THE IMPACT OF CLIMATE CHANGE ON THE EFFICIENCY OF THE TRANSPORT SECTOR AND WAYS TO REDUCE IT

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The aim is to review the impact of climatic manifestations on the indicators of the transport sector and analyze ways to reduce it. Transport is one of the most weather-dependent sectors of the national economy. All sorts of climate change, whether high or low, in one way or another negatively affect the performance of the transport sector and additional sources of funding are required to reduce their impact. The transport sector has traditionally been predominantly publicly funded area. This is due to the strategic importance of the transport infrastructure for the socio-economic development and the defense capability of the country. Today the main sources of funding are subsidies and subventions from the state budget, tax revenues and additional (alternative) sources. One of the mechanisms for raising funds can be public-private partnerships and legislative consolidation of tax benefits for recipients of donations to the transport sector. Among the representatives of private capital there is a number of entrepreneurs who are directly interested in the development of transportation as a part of their business.

Keywords: *transport, infrastructure, climate, efficiency, public-private partnership.*

Of all sectors of the economy, transport is one of the most dependent on climatic conditions, and it is vulnerable not only to extreme events, but also to the so-called “slow-moving” adverse processes [1].

All climatic manifestations in one way or another negatively affect the efficiency of the transport sector. The most significant are:

- ✓ heavy rains;
- ✓ fog;
- ✓ snow drifts;
- ✓ snow avalanches;
- ✓ blizzards;
- ✓ sandstorms, etc.

On the other hand, heavy rainfall affects the condition:

- ✓ roads and railways;
- ✓ bridges;
- ✓ tunnels;
- ✓ drainage systems.

The Republic of Tajikistan is characterized by the following factors affecting the efficiency of the transport sector;

- ✓ frequent temperature changes destroy the road surface;
- ✓ heat waves and very hot days can cause thermal expansion of joints in bridges, warping of road surfaces and deformation of railway tracks.
- ✓ high summer temperature causes softening of the asphalt pavement, and also lead to restrictions on the take-off weight of air transport, especially in high-altitude airports with insufficient runway lengths, that leads to flight cancellations or reduced payloads;
- ✓ warming in the mountains can lead to the melting of glaciers, which in turn can cause mudflows and the destruction of transport communications;
- ✓ heavy rainfall in the form of snow or rain can overload drainage systems, wash roads, damage railway embankments and cause landslides. It can also lead to the failure in the mode of operation of the entire transport sector;
- ✓ overall reduction in precipitation can exacerbate drought and put infrastructure at risk of forest fires and, as a result, landslides. Visibility at airports close to fire hazard areas will decrease.

Weather and climatic factors (for example, negative phenomena) affect the condition of roads and traffic conditions as follows:

- ✓ The coupling qualities of the coating are reduced, the interaction of the vehicle with the road is changing, the evenness of the coating is deteriorating under the influence of precipitation, ice, fog, high humidity and other factors.
- ✓ Resistance to movement increases due to deposits of snow, dirt, roughnesses on the road, as a result of which the free power of the car engine is reduced.
- ✓ The shape and appearance of the carriageway and roadsides, the parameters of the transverse profile due to snow deposits and the formation of coastlines change, which leads to a change in the perception of the road by the driver.
- ✓ The meteorological visibility during the period of fogs, precipitation, snowstorm, dust storms, blinding action of the sun is reduced, which leads to a change in the perception of driving conditions by drivers.
- ✓ The operational and technical qualities of vehicles are deteriorating, especially systems that provide comfort and safety, which include the brake system, steering, visibility, and the alarm system.

The main impacts of hazardous geocryological processes on objects of transport infrastructure can be divided into three groups [2] [3]:

1) pressure on the perceiving surface of transport structures, due to shifts of large tracts of soil (landslides, curums, etc.);

2) the formation of voids in the soil, which leads to a significant change in the stress-strain state of the transport object or its foundation (thermokarst, erosion processes, karst, etc.);

3) violation of the road and railroad tracks, aerodrome coatings, infrastructure of sea and river ports (ice, flooding, etc.).

Transport is one of the most weather-dependent sectors of the economy. This is especially true for air transport, which requires the most complete, detailed weather information, both about what is observed and what is expected from the forecast, to ensure normal operation. The specificity of transport requirements for meteorological information lies in the breadth of weather information - the routes of air, sea vessels and automobile cargo transportation have a length measured in many hundreds and thousands of kilometers; in addition, weather conditions have a decisive influence not only on the economic performance of vehicles, but also on traffic safety; life and health of people often depend on weather conditions and the quality of information about it.

Natural disasters affecting the functioning of transport:

1. Avalanche - fast descent or collapse (collapse) of snow cover from a steep mountain slope.

2. *Sel* is a stream of stones, mineral particles and rock fragments, descending from the hills due to the rapid melting of snow or prolonged rainfall. In common parlance, the mudflow is called a “mud stream”.

3. A landslide is the separation and fall of large masses of rocks on the steep and steep slopes of the mountains.

4. Rockfalls. Separation of scree - accumulation of stones on the slopes of mountains and rocks, as well as accumulation of rock fragments of various sizes on the slopes or at the foot of mountains and hills.

5. Flooding - water flooding of the area adjacent to the river and other significant water sources. Because of floods, significant material damage is caused, damage to human health, including death.

6. A hurricane is violent storm with a circular winds of at least 120 km per hour.. The destructive power of hurricanes is created by a very high-speed wind, which carries significant masses of water, mud and sand.

7. Tornadoes, in contact with the surface of the earth, cause the same damage as severe hurricanes, but in much smaller areas.

8. Dust storms caused by the wind, with a speed of 62–101 km. per hour, cover fields, settlements and roads with a layer of dust and sand.

9. A blizzard is one of the varieties of a hurricane, characterized by significant wind speeds, which contributes to the movement of huge masses of snow through the air, has a relatively narrow range (up to several tens of kilometers). During a storm, visibility sharply deteriorates, both intercity and intercity transport communications may be interrupted.

The most typical natural disasters for the conditions of the Republic of Tajikistan are: avalanches; sat down; landslides; rockfalls and floods.

To protect the transport infrastructure from the negative impact of emergency situations, a series of measures are being taken to prevent damage to airports, roads, structures at them and vehicles to ensure convenient and safe traffic.

Preventive measures for protection against mudflows include:

1. Prohibition of blasting in the area of possible mudflows (when laying roads and railways);

2. Prohibition of quarrying for the extraction of sand, clay, stone in the mudflow zone with blasting;

3. Prohibition of civil and military-technical construction of buildings and structures in the mudflow zone;

4. Monitoring the condition of the slopes;

5. Protection of mountain pastures, forest stands (trees, shrubs) and grass on the slopes;

6. Installation of warning signs and inscriptions in and near the mudflow zone.

7. Planting trees and shrubs with a powerful root system directly in the mudflow zone and around the perimeter of its upper part;

8. The construction of special engineering and hydrotechnical facilities that either delay the mass of rocks or divert them away from buildings and roads.

There is a set of means to protect roads from avalanches. Most of them should be provided at the design stage and implemented during its construction. All structures, devices and means of

protecting roads from avalanches by their purpose can be divided into five groups:

1. The first (way of solution) group of means is designed to prevent snow from getting during the blizzards to the avalanche slope, to keep it on the approach to the slope (for this purpose snow-holding forest stands or fences on mountain plateaus suitable for steep slopes are arranged).

2. The second (way of solution)group of funds is designed to prevent snow deposits on the top of the avalanche hazardous slope, to remove snow from this site (for this purpose, fences of snow-transmitting or snow-blowing action are arranged).

3. The third (way of solution) group of tools is designed to keep the snow on the slope, to prevent or slow down its slipping (for this purpose they arrange terraces, earthen ramparts and dams, install snow-retardant fences, kolktafely, planted on the slope of afforestation).

4. The fourth (way of solution)group of means is intended to reduce the mass and energy of a descending avalanche, to divide it into parts and to direct their movement in different directions, to reduce the speed of movement, to take the impact of an avalanche on oneself (for this purpose avalanche cutters, fenders and fenders with snow protection dams).

5. The fifth (way of solution)group of tools is designed to let an avalanche flow over the road (for this purpose, avalanche galleries, canopies and tunnels are built).

Measures to prevent and reduce damage from landslides, rockfalls and landslides.

1. Observations of the condition of the slopes;

2. Prohibition of construction in areas of possible landslides and landslides;

3. Protection of mountain pastures, plantations and grass on the slopes;

4. Planting trees with a branched root system and deeply penetrating roots in combination with shrubs. Such plantings in zones dangerous for landslides and landslides give a double effect: firstly, they strengthen the soil with roots, and secondly, they actively absorb water, preventing overmoistening;

5. The construction of special engineering and hydrotechnical facilities in order to avoid the descending mass of landslides and landslides over the road (galleries, canopies and tunnels).

Important measures to protect transport communications from floods are:

1. The construction of special flood-control reservoirs that are used to redistribute the maximum runoff of their useful volumes;

2. The construction of enclosing dams (shafts);

3. Carrying out channel straightening works;

4. Plowing land across slopes and planting forest shelterbelts in river basins;

5. Terracing of slopes, preservation of woody and shrubby vegetation;

6. Construction of mountain roads at a considerable height from the level of rivers.

As follows from the above analysis, in order to reduce the negative impact of climate change on the transport sector, it is necessary to take appropriate measures that require significant investment.

– International cooperations play an important role in mitigating the effects of climate change, contributes to the implementation of the main provisions of the National Program at the national level and includes:

– increasing the country's potential in climate change activities;

– expanding cooperations with foreign and international partners on the implementation of measures developed by the UNFCCC to reduce emissions of GHG (greenhouse gases);

– attracting foreign investments to adapt the transport sector to climate change.

The transport sector has traditionally been an area mainly funded by public funds. This is due to the strategic importance of transport infrastructure for socio-economic development and the country's defense.

Today, the main sources of financing are subsidies and subventions from the state budget, tax revenues and additional (alternative) sources.

In addition to allocations from the state fund, financial support is provided from private capital, external investments, income from toll roads, bond loans and voluntary donations.

One of the mechanisms for raising funds may be public-private partnerships and legislative fixation of tax benefits for recipients of donations to the transport sector. Among representatives of private capital there is a layer of entrepreneurs who are directly interested in the development of transportation, as part of their business.

Total spending for the medium term from 2015 to 2030 is projected at $ 6671.5 million. Medium-term expenses until 2030 are distributed as follows: roads require $ 2,400 million, railways require $ 3,400 million, and civil aviation require $ 680 million. The state’s contribution in this period is estimated at $ 3,760 million, which will be spent on: roads - $ 1,600 million (including $ 912 million for maintenance), and $ 2,100 million for railways (in including 42 million US dollars for maintenance),

for civil aviation - 240 million US dollars, for the development of container terminals and logistics centers for multimodal transportation - 60 million US dollars [4].

It is estimated that the remaining $ 2,900 million will be financed from external funds until the establishment of self-sufficiency mechanisms.

Long-term expenses are associated with the construction of strategic railways, the establishment of unmanned aerial vehicles in the Republic of Tajikistan, the restoration and construction of airfields and container terminals, the further development of road, rail and air transport, the construction of the subway in Dushanbe.

Risks of climate change for transport communications

1. Climate change risks for transport communications in our country may arise as a result of:

- increase in temperature;
- changes in precipitation;
- changes in wind speed;
- increase water levels in rivers, floods;
- changes in solar radiation;
- melting glaciers;
- excessive snowfall,
- avalanches;
- sat down and landslides.

Climatic risks can become apparent during the implementation and operation of the project, lead to losses for the infrastructure, reduced productivity, or lead to higher maintenance requirements and costs.

2. Extreme climatic events can increase the risk of stopping the transportation process.

3. A change in flow direction due to changes in precipitation can have a serious impact on road infrastructure. There may be direct damage during and immediately after precipitation. They can generate problems for the structural integrity and maintenance of roads, bridges, drainage systems and tunnels, which necessitates more frequent repairs and reconstruction.

4. Frequent temperature changes destroy the road surface. An increase in the frequency and severity of hot days can lead to a rut on the roads, as well as the outflow of liquid asphalt (flushing and flow) on the pavement of old or poorly constructed roads. The increase in frost-thaw cycles in the mountainous regions of the country can increase road degradation.

5. Climate change is a reality and the motor transport sector with its infrastructure, as the main sector of the country's transport sector, must be resistant to climate change.

Table 1.

Hazards, vulnerabilities and adaptive capacity of Tajikistan's transport sector to climate change.

Climate change	Dangers	Sector vulnerability	Adaptation potential
Warming in Central Asia is above global average	The increase in average temperature in the lowland regions from 0.5 to 0.8 ° C and temperature in the mountainous regions from 0.3 to 0.5 ° C over a period of 60 years	• Melting glaciers; • Rural landslides	A very limited understanding of exactly how these climate changes will affect people, life and livelihoods in Tajikistan. Poor understanding coupled with limited resource problems has led to poor adaptability to climate change. These problems are compounded by the fact that in almost all areas there is very little scientific evidence and data, which makes the adoption of adequate adaptive measures impossible. Gaps in the main institutional structures include: - Lack of climate change risk integration in the
An increase in the frequency and severity of hot days and a decrease in summer precipitation	The number of hot days increased but decreased with precipitation.	An increase in the frequency and severity of hot days can lead to a rut on the roads, as well as the outflow of liquid asphalt (flushing and flow) on the pavement of old or poorly constructed roads.	
temperature increase precipitation changes; changes in wind speed; rising water levels in rivers, floods; changes in solar radiation; melting glaciers; excessive snowfall,	Expert estimates of expected climate change suggest an increase of 5-14 percent, as well as fumes of 10-20 percent	Inadequate availability of water for agricultural production.	

Climate change	Dangers	Sector vulnerability	Adaptation potential
avalanches; sat down and landslides.			framework of national development strategies and sectoral investment plans. - Weakness of national systems for the collection and processing of meteorological and hydrological data, with serious consequences, so that the immediate and long-term climate change trend can be analyzed, as well as limited access to climate change information; - Low awareness of government officials, academic institutions, business and the public about the negative effects of the risks and impacts of climate change, as well as limited technical skills
Decrease in snow cover and ice	Long periods, for example, from 1970-1984, low rainfall.	Direct impact on the availability of water in rivers, the size of floods and the level of moisture in the soil, which leads to less available water, for other sectors - energy and agriculture	
An increase in the frequency and intensity of extreme events, in particular, heavy rains causing landslides and severe floods	Heavy rains, floods caused by mudflows, high air temperatures, accompanied by droughts, strong winds and dust storms, frosts and extreme cold temperatures cause the greatest damage to agriculture.	• Difficulties in agriculture, problems such as irreparable damage to the cotton crop, especially in spring. • Flood increase causes precipitation to fill irrigation infrastructure • Hail damages plants, breaks stems, reducing the quality and yield of crops	

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ТАЪСИРИ ТАҒИРЁБИИ ИҚЛИМ БА ФАЪОЛИЯТИ БАХШИ НАҚЛИЁТ ВА РОҲҲОИ КОҲИШ ДОДАНИ ОН

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Мақсад асосим мақолаи мазкур, ин баррасии таъсири зуҳуроти иқлим ба нишондиҳандаҳои сектори нақлиёт ва таҳлили роҳҳои коҳиш додани он мебошад. Нақлиёт яке аз соҳаҳои иқтисоди миллӣ мебошад, ки фаъолияти он аз иқлим вобастагии ҳаматарафа дорад. Тағйири иқлим, дар кадом шакле, ки набошаб,ба ин ё он тарз, ба фаъолияти бахши нақлиёт таъсири манфӣ мерасонанд ва барои коҳиш додани таъсири онҳо манбаъҳои иловагии маблағгузорӣ талаб карда мешавад. Соҳаи нақлиёт таърихан , сохтори давлатӣ буда, асосан аз ҷониби давлат маблағгузорӣ мешавад. Ин ба аҳамияти стратегии инфрасохтори нақлиётӣ барои рушди иҷтимоию иқтисодӣ ва қобилияти мудофиавии кишвар вобаста аст. Имрӯз манбаъҳои асосии маблағгузорӣ, субсидияҳо ва субвенсияҳо аз ҳисоби буҷети давлатӣ, даромадҳои андоз ва манбаъҳои иловагӣ (алтернативӣ) мебошанд. Яке аз механизмҳои ҷалби маблағ ин шарикии давлат бо сармоягузорони хусусӣ ва консолидатсияи қонунгузорӣ андар имтиёзҳои андоз барои гирандагони хайрия дар бахши нақлиёт мебошад. Дар байни намояндагони капитали хусусӣ як қатор соҳибкороне ҳастанд, ки бевосита ба рушди нақлиёт ҳамчун як қисми тиҷорати худ манфиатдоранд.

Калимаҳои калидӣ: нақлиёт, инфрасохтор, иқлим, самаранокӣ, шарикии давлат ва бахши хусусӣ.

ВЛИЯНИЕ ИЗМЕНЕНИЯ КЛИМАТА НА РАБОТОСПОСОБНОСТЬ ТРАНСПОРТНОГО СЕКТОРА И ПУТИ ЕГО СНИЖЕНИЯ

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Основная цель – обзор влияние климатических проявлений на работоспособность транспортного сектора и анализ пути его снижения. Транспорт - одна из наиболее зависимых от погоды отраслей народного хозяйства. Все климатические проявления так или иначе отрицательно воздействуют на работоспособность транспортного сектора и для снижения их воздействия требуется дополнительные источники финансирования. Транспортная сфера традиционно является областью, преимущественно финансируемой за счет государственных средств. Это обусловлено стратегическим значением транспортной инфраструктуры для социально-экономического развития и обороноспособности страны. На сегодняшний день основными источниками финансирования являются субсидии и субвенции из государственного бюджета, налоговые поступления и дополнительные (альтернативные) источники. Одним из механизмов привлечения средств может стать государственно-частное партнерство и законодательное закрепление налоговых льгот для адресатов пожертвований в транспортную сферу. Среди представителей частного капитала есть слой предпринимателей, которые напрямую заинтересованы в развитии транспортных перевозок, как составляющей своего бизнеса.

Ключевые слова: транспорт, инфраструктура, климат, работоспособность, государственно-частное партнерство.

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METHODOLOGY OF OPTIMIZING PLACEMENT OF MOBILE CAR SERVICE STATIONS IN SPARSELY POPULATED AREAS

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The article deals with the development of a method of optimizing placement of mobile car maintenance stations (MMSs) in sparsely populated areas. The method includes the analysis of the territorial location of settlements, number of vehicles in those settlements, calculation of the MCSS travel time between settlements, determination of the optimum base site for MMS by a series of criteria.

Key words: *method, mobile car service, optimizing, sparsely populated areas.*

1. Introduction: The necessity of the development of a method of optimizing placement of mobile car maintenance stations (MMSs) is caused by undercoverage of cars in sparsely populated areas with technical services, therefore, the number of road traffic accidents (RTAs) increases due to faulty condition of vehicles. One of the main measures to ensure operability of vehicles is carrying out scheduled maintenance including obligatory state maintenance [1]. In the Republic of Tajikistan, there are many sparsely populated areas, for example, to the Republic of Tajikistan, in which the creation of points maintenance is not economically feasible [7].

Therefore, creation of mobile maintenance stations makes sense, temporary base sites of which will be in direct proximity to the territorial placement of vehicles.

2. Main text: The territorial placement of mobile car maintenance stations base sites is defined by three factors:

- demand of the population for maintenance in mobile stations;
- territorial dispersion of settlements where vehicles are situated;
- technical capabilities of rendering this service by means of MMS.

When solving tasks of choice of the optimum territorial placement of service facilities, geoinformational technologies [1] and linear mathematical programming methods [2, 3] are applied.

Let us assume that according to the administrative territorial division, there are N districts in the region. Each district is the location of consumers — owners of vehicles, living in n settlements. Let us denote the time of accessibility to mobile car maintenance stations base site j for inhabitants of settlement i through t_{ij}. The total