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DENSITY ANALYSIS OF LINEAMENTS USING REMOTE SENSING DATA

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ABSTRACT

Lineament analysis is an important structural and geological indicator for determining general and local tectonic trends and fracture zones in rocks, especially in mining zones. In this study we used optical and radar satellite data to analyze the density map of lineaments structure data for territory of Kashkadarya region - one of the main gas producing regions in Uzbekistan. The results show that according to Landsat 8 high density of lineaments is located near geology faults. During a detailed exploration, the density map according to SRTM data found that at an azimuth of 180^0, 225^0, 270^0, and 315^0 the density is much higher than at an azimuth of 0^0, 45^0, 90^0, and 135^0.

KEYWORDS: *lineaments, optical and radar data, density map, hillshade, rose-diagram*

1. INTRODUCTION

In recent years, interest in the use of Earth remote sensing data in applied research in earth sciences has increased in many countries. Analysis of the results of scientific research to solve geological, natural resource and environmental problems showed that the method of the lineament analysis is one of the most popular methods for thematic analysis of the spatial structure of the earth's surface. This method can be effectively used to detect and monitor linear structures of various natures displayed on space images of the earth's surface. Lineaments reflect underground phenomena occurring as a result of different deformation processes. Spatial properties of lineament structures such as orientation, length, and density can provide important information to demarcate the groundwater potential zones. Traditional methods of ground mapping are ineffective due to the complexity and time consumption for studies of the geological structural features in unreachable mountain areas. Therefore, it is advisable to use automatic methods, less time-consuming approaches to geological mapping of regions using remote sensing data, and GIS technologies.

A previously published scientific paper has used different interpretation methods. Thannoun (2013) presents a method for processing the extraction of lineament structures using the Edge enhancement algorithm. The method was chosen to use directional filters to improve, extract, and classify

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the orientations of the lineaments [1]. Ni C (2016) et al., were developed a computer program in Matlab to analyze the lineament lengths and densities. The results provide significant advances in the field of ore body exploration [2]. The use of such software tools as LESSA, LEFA makes it possible to automatically search for linear elements and analyze their orientation and location, and also their density [3, 4]. PCA Geomatica software includes a special LINE module. The algorithm of this module consists of three stages of automatic processing: edge detection, threshold determination, and curve extraction [5]. The most widely used spatial analyst hillshade tool in a tectonically active region using radar data [6].

This research aimed to analyze the density map of lineaments structure getting from Landsat 8 and SRTM.

2. STUDY AREA

Kashkadarya region is located in the southern part of Uzbekistan in the Kashkadarya river basin, on the western slope of the Pamir-Alay Mountains. The South Tien Shan, South Kyzylkumu-Gissar, Bukhara-Gissar, Poperechno Tien Shan, and other large faults are located in the territory of the Kashkadarya region. The region occupies one of the first places in the country for the extraction of hydrocarbons (oil, gas, and condensate) and the processing of natural gas. The digital elevation model with tectonic faults of the Kashkadarya region is shown in Figure 1.

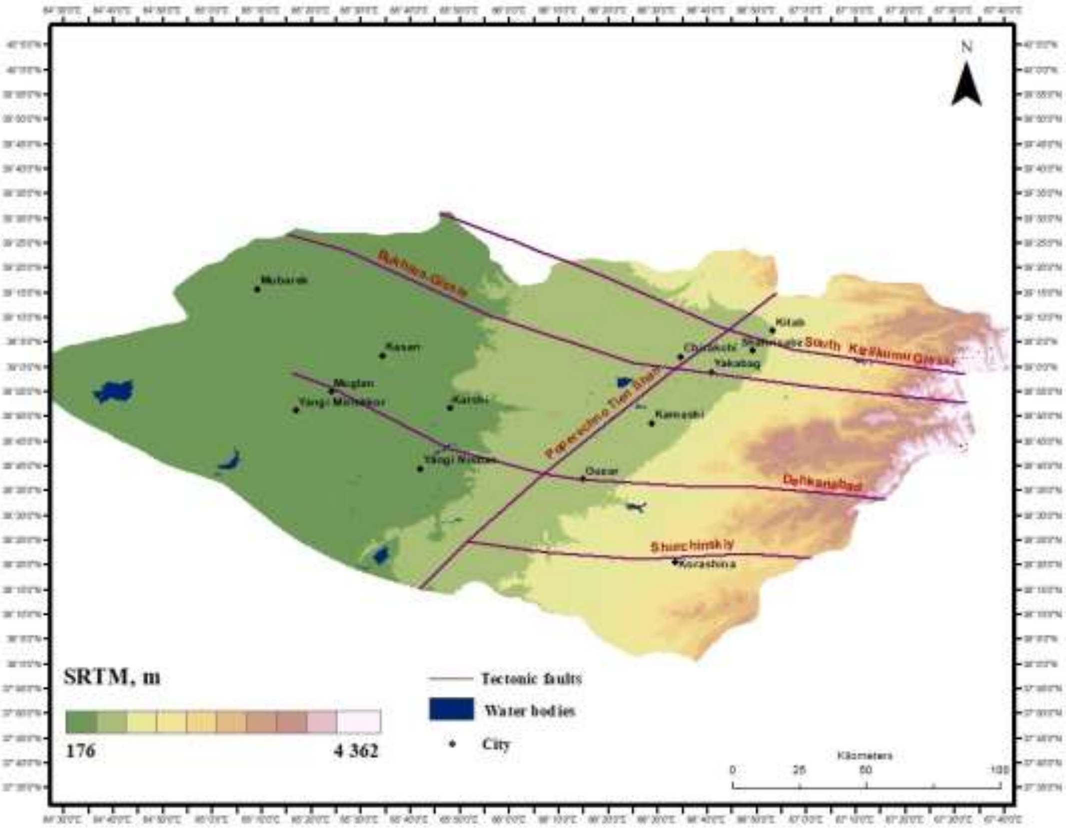

Figure 1: Digital elevation model (SRTM) with tectonic faults (geological data).

3. MATERIALS AND METHODS

The study area includes the satellite dataset a mosaic of three scenes of Landsat 8, and a mosaic of seven scenes of SRTM (Shuttle Radar Topography Mission). In this study, Landsat 8 and SRTM scenes covering the study area were downloaded from the USGS Earth Explorer website. The Red, Green, Blue, IR channels of the Landsat 8 data with a spatial resolution of 30 m were used. The acquisition date of the provided Landsat 8 data is August 2019. A SRTM 1-arc second elevation data product was used. Mosaic of the Landsat 8 satellite was combined with a panchromatic channel (15 m) to improve the quality of optical data resolution. At the output, we have got a synthesized image with a resolution of 15 m. The tool Create Pan-sharpened in ArcGIS has been used for merging lower quality raster image with a higher quality panchromatic raster layer. Then, based on the obtained image was the extraction of lineament structures was carried out in the LEFA program.

The hillshade method was applied to SRTM to extract lineament structures in the study area. Its principle of operation is to set the position of a hypothetical light source and calculate the azimuth

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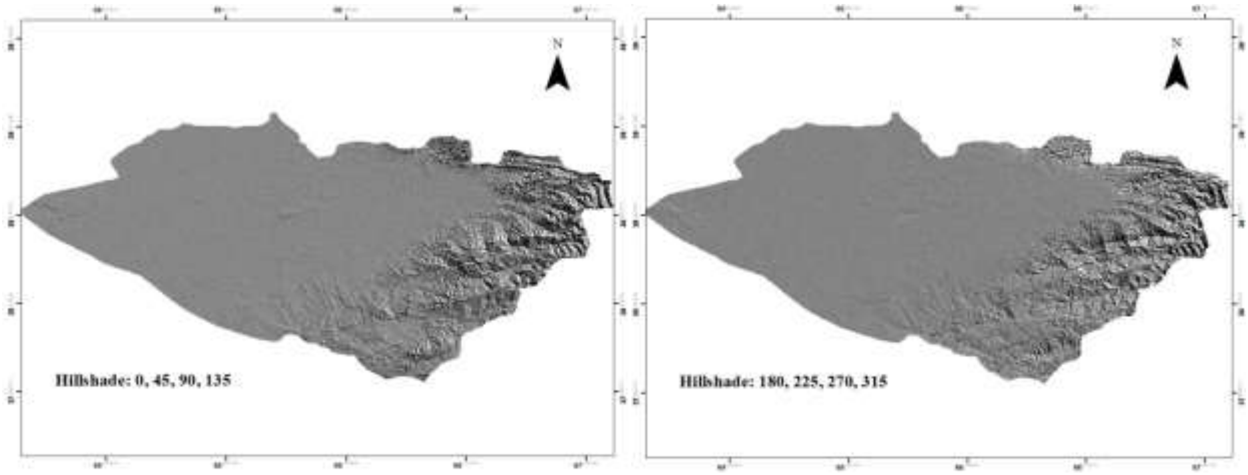
values (225^0, 270^0, 315^0 и 360^0) [7]. In this study, we applied the hillshade tool to SRTM to create two raster images. The first hillshaded image resulted from combining four images from 0^0, 45^0, 90^0, 135^0 azimuth angles (fig. 2, a), and the second hillshaded image with azimuth angles of 180^0, 225^0, 270^0, 315^0 (fig. 2, b). For all images, the altitude angle of the light source above the horizon (height) remained constant at 45^0, which is the default in ArcGIS. By combining different azimuth angles into one image, we can get more information about linear objects that will not be noticeable if, for example, we use an image with one azimuth angle [7]. The results show that the visibility of linear structures varies greatly with azimuth changes.

The lineament density parameter was built in ArcGIS using the density tool.



a) Azimuth angle 0^0, 45^0, 90^0, 135^0 **b) Azimuth angle 180^0, 225^0, 270^0, 315^0**

Figure 2: Hillshaded images

RESULTS AND DISCUSSION

The LEFA (Lineament Extraction and Fracture Analysis) program, carry out in the MATLAB environment, was used to extract lineament systems from optical and radar data. The LEFA program contains several edge detection algorithms, but the Canny method is most applicable to the study of a linear network. The cracks that form on the surface have degrees of different origins, which are expressed as linear objects. To find them, the Hough transformation is applied to the raster image. In the functional area, the main parameters of the Hough transformation are set [4].

The total count of lineaments according to the Landsat 8 was 302, the minimum length was 1.05 km and the maximum length was 3.42 km. The main trends indicate two main directions Northwest (NW), Southeast (SE). Subdominant was also revealed in two directions - northeast (NE) and southwest (SW). Based on the results of the automated processing of SRTM radar data at azimuths of 0^0, 45^0, 90^0, 135^0 were extracted 7049 lineaments with a minimum length of 0.03 km and a maximum length of 7.01 km. And at azimuth 180^0, 225^0, 270^0, 315^0 were extracted 7198 lineaments with a minimum length of 0.03 km and a maximum length of 7.49 km. It was revealed that the two main directions of the lineaments - West-North-West (WNW), East-South-East (ESE) coincide at different azimuths angle.

The density map of the lineaments structure provides information about the concentration of lineaments per unit area [8]. The lineament density maps are derived for the optical, and radar, to analyze the distribution of the lineaments (Fig.3-5).

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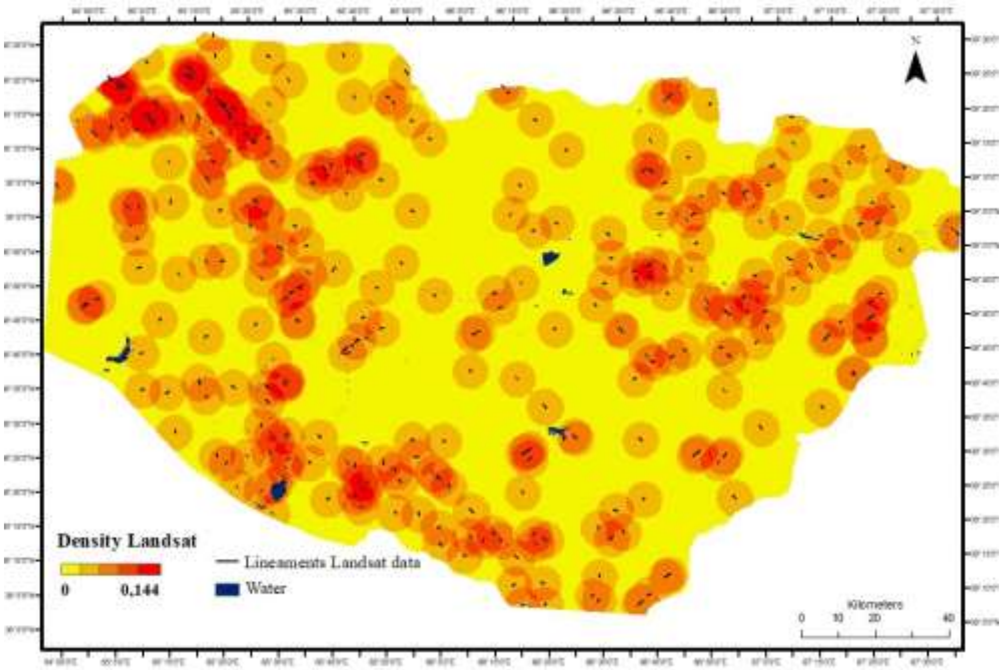

Figure 3: Density map of Landsat 8 data

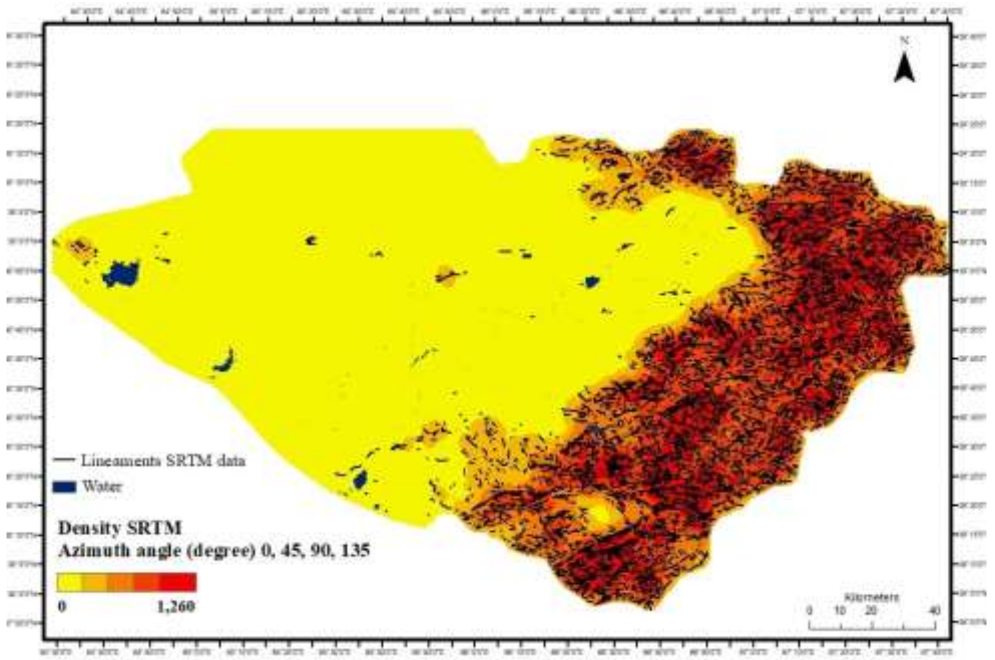

Figure 4: Density map of SRTM data, azimuth angle 0^0, 45^0, 90^0, 135^0

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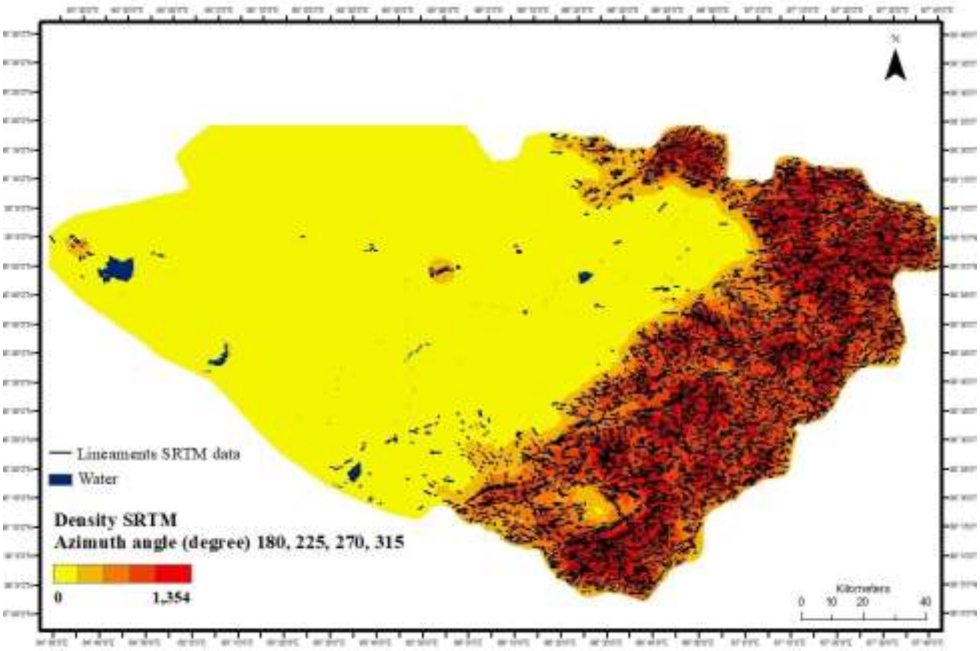
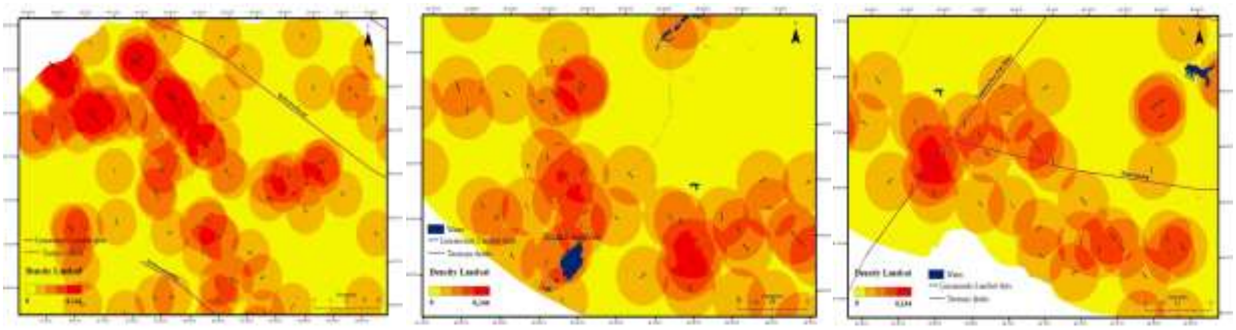


Figure 5: Density map of SRTM data, azimuth angle 180^0, 225^0, 270^0, 315^0

Figure 3 shows a density map based on Landsat 8 data. As we can see from the result obtained, the high density of lineaments is located in the north-western part of the study area (Fig. 6 a). According to geological data, the Bukhara-Gissar fault was placed in this region. The length of this fault is approximately equal to 474 km. A lower density is observed in the south-western part of the study area. The accumulations of these lineaments are located near the Jizzakh reservoir (Fig. 6 b). And in the southern part of the region, a low density of lineaments is also observed (Fig. 6 c). In this part of the region, the density is observed at the intersection of two geological faults of the Poperechno Tien Shan and Shurchinsky, their length is approximately equal to 307 km and 202 km, respectively.



a *b* *c*

Figure 6: Detailed of the Landsat density map of the considered region

Figure 4-5 shows the density map according to Landsat 8 data. As we can see from the results obtained, the high density is concentrated in the mountainous terrain of the study area. During a detailed exploration, it was found that:

1. In the eastern part of the area at an azimuth of 0^0, 45^0, 90^0, and 135^0, the density was less than at an azimuth of 180^0, 225^0, 270^0, and 315^0 (fig. 7. a, b). The maximum density in this part of the territory is located on the area of the Dekhkanabad geological fault. The length of this fault is approximately equal to 323 km.

2. In the south-eastern part of the area, changes in density are observed. At an azimuth of 180^0, 225^0, 270^0, and 315^0, the density is much higher than at an azimuth of 0^0, 45^0, 90^0, and 135^0 (fig. 7 c, d).

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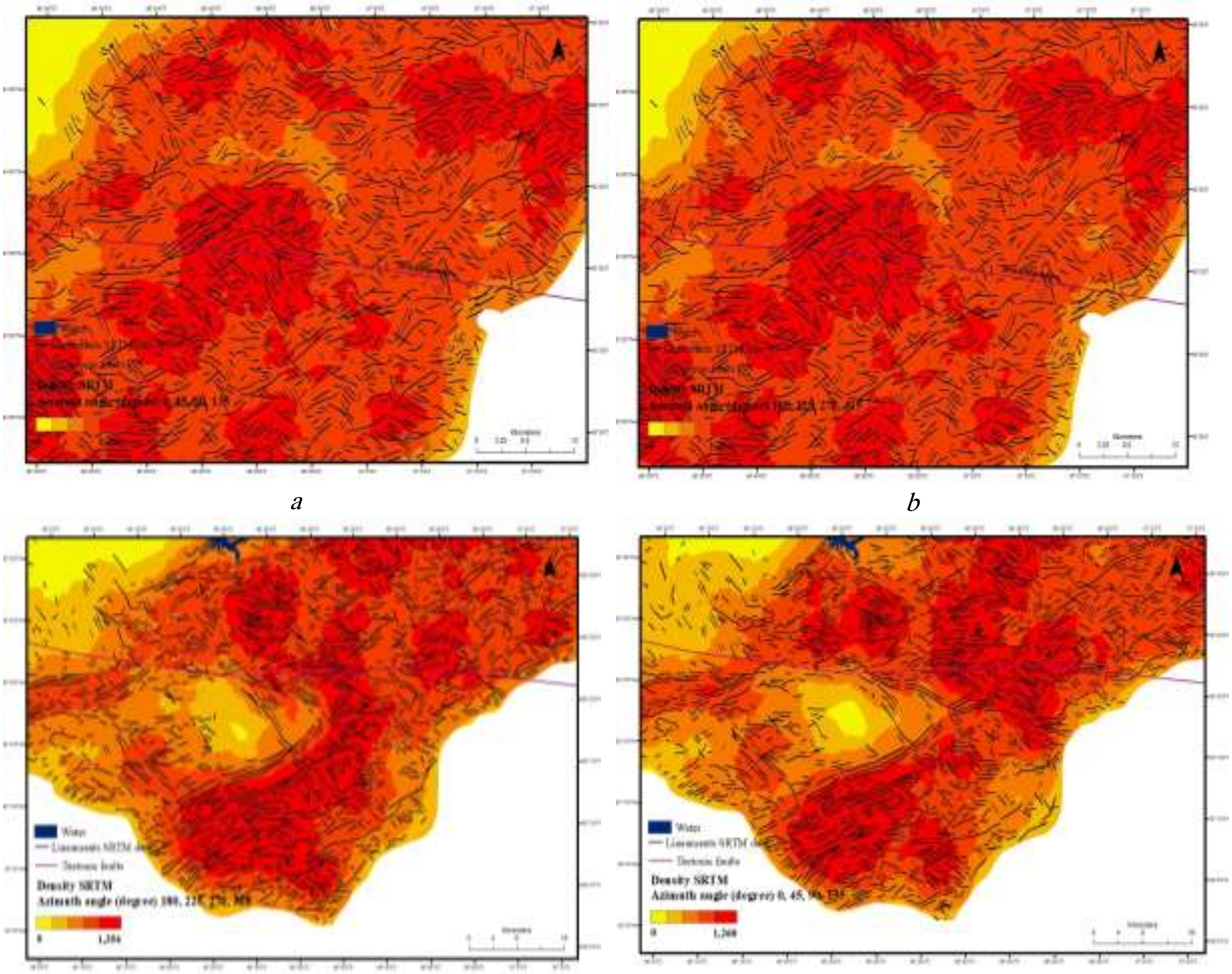

a *b*

c *d*

Figure 7: Detailed of the SRTM density map of the considered region

4. CONCLUSION

This research aimed to analyze the density map of lineaments structure getting from Landsat 8 and SRTM. The results of the density map show that, according to Landsat 8, the high density of lineaments is located in the north-western part of the study area near the Bukhara-Gissar fault. A lower density is observed in the south-western part of the study area near the Jizzakh reservoir. And in the southern part of the region, a low density of lineaments is observed at the intersection of two geological faults of the Poperechno Tien Shan and Shurchinsky. During a detailed exploration of the density map according to SRTM data found that in the eastern part of the area at an azimuth of 0^0, 45^0, 90^0, and 135^0, the density was less than at an azimuth of 180^0, 225^0, 270^0, and 315^0 and the maximum density is located on the area of the Dekhkanabd geological fault. In the south-eastern part of the area at an azimuth of 180^0, 225^0, 270^0, and 315^0, the density is much higher than at an azimuth of 0^0, 45^0, 90^0, and 135^0. Also analyzing the results, it was noted that the lineaments extracted after the hillshaded procedure display a wide range of directions. Moreover, the main directions of the lineaments coincide at different azimuths. The extracted lineaments from SRTM data are located mainly on the slopes and in the shadow area, which indicates the high sensitivity of the radar data to the geomorphology of the area. But at the same time, radar data do not allow determining the accuracy of detecting lineament structures on flat terrain.

5. Acknowledgements

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