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Geomorphological Features of the Dokan Area- Northeast Iraq

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Abstract:
Numerous geomorphological characteristics that have been sculpted throughout time by geological, climatic, and hydrological processes define the Dokan region in Iraq's Kurdistan Region. A structural impact resulting from the collision of the Arabian and Anatolian-Iranian plates is linked to the majority of geomorphological characteristics. In the research region, three distinct geomorphological units may be identified: structurally derived units associated with the Alpine Orogeny. These units' primary characteristics include Homoclinal structures (cuestas, hogbacks, and flatirons) and anticlinal ridges, also known as synclinal troughs. In contrast to the third geomorphological units, which are of fluvial origin and are ascribed to the loaded stream sediments and their exchanged velocity, such as alluvial fans, terraces, and flood plains, the other units are of denudation origin, which is associated with the intense erosion of the resistant rocks, climate, and high relief (glacis and badlands).

Keywords: Geomorphological Landscapes, Dokan, Remote sensing, GIS.

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Introduction:

According to [1], the research region is a part of the Iraqi Kurdistan Region, which is the far northeastern portion of the Arabian Plate that is colliding with the Eurasian Plate via a convergent plate tectonic boundary. The collision between the two plates created the Zagros Thrust–Fold Belt, which is where the Zagros Foreland is situated, and it is still happening now.

The output of tectonics and climatic change throughout time is the Earth's landscape; the former produces topography and preserves relief [2–5]. The second product, on the other hand, promotes the erosional processes that gradually destroy highland regions over time [6, 7]. An essential archive of the rates and spatial distribution of these deformations may be found in the landscape. Tectonic geomorphology enables both quantitative and qualitative examination of such landscapes and unrevealing deformation from the landscape [8–9].

Geologically, the research area is situated in the Zagros Fold-Thrust Zone [10] and [11] (Fig. 1). The Zagros Fold-Thrust Belt, which includes the Dokan region, is distinguished by several synclines and anticlines. Sedimentary rocks from the Cretaceous and Tertiary eras, such as sandstone, shale, and limestone, make up most of the area. The region's rough landscape results from extensive bending and faulting caused by tectonic activity. The surface displays recent alluvial deposits from the Qamchuqa, Kometan, Shiranish, Tanjero, Kolosh, and Sinjar formations (Fig. 2). The main anticlines are asymmetrical, trending double plunges from NW to SE, and veering toward the southwest. In appearance, they resemble a large box with narrow, deep anticlines separating it [12] [13]. The Mesozoic limestone strata that make up the cores of these main anticlines are flanked by Palaeogene and Neogene limestone and clastics [14]. The aim of this study is to use GIS and remote sensing data to determine the geomorphological aspects of this region.

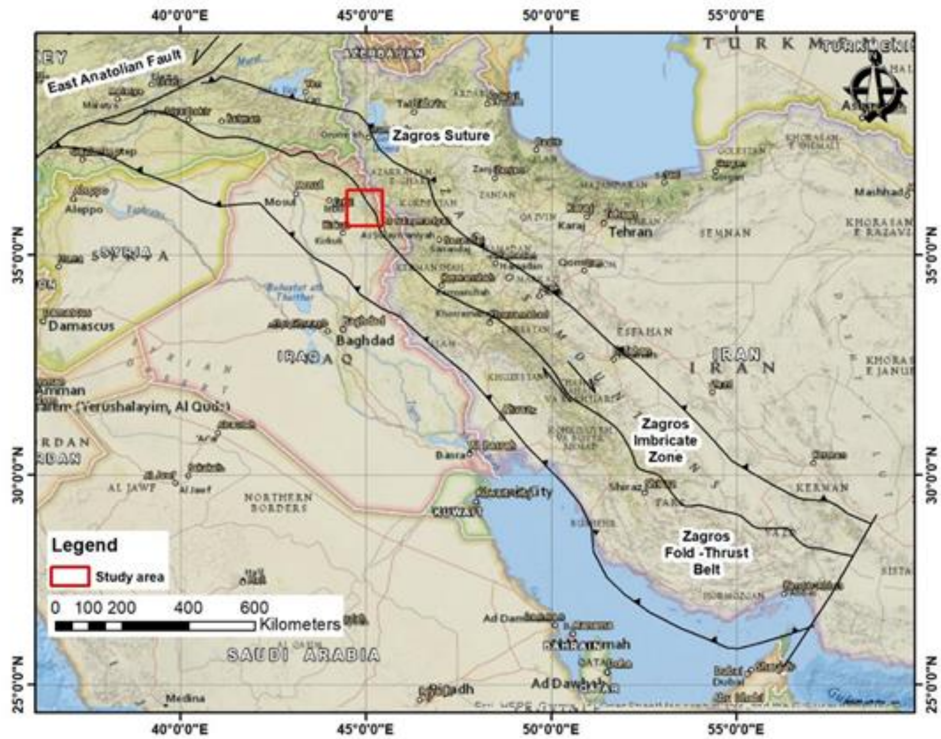

Fig. 1: shows a map of Iran's primary tectonic units, created by the Arabian and Eurasian plates' deformation (after [15] and [12]).

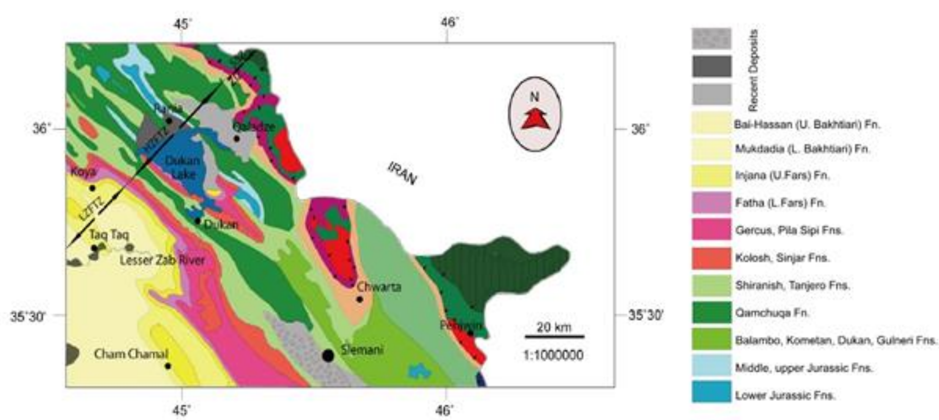

Fig. 2: Geological map of the study area [16].

Materials and methods

Different imageries from Quick Bird with 0.6 m resolution and Rapid Eye with 5 m resolution have been used for visual interpretation and geomorphometric analysis, besides the usage of the geological, and topographical maps at scales of 1:250,000. The final maps preparation was all compiled in ArcGIS 10.8.

Geomorphological Features:

Three main parts include a wealth of information about the agents and processes that influence the formation of landforms. They are Units of Denudational Origin, Units of Fluvial Origin, and Units of Structural-Denudational Origin.

Units of Structural-Denudational Origin

Anticlinal ridges and synclinal troughs

The Alpine Orogeny is linked to the units formed by the anticlinal ridges and synclinal troughs [17]. During the Pleistocene, the structures' morphology underwent a major change. The Azmer and Pierre-Magron anticlines are the best-preserved anticlinal ridges in the study region (Fig. 3). Other folds, such as Cuesta and Hogbacks, are extremely disturbed. Alluvial deposits that are deep and thick typically fill the associated basins. Only a small number of the related lineaments create homoclinal ridges, such as hogbacks and cuestas, which are found, for instance, southeast and northwest of Lake Dokan.

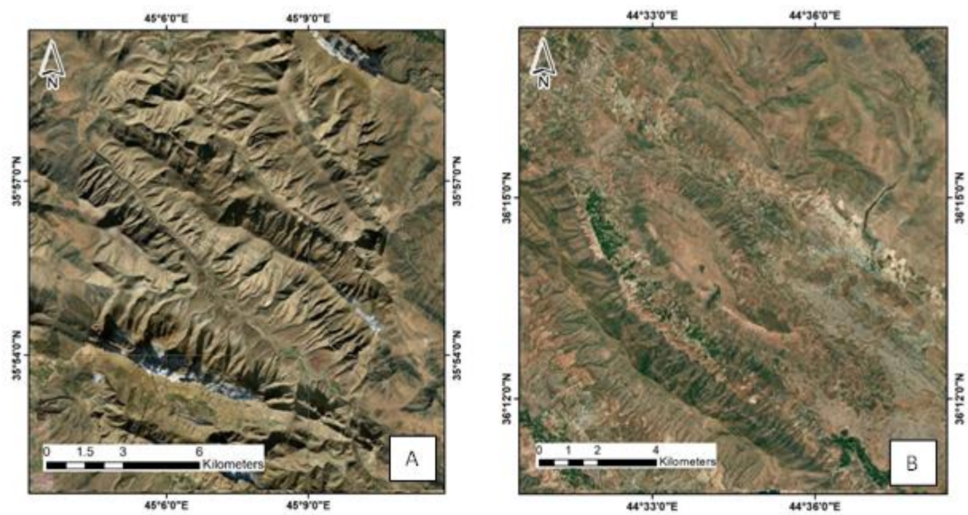

Fig. 3: satellite image shows A- Anticlinal ridges, B-synclinal troughs in the study area.

Homoclinal structures

Where rock strata vary in their resistance to weathering and erosion, topographic features known as homoclinal structures form. The degree of slope is the primary distinction between features [18].

Any hill or ridge with both a steep face (a steep slope) and a gently sloping face (a steep slope) is called a cuesta. A cuesta forms where the strata slope softly or moderately less than roughly 45 degrees. The erosion of a resistant, sloping bedrock controls the form [21]. The Schaller Valley is another location where topography Costas form. Above the barren Red Bed Range, several features develop.

A hogback is a high, crested hard rock ridge with almost symmetrical slopes and sharply sloping beds. Slow differential erosion of alternating hard and soft layers over time creates hogbacks. Steeper, slower erosion-resistant rocks replace the soft rocks, which are preferentially eroded (Encyclopedia 2003). Cuestas and rock piles are frequent in the research region. Due to extensive erosion in its core, the Kara Dagh Fold is entirely composed of Cuestas (Fig. 4).

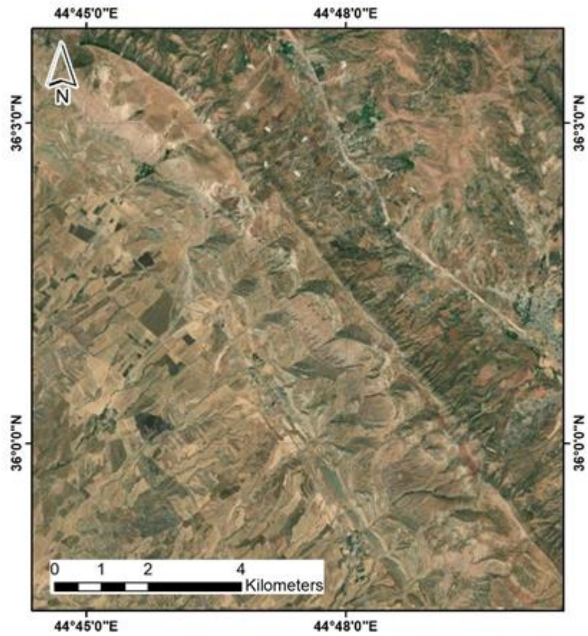

Fig. 4: satellite image shows Cuesta's landforms in the study area.

According to the third edition of Geomor, a flatiron is an approximately triangular face created by streams that are regularly spaced and erode a slope or ridge, particularly Cuestas or homogenous ridges. On certain slopes, particularly on the southwest edge of the Surdash Fold, sandstone creates rock piles (Fig. 5 and 6). Large boulders may be found directly downslope from the ridges at the top of rock heaps, which are distinguished by the fact that they offer the only noticeable sandstone outcrops.

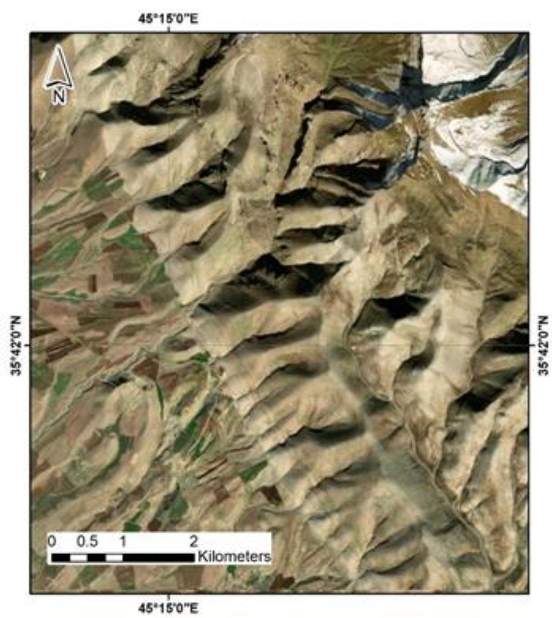

Fig. 5: satellite image shows hogback landforms in the study area.

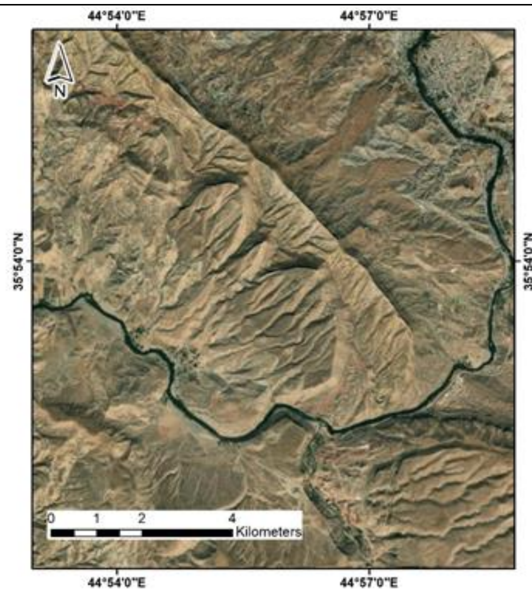

Fig. 6: satellite image shows Flatiron landforms in the study area.

Units of Denudational Origin

Relief of mountain slopes with expressive erosional modeling.

Climate, high relief, and the severe deformation of varied resistant rocks (igneous, metamorphic, and sedimentary) are all factors that affect the creation of terrain units in mountain slopes utilizing expressive erosional modeling [19]. Large erosional scars, plains, towering cliffs, abrupt divides, steep slopes with valleys, and noticeable rock faces are the primary characteristics that define this unit. Below is a description of some of the key characteristics.

The Norbab plain is a wide plain located east of the Azmar anticline. The plain is the mostly exposed portion of the historic Qulqula mountain range. On the Qulqula Formation, a re-dissected plain has developed northeast of Halabja. It is equivalent to Chwarta's Nurbab plain (Fig. 7). This unit is limited to the heavily dissected and eroded limbs of some of the anticlines, including Qara Dagh, or the deeply eroded cores of the study region.

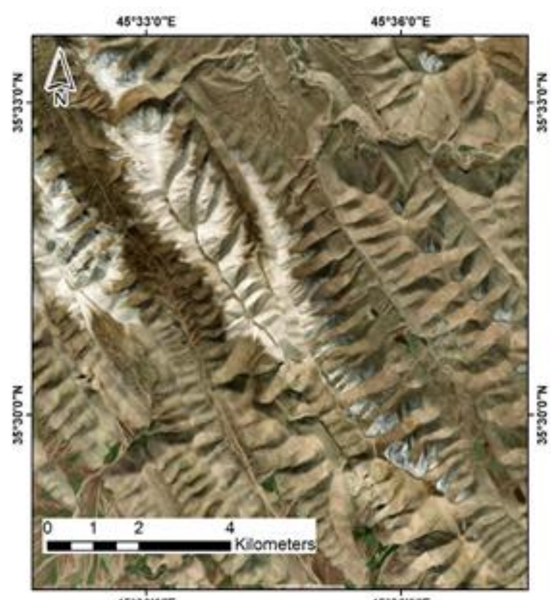

Fig. 7: satellite image shows Relief of mountain slopes with expressive erosional modeling landforms in the study area.

Glacis

Glacis are mild, half-degree to seven-degree slopes that have been eroded. Hills are synonymous with this Glaci. The kinds of rocks that produced the two landforms are different from one another. Whereas glacial hills originate on igneous and metamorphic rocks, ice hills form on sedimentary rocks.

The studied region has two different kinds of glaciers: depositional and erosional. Both kinds create wide mountains that abut the foothills and mountains of the high fold zone.

Altered rocks (limestone, sandstone, mudstone, gypsum, and conglomerate) give rise to eroded bedrocks known as erosional Glacicis, which often occur at the mountain's foot.

On thick clay deposits, usually on ancient bajada and alluvial fans, depositional glaciers form away from the mountains. As shown in the plains around the lakes of Deir Bandikhan and Dokan, this kind of glacial plain creates broad plains that are suitable for agriculture. Sulaymaniyah and Halabja are situated on broad glacial sedimentary plains (Fig. 8).

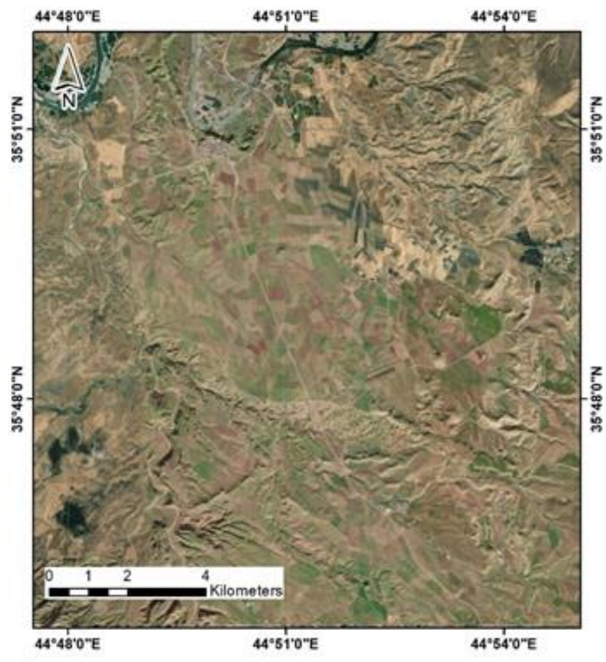

Fig. 8: satellite image shows Glacis landforms in the study area.

Badland

In the study area, small size areas of badland are formed on the clastic rocks of Kolosh, Tanjcro and Gercus formations (Fig. 9). Red Beds Series are suitable rocks for the formation of badland.

Badlands are extensively divided terrains with high erosion rates, high drainage density, and steep, barren slopes. From a Canadian perspective, they form in relatively weak, fine-grained rocks (clay, siltstone, and mudstone) where short, intense summer rainstorms provide periods of concentrated runoff and where rapid surface weathering, erosion, and low infiltration rates prevent soil formation and the growth of dense vegetation. Excess seepage (overland) flows are the main source of badlands, creating V-shaped valleys at the base of slopes and smooth, rounded drainage divides. Effective surface weathering mechanisms include wetting, drying, freezing, and thawing.

Subsurface pipes may form as overland flow moves downhill through plant roots, animal burrows, and fissures.

Rapid surface runoff-induced erosion rates in southern Alberta have produced deeply carved landscapes with a complex network of streams and channels [20]. The clastic rocks of the Kolosh, Tanjero, and Gercus formations produce small-scale badland regions in the research area (Fig. 9). The rocks of the Red Beds series are appropriate for creating badlands.

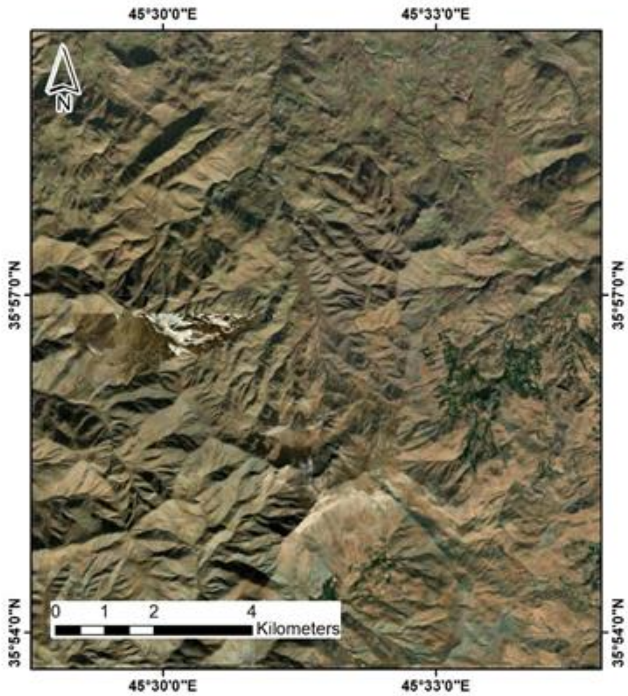

Fig. 9: satellite image shows Badland landforms in the study area.

Units of Fluvial Origin

Alluvial fans

Stream-deposited sediments that create valley fills, alluvial fans, or continental alluvium are referred to as alluvium. The sediments of heavy streams that abruptly change gradient and velocity when they emerge from steep valleys onto comparatively level areas make up alluvial formations. The smallest of the three types, alluvial fans are made up of sediments that are left behind when heavily laden streams suddenly shift their gradient when they approach a lowland region with a gentle slope. This landform's idealized planimetric shape is that of a fan that slopes between 1 and 10 degrees and climbs gradually toward its apex or central point of origin. Finer soil materials are deposited close to the fan's edge, whereas the coarsest soil elements are found at the apex, where the velocity first decreases [21].

Every tectonic or physiographic unit in Iraq has alluvial fan topography. Numerous converging alluvial fans that create a pediment may be found in the research area along the front of the Pira Magrun, Surdash, and Sara anticlines. When silt from a stream settles on flat land close to the base of a mountain, fan-shaped depositional terrains are formed. Since the conclusion of the last Orogeny, alluvial fans have been in operation. Particularly during the Pleistocene, the positive regions (anticlines) experienced severe erosion. Alluvial fans are the result of the erosional products being carried by gullies and deposited in synclines (Fig, 10).

The fans' convex shape has been lost since the start of the Holocene, and the terrain has transformed into depositional glaciers. Small individual fans or thin bajadas are currently identifiable at the base of the majority of anticlines. The rocks of the mountains from whence the fan material originated determine the makeup of both young and ancient alluvial fans. Igneous metamorphic and sedimentary gravels make up the Thrust Zone fans along the Shalair Valley. Carbonate makes up the majority of the gravels found in fans in the High Folded Zone. Gravels of different lithologies make up the Foothill Zone's alluvial fans.

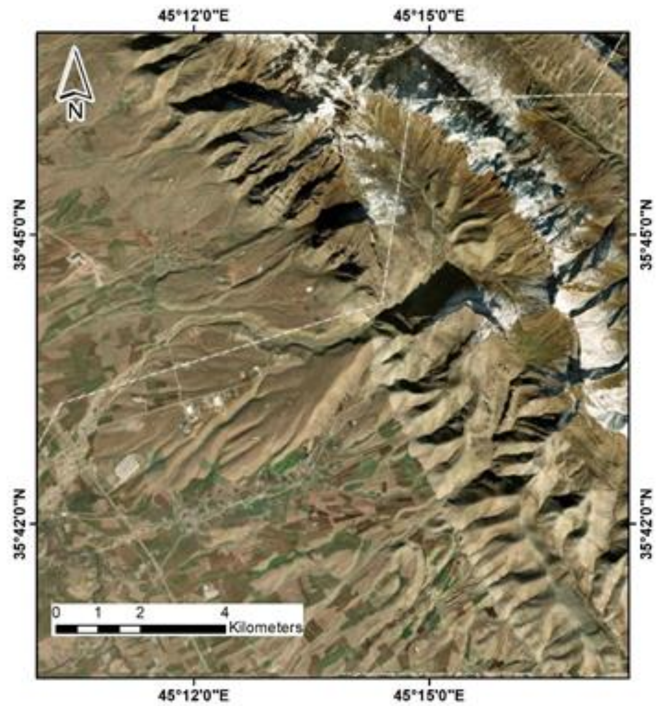

Fig. 10: satellite image shows large alluvial fans in the study area.

Terraces

Topographic features known as terraces are carved into wide floodplains or deep alluvial beds. They frequently result from the erosion of large alluvial deposits during a glacial epoch. Streams deeply pierce the alluvial material to create terraces as the weight lowers. Slow-moving floodwaters deposit the silt on floodplains in thick deposits, which are subsequently worn away by regular flow. Terraces are not treated independently in the following sections on topography but in connection to the terrain in which they normally occur, such as floodplains and alluvials [21]. The highest point of the valley floor prior to incision is represented by the tread, which is the level surface of a terrace. Terrace treads, often termed benches or platforms, consist of alluvium, bedrock, or bedrock covered by thin layers of alluvium [22].

One geographic feature that defines the previous valley floor is a river terrace. On both sides of their higher sources in the Mesopotamian plain, the Tigris and Euphrates rivers have formed terraces in many phases. Stages of terraces have been formed in the Dohuk, Little Zab, Great Zab, Diyala, and Greater Zab (Fig. 11) rivers, which are permanent tributaries. Each river has a different number of phases, as does the actual river [18]. The terraces of the Tigris, Greater Zab, and Khazir rivers in the Mosul region were examined by [18]. They distinguished four terrace levels.

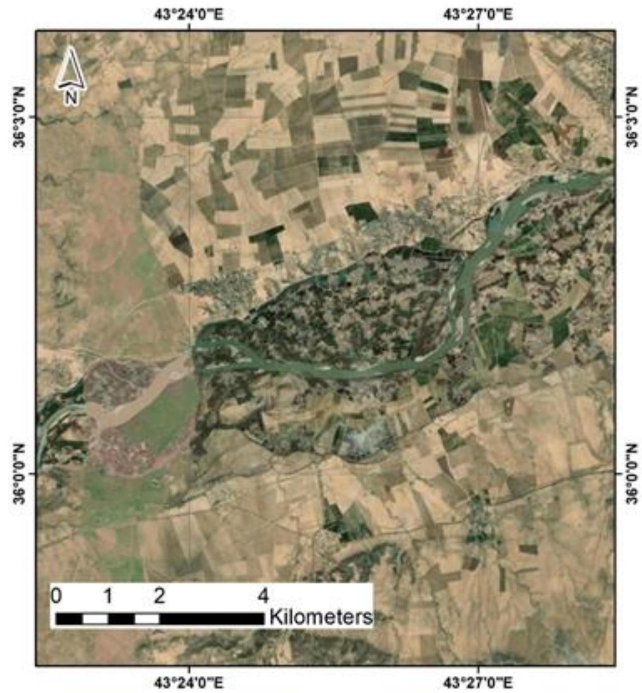

Fig. 11: satellite image shows Flood Plain in the study area.

Fig. 12: satellite image shows terraces in southwest of the study area.

Flood Plain

Floodplains are created when low-velocity regions of standing water receive sediments delivered by rivers and streams during floods. Many characteristics are connected with floodplains, including ancient meandering channels or meandering coils, water-filled depressions known as oxbow lakes, natural dams, point barriers, regions of standing water, and varied elevations of terraces (Fig. 11). These formations contain a wide range of soil types and depths, organic content, and moisture [21].

[18], [23], [24], and [25] have all detailed the floodplains of the Greater Zab and Lesser Zab rivers. These rivers' floodplains are likewise composed of clay, silt, and sand, with occasional gravel. Uneven bands with a width of 0–5 km are known as floodplains (Fig. 11).

Results and Discussion

Eleven geomorphological elements were identified from the research area's satellite imagery by visual interpretation. These characteristics can be categorized as follows and vary depending on where they originated from:

- Structural-denotational origin, such as homoclinal structures (Hogback, Questa, and Flatirons) and anticlinal ridges and synclinal troughs.
- Denotational origin, such as Glacis, Badland, and relief of mountain slopes with expressive erosional modeling
- Fluvial origin, as seen in flood plains, terraces, and alluvial fans. Differences in feature types are also significantly influenced by the sorts of rocks and the orientation of the beds. Rock joints have an impact on the degree of erosion and the resulting geomorphological characteristics. Another important factor that distinguishes various types is stability or instability. Some of these features vary in size, ranging from a few hundred meters to a few kilometers.

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