An integrated risk assessment of the environmental hazards influence on Kazakhstan section (from Khorgas and Dostyk dry ports to Aktau seaport) of the international transport corridor

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Abstract. The article outlines research results on the assessment of natural hazards impact risk on the international transport corridors’ Kazakhstan section (from Khorgas and Dostyk dry ports to the seaport of Aktau) functioning. Based on the component-by-stage analysis of physical and geographical conditions with the use of qualimetric approach, the areas with different risk levels of natural disasters were identified. To minimize the risk of natural problems exposure, a set of environmental recommendations has been developed.

1. Introduction
In the context of modern globalization, a noticeable increase in the trade and ridership has been noted on the Eurasian continent [1]. Kazakhstan's advantageous geographical position as a land bridge between the main macroeconomic markets, such as China, Russia, the countries of European Union and Asia-Pacific region, significantly shortens cargo delivery time and increases the potential for transit opportunities and foreign trade balance of all the participants (figure 1). The implementation of the transit potential is one of the priority directions of the economic policy of Kazakhstan, which is crossed by six international transport corridors: Northern TARM, Central TAR, South TAR, North-South, Chongqing-Duisburg, TRACECA. Natural characteristics of the territories near transport corridors play an important role in the efficient and stable operation of the transit [2]. They can have both direct and indirect influence on the operation of the corridor. In order to provide possible convenient conditions for the international cargo transportation and trade and economic relations, on the assumption of the need to ensure a reliable and stable year-round communication, it was important to study the environmental risks that could affect international transport corridors’ capacity [3]. In this regard, it is important to study and assess the risks, identify areas of hazardous natural processes and develop recommendations for their minimization and safe transportation.
2. Assessment

The Kazakhstan section of the multimodal transport corridors from Khorgas and Dostyk to the Aktau port was studied, it includes sections of various types of transport - rail, road, pipeline, and their combination. International transport corridor’s total length within the territory of Kazakhstan is around 5424 km. The transport corridor passes through the territory of 8 administrative regions of Kazakhstan, including 47 administrative districts and 17 city akimats. The area of the investigated zone is approximately 522.8 thousand km². As of 01.01.2015, about 44% of the population of Kazakhstan or 7.8 million people live here [4].

The natural characteristics of the territories along which the transport corridor goes are quite diverse. The greater part of the corridor lies along the flat territory, the rest along the more dismembered foothill regions. The corridor is located within two natural zones - semi-deserts and deserts. The risk has been assessed as the hazardous natural phenomena and processes influence probability on the operation and the construction of the Kazakhstan section of the multimodal transport corridor [5]. To assess the risk, an exploratory activity, as well as a comprehensive analysis of the natural conditions including relief, climate, natural waters, soil and vegetation, were carried out.

To assess the risk of impact, main components of the natural environment were determined with indicators and quantitative parameters. To assess the relief impact on the functioning of the transport corridor, there were used the indicator of compartmentalization and exogenous processes exposure risk [6]. The climate is determined by the risk of extremely high and low air temperatures exposure, strong fogs, heavy rainfall and snowfalls, the risk of ice and frost, strong wind, heavy snowstorms and dust storms. For soils - the risk of soil degradation and the content of mobile metals. The indicators and quantitative parameters for risk levels of surface and ground waters, vegetation cover, are given as an example in tables 1, 2 [7, 8].

The risk levels (high, medium high, medium, medium low, low) of each of the components impact on the Kazakhstan section of the multimodal transport corridor were assessed based on the parameters of the natural environment analysis and mapped in ArcGIS10.2. A qualimetric approach was applied to the impact integrated assessment, which is related to the differences between components of the natural environment, because of their nature, scale and influence on each other. Using the method of analyzing the hierarchies (Analytic hierarchy process) of Thomas Saati the weight coefficients of each type of risk were defined (table 3) [9].
Table 1. Parameters for risk levels of surface and ground waters.

| Hazard type                  | Parameter                                      | Low risk level | Medium risk level | Medium high risk level | High risk level |
|------------------------------|------------------------------------------------|----------------|-------------------|------------------------|-----------------|
| Flooding                     | the repeatability of water level excess, %     | 10-50          | 5-10              | 2-5                    | < 2             |
|                              | maximum rising level, m                        | < 1            | 1-1.5             | 1.5-2                  | > 2             |
| Groundwater flooding         | depth, m                                       | > 5            | 3-5               | 2-3                    | < 2             |
|                              | relief compartmentalization, m                | > 50           | 10-50             | 5-10                   | < 2             |
| Rivers drying out            | The frequency of years with the rivers drying out, % | heavily drained | wasn’t observed | below 30               | 30-70 | over 70 |

Table 2. Parameters for risk levels of vegetation.

| Hazard type                  | Parameter                                      | Low risk level | Medium risk level | Medium high risk level | High risk level |
|------------------------------|------------------------------------------------|----------------|-------------------|------------------------|-----------------|
| Productivity reduction       | Productivity, % from average long-term values | <80            | 50-80             | 10-50                  | >10             |
| Foliage cover reduction      | Foliage cover, %                               | 50-80          | 15-30             | 10-15                  | >10             |
| Vegetation degradation from  | Average livestock density, livestock unit per km² | 0.3-0.68        | 6.8-20.4          | 20.4-36.1              | 36.1-109.6     |
| overgrazing                  | Fire frequencies                               | rare fires      | rare spotting fires | frequent fires, regeneration with a change of dominants | burnout of all layers |

Table 3. Weight coefficients of each type of natural risk.

| Risks            | Climate | Waters | Relief | Soils | Vegetation |
|------------------|---------|--------|--------|-------|------------|
| Climate          | 0       | 2      | 7      | 0     | 1          |
| Waters           | 9       | 0      | 7      | 2     | 1          |
| Relief           | 3       | 8      | 0      | 1     | 4          |
| Soils            | 8       | 6      | 8      | 0     | 7          |
| Vegetation       | 9       | 8      | 7      | 9     | 0          |
| **Total**        | **29**  | **24** | **29** | **12**| **13**     |
| **Proportion, %**| **100** | **83** | **100**| **41**| **45**     |

Taking the obtained results into account risk levels were recalculated and on their basis the integrated index that reflects the general risk of natural hazards impact was determined. They were calculated as the sum of scores of all types of risk: \( \Pi = \sum(G + M + H + S + P)/n \) where, \( \Pi \) –
integrated index; G – geomorphological risk level; M – meteorological risk level; H – hydrological risk level; S – soil risk level; P – vegetation risk level; n – the number of natural risks types

The integrated index is represented by 5 categories of risk of natural hazards impact on transit potential: from low to high. Based on the grading of the risk of natural hazards impact, a map of integrated risk was drawn up (figure 2).

Figure 2. Map of integrated risk of natural hazards impact on Kazakhstan section of the international multimodal transport corridor (from Khorgas and Dostyk dry ports to Aktau seaport).

3. Conclusion
Thus, the analysis showed that 45% of the investigated zone along the Kazakhstan section of the multimodal transport corridor is characterized by a low and a medium low risk of natural hazards. 17% of the transport corridor area is subjected to put at medium risk levels and 38% to medium high and high levels (figure 3). It should also be noted that their distribution across the corridor is uneven.

Figure 3. The diagram of risk levels proportion of natural hazards impact on the functioning of the Kazakh corridor section

The greatest dangers to the functioning of the transport corridor are the territories characterized by a dissected relief and a dense hydrographic system, where the risk of hydrological hazards is possible. This combination of natural conditions is typical for the foothill zones of southern and southeastern Kazakhstan (figure 2). These areas can be considered as ecotonic ones – with high biological diversity, so they are also characterized by a high level of vegetation degradation risk [10].

Risk for the sections of the transport corridor located in the immediate vicinity of large water bodies or a watercourse is increased, too. Significant danger is represented by the transport corridor
sections that run along the floodplain and alluvial-deltaic plain of the Syrdaria river, which is associated with a high risk of flooding.

The level of risk is significantly reduced for sparsely populated desert and semi-desert areas of the transport corridor with a predominantly flat terrain and a poor hydrographic system. Here there are only some areas that can be obtained due to the manifestations of climatic hazards: dust storms and heavy snowstorms (near the cities of Shalkar and Zhezkazgan), ice-frost phenomena (southern part of the Ulytau mount), strong fogs (near Lake Shalkar) [7].

Thus, a detailed assessment and mapping of the risk of possible natural hazards impact on multimodal transport corridor within the territory of Kazakhstan allowed the developing of a set of georeferenced and risk level depended recommendations to minimize the influence on the functioning of the transport corridor. The recommendations will contribute to increasing the security of cargo and passenger traffic and strengthening the transport potential of Kazakhstan from its western (seaport of Aktau) to eastern (dry port of Khorgas) "gateways".

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