ASSESS THE POTENTIAL TO DETERMINE THE VERTICAL AND HORIZONTAL AXES OF NATIONAL INFRASTRUCTURE

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Abstract: The development of our country's transport network is diffuse, with a concentration of population in a few settlements, creating an unbalanced or centralized system. For Mongolia, which has a small population, large territory, and abundant agricultural, natural, and mineral resources, the Regional Development Tool is important for the balanced development of its territory. In this context, many domestic and foreign scholars have identified the most effective way to develop the national transport network based on the axis. Proper placement and planning of the axis have the advantages of creating the human settlements, the main pillar city in settlements of the population, providing policy support, proper placement of the labor force, and has the advantage of regulating the flow of migration. In our country, the axial version has been proposed by many researchers, but it is not clear what rationale and methodology were used and which version is correct. Defining vertical and horizontal axes in Mongolia is important for spatial planning of national and regional development, and for accurate and scientifically based identification and planning of population, settlement development, and regional development policy documents to ensure inter-sectoral coordination. It will also be a basic indicator for the development and implementation of state policies and programs on roads and railways.

Keywords: National vertical and horizontal axes, Transportation-Logistic, Road, Railway, Regional development

Introduction

The development of our country's transport network is diffuse. As a result of socio-economic development, migration from rural to urban areas has led to population concentration in a few settlements, creating an unbalanced or centralized system (Bazargur D, et al, 2017). In order to reduce the migration, it is important to develop local infrastructure (Altanbagana M, et al, 2016), including the road network. Infrastructure development and further planning is an important factor in spatial planning for population and settlement development (Altanbagana M, et al, 2016). Therefore, researchers from the Institute of Geography of the Academy of Sciences (former name) proposed the "Concept of Axis Socio-Economic Development of Mongolia". The concept of axial development is considered to be a "basic" indicator for the development of strategic planning for the country's socio-economic development. Many foreign and domestic scientists have identified the most effective way to develop the spatial planning of the transport network based on the axis.

The concept of the axis

The national vertical and horizontal axes are not about inter-city or national or local roads, but a broader concept. In socio-economic geography, The linear development that forms the industrial-territorial complex which connecting the main points of overlap, attraction and intersection of industrial-technological, social and ecological areas; and they are interconnected is called the axis (Bazargur D., et al, 2000) . Proper placement and planning of the axis have the advantages of creating the

human settlements, the main pillar city in settlements of the population, providing policy support, proper placement of the labor force, has the advantage of regulating the flow of migration, develop freight turnover, information exchange and communication (Litvinov A.A & Kutyavin S.V, 2009). Within the framework of our basic research project on "Renewing and Developing of theoretical foundations, integrated approaches and methodology of the regional development of Mongolia", the concept of axis in Mongolia has been redefined based on social and economic needs, scientific and technological development trends, and external and internal conditions. The national vertical and horizontal axes are economic-infrastructure linear zone to increasing trade, freight turnover, and information exchange by connecting national and provincial cities to regional economic integration and the main axis, to enhance their role, to support the social and economic development of the region and the optimal spatial structure of population, settlement and labor force. In connection with the concept of axial development, let's take a look at the axial options proposed by policy planning and scientists in the past

1. The Concept of Regional Development of Mongolia (State Great Hural, 2001), approved by the Parliament in 2001, defines the axis as the basis for the development of central settlements. The principles of regulating urban location and development, preserving the space of nomadic and settled civilizations, ensuring a harmonious combination, making the economy socially and ecologically oriented, and connecting to international and intercontinental networks are defined as having 1 horizontal and 5 vertical axes.
2. Researchers from Dr. D. Bazargur and others believe that the basic conditions for the axis are railways and national roads. Its proposed 1 horizontal and 3 vertical axes using socio-economic factors such as road congestion, settlement density, axis baseline conditions, and infrastructure supply (Bazargur D., et al, 2000).
3. In 2019, the National Development Agency is developing a new Regional Development Policy (National Development Agency, 2019). Its proposed six vertical corridors and one horizontal corridor, taking into account the industrial development zone and the possibility of transport corridors connecting with neighboring countries.
4. In 2019, the Japan International Cooperation Agency (JICA) developed the "Comprehensive Development Plan of Mongolia" (Ministry of Construction and urban development, et al, 2019). The team of Japanese scientists proposed 7 vertical corridors using indicators such as number of soums, the number of people living within a radius of 20 km, the number of people per 1 sq / km, travel time, traffic congestion, the volume of exports, earthquakes, geological formations, dzud-affected areas, economic corridors and vertical corridors connecting with neighboring countries

In our country, the axial version has been proposed by many researchers, but it is not clear what rationale and methodology were used and which version is correct. Therefore, the purpose of the study is to determine the vertical and horizontal axes based on the potential assessment, which are located optimal at the regional level, have good geographical conditions for roads, connect major economic regions and centers with goods, production and population concentration, and have a transport and logistics networks. Defining vertical and horizontal axes in Mongolia is important for spatial planning of national and regional development,

and for accurate and scientifically based identification and planning of population, settlement development, and regional development policy documents to ensure inter-sectoral coordination. It will also be a basic indicator for the development and implementation of state policies and programs on roads and railways.

Method

In order to determine the national vertical and horizontal axes, the variants of the axes proposed by the researchers and approved in the framework of government policies and documents were studied. As a result, the possible 10 vertical and 6 horizontal axes in Mongolia are determined by the direction (Figure 1). Including vertical axes; I. Tsagaannuur - Ulgii - Khovd - Bulgan, II. Borshoo - Ulaangom - Khovd - Bulgan, III. Artssuuri - Tudevtei - Uliastai - Altai - Burgastai, IV. Hankh - Murun - Tosontsengel - Uliastai - Altai - Burgastai, V. Hankh - Murun - Kharkhorin - Arvaikheer - Shiveekhuren, VI. Baga-Ilenkh - Bulgan - Arvaikheer - Shiveekhuren, VII. Altanbulag - Darkhan - Ulaanbaatar - Mandalgobi - Tsogttsetsii - Gashuunsukhait, VIII. Altanbulag - Darkhan - Ulaanbaatar - Choir - Sainshand - Zamiin-Uud, IX. Ereentsav - Choibalsan - Baruun-Urt - Bichigt, X. Ulkhan - Choibalsan – Bichigt, Horizontal axes; 1. Tsagaannuur - Ulgii - Khovd - Uliastai - Tsetserleg - Ulaanbaatar, 2. Tsagaannuur - Ulgii - Khovd - Altai - Bayankhongor - Arvaikheer - Ulaanbaatar, 3. Borshoo - Ulaangom - Uliastai - Tsetserleg - Ulaanbaatar, 4. Sumber - Choibalsan - Chinggis - Ulaanbaatar, 5. Bichigt - Baruun-Urt - Chinggis - Ulaanbaatar, 6. Tsagaannuur - Ulgii - Khovd - Altai - Bayankhongor - Arvaikheer - Mandalgobi - Sainshand - Baruun-Urt - Choibalsan - Ereentsav

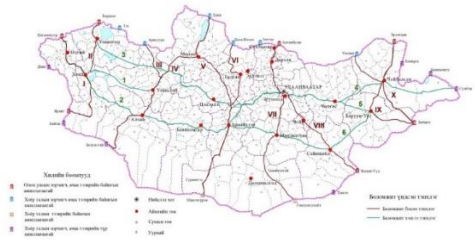

Figure 1. All possible variants of the national vertical and horizontal axes

In this study, we use information such as Central Asia Regional Economic Integration, Northeast Asian Regional Economic Integration, Mongolia-Russia-China Economic Corridor Program, population, city status, border crossings, number of vehicles and passengers, traffic intensity, suitability assessment of road network land, and industrial development zone. In evaluating the axes, 18 sub-indicators from a total of 9 groups were selected (Table 1). Multi criteria decision analysis based on a geographic information system was used to evaluate each indicator. Multi-criteria decision-making (MCA) is a decision-making tool using multiple qualitative or quantitative indicators. Multi-criteria decision-making is the most appropriate method for transportation-related assessments (Macharis C & Ampe J, 2011). The axial assessment using GIS was performed in two stages: first selecting the factors to be used in the assessment and establishing criteria for evaluating them, and second consolidating the assessment of each facto

Table 1. Criteria for determining the national vertical and horizontal axis, their rationale and scope

№	Indicators	Sub indicators	Main concepts	Rationale, Commentary, Scope
1	The number of population involved in the axis		At the regional level, the vertical and horizontal axes to support social and economic development are the main infrastructure to support the socio-economic development of cities and	**Rationale:** The vertical development of the axis and the demands of the nomads attracted to it create a "horizontal development" or an axial region (Bazargur

			settlements in the region, in addition to the basic infrastructure for transportation, freight turnover, exports, imports, foreign and domestic trade. In this context, for this axis, the number of population to be involved to the axis of the region is taken as a criterion.	D, et al, 2000). According to scientists, the impact zone of the road is 100 km. **Scope:** Covers the population of aimag centers and soums within 100 km of the axis.2019 population statistics will be used.
2	Cities located along the axis and at the node, the current state of their population, social and economic development	State and provincial level cities located along the axis and at the node Population growth in state and provincial level cities along the axis	Nationwide, 44% of the population lived in urban areas in 1970, 57% in 1990, and about 70% in 2019. The role of cities in the social and economic development of the region has increased dramatically. On the other hand, the axis is the infrastructure that supports the development of the those, passing through the major development strategies center of the region - cities, promising development potential soums and settlements. In this sense, the axis is the basis for the development of large cities and towns and regulates their location and development (Mongolian Development Research Support Center, 2001). In this context, one of the criteria for determining the social and economic significance of an axis is the location of major cities and settlements along the axis and at the node of infrastructure.	**Rationale:** Large and medium-sized settlements provide the basic conditions for the formation of the axis and the basis for territorial stability (Litvinov A.A & Kutyavin S.V, 2009). **Scope:** The Law on the Legal Status of Towns and Villages defines a city as a village with a population of 500-15,000, a city with a state or provincial status if it has a population of at least 15,000, and a city with a population of more than 50,000 (Law on the Legal Status of Urban and Rural Areas of Mongolia, 1993). Data sources will use data on cities, towns and their population, social and economic development.
3	Rank and classification of axis start and end border ports		The axis is to support the social and economic development of the region, as well as foreign trade, exports and imports. In other words, is the notion that the axis has an outlet. In this context, the classification, rank and capacity of the border crossing point at the start and end points of the axis are taken as one criterion. A border crossing is a point of contact between a country and a foreign country.	**Rationale:** "The main free zone between countries" will be established in the cities bordering Russia and China, which are the exits of the Axis. "Interstate Free Zones" will be established at the ports of communication between the peoples of the two neighboring territories. **Scope:** Free zones and border crossings are considered by classification, rank and capacity. It includes 21 permanent and temporary ports (Mongolian Logistics Association, 2018) .
4	Coherence of axes with foreign programs and policies (Connectivity and Coherence with Regional economic integration, economic corridors)	Central Asian regional economic integration Northeast Asian regional economic integration	Mongolia needs to take advantage of its geographical location to join the Central Asian Regional Economic Integration (CAREC) and the Northeast Asian Economic Integration (NEA). In 2015, the Government of Mongolia has approved the "Mongolian Foreign Economic Relations Program" and Article 3.1.3 of the program calls for joining the regional economic integration; 3.1.4 sets goals to mitigate the effects of landlocking and develop infrastructure (Government, 2015) . In this context, it depends on how Mongolia plans its vertical and horizontal infrastructure to join the Central Asian Regional Economic Integration (CAREC) and Northeast Asian Economic Integration (NEA).This axis should provide greater access to regional integration.	**Rationale:** The "Regions and Roads" initiative of the People's Republic of China and the road transport projects implemented by the Russian Government within the framework of the "Eurasian Economic Union" will be developed in coordination with the projects and programs to be implemented in Mongolia. This is fully in line with the government's goals and objectives of joining the Regional Economic Integration (Government, 2017). **Scope:** In the study, including Economic corridors 4a, 4b, 4c proposed by CAREC, Mongolia-Tianjin, Tumen River Corridor proposed by Northeast Asian Economic Integration and Mongolia-Russia-China Economic Corridor Program" proposed 3 roads and 6 railway corridors
		Mongolia-Russia-China Economic Corridor Program	China's "Regions and Roads" initiative and the Russian government's "Eurasian Economic Union" are initiating and implementing mega-projects in transport, energy and infrastructure. In line with these initiatives and mega-projects, the "Mongolia-Russia-China Economic Corridor Program" was approved by the Presidents of the three countries in Tashkent in 2016 (Mongolia-Russia-China Economic Corridor Program, 2016). Under this program, 13 projects (railway 6, road 4) are planned to be implemented in the transport infrastructure sector. In this context, one of the criteria for determining the axis overlaps with the road and rail	

			routes of the three countries economic corridor program.	
5	Connectivity of axis with international road network	Asian Highway network Connectivity of cross-lots to axes in China and Russia	One of the criteria for assessing the importance of the axis is that it coincides with the international road transport network and is connected to the main transport axes of Russia and China at the shortest distance from the Mongolian border.	**Rationale:** The axis selects "short distances" through as many "aimag and soum centers" as possible, and the ends of the main axis are connected to the "main axis" of the development of the two neighbors region (Bazargur D, et al, 2000). **Scope:** These include the AH3, AH4, and AH32 networks approved by international agreements (International agreements of Mongolia, 2005), 10 horizontal and vertical transport corridors in China, and transport corridors in Russia.
6	Sustainable zones and locations for industrial development along the axis	Light industry Food factory Heavy industry	Depending on the geographical location, nature and ecology, location of mineral resources of Mongolia, the zone and locations for the development of light, heavy and food industries are different. On the other hand, the axis must support the industry development strategy and planning. In other words, the Axis must be designed in line with the industrial development region. The state policy in the road transport sector (Government, 2018) states that the road network planning will be planned in accordance with the future traffic flow forecast, population, tourism zone and industrial planning. In this context, the importance of the axis increases if it transient a potential area for industrial development.	**Rationale:** Section 2.1 of the "Sustainable Development Concept of Mongolia-2030" "We will give priority to the development of agriculture, industry, tourism, and mining, and develop energy and infrastructure at first". In 2018, the Institute completed the "Development of Integrated Industrial Location Planning and Mapping Methodology (Institute of geography and geoecology, 2019). The work identified sustainable regions for the development of heavy, light, and food industries. **Scope:** The light industry includes leather, wool and cashmere processing plants, the food industry includes dairy products, flour and bakery products, meat and meat products processing plants and the heavy industry includes copper, oil and iron processing plants.
7	Assessment of the sustainable of the land for the construction of road and line networks along the axis		Depending on the natural conditions of Mongolia, the surface height increases from east to west. Due to this feature, surface roughness is relatively high in the western part of the country. The development of the road transport network is directly influenced by the height of the surface and the roughness. For example, increasing the height of the surface reduces the engine capacity, and increases fuel consumption, while in areas with high surface roughness, it can cause economic problems such as road cracks, snow in winter, and slippery roads region (Bazargur D, et al, 2000). In this context, the assessment of the sustainbility of land for road and line network construction is taken as one of the criteria. Significance increases when the axis route passes through an area sustainable for road and line networks construction.	**Rationale:** The development of the road network is influenced by natural conditions such as depressions, elevations and hydrological networks (Badambazar M, 1979). The more natural barriers, the higher the cost of road construction and the less economically viable it is (Bazargur D & Urantamir G, 2017) **Scope:** Sustainable land for road and line network construction was determined using a total of 13 indicators, including land surface, engineering geological assessment, and baseline land use assessment. The territory of Mongolia is divided into three categories: normal, difficult and very difficult to builds road and line networks (INJGEOTEK Kompany, 2016). The vertical and horizontal axes will be compared with the areas sustainable for the construction of the road and line network.
8	The current use of the axle	Freight turnover Passenger turnover Traffic intensity	The Axis is the main infrastructure for transportation, freight turnover, exports, imports, and foreign and domestic trade. Regular transportation between countries, regardless of the road surface conditions, is an advantage. In other words, the question is whether the axis can be used sustainably for various transport purposes. In this context, the road use conditions are taken as one of the parameters to determine the axis. Road use was assessed using three sub-criteria: freight turnover, passenger turnover, and traffic intensity. The greater the traffic intensity, freight and passenger turnover along the axis, the greater the importance of the axis.	**Rationale:** The axis is developed in order to develop the country evenly on the one hand and to increase international trade on the other. Therefore, it is important to develop a transport network that is used internationally and domestically for a variety of purposes. **Scope:** Based on passenger and freight information inbound and outbound the border crossing. 2019 statistics of border ports beginning and ending the axis will be used. 2016 and 2019 traffic intensity census data for each road route will be used.
9	Railway		In international transportation and trade railway freight plays a major role. The population, industry and services are being concentrated and developing rapidly along the main vertical road with the railway network of our country. Therefore ɜhe	**Rationale:** The basic conditions of the axis are railways and national road networks region (Bazargur D, et al, 2000). Most countries in the world use the railway network to transport large amounts of cargo between country by land. Therefore,

		combined development of road and rail networks will have an advantage in axial development. Therefore, the railway was taken as a separate criterion	it is important that the axis based on the rail network **Scope:** The country has a network of 1,815 km of railways, based on spatial data from the network.

Results

The potentials of the national vertical and horizontal axes were assessed using 18 indicators from a total of 9 groups. As a result of the assessment, the vertical Tsagaannuur - Ulgii - Khovd - Bulgan, Altanbulag - Sukhbaatar - Darkhan - Ulaanbaatar - Choir - Sainshand - Zamiin-Uud, Altanbulag - Sukhbaatar - Darkhan - Ulaanbaatar - Mandalgobi - Tsogttsetsii - Gashuunsukhait, horizantal Ereentsav - Choibalsan - Baruun-Urt - Tsagaannuur - Ulgii - Khovd - Altai - Bayankhongor - Arvaikheer - Ulaanbaatar - Chinggis - Choibalsan - Sumber axes are getting good marks, while vertical Borshoo - Ulaangom - Khovd - Bulgan, Khankh - Murun - Tosontsengel – Uliastai - Altai - Burgastai, Hankh - Murun - Kharkhorin - Arvaikheer - Shiveekhuren, horizontal Tsagaannuur - Ulgii - Khovd Uliastai - Tsetserleg - Ulaanbaatar, Bichigt - Baruun-Urt - Chinggis - Ulaanbaatar axes are rated as medium (Figure 2).

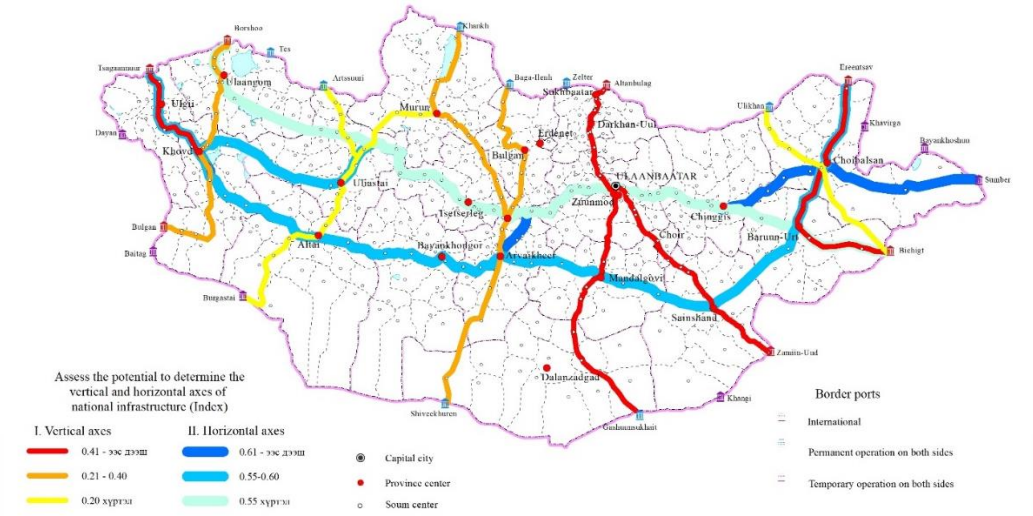

Figure 2. Assess the potential to determine the vertical and horizontal axes of national infrastructure

Conclusion

The potentials of the national vertical and horizontal axes were assessed using 18 indicators from a total of 9 groups. Tsagaannuur - Ulgii - Khovd - Bulgan in the western part of Mongolia, Altanbulag - Ulaanbaatar - Sainshand - Zamyn-Uud in the central part, Ulaanbaatar - Mandalgobi - Tsogttsetsii - Gashuunsukhait, Ereentsav - Choibalsan - Baruun-Urt - Bichigt vertical axes in the eastern part is have more development potential. Research shows that these axes are the main directions for intensifying international trade and transportation, supporting national and regional social and economic development, and creating economic growth. In the horizontal direction, the Tsagaanuur-Ulgii-Khovd-Altai-Bayankhongor-Arvaikheer-Ulaanbaatar-Chinggis-Choibalsan-Sumber axes have more potential. This axis is important for the balanced development of the territory

and the creation of favorable conditions for the settlement of the population.

The proposed vertical and horizontal axes are the basis for spatial planning of national and regional development, as well as a scientific basis for the government to develop a general project on population and settlement development and regional development policy in Mongolia. As a result of the assessment, the vertical Borshoo - Ulaangom - Khovd - Bulgan, Hankh - Murun - Tosontsengel - Uliastai - Altai - Burgastai, Hankh - Murun - Kharkhorin - Arvaikheer - Shiveekhuren, horzantal Tsagaannuur - Ulgii - Khovd - Uliastai - Tsetserleg - Ulaanbaatar, Bichigt - Baruun-Urt - Chinggis - Ulaanbaatar axes are rated as medium. These axes can be developed as sub-axes for special purposes (tourism, mining, intercity transportation).

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