Urban and Rural Settlements Distribution of the Republic of Crimea by Absolute Altitudes

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Abstract. This research focuses on the location of the settlements of the Republic of Crimea by absolute altitudes. The study is relevant as it considers an elevation of a settlement above sea level which is known to be one of the main factors characterizing the degree of national economy development and well-being. The construction conditions and settlements’ functioning are greatly affected by the natural conditions, and accessibility of the settlements significantly decreases economic expenses. The latest geo-informational methods of study such as (Quantum GIS Desktop) and the data provided by the satellite radar surveying (SRTM) helped to analyse the range of the altitudes, within which the settlements of the Republic of Crimea had been set up. It was determined that urban settlements were formed within the range of altitudes between -7 and 553 m (amplitude – 560 m), but rural ones – between -6 and 1216 (amplitude – 1222 m). Also the distribution of the settlements by landscapes has also been analysed. There are 4 landscape-levels (in increasing average absolute altitudes) – hydromorphic, flat interfluve, low mountain and middle mountain levels on the territory of the Crimean peninsula. It is defined that 346 settlements are located in hydromorphic level, 296 settlements – in flat interfluve level, 342 – in low mountain level and 63 – in the middle mountain level. The most developed and populated levels on the territory of the Republic of Crimea turn out to be hydromorphic and low mountain levels due to the favourable natural conditions, with the least developed region being middle mountain landscape level.

1. Introduction

According to the law of the Republic of Crimea “About the administrative and territorial arrangement of the Republic of Crimea”, May, 28, 2014 [1] there are 16 urban and 1004 rural settlements on the given territory, located rather irregularly (see Figure 1).

Most part of urban settlements is located in the coastal area or in the vicinity of the Black Sea or the Sea of Azov (Yalta, Alushta, Gurzuf, Sudak, Kerch, Yevpatoriya, Saki, etc.) or at the crossroads of the main automobile and railway highways (Simferopol, Dzhankoy, Belogorsk etc.)
The purpose of this work is to analyze the influence of the absolute altitude index of the locality on the formation of urban and rural settlements distribution.

2. Materials and methods

A great number of works consider thoroughly the location of settlements by absolute altitudes. So, Murseli and Dana [2] studied the absolute elevation of settlements in the Republic of Kosovo; Penkov and Dimitrov [3] explored the absolute altitudes of the settlements in the republic of Bulgaria; Liu and co-authors [4] and Han and Yan [5] considered the impact of climate change on the settlements, situated in the coastal area of China; Small and Nicholls [6] dealt with the propensity for coastal settlements influenced by unfavourable natural processes; McGranahan, Balk and Anderson [7] studied the settlements located in lowlands which are subjected to flooding as a result of climate change; Dimitriou and Ksassomenos [8] were engaged in learning meteorological peculiarities of high mountain regions of central Greece; Gong and co-authors [9] dealt with ecological conditions of high mountain towns; Ruiz and co-authors [10] and Ramirez-Sandoval and co-authors [11]; Gonggalanzi [12] studied the connection of medical and biological conditions and the growth of absolute altitude of the cities; Juan, Manuel and Barradas [13] studied how the change of urban vegetation in the cities is affected by the change of altitude in Mexico; Elkhatib and co-authors [14] studied how the effectiveness of solar panels depends on absolute altitudes of the cities; Sakhnova and Voitekhovsky [15] dealt with the geomorphological conditions of the development of Crimean peninsula cities; Sokolov [16-17] explained how the development of Belorussian settlements is connected with different types of landscapes; Elizbarashvili and Nikaashvili [18] were engaged in studying the population distribution and settlements on the territory of Georgia and their natural landscapes. Thus the study of absolute altitudes of the settlements has both fundamental and applied aspect.

For a long time the data of field measurements have been the bases for getting the information about absolute altitude which were introduced then into topographic and gypsum metric maps. At present the data of satellite radar surveying are used to analyze the absolute altitudes of the settlements mentioned in [19], the most accurate data are those provided by radar surveying – Shuttle Radar Topographic Mission (SRTM). The SRTM data are in the open access in the Internet.

The authors have applied the most modern methods of study – geo-informational, cartographic, cart metric, geo-informational systems. The research is being carried out aided by Quantum GIS Desktop 2.18.27 (Las Palmas). Any alternative geo-informational programs are also used such as (ArcGIS, MapInfo, Global Mapper, etc.). However, the advantage of Quantum GIS Desktop is its open access.

The methods of study include the following stages:

- Getting SRTM data for the territory of the Republic of Crimea. SRTM data are displayed in the Internet address http://srtm.csi.cgiar.org/srtmdata/ and represent the squares 1x1 degree in

**Figure 1.** Settlements of the Republic of Crimea.

**Figure 2.** Landscape levels of the Republic of Crimea.
size which are loaded as archives. SRTM archives were unloaded for the territory of the Republic of Crimea (srtm_43_03, srtm_43_04, srtm_44_03, srtm_44_04).

- Processing SRTM data for the territory of the Republic of Crimea. The received data after file unpacking are being processed and united in a Quantum GIS Desktop 2.18.27 (Las Palmas) by “To create virtual raster” in “Raster” menu.
- Digitizing rural and urban settlements’ boundaries of the Republic of Crimea. To outline and define more precisely the present boundaries of the settlements and clear up the regularity of the location of urban and rural settlements of the Republic of Crimea using the “Absolute Altitude, m” together with outer space HD photos (connected with Quantum GIS Desktop 2.18.27 (Las Palmas) and “Quick Map Service” digitizing and settlements boundaries are carried out. The polygonal shape-file in which the boundaries of urban and rural settlements of the Republic of Crimea is created.
- Getting the data about absolute altitudes of urban and rural settlements of the Republic of Crimea using SRTM data. To get the information about the absolute altitudes of the settlements of the Republic of Crimea by Quantum GIS Desktop 2.18.27 (Las Palmas) “Zone statistics” in "Raster" menu was applied, where the set of SRTM data was used to compute the altitudes of the objects.
- Data processing and analysis. As a result the database of the absolute altitudes of each settlement is obtained and presented as the attributive table for each settlement. The distribution of settlements in the Republic of Crimea according to landscape levels of the Crimean peninsula is analysed.

3. Results and discussion

Analyzing the SRTM raster image it is revealed that the Crimean settlements can form in the range of altitudes between -6 (adjacent lowlands lying below sea level) and 1545 m. (the highest elevation of the Crimean mountains – the Roman Kosh). Thus the maximum range of the altitudes on the territory of the Republic of Crimea is 1551 m. However the settlements were set up only within a certain part of the above-mentioned range of altitudes. It is defined that the urban settlements are characterized by the range of altitudes between -7 and 553 m (the amplitude is 560 m, but rural ones – between -6 and 1216 m (the amplitude is 1222 m). Thus, having taken into account the range of the altitudes within the Crimean Republic we can conclude that the urban settlements occupy only 35% of the total range of the altitudes, whereas rural ones – 79%. And the settlements take the whole range of altitudes most irregularly. So, an average height of urban settlements within the Republic of Crimea is 113 m., rural ones – 93 m.

Most part of urban and rural settlements is formed in range between 0 and 100 m. It is stipulated mainly by historical reasons. The territory of the Crimean peninsula since the ancient Greek colonization (not taking into account Scythian and other formations of nomadic people, who hadn’t established constant settlements) is located mainly in the coastal areas of minimum heights. So the people could cultivate the land and use intensive farming methods.

The area of the Republic of Crimea and the total area of urban and rural settlements are measured by geometrical tool known as a shape-file “To compute the area”. As a whole the settlements occupy approximately 7% of the territory, including 2% of urban settlements and 5% of rural settlements in the Republic of Crimea.

Taking into account the heterogeneity of settlements’ location, the landscapes, the distribution of them on the territory of the Republic of Crimea there are 4 types of landscape-levels as defined by Grishankov [20]. So, there are hydromorphic, flat interfluve, low mountain and middle mountain level (see Figure 2).

According to Grishankov [20] landscape levels are planetesimal geomorphological formations relatively homogeneous in relief surface pattern and ground moisture but differ in geographical zonality. Hydromorphic and flat interfluve levels are characterized by gently sloping territories of suitable depth and density to break up the relief without using special techniques for building and
construction. The peculiar feature of the settlements is their unplanned laying-out regardless of the elevation of the relief, of engineering and geologic conditions. But low and middle mountain landscapes represent the territories which differ greatly by altitudes and have high steep slopes. So, special techniques should be applied in erecting buildings and constructions. Thus, the relief, engineering and geologic conditions make the laying-out of the settlements more complicated.

According to spatial analysis, a part of settlements is located on the line between landscape levels. So, such settlements were computed twice for each landscape level which they are a part of. As a result Table 1 which shows the number of settlements by landscape levels is made up. It demonstrates that most settlements were set up in hydromorphic and low mountain landscape levels, and fewer – in middle mountain landscape levels.

Table 1. The number of settlements by landscape levels in the Republic of Crimea.

| Landscape level   | Total number of settlements | Number of urban settlements | Number of rural settlements |
|-------------------|-----------------------------|----------------------------|-----------------------------|
| Hydromorphic      | 346                         | 9                          | 346                         |
| Flat interfluve   | 296                         | 5                          | 291                         |
| Low mountain      | 342                         | 9                          | 333                         |
| Middle mountain   | 63                          | 3                          | 60                          |

Table 2. The urban settlements distribution of the Republic of Crimea by absolute altitudes within the landscape levels (made by the authors).

| Absolute altitude, m | Hydromorphic | Flat interfluve | Low mountain | Middle mountain |
|----------------------|--------------|-----------------|--------------|-----------------|
| Mean                 | 11           | 38              | 217          | 157             |
| Median               | 10           | 33              | 242          | 70              |
| Min                  | -7           | -2              | 2            | 39              |
| Max                  | 84           | 105             | 553          | 491             |
| Range                | 91           | 107             | 551          | 452             |

Table 3. The rural settlements distribution of the Republic of Crimea by absolute altitudes within landscape levels (made up by the authors).

| Absolute altitude, m | Hydromorphic | Flat interfluve | Low mountain | Middle mountain |
|----------------------|--------------|-----------------|--------------|-----------------|
| Mean                 | 17           | 60              | 174          | 378             |
| Median               | 14           | 47              | 152          | 375             |
| Min                  | -6           | -3              | 1            | 59              |
| Max                  | 166          | 146             | 871          | 1216            |
| Range                | 172          | 149             | 870          | 1157            |
The urban and rural settlements distribution was analyzed by “Absolute altitude, m” within each landscape level (see table 2 and 3). Tables 2 and 3 show that within hydromorphic landscape level the settlements are located on absolute altitudes between -7 and 166 m., in flat interfluve level – between 3 and 146 m., low mountain – between 1 and 871 m., middle mountain – between 39 and 1216 m. The total range of the altitudes is minimum within hydromorphic and flat interfluve landscape levels on the territory of the Republic of Crimea and it increases from the north to the south, and it is maximum within low mountain and middle mountain landscape levels.

4. Conclusion
The distribution of settlements on the territory of the Republic of Crimea has got clear-cut marked geographical and historical regularities and depends mainly upon the elevation of the area where the settlement is located as well as upon the history of territory’s development. Most of urban and rural settlements are set up on the elevations up to 100 m on the territory of the Republic of Crimea. The largest number of settlements is located in the hydromorphic landscape level but the least number is in the middle mountain landscape level.

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