Green Infrastructure Development – Challenge of the Modern Urban Dynamic Growth

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Abstract. **The aim of the scientific paper is to analyse the aspects of development of the green infrastructure that is considered to be one of the challenges of the modern urban dynamic growth. The research hypothesis – development of the green infrastructure providing unification of the existing natural areas and human settlements is a strategically important process for the creation of the ecologically friendly urban environment, as well as for the satisfaction of the socio-economic needs of city dwellers without harming the nature. The main results of the study are related to the analysis of ecological aspects of the modern urban environment and the process of development of the green infrastructure.**

Keywords: **biodiversity conservation, green infrastructure, urban environment, urban growth.**

INTRODUCTION

Scientific studies on the historical development of the nature show that millions of years the nature evolved on its own laws. Only with the emergence of the modern civilization the balance of the nature was destroyed. Once the Romans cut a wide range of forested areas in Italy, but in recent times and in the 20th century people inhabited and transformed almost all regions of the world. Creating their own settlements, people increasingly have tried to adapt the environment according to their socio-economic needs for comfort. Providing the historical insight into the specificity and trends of the development of human settlements, it could be concluded that very often the transformation of natural environment by people, according to their understanding and vision of the living conditions and quality of life, causes irreversible degradation of the environment. During the process of the development of the human settlements, wild forests were converted to arable lands; high-altitude alpine meadows were turned into ski slopes etc. Almost all raised bogs were drained, rivers were straightened and the dams around flooding areas were built. Consequently, natural environment was transformed and adapted to the conditions more appropriate for the human life. Currently, human settlements form basis of the dynamic growth of the region and state in the world. However, many plants, insects, birds and animals, which occupied a certain land or water area, lost their familiar living environment, being able to adapt to man-made environmental technical modifications. Thus, for the harmonization of the socio-economic needs of the modern society and natural environment regularities, it is important to provide links between the existing natural areas and human settlements – to provide the development of the green infrastructure of the human settlements. It includes parks and gardens, rivers and lakes, the canal embankment and forests, as well as other natural and partly related resources that are key elements of the services provided by the ecological systems. It is considered that the development of the green infrastructure of the human settlements is important for the conservation of the sustainable environment, for providing the possibilities of the harmonization of the socio-economic needs of the modern society and natural environment regularities, as well as for identification of potential solutions for the prevention and minimization of the social abuse and offence of the nature caused by the society or an individual in all possible spheres of the human life and economic activities. Development of the green infrastructure is especially important for Latvia that is one of the greenest countries in Europe. It is characterized by a unique environmental diversity, unique flora and fauna. However, as in other countries, the majority of the population of Latvia lives in cities – an environment developed by the distinctive interaction between a human and nature. The aim of the scientific paper is to explore challenges and opportunities of the development of the green infrastructure in the context of the dynamic growth of modern urban areas. Thus for achieving the aim of the research, the following tasks have been defined: 1) to provide justification of the development of the green infrastructure; 2) to explore the importance of creation of the green infrastructure and its impact on the urban development; 3) to characterize key elements of green infrastructure of the modern urban environment. In order to achieve the aim of the research paper the following scientific research methods have been used:

- a monographic method – the interpretation of the data based on the proven knowledge about the development of the relations between a human and nature in the context of space and time;
- a logically constructive method – the logical interpretation of the already published data by other authors on the analysis of the urban environment as a natural phenomenon, as well as of ecological aspects of the modern urban environment;
- a document analysis method – the study and evaluation of the existing policies and regulations in the area of protection of biodiversity, as well as development of the green infrastructure.

The main results of the study are related to the development of the guidelines and recommendations on the improvement of the process of providing flexible links between the existing natural areas and human settlements.

I. SYMBOLS OF THE NATURAL WORLD

Towards a more comprehensive understanding of the importance of the development of flexible links between a human and nature, it is necessary to evaluate the significance of the elements of the natural world in the human life at the flow of time. The direct experience of nature was the most powerful influence on the perception of the ancients. Their concepts of space and time, and of their own position in the universe could be understood only in relation to the natural world, every aspect of which was believed to express a particular feature of divine energy [1]. After all, the earliest gods were, not surprisingly, embodiments of nature. Nearly all ancient cultures originally represented the earth and nature itself as a maternal goddess. There was also a widespread belief that all forms of life were interrelated and interchangeable. From this point of view the mankind was a part of nature, rather than its master.

It is important to note that one of the mankind's most potent symbols is tree. It is the embodiment of life, the point of union of the three realms – heaven, earth and water –, and a world axis, around which the entire universe is organized. Ancient peoples widely believed that the tree was infused with the abundance of divine creative energy (often personalized in the form of supernatural creatures), which could be consciously harnessed by the adept, allowing access to other states of being. Forests came to symbolize mystery and transformation, and were home to sorcerers and enchanters. Tree worship was widespread in nearly all parts of the globe, where the climate was favourable to tree growth. It should be noted that some tree symbols are virtually worldwide. For example, evergreens universally stand for longevity and immortality, while deciduous trees represent regeneration and rebirth: in their own way, both serve to reassure men and women of their own continuing existence. However, in general, individual species acquired their own, culture-specific significance. The oak was revered by the Celtic and Norse peoples, while in ancient Greece the elder was considered sacred to Pan, the ivy to Bacchus, the bay to Apollo and the laurel to Dionysus. In Egypt the tamarisk was sacred to Osiris. In ancient China, trees in the vicinity of tombs or temples were protected as it was believed that the spirits of the dead of the gods resided in them. In fact, many trees were believed to have healing properties because they symbolized specific illnesses. Thus, since the aspen trembles in the wind, it was used in the treatment of fevers. Hazel was thought to possess magical powers and was used for water divining and to make the magician's wand. Wood itself also carried symbolic meaning and was thought in the Middle East and India to represent the *prima materia*, the fundamental material from which all things were made [1].

Other important symbols of the natural world for the ancient peoples were flowers and plants. The Greeks believed that paradise was carpeted with asphodels. The Chinese imagined that for each woman living in this world, a flower bloomed in the next. The two ancient beliefs exemplify the most common symbolic meanings of the flower: the divine state and feminine beauty. Furthermore, the opening of the flower from the bud represents creation (the manifestation of energy moving outward from the centre) and the energy of the sun. Flowers are universal symbols of youth and vitality, but because of their impermanence they also connote fragility. Plants represent the cycle of life (fertility, death and rebirth) and many were thought to thrive on the life-force (body or blood) of a particular god: the ancient Egyptians believed that wheat grew from the body of Osiris [1]. Particularly, many herbs were considered sacred. Some of them because of their medicinal properties and others because of their growth habit or appearance suggested a link with the gods or mankind.

II. Urban Environment as a Natural Phenomenon

Generally, cities provide an inevitable contrast to the *"natural"*. A consistent strand of thought has sought to place the city as a human invention in opposition to the *"natural"*, the *"pristine"*, and the *"wilderness"*. Protecting the environment has usually meant halting the encroachment into pristine areas such as rainforests and tundra. Most often, environmental protection has been defined as meaning something outside of, and mostly unrelated to, the concerns and interests of our cities. Cities have been described and understood as somehow separate from the so-called *"natural world"*. This has been reinforced by the appearance of an increased separation of life in the city from the wider environmental context [2]. For example, when food is more available in a supermarket aisle instead of in the fields outside our homes and when people can turn up the heating to keep out the cold or turn on the air conditioning to keep out the oppressive heat there is a tendency to see the city as somehow removed and independent from the physical world.

Urban theorizing has for a long time been conducted as if a city was on a flat, featureless plain. Urban studies have long ignored the physical nature of cities. Instead, the emphasis has been placed on the social, political and economic rather than ecological aspects. And yet cities are ecological systems, they are predicated upon the physical world as mediated through the complex prism of social and economic power. In recent years there has been a renewal of interest in the city as an ecological system with emphasis on the complex relationships between environmental issues and urban concerns, and between social networks and ecosystem flows. In this new exciting body of urban ecological work, cities are now seen as much natural as wilderness and the environment as much social as the city. The city is implicated in the *"natural"* world in connections that embody and reflect social, economic and political power. The city is an integral part of nature, and nature is intimately interwoven into the social life of cities. Existence and development of the city is related to the inputs of energy and water, as well as to the outputs of noise, climate change, sewage, and air pollutants [3]. The measurable evaluation of the equipoise between the input and output flows provides an additional opportunity to consider relationship between the city and nature.

Human activity in the city is dependent on large and consistent inputs of energy. When people leave heated buildings to drive in cars, to purchase goods they use energy. The commercial activities urban dwellers pursue and the

microclimates they create (heating in winter, cooling in summer) consume energy. In seeking to overthrow the tyranny of nature, cities use prodigious amounts of energy. Cities are deeply dependent on energy sources. In the United States, since the beginning of the twentieth century, petroleum has traditionally been very cheap and cities now sprawl across the landscape. In countries where energy is more expensive, cities tend to be higher in density and more reliant on public transport. Large-scale suburban sprawl is a function of cheap energy [4]. It is tempting to theorize the impact of a long-term, sustained increase in energy prices on suburban sprawl and urban structure. Water is an essential ingredient of life. The people and commerce of cities are utterly dependent upon water. One of the largest urban differences in the world is between cities with clean, easily accessible water and others with expensive, inaccessible and polluted water supplies. In order to provide inexpensive and clean water, immense engineering projects have been undertaken. Also as cities have grown, the catchments areas have extended outwards and the engineering sophistication of piping in water has grown and deepened [2]. In any case, in poorer cities polluted urban water remains a major source of disease and illness especially for children. Moreover, even in rich countries the availability of fresh water is a determinant of the limits of urban growth.

III. Ecological Aspects of the Modern Urban Environment

In fact, cities also modify the environment. The most obvious example is the urban heat island. Cities tend to be warmer because of the amount of extra heat produced in the city and the heat absorption of man-made materials such as tarmac, asphalt and concrete. Heat is absorbed by these surfaces during the day and released at night. The net result is that cities are warmer than surrounding rural areas. One side effect is to reduce the need for heating in the winter but to increase the need for air-conditioning in the summer. The heat island means you can turn the heating down in London in December but need to increase the air conditioning in Washington, DC in August. The extra heat causes a thermally induced upward movement of air, and an increase in cloud and raindrop formation. Cities are often cloudier, more prone to thunder and slightly warmer than surrounding rural areas. Human activity in the city also produces pollutants. Industrial processes and auto engines emit substances that include carbon oxides, sulphur oxides, hydrocarbons, dust, soot and lead. The air in cities has traditionally been very unhealthy, which is part of the reason for the higher urban death rate throughout most of human history. The pall of smog that hangs over many cities is a visible reminder of the effects of concentrated human activity on the environment [2]. Above all, the pollutants of cities are not only dangerous to the health of individuals, but also cause more general damage. It is important to note that cities are in part a major cause of global warming and ozone depletion.

A major output of cities is waste. High mass consumption in association with elaborate packaging has created a rising amount of waste in cities. Burning it causes air pollution, while hiding it leads to massive landfills. The environmental justice literature shows that many environmentally hazardous facilities are generally located in poor, minority and more weakly organized communities. Issues of environmental management are tied in to wider issues of equity and social justice [4]. Chiefly, patterns of environmental racism are clear when we note that most noxious facilities are located in lower income, more marginal communities.

Cities also emit noise. Cities are noisy places and households who inhabit busy urban streets for more than 15 years are on average likely to experience a 50 per cent reduction in hearing capacity. The effects of noise pollution vary from annoyance to deterioration in hearing. A high backroom noise level leads to a general increase in stress and the lessening of the quality of urban life [2].

Cities are an integral part of the hydrological cycle. Cities impact the daily and seasonal flows of water. The large amount of impermeable surfaces, for example, means that when it rains run off levels spike dramatically. Cities thus need to create modified flows through channels and conduits that can cope with the irregular high flow rates. But the large amount of impermeable surfaces in association with the channelization of water courses can lead to distinct surges in water flow after rain and in many cases to patterns of flooding. As urbanization increases so does the overloading of the hydrological cycle. Cities also modify the flow and direction of rivers in order to increase commercial activity [2]. Moreover, cities tend to pollute water systems, thus reducing the amount of fresh water and in some case posing major health hazards.

It should be concluded that the planning and control over the measurable flows of input and output between the city and the nature open new possibilities for understanding the environment inputs necessary for urban growth and the environmental impacts of urban growth. Nature is present in cities in often unforeseen and unplanned ways. Wildlife in a variety of forms continues to find ecological niches in the city. Urban tensions can be written through the narration of the relationship between cities and wildlife. Urban animal geographies can tell us a great deal about the city – nature dialectic, whether it is in the stories of rats in cities or the story of hawks in the city. There is also a more self-conscious referencing of nature in cities. Consider urban parks. It is difficult to imagine London without Hyde Park, New York without Central Park or Washington, DC without the National Mall. Landscape architects such as Frederick Law Olmsted have left a permanent legacy in cities. The modern park movement is more closely tied into active participation than the environmental contemplation so beloved of the early park movement. City parks are now developed as much for their recreational opportunities as their aesthetic appeal. Urban planners realize that the successful referencing of nature is an important element in creating the right atmosphere, and it is often linked with the promise of economic redevelopment. Whether it is in the beaches of southern California, the lakeside shore of Chicago, or the parks of London and Paris, a commonly accepted attractive feature of urban life is the

successful (re)incorporation of nature into the urban lifestyle, the city's image and the metropolitan experience [2].

IV. Significance of the Development of the Green Infrastructure

Consequently, the need for healthy ecosystems is now widely recognised. This is not only necessary if we are to halt the loss of biodiversity across Europe, but it will also contribute to achieving a wider range of goals, including adaptation to climate change and the maintenance of ecosystem services such as clean water, productive soils and attractive recreational areas. It is vital to ensure that the functional elements of ecosystems can continue to interact, both between themselves and with their physical environment. However, ecosystems and habitats throughout Europe are becoming increasingly fragmented. This presents us with a major challenge. Many policy initiatives are already playing a role in tackling this issue. For example, Natura 2000 is establishing the European Union wide representative system of legally protected areas, progress is being made in integrating biodiversity objectives into other policy sectors, and programmes specifically aimed at strengthening ecological coherence are underway in many European countries [5]. The special informative logo of the network of nature protected areas of European importance is schematically shown in Figure 1.

Fig. 1. The special informative logo of the network of nature protected areas of European importance [6]

In accordance with the recommendations of the European Commission, where appropriate, for the improvement of the public awareness, the following text should be used when using the Natura 2000 logo shown in Figure 1: *"Natura 2000 – Europe's nature for you. This site is part of the European Natura 2000 Network. It has been designated because it hosts some of Europe's most threatened species and habitats. All 27 countries of the European Union are working together through the Natura 2000 network to safeguard Europe's rich and diverse natural heritage for the benefit of all"* [6]. The special informative sign, shown in Figure 1, is the emblem of the ecological network of nature protected areas Natura 2000. It is the key instrument to protect biodiversity in the European Union. It has been established to protect rare and endangered plant and animal species and their habitats (biotopes) in Europe. Natura 2000 is based on the Birds Directive (1979) and the Habitats Directive (1992). Natura 2000 is a network of nature protected areas of European importance. In Latvia the network was based upon the existing nature protected areas, adding 122 new sites. It means that every country of the European Union develops its own system of Natura 2000 sites as part of the whole Natura 2000 system. The green infrastructure in this context provides safeguards numerous ecosystem services and ensures that Europe's natural systems remain healthy and resilient. However, given the scale of the challenge, there is clearly a need to assess the seriousness of the threats, the effectiveness of the responses taken to date and the need for further action in the European Union perspective [7; 8]. Nowadays an insufficient incentive and involvement in cooperation between business, society and state for green and sustainable future is observed. As a result Europe's landscape has faced more habitat loss and fragmentation than any other continent. Consequently, this is a major problem for biodiversity.

It is stressed at the Communication from the Commission to European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions *"Our life insurance, our natural capital: an European Union biodiversity strategy to 2020"* that biodiversity – the extraordinary variety of ecosystems, species and genes that surround us – is our life insurance, giving us food, fresh water and clean air, shelter and medicine, mitigating natural disasters, pests and diseases and contributes to regulating the climate [9]. Exactly for the successful implementation of the above mentioned strategy it is vitally important to realize the present and the future value of *the "human life insurance"* – natural capital, including biodiversity. Its deterioration and loss jeopardises the provision of these services: we lose species and habitats and the wealth and employment we derive from nature, and endanger our own wellbeing. This makes the loss of the biodiversity one of the most critical global environmental threats. It is important to note that current rates of species extinction are unparalleled. Driven mainly by human activities, species are currently being lost 100 to 1,000 times faster than the natural rate, as for instance, [9]:

- 60,0% of the world's ecosystems are degraded or used unsustainably;
- 75,0% of fish stocks are over-exploited or significantly depleted;
- 75,0% of the genetic diversity of agricultural crops has been lost worldwide since 1990;
- an estimated 13 million hectares of tropical forests are cleared each year;
- 20,0% of the world's tropical coral reefs have already disappeared, while 95% will be at risk of destruction or extreme damage by 2050 if climate change continues unabated.

Although core nature areas in the European Union are now largely protected under the Natura 2000 network, species still

need to be able to move between these areas if they are to survive in the long term. New scientific research shows that providing the protection of the biodiversity, as well as successful integration of the human settlements into the natural environment in the future is closely related to the process of development of the green infrastructure. It is best achieved through an integrated approach to the improvement of the public awareness, as well as cooperation between business, society and state in area of the development of green infrastructure, for example, promotion of the environmentally friendly innovations, social campaign oriented to the nature conservation and eco-friendly consumption, aggregation and popularization of good practice experience, etc. Particularly, all members of the society should be engaged early on in the process of careful strategic planning and developing a green infrastructure and apportioned a share of the responsibility in its delivery. As the world practice shows, a green infrastructure could help maintain healthy ecosystems so that they can continue to deliver valuable services to society such as clean air and fresh water [10].

V. Development of the Green Infrastructure

The rise in green infrastructure research has coincided with a reassessment of what landscapes should be in terms of form and function. The term "green infrastructure" first came to prominence in the United Kingdom following the work of the President's Council on Sustainable Development in the work of the Urban Task Force in 1999 and the Department for Environment, Transport and the Region's in 2000 proposals for the Urban Renaissance. Within these documents the benefits of a strategic network of green infrastructure was proposed as a method of providing a wider access to green spaces and allowing a greater proportion of the public to benefit from them [11]. Symbols of the urban environment are interpreted as expressions of human nature. The development of the urban environment has accompanied the development of civilization. Shapes and colours of the green infrastructure are the building blocks of the modern urban environment.

Green infrastructure as a term relates to the connective matrices of green areas that can be find in and around human settlements, for example, parks and gardens, waterways and woodlands, green corridors and street trees, countryside and mosaic landscapes, etc. World practice shows that green infrastructure brings many social, economic and ecological benefits to local people and communities and has been increasingly viewed as a concept that both planners and practitioners can draw on. Policy and planning integration, landscape multi-functionality and organisational cooperation are all ideas that underpin the growth of green infrastructure, but are also important developments in planning policy as a whole [11]. Green infrastructure is a concept that aims at recreating a system, which is robust and enables species and their communities to move and adjust. Investing in a green infrastructure also makes economic sense. Having to find man-made solutions to replace the services that nature offers for free is not only technically challenging, but also very expensive. Putting valuable natural areas under nature protection is an important step towards maintaining ecosystem functions, but it is not enough. Only integrating the protected areas into the broader land/seascape can create the necessary connectivity among sites, between sites and with the wider environment. Green infrastructure can therefore be regarded as the complementing element for protected areas. Such a robust multi-functional system of protected and unprotected green areas will strengthen ecosystem resilience and enable migration, dispersal and genetic exchange of wild species [12]. In accordance with the report published in the framework of the World Wildlife Fund Danube-Carpathian Programme *"Green Infrastructure – Sustainable Investments for the Benefit of Both People and Nature"*, green infrastructure describes all elements of an interconnected green space network that conserves natural ecosystem values and functions and provides associated benefits to human populations. It consists of natural and man-made elements, such as the following [12]:

- reforestation zones;
- green bridges;
- green urban areas;
- green roofs and green walls;
- high nature value farmlands or forest areas.

It ensures the efficient and sustainable use of land by integrating interacting functions or activities on the same piece of land. By giving back space to ecosystems, green infrastructure can maintain and create landscape features, which guarantee that ecosystems continue to deliver services such as clean water, productive soils and attractive recreational areas [12]. Generally, it is the way of support of economies and societies and it makes an essential contribution to natural mitigation of, and adaptation to climate change.

VI. Key Elements of the Green Infrastructure

It is important to note that every ecosystem has a complex structure that is impacted by processes caused by nature and human activity. Species migrate across the land or along a stream, breed in places away from their winter habitation, need different places to breed and feed and so require a complex set of linked habitats. Changing conditions in climate and water regime lead to a change in the habitats, which requires species to adjust their location and move to areas with better conditions. Healthy ecosystems are resilient systems that can withstand changes (e.g. climate change) to a much larger degree than degraded ones [12]. Ordinarily, as the human life also depends on ecosystem services, the coherence of the ecosystem and its resilience are also essential to our existence.

An essential condition for healthy ecosystems and the provision of their services is consequently the maintenance of ecological regularities in the human everyday life, renewable and non-renewable natural resource use, business activities, etc. In Europe, this maintenance is increasingly getting lost as a result of the massive expansion of urban zones and infrastructure development, unsustainable resource use, etc. In addition, traditional land use practices have been replaced by more intensive, mechanised and industrial scale activities,

especially in agriculture. As a consequence, species have difficulty in dispersing and moving to fulfil their needs and adjusting to environmental change. Subsequently, ecosystem functions are disrupted as they become isolated, even in protected areas, since these too have often been fragmented and become *"islands".* In accordance with the modern scientific studies, a green infrastructure concept in Europe can serve the following purposes [12]:

- combating biodiversity loss by increasing connectivity between the existing natural areas and increasing their ecological coherence (elements such as hedgerows, wildlife strips in fields, small watercourses, *"eco-ducts"*, green urban areas and habitat patches could help in this respect);
- strengthening the functionality of ecosystems for delivering goods and services;
- increasing the resilience of ecosystems by improving their functional and spatial connectivity, constituting an *"insurance policy"*, which is vital in the face of global change, including climate change;
- promoting integrated spatial planning by identifying multi-functional zones or by incorporating habitat restoration measures and other connectivity elements into various land-use plans and policies;
- contributing to developing a greener and more sustainable economy by investing in ecosystem services instead of purely technical solutions, and mitigating adverse effects of transport and energy infrastructure;
- reconstructing or adjusting the existing or planned infrastructures (e.g. in the field of water management or transport, urban development) to mitigate barrier effects and create ecological corridors.

For achieving the above-mentioned purposes related to the implementation of the concept of development of green infrastructure in Europe, a variety of techniques could be used. They can include, for instance [10]:

- improving connectivity between the existing nature areas in order to counter fragmentation of the natural areas, e.g. by safeguarding hedgerows, wildlife strips along field margins, small watercourses;
- enhancing landscape permeability to aid species dispersal, migration and movement, e.g. through the introduction of wildlife friendly land uses or agricultural/forest environment schemes that support extensive farming practices;
- identifying multifunctional zones. In these areas, compatible land uses that support healthy ecosystems are preferred over other more destructive practices. They may, for instance, be areas where farming, forestry, recreation and ecosystem conservation all operate together in the same space. Such *"win-win"* or *"small loss, big gain"* combinations can deliver multiple valuable benefits, such as water purification or soil improvement and the creation of attractive *"breathing spaces"* for people to enjoy nature beauties.

World practice shows that there are the following potential components of green infrastructure that could be used for providing flexible links between the existing natural areas and human settlements [10]:

- protected areas, such as Natura 2000 sites;
- healthy ecosystems and area of high nature value outside protected areas such as floodplain areas, wetlands, coastal areas, natural forests etc.;
- natural landscape features such as small water courses, forest patches, hedgerows, which can act as eco-corridors or stepping stones for wildlife;
- restored habitat patches that have been created with specific species in mind to help expand the size of a protected area, increase foraging areas, breeding or resting for these species and assist in their migration/dispersal;
- artificial features such as eco-ducts or eco-bridges that are designed to assist species movement across insurmountable landscape barriers;
- multifunctional zones, where land uses that help maintain or restore healthy ecosystems are preferred over other incompatible activities;
- areas, where measures are implemented to improve the general ecological quality and permeability of the landscape;
- urban elements such as green parks, green walls and green roofs, hosting biodiversity and allowing for ecosystems to function and deliver their services by connecting urban, partly urban and rural areas;
- features for climate change adaptation and mitigation, such as marshes, floodplain forest sand bogs – for flood prevention, water storage and CO_2 intake, giving space to species to react to changed climate conditions.

Finally, it is important to note that there is no one universal way for the integration of the human settlements to the natural environment that could be used by each country in the European Union. It is necessary to find more appropriate techniques for the successful implementation of the concept of development of green infrastructure and to choose more suitable components of the green infrastructure taking into account uniqueness of the environmental diversity, as well as characteristics of the human settlements of the state. Thus, the research hypothesis that the development of the green infrastructure providing unification of the existing natural areas and human settlements is a strategically important process for the creation of the ecologically friendly urban environment, as well as for the satisfaction of the socio-economic needs of city dwellers without harming the nature is approved.

VII. Conclusions

In conclusion, it is important to note that green infrastructure describes all elements of an interconnected green space network that conserves natural ecosystem values and functions and provides associated benefits to human populations. Consequently, green infrastructure of the state, providing flexible links between human settlements and natural environment should be planned and developed. The world practice shows that one of the most effective ways to

build up green infrastructure is to adopt an integrated spatial planning approach to improve spatial interactions over a large geographical area. This approach can guide future grey infrastructure (e.g. roads, urban settlements, hydropower plants) development away from sensitive sites, and help prevent further biodiversity loss and fragmentation. Integrated spatial planning can also help identify barriers for wildlife in the existing infrastructures, as well as find ways to spatially connect the existing separate nature areas. The good practice examples show that this could be provided by encouraging habitat restoration projects in strategically important places or by integrating elements of ecological connectivity (e.g. eco-ducts, natural stepping stones, eco-bridges) into new development schemes. With the help of innovative approaches to the spatial planning, multi-functional green spaces could be created in human settlements. As a result, the quality of urban environment could be improved.

For the greening of urban areas, the construction of green bridges, tunnels, fish passes and the removal of obsolete infrastructure in rivers, as well as in the maintenance and restoration of ecosystems, it is strategically important for the Members of the European Union to use different financial opportunities offered by the European Union's funds, for instance, Regional Development Funds and the Rural Development Fund, etc. These investments could positively impact local economy, providing jobs and business opportunities.

For the successful development of the state green infrastructure it is necessary to provide opportunities for each member of the society to satisfy his or her social and economic needs beyond the boundaries of the city. It could have the positive effect on the revitalization of the rural areas and their closer development in accordance with the tendencies of the urban dynamic growth.

Development of the green infrastructure should be supported by the day to day activities and cooperation of the public since the lock of agreeing that could bring benefits to each member of the society prevents identification of the potential present and future advantages of the sustainable and environmentally friendly lifestyle and business activities, including the development of the green infrastructure. Cooperation between business, public and state should be oriented to the increase of the advantages of development of green infrastructure in comparison with grey infrastructure.

At the end of the conclusions of the scientific paper the following words should be mentioned: *"There are not so many places around the world where nature comes into the city, becoming its integral part in such a magnificent way."* The words dedicated to one of the most beautiful cities of Latvia – Sigulda – could be largely applied to all human settlements in Latvia and inevitably show significant traditions of the harmonization of human and natural environment of the state. These traditions should be kept alive and supported for the benefit of both people and nature.

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Jurijs Grizāns, Armands Auziņš, Jānis Vanags. Zaļās infrastruktūras attīstība – mūsdienu pilsētu dinamiskās izaugsmes izaicinājums
Zinātniskie pētījumi par dzīvās dabas vēsturisko attīstību, liecina, ka miljoniem gadu daba attīstījās pati pēc saviem likumiem. Tikai līdz ar mūsdienu civilizācijas rašanos līdzsvars dabā tika izjaukts. Savulaik romieši izcirta plašus mežu apgabalus Itālijā, bet jaunākajos laikos un 20.gadsimtā cilvēki apdzīvoja un pārveidoja gandrīz visus pasaules reģionus, arī nedaudzos nepieejamos apvidus. Veidojot un attīstot savas apmetnes, cilvēki arvien vairāk centušies pielāgot apkārtējo vidi atbilstoši savam sociāli ekonomiskajām vajadzībām pēc komforta. Sniedzot vēsturisko ieskātu cilvēku apdzīvoto vietu veidošanās īpatnībās un tendencēs, nākas secināt, ka ļoti bieži cilvēks pārveidojot apkārtējo dabas vidi atbilstoši savai izpratnei un redzējumam par dzīves apstākļiem un dzīves kvalitāti, izraisa neatgriezeniskās vidi degradējošās pārmaiņas. Pilsētu un citu apdzīvoto vietu attīstības gaitā pirmatnējie meži tika pārvērsti par aramzemi, augstkalnu alpīnās pļavas pārtapa par slēpošanas trasēm. Gandrīz visi augstie purvi tika nosusināti, lielās upes iztaisnotas un ap applūstošajiem rajoniem tika uzcelti dambji. Tādējādi cilvēka un dabas mijiedarbības rezultātā vēsturiski izveidojušās cilvēka apdzīvotās vietas ar cilvēka dzīvei, saimnieciskai darbībai un atpūtai piemērotiem apstākļiem. Patlaban tās veido jebkura reģiona un valsts dinamiskās izaugsmes pamatu un ir viens no galvenajiem valsts sociāli ekonomiskās un teritoriāli telpiskās sistēmas elementiem. Tomēr daudzviet augi, kukaiņi, putni un dzīvnieki, kas aizņēma kādu noteiktu sauszemes vai ūdens teritoriju, zaudēja tiem pierasto dzīves vidi, nespējot pielāgoties cilvēka izraisītajiem apkārtējās vides tehniskajiem pārveidojumiem. Tādējādi mūsdienu sabiedrības sociāli ekonomiskās izaugsmes vajadzību un dzīvās dabas likumsakarību harmonizēšanai, svarīgi veidot saiknes starp esošajām dabas teritorijām un cilvēka apdzīvotām vietām – attīstīt cilvēka apdzīvoto vietu zaļo infrastruktūru. Tā sevī ietver parkus un dārzus, upes un ezerus, kanālmalu apstādījumus un meža masīvus, kā arī citus dabas un daļēji ar to saistītus resursus, kuri ir ekoloģiskās sistēmas pakalpojumu sniegšanas galvenais elements. Tiek uzskatīts, ka apdzīvoto vietu zaļās infrastruktūras attīstība ir svarīga, lai saglabātu ilgtspējīgu vidi, kurā tiek meklētas iespējas cilvēku sociāli ekonomisko vajadzību un dabas procesu līdzsvarošanai, kā arī potenciālie risinājumi sabiedrības un indivīdu sociālo pāridarījumu un nodarījumu dzīvajai dabai visās iespējamās cilvēka dzīves un saimnieciskās darbības sfērās novēršanai un samazināšanai. Zaļās infrastruktūras veidošana un attīstība ir īpaši svarīga Latvijai, kas ir viena no zaļākajām valstīm Eiropā. Tai raksturīga vides daudzveidība ar savdabīgu un unikālu floru un faunu. Taču, tāpat kā citās pasaules valstīs, Latvijā lielākā daļa iedzīvotāju dzīvo pilsētās – savdabīgajā dabas un cilvēka savstarpējās mijiedarbības rezultātā radītajā vidē. Zinātniskā raksta mērķis ir izanalizēt zaļās infrastruktūras, kas tiek uzskatīta par vienu no mūsdienu pilsētu dinamiskās izaugsmes izaicinājumiem, attīstības aspektus un īpatnības. Zinātniskā raksta hipotēze – zaļās infrastruktūras attīstība, nodrošinot vienotību starp esošām dabas teritorijām un cilvēku apdzīvotām vietām, ir stratēģiski svarīgs process ekoloģiski draudzīgas pilsētvides radīšanai. Tas ir svarīgs arī pilsētu iedzīvotāju sociāli ekonomisko vajadzību apmierināšanai, izvairoties no negatīvās ietekmes uz apkārtējo vidi. Pētījuma galvenie rezultāti tiek saistīti ar mūsdienu pilsētvides, kā arī zaļās infrastruktūras attīstības procesa ekoloģisko aspektu izpēti.

Юрий Гризанс, Армандс Аузиньш, Янис Ванагс. Развитие зелёной инфраструктуры – вызов динамичному росту современных городов
Научные исследования об историческом развитии живой природы свидетельствуют о том, что миллионы лет природа развивалась по своим собственным законам. Только лишь с появлением современной цивилизации существующее в природе равновесие было нарушено. В своё время, древние римляне вырубили большие лесные массивы на территории Италии, а в новые времена и в 20-м веке люди заняли и трансформировали почти все регионы мира, в том числе и некоторые труднодоступные округи. Создавая и развивая свои поселения, люди всё более старались приспособить окружающий мир относительно своих социально-экономических потребностей и желаний в отношении комфорта. Осуществляя исторический обзор особенностей и тенденций развития населённых пунктов человека, можно сделать вывод, что человек, трансформируя природную среду в соответствии со своим пониманием и видением жизненных условий и качества жизни, очень часто вызывает необратимые, деградирующие окружающую среду изменения. В ходе развития городов и других населённых пунктов первобытные леса были превращены в пахотные земли, высокогорные альпийские луга были преобразованы в курортные лыжные трассы. Многие болота были орошены, русла больших рек выпрямлены, а вокруг районов, подверженных затоплению, были возведены защитные дамбы. Таким образом, в результате исторического взаимодействия человека и природы были образованы населённые пункты с условиями, благоприятными для жизни человека, его хозяйственной деятельности и отдыха. На данный момент они являются основой динамичного роста любого региона и государства, а также одним из главных элементов социально-экономической и территориально-пространственной системы региона и государства. В тоже же время во многих местах растения, насекомые, птицы и животные, занимавшие определённую территорию суши или водного пространства, потеряли свой обычный образ жизни, не сумев приспособиться к техническим преображениям окружающего мира, вызванными человеком. Таким образом, для гармонизации социально-экономических потребностей и желаний современного общества и закономерностей живой природы важно создавать связь между существующими природными территориями и населёнными пунктами человека, т.е., развивать зелёную инфраструктуру населённых мест. Она включает в себя парки и сады, реки и озёра, насаждения каналов и лесные массивы, а также другие природные и частично с ней связанные ресурсы, которые являются главным элементом экологической системы предоставления жизненно необходимых услуг. Считается, что развитие зелёной инфраструктуры населённых мест очень важно для сохранения устойчивой среды, в которой осуществляется поиск возможностей для равновесия социально-экономических потребностей и желаний человека и природных закономерностей, а также потенциальных решений для предотвращения и уменьшения социального вреда живой природе, вызванного индивидуумом и обществом в целом во всех возможных сферах жизни и хозяйственной деятельности человека. Создание и развитие зелёной инфраструктуры особенно важно для Латвии, которая является одним из самых зелёных государств в Европе. Ей характерно природное многообразие, а также своеобразная и уникальная флора и фауна. Но также как и во многих других государствах мира, большая часть населения Латвии живёт в городах – в своеобразной среде, созданной в результате взаимодействия человека и природы. Основной целью данной статьи является анализ аспектов и особенностей развития зелёной инфраструктуры, считающейся одним из вызовов динамичному росту современных городов. Гипотеза научной статьи – развитие зелёной инфраструктуры, обеспечивая единение природных территорий и поселений человека, является стратегически важным процессом для создания экологически благоприятной городской среды. Это также важно для удовлетворения социально-экономических потребностей общества, избегая негативного влияния на окружающую среду. Главные результаты исследования связаны с изучением экологических аспектов современной городской среды, а также процесса развития зелёной инфраструктуры.