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NATIONAL AND INTERNATIONAL EXPERIENCE REGARDING DEVELOPMENT OF BICYCLE INFRASTRUCTURE

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Abstract. Cyclists, together with pedestrians, as traffic participants, are the most vulnerable. Every year in the world over 40000 cyclists die on the roads, which represents approximately 3% of the number of people who died in road accidents. Ensuring the safety, including of these road users, must be part of the basic priorities of any country. The development of bicycle infrastructure brings social, economic and ecological benefits. The article presents a brief description and analysis of state programs in some countries and in Republic of Moldova (the city of Chisinau) regarding the development of cycling in urban road traffic.

Keywords: *bicycle infrastructure, road accidents, traffic accidents, cyclists, traffic participants, cycle lane.*

Rezumat. Bicicliștii împreună cu pietonii, ca participanți la trafic, sunt cei mai vulnerabili. Anual în lume mor pe drumuri peste 40000 de bicicliști, ceea ce reprezintă aproximativ 3% din numărul persoanelor decedate în accidentele rutiere. Asigurarea securității, inclusiv a acestor participanți la trafic, trebuie să facă parte dintre prioritățile de bază ale oricărei țări. Dezvoltarea infrastructurii de biciclete aduce beneficii atât sociale, cât economice și ecologice. Articolul cuprinde o descriere și analiză succintă a programelor de stat în unele țări și în Republica Moldova (orașul Chișinău) privind dezvoltarea ciclismului în traficul rutier urban.

Cuvinte cheie: *infrastructura de biciclete, accidente rutiere, accidente de circulație, bicicliști, participanți la trafic, pistă pentru bicicliști.*

1. Introduction

Modern cities are growing very rapidly, Chisinau not being an exception, and together with them the number of vehicles is growing, at a rate where the road infrastructure does not keep up with them. According to official data on 01.08.2022, 335617 vehicles were registered in Chisinau municipality [1] (239359 cars, 56000 trucks, 7106 minibuses and buses, 6006 tractors, 7480 motorcycles, 15036 trailers and 4630 semi-trailers) with an official population

of 870093 inhabitants [2]. So, in Chisinau there are about 386 vehicles per 1000 inhabitants, at the recommended norms of 60...80 cars per 1000 inhabitants [3].

Despite the rapid motorization of most countries of the world, in many cases reaching the maximum value (over 600 automobiles per 1000 inhabitants), the bicycle as a vehicle has not lost its significance. In 1990, in the USA, the Netherlands, Japan, China, there were more than 400 bicycles per 1000 inhabitants. The largest area of bicycle use for work and business travel is typical for countries in the Asian region. For example, in Hanoi (Vietnam) the saturation level of these vehicles exceeds 480 bicycles per 1000 inhabitants, and in Ho Chi Minh City – 530 bicycles per 1000 inhabitants. At the same time, the maximum traffic intensity of cyclists on some streets reaches 5000...15000 un/h [4].

The safest are the bicycle lanes organized outside the carriageway of highways and city streets. The lane for cyclists must be allocated on the streets in the form of a lane separated from the roadway (*figure 1, a*) or an extreme lane of the sidewalk or parallel to the sidewalk and separated from the roadway by a green lane (Figure 1, b) [4-7].



Figure 1. Lanes for cyclists [4-6]:

- a) – track for cyclists separated from the road by a green strip; b) – track for cyclists parallel to the pavement and separated from the road by a green strip.

Also, tracks for cyclists can be combined with tracks for pedestrians (Figure 2, a). In restricted road conditions, including entrances to artificial constructions, the track for cyclists can, as an exception, be located near the edge of the road, but separated from it by a curb with a height of at least 0,25 m or by a road marking (Figure 2, b) [4-7].



Figure 2. Tracks for cyclists [4-6]:

- a) – track for cyclists combined with the track for pedestrians; b) – track for cyclists separated from the road by a curb or road marking.

Bike tracks can be designed for one-way traffic (with width not less than 1.2 m) or for two-way traffic (with width at least 2.5 m). The longitudinal gradients of the tracks for cyclists must not exceed 5%. The most difficult thing is to ensure safety at intersections with road flows. In accordance with international experience, it is possible to use traffic lights for cyclists on specially designed tracks that intersect the carriageway. Such directed intersections are unacceptable to be organized on streets with continuous traffic and high speed. As a rule, the green phase of the traffic light for cyclists must coincide with the red phase of the traffic light of the main direction of traffic.

2. Statistics of road traffic accidents

The rapid urbanization as well as motorization of the population in the world is accompanied by an rise of the number of road traffic accidents, which results in people die, people traumatized and people injured. According to appraisals, every year in the world in road traffic accidents die more than 40000 cyclists representing about 3% of the overall deaths in road traffic accidents (Figure 3). Among those who died in traffic accidents 29% belong to car drivers and passengers, 28% to motorcyclists, 23% to pedestrians, and the remaining 17% to other road traffic participants [8-14].

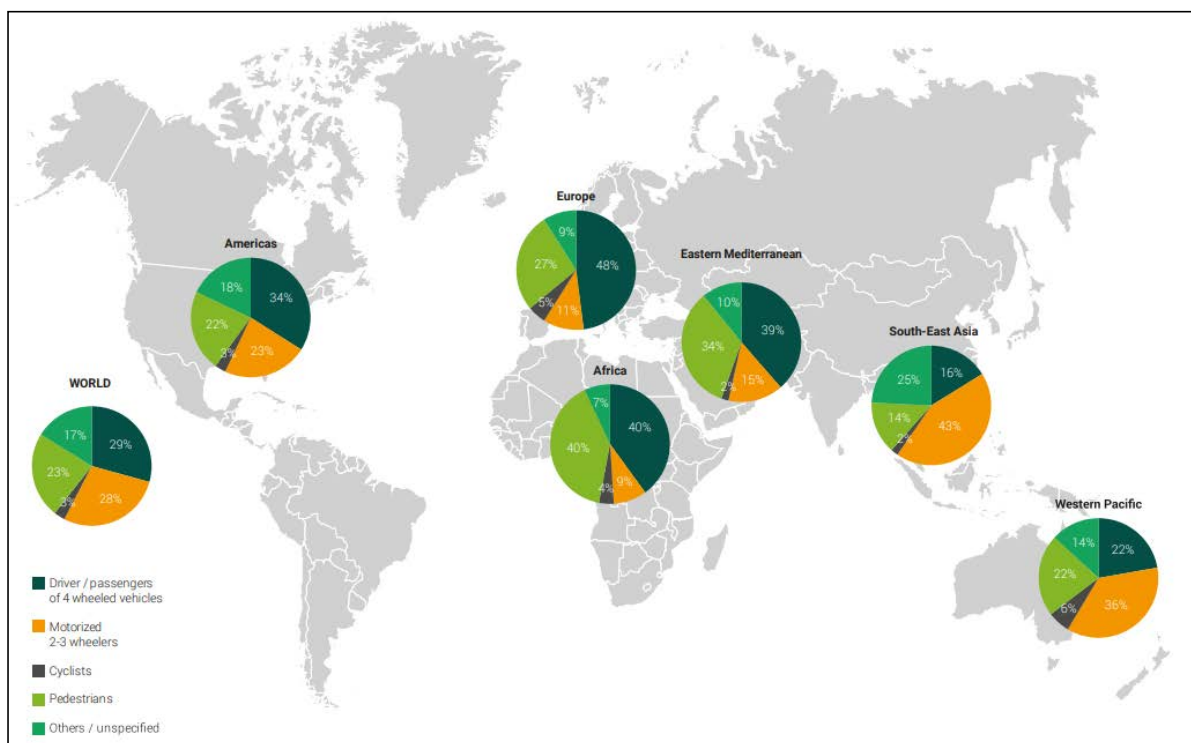


Figure 3. Distribution of deaths by categories of road users by WHO (World Health Organization) regions [9, 13, 14].

The situation differs significantly among world regions. The value of income influence the percent of the victims in traffic accidents. So, the low and middle-income countries has a higher rate victims, such as pedestrians, cyclists, drivers and passengers of motorized two and three-wheeled vehicles, than in high-income countries. For example, 40% of all road traffic fatalities are pedestrians according to WHO for African Region, and in the WHO Western Pacific Region 36% are motorcyclists, which are drivers and passengers of 2- or 3-wheeled motorized vehicles (Figure 3). Car drivers and an car passengers represent 16% of those killed in road traffic accidents in the Southeast Asian Region and 48% in the European Region [8-14].

The WHO region with the highest proportion of cyclist deaths in road accidents is the Western Pacific Region with 6%, followed by the European Region with 5%, the African Region with 4%, the American Region with 3%, the Eastern Mediterranean Region and the Asian Region with Southeast with 2% each [8-14].

Between 2000 and 2020, 2438 (about 106 per year) road accidents involving cyclists were recorded in the Republic of Moldova, which is about 4.11% of the overall accidents (Table 1) [13-27].

The accident situation in the Republic of Moldova took a negative direction during the last 5 years (Table 1), when the number of road accidents involving cyclists suddenly increased from year to year, registering 794 (about 159 per year) road accidents, which is about 6.58% of the total number of accidents in the mentioned period, exceeding by 1.9 times the percentage average of the previous period (years 2000-2017). In the years 2020 and 2022, the highest annual share of the number of road accidents involving cyclists from the total number of accidents was recorded, respectively 8.09% and 7.92%. 2021 is the year with the highest number of road accidents involving cyclists in the period 2000-2022.

Table 1

Frequency of road accidents in the Republic of Moldova (years 2000–2022)

The year	Road accidents in total	Road accidents involving cyclists	% of the total number of road accidents	The year	Road accidents in total	Road accidents involving cyclists	% of the total number of road accidents
2000	2580	112	4.34	2012	2712	82	3.02
2001	2666	117	4.39	2013	2603	79	3.03
2002	2899	102	3.52	2014	2564	85	3.32
2003	2670	99	3.71	2015	2527	80	3.17
2004	2447	78	3.19	2016	2479	66	2.66
2005	2289	88	3.84	2017	2640	66	2.50
2006	2298	85	3.70	2018	2615	111	4.24
2007	2437	86	3.53	2019	2585	152	5.88
2008	2875	111	3.86	2020	2003	162	8.09
2009	2755	110	3.99	2021	2548	186	7.30
2010	2930	118	4.03	2022	2312	183	7.92
2011	2826	80	2.83	Total	59260	2438	4.11

The statistical analysis of road accidents involving cyclists in the period 2008–2022 (Table 2) [13-15, 17-19, 21-26] in the Republic of Moldova shows that 188 (about 13 per year) cyclists died as a result, and another 1516 (about 101 per year) were traumatized.

After a more disastrous period of the years 2008-2013, when between 14-18 cyclists died in road accidents, a more „quiet” period followed, the years 2014-2018 (except for 2016), when they were registered between 6-9 deceased cyclists (Figure 4). Starting from 2019, the number of cyclists who lose their lives in road accidents has started to increase sharply again. In 2022, the number of cyclists killed in road accidents is 2.3 times higher than in 2017 and 2.7 times higher than in 2014.

Table 2

Number of cyclists killed and injured in road accidents in the Republic of Moldova (years 2008–2022)

The year	Totally die in road accidents	Cyclists killed in road accidents	% of the total number of dead	Totally traumatized in road accidents	Cyclists injured in road accidents	% of the total number of traumatized	Coefficient of severity of road accident consequences
2008	508	15	2.95	3511	95	2.71	13.64
2009	487	18	3.70	3297	92	2.79	16.36
2010	452	14	3.10	3747	94	2.51	12.96
2011	443	14	3.16	3535	92	2.60	13.21
2012	441	16	3.63	3510	83	2.36	16.16
2013	295	17	5.76	3221	81	2.51	17.35
2014	324	6	1.85	3080	72	2.34	7.69
2015	297	9	3.03	3021	76	2.52	10.59
2016	311	13	4.18	2928	75	2.54	14.77
2017	302	7	2.32	2993	58	1.94	10.77
2018	274	8	2.92	3123	100	3.20	7.41
2019	277	10	3.61	3031	136	4.49	6.85
2020	245	10	4.08	2265	146	6.45	6.41
2021	257	15	5.84	2864	159	5.55	8.62
2022	217	16	7.37	2586	157	6.07	9.25
Total	5130	188	3.66	46712	1516	3.25	11.03

For the first time, the number of cyclists injured in road accidents in the mentioned period exceeded 100 in 2018, after which an even more pronounced increase followed. In 2022, the number of cyclists injured in road accidents is 3.1 times higher than in 2017 and 2.7 times higher than in 2014.

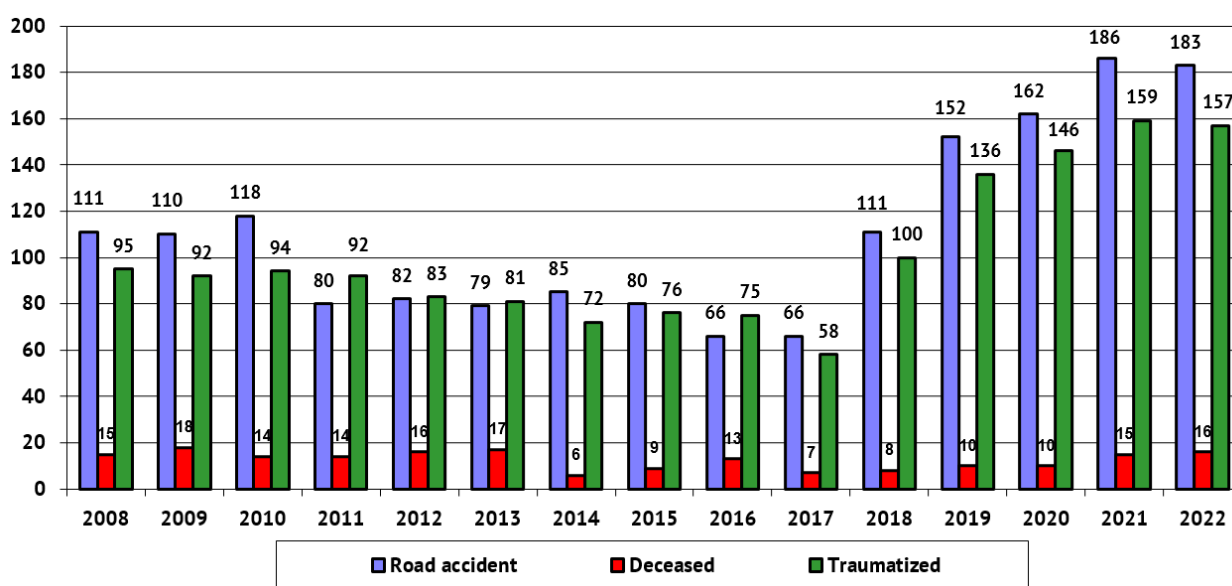


Figure 4. Frequency of road accidents involving cyclists in the Republic of Moldova (years 2008-2022).

The severity index of the consequences of road accidents involving cyclists in the period 2008-2022 is 11.03, being less than 10 percentage units in the last 5 years (2018-2022) and 2014 with an increasing trend in recent years, which puts us look with concern at the future traffic accident statistics.

Reducing the number of road accidents involving cyclists is a task of great socio-economic importance for all countries of the world, the Republic of Moldova not being an exception. Although the figures do not give us a complete picture of the real state of affairs in this field of human life, we cannot neglect the statistical data, which in the last 5 years are somewhat worrying.

3. The problem of transport in cities

The main negative factors of the transport problem in big cities are the following [28, 29]:

1. degradation of the ecological situation due to the large amount of concrete and concrete-asphalt pavement, without it being sufficiently compensated with green areas and parks;
2. pollution of the atmosphere with harmful exhaust gases and fuel vapors, especially in city centers, where a maximum accumulation of vehicles is aimed at;
3. pollution of the environment with dust and wear products of tires, brake shoes, clutch discs and road pavement;
4. the discomfort created by vibrations, electromagnetic waves and the high level of noise, which negatively affects the health of residents;
5. thermal emissions, which exceed the emissions of thermoelectric plants and liquid emissions, composed of leaks of fuels, lubricants, acids, alcohols, antifreezes, which pollute the air, soil and water bodies;
6. large losses of time of residents for traveling from home to work and vice versa, etc., which increase with the increase of cities and traffic jams;
7. the large number of road accidents, which affect the population both morally, socially and economically;
8. as cities grow, so does the need for automobiles, which requires an appropriate transport infrastructure (roads, parking spaces, gas stations, self-service etc.).

The main reasons for the formation of such a difficult road situation include: the lack of clear urban plans in the post-Soviet period; large-scale destruction of the former public transport infrastructure without adequate replacement with large modern vehicles; the imperfection of the traffic rules in relation to the existing traffic and the slow development of the road infrastructure etc. Public policies in the field of urban mobility in the city of Chisinau are focused on encouraging the use of private transport through the development of road infrastructure, widening of streets and the arrangement of parking spaces at the expense of the sidewalk. Although investments are also made in public transport, it remains uncompetitive and unattractive, stimulating citizens to invest in private transport [30].

The problem of modernizing the road infrastructure of cities and the country as a whole is a current one. The large volume of capital and the scale of infrastructure projects require significant investment. Historically, transport projects are initiated and financed by the state. The weak interest of private business to invest in infrastructure objects is explained by the uncertainty of investment recovery guarantees, by the non-competitive selection of contractors, as well as by the unclear understanding of infrastructure development priorities, which makes it difficult to evaluate the prospects of these investments [28].

4. The experience of the city of Chisinau regarding the development of bicycle infrastructure

The city of Chisinau can be classified in the category of cities that avoid investing or invest very little in urban cycling. Although thematic events, such as: Velo Hora (2009-2016) and Velo Fun (2015-2019), „Girls on Bikes”, Chisinau Bike Tour (every year on October 14, Chisinau City Day, „World Bicycle Day” and „World Car Free Day” (within the European Mobility Week) etc. [31], manage to gather more and more bicycle fans, the municipality is in no hurry to develop this mode of travel. At the moment there are no official data on the number of cyclists in Chisinau, but indirect data suggest a constant increase of the interest of Chisinau residents in this type of travel, especially recently, favored by the effects of the „COVID” pandemic and high fuel prices. Although at the events dedicated to cyclists, their number is impressive, in everyday life cyclists represent an insignificant part of urban traffic and are very difficult to notice on city streets [28].

Cycling on the streets of Chisinau is a real challenge for cyclists. The lack of infrastructure and means of signaling traffic, damaged roads, but also less friendly drivers in traffic, endanger the lives of cyclists, whose number has increased recently. For these reasons, the number of road traffic accidents involving cyclists has also increased.

Analyzing the General Urban Plan [32] and the Public Transport Strategy of the City of Chisinau [33] until year 2020, it can be seen that all these strategic development documents of the city of Chisinau were focused exclusively on road traffic and the development of the infrastructure for motorized transport. Moreover, all the studies [34], research and public policy analyzes developed by non-governmental organizations and experts outside the Chisinau City Hall had the same priorities – the circulation of motor vehicles [30].

None of these documents provided for or mentioned the construction and design of bike lanes and parking, pedestrian infrastructure, or addressing alternative transportation as a means of getting around the city. However, despite the lack of strategic documentation, the municipal authorities regularly addressed the issue of bicycle infrastructure and experimented with their arrangement. However, due to a lack of experience, expertise and a systematic and serious approach, these attempts have proven to be ineffective further compromising the idea of urban cycling.

Among the most well-known examples of the arrangement of bike lanes is the experiment from 2014 with the application of yellow markings on the pavement on some streets in the city of Chisinau (Figure 5), which were drawn in hard-to-reach places with numerous impediments, bumps and dangerous crossings [30, 31].



Figure 5. Bicycle lanes marked with yellow paint [30, 31].

Another example took place in 2016 on Stefan cel Mare si Sfant Blvd., the bicycle track was laid out on the sidewalks, in the form of a strip of pavement of a different color, with a width of 1 m on each side of the street (Figure 6). In the absence of a physical demarcation, the track was always occupied by pedestrians, parked cars on the sidewalk or street vendors, which made it impossible for cyclists to use it [30, 31].

In 2018, in the Valea Morilor park, a bicycle lane was marked in the pedestrian zone (Figure 7), which, however, is designed semi-legally, due to the current road regulations that do not allow the circulation of cyclists in parks and on sidewalks. The lane is actively used for recreational purposes, but cyclists cannot move safely, being forced to always be cautious, as the lane is often occupied by people with strollers, minor children, pets etc. [31].

The practices of European and American cities demonstrate, however, that the arrangement of bicycle lanes on the sidewalk is inefficient and dangerous, as it generates a constant conflict between pedestrians and cyclists due to the difference in travel speed. While the average speed of a pedestrian is 4 km/h, cyclists can easily develop a speed of 20 km/h, which inevitably leads to accidents and serious trauma [30].



Figure 6. Bicycle lane laid out on sidewalks, in the form of a strip of pavement of a different color [31].



Figure 7. Bicycle path arranged in the pedestrian area [31].

In May 2020, the lane for public transport was demarcated on Alexandr Puskin Street, which offers the possibility of being used by cyclists as well (Figure 8). This pilot project presents a gradual inclusion of dedicated lanes for public transport and as well as for bicycles on other central streets, such as: Stefan cel Mare si Sfant Blvd., Gavriil Banulescu-Bodoni str. and Grigore Vieru Blvd. [31].

In September 2020, as part of the repair of the pedestrian zone, the construction of the bicycle path on the alley on Mircea cel Batran Blvd., which reaches a length of about 2 km (Figure 9). This variant is so far the best designed, but due to the lack of continuity of the route, the track exists only on the alley route [31].

Meanwhile, the situation started to evolve for the better. The City Hall of Chisinau with the support of the EcoPro Public Association in partnership with UNDP (United Nations Development Programme), Green City Lab, Automobile Club of Moldova and the help of experts in the field of bicycle infrastructure design and the cycling community in Chisinau in 2020 developed the „Infrastructure Development Strategy for Alternative Transport in the city of Chisinau”, which has as its main purpose the development of bicycle infrastructure in the city of Chisinau.



Figure 8. Delimited lane for the shared circulation of road vehicles and bicycles [29].



Figure 9. Bike lane parallel to pedestrian lane [photo: Ziarul de Garda].

Following the surveys carried out by the „Working group for the development of alternative transport” and the organization EcoPro, the sectors with the greatest flow of cyclists were determined, as well as the most used streets for the movement of cyclists in the city.

Based on the statistical data and the projects to be carried out, 4 stages of bicycle infrastructure implementation were established [31].

STAGE 1, years 2020–2022.

- Implementation of shared lanes for public transport and bicycles (Figure 10):
 - ① Gavriil Banulescu-Bodoni str.;
 - ② Stefan cel Mare si Sfant Blvd.
- Implementation of bicycle lanes in the framework of street renovation (Figure 10):
 - ③ 31 August str.
- Realization and implementation of a route project for alternative transport, which will connect the 3 most popular sectors: Botanica, Centru, Rascani (Figure 10):
 - ④ Moscova Blvd., Kiev str., Renasterii Blvd., Grigore Vieru Blvd., Gavriil Banulescu-Bodoni str., 31 August str., Ciuflea str., Dacia Blvd.

STAGE 2, years 2022–2023.

Development of routes for alternative transport that will connect the Center sector with other sectors through streets with the greatest flow of cyclists (Figure 10). The total length of the routes – 50 km.

- | | |
|--|--|
| <ul style="list-style-type: none"> • Center: <ol style="list-style-type: none"> ① Alexei Mateevici str. • Telecentre: <ol style="list-style-type: none"> ② Hancesti road; ③ Gheorghe Asachi str. • Buiucani: <ol style="list-style-type: none"> ④ Ion Creanga str.; ⑤ Alba-Iulia str. | <ul style="list-style-type: none"> • Sculeni: <ol style="list-style-type: none"> ⑥ Calea Iesilor str. • Posta Veche: <ol style="list-style-type: none"> ⑦ Calea Orheiului str.; ⑧ Socoleni str. • Rascani: <ol style="list-style-type: none"> ⑨ Bogdan Voievod str.; ⑩ Alecu Russo str. |
|--|--|

STAGE 3, 2023–2024.

Development of routes on the secondary streets inside the sectors (*Figure 10*). The total length of the routes – 46 km.

- Center:
 - ① Constantin Negruzzi Blvd.;
 - ② Iurii Gagarin str.;
 - ③ Ismail str.;
 - ④ Vasile Alecsandri str.
- Rascani:
 - ⑤ Florilor str.;
 - ⑥ Nicolae Dimo str.
- Botanica:
 - ⑦ Decebal Blvd.;
 - ⑧ Traian Blvd.
- Buiucani:
 - ⑨ Vasile Lupu str.;
 - ⑩ Nicolae Costin str.
- Telecentre:
 - ⑪ Miorita str.

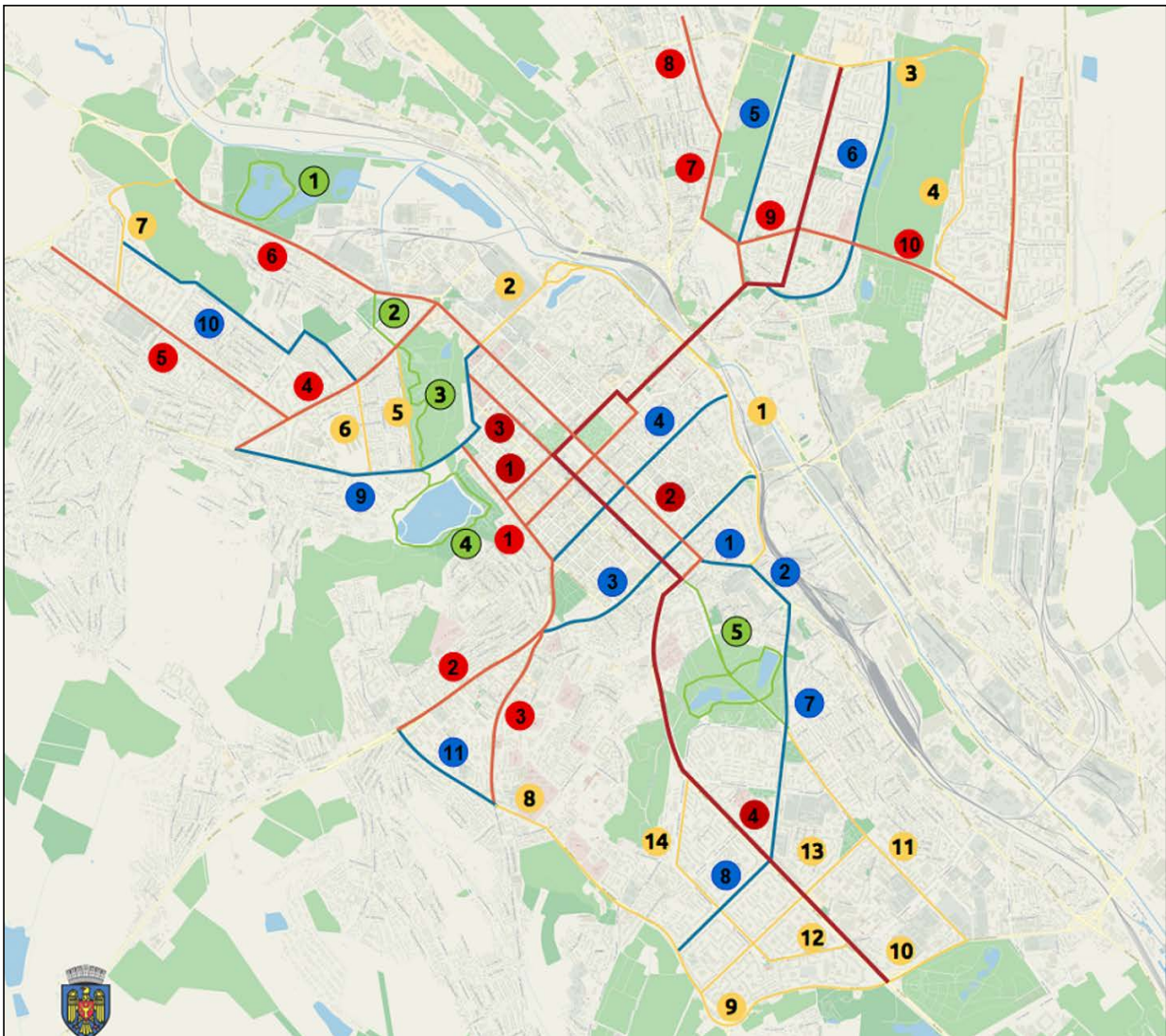


Figure 10. Map of bicycle routes in the city of Chisinau [31].

STAGE 4, 2024–2026.

Development of local and recreational routes (*Figure 10*). The total length of local routes – 65 km and recreational routes – 12 km

In total, for the period of implementation of the development strategy, it is planned to develop a network of trails with a length of 203 km and recreational trails with a total length of 12 km [31].

- Center:
 - 1 Albisoara str.;
 - 2 Mihai Viteazul str.
- Rascani:
 - 3 Studentilor str.
- Buiucani:
 - 4 Eugen Coca str.,
 - 5 Vissarion Belinski str.;
 - 6 Liviu Deleanu str.
- Ciocana:
 - 7 Mihai Sadoveanu str.
- Botanica:
 - 8 Grenoble str.;
 - 9 Valea Crucii str.;
 - 10 Gradina Botanica str.;
 - 11 Sarmisegetusa str.;
 - 12 Independentei str.;
 - 13 Cuza Voda str.;
 - 14 Hristo Botev str.
- Park La Izvor
 - 1 Park Alunelul
 - 2 Park Dendrariu
- Park Valea Morilor
 - 4 Park Valea Trandafirilor

5. The benefits of bicycle infrastructure development

Authorities in several cities around the world have understood that the bicycle has not only fun and sporting functions, but is an efficient means of transport for covering short and medium distances. Therefore, suitable alternative transport infrastructures were created, which encouraged people to leave their cars at home and go around the city or to work by public transport, bicycle or scooter, and this reduced the pressure on road networks and prevented the formation of traffic jams.

Cycling is part of transport, urban and environmental policies, as well as health and tourism policies. It complements public passenger transport, providing mobility to the population over short and medium distances.

An analysis of experience in different countries of the cycling's development in large cities has shown that bicycle infrastructure can bring together the results in the development of the city obtained both in short-term and long-term, can improve the quality of life of its citizens.

The development of bicycle infrastructure can be viewed by 4 aspects [35]: transport, social, ecological and economic. By the transport view, we mean the impact of the development of the bicycle infrastructure on the indicators of the use of various types of transport or user preferences. One of the most important social and ecological consequences of using a bicycle is the improved health of city dwellers. It also make more accessible the movement around the city for those who cannot get or drive a car, and also cannot use taxi services. The economic effect of the development of the bicycle infrastructure is evaluated from several directions: the economy of resources, due to the reduction of car traffic; reduced economic damages related, for example, to health or ecology; increased income of the city's, due to the better accessibility to transport and increasing the income of businesses, related to the development of cycling.

World experience shows that it takes about 10...15 years to create a developed bicycle infrastructure. The transition to cycling has a number of undeniable advantages [28, 31]:

- reducing harmful emissions in the atmosphere of cities and the noise level;
- reducing traffic jams in the city and the time spent in them;
- less need for parking spaces, because more bicycles can be parked on a place occupied by a car;

- the economy of budgetary resources for health, as a result of the increased physical activity of the population;
- significant resource savings for fuel, consumables and automotive components;
- reducing costs associated with road safety and environmental pollution;
- the possibility of closer communication with people and the study of new places and routes, which lead to an increase in the tourist attractiveness of cities;
- provides an additional impetus for the development of related branches and creates opportunities for the development of small business enterprises;
- greater mobility of this type of transport compared to a car;
- reducing social inequalities, giving people with lower incomes the ability to move from residential areas to the city center, integrating them into the full life of the community;
- increasing road safety, because with a maximum bicycle speed of 30 km/h and an average of 15...20 km/h, fatal accidents involving cyclists and pedestrians are minimal, and under the same conditions, the percentage of road accidents with serious trauma and less serious is significantly reduced etc.

Other health benefits of cycling [31]:

- at an average speed, a person burns from 500 to 700 calories per hour;
- the production process of endorphins („hormones of happiness”) takes place, which help fight depression and increase immunity;
- reduces the risk of cancer by 45%, and the risk of cardiovascular diseases by 46%;
- increases the amount of „good” cholesterol, decreases the amount of „bad”;
- strengthens the spine;
- regulates the activity of the circulatory system, lungs and improves the oxygen absorption process;
- strengthens bones and muscles, and keeps a good physical shape. And all this they give results without stressing the joints etc.

In many developed countries, bicycle transport is developing faster than car transport, and the number of bicycle trips is constantly increasing. Bicycles have gained more popularity in Northern and Western European countries, as well as in the USA and Canada, compared to Southern European countries. According to the number of bicycles and the diversity of bicycle infrastructure objects, the city of Helsinki leads, followed by the cities of Copenhagen, Stockholm and Hanover [28].

In most European countries, as well as in the USA, the development of bicycle transport has long been managed at the government level [28]. The network of bicycle routes must be based on subway and railway stations, large commercial and educational centers, parks, rest areas, recreation and residential spaces, to ensure optimal routes for people's travel.

It should be noted that the development of the bicycle infrastructure can serve as an impetus for the development of urban areas and constitutes a high demand on the service market: sports shops; technical services; construction of parking lots and bicycle rentals; storage of bicycle equipment as a service in the housing sector; secure parking service; cafes and grocery stores; production of bicycle components etc.

In order to use the positive potential of bicycle transport, it is necessary that the bicycle infrastructure be attractive and safe, allowing cyclists to reach their destination comfortably and quickly. In addition, in order to switch from automobile to bicycle in the

desired volume, it is necessary to form a positive attitude towards cycling in society, to raise the social status and prestige.

To use efficiently the bicycles in urban transportation, the organization of bicycle parking and storage is as important as the presence of bicycle infrastructure. Bicycle parking and storage are necessary to be able to rent a bicycle in crowded places such as shopping malls, subway stations, amusement parks, and residential areas, etc. The demand for bicycle parking spaces arises for two reasons: the possible theft of the bicycle and the need to organize the parking of a large number of bicycles in the urban space, especially in the city center. The organization of bicycle parking must be included in the city's parking organization policy, in the planning and design of streets, neighborhoods and separate buildings, similar to what happens with car parking.

An important factor that negatively affects the level of bicycle ownership is the lack of conditions for storing bicycles at home or near buildings. Currently, both in the neighborhoods of old buildings and in those with new buildings, there are no places to store bicycles. As a result, in new construction, building regulations should take into account the minimum requirements for providing bicycle parking and storage spaces.

The integrated development of bicycle infrastructure is an effective contribution of infrastructure investment, which can generate economic benefits, creating a reserve for further development of the city.

6. World experience on bicycle infrastructure development

Traditionally, a study of world experience of cycling starts with the „cycling cities” Amsterdam and Copenhagen.

In the mid-20th century, Copenhagen was plagued with transportation issues due to the mass carization of the city. However, in the 1990s, a movement to shift towards bicycle transportation began to emerge. Today, the distance traveled by cyclists in Copenhagen has increased by 36% compared to 1996. An astounding 52% of the city's residents use bicycles to commute to work or school. This is the highest percentage of bicycle commuters in any city in the world, with 650000 bicycles and only 125000 cars for a population of 550000. The growing number of cyclists has also led to a decrease of the number of road accidents involving cyclists. The city has adapted its transportation system to better accommodate cyclists, with an impressive cycling infrastructure that includes well-thought-out bike lanes, special steps at intersections, and bike pumps installed in various places on the tracks. Cargo bikes also have a special place in the city, with dedicated parking lots. In fact, 17% of families in Copenhagen now use cargo bikes. In addition to its impressive cycling infrastructure, Copenhagen is also developing an intelligent road system that uses special LEDs to determine the priority of certain types of transport on certain road sections. This system will help alleviate traffic congestion and is set to be fully operational by 2025. The city has also included its bike rental system as part of its public transportation network, giving it equal status alongside buses, trains, and the metro. Helsinki has taken a different approach to promoting cycling. Rather than a large number of bike lanes, the city has created a series of large lanes with one-way traffic along the main highways. The speed limit for all vehicles has also been reduced to 30-40 km/h. Intersections are equipped with special features, and the priority of traffic in Helsinki is as follows: pedestrians, cyclists, public transport, logistics, and private cars [36].

London faced significant traffic problems in the early 2000s, with constant traffic jams in the city center reducing the average speed of private cars to just 19 km/h. The city implemented restrictions on parking and circulation through the city center while promoting cycling as an alternative. The goal was to increase the number of cyclists by 400% by 2026. In 2001, Londoners made 320,000 trips by bicycle per day, which increased to 570,000 trips in 2010. The share of bicycles in the city's volume of transport is currently 5% [36].

Hamburg is one of the largest cities in Europe that is actively promoting cycling. The city has a 12% share of bicycles in total traffic, with a network of 280 km of bicycle paths divided into 14 routes. Special bridges for cyclists and pedestrians have also been provided, and the bike rental system includes 130 stations and almost 2000 bikes. Hamburg is also working to improve legislative aspects of traffic to further improve cycling. Beijing is another city that is making a significant effort to promote cycling. In the past, bicycles were the primary mode of transportation in China, but the automobile started to be in the 1990s a symbol of success, as well as a symbol of prosperity, leading to restrictions on bicycles to allow for automobile circulation. However, this led to serious transportation issues and air pollution. In response, the city is working to modernize and expand its bicycle infrastructure, as well as improve the perception of cycling among its residents, as part of its goal to become the world's first "green civilization" [36].

The Singaporean authorities have adopted an economic solution to the problem of traffic jams [37]: the customs duty of 40% for a car and the cost for registration – another 140%. Short distances between objects in Singapore, the accessibility of taxis, and an acceptable public transport system determines the use of bicycles.

Montreal has been recognized as North America's most bike-friendly city despite the dominance of automobiles and its hilly topography and cold, snowy winters. Bike infrastructure and culture are actively developed in the city. Other cities and countries also prioritize bike transport, and the government is involved in promoting this mode of transport. Austria has a cycling development plan called Masterplan Radfahren Strategie zur Forderung des Radverkehrs in Österreich, which aims to achieve a 10% share of travel by bicycle. The strategy creates an attractive and safe infrastructure for bicycles, organizes traffic according to cyclists' needs, optimizes intermodal transport networks, and educates and informs all participants in urban traffic. Czech Republic adopted a strategy for the development of the cycling which the goal to increment the share of cyclists in the city's road flow up to 10% in 2020 and up to 25% in 2025. The other goal of the national strategy for the period 2013-2020 was to popularize the bicycle as part of the city's transport system with equal rights to other ways of transportation, aiming to transform "popular and irregular" bicycle use into "civilized bicycle movement with continuous support". The Denmark's national strategy goal is to overcome the current trend of reducing the use of bicycles for city trips, although as early as 2014, the share of bicycle trips was 23%. Finland's National Action Plan for Walking and Cycling 2020 aimed to increase the political status and importance of walking and cycling and recognize them as equal types of travel to the city. The strategy provided for a 20% increase in the share of cyclists in 2020, compared to 14% in 2014. The France's national plan for cycling is aimed at revising existing policies and developing new types of mobility in cities. The strategy propose to include a mandatory exam in secondary school on the knowledge of traffic rules when traveling by bicycle. The National Cycling Plan in Germany until 2020 is part of a policy for mobility and integrated transport. Its proposed policies go beyond the boundaries of bicycle circulation and include in the development of the so-called

concept of "eco-mobility," which includes walking, cycling as well as local public transport. In the UK's 'A Sustainable Future for Cycling' document the results of the "Cycling England" program are presented. There are different strategies for the development of the cycle infrastructure for different parts of the the UK, such as England, Wales, Scotland, and Northern Ireland. The strategy for the development of cycling and pedestrian activity in England envisages an increase in segments traveled by bicycle from 800 millions in 2013 to 1600 millions in 2025. The development of cycling infrastructure and the promotion of cycling as a means of transportation is a global trend that aims to achieve a more sustainable society and a higher quality of life. Many countries have adopted national cycling strategies that aim to increase the number of bicycle riders and make cycling a safe and accessible transportation option for all [35].

These strategies include various objectives and tasks, such as increasing physical activity, developing urban and regional bicycle infrastructure, and promoting cycling among different age groups. For instance, the Hungarian cycling strategy aims to increment the relative amount of bicycle rides when considering the overall number of rides, while the goal of the Swedish national cycling strategy is to make the bicycle as a type of transport with equal rights and safety. Cycling can be used in different conditions, and cities around the world are finding innovative solutions to make cycling safe and comfortable for their residents. For example, the Norwegian city of Trondheim installed special bicycle lifts on difficult sections of the road to make cycling possible on hilly terrain, while the Finnish city of Oulu has achieved a high percentage of winter bicycle riders by providing snow-cleared tracks and winter tires. These examples show that cycling can be a viable option even in extreme conditions.

7. Conclusions

The car itself deals with comfort and speed, but in many transition economies, including also Republic of Moldova, it is also a social status as a symbol of success and prosperity of its owner.

The bicycle, as a means of transport, is still not part of the usual lifestyle of the majority of Moldovans, especially Chisinau residents, as in the Netherlands or Beijing, and the hills of Chisinau city differ significantly from the flat relief of Amsterdam or Copenhagen. Periods of cold weather and heavy rainfall should not be an obstacle to bicycle use, this can be overcome by better quality of bicycle infrastructure and better level of its maintenance. Being an ecological means of travel and replacing personal automobiles for short and medium-distance city travel, the bicycle also represents an effective way to increase the physical activity as well as time for rest and enjoyment.

A well-developed bicycle and pedestrian infrastructure is a sign of a modern city, where the administration takes care of the comfort, safety and health of the inhabitants. The city of Chisinau has potential and can become in the future a friendly and attractive city for pedestrians and cycling.

The distribution of deaths according to the categories of traffic participants shows, as mentioned above, that, according to estimates, more than 40000 cyclists die in road accidents annually, which constitutes about 3% of the total number of deaths in road accidents worldwide and about 5% at the level of the European Region. The analysis of the statistics regarding the deaths of cyclists as a result of road accidents in the Republic of Moldova during the years 2008-2022 finds that the Republic of Moldova exceeds the world share by 0.66%,

but it is below the share of the European Region. But, the last two years, especially the year 2022, should worry us, because the share of the European Region has been exceeded by about 1.5 times and almost 2.5 times the global one.

It is recommended to hurry the implementation of the bicycle infrastructure development plan in Chisinau city. or, at least compliance with the implementation schedule, as well as taking over the good practice for other localities in the Republic of Moldova, which would contribute to raising the level of road traffic safety and ecology. Also, the development of bicycle infrastructure facilitates the circulation of new means of transport for pedestrians – electric scooters, which are increasingly common on public roads.

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