shoulders, and depressions, might be easily recognised by their shapes (Figure 4). Based on the 3D map in Figure 5, the Tula gorge can be considered the greatest valley found on the plateau, with a depth of roughly 160 meters. The elevations of the landforms range from 760 to 400 meters above sea level. In Fig. 5, these are shown in rich blue tones.

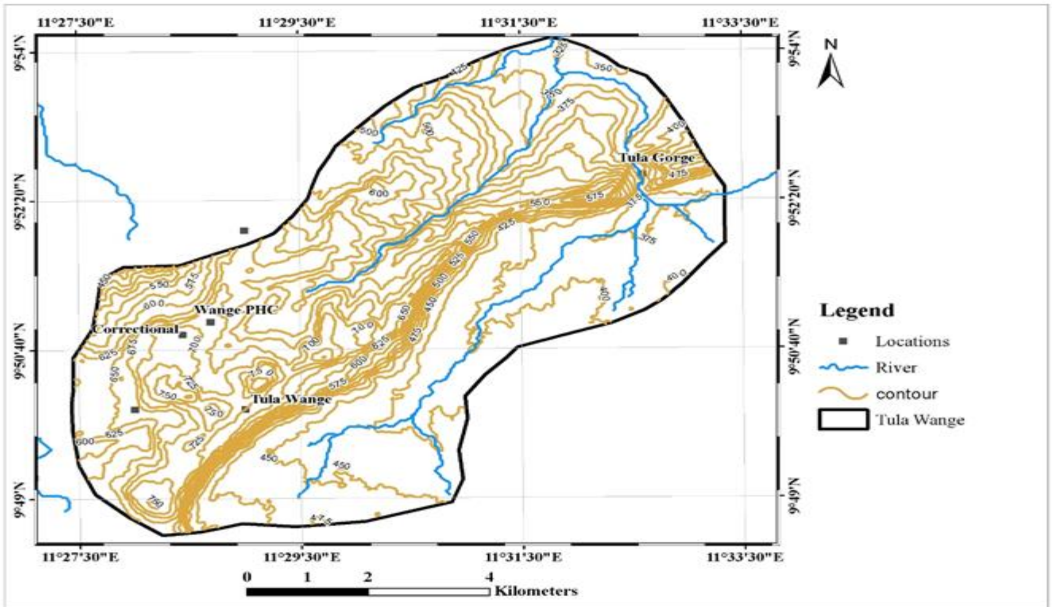

Figure 4: The Contour of Tula Plateau
Source: GIS Analysis (2022)

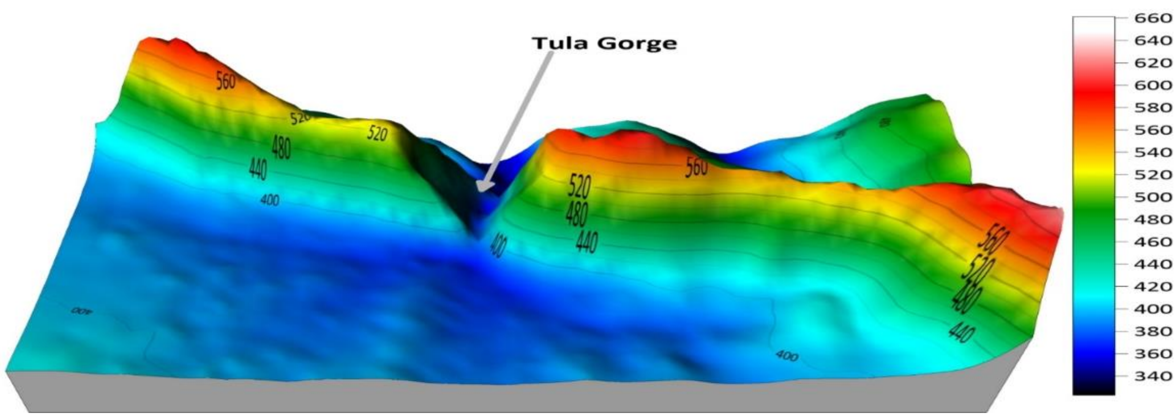

Figure 5: 3D Model of Tula Gorge
Source: GIS Analysis (2022)

According to Figure 6 DEM, flatland, shoulder, and footslope cover approximately 85.5% of the Tula Plateau's total area. The results showed that 25.17 square killometres, or roughly 40.16 percent of the plateau's total area, were covered by flatland on the plateau. Subsequently, the shoulder region included 16.04 square killometers, or roughly 25.60% of the entire plateau area. The footslope, which accounted for 19.69% of the Tula plateau's total surface, is the next in size, measuring roughly 12.34 square killometers. The remaining 14.55% of the plateau is made up of features such as the slope, which covers 6.52 square kilometres and accounts for roughly 10.41% of the total area, and the ridge, which covers 0.77 square kilometres and accounts for approximately 1.23% of the total area. Following is Hollow, which occupies 0.43 square kilometres, or roughly

0.64% of the entire area. Valley then accounted for 1.26 square kilometres, or 2.01%, of the total area. The areas of Spur and Depressions were 0.11 and 0.002 sq km, or 0.18% and 0.0004% of the total area, respectively (Table 1).

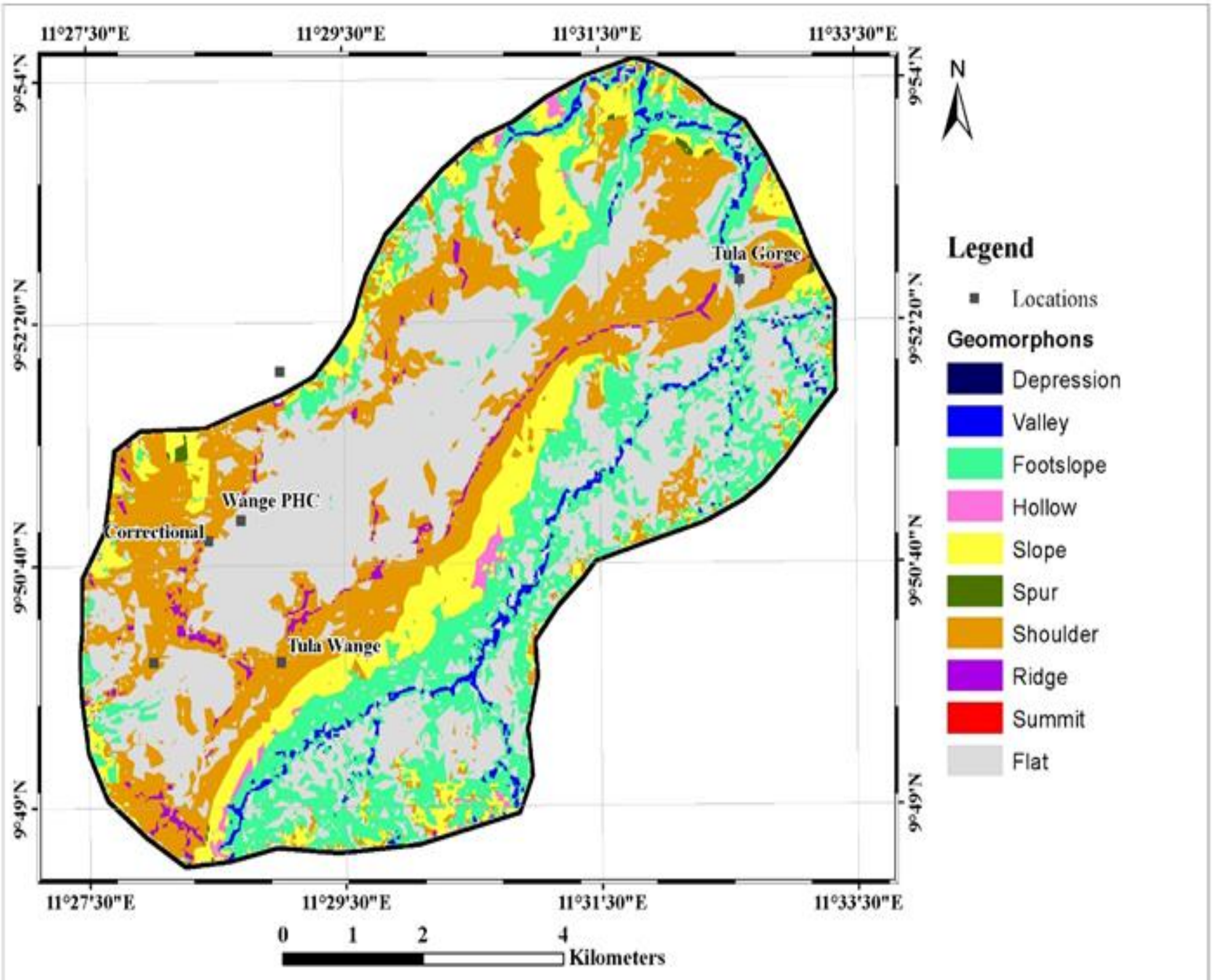

Figure 6: The Geomorphosites of Tula Plateau
Source: GIS Analysis (2022)

Table 1: The Geomorphons' Surface cover

Geomorphons	Area(sqkm)	Percentage
Flat	25.17	40.16
Summit	0.01	0.01
Ridge	0.77	1.23
Shoulder	16.04	25.60
Spur	0.11	0.18
Slope	6.52	10.41
Hollow	0.43	0.69
Footslope	12.34	19.69
Valley	1.26	2.01
Depression	0.002	0.004
Total	**62.66**	**100.00**

Due to various geomorphological factors and human activity, the Tula Gorge underwent a significant morphological alteration. In Tula Gorge, it was found that the main natural mechanism causing morphological adjustment was continuous erosion. Whereas deposition and siltation characterized the downstream portions of the valley, erosion took place in the upstream sections. This occurrence truly demonstrated how the Tula Gorge was evolving in terms of both dimensions and form. See the plate attached for evidence. Consequently, it is currently uncertain how the valley's upstream erosion and downstream deposition will react to shifting flow stages. Erosion in the Tula Gorge has had a significant and far-reaching effect such as the ability of the gorge slopes to absorb and permeate rainwater has decreased due to the lack of vegetation cover.

In addition to geomorphological factors, Tula Gorge's morphological adjustment was influenced by a wide range of human activities, such as cultivation, indiscriminate tree-cutting, and the use of water for domestic purposes. The authorities bear responsibility for their incapacity to implement forest management and for endorsing development initiatives without discernible purpose. The gorge have seen severe deforestation as a result of the careless felling of trees for firewood and animals feed. Due to this, there has been an increase in runoff that is going downstream and, on the one hand, the drying up of the gorge, resulting from reduction in the amount of water available. Furthermore, the loss of biodiversity, water shortages, numerous injuries, and the cost of dredging and cleaning the gorge's water source are all short-term but long-term effects of these phenomena.

Plate 1: The cross section of Tula Gorge

5. Conclusion

The Tula gorge serves as an important geomorphological topographic feature with an elevation of 321 meters above sea level, whereas the plateau areas have the highest elevation, which is about 760 meters above sea level. The gorge's steepness has a correlation coefficient value of R2 = 0.88. The geomorphosites features, such as flatland, shoulder, and footslope cover approximately 85.5% while remaining 14.55% of the plateau is made up of spurs, valleys, hollows, ridges, and depressions. The study's key findings indicated that the main natural mechanism causing morphological adjustment was continuous erosion which had a significant and far-reaching effect such as the ability of the gorge slopes to absorb and permeate rainwater. In addition, human activity, such as cultivation and careless felling of trees for firewood affected the morphological adjustment, which means that human intervention in Tula Gorge has undoubtedly hastened the rate of denudation. Concequently, causing increase in runoff and drying up of the gorge.

6. Recommendations

Based on the findings of this study, the following are recommended: More research on how the valley's upstream erosion and downstream deposition will react to shifting flow stages. Human activities in and around the gorge should be well controlled by the local authority so as to ensure sustainable use of Gorge.

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