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Geomorphological Risks Which Prevent from Physical Development of Kowsar City

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ABSTRACT

Many Iranian cities have geomorphological restrictions ahead of their physical development. Kowsar is a valley-shaped city in Ardebil Province which has spatial limitations in future development. Presence of stiff petrologic and unconsolidated sediments belonging to Miopliocene, trend of Hir-Firouzabad fault which exposes Eocene volcanic formations to Miopliocenesedimentary formations, has resulted in instability of slopes and even new areas allowed for future physical development of the city are not geomorphologically safe. The present research aims to investigate geomorphological capabilities and limitations ahead of physical development of Kowsar City and identify risks which are resulted from geomorphological processes. The research is an analytical-descriptive study. We used library study, 1:50000 topography maps and 1:100000 geological map and GIS software. Results showed that Kowsar City has restrictions with physical development because it is located in a deep narrow valley and is surrounded by steep slopes. Givi Sophla (lower Givi) is located on an inappropriate slope and this part of the city is threatened by drop of gravels and neighborhood of river and being located on the fault and because it is located on an unconsolidated loose formation. In general, it can be said that about 60% of the city is located on risky areas. Therefore, the risks and restrictions must be considered in physical development of the city.

KEYWORDS: geomorphological risks, physical development, geomorphological processes

INTRODUCTION

In spite of considerable advances in science and technology, human is still worried about nature wrath and natural disasters. Disasters still occur and human is not able to completely control his life and overcome unprecedented events. Damage and toll amounts in any crisis have direct relationship with human vulnerability. Iran's geographical situation is worrying in terms of precipitation and temperature variations and other phenomena and Iran is considered as the 10thcalamity-rich country all over the world (Faraj Zadeh et al, 2011). Stable urban development is seriously linked to natural disasters resulted from physical development and physical development of a city without considering its natural conditions and risks can lead to development of cities in risky areas. Therefore, it is necessary to consider risks and natural conditions in development of cities (Sharifikia et al, 2010). Usually, damages exerted to buildings are not related to engineering and architectural operations but more than 90% of damages are related to inappropriate location of the buildings. As a city develops, not only earth's surface is changed but also new landforms are formed (Abedini et al, 2012). The present research tries to investigate whether the natural environment is appropriate for physical development of Kowsar City. Geomorphology is a branch of science which deals with spatial analysis of land risks-which include landslide and … in this research- and evaluates risk potential for taking residence in different areas.

Theoretical fundamentals

Geomorphology

Geomorphology can be defined as the science of systematic and interdisciplinary study of landforms as well as internal and external processes of the earth which form and alter landforms. In Persian language, many equivalents have been used for description of geomorphology: earth structurology, identification of earth roughness, identification of earth topography, earth formology, identification of earth's morph, surficial geology and so on. In spite of this, most researchers and experts of this subject in Iran prefer to use the word geomorphology (Hoseinzadeh, 2008). Definitions and concepts related to risk: in general and non-technical meaning, risk refers to situations, processes, actions or reactions which are able to cause damage and loss to human valuable objects. Although adverse impacts of risk can be predicted, exact time determination of some risks especially geomorphological risks is impossible at present. Study of urban geomorphological risks for dividing urban physical development into 4 categories: stable or very low-risk, relatively stable (low-risk), instable (risky) and very risky plays an important role in urban management and planning. Usually, damages exerted to buildings are not related to engineering and architectural operations but more than 90% of damages are related to inappropriate location of the buildings (Rajaee, 1994). As a city develops, not only the earth is

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altered but also new landforms are created. The structure of a city brings a prospect of walls and even, long and thin surfaces which are occasionally disconnected by artificial or natural channels or network of decorative waters. Emergence of such an outlook alters energy, water and materials balance and its impacts are reflected in changes in earth and geomorphological processes (Roustayee et al, 2006).

Research background

A review of previous disasters allows for recognition of vulnerable communities. An analysis of the impacts of past disasters on different social groups will help understand the relationship between the nature of risks and their impacts on exposed-to-risk elements. FarajZadehet l (2011) investigated risks such as landslide, earthquake, erosion and development of desert in Golestan Province (Iran) and studied risks zonation maps in this province. They found that 30.36% of the area of the province is exposed to landslide high risk, 51.84% of the area of the province is prone to average earthquake risk, 28.63% of the province area is prone to low flood risk, 39.23% of the province area is exposed to average erosion risk and 43.93% of the province area is exposed to low desertification risk. SharifiKia et al (2010) used zonation maps for earth riskswhich included three geomorphological risks (earthquake, landslide and flood). They found that a large part of physical base of Mahneshan City is exposed to the aforementioned risks and adequate attention had not been paid to the risks as city developed physically and high-risk areas had been used for construction even by public and national institutes. Afshari Azad et al (2012) prepared regional geomorphological risks zonation map and found that 64% of the investigated area is exposed to high and very high risk and in general, the region is highly risky. The geomorphological evaluation revealed the vulnerability of the road and other installations.

Research hypotheses

1. "Slope movements" is the main factor which prevents from physical development of Kowsar City.
2. Physical development of Kowsar City is a function of geomorphological forms and city foundation.
3. The present topographic surfaces are effective in development of Kowsar City.

METHODOLOGY

The present research is a scientific applied study in terms of its goal. In terms of nature, it is a descriptive analytical study. GIS system was used to evaluate the data collected from library and field study. Data were collected from resources like papers, documents and reports present in departments like: (statistics and information, GIS unit of deputy of planning and political and security affairs of provincial government, organization of agricultural Jihad, water and soil laboratory, studies unit of organization of water affairs, organization of meteorology), books, journals, internal periodicals and internet websites. Instruments and equipment which were used in field study include:

Topographic maps (scale=1:50000) for Firouzabad

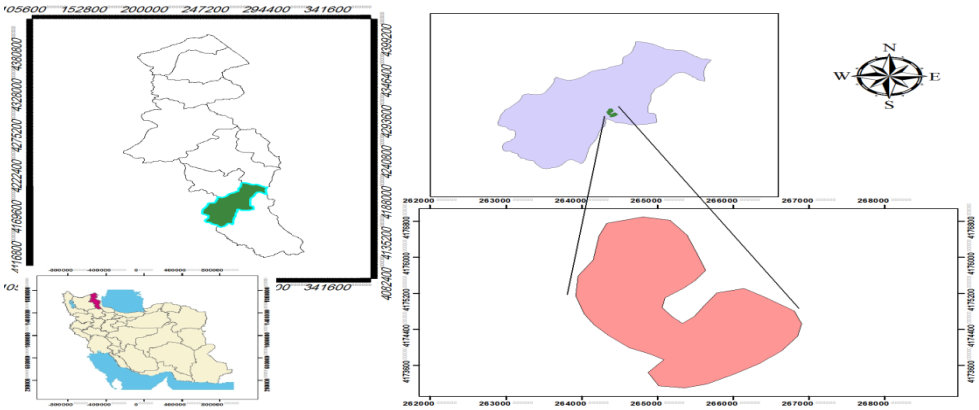
Geological maps (scale= 1:100000) for Kowsar city

Maps present at text in GIS software

Field observation was also done in order to match mental perceptions with real natural realities and exacter identification of environment and taking photo.

Geographical situation of the area under study

Givi is the center of Kowsar city and has two districts: lower Givi and upper Givi. Its area is 124 hectares and its altitude is 1400 meters in lower Givi and 1500 meters in upper Givi. In terms of geographical situation, the city is bound between 48 degrees and 19 minutes and 55 seconds to 48 degrees and 21 minutes and 3 seconds of eastern longitude and 37 degrees and 42 minutes to 37 degrees and 41 minutes and 20 seconds of northern latitude. Kowsar or Givi was formerly a part of Khalkhal City in Ardebil Province.



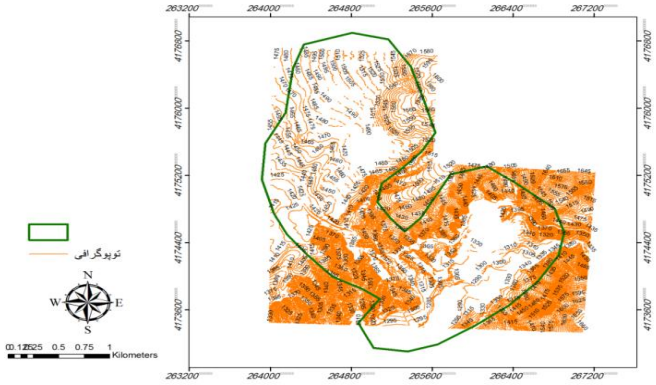
Map 1: geographical situation of Kowsar City

Topography and geology of Kowsar City

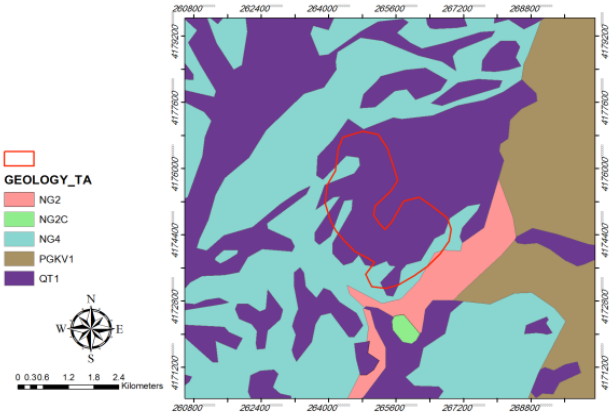
Topography and slope are main features of the earth. Each of these two elements can be used in identification of the shape of the land in a particular area. Topography or the very apparent shape of the earth indicates the slope, troughs and heights of a land and is a determining factor in human activity spread and residence. Kowsar City has a mountainous outlook and is bounded by Talesh mountain range from east and Bajilar mountain range in west. Its lands are mountainous and full of hills and sometimes in the form of plain.

There are many mountains in the area. Dash Boulaq (3195 meters) is a famous mountain in ArpaChayee village and GuoniDaqi (2045 meters) is a famous mountain in northwestern part of AbliOliya village.

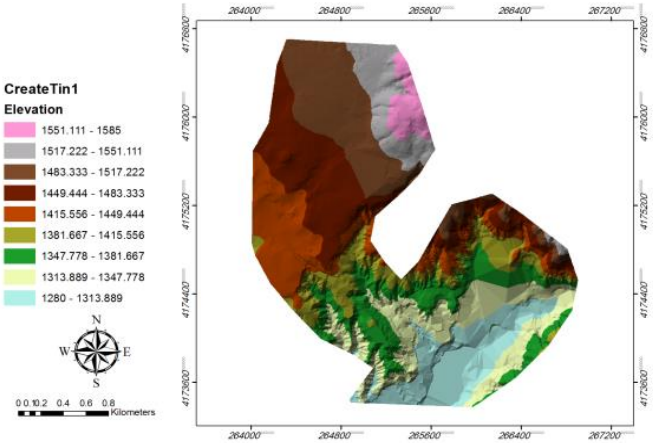
From a geological viewpoint, the area under study is situated in Alborz-Azerbayjan geographical zone. This zone composes a part of western Alborz and Azarbayjan and of course has the features of this zone. Western Alborz-Azerbayjan zone is bounded to Gorgan-Rasht zone by Alborz Fault in the north, central Iranian zone by Semnan Fault in the south and to color mélange zone and Khuy-Mahabad zone by Tabriz and Urmia Faults in the west, respectively. This part of Alborz formed a height along with another part of western and southern Iran in Silurian and Devonian age and has been linked to central Iranian and eastern Alborz sedimentary basin in late Devonian. Presence of phosphoric sediments in upper Devonian along this zone and its presence in central Iranian zone indicate the link between these two zones. Intrusive bodies which belong to Carboniferous (Marand and Jolfasyenites) and red-colored clastic sediments of early Permian possibly indicate the Hercynian Orogeny in northern Iran.



Map 2: topography of the area



Map 3: geology of the area



Map 4: digital elevation model (DEM)

ANALYSIS AND DISCUSSION

Internal morphodynamic risks which threaten Kowsar City

Landforms and processes which are created in earth's surface as a result of internal earth activities or tectonic activities are called tectonic geomorphology or morphotectonic. Tectonic geomorphology includes deals with landforms created by tectonic forces and application of geomorphological principles to solve problems occurred by tectonic activities. Morphotectonic investigates the impacts of active tectonic processes (Like fault, fold, uplift, subsidence and so on) on landforms (Rajabi et al, 2013)

Figure 1: a close view of fold in Oligocene sediments composed mainly of sandstone and unconsolidated marls which constitute the base of Kowsar City.

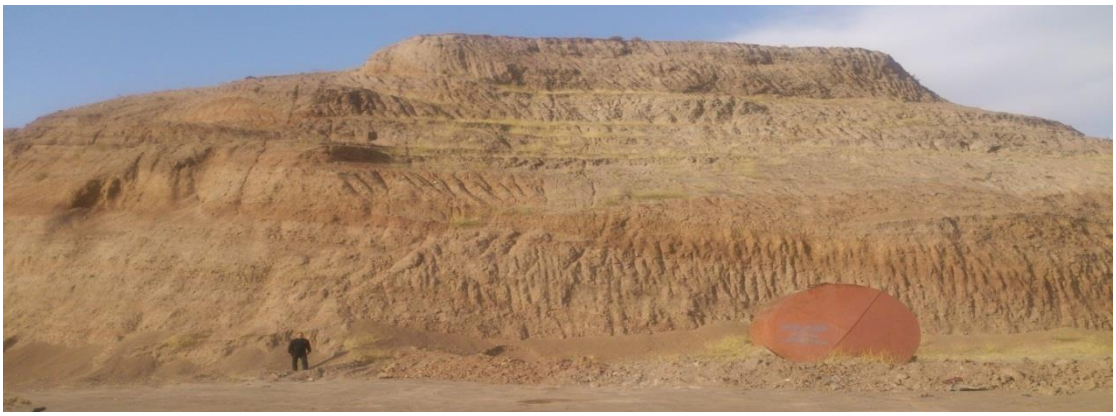
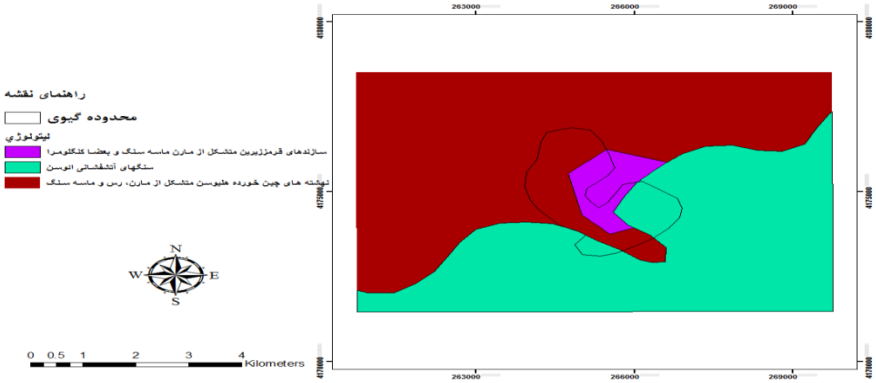


Figure 2: the continuation of the folded sediments of Oligocene: pay attention to slopes unloading aimed at minimizing slope instabilities.

Faults and possible risks of their re-activations

Kowsar City has a minimum elevation of 1200 to 1400 meters, maximum elevation of 2200 meters and average elevation of 1700 meters is a valley-shaped city. The mountains summits which surround the city have elevations of about 1900 to 2155 meters. The faults of the area have north-eastern to south-eastern trends due to new tectonic forces. The lithology of the area (material and strength of formations) is investigated in order to help identify geomorphological risks. Rocks of the area are divided into three categories in terms of lithology:

- Resistant formations: porphyry andesite
- Non-resistant formations: recent alluvial terraces, gray marls, gypsum-bearing and salty red marls
- Semi-resistant formations: alluvial fan, travertine, old and high terraces.

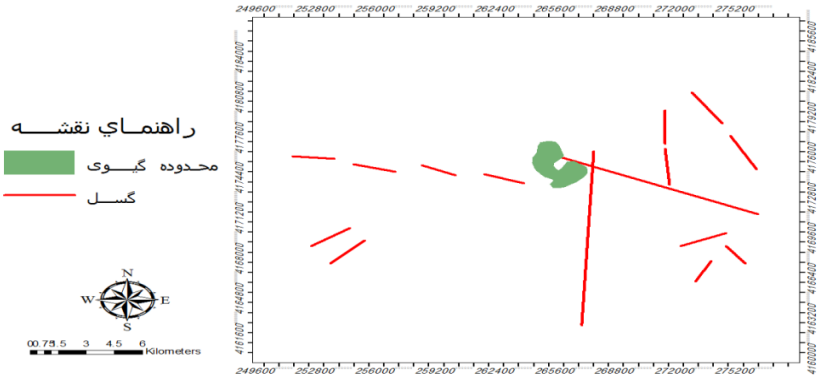


Map 5: Kowsar lithology

Figure 3: a close view of Kowsar fault which goes through the center of Kowsar City as well as displacing Miocene layers

Firouzabad fault

The main fault (Firouzabad) is 20 kilometers long. Considering the spread of faults in eastern and south-eastern part of the city and their impacts on resistant and semi-resistant formations, possible risks of faults on loose and semi-resistant are increased and cause fracture in resistant formations. If Firouzbad fault is displaced, a large amount of energy is released under internal geodynamic activities and the possibility of earthquake and city destruction will increase.



Map 6: faults of the area

Figure 4: the continuance of Givi Fault towards south which goes through southern area of the city. Notice direction change in channels due to performance of fault slide

External geomorphic risks which threaten the physical development of Kowsar City

The main morphodynamic factors which affect instability of the studied area are slope movements (downfall, slide, crawling). Rock fall refers to free movement of stones towards downstream of the steep slopes. Rock fall dimensions range from single rubbles to sudden downfalls weighed millions of cubic meters (Samadzadeh et al, 2010). The mountainous area with an average slope of 8.3% is prone to downfall. Presence of steep slopes adds to this problem. When the rocks fall in the valley in which the city buildings are located, industrial units and roads will be confronted with severe risks and threats. The area is susceptible to rock fall because of high annual precipitation (323.5 millimeters) and temperature variations and presence of steep slopes. A large part of the downfalls takes place in spring and buildings and roads are threatened in this way.

Crawling

Studies have shown that crawling factor is relatively active in the area and threatens the urban area. Construction of buildings on weathered and loose formations has put the urban area under environmental risks. Unfortunately, inappropriate building constructions are still continuing. Studies show that the city is under frost in about 52.2 days in a year and this in part contributes to physical destruction and put the area exposed to crawling.

Slide

Slope and water are two important factors in creating slope movements. In Sanfransisco Gulf environmental and resource planning, landslide potential has been classified into the following categories in terms of relative stability of slopes (Roustayee et al, 2012).

There are five groups of landslide potential. Group 1 is the stable group and group 5 is the unstable group.

Group 1. Slope below 5%

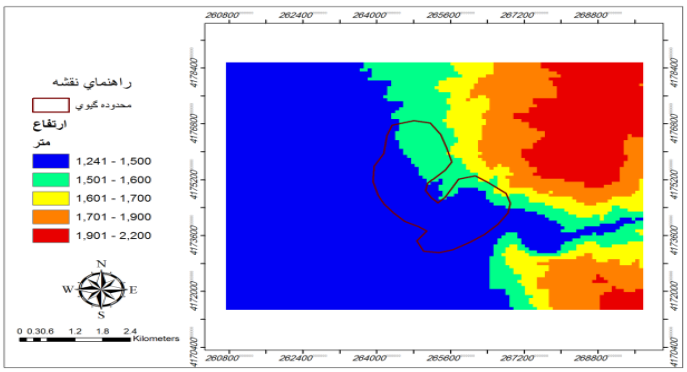
Group 2: slope between 5 and 15%

Group 3: slope above 15% and the base is filled with stable materials

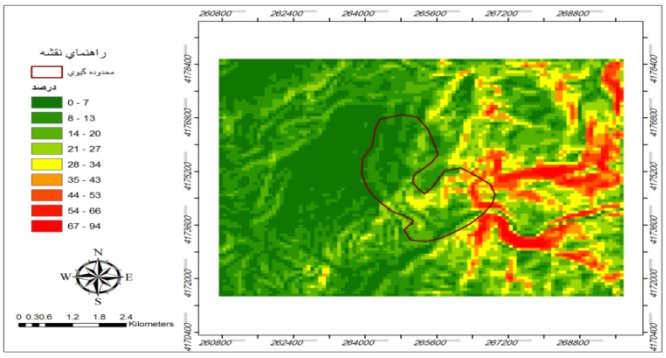
Group 4: slope above 15% and the base filled with unstable materials

Group 5: landslide areas, without paying attention to slope and material percentage

Investigations showed that landslides compose a large part of the slope movements in the studied area. Creation of cuts and trenches in slopes in order to build a road has increased the risk of landslide in lower Kowsar area. Kowsar city is being developed on semi-resistant formations and alluvial sediments of quaternary era and is located on steep mountainous slopes and has an average annual precipitation of 323.5 millimeters. Therefore, it is exposed to landslides. This phenomenon (landslide) can be clearly observed in lower Kowsar. Landslide will be followed by road, installations and construction risks and has led to inappropriate physical development. An earthquake (3 degrees on the Richter scale) hit the Givi city in Ardebil province. This earthquake took place at 5.28’ in the morning of Saturday, 21st of April (geographical position: (37.60 northern degree and 48.25 eastern degrees). This earthquake was felt weakly in Khalkhal, Givi and Hashtjin cities because of its depth (10 kilometers below earth’s surface) and distance to the cities. The earthquake occurred in northern Ardebil province and its spot had a distance equal to 13 kilometers to Givi city, 25 kilometers to Khalkhal city and 26 kilometers to hashtjin city. Furthermore, another recent earthquake occurred at 22.19’.39” in 2014 (2.9 degrees on the Richter scale). Its focus was Givi City, 85 kilometers south Ardebil City and it was 6 kilometers below earth’s surface. Considering the slope direction in the area, it can be said that the southern slopes are more appropriate for building and physical development due to receiving more sunlight and better air flux. The southern slopes have the highest score and eastern slopes have the lowest score for development.



Map 7: elevation levels



Map 8: area slope

Erosion

Erosion is an important factor in morphology and application of land and can cause wide changes in a particular area. Factors like weather, topography, geological situation and lithology are effective in erosion. Human factors and it's concerning activities like agriculture, road trenches and smoothing hills lead to erosion intensification.

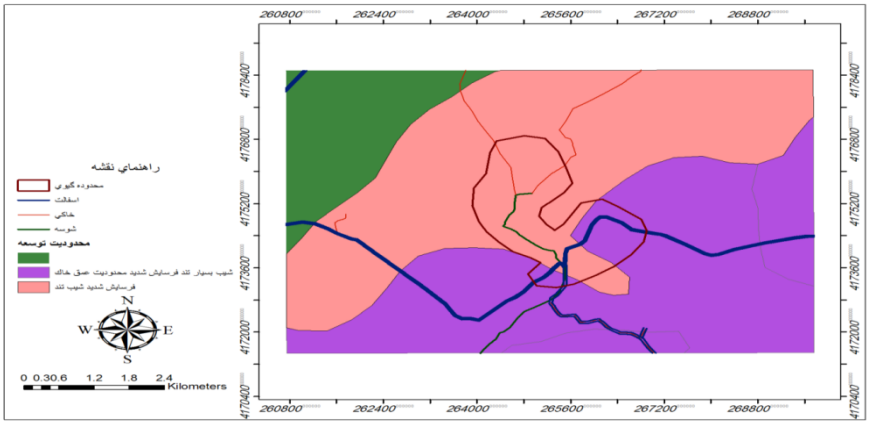
Figure 5.a part of high terrace levels on which new Kowsar has been built. Notice water erosion and regressive erosion

There are numerous rill erosions in the lower Kowsar urban area. This has caused and intensified by activity of rivers and presence of instable formations of neogene era. Inappropriate building location can be clearly observed in the area. Erosion in city area may cause blockage of pipes, reduction in permeability, intensification of floods and so on.

Figure 6.the bed of GiviChay River and location of residential buildings in garden and agricultural lands close to the river

Figure 7.tiltingchannels due to Kowsar fault performance

In the northern and eastern parts, the city is being developed on relatively steep slopes and this has resulted in reduction of certainty and strength of the marl formations and has intensified small slides and has made it possible for large landslides in case of possible earthquakes.



Map 9. Development restriction as a result of erosion and steep slope

First hypothesis: “slope movements” is the main preventive factor in physical development of kowsa City.

Investigates revealed that landslides compose a large portion of slope movements in the area. Creation of road trenches and cutting slope supports increase landslide risk in the southern roads leading into lower Kowsar. Kowsar City is being developed on Non-resistant and semi-resistant formations and alluvial sediments of Quaternary era. It is on steep slopes and has a high average annual precipitation level (323.5 millimeters) and therefore is prone to landslides. Landslide can be clearly observed in lower Kowsar area. Crawling factor is relatively active in the slopes and has caused many risks in urban development. The area is prone to downfall because there are steep slopes (average slope=8.3%).

Second hypothesis: Kowsar City physical development is a function of geomorphological figures and phenomena and city foundation.

Geomorphological risks like downfall in eastern part, crawling and landslide in northern part and flood risk in southern part resulted in development of new Kowsar in the north on a smooth surface. Furthermore, the main possible risk is occurrence of earthquake due to being close to the main Firouzabad fault. No significant hydromorphological risk threatens the city. Results of the study showed that the Kowsar City is prone to some geomorphological risks and these risks may be harmful to the city physical development. The city is confronted with development challenges because it is situated in a narrow and deep valley with steep slopes.

Third hypothesis: the present topographic levels are effective in development of Kowsar City.

New Kowsar has been designed a relatively smooth topographic area and is developing rapidly (in plains and low-slope areas). The lower Givi is situated on an area which has a rough and steep topography and geomorphological risks threaten the residential buildings in this area.

Conclusion

Kowsar city has a population equal to 7185 people in Ardebil Province and is situated in the southwestern part of the province. This area has a lot of geomorphological risks and these can have serious adverse impacts on future development of the city. Lowsar city (Givi) has limitations in physical development because it is situated on a narrow and deep valley. Geomorphological risks like downfall in eastern part, crawling and landslide in northern part and flood risk in southern part has stopped development of old Kowsar and formed new Kowsar City in the northern part on a smooth surface. New Kowsar is situated on a relatively smooth topographic area and is being developed rapidly (development in low-slope slopes). No significant hydromorphological risk threatens the new Kowsar. The main possible risk in the area is occurrence of earthquakes due to neighborhood to Firouzabad fault. Firouzabad fault has a north-south trend in Kowsar city area and the area is tectonically active especially in lower Kowsar. Kowsar's main fault is the end part of Firouzabad fault and has caused abnormal neighborhood of Eocene volcanic rocks to Miocene's folded sediments and passes through the center of Kowsar City. Kowsar fault directs hot water solutions upwards and has caused alterations in Eocene's volcanic rocks. Development of the city must be planned based on the geomorphological risks in the area. Some residential buildings have been built close to the river's bed and channels have been tilted due to performance of Kowsar fault system. These two factors are also important risks. The lower Givi is situated on steep slope and is close to river's bed and a fault goes through the center of the city. Furthermore, it is situated on a Non-resistant formation and drop of gravels threaten the city.

Recommendations:

1. Experts and researchers are proposed to do studies on the natural talents of the area in order to recognize the natural capabilities.
2. We recommend that the risks of construction around fault area, landslide-prone areas, and flood-prone areas and … should be explained for local people in order to help them observe safety regulations in all civil activities and development of the city.
3. Evaluation of the behavior and zonation of landslide of slopes in the area by means of statistical models are also recommended.

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