# Contemporary Challenges of Cities and Regions Development

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# Współczesne wyzwania rozwoju miast i regionów

redaktor naukowy

Arnold Bernaciak

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# Contemporary Challenges of Cities and Regions Development

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Arnold Bernaciak

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# Introduction

Nowadays cities, regions and whole countries are developing in a rapidly changing environment. They are influenced by different factors and forces. Technological changes, digital revolution, globalization or environmental pressure are the biggest challenges that socio-economic systems of cities and countries have to face.

Measures aimed at addressing the challenges associated with the uncertain environment could be a key to success while underestimating them could lead to a downfall.

Many scholars and researchers publishing in periodicals and journals make an attempt to identify factors that characterise emerging spatial units, factors that shape conditions of the social, economic and spatial development. This is the subject addressed in the current issue of *Studia Periegetica*, which offers a collection of studies that approach the research problem from very different perspectives.

Relevant aspects of international cooperation on transport networks are discussed by Galina Gavrilko, Dariya A. Dashkevich and Qi Peiyu in the article entitled "Economic Cooperation Between the Republic of China and the Republic of Belarus in the Context of Implementation of the One Belt, One Road Foreign Economic Strategy." The analysis is conducted in the context of cooperation between China and Belarus concerning the implementation of the new economic connection between the two countries. Belarus is a country eager to start co-operation with China but opening its market to Chinese products could be both an opportunity and a threat.

Alla Pakina looks at the problem of environmental pressure from a national perspective by investigating the question of carbon intensity of the regional economy. She analyses the example of Russia and in terms of carbon intensity as a land use management factor and tries to assess its applicability and usefulness.

Russia is also the subject of interest to Anna V. Belova, who analyses semi-medium-sized towns of North-West Russia and their potential to become drivers

of regional development. Anna V. Belova presents different level of analysis focusing on the city level, which seems to be the most adequate in describing local development drivers.

City level is the perspective adopted by Agnieszka Sobol, who examines participatory budgeting in the city of Katowice, Poland. In her analysis, she tries to establish whether participatory budgeting can push the city on its way towards sustainability. It is worth mentioning that participatory budgeting is a process implemented by local authorities to improve social participation and involvement in the decision-making process and sharing responsibility for the common future.

Deeply local solutions, arising from grassroots initiatives, are discussed by Barbara Borusiak and Barbara Kucharska. In the article entitled "Sustainability in Retailing: A Study of Consumer Intentions Regarding Involvement in Charity Shop Activities" the authors examine the main factors that motivate people involved in a charity-shopping idea.

Education, which is the topic raised by covered by Volha Kremleva and Alena Jukh, seems to be the common denominator of the previous and following articles. In their article "Possibilities and Practices of Competences for Sustainable Development in Teacher Education at Yanka Kupala State University of Grodno," they discuss the role of education in shaping environmental consciousness and developing responsible governance. Only an effective teaching process and its capacity for adaptation to the changing external conditions can be the key to success for both individuals and units.

This current issue concludes with the article by Yelizaveta Chernysh, entitled "The Environmental Friendly Solution for Stimulation of the Soil Protective Properties." The author presents detailed technological aspects of solutions to enhance protective properties of the soil.

*Arnold Bernaciak*

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Galina Gavrilko*, Dariya A. Dashkevich**, Peiyu Qi***

# Economic Cooperation between Republic of China and Republic of Belarus in the Context of Implementing the One Belt, One Road Foreign Economic Strategy

**Abstract.** This article provides insight into the dynamics and commodity pattern of the Chinese-Belarusian bilateral trade, the current state and prospects for the investment, scientific and technological cooperation between the two countries for the purpose of implementing the One Belt, One Road foreign economic strategy. With the advancement and financial support of the project, the Chinese-Russian bilateral balance of economic relations will be shifting in favor of China. Russia will act as a "subordinate partner"; its global economic and financial interests in the global economy and in the post-Soviet space will be represented less than those of China.

**Keywords:** foreign economic strategy, foreign trade cooperation, investment cooperation, scientific and technological cooperation, gravity model of bilateral trade, foreign investment, direct investment, portfolio investment, technology transfer, innovation-driven development

## 1. Introduction

A foreign economic policy is becoming the main driver of China's economic development. The growth rate of domestic consumption is insufficient to compensate for losses from the slowdown of foreign trade turnover growth, in general, and exports, in particular. Chinese high-technology goods are hardly penetrate

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the markets of developed countries. This is due to a fall in demand in the main export markets of the USA and EU, high volumes of Chinese goods and partial non-compliance of Chinese goods with the standards of developed countries.

The main element of China's new international strategy is its plans for a profound impact on the development of the global economy in the coming decade.

The main areas of this process are as follows:

First, the restructuring of the world economic development infrastructure through the active promotion of the One Belt, One Road initiative. China offers the Silk Road member countries far-reaching possibilities for trading, economic, investment, scientific and technological cooperation.

Secondly, a change in the world monetary and financial system and China's entry into the group of the world's major financial players. If the financial component of the Silk Road initiative is implemented successfully, China will be able to strengthen the yuan as the third world currency (after the dollar and the euro).

In the West, China's new push under the One Belt, One Road initiative is called "a Chinese version of the Marshall Plan." By creating an infrastructure along the ancient Silk Road, China proposes not only to stimulate a bilateral trading, economic, investment, scientific and technological cooperation in South, Central and West Asia, Central and Eastern Europe, but also to strengthen China's influence in this region, including the former Soviet Union.

## 2. Trade and economic cooperation between China and Belarus

The assessment of bilateral trade between Belarus and China can be made according to E. Leamer and J. Levinsohn's gravity model developed by analogy with Newton's law of universal gravitation [Leamer & Levinsohn 1995]. For purposes of comparison, in order to minimize the impact of the distance factor, Table 1 shows indicators of European countries that are more or less equidistant from the People's Republic of China (PRC).

The correlation coefficient for the countries under consideration between the size of their GDP and the volume of bilateral trade turnover with China is –0.889, that is, the greater the country's economy, the higher the bilateral trade turnover. According to this theory, the potential of Belarusian-Chinese trade depends on the growth of the Belarusian economy. Taking into account the most optimistic forecasts, a long-term average annual economic growth in Belarus does not exceed 3% [Rudy 2016: 16]. For example, according to the Oxford Economics Group, the average annual increase in GDP in Belarus from 2018 to 2030 is predicted to be 2.7% [Ross 2016].

Table 1. Components of the gravity model of bilateral trade, 2017

| Country | Trade turnover with the PRC, billion dollars | Ratio of the country's nominal GDP to that of the PRC, times | Distance to the PRC, km | Trade turnover with the PRC per capita, dollars |
|---|---|---|---|---|
| Belarus | 3.1 | 136 | 6,016 | 340 |
| Ukraine | 8.6 | 79 | 5,947 | 202 |
| Lithuania | 0.8 | 214 | 6,230 | 285 |
| Poland | 25.7 | 19 | 6,640 | 669 |
| Czechia | 19.4 | 50 | 6,968 | 1,847 |
| Slovakia | 6.2 | 103 | 6,736 | 1,148 |

Source: Rudy 2016: 17, 42.

A trade deficit with China is typical of all the countries under consideration, so the potential for increasing trade turnover is primarily in the growth of Chinese imports, which depends on the market capacity and competition. Taking into account the capacity of the domestic market, per capita trade turnover of Belarus is higher than in Lithuania, but it is significantly inferior to that of Poland, the Czech Republic and Slovakia (Table 1). The competitiveness of Chinese products is confirmed, for example, by the fact that in 2017 Belarusian imports from China included products traditionally produced domestically, such as onions and garlic (to the amount of 1.9 million dollars), cabbage (to the amount of 2.1 million dollars), fresh apples, pears (together with papaya to the amount of 33.7 million dollars).[1]

As for exports to China, they are restricted to raw material and technological opportunities of the exporting countries. The main goods purchased by China are electrical equipment, oil, vehicles and engines; for this reason, only innovations can be a competitive advantage in the Chinese market.

It should be noted that Belarusian commodity exports indicate China's investment interests in the potash industry. Besides, the popularity of Belaruskali, JSC in Asian countries accounts for the issue of its shares in Hong Kong. In its turn, direct investments from Belarus were used to promote Belarusian non-resource exports to China. For example, co-production for the MZKT, BelAZ, Gomselmash and MTZ machinery assembly was set up in China.

At the same time, Chinese investment imports in the form of procurement of processing lines and contract work serves as a prerequisite for Chinese direct investment in Belarus. However, a full-fledged transition from tied credits to the cor-

[1] www.belstat.gov.by/ofitsialnaya-statistika/makroekonomika-i-okruzhayushchaya-sreda/vneshnyaya-torgovlya_2/operativnye-dannye_5/eksport-import-s-otdelnymi-stranami/ [access: 14.03. 2018].

poratization of investment projects focused on exports to China has not occurred yet. Initially, Chinese intensive direct investments in Belarus were aimed at return due to the domestic demand (the *Beijing* Hotel, the *Lebyazhy* residential community). The subsequent investments (The *BelGee* automobile plant, the *Great Stone* industrial park) were oriented to the external market. At the same time, Chinese direct investment does not imply exports to the Chinese market. Besides, to minimize risks, Chinese direct investment in Belarus often has a complex financing model with a mix of own and borrowed capital on the part of China and Belarus.

The analysis of the Belarusian-Chinese trading pattern shows that the goods of the two countries complement each other well and cooperation has a great potential. In recent years, the main Belarusian exports to China have included potash fertilizers, polyamides, machines and mechanisms for harvesting and threshing crops, processed raw flax, integrated circuits, heterocyclic compounds containing nitrogen atoms, etc. (Table 2).

The analysis of China's exports to Belarus according to the enlarged commodity sections (Table 3) shows that main type of products exported by China to Bela-

Table 2. Belarusian commodity exports to China

| Description of goods | 2015 | | 2016 | | 2017 | |
|---|---|---|---|---|---|---|
| | Q-ty | Cost, thousand dollars | Q-ty | Cost, thousand dollars | Q-ty | Cost, thousand dollars |
| Compounds containing functional nitrile group, tons | 5,349 | 4,801.4 | 4,905 | 4,650,1 | 4,516 | 2,400.8 |
| Potash fertilizers, thousand tons | 434,0 | 243,807.6 | 1,137.4 | 493,849.7 | 1,397,9 | 646,712.0 |
| Ethylene polymers, tons | – | – | 9 | 3.2 | 3,500 | 3,034.3 |
| Polyamides, tons | 25,664 | 59,272.1 | 24,660 | 54,590.6 | 38,060 | 56,097.7 |
| Heterocyclic compounds with nitrogen atoms, thousand tons | 27.8 | 62,361.8 | 9.9 | 20,878.3 | 12.3 | 16,214.2 |
| Rough timber, thousand $m^3$ | 160.8 | 8,620.9 | 129.0 | 6,351.8 | 83.0 | 2,810.3 |
| Unkempt wool, tons | 399 | 2,345.2 | 284 | 1,194.1 | 886 | 2,379.0 |
| Raw or processed flax, tons | 2225 | 1,961.7 | 6,120 | 6,651.0 | 12,711 | 14,173.7 |
| Synthetic filament tow, tons | 4,590 | 9,810.1 | 3,146 | 6,575.6 | 2,298 | 3,607.6 |
| Machines and mechanisms for harvesting and threshing crops, pcs. | 893 | 18,011.1 | 305 | 6317.9 | 179 | 10,417.4 |
| Electronic integrated circuits, tons | 1 | 3,304.7 | 1 | 4716.7 | 1 | 4,357.9 |
| Parts and accessories for vehicles and tractors, tons | 115 | 1,494.9 | 36 | 470.6 | 162 | 1657.3 |

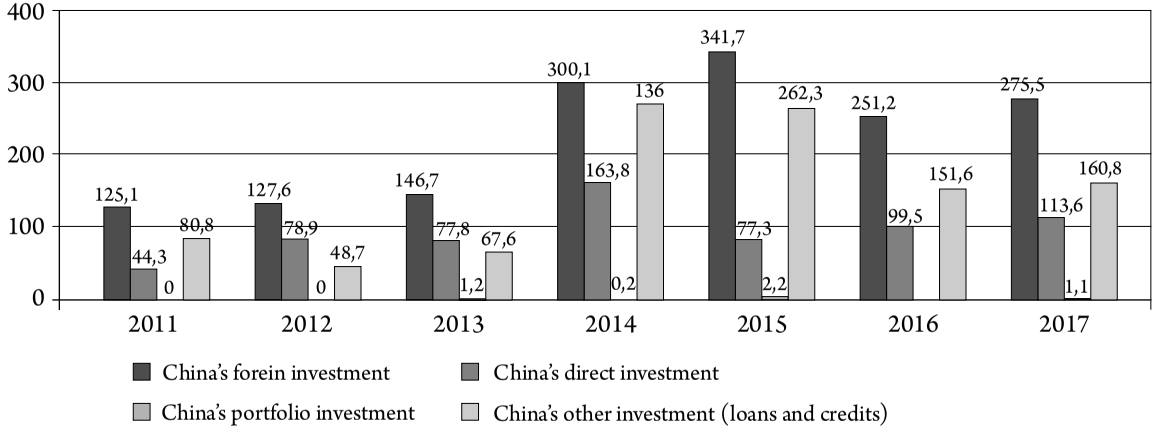
Source: based on National Statistical Committee of the Republic of Belarus, 2017: 184-185, 38.

Table 3. Chinese commodity exports to Belarus

| Description of goods | 2015 | | 2016 | | 2017 | |
|---|---|---|---|---|---|---|
| | Q-ty | Cost, thousand dollars | Q-ty | Cost, thousand dollars | Q-ty | Cost, thousand dollars |
| Equipment for manufacture of paper pulp, paper and cardboard, pcs. | 213 | 736.5 | 24 | 63.3 | 17 | 232,724.0 |
| Telecommunications equipment and equipment parts, thousand pcs. | 1,958.7 | 224,392.5 | 2,968.3 | 204 858.5 | 3,278.7 | 192,193.8 |
| Computing machines for automatic information processing, thousand pcs. | 3,002.6 | 200,470.4 | 3,655.4 | 231,905.4 | 1,516.6 | 75,469.2 |
| Parts and accessories for vehicles and tractors, tons | 19,500 | 76,919.3 | 17,770 | 71,622.4 | 13,234 | 49,675.6 |
| Electrical transformers, thousand pcs. | 12,087.3 | 25,661.9 | 6,773.2 | 19,769.2 | 5,821.4 | 39,879.6 |
| Parts of footwear, tons | 3,453 | 73,831,5 | 4,033 | 79,336.7 | 2200 | 39,488.0 |
| Centrifuges, equipment and devices for the filtration of liquids or gases, thousand pcs. | 1437.3 | 16,803.7 | 2,411.0 | 7,051.0 | 4,435.8 | 37,976.2 |
| Antibiotics, tons | 478 | 30,537.9 | 378 | 25,308.0 | 680 | 35,859.9 |
| Heterocyclic compounds with nitrogen atoms, tons | 1,326 | 33,302.0 | 1,412 | 32,182.0 | 2,258 | 35,473.1 |
| Ferrous metal structures, tons | 8,965 | 33,480.4 | 5,331 | 14,595.7 | 15,820 | 35,049.7 |
| Apples, pears and quinces, fresh, tons | 201 | 253.3 | 318 | 290.0 | 45,404 | 33,751.6 |
| Heat-treating equipment, pcs. | 9,311 | 3,000.4 | 4,431 | 3,070.1 | 6,483 | 30,136.1 |
| Insulated wires, cables, tons | 2,196 | 67,711.8 | 1316 | 11 073,5 | 2,022 | 29,200.7 |
| Accessories and fasteners from base metals used for furniture and doors, tons | 7,609 | 29,061.0 | 9,149 | 33,292.8 | 8,184 | 27,326.7 |
| Vegetables, frozen, tons | 141 | 245.5 | 1,2493 | 8,390.5 | 38,356 | 26,838.5 |
| Toys and puzzles, tons | 4,032 | 31,299.6 | 4,572 | 38 257.9 | 3,146 | 24,296.6 |
| Machines and devices for hoisting, transfer, loading or unloading, pcs. | 1,856 | 6,702.9 | 1,364 | 8,700.6 | 1,026 | 22,715.6 |
| Amino compounds with oxygen-containing functional group, tons | 6,459 | 17,566.6 | 7,068 | 16,675.5 | 8,675 | 20,422.4 |
| Footwear with genuine leather upper, thousand pcs. | 1,613.5 | 48,007.5 | 1,455.9 | 38,837.2 | 802.6 | 18,839.4 |
| Control units, panels, tables for electrical equipment, tons | 489 | 24,407.8 | 449 | 9,260.9 | 609 | 18,566.7 |

Source: based on National Statistical Committee of the Republic of Belarus, 2017: 319-324, 38.

Chart 1. China's foreign investment in the Republic of Belarus by type in 2011-2016 (in millions of dollars)




Source: Presnyakova 2017: 168, 38.

rus is equipment for the production of pulp, paper and paperboard, whose volume in 2017 as compared to 2016 increased by 366.7 times (by 225.3 million dollars as compared to 2015). This is followed by telecommunications equipment and its parts (8.28% of Belarus' imports from China in 2017), computers for automatic information processing (3.25% of Belarus' imports from China in 2017), spare parts and accessories for vehicles and tractors (2.14% of imports to Belarus in 2017), electrical transformers (1.72% of Belarus' imports from China in 2017), etc.

After the establishment of diplomatic relations between China and Belarus (from 1992 to 2017), trade turnover increased 91 times. In 1992, trade turnover between China and Belarus amounted to about 33.9 million dollars, and in 2015 reached 3.1 billion US dollars, in 2017 – 2.7 billion US dollars. Throughout 1992-2005, a consistent increase in foreign trade turnover was recorded with a fairly stable surplus in favor of Belarus. However, since 2006 the situation has been changing. Despite the fact that trade turnover continued to grow, in 2006 a deficit was registered for the first time. In 2009, the global economic crisis reduced the level of mutual trade in goods. Trade turnover in 2009 compared to 2008 decreased by 38.17%. In addition, in 2014 and 2016 the consequences of the crisis persisted in Belarus, therefore during this period there was a decline. In 2017, the growth of foreign trade turnover between Belarus and China was 119.4%.

China is becoming one of Belarus' most important trade and economic partners. As of the end of 2015, China for the first time became Belarus's second highest ranked import partner (after Russia). The share of imports from China in Belarus' total imports was 7.9% [National Statistical Committee of the Republic of Belarus 2017: 52].

According to customs statistics in the Republic of Belarus in January-March 2018, China ranked the fourth in the rate of foreign trade in goods (5.0%), after Russia – 49.7%, Ukraine – 6.6%, the United Kingdom – 5.8%. The following countries ranked among top ten major trading partners of Belarus by Germany (4.7%), Poland (3.9%), the Netherlands (3.1%), Lithuania (2.1%), Turkey (1.7%), Italy (1.2%).

## 3. Investment cooperation between China and Belarus

Trade relations between the countries are a prerequisite for investment cooperation. A significant amount of foreign direct investment came from the Russian Federation in 2017 (in the amount of 453.6 million dollars), which accounted for 35.6% of the total net inflows of direct investments from abroad. In addition to residents of the Russian Federation, the main direct investors of the Belarusian economy were residents of the United Kingdom, Cyprus, Poland, Lithuania, Latvia.

The People's Republic of China holds a special place among Belarus' foreign economic partners, and its investments are of great importance for the Republic of Belarus.

From 2011 to 2017, the Belarusian economy received Chinese investments to the amount of 1,567.7 million dollars, of which 655.2 million dollars (41.8%) was direct investment, 907.8 million dollars (57.9%) – other investments in the form of loans and credits (Chart 1).

In 2017, Belarus received 275.5 million dollars of gross foreign investments from China, which is 109.6% more than in 2016 (in 2016 it was 251.2 million dollars). Most of them were in the form of loans and credits that did not come from a direct investor (in 2017 – 160.8 million dollars or 58.3%).

Direct investments in 2016 amounted to 99.5 million dollars, which is 22.2 million dollars more than in 2015. In 2017, 113.6 million dollars of direct investment was attracted, which is 14.1 million dollars or 114.2% in relation to 2016.

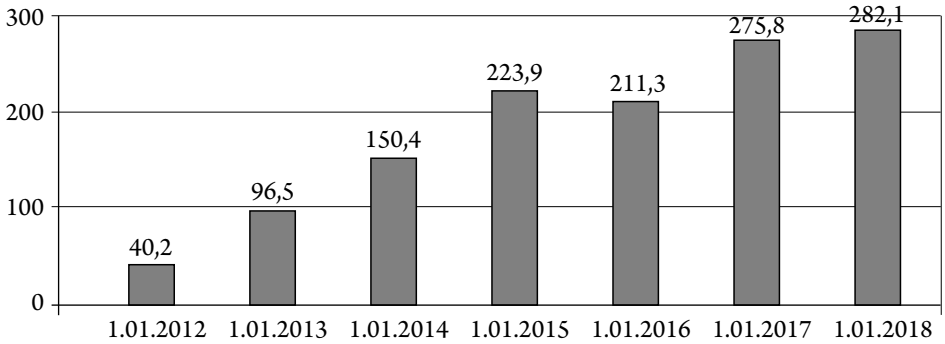
At the same time, it should be stressed that most Chinese direct investments in 2017 were debt instruments (accounts payable, loans, credits, etc.) – 63.5%.

On January 1, 2013, the amount of Chinese FDI in Belarus was 282.1 million dollars, which is 235.6 million dollars more than the value recorded one year earliery (growth by 7 times) (Chart 2).

Belarusian-Chinese relations are based on bilateral credit and investment cooperation. With the loan support of Chinese banks, a number of investment projects important for the country's economy were implemented in Belarus:

1. Creation of the *Best* mobile communications operator (a loan of 234 million dollars granted by the Export-Import Bank of China; the *Best* mobile operator (later – Life) was sold to the Turkcell Company (Turkey)).

Chart 2. Accumulated Chinese FDI in the Republic of Belarus in 2012-2017 (in millions of dollars)




Source: based on Presnyakova 2017: 168, 38.

2. Modernization of Minsk CHP-2 (a concessional loan of 42 million dollars granted by the Chinese government).

3. Reconstruction of Minsk CHPP-5 (a loan of 260 million euros granted by the China Development Bank).

4. Modernization of the cement industry in Belarus (Belarusian Cement Plant, JSC and Krasnoselskstroimaterialy, JSC) (a loan of 530 million dollars granted by the Export-Import Bank of China).

5. Construction of CCGT-400 MW at Bereza Hydropower Plant; PGU-400 MW at Lukoml Hydropower Plant (a concessional loan of 633 million dollars granted by the Chinese Government).

6. Assembly factory for Geely passenger cars (a loan of 158.7 million dollars granted by the Export-Import Bank of China), etc. [Zhuravlev 2015: 104].

In 2017-2022, Belarus is expected to take out a buyer's credit from the Export-Import Bank of China amounting to 192.7 million dollars to build a plant for the production of front loaders and energy-saturated tractors in the village of Kolodishchi (Minsk district) by the Amkodor Holding Company together with the Chinese state corporations of CITIC Group and Sinomach.

The advantages of project financing from the Chinese credit line are as follows:

– a long loan term – up to 15 years (including a privilege period – up to 5 years, repayment period of the main debt – up to 10 years);

– no need to obtain a guarantee from the Belarusian government for each loan provided from the credit line;

– no need to obtain coverage of the SINOSURE export credit insurance agency, which reduces the cost of credit resources for the final recipient.

The peculiarity of Chinese loans is that their delivery is associated with the obligation to purchase Chinese equipment and often Chinese labor for the implementation of a specific investment project. Advantages of this form of cooperation for Belarus are favorable loan terms and conditions: relatively low interest and maturity with a delay of the first payment. But at the same time, Belarus is deprived of the freedom to choose its suppliers and is forced to rely on the quality of services and equipment offered by China. On the other hand, Chinese investment imports in the form of the supply of technological lines and contract work is a prerequisite for Chinese direct investment in Belarus.

The development of international cooperation under the One Belt, One Road project and targeted incentives for manufacturers in the *Great Stone* industrial park provide a competitive advantage to this facility by combining high competencies, investment and human capital, and a unique infrastructural location. The park has a significant capacity to launch quickly and increase its output of in-demand high-tech products in a comfortable business and legal environment with effective administrative and economic incentives. As a consequence,

the development of the industrial park, as well as an industrial, scientific and technological cooperation with the PRC is generally an incentive to strengthen Belarus' economic and technological position in the international space significantly.

Thus, the cooperation between the Republic of Belarus and China in the field of attracting investments is currently being implemented both by offering privatization opportunities and creating new production facilities and building large real estate objects. The majority of Chinese investments in Belarus are related credit lines for the modernization of facilities in the energy sector, manufacturing industry and road construction.

At the same time, there is a shortage of direct foreign investment in Belarus, while indicators for other types of investments are high. The *Great Stone* Chinese-Belarusian Industrial Park is the key infrastructural object of economic cooperation between Belarus and China under the One Belt, One Road project.

## 4. Scientific and technological cooperation between China and Belarus

The analysis of the modern scientific and technological development of the Republic of Belarus makes it possible to come to the following conclusions:

– the country's scientific and technological development is one of the priorities of the Belarusian state. The country is implementing the State Program of Innovative Development for 2016-2020, which includes 75 scientific and engineering projects;

– there were 428 organizations conducting research and development in 2017, a fall by 3 compared to 2016. A decrease in the number of organizations was followed by a reduction in the number of employees conducting research and development – in 2017 the number of employees fell by 194 persons or by 0.8%. This resulted in a smaller number of researchers per 10.000 inhabitants. In 2016, the number of researchers per 10,000 population was 17.76; in 2017 – 17.72. In recent years this ratio has increased from 37.73 to 38.87 researchers per 10,000 population;

– from 2001 to 2016 there was a steady increase in the number of new works published by Belarusian scientists in periodicals listed in the Scopus database. However, despite this growth, since 2001, there has been a decline in scientific contributions to the global volume of scientific publications. For example, since 2001 this value has decreased from 0.12% to 0.05% in 2016;

– the percentage of GDP spent on research in 2016-2017 was 0.50%, which is 0.02 percentage points less than in 2015 and it continues to decrease;

– in 2017, the percentage of innovative products in the total shipping volume of industrial organizations was 16.9%, which is 0.6 percentage points higher in 2016. In 2017, the indicator of "the share of exports of high-tech and science-intensive products in the total volume of Belarusian exports" increased by 0.5 percentage points compared to 2016 and amounted to 33.7%.

The analysis of economic aspects of scientific and technological development of the PRC makes it possible to come to the following conclusions:

– the development of China's scientific and technological complex was a top-priority goal in the country. In 2016, the *Fundamental Provisions of the National Strategy of Innovation-Driven Development* determined the main objectives and areas of the country's innovation-driven development for the mid-term. The PRC State Development Plan for 2016-2020 is based on the development of technological innovation;

– China ranks second in the world for the total R&D expenses amounting to 251.9 billion US dollars in 2017, or 14.6% more than in 2016.

– Chinese R&D spending accounts for more than 12% of the global R&D expenditures. The share of expenses for scientific, technical and innovative activity in 2017 was 2.1%;

– China pays special attention to the staffing in the scientific sector. Chinese universities hold the top spots in the world ranking. China ranked first in the world in terms of the number of students studying abroad. During the last 10 years more than 50% of Ph.D. holders in engineering and industrial technology sciences studied abroad. 79% and 46% of teachers respectively are younger than 45 and 35 years old. In 2016, China was the world's second in terms of the number of international scientific publications of Chinese scientists and their citation;

– exports of medium- and high-tech products accounted for 54.6% of total exports in 2017. China's contribution to the world exports of ICT goods in 2017 was 30.6%. China is the biggest manufacturer of telecommunications equipment, computers and semiconductors.

The prospects for scientific and technological cooperation between the two countries are based on the orientation of Belarus and China towards innovation-driven development. In China, in the field of information technology, special emphasis is put on the implementation of the *Made in China 2025* and *Internet* + strategies, the development of technologies that ensure the updating and ubiquity of "intellectual" computer systems.

The *Made in China 2025* strategy envisages the country's innovation-driven development in the following areas of information technology, automated control systems and robotics, aerospace engineering, marine engineering equipment and high-tech maritime transport, railroad equipment, energy saving and vehicles using alternative energy sources, power equipment, new materials, medicine and medical devices, and agricultural machinery.

Table 4. Areas of institutional support for the introduction of mechanisms of scientific and technological cooperation between Belarus and China

| Areas | Activities |
|---|---|
| Political | Determination of scientific and technological priorities in the domestic and foreign policy of the countries;Development of the national technological policy, as well as a system to provide advantages in the avenues of research for the concentration of the scientific and technological potential of the country in the corresponding "technological niches" |
| Statutory and regulatory | Development and adoption of laws and regulations that will ensure an open procedure for production cooperation between the countries, taking into account the criteria of upgrading of the technological level of production in all types of economic activity. Harmonization of the regulatory and legal framework in the field of intellectual property management towards the more effective legislative consolidation at all levels of interstate regulation of intellectual property rights and providing the legal basis for their effective protection. |
| Information | Development of the system of communication platforms for the selection of potential partners of the cooperation between the Republic of Belarus and the People's Republic of China. The formation of a favorable image of a scientist, an engineer of an inventor, whose contribution to the social development is highly appreciated in the country. Creation of awareness about the achievements of Belarusian and Chinese science in the technological area. |
| Management | Provision of assistance in solving organizational issues, for example, within the framework of the functioning of the general innovation and technological infrastructure of „incubators", „technoparks", etc. Reduction of administrative barriers that block the establishment of entities with different structures with a focus on scientific and technological cooperation between the countries. |

Source: Fu Jingcheng 2017: 48.

The *Internet* + strategy includes the following areas:
- Internet + Entrepreneurship and Innovation
- Internet + Industry
- Internet + Agriculture
- Internet + Energy Efficiency
- Internet + Finance
- Internet + Public Services
- Internet + Logistics
- Internet + E-Commerce
- Internet + Transport
- Internet + Ecology
- Internet + Artificial Intelligence.[2]

[2] www.ved.gov.ru/exportcountries/cn/about_cn/eco_cn/, p. 72-72 [access: 19.02.2018].

To implement these strategies, special investment funds have been established in China. They are supported by enterprises operating under these strategies.

China focuses on the development of ICT technologies as the main basis for a strategic leap in such areas as industry, agriculture, energy, medicine, trade and others. In this regard, promising areas of scientific and technological cooperation between Belarus and China are as follows:

– technology transfer;
– inclusion in production chains;
– experience exchange;
– joint projects in the field of ICT;
– training of specialists;
– cooperation of the *Great Stone* Industrial Park with *Zhongguancun*, the main innovation park of high technologies in China;
– creation of a joint venture fund for the implementation of Belarusian-Chinese projects in the context of cooperation with the *Zhongguancun* Science Park;
– use of China's experience in the field of e-commerce, which is one of the main engines of the Chinese market, the Internet + development plan, as well as Big Data, Internet of Things for their implementation in the Republic of Belarus.

The development of mechanisms of institutional support for the implementation of the policy of scientific and technological cooperation between Belarus and China as a whole, as well as cooperation in the areas specified in Table 4, is important for the two countries.

Industrial and technological cooperation and trade in know-how between Belarus and China should become a sphere of growing international economic relations and contribute to the important changes in the structure of the economy of the two countries. It should be supplemented by scientific and technological cooperation at the product development stage; cooperation in direct production; provision of technological services at the stage of installation and commissioning of the facility; engineering during its operation.

## 5. Conclusion

In the West, China's new attack within the framework of the Belt and Road Initiative is called a Chinese version of the Marshall Plan. At the current stage, B&R is not only an investment strategy but rather a geopolitical strategy. By means of the infrastructure created along the ancient Silk Road it suggests not only stimulating bilateral trade and economic relations in South, Central and West Asia, Central and Eastern Europe and boosting China's direct foreign investment and trade but also strengthening the influence of the country in this gigantic region.

Russia attributes the reduction of risks associated with the implementation of the Silk Road project to the creation of balancers in case of an unfavorable scenario. These are, first, the formation of a legal, financial and institutional infrastructure to ensure Russian interests in the implementation of Chinese projects in the territory of the Eurasian Economic Union, primarily Russia, Kazakhstan and Belarus.

For China, the EAEC countries are mostly suppliers of raw materials and fuel and energy resources, as well as a market for the sale of finished products. Trade between China and the EU has a fundamentally different character, which is expressed in the predominance of non-resource-based goods with high added value in the trade structure. European countries sell mainly technically sophisticated goods to China (cars, aircraft, spare parts, electric machines and equipment, tools, microcircuits, etc.), pharmaceutical and chemical products, as well as metal waste and scrap. The basis of China's exports is mechanical and electrical machinery and equipment, clothing and footwear, furniture, photo equipment.

It is also important to note the difference in the scale of the markets of the EAEC and the EU for the PRC. While the market of the Eurasian Economic Union is 3% of China's export sales, the European market –17%, for imported supplies, this ratio is respectively 3 and 12%.

Secondly, the creation of strategic balancers in case of increasing dependence on China: in the military and political aspect – due to the normalization of relations with the United States, in the economic – with the European Union, Japan and South Korea.

In the context of the implementation of the One Belt, One Road project, the peculiarities of the development of trade and economic relations between Belarus and China are as follows:

– the key role of the political leadership in the trade of the two countries. Reciprocal visits, summit meetings and adoption of economic policies are sure to contribute to an increase in the volume of trade turnover between the two countries. In some cases, administrative incoordination, lack of information from competitive markets, political willpower are constraints of the natural long-term development of free trade;

– China's surplus in foreign trade in goods with Belarus has been increasing since 2006. For Belarus, this situation in the long term development of trade and economic cooperation is unprofitable.

– in comparison with China's imports, the structure of Belarus' export to China is not diversified. At the same time, the goods are not unique and have analogues in other countries, which presupposes a constant analysis of the competitors' positions and caution in the field of foreign trade pricing, where there is either little or no margin for maneuver and price increase by Belarusian exporters.

In general, China's share in total turnover of the Republic of Belarus is 4.9-5.0% and is growing; the share of the Republic of Belarus in China's total trade turnover in 2009-2017 is much lower and remains at the same level (0.07-0.08%).

– currently, despite the operation of more than 40 representative offices of Chinese companies in Belarus and the implementation of about 30 joint projects, the share of Chinese direct investment on a net basis remains low (in 2017 – 34.4 million dollars, which is 2.6% of the total FDI inflows on a net basis);

– from the point of view of investment priorities, Belarus is still not significant for China in comparison with other countries of Central and Eastern Europe. At the same time, in 2011-2017 the share of Chinese investments in the total amount of foreign investments in Belarus increased from 0.7% to 2.9%, while the share of China's direct investments – from 0.3% to 1.43%.

For Belarus, trading, economic, investment, scientific and technological cooperation with the PRC is of great importance, since the implemented initiatives affect economic growth. The bilateral Chinese-Belarusian cooperation is based on common goals and objectives, which include sustainable social and economic development, increasing competitiveness, assistance in solving social and environmental problems, and protection of national interests at the regional and international levels.

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# Współpraca gospodarcza między Republiką Chin a Republiką Białorusi w zakresie wdrażania strategii gospodarczej One Belt, One Road

**Streszczenie.** Artykuł przedstawia dynamikę i wzór towarowy chińsko-białoruskiego handlu dwustronnego, aktualny stan i perspektywy inwestycji, współpracy naukowej i technologicznej między dwoma krajami w celu wdrożenia zagranicznej strategii gospodarczej One Belt, One Road. Wraz z postępem i finansowym wsparciem projektu chińsko-rosyjska bilateralny układ stosunków gospodarczych będzie coraz bardziej korzystny dla Chin. Rosja będzie działać jako „partner podrzędny"; jej globalne interesy gospodarcze i finansowe w globalnej gospodarce oraz w przestrzeni poradzieckiej będą reprezentowane w mniejszym stopniu niż w Chinach.

**Słowa kluczowe:** zagraniczna strategia gospodarcza, współpraca w handlu zagranicznym, współpraca inwestycyjna, współpraca naukowa i technologiczna, grawitacyjny model handlu dwustronnego, inwestycje zagraniczne, inwestycje bezpośrednie, inwestycje portfelowe, transfer technologii, rozwój oparty na innowacjach

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# Carbon Intensity of the Regional Economy as a Land Use Management Factor[1]

**Abstract.** As stated in the National Greenhouse Gas Inventory Report, $CO_2$ emissions and carbon balance vary significantly between Russia's regions. In this regard, estimations of regional capabilities to absorb GHG and $CO_2$ specifically are quite important. The analysis, undertaken in this study, made it possible to identify the territorial differentiation of the carbon capacity for the districts of the Republic of Tatarstan – one of the leaders of economic development in Russia. The author also considers the role of evaluating carbon intensity in the regulation of regional economy by optimizing land use structure.

**Keywords:** ecosystem service, land use, $CO_2$ balance, Tatarstan Republic

## 1. Introduction

The "Assessment Report on Climate Change and Its Consequences on the Territory of the Russian Federation," issued by the Federal Service for Hydrometeorology and Environmental Monitoring (Rosgidromet), states that the current climate change "has a serious impact on the socio-economic development of Russia" [Assessment Report… 2014]. That's why, according to many Russian researchers – ecologists and economists alike, the transition to a low-carbon

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economy in Russia has to be the key direction of development towards sustainability. As stated in international documents, a low-carbon economy is an innovative "socio-economic and technological system aimed to reduce GHG emissions without compromising the pace of socio-economic development" [Ecological footprint… 2016].

According to BP Statistical Review of World Energy, Russia is ranked 4th in carbon dioxide emissions after China, the US and India: in 2016, $CO_2$ emissions in Russia amounted to 1.5 billion tons. However, these calculations do not take into account the absorption of $CO_2$ by natural ecosystems. According to the National Greenhouse Gas Inventory Report, the rate of such absorption in Russia is estimated at about 500 million tons per year. However, $CO_2$ emissions and $CO_2$ balance vary significantly across Russia's regions. In this regard, estimations of regional capabilities to absorb GHG and specifically $CO_2$ are quite important: land use adaptation to climate change impacts can be quite an effective instrument to elaborate a mitigation policy and to create a new low-carbon economy.

The analysis, undertaken in this study, made it possible to identify the territorial differentiation of carbon intenisty in the districts of the Republic of Tatarstan, as well as the role of the regional land use policy to regulate carbon intensity of the regional economy for purposes of sustainable development.

## 2. The Republic of Tatarstan as a leader of economic development in the Volga region

The regional level of research activity is the most reliable way to evaluate the current situation. The methodical approach based on the calculation of the carbon absorption capacity of natural ecosystems and on a comparison with carbon intensity of the regional economy were analyzed for one of the most developed Volga regions – the Republic of Tatarstan.

The region was selected for a number of reasons: economic (high level of economic development and diversified structure of the economy), environmental (location in the highly significant environmental region of the Volga river basin) and social (an inequality in the standard of living of the local population).

The natural conditions of the region are determined by the fact that the territory spans two natural zones: the southern taiga and forest-steppe. Agriculture (both crop and livestock production) plays an important role thanks to favourable agro-climatic conditions and rich soils, such as sod podzolic soils and chernozems. The industry is mainly based on rich oil reserves, as well as knowledge-based manufacturing industry. As a result, in 2016 the Republic ranked 6th among

85 regions of the Russian Federation in terms of GRP, 4th and 5th in terms of agricultural and industrial production, respectively [Federal state statistics… 2016].

The evaluation of human development's sustainability is currently one of the topical issues for the world economy, given that a lot of resources – human, material and financial – are being consumed to reach sustainability. The current practice in sustainability assessment is based on a number of complex indicators, which are not without certain shortcomings. The most popular ones include the Human Development Index (HDI), the indicator of Adjusted Net Savings, indicators of Ecological Footprint (EF) and the Living Planet Index, both developed by WWF. In Russia, the Ecological-Economic Index (EEI) was suggested as an adaptation of the Adjusted Net Savings index to the Russian reality. To consider environmental and social aspects, in addition to economic ones, the Tatarstan Republic was compared to other Volga regions by complex indicators, based on [Bobylev et al. 2012; Ecological footprint… 2016; Bobylev & Grigor'ev 2016].

Table 1. Economic, ecological and social indicators of the Volga region's

| Subject of the federation | GRP, bln. RR | HDI | EEI, % | EF, gha per capita |
|---|---|---|---|---|
| Mari El Republic | 165.5 | 0.835 | 35.47 | 4.07 |
| Republic of Tatarstan | 1833.2 | 0.894 | 19.91 | 4.97 |
| Chuvash Republic | 250.4 | 0.839 | 33.94 | 3.95 |
| Samara Region | 1240.3 | 0.865 | 9.38 | 5.59 |
| Ulyanovsk Region | 301.4 | 0.843 | 39.79 | 4.46 |

Source: State report… 2016; Bobylev et al. 2012; Ecological footprint… 2016; Bobylev & Grigor'ev 2016.

The data presented in Table 1 show that Tatarstan has high levels of economic and social indicators (GRP and HDI) and lower levels of environmental indicators (EEI and EF) of development.

## 3. Data and methods

It is widely known that land use change is a key factor associated with carbon emissions and carbon dioxide absorption at the regional level [De Cara & Jayet 2011; EEA 2017; Kirillov et al. 2017; Lungarska & Chakir 2018], and carbon intensity of the regional economy can be considered as an indicator of the efficiency of economic activity. We evaluated carbon intensity of the regional economy taking into account carbon dioxide emissions from fuel combustion in the industrial, transport and housing sectors. The calculation is based on the approach proposed in the Recommendations on GHG Inventory developed by the Intergovernmental Panel on Climate Change (IPCC).

The basic formula used for calculating emissions from fuel combustion (1) is as follows:

$$E = M \times K_O \times TH3 \times K_B \times \frac{44}{12} \quad (1)$$

where:

$E$ – total $CO_2$ emissions from fuel combustion, tons/year;
$M$ – amount of fuel per year, thousand tons/year;
$K_O$ – coefficient of carbon oxidation, tabular data;
$K_B$ – carbon emission factor, tons/TJ, tabular data;
$TH3$ – net calorific value that allows to convert fuel to energy units TJ/thousand tons

The data on fuel consumption were taken from official statistical sources. Since the required data are provided by national statistical agencies for administrative territorial units only, our calculations were made at the level of municipal districts of Tatarstan.

Taking into account a high level of diversification of the regional economy, different sources were used to analyze the territorial structure of land use and the level of development: cartographic materials, space images, statistical compilations, state reports on environmental protection [State report… 2016; The Republic of Tatarstan… 2016] from the official web-sites of the regional and municipal administrations [The Republic of Tatarstan… 2016; The portal of municipalities… 2017], etc.

The amount of carbon dioxide absorbed by forest ecosystems and agricultural land was calculated at the level of forestry districts and arable lands respectively, because relevant statistical information is also available at the level of administrative territorial units. The calculations were made using data about the amount of carbon accumulated by different types of plant communities - for stands, litter and soils – according to the approach recommended by IPCC and adopted by the Russian Ministry of Natural Resources and Environment [The Order… 2017]. For example, the amount of carbon in a tree stand (growing stock) is calculated according to the formula (2):

$$C = V \times K_K \quad (2)$$

where:

$C$ – quantity (stock) of carbon in the biomass of trees of a certain age and breed;
$V$ – volume of stem wood of a certain age and breed;
$K_K$ – conversion factor to calculate the amount of carbon in the volume of trees biomass for a certain age and group, tons/m$^3$, table value.

Calculations of carbon volumes, absorbed by other types of land, were made in a similar fashion, according to the guidelines [The Order… 2017]. The meth-

Table 2. Conversion factors for some tree species common in Tatarstan

| Tree species | Age category | | | |
|---|---|---|---|---|
| | Sapling (1st and 2nd classes) | Middle-aged trees | Trees ripen | Overmature forest |
| Pine | 0.435 | 0.352 | 0.329 | 0.356 |
| Spruce | 0.614 | 0.369 | 0.351 | 0.364 |
| Larch | 0.392 | 0.371 | 0.398 | 0.398 |
| High-stem oak | 0.616 | 0.491 | 0.418 | 0.478 |
| Birch | 0.437 | 0.396 | 0.367 | 0.367 |
| Aspen, poplar | 0.356 | 0.363 | 0.335 | 0.365 |

Source: National Greenhouse Gas… 2017.

odology includes adjustments for losses from forest fires, deforestation and forest cutting.

Since the region of interest belongs to the subzone of the southern taiga and forest-steppe, we used appropriate coefficients for tree species and other types of plant communities prevailing in the region. For each of forests and agricultural plant communities (including stands, litter and soils) the calculation was carried out in several stages: 1) the amount of carbon in biomass of every type of plant communities; 2) the absorbing capacity of biomass; 3) losses (emissions) of carbon in biomass; 4) the carbon balance in biomass.

The calculation follows a typical procedure for such estimations and takes into account such parameters of plant communities as the stock of carbon in the biomass of trees (accounting for different age and breed), grass cover or soil; the volume of stem wood and other types of vegetation; conversion factors to calculate the amount of carbon in the biomass of each group (Table 2).

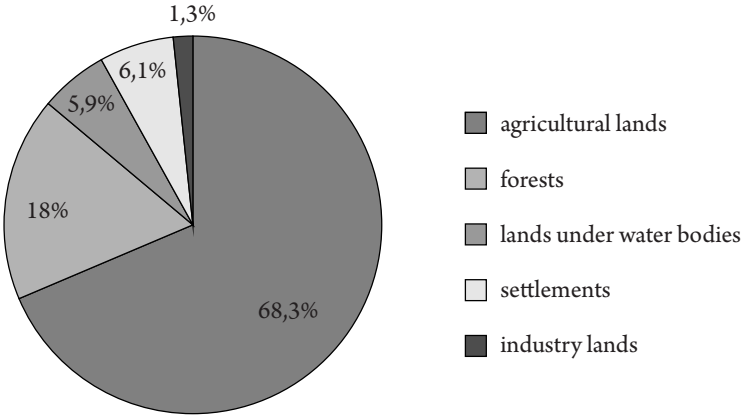
The total value of the absorbing capacity of forests, arable lands and pastures, and carbon deposits within the boundaries of the region were analysed using the MapInfo program, which can be used to determine areas of positive and negative balance of carbon dioxide.

## 4. Land use structure and carbon absorption capacity

The land use structure in the region is represented by a donut chart showing different industrial centers, including oil production and processing, agricultural lands, water bodies, etc. (Chart 1).

$CO_2$ emissions in the republic come mainly from industrial enterprises, which are located in the districts with a high share of transformed landscapes.

Chart 1. Land use structure in the Republic of Tatarstan (2016)




Source: State report… 2016.

They are usually deprived of forests and other forms of natural vegetation and their $CO_2$ absorption capacity is quite low. In contrast, in agricultural areas, $CO_2$ emissions are not significant, and agricultural lands have a high level of carbon absorption capacity.

As mentioned above (section 2), the data on fuel consumption were obtained on request from an official statistical source – the statistical service of the Republic of Tatarstan. Since the data are only available for administrative territorial units, all the calculations were made at the level of municipal districts of the republic, taking into account the coefficients for each fuel type given in the IPCC methodology. Unfortunately, information about fuel combustion in 5 of 45 Tatarstan's districts – Agryzsky, Apastovsky, Kaybitsky, Rybno-Slobodsky and Spassky – was unavailable, therefore calculations for these areas could not be performed. Emission values vary quite significantly in different administrative units: the highest volumes (8 538 780 t/year) were observed in the Nizhnekamsk district, 3,662,261 and 2,082,604 t/year in the towns of Kazan and Naberezhnye Chelny, respectively. The lowest volumes of carbon emissions (4,893 t/year) were recorded in the Muslyumovsky district. Thus, the highest rates exceed the lowest by more than 1.5 thousand times. The distribution of the main centers of $CO_2$ emissions in the Republic of Tatarstan is shown in Fig. 1.

The comparison of economic development indicators (GTP, gross territorial product) of the Tatarstan districts shows that they are not correlated with the emissions rates, which indicates different levels of carbon intensity across districts: thus, in the Nizhnekamsk district, which has the largest level of emissions, GTP is 180.5 billion RR, which is less than a third of the GTP of Kazan

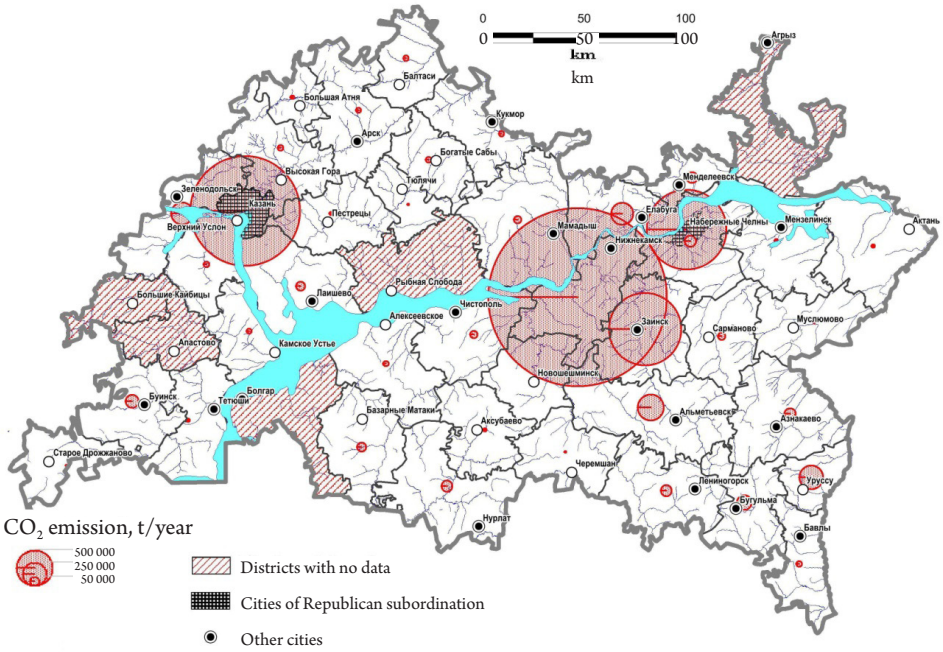



Figure 1. The main centers of $CO_2$ emissions in the Republic of Tatarstan

Source: own elaboration.

(605 billion RR). GTP of the town of Naberezhnye Chelny is also higher (187billion RR).

In order to evaluate the role of regional ecosystems in carbon absorption, its value was estimated for forest and agricultural lands (for forestry districts and administrative units respectively). Analysis of land use structure and its differences across the districts of Tatarstan shows a correlation between the carbon intensity of the regional economy and the carbon absorption capacity of the local ecosystems. According to our calculations, one hectare of agricultural crops in the Republic of Tatarstan absorbs from 13.4 to 14.5 tons of carbon dioxide per year, depending on the combination of agricultural crops. However, real figures ranged from 2.15 to 4.9 tons per year, taking into account the value of soil respiration. At the same time, one hectare of forest stands absorbs from 0.7 to 2.8 tons of $CO_2$ per year, depending on the combination of different tree species, their age and other characteristics taken into account in the assessment. It means that agricultural fields are more effective as absorbers of carbon dioxide. At the same time, forest communities are more efficient when it comes to carbon storage. Using the data on absolute values we compared relative carbon intensity and carbon capacity per GRP unit for the Tatarstan districts (Table 3).

Table 3. Carbon intensity and carbon absorption in some districts of the Tatarstan Republic

| Carbon intensity and carbon capacity indicators | $CO_2$ emission, t/year | $CO_2$ absorption by forests and agricultural lands, t/year | Relative carbon intensity per GRP unit, t/RR | Relative carbon capacity per GRP unit, t/RR | Balance |
|---|---|---|---|---|---|
| Negative balance* (Nizhnekamsk district) | 8 538 780.0 | 65 003.5 | 47.2 | 3.15 | –44.05 |
| Parity of emissions and absorption (Almetyevsk district) | 290 266.5 | 49 722.7 | 1.06 | 2.27 | 1.21 |
| A positive balance (Bugulma district) | 110 467.5 | 42 263.7 | 2.30 | 9.04 | 6.74 |

* Negative balance – carbon intensity exceeds carbon absorption capacity; positive balance – carbon absorption capacity exceeds carbon intensity.

Source: own elaboration.

Thus, all districts of Tatarstan can be divided into three groups in terms of their capacity to absorb $CO_2$:

– districts exceeding the limit (Nizhnekamsk and Zainsky districts and towns of Naberezhnye Chelny and Kazan);

– districts close to the limit (Yutazinsky, Almetyevsky, Zelenodolsk, Elabuga);

– districts well under the limit (the remaining ones).

Our study allowed us to conclude that the transition to a low carbon economy can be carried out not only by using alternative energy sources but also by regulating land use patterns. The ratio of transformed to natural ecosystems plays a key role in regulating carbon intensity. Natural landscapes, such as forests, swamps and natural meadows, absorb greenhouse gas emissions, while reducing environmental impacts. However, economic incentives to manage the land use structure often face barriers. From this perspective all the issues considered in the article are highly relevant directions of ecological-economic research.

The expansion of arable land and the consequent reduction in forest areas in the region have caused a carbon imbalance in regional landscapes. The digital map of regional land use, based on space images and statistical data, made it possible to evaluate the predominant types of landscape in the region of interest. In other words, land use efficiency and sustainable regional development can be used as key criteria in the assessment of carbon balance in the industrial and agricultural production and for purposes of regulation by increasing natural areas, especially in regions of economic growth, such as the Republic of Tatarstan.

Further studies will contribute to land use management as an important tool for sustainable regional development policies aimed at achieving and harmonizing environmental, economic and social parameters.

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## Intensywność zużycia węgla w gospodarce regionalnej jako czynnik zarządzania użytkowaniem gruntów

**Streszczenie.** Jak czytamy w krajowym raporcie inwentaryzacji, emisja gazów cieplarnianych, emisja $CO_2$ i bilans węglowy znacznie różnią się w poszczególnych regionach Rosji. W związku z tym bardzo ważne są oceny regionalnych możliwości pochłaniania gazów cieplarnianych i emisji $CO_2$. Przeprowadzona w wyniku badania analiza pozwoliła zidentyfikować terytorialne zróżnicowanie intensywności zużycia węgla w rejonie Republiki Tatarstanu – jednego z liderów rozwoju gospodarczego Rosji. Analizie poddan również rolę oceny intensywności zużycia węgla w regulacji gospodarki regionalnej poprzez optymalizację struktury użytkowania gruntów.

**Słowa kluczowe:** usługi ekosystemowe, użytkowanie gruntów, bilans $CO_2$, Republika Tatarstanu

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Anna V. Belova*

# Semi-medium-sized Towns of the North-West of Russia as Drivers of Regional Development

**Abstract.** Among the cities of Russia and Europe, including the Baltic Sea region, it is possible to single out the category of cities (towns) with a population of 20 to 50 thousand inhabitants, which is of particular interest for study, since it is the borderline category between small and medium-sized towns. Semi-medium-sized towns perform various functions in regional settlement systems, especially as centers for the formation of socio-economic regions. Another important factor in regional development is the active participation of semi-medium-sized towns in international cooperation with municipalities of the EU border states. The study deals with semi-medium-sized towns and their functions in five regions of Russia's Northwestern Federal District, and the socio-economic regions formed by semi-medium-sized towns are visually represented. As an example, five semi-medium-sized towns of the Kaliningrad region are considered, with emphasis on the role of each town in regional development. The author analyses the participation of semi-medium-sized towns of the Kaliningrad region in cross-border cooperation projects, identifying tendencies in territorial interactions of semi-medium-sized towns in the region with municipalities of the EU countries undertaken as part of trans-border and cross-border cooperation and benefits this cooperation has for the region.

**Keywords:** semi-medium-sized cities, settlement system, Baltic region, socio-economic region, Northwestern Federal District, Kaliningrad region, international cooperation

## 1. Introduction

Territorial development is impossible without a sustainable settlement system. Undoubtedly, a sustainable settlement system operates according to the concept

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of "Center-Periphery" with agglomerations acting as centres of development. However, practice shows that small and medium-sized cities can also become points of growth for territorial development and are important components of supporting frameworks of settlement. In our study, we identified a category of towns with a population of 20 to 50 thousand inhabitants. In one of the classifications [Davidovich 1962], these towns are referred to as semi-medium-sized. Such towns mainly functions as administrative centers of municipalities, but they can expand their influence over wider territories.

In the European part of Russia, the Northwestern Federal District, there are more than 30 such towns, but we focus our interest on 18 semi-medium-sized towns from five regions (Leningrad Region, St. Petersburg, Novgorod Region, Pskov Region and Kaliningrad Region). The choice of this district is motivated by the similarity of natural, historical and economic-geographical conditions that affect the development of settlement systems. Another important factor in regional development is the participation of semi-medium-sized towns of the Kaliningrad region and the entire Northwestern Federal District in international cooperation with municipalities of the EU border states, involving the creation of sustainable networks of cooperation between municipalities.

## 2. Theory

Russian socio-economic geographers and economists have devoted a lot of attention to theoretical and empirical studies on the subject of settlement, cities and regional development. However, there has been little research on semi-medium-sized towns in either Russian and foreign literature. The category of semi-medium-sized towns was introduced by L.L. Trube [1955], and V.G. Davidovich [1962] used this category in his classification of urban settlements. Later, the term "semi-medium-sized town" was used by economic geographers, such as O.A. Konstantinov [1963], D.G. Khodzhaev [1967], B.S. Khorev [1975]. Semi-medium-sized towns are of interest in the study of settlement systems, since they are a kind of a transition category combining the functions of small and medium-sized towns, and, depending on geographical location, they can replace mid-sized towns by performing a set of functions and providing adjacent territories with socio-economic services typical of mid-sized towns.

The group of foreign researchers invetigating problems of semi-medium-sized towns includes mainly European researchers, such as A. McGregor, M. McConnahie [1995], N.B. Groth, Th. Lang et al. [2005]. They have considered both theoretical and practical aspects of urban development and regional (territorial) development in European countries. In addition, research organizations and in-

stitutions, departments of government ministries, for example, the Ministry of Transport, Building and Housing of Germany, the ESPON organization (Sweden), etc., are involved in the development of small, medium-sized and semi-medium-sized towns in the Baltic region. In the last 20 years small towns in the Baltic region (with 20 to 50 thousand inhabitants) have undergone dynamic development and at the moment play a very important role in settlement systems, acting as support centers for regional and socio-economic development of the surrounding territory [Anokhin & Zhitin 2014; Lang 2005]. The development of semi-mid-sized towns in the exclave region, including their international cooperation in the Baltic region, has been studied by such economists and geographers as G.M. Fedorov, V.S. Korneevets, Yu.M. Zverev, A.V. Levchenkov, N.A. Klimenko [2011], P.V. Pogrebnyakov [2009], including a number of works by the author.

## 3. Research methodology

The author used materials from the Federal State Statistics Service for the period from 2005 to 2015; statistical compilations of the European Commission (Eurostat), reporting data of international projects of trans-border and cross-border cooperation programmes between Russia and the European Union (INTERREG, Tacis, etc.), implemented with the participation of the Kaliningrad region in the period from 2005 to 2017. These materials included results of international projects implemented by the author to study the potential of semi-medium-sized towns in the Kaliningrad region. For better clarity of the results, the cartographic method was applied, and the results are presented in tables and graphs.

## 4. Research results

In the theory and practice of socio-economic micro zoning, intraregional socio-economic regions are the highest level of micro-regions allocated in meso-regions (in Russia, the level of meso-regions is made up of federal subjects of Russia). They play an important role in the cultural and everyday services of significant parts of meso-regions [Anokhin, Zhitin, Krasnov & Lachininsky 2014; Belova & Levchenkov 2012; Klimenko 2011]. Their centers are often not only large cities and mid-sized towns, but also semi-medium-sized towns. To give a typical example, Figure 1 shows intra-oblast socio-economic regions identified in the 5 regions of the Northwestern Federal District (St. Petersburg, Leningrad, Novgorod, Pskov and Kaliningrad regions). They were selected after analysing in-

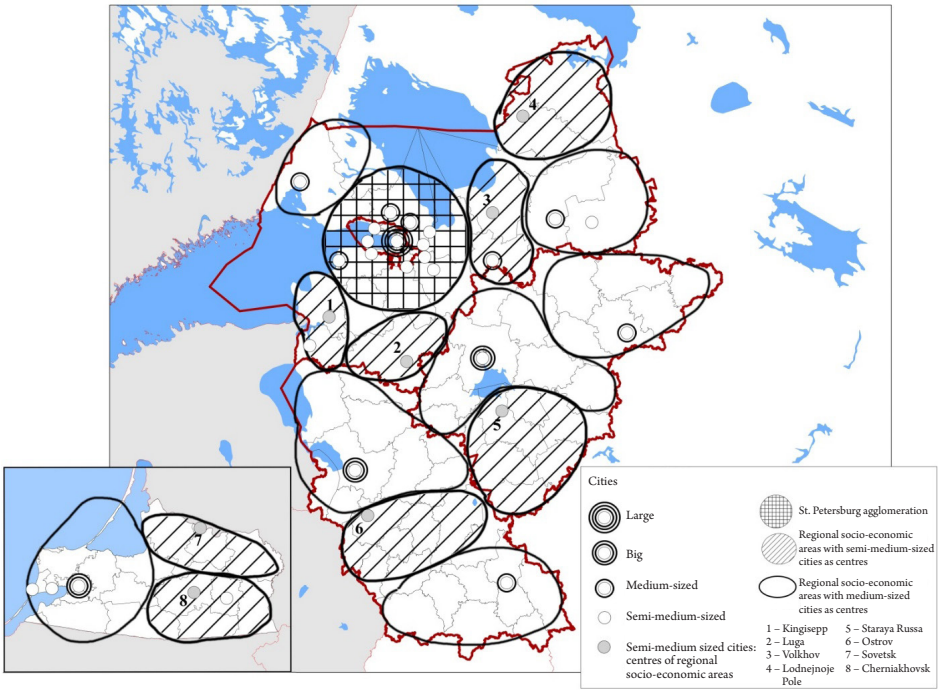


Figure 1. Intraregional socio-economic regions in the subjects of the Northwestern Federal District

Source: own elaboration.

tra-oblast transport routes and regional systems of territorial planning of the subjects of the federation. Only 8 of the 18 semi-medium-sized towns in the Northwestern Federal District are centers of intra-oblast socio-economic regions, of which 15 were considered.

It can be noted that in the Leningrad Region, the four semi-mid-sized towns (Kingisepp, Luga, Volkhov and Lodeynoye Pole) are the centers of intra-oblast socio-economic regions. In the Kaliningrad region – two (Chernyakhovsk and Sovetsk). In the Novgorod region – one (Staraya Russa), in the Pskov region – also one (Ostrov).

In four intraregional districts, the centers are large cities and in three – mid-sized towns. In addition, the surrounding area of St. Petersburg, which includes 4 mid-sized and 5 semi-medium-sized towns, as well as a number of small towns, belonging to the St. Petersburg urban agglomeration, which, to a certain extent, can also be considered as a region in its own right.

In regional settlement systems, many semi-medium-sized towns are multifunctional and can perform several functions associated with socio-economic

support and maintenance of the territory that is part of their zone of influence (Table 1). At the same time, the most pronounced functions of these towns determine the trends in their own development and that of the adjacent territories.

Table 1. Functions of semi-medium-sized towns in settlement systems of the Northwestern Federal District

| Subject of Russian Federation | Semi-medium-sized town | Functions of semi-medium-sized towns* | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Leningrad region | Kingisep | +! | | + | | | + | | + | |
| | Volkhov | + | | +! | + | | | + | + | |
| | Tosno | | + | + | + | | | | +! | |
| | Luga | + | | + | | | | | + | |
| | Slantsy | | | + | +! | | | | | |
| | Kirovsk | | +! | + | | | | | | |
| | Otradnoje | | + | | | | | | | |
| | Kommunar | | | | +! | | | | | |
| | Nikolskoje | | + | | + | | | | | |
| | Lodejnoje Pole | +! | | + | | | | | | |
| | Pikalevo | | | | + | | | | | |
| Kaliningrad region | Sovetsk | +! | | + | | | + | | + | |
| | Cherniakhovsk | +! | | + | + | | | | + | |
| | Gusev | | | + | + | +! | | | + | |
| | Svetly | | + | | + | | | | | |
| | Baltijsk | | | | | | | | + | +! |
| Novgorod region | Staraya Russa | +! | | + | | | | + | + | |
| Pskov region | Ostrov | + | | + | | | + | + | + | |

* 1 – centers of intra-oblast socio-economic regions; 2 – satellite towns of large and extra-large cities; 3 – centers of municipalities of the second level; 4 – industrial towns; 5 – centers of innovation development; 6 – towns performing trans-border and cross-border interaction functions; 7 – centers of tourist and recreational zones; 8 – transport hubs; 9 – centers with a defence function; +! – the most pronounced function of the town in the settlement system.

Source: compiled by the author on the basis of existing industries and prevailing economic activity.

All the semi-medium-sized towns of the Northwestern Federal District can be divided into the following functional types:

1. Centers of intraregional socio-economic regions (Kingisepp, Luga, Volkhov, Lodeinoe Pole, Staraya Russa, Ostrov, Sovetsk, Chernyakhovsk). All these towns are centers of municipalities of the second level and have the corresponding social infrastructure (educational, health, culture, etc.). Some of them also perform an industrial function (Sovetsk, Chernyakhovsk), and almost all – an important transport function, because they have a favorable economic and geographical location. Kingisepp, Sovetsk, and Ostrov perform cross-border functions, Staraya Russa – resort and recreational functions.

2. Towns which are satellites of the large city of St. Petersburg and other large ones with industrial, transport and administrative functions (Volkhov, Tosno), with industrial functions – Kirovsk, Nikolskoe, Otradnoe, and also Svetly with industrial and transport functions, the satellite town of a large city – the regional center of Kaliningrad.

3. Industrial points and centers (Pikalevo, Kommunar), the same with administrative functions (Slantsy).

4. Centers of innovative development (Gusev).

5. The center with a defence function – the naval base of Baltiysk.

Population dynamics of semi-medium-sized towns depends on their functional type (for example, the number of residents in the industrial satellite towns of St. Petersburg is growing most rapidly: Kirovsk, Nikolskoe, Otradnoe). But the main factors in this case are the size and geographical location. Towns situated on the periphery of the regions usually lose their populations the fastest. In general, in all the semi-medium-sized towns of the North-West in the decade (2006-2016), the population decreased by 2.3%. At the same time, the population of St. Petersburg increased by 14%, in large cities regional centers – by 6%, in medium-sized towns – by 4%, in small towns – it decreased by 6%.

In the semi-medium-sized towns which are centers of intra-oblast socio-economic regions, the population decreased by 8%. This is due to their predominantly peripheral location (cf. Fig. 1). In connection with the important role of such centers in the socio-cultural development of the territory, priority measures on the part of both the region and the Federal Center are required to support their development.

In the Kaliningrad region, given its geographical size and its population, the semi-medium-sized towns have a set of specific functions and perform the role of mid-sized towns, with some of them forming socio-economic regions of a new level in terms of territorial and functional characteristics. Based on territorial and administrative data, the semi-medium-sized towns and regions gravitating towards them can develop in certain directions [Belova 2008].

Based on the prevailing conditions, in addition to administrative functions, three main areas of development of the semi-medium-sized towns of the Kaliningrad region can be distinguished: tourism (resort and tourism in the case of Baltiysk and education and tourism in the case of Gusev), transport (this configuration is being implemented in Chernyakhovsk and Sovetsk, with the additional advantage of the latter resulting from the presence of a border crossing) and industry (this orientation is implemented by Svetliy, which is part of the transport network for the disposal of sewage sludge from the Kaliningrad agglomeration). It is also necessary to take into account the increased defence function of the region (Baltiysk) (Fig. 2).

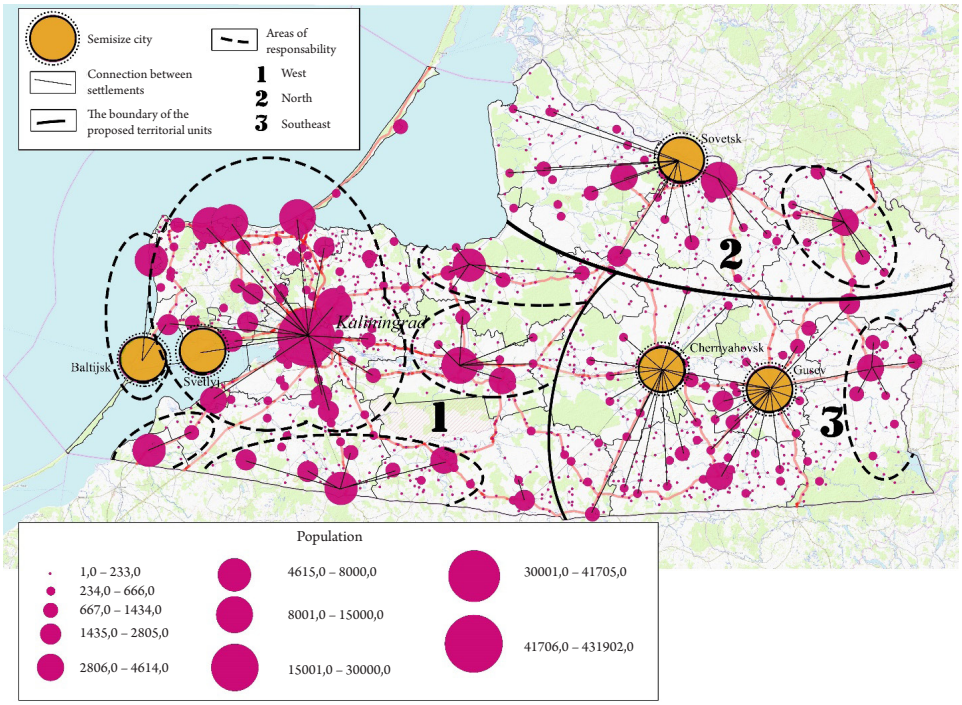


Figure 2. Semi-medium-sized towns in the settlement system of Kaliningrad region

Source: own elaboration.

One of the drivers of regional development in semi-medium-sized towns of the exclave region is their active involvement in international cooperation. Cross-border and trans-border cooperation of the Kaliningrad Region was included in the Strategy of Social and Economic Development of the Kaliningrad Region until 2020 as one of the priorities for ensuring the vital activity of the region, which enables effective and comprehensive solutions to environmental, cultural and social problems in the development of the region's border areas. In addition to its important role in the social and economic development of the region, and in resettlement, such activities are crucial in the international (cross-border and cross-border) cooperation of the Kaliningrad region in the Baltic region.

By participating in projects of border and trans-border cooperation programs from 2005 to 2015 semi-mid-sized-sized towns were able to establish contacts and partnership relations with 27 cities from six Baltic region countries. Over the past 10 years semi-mid-sized towns have implemented 43 projects for a total of 8,557,000.00 euros. A number of projects included an infrastructural compo-

nent, that is, the construction of new or reconstruction of existing infrastructure. For example, in Sovetsk a new bridge was built across the Niemen river, which connects Lithuania and Russia. The bridge will relieve the burden of traffic on the Queen Louise Bridge, which is now the only crossing on the Russian-Lithuanian border in Sovetsk for road transport, including freight [Belova 2018].

Analyzing the relations of the semi-mid-sized towns with their partner cities, we can talk about the formation of three clusters of cooperation: Scandinavian and Western trans-border clusters and one cross-border cluster, the most active and strategically important for the modern development of the region and the formation of sustainable integrated links between semi-medium-sized towns of the Kaliningrad region and neighboring regions of Poland and Lithuania (Fig. 3).

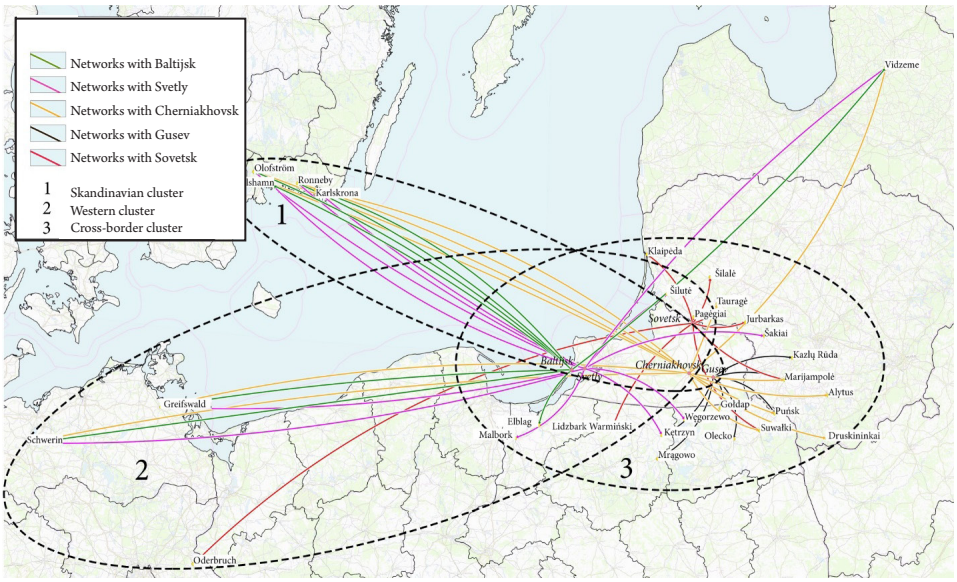


Figure 3. Links established by the semi-medium-sized towns in the Kaliningrad region as a result of the implementation of international projects in 2005-2015

Source: own elaboration.

International cooperation is one of the most important tools for enhancing the development potential of the semi-medium-sized towns in the Kaliningrad region; the semi-medium-sized-sized towns of the Kaliningrad region have accumulated considerable experience in this area. As a result of various cooperation projects, those semi-medium-sized towns could benefit from the creation of industrial facilities, agricultural enterprises, the establishment of educational and cultural networks and the introduction of new management technologies and

organization of the economy. To develop this potential, it is necessary to implement a set of measures, including the development of spatial models and the implementation of pilot projects for cooperation between the semi-medium-sized-sized towns of the Kaliningrad region and the Baltic region, the development of industrial zones and the modernization of transport networks, the creation of an international support network for small and medium-sized enterprises interested in entering the foreign markets.

## 5. Conclusion

As a result of the study, a number of main conclusions can be drawn. In the Northwestern Federal District, semi-medium-sized towns have a similar functional purpose and can be classified into functional types. It is possible to distinguish nine functional types of semi-medium-sized towns.

In terms of their functional purpose, semi-medium-sized towns are similar to towns of Western Europe with similar populations, although they are usually classified as „medium-sized."

The role of semi-mid-sized towns as engines of regional development in the Kaliningrad exclave is most pronounced. Here, owing to the legacy of the settlement system adopted after 1945, in addition to the existence of a large regional capital, Kaliningrad, there are five towns with a population of 20 to 50 thousand inhabitants – Gusev, Chernyakhovsk, Sovetsk, Svetly and Baltiysk. These semi-mid-sized towns perform the same function in the region as mid-sized towns elsewhere. Three of them are centres of socio-economic areas, the other two are play the role of companions to the regional center – Kaliningrad.

In recent years the semi-medium-sized towns of the Kaliningrad region have been involved in various forms of international cooperation:

– cross-border cooperation as part of 5 Euroregions: Baltika, Neman, Lyna-Lava, Sheshupe and Saule. The Kaliningrad region, with the support of the Euroregions, 23 projects focusing on various areas from 2005 to 2016;

– implementation of projects as part of cross-border and cross-border cooperation programs. Participation in the projects from 2005 to 2015 allowed semi-mid-sized towns to establish contacts, partnership relations with 27 cities from 6 countries of the Baltic region. A total of 43 projects amounting to 8.5 million euros have been implemented over 10 years. The largest number of projects took place in Chernyakhovsk, while Sovetsk received the largest amount of grant funds (to implement a smaller number of large infrastructural projects). In other cities, project participation was less active owing to weaker involvement of potential actors of cross-border cooperation.

In view of the above, it is essential, in the opinion of the author, to actively develop new functions in semi-medium-sized cities to foster their effective socio-economic development as regional development engines. Priority functions for the ex-Russian region are as follows: the functions of innovation centers and centers of international (trans-border and cross-border) cooperation.

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## Miasta średniej wielkości północno-zachodniej Rosji jako czynnik rozwoju regionalnego

**Streszczenie.** Wśród miast Rosji i Europy, w tym należących do regionu Morza Bałtyckiego, można wyróżnić kategorię miast o populacji 20-50 tys. mieszkańców, co ma szczególne znaczenie dla badań, gdyż jest to granica oddzielająca małe i średnie miasta. Miasta średniej wielkości pełnią różne funkcje w lokalnych systemach osadniczych, zwłaszcza stanowią ośrodki tworzenia regionów społeczno-gospodarczych. Ważnym czynnikiem rozwoju regionalnego jest też aktywny udział miast średniej wielkości we współpracy międzynarodowej z gminami państw granicznych UE. Badanie dotyczy miast średniej wielkości i ich funkcji w pięciu regionach północno-zachodniego okręgu Federacji Rosyjskiej, a regiony społeczno-gospodarcze utworzone przez miasta średniej wielkości są zaprezentowane w formie wizualnej. Analizie poddano pięć miast średniej wielkości w Obwodzie Kaliningradzkim i ich rolę w rozwoju regionu. Zbadano też udział tych miast w projektach współpracy transgranicznej, określając tendencje w stosunkach terytorialnych miast średniej wielkości w regionie z gminami krajów UE w ramach współpracy przygranicznej i transgranicznej oraz korzyści, jakie ta współpraca ma dla regionu.

**Słowa kluczowe:** miasta średniej wielkości, system osadniczy, region bałtycki, region społeczno-gospodarczy, Północno-Zachodni Okręg Federalny, Obwód Kaliningradzki, współpraca międzynarodowa

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# Towards Sustainability? Analysis of Participatory Budgeting in the City of Katowice

**Abstract.** Cities are essential for implementing sustainable development. Nevertheless, the goal of making cities sustainable is a complex process that includes many social, economic and environmental aspects. The aim of this article is to identify connections between civic participation in local policy making and actions towards sustainability at the city level. It is well established that with the help of governance and the collaborative approach the process of local development is conducted with a better recognition of the needs of the community. This results in a higher quality of life. Moving towards sustainability is therefore the outcome of local management, the governance mechanism and the capacity of citizens to self-organize. This requires awareness and the willingness to cooperate on both sides i.e. on the part of the local authorities and the local community. The author explains how different benefits derived from citizens' engagement affect sustainable development of cities. The analysis is based on a case study of participatory budgeting in the city of Katowice. As it is a learning process, the author evaluates consecutive editions of the participatory budgets in Katowice to determine if this process helps Katowice make a step towards sustainability.

**Keywords:** sustainable development, participatory budgeting, local development, governance

## 1. Introduction

It is well established that cities are essential for implementing sustainable development. Nevertheless, making cities sustainable is a complex process that includes many social, economic and environmental aspects. The process of sustainable development should be viewed from a systemic perspective. It is essential

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but is not sufficient, since the process essentially depends on the integration with embedded social networks.

"A nation is democratic to the extent that its citizens are involved, particularly at the community level" [Hart 1992: 4]. Democratization is fundamental for sustainable development. Nevertheless, democratization is not a simple right during public elections. It is the empowerment of citizens and the implementation of governance mechanisms. Regardless of the growing body of knowledge in this field and many examples of good practices worldwide, most economic theories represent the modern world through the eyes of governments. "The government is supposed to have the responsibility, the will and the power to restructure society. [...] Individuals, in contrast, are credited with little or no ability to solve collective problems among themselves. This makes for distorted view of some important economic and political impact" [Sugden 1986: 3].

The mechanism of governance tries to unite different individual realities and turn them into synergy. The local government is responsible for coordination of the process. Nevertheless its role is different from that in standard government mechanism, a concept which places authorities at the centre of the decision-making process. When it comes to governance many local actors are engaged, collaborate both mutually and with the government. The difference between government and governance is formed on the question of the role of public representatives and the size of empowerment of the rest of the society.

The role of communities in urban policy making for many years has remained neglected in Poland. Nevertheless, the growing social movement demanding the 'right to the city' has made local policy more community-oriented. Municipal authorities, especially in bigger cities started to be more open to their residents' ideas. On the other hand, residents felt their actions had a real impact.

Participatory budgeting is a direct tool of citizen's engagement, which is becoming increasingly popular worldwide. Its "expansion" can also be observed in Poland. Impacts of participatory budgeting on sustainable development are rather difficult to evaluate. The challenge has to do with the complexity of the problem, time frame and reliable data.

The article is focused on how different benefits derived from citizens' engagement affect sustainable development of cities. The analysis is based on a case study of participatory budgeting in the city of Katowice. As it is a learning process the study evaluates subsequent editions of the participatory budgets in Katowice.

## 2. Sustainable development and local governance

The traditional way of managing cities does not work very well in terms of sustainable development. One of the main categories associated with sustainable

development is the quality of life. One important question in this respect concerns the responsibility for formulating criteria of the quality of life. Who defines the quality of life in a city and in a neighbourhood? How this question is answered determines policy and has major implications for local development. In the case of governance, this question is determined by people who live and work in a given area. From the perspective of government, this is primarily the task of local government. Developing a city according to the principle of governance means that local government should respond to the needs expressed by citizens, professionals and organisations in the city. All these actors should be allowed to speak and be involved in local development. In this sense sustainability includes democracy and identity topics.

Governance introduces tools of open cooperation to shape familiar conditions of life in the city. It describes the key role of local authorities who engage and coordinate actions of many different local actors. It is based on the general principle whereby local decision-makers, citizens and different social capital organizations work in partnership to create the local environment. Governance provides effective delivery of required services to various local stakeholders. Nevertheless its single greatest virtue is closeness to people who are being governed.

In line with the principles of governance, they do not consider themselves to be the only ones with the right to know and decide. Local authorities show that they are committed to making transparent and pro-community decisions. Governance results in stronger communities and deepening of democracy, which is the fundament of sustainable development. Confidence in democracy increases when the decision-making process is transparent and when there is an opportunity to take part in the process. This contributes to a higher degree of acceptance of decisions made by local government and of the political system in general [Sobol 2006]. Nevertheless, some findings show that there is no evidence of either top-down or bottom-up initiatives being more effective than the other [Van der Jagt et al. 2017].

Regarding the dimension of governance, it is important to show how different tools involve civil society actors in the decision making process. Polycentric governance should be regarded in both directions i.e. government-initiated projects involving citizens and grassroots projects. The biggest benefits can be observed when government and non-government actors are open to cooperation. Increasing citizen input in local decision making contributes to building community capacity and better quality of life [Ostrom 2010]. Bringing people together to identify local problems and solve them collectively starts to create stronger relationships within the community and between elected officials and residents.

An increase in effectiveness is a very important measure, especially from the economic point of view. Nevertheless, governance gives much more. It teaches cooperation, increases responsibility for other co-residents and the city. The im-

portance of the city and its public spaces is higher when its inhabitants interpret them as the commons. The process of co-deciding makes them feel co-owners of public resources.

The arguments in favour of local governance in relation to sustainable development seems to be very strong. The key benefits can be recognized as improvements in democracy and social capital and as a progress in effectiveness and organizational functioning of the community.

## 3. Mechanisms of empowering the local community

Social capital is key for local sustainable development. I agree with Luís Bettencourt, who writes that: "cities are first and foremost large social networks. In this sense cities are not just large collections of people, they are agglomerations of social links. Space, time and infrastructure play a fundamental role in enabling social interactions to form and persist, and in allowing them to become open-ended in terms of increased connectivity, and sustainable from the point of view from energy use and human effort" [Bettencourt 2013: 6].

Empowered residents are more conscious of their role in the community and in the local development. The perspective of cities as interaction networks requires conditions and tools directed by local authorities. Democratization of cities should go further than the right to vote during public elections. Local planning, "when it is conducted with transparency from the bottom-up results in a place where the community feels ownership and engagement, end where design serves function. Here, human needs will be met and fulfilled, for the betterment of all" [UNHABITAT 2012: 4].

Initiatives aimed at empowering citizens' in the local development are receiving more and more attention in the public discourse in Poland. Social involvement is becoming increasingly visible and appreciated. City residents are aware that their participation in local affairs can go far beyond the right to vote. Decision-makers also understand that they cannot stay passive in relation to public involvement. The existing policy of 'openness to residents' has mostly been limited to providing information. Some units of local government have used the process of public consultation, but in many cases the results did not come up to the expectations.

Civic engagement can be recognized through activity and participation in local development. Participation refers to the process of sharing opinions and making decisions which affect one's life and the community in which one lives. It should be emphasized that participation in local development is a fundamental right of citizens.

## 4. Participatory budgeting as a tool of empowerment

One of the most important tools of empowering the local community is participatory budgeting (PB). The process is recommended by international agencies, such as the European Union, the World Bank, UNDP and USAID. They recognize it as a strong tool supporting citizen empowerment, improved governance and better accountability [Wampler, McNulty & Touchton 2018: 3].

Participatory budgeting is a tool of involving ordinary citizens in the spending of public funds. The idea is that the residents come up with proposals to improve local development. In the next step through elections the community decides which ideas to fund. The procedure applies to a fraction of resources from the city budget (in Poland usually less than 1%).

In 2018, the participatory budgets were formalised through legislation in Poland. After the amendment of Article 5a of the Act of municipal self-government it points out: "Within the framework of a civic budget, the inhabitants vote directly for their part of a municipal budget expenditures each year. The tasks selected in the process are included in the municipal resolution." Participatory budgeting since then is obligatory in cities with district (powiat) rights is obligatory.

There are many positive aspects of participatory budgeting. One important element of the PB concept is that it gives citizens direct causative power. At the stage of proposing projects, as well as during project selection, inhabitants have the right to express their opinions about local investments. PB reinvigorates people's civic participation and makes residents more involved in the civic life of their communities. As a consequence of broader participation, more community members can learn leadership skills, build connections with other participants and gain trust in the government. In general, PB is connecting community members with one another. American research also finds that PB is an effective way to increase engagement in elections. It shows that people who vote in PB are on average 7% more likely to vote in the subsequent elections (www1). There is also "general consensus that participatory budgeting opens new channels to amplify participation, rather than supplanting the existing forms of citizens engagement" [Wampler, McNulty & Touchton 2018: 26].

Activity of residents in participatory budgeting changes public spaces and in general the "look" of cities. It opens up opportunities to create new spatial solutions and to obtain social approval for their implementation [Sadura & Olko 2017; Bernaciak, Rzeńca & Sobol 2018]. The physical environment offers opportunities to see direct efforts of joint, community teamwork. What is also very important that by co-creating the city people identify themselves more with the changes. They are more useful, more familiar and more acceptable.

In Poland participatory budgeting is quite simple procedure, based on proposing the projects and voting on the proposals. It doesn't introduce much of public debate. In its initial level it is far from deliberation as a way of empowering civil society and management of public resources.

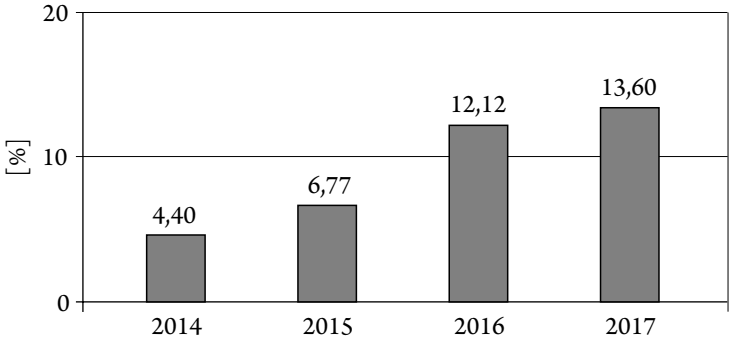
## 5. Participatory budgeting in Katowice – general outlook

Participatory budgeting was introduced in Katowice in 2014. It was a political decision of the city hall. The term "political" is used intentionally, as it was not only a matter of looking for effectiveness in local management. Social partners i.e. active residents and some non-governmental organisations (NGO) had been calling for PB in Katowice for some years. Finally, the local government was 'mature' enough to make this decision, probably as a side effect of political calculation.

2018 saw the fifth edition of participatory budgeting in Katowice. As this procedure is still in progress, it cannot be fully compared with the previous editions. The analysis is based on data related to the processes from the 2014 to 2017.

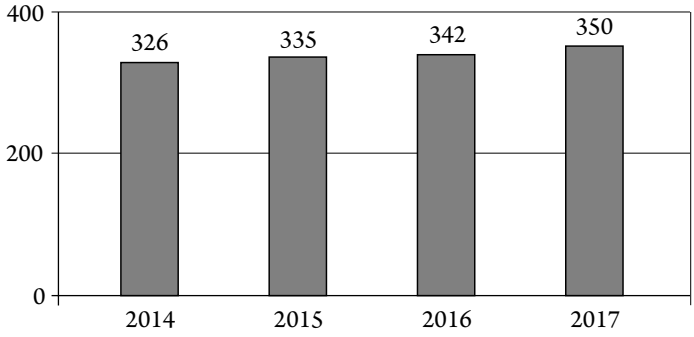
The Charts 1-3 show progress in different aspects of participatory budgeting in the city of Katowice. PB is a learning process. People get learn about their impact on the immediate surroundings and the environment as a whole. The subsequent editions bring new insights based on the evaluation and residents are better prepared for the process. Since the first edition of PB in Katowice, the procedure has been changing each year. The beginning was quite chaotic, with many organizational failures. One of the most important mistakes was an almost complete

Chart 1. Total turnout in participatory budgeting in Katowice in the following editions 2014-2017



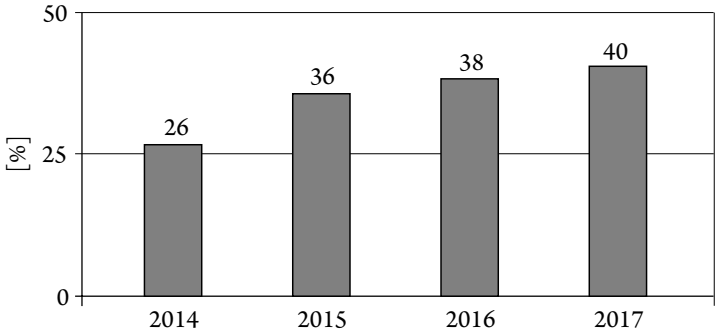

Source: own research based on studies.

Chart 2. Total number of projects in participatory budgeting in Katowice in the editions 2014-2017




Source: own research based on studies.

Chart 3. Relation of the selected PB projects to project proposals in participatory budgeting in Katowice in the editions 2014-2017




Source: own research based on studies.

lack of promotion and information action directed to the local community. The residents were disoriented and even suspicious of those who applied for the projects. The evaluation of the procedure and the adoption of good practices from other cities helped to minimise or eliminate many failures in subsequent editions of PB. The most radical changes included:

- the start of information and promotion campaign in 2015;
- the opening procedure for citywide projects in 2015;
- the implementation of on-line voting 2016;
- the implementation of kids voting in 2018.

The projects listed in Table 1 show the variety of proposals with the highest amount of votes in projects approved for implementation. In relation to the

Table 1. Top-ranked projects in relation to the number of votes in participatory budgeting in Katowice in the following editions 2014-2017

| Year | Order | Name of a project | Number of votes | Value (zł) |
|---|---|---|---|---|
| 2014 | 1. | Construction of walking and cycling route | 690 | 600 000,00 |
| | 2. | "The Land of Generational Integration" – playground for play and recreation | 525 | 399 927,00 |
| | 3. | Construction of a recreation area – playground with gym | 317 | 391 000,00 |
| 2015 | 1. | Water playground for children next to the municipal beach in the "Valley of Three Ponds" | 13 078 | 1 515 000,00 |
| | 2. | Equipment and replenishment of used resources in day-care homes of social welfare | 3 363 | 278 818,00 |
| | 3. | Construction of football pitch and athletic track for Gymnasium No 9 | 2 584 | 735 666,08 |
| 2016 | 1. | Brine graduation Tower for Katowice | 15 151 | 2 100 000,00 |
| | 2. | Construction of a synthetic grass football pitch on the Witosa neighbourhood | 6 481 | 840 000,00 |
| | 3. | "Safe Katowice" – Professional rescue equipment for the Voluntary Fire Brigade in Kostuchna neighbourhood | 3 816 | 55 000,00 |
| 2017 | 1. | Construction of an artificial ice rink | 14 490 | 1 545 000,00 |
| | 2. | "Safe Katowice" – purchase of middle-sized rescue vehicle for the Voluntary Fire Brigade in Szopienice neighbourhood | 7 994 | 900 000,00 |
| | 3. | Cottages for stray cats – shelter and safety | 6 346 | 38 000,00 |

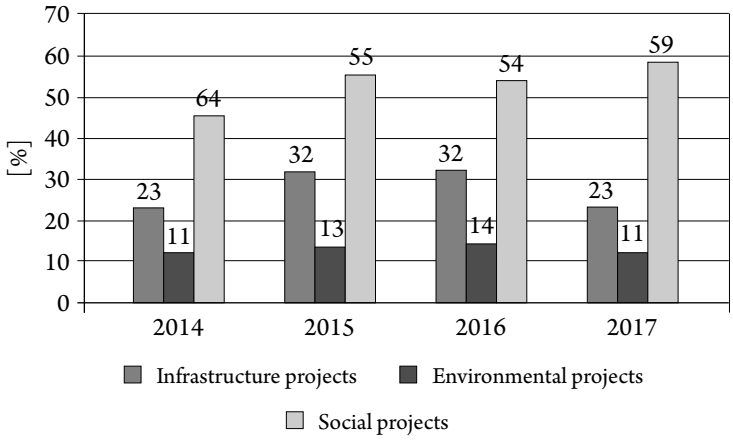
Source: own research based on studies.

above data we can observe the growing number of voters and the growing value of the selected projects. The character of the projects also is associated with residents' recreational and infrastructural needs. The proposals and choices made by citizens of Katowice show interest in investments that go beyond the scope of standard municipal products and services. Some proposals reflect a very innovative approach to urban spaces. This trend is also confirmed by another study showing that "Creative residents help develop new functions in the city and improve the quality of life" (Bernaciak, Rzeńca, Sobol 2018).

Nevertheless, many projects try to redress long years of neglect concerning basic infrastructure. Other project proposals represent resourceful and innovative approaches to the modernisation and management of urban space. The share of the infrastructural projects is high, ranging from 23% to 32%, many of which involve simple tasks, such as repairing pavements, city toilets and street lightning.

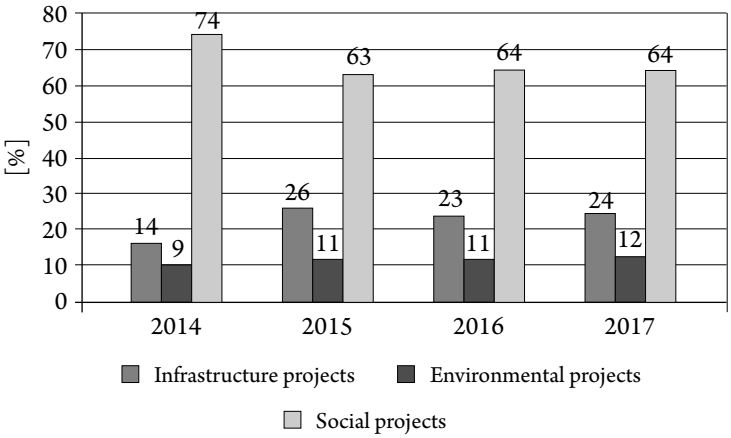
Charts 4 and 5 present the key categories of the project proposals and selected projects in each PB edition in Katowice. It is clear that most of them are social projects (playgrounds, outdoors gyms, football pitches). Residents indicated high deficits in this area. Negligence was especially evident with regard to recreational functions of the city's public spaces. Residents are also interested in

Chart 4. Categories of project proposals in participatory budgeting in Katowice in the following editions 2014-2017



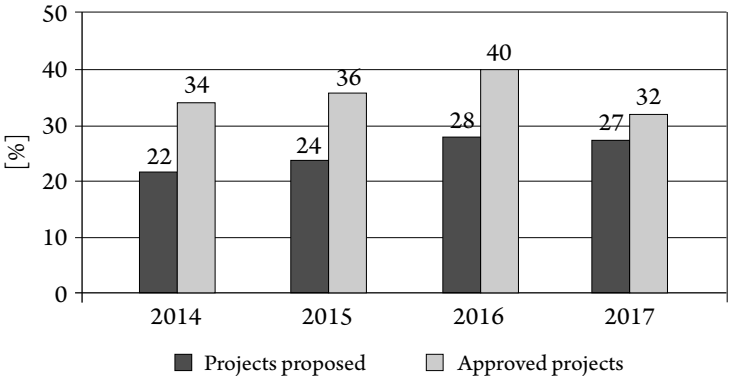

Source: own research based on studies.

Chart 5. Categories of selected projects in participatory budgeting in Katowice in the editions 2014-2017




Source: own research based on studies.

Chart 6. Projects proposed by organisations in participatory budgeting in Katowice in the editions 2014-2017




Source: own research based on studies.

Table 2. The value of PB projects in districts of Katowice in the editions 2014-2017 (in PLN)

| District | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|
| Śródmieście | 795 150 | 1 292 018 | 661 184 | 1 572 382 |
| Brynów Część Zachodnia | 479 000 | 828 262 | 861 370 | 828 850 |
| Zawodzie | 430 000 | 697 040 | 784 000 | 804 780 |
| Os. Paderewskiego – Muchowiec | 390 000 | 648 700 | 831 000 | 784 304 |
| Brynów Część Wschodnia | 10 000 | 533 466 | 273 602 | 570 324 |
| Ligota – Panewniki | 803 500 | 1 358 900 | 1 373 320 | 1 376 827 |
| Załęże | 391 000 | 655 000 | 744 640 | 669 813 |
| Osiedle Witosa | 436 869 | 676 000 | 779 500 | 962 818 |
| Osiedle Tysiaclecia | 466 154 | 787 814 | 1 349 576 | 1 488 938 |
| Dąb | 15 000 | 459 142 | 840 580 | 731 380 |
| Wełnowiec - Józefowiec | 460 900 | 810 650 | 559 400 | 779 586 |
| Koszutka | 395 000 | 632 000 | 593 920 | 929 416 |
| Bogucice | 453 000 | 812 010 | 799 500 | 880 330 |
| Dąbrówka Mała | 207 500 | 490 000 | 513 597 | 506 885 |
| Szopienice – Burowiec | 479 692 | 826 377 | 891 634 | 867 737 |
| Janów – Nikiszowiec | 361 000 | 665 000 | 725 000 | 699 400 |
| Giszowiec | 527 500 | 884 100 | 1 039 700 | 967 217 |
| Murcki | 291 273 | 494 487 | 242 127 | 494 913 |
| Piotrowice – Ochojec | 666 303 | 1 098 280 | 1 221 200 | 989 136 |
| Zarzecze | 225 000 | 301 440 | 437 400 | 518 738 |
| Kostuchna | 370 000 | 584 174 | 650 650 | 835 467 |
| Podlesie | 300 000 | 322 500 | 269 410 | 786 441 |

Source: own research based on studies.

Table 3. Per capita value of the PB projects in districts of Katowice in the editions 2014-2017 (in PLN)

| Per capita value/Year | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|
| Śródmieście | 28 | 45 | 23 | 55 |
| Brynów Część Zachodnia | 33 | 57 | 59 | 57 |
| Zawodzie | 36 | 59 | 66 | 68 |
| Os. Paderewskiego – Muchowiec | 35 | 58 | 74 | 70 |
| Brynów Część Wschodnia | 2 | 80 | 41 | 86 |
| Ligota – Panewniki | 27 | 46 | 47 | 47 |
| Załęże | 40 | 67 | 77 | 69 |
| Osiedle Witosa | 35 | 55 | 63 | 78 |
| Osiedle Tysiaclecia | 21 | 36 | 62 | 68 |
| Dąb | 2 | 62 | 113 | 98 |
| Wełnowiec – Józefowiec | 32 | 56 | 39 | 54 |
| Koszutka | 37 | 58 | 55 | 86 |
| Bogucice | 32 | 57 | 56 | 62 |
| Dąbrówka Mała | 40 | 95 | 99 | 98 |
| Szopienice – Burowiec | 33 | 56 | 61 | 59 |
| Janów 2 Nikiszowiec | 36 | 67 | 73 | 71 |
| Giszowiec | 32 | 53 | 63 | 58 |
| Murcki | 56 | 96 | 47 | 96 |
| Piotrowice – Ochojec | 28 | 47 | 52 | 42 |
| Zarzecze | 89 | 119 | 173 | 205 |
| Kostuchna | 36 | 57 | 63 | 81 |
| Podlesie | 49 | 52 | 44 | 127 |

Source: own research based on studies.

environmental projects. Their share in selected projects is steadily growing and ranges from 9% to 12%.

Chart 6 shows the large share of projects proposed by organisations (schools, kindergartens, Voluntary Fire Brigade, libraries etc.). These projects are indicative of large budget shortfalls these organizations are faced with. For them, participatory budgeting is a way of obtaining additional funds to meet their needs. Many projects involve the purchase of equipment and the upkeep of the infrastructure of schools and kindergartens. The large number of such projects in the proposals, and especially among the selected ones, goes against the basic idea of participatory budgeting, which is intended to enable citizen participation. The share of the approved proposals submitted by various organizations ranges from 32% to 40%. Their "lobbing power" is very strong.

The data show that residents of Katowice get more and more engaged in transforming their city. They scope of activity is also expanding, moving from

concentration on the neighbourhood to other parts of the city. It is the result of changes in PB regulations, but also the consequence of a higher uawareness of being the resident of Katowice. In the second edition citywide projects could be proposed. This resulted in more expensive projects. In 2014 the most expensive project was valued at PLN 745,000 zł and in 2015 the figure doubled reaching PLN 1.515.000 for a citywide project of a water park for kids.

The amount allocated for the participatory budget is based on the number of residents in particular neighbourhoods. The final per capita value of the project depends on the engagement of residents in the phase of proposing and voting. It is also the matter of strategic decisions of the local community.

## 6. Conclusions

Sustainable development is a work in progress. It is a race without the finish line. No city can stop and treat the task of moving towards sustainability as completed. Improvement activities involve looking for new mechanisms to advance towards sustainable development.

Promoting civic engagement and community building is an important task of sustainable development. With the help of governance and the collaborative approach the process of local development is conducted with a better recognition of the needs of the community. This results in a higher quality of life. Moving towards sustainability is therefore the outcome of local management, the governance mechanism and the capacity of citizens to self-organize. This requires awareness and the willingness to cooperate on both sides i.e. on the part of the local authorities and the local community. The overall form of the city is determined by an interplay of many different actors and their actions. In this sense, local development should not be limited to teams of experts and local administration. Residents should know that the city is their right and their responsibility.

The shift from government to real governance is a long term process. It requires social changes: changes in people, in organisations, in their way of thinking, in their attitudes and their expectations. The empowering of residents results in improved social, economic and physical conditions.

Moving towards the sustainable city means giving priority to the community in local development. To make this goal a reality, not just a political declaration, we need adequate tools and instruments. Participatory budgeting seems to be one of such community-oriented tools. It is an effective way to increase engagement in local development. It is an opportunity to learn teamwork. The biggest benefits can be observed when government and non-government actors, especially residents are open to cooperation. Increasing citizen input in local de-

cision making contributes to building community capacity and a better quality of life.

Participatory budgeting shows that residents have the best understanding of the assets, problems and challenges of the local place. Conditions change and new experiences of working together make people more aware of different aspects of local development. PB encourages collaboration and the exchange of ideas. By co-creating the city people identify themselves more with the city. Participatory budgeting provides them with new citizen skills. It also involves knowledge expansion. Many citizens that used to be uninformed come to recognize new paths of local activity. PB is an instrument which proves that local planning can be improved by individuals and communities working together.

Participatory budgeting is a democratic project. The tool allows citizens to intervene directly in government spending. In Katowice it was a catalyst of the latent power of its residents. The process revealed that the grassroots are ready to work for the city and engage in public issues. They are more active in shared decision making in local development. It is probably the most important benefit of governance and social capital through participatory budgeting in Katowice. Democracy is on the rise. Regarding sustainability conditions, it is the greatest advantage that this procedure brings to the city and especially to the community of Katowice.

Nevertheless, the process is not free from failures. A lot has been learned and a lot can be improved. One important lesson is that the residents discuss the prospects of their city more often. Unfortunately, there are still problems in terms of co-operation and kinds of "rival strategies." In the future, the procedure could be changed from the so called "plebiscite" to a more deliberative process. The idea is that residents would have an opportunity to discuss and debate the needs of the neighbourhood and the city. The strategic approach to participatory budgeting leads to consensus and optimal solutions from the perspective of all residents. Another aspect is that the "civic spirit," originally associated with the idea of participatory budgeting, requires a departure from deepening "professionalization" of the procedure. The fact is that a significant part of the budget is appropriated by various organisations (schools, kindergartens, Voluntary Fire Brigade, libraries etc.), whose lobbying power excludes typically civic projects.

The experiences of participatory budgeting to date show a lot of promise. Based on the example of the city of Katowice, PB can be regarded as a positive and progressive process. In terms of moving towards sustainability, it brings people together and reflects community values and needs. It improves the quality of life in the city and leads to direct results for the residents.

Sustainable development is a long-term, systematic process. Citizen empowerment is an important factor of success. The necessary civic competences should be gradually acquired through practice. Participatory budgeting is not a remedy

for unsustainability, since not every local decision can be made by means direct democracy. Nevertheless, if citizens get used to the process by which their ideas are heard, voted on, funded, and implemented, they are likely to accept the power and responsibility required to make local development sustainable.

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## W kierunku zrównoważonego rozwoju? Analiza budżetu obywatelskiego miasta Katowice

**Streszczenie.** Miasta są kluczowym podmiotem rzeczywistej implementacji zrównoważonego rozwoju. Jednocześnie transformacja miast w stronę zrównoważonego rozwoju jest procesem złożonym wymagającym integracji wielu aspektów społecznych, ekonomicznych i środowiskowych. Celem artykułu jest identyfikacja powiązań pomiędzy partycypacją obywatelską a ukierunkowaniem miasta na zrównoważony rozwój. Bogaty dorobek badawczy wskazuje, iż współrządzenie i współpraca mieszkańców sprzyjają lepszemu rozpoznaniu potrzeb społeczności lokalnej. Efektem jest wyższa jakość życia w mieście. Działanie na rzecz zrównoważonego rozwoju jest wynikiem zarządzania lokalnego opartego na współrządzeniu oraz zdolności mieszkańców do samoorganizacji. Niezbędna jest zatem świadomości oraz wola współpracy dwóch stron tj. władz lokalnych i mieszkańców. W artykule wyjaśniono jakie są korzyści związane z zaangażowaniem mieszkańców w budowanie zrównoważonego rozwoju miasta. Analiza oparta jest o studia budżetowania partycypacyjnego w mieście Katowice. W związku z tym, że jest to proces 'uczący się' analiza obejmuje kolejne edycje budżetu partycypacyjnego w Katowicach. Wnioski wskazują czy dzięki budżetowi partycypacyjnemu dokonuje się w Katowicach transformacja w stronę zrównoważonego rozwoju.

**Słowa kluczowe:** zrównoważony rozwój, budżet partycypacyjny, rozwój lokalny, współrządzenie

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# Sustainability in Retailing: A Study of Consumer Intentions Regarding Involvement in Charity Shop Activities

**Abstract.** Charity shops are an example of alternative retail formats that specialize in selling second-hand products. This activity is seen as a way of promoting sustainability since selling used products reduces wasteful purchasing of new products. What is more: by giving used products a second life, it is possible to raise money that can be transferred to people in need. The purpose of this article is to examine the relationship between past charity involvement of young consumers and their intentions of engaging in charity retailing; investigate which of the declared forms of engagement in charity retailing is preferred by respondents and how these variables are affected by such factors as gender and religiosity. Data for the analysis were obtained from a survey conducted in March 2018 using the PAPI method on a sample of 326 Poles aged 16-24. It was found that previous involvement in charitable activity correlates positively with an intention to engage in charity retailing activities. The study also showed that the most popular form of getting involved in charity retailing indicated by respondents is to donate something to a charity shop, while the least popular one is volunteer work for such a shop.

**Keywords:** sustainability in retailing, alternative retail format, charity shop

## 1. Introduction

Although the concept of sustainable development, formulated over 30 years ago [Report of the World Commission 1987] is nowadays recognized as one of the most fundamental principles ever postulated in the management of businesses

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[Aras & Crowther 2010: 565-576], the question remains whether it is possible for a company to achieve growth while seeking to provide future generations with undiminished opportunities for meeting their needs [Seifi & Crowther 2017: 91-105]. The view that this is possible is based "on the assumption that the pricing system mediates the acquisition of the additional resources required for such development" and growth [Crowther & Seifi 2015: 59-79]. Unfortunately, the existing solutions in this respect are highly ineffective and the excessive exploitation of resources continues at a level that does not permit the implementation of the sustainability concept [Seifi & Crowther 2017: 91-105]. Increasing consumption is considered to be the main factor that hinders sustainability [Fischer, Böhme & Geiger 2017: 312-326]. A logical consequence of this is the call to reduce consumption, especially in those countries where its level is very high. The question arises how this postulate can be reconciled with the objectives of retailers seeking to increase their turnover. The answer to this question is complicated since a reduction in consumption may take the form of a direct reduction in the consumption of certain goods (mainly non-food); a reduction in the volume of purchases as a result of limiting wastage (food and non-food products); or changing the type of products purchased to those whose manufacturing and distribution are more environmentally friendly [Lehner 2015: 404-423]. An analysis of research into sustainability measures shows that those implemented by retailers are relatively less advanced than, for example, those in such cooperating sectors as transport and agriculture; and at a lower level than their key role as retailers in the supply chains would suggest [Wiese et al. 2012: 18-335]. In addition, research conducted in the UK into solutions applied in practice shows that despite declarations about implementing the concept of sustainability and promoting sustainable consumption, leading British retailers do very little in this respect [Jones, Hillier & Comfort 2014: 702-715]. Similar results were obtained in a study conducted in Sweden [Lehner 2015: 386-402]. At the same time, however, it can be observed that consumers have begun "to react more sensitively towards the eco-friendliness of product offerings" [Trudel & Cotte 2009: 61-68].

## 2. Literature review

The growing awareness of the need to restrict purchases, especially of new products, creates the basis for the development of such retail formats that allow people to buy used goods [Klouda 2008: 16-20].

For many years the retail sector has been undertaking actions aimed at reintroducing products on the market. In the case of food this mainly relates to redistributing excess food or food products which due to the short remaining

expiry date may have to be destroyed [Holweg & Lienbacher 2011: 307-326]; and in the case of non-food products this concerns the possibility of extending the usage cycle of products by giving them a second life. Recently, the number of second-hand shops has grown at about ten times the rate of other stores [Yan, Bae & Xu 2015: 85-98]. They adopt one of the retail formats referred to as alternative retail formats [Stone, Horne & Hibbert 1996: 4-15]. Their common, and at the same time important, distinguishing feature is that they implement the postulate of sustainable development in a much more radical way than traditional formats which sell new products. Their activities help to make better use of manufactured goods, which reduces the extent of product waste. As a result, excessive exploitation of natural resources can be limited, and at the same time it is possible to create an attractive offering for customers seeking unique products.

Charity shops (thrift shops in the USA) are one of the alternative retail formats. Such shops are especially popular in Great Britain and Ireland, their origin dating back to the end of the 19th century. In a book published in 1886 entitled *In Darkest England and the Way Out*, General Booth, the founder of the Salvation Army, expressed the view that there was a lot of wastage of goods in wealthy homes and that unnecessary things should be collected and re-introduced onto the market. He put his idea into practice by organizing groups of people who visited affluent homes and collected used items. These items were then sold from 'salvage stores' in London and provincial centres. The first charity shop in the form that is known today was opened in 1947 in Oxford by Oxfam. It sold surplus goods obtained in response to an appeal for helping the Greeks in Great Britain [Horne 2000: 113-124].

Since the 1990s a dynamic development of charity shops has been observed. While in 1992 there were 3480 such shops in the British Isles, in 2002 this number had increased to 6 220 [Parsons 2002: 586-594], and in 2018 to 11200. The vast majority of these stores (83%) are located in England. In Ireland there are currently about 400 charity shops [Charity Retail Association 2018].

Charity shops are defined by Parsons [Parsons 2002: 586-594] as stores that sell gently-used donated goods where the profits are used for charity. In some charity stores new products are also offered but they are in the minority [Horne & Broadbridge 1995: 17-23]. Merchandise that cannot be re-sold is recycled. An important distinctive feature of such shops is the low price level, which can be achieved thanks to the low costs connected with the involvement of volunteers in running the stores. Thus, when characterising charity shops, it is necessary to indicate three elements, which in themselves have been the subject of numerous studies and which go far beyond the area of retail trade. These are purchases of used products, voluntary work, and supporting others through donations (in the case of charity stores this means giving products to the shop for free). The first area in particular has been extensively researched [Herjanto, Scheller-Sampson

& Erickson 2016: 1-15], with purchases of used clothing being the most frequently studied aspect [Hansen 2000: 245-274; Hansen 2004: 369-392; Beard 2008: 447-468; Milgram 2012: 200-221; Yan, Bae & Xu 2015: 85-98], with particular emphasis on the motives for purchasing used clothes [Hansen 1999: 343-365; Roux & Korchia 2006: 29-35; Roux & Guiot 2008: 63-91; Guiot & Roux 2010: 355-71; Cervellon, Carey & Harms 2012: 956-974; Waight 2013a: 197-211; Waight 2013b: 159-162; Ferraro, Sands & Brace-Govan 2016: 262-268; Steffen 2017: 189-207; Liang & Xu 2018: 120-130].

Selling used products in a charity shop, however, has a distinctive character because it involves charitable activity; whether by donating something to the store or by buying used products with the intention of supporting the beneficiary. Thus, the motivations of people who engage in charity retailing in these two ways and through doing voluntary work vary significantly. Apart from pragmatic motives such as "seasonal cleaning" and the "need to free up space" in the case of donations [Mitchell, Montgomery & Rauch 2009: 255-269], and to "meet people, previous retail experience" and "near home" in the case of the motivations of volunteers [Broadbridge & Horne 1994: 421-437], respondents also mention such universal motives for all forms of involvement as "the willingness to help others and do good" [Mitchell, Montgomery & Rauch 2009: 255-269; Harrison-Evans 2016].

Poland has no tradition of charity stores. For most of the second half of the 20$^{th}$ century, i.e. in the years 1945-1989, it was a communist country struggling with excess demand for all consumer goods, and the resulting product shortages in stores. For many years after the fall of communism, shops offering used products were associated with poverty; shopping in them was a result of economic necessity, and the use of second-hand products was perceived as an indicator of low social status. What is also significant is the fact that Poland has a masculine culture (a masculinity index of 64 according to Hofstede – Country Comparison Tool 2018; Hofstede – Country Comparison Tool 2018), i.e. Polish people are more oriented towards material success than towards good quality of relationship among people. And it is much easier to demonstrate material success using new than second-hand products. Up till now buying used products by many people in Poland has been associated with poverty.

Most probably, the first charity stores in Poland were established by the Sue Ryder Foundation in the early 1990s. Only a few of them have survived to date. Currently, there are over 20 charity stores run by various organizations, including Caritas - the largest charity organization in Poland connected with the Catholic Church, but also by foundations which operate on a local scale. Some charity stores in Poland operate within the concept of social entrepreneurship. The majority of charity shops were established less than 5 years ago, and an evident growth trend in the number of stores of this format can be observed.

The authors undertook to investigate people's intentions of engaging in charity shop activities, which according to the Theory of Planned Behaviour (TPB) is a prerequisite for taking action in this respect [Fishbein & Ajzen 1975]. Staying within the scope of this theory, it was observed that past behaviour is a variable which strongly and positively contributes towards actual behaviour to donate money [Kashif, Sarifuddin & Hassan 2015: 90-102]. Assuming that TPB remains the main theoretical framework in the current study, a research model was formulated which is presented in Figure 1.

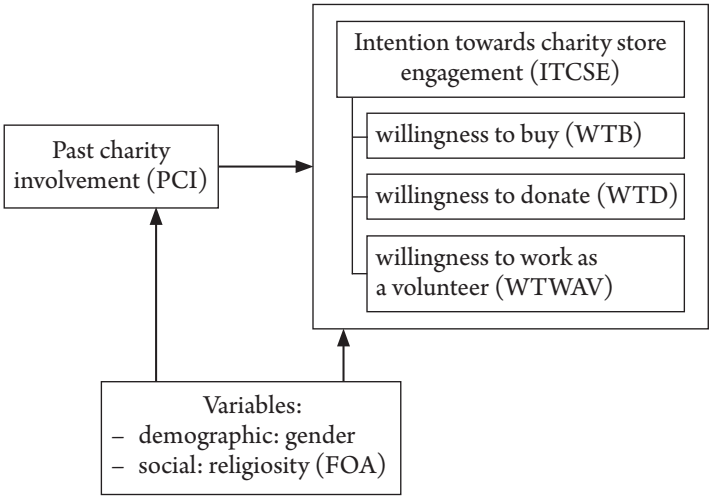


Figure 1. Research model

Source: own elaboration.

The main aim of the study was to investigate the relationship between past charity involvement (PCI) and the intention towards charity store engagement (ITCSE), which can take three potential forms [Borusiak & Paluchova 2018: 7-17]: willingness to buy something in a charity store (WTB), willingness to donate something to a charity store (WTD), and willingness to work for a charity store as a volunteer (WTWAV). With regard to this aim, the following research hypotheses were formulated:

**H1:** There is a significant positive correlation between past charity involvement (PCI) and intentions towards charity store engagement (ITCSE).

**H2:** The evaluation of intentions towards charity store engagement (ITCSE) depends of the level of past charity involvement (PCI).

Taking into consideration the three basic forms of engagement in charity retailing, i.e. donating something, buying something and working for a charity store as a volunteer; as well as the findings of previous research, which show that young

people are more likely to donate something than to buy something in such a shop [Montgomery & Mitchell 2014: 1-13]; a third hypothesis (H3) was formulated, which states that the manner of engagement in charity stores most preferred by young people is to donate something, while the least preferred one is to work as a volunteer.

**H3:** The most preferred way of engaging in charity store activities reported by respondents is a willingness to donate (WTD), while the least preferred is a willingness to work as a volunteer (WTWAV).

In view of the high level of professed religiosity among Poles (92% describe themselves as believers ["Kler" a stosunek do Kościoła 2018] as well as research results indicating that religious people are generally considered more moral; i.e. inclined, among other things, to be more generous [Ranganathan & Henley 2008: 1-11; Teah, Lwin & Cheah 2014: 738-760], as well as being more aware of the need to protect the environment [Felix, Asuamah, Darkwa 2013: 381–387], hypothesis H4 was formulated:

**H4:** Past charity involvement and intentions of engaging in charity store activity including its components (WTB, WTD and WTWAV) depend on the level of religiosity measured by the frequency of attendance (FOA).

Previous research also shows that women more frequently engage in charitable activities than men [Parsons & Broadbridge 2007: 552-567; Einolf 2011: 1092-1112; Toubman 2013: 121-131]. Therefore, the authors attempted to verify this finding with regard to Polish young men and women by formulating hypothesis H5:

**H5:** Both past charity involvement and intentions of engaging in charity store activity including its components (WTB, WTD and WTWAV) depend on the respondents' gender.

## 3. Materials and methods

In order to verify the hypotheses, a survey was conducted using the PAPI method on a convenience sample of 326 Poles aged 16-24 as charity/thrift shopping has been found to be more popular among young people aged between 16 and 24 years [Parsons 2000: 141-151]. The survey questionnaire consisted of three groups of questions: questions relating to past involvement in charitable activities (over the last year); questions relating to intentions of engaging in charity shop activities such as buying something from such a shop, donating something to a charity shop, or volunteer work; as well as demographic questions. The survey was conducted among students of Poznań University of Economics and Business and University of Economics in Katowice.

The following variables were defined in the study:

a) past charity involvement (PCI) – as regards past charity involvement (PCI) the authors, based on the results of focus group research, compiled a list of 15 actions divided into three groups and distinguished on the basis of four criteria: time spent on a given activity; the level of cost/expense; the level of risk; and potential long-term benefits. Table 1 shows a ranked list of charity activities, divided into those that require low engagement (item 1-5), moderate engagement (item 6-10), and high engagement (item 11-15), and the scores for affirmative answers.

Table 1. Potential charitable activities and their scoring

| Item | Activity | Number of points for single activity | Number of points for repeated activity |
|---|---|---|---|
| 1. | Sending an 'I am helping' text message | 1 | 2 |
| 2. | Putting a small donation into a box during a public charity collection | 1 | 2 |
| 3. | Giving a small amount of money to a street beggar | 1 | 2 |
| 4. | Supporting a person asking for food | 1 | 2 |
| 5. | Donating items during a food collection | 1 | 2 |
| 6. | Giving 1% of tax to a charitable organisation | 2 | – |
| 7. | Donating clothes to a person in need | 2 | 4 |
| 8. | Preparing a parcel for the needy | 2 | 4 |
| 9. | Supporting a specific known person with a larger sum of money | 2 | 4 |
| 10. | Participating in a charity auction | 2 | 4 |
| 11. | Supporting a specific unknown person with a larger sum of money | 3 | 6 |
| 12. | Donating a larger sum of money to a charitable organization | 3 | 6 |
| 13. | Donating blood | 3 | 6 |
| 14. | Voluntary work for a charitable organisation | 3 | 6 |
| 15. | Registering as a bone marrow donor | 3 | – |

Source: own elaboration.

Each respondent could obtain a maximum of 55 points. Table 2 shows the point ranges on the basis of which the respondents were divided into three categories: those whose engagement was low, moderate, and high.

b) intentions towards charity store engagement (ITCSE) – to assess attitudes of consumers towards charity retailing, respondents' declarations regarding the possibility of their future engagement in the following types of activities related to charity store operations were used:

Table 2. Point ranges for dividing respondents according to their level of involvement

| Level of engagement | Point ranges |
|---|---|
| Low | 0-10 |
| Moderate | 11-28 |
| High | 29-55 |

Source: own elaboration.

– purchasing products that differ in terms of the degree of use (new, used) and the ability to meet the respondents' needs (necessary, unnecessary);

– donating to a charity shop products that differ in terms of the degree of use (new, used) and value;

– working in a charity store (e.g. working as a shop assistant, helping with cleaning the store, helping with receiving and sorting products) and/or working for a charity store (intellectual work, promotion activities). Such work would be provided on a voluntary basis.

The above potential activities require different levels of engagement on the part of consumers in terms of money, time and emotions. Table 3 shows the scoring adopted for purposes of further analysis (from 1 to 6 points) for each of the analysed types of engagement.

The ITCSE variable was calculated as a weighted average of points obtained in these three categories, i.e.:

– willingness to buy (WTB) (weight 0.25),
– willingness to donate (WTD) (weight 0.25),
– willingness to work as a volunteer (WTWAV) (weight 0.5).

The weights used reflect the different intensity of engagement in particular types of activities. It was assumed that donating and buying items have the same weight, while in the case of work the value is doubled because volunteering requires much more sacrifice(in terms of time expenditure and loss of profits) than donating and buying.

Willingness to buy (WTB) – this variable was determined on the basis of the scores for the individual potential options of purchasing products in a charity shop listed in Table 3.

Willingness to donate (WTD) – this variable was determined on the basis of the scores for the individual potential options of donating products to a charity shop listed in Table 3.

Willingness to work as a volunteer (WTWAV) – this variable was determined on the basis of the scores for the individual potential options of working for a charity shop listed in Table 3.

Table 3. Potential forms of engagement in charity retailing activities and their scoring

| Potential form of engagement | Intensity of potential engagement | Number of points |
|---|---|---|
| Buying from a charity shop | Only a new item which I need | 1 |
| | Only a new item | 2 |
| | Only an item which I need, regardless of whether it is new or used | 3 |
| | Regardless of whether it is a new or used item | 4 |
| | Only a new item, even if I do not need the product, just to support the shop | 5 |
| | Even if I do not need the product, regardless of whether it is a new or used item just to support the shop | 6 |
| Donating something to a charity shop | Used item of little value | 1 |
| | Only a used item | 2 |
| | Only items of little value | 3 |
| | New item of little value | 4 |
| | Even a new item | 5 |
| | Any item | 6 |
| Voluntary work for a charity shop | Promoting the idea and shop, for example on Facebook profile | 1 |
| | Doing intellectual work for a charity shop (e.g. preparing a promotional campaign) | 2 |
| | Doing direct work in a charity shop (e.g. working as a shop assistant, receiving and sorting donated goods, cleaning) | 3 |
| | Doing intellectual work for a charity shop and promoting the idea and shop | 3 |
| | Doing direct work in a charity shop and promoting the idea and shop | 4 |
| | Doing both direct and intellectual work for a charity shop | 5 |
| | Doing both direct and intellectual work for a charity shop; promoting the idea and shop | 6 |

Source: own elaboration.

Frequency of attendance (FOA) – to determine the level of religiosity, a variable in the form of frequency of attendance (FOA) was used. Based on the potential values of this variable, the sample was divided into three groups:

– very religious, characterized by a high frequency of attendance at religious services (once a week – several times a week),

– nominally religious, characterized by a low frequency of attendance at religious services (several times a year – 1-2 times a month),

– non-religious, not participating in religious practices and those refusing to answer the question about their frequency of attendance at religious services.

## 4. Results

Statistical analysis was performed using STATISTICA software (version 10). A *p* value of less than 0.05 was regarded as statistically significant.

Verification of hypothesis 1 was preceded by analysing the variables *Past charity involvement* and *Intention towards charity store engagement.* Table 4 shows the descriptive statistics – the mean, median, standard deviation (SD), coefficient of variation (CV %) and skewness – of both variables.

Table 4. Descriptive statistics of variable analysis

| Variable | *N* | Mean | Median | Min | Max | *SD* | *CV* % | Skewness |
|---|---|---|---|---|---|---|---|---|
| Past charity involvement (PCI) | 326 | 15.10 | 14.0 | 0.0 | 47.0 | 8.45 | 55.95 | 0.79 |
| Intention towards charity store engagement (ITCSE) | 326 | 2.127 | 2.0 | 0.0 | 6.0 | 1.35 | 63.71 | 0.69 |

Source: own elaboration.

The distributions of both variables are right skewed and are not normal. The empirical distributions, Gaussian curve and results of the Kolmogorov-Smirnov test are presented in Figure 2.

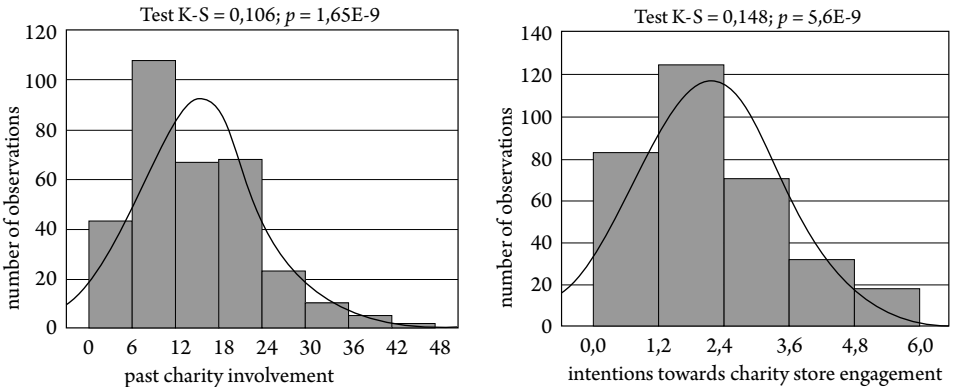


Figure 2. Empirical distributions of PCI and ITCSE variables:
past charity involvement and intentions towards store engagement

Source: own elaboration.

In this situation Spearman's correlation coefficient was calculated to verify H1, and the results of the t-test are presented in Table 5.

Table 5. Value of Spearman's correlation coefficient and the results of the t-test

| *N* | *RS* | *t*(*N*-2) | *P* |
|---|---|---|---|
| 326 | 0.262459 | 4.895898 | 0.000002 |

Source: own elaboration.

Since the *p*-value for the t-test was less than 0.05, it can be concluded that there is a significant positive correlation between the analysed variables.

Before the verification of hypothesis 2, the values of the *Past charity involvement* variable were analysed. The structure of the sample according to the level of PCI is presented in Figure 3.

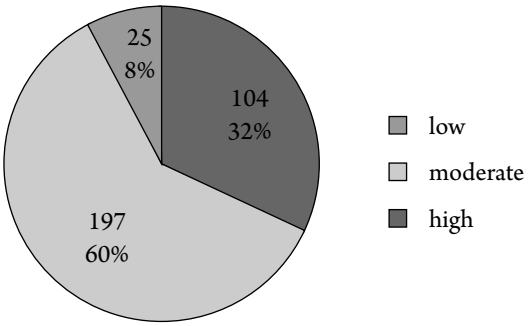


Figure 3. Structure of the sample according to the level of *Past charity involvement*

Source: own elaboration.

The most numerous group of respondents were those declaring a moderate degree of involvement, while the subgroup of those with a high degree of involvement accounted for only 8% of respondents.

Descriptive statistics for the ITCSE variable in each group are presented in Table 6.

Table 6. Descriptive statistics for the variable *Intention towards charity store engagement* in three groups with different levels of past charity involvement

| Level of involvement | *N* | Mean | Median | Min | Max | *SD* | *CV* % |
|---|---|---|---|---|---|---|---|
| Low | 104 | 1.89 | 1.50 | 0.0 | 6.0 | 1.32 | 69.86 |
| Moderate | 197 | 2.16 | 2.00 | 0.0 | 6.0 | 1.36 | 62.81 |
| High | 25 | 2.86 | 2.50 | 0.5 | 5.5 | 1.24 | 43.49 |

Source: own elaboration.

The largest variation in the analysed variable can be observed in the group of respondents with a low degree of past involvement (the coefficient of variation is almost 70%).

To verify hypothesis H2, a non-parametric ANOVA Kruskal-Wallis test was performed. Its result indicates that the distribution of the variable *Intentions towards charity store engagement* varies across three groups: with low, moderate and high level of past charity involvement (results of Kruskal-Wallis test: H ($df = 2$, $N = 326$) $= 13.158$; $p = 0.0014$)). The results of the Kruskal-Wallis test are presented in Figure 4.

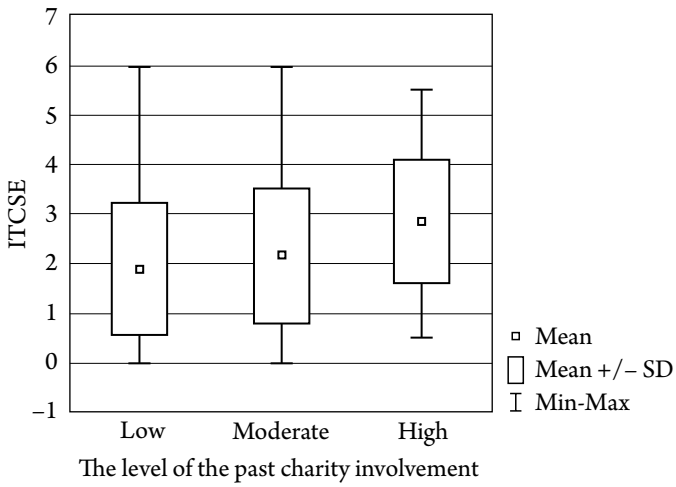


Figure 4. Graphical representation of the Kruskal-Wallis test results

Source: own elaboration.

Differences in the level of *Intentions towards charity store engagement* within the defined groups were examined using the Dunn *post hoc* test. The obtained results of pairwise comparisons confirmed that higher values of the ITCSE variable for the group with a high level of PCI were statistically significant, whereas differences in the level of ITCSE for the groups with low and moderate levels of *PCI* were not found to be statistically significant.

The variable *Intentions towards charity store engagement* is composed of three variables (WTB, WTD, WTWAV), whose descriptive statistics are presented in Table 7.

Empirical distributions of these variables are presented in Figure 5.

To verify hypothesis H3, a non-parametric ANOVA Friedman test was conducted. The null hypothesis for the Friedman test is that there are no differences between the distributions of the three variables WTB, WTD and WTWAV.

Table 7. Descriptive statistics for the variables WTB, WTD, WTWAV

| Variable | N | Mean | Median | Min | Max | SD | CV % | Skewness |
|---|---|---|---|---|---|---|---|---|
| Willingness to buy (WTB) | 326 | 2.466 | 2 | 0 | 6 | 1.817 | 73.68 | 0.197 |
| Willingness to donate (WTD) | 324 | 3.824 | 4 | 0 | 6 | 2.292 | 59.94 | –0.580 |
| Willingness to work as a volunteer (WTWAV) | 326 | 1.120 | 0 | 0 | 6 | 1.775 | 158.56 | 1.508 |

Source: own elaboration.

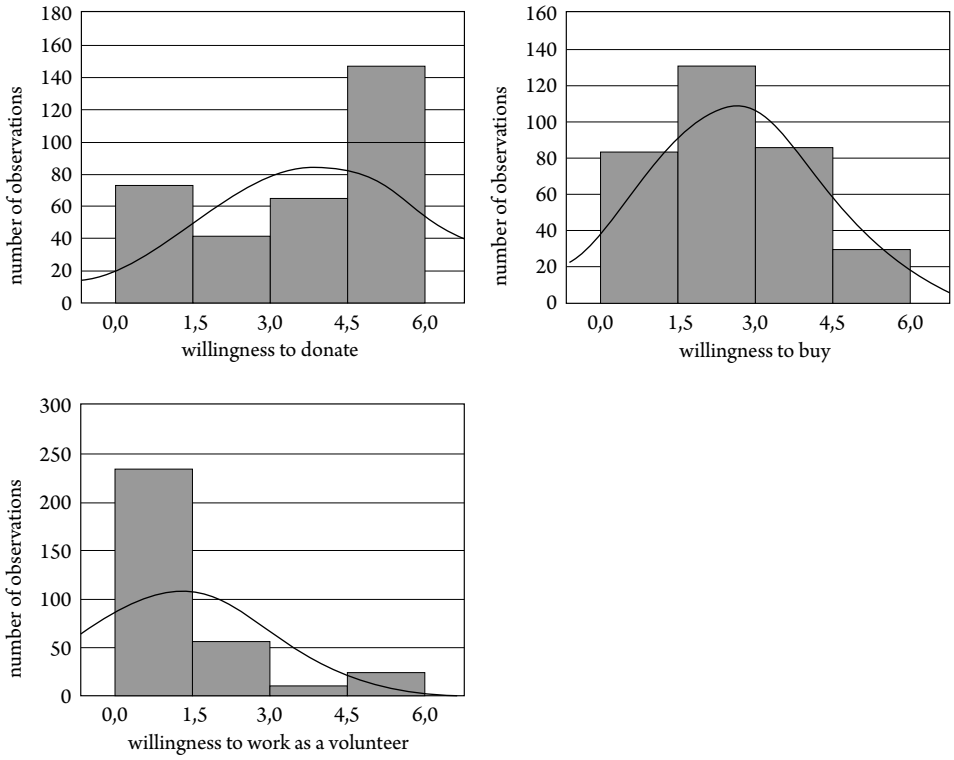


Figure 5. Empirical distributions of the variables WTD, WTB and WTWAV: willingness to donate; willingness to buy; willingness to work as volunteer

Source: own elaboration.

The test was significant – $Chi^2$ ANOVA $(df = 2, N = 324) = 236.2420; p = 0.00000$ – with Kindall's coefficient of concordance of 0.36 indicating fairly strong differences among the three concerns. The Friedman test rejects the null hypothesis of no difference among the distributions, so post-hoc analysis was carried out to

assess which differences are significant. For pairwise comparison, the Wilcoxon signed-rank test was conducted with a Bonferroni correction applied, resulting in a significance level set at $p < 0.017$ (0.05/3).

Results of pairwise comparisons using the Wilcoxon rank sum test are presented in Table 8.

Table 8. Results of the pairwise comparisons

| Pair | *N* | *T* | *Z* | *p* |
|---|---|---|---|---|
| WTD &WTB | 259 | 7183.00 | 8.00 | 0.000000 |
| WTD & WTWAV | 259 | 1693.50 | 12.55 | 0.000000 |
| WTB & WTWAV | 243 | 4369.00 | 9.53 | 0.000000 |

Source: own elaboration.

It can be concluded that for each pair of variables the difference between their distributions is significant (all p values are less than 0.017). *Willingness to donate* received the highest scores and *Willingness to work as a volunteer* the lowest. These results are presented graphically in Figure 6.

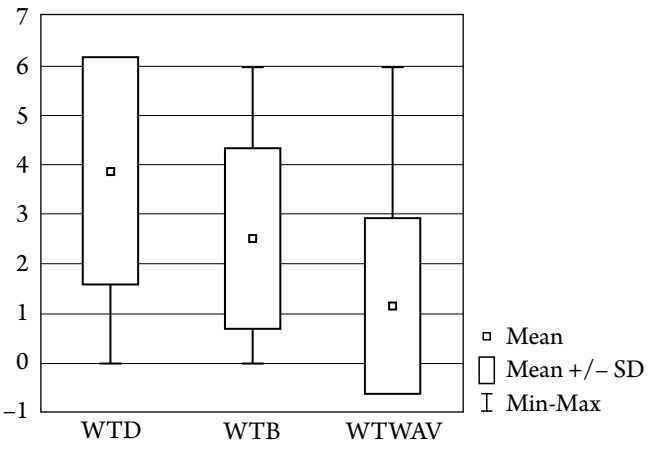


Figure 6. Graphical representation of the Friedman test results

Source: Source: own elaboration.

Considerably more women (224; 69%) than men (102; 31%) took part in the study. The structure of respondents according to *Frequency of attendance* is shown in Figure 7.

To verify hypothesis H4, a non-parametric ANOVA Kruskal-Wallis test was used. The results of the test are presented in Table 9.

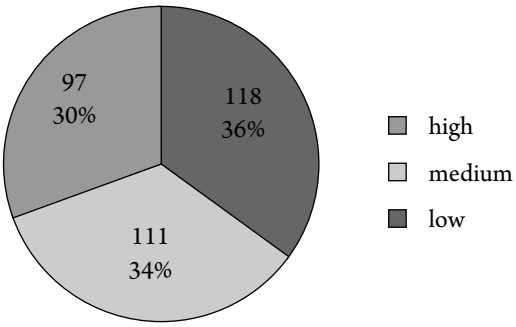


Figure 7. Structure of the sample according to *Frequency of attendance*

Source: own elaboration.

Table 9. Results of the Kruskal-Wallis test

| Variable | Results of Kruskal-Wallis test |
|---|---|
| Past charity involvement | H (2, $N$ = 326) =1.2675; $p$ = 0.504 |
| Intentions towards charity store engagement | H (2, $N$ = 326) =10.564; $p$ = 0.0051 |
| Willingness to donate | H (2, $N$ = 324) =5.91; $p$ = 0.0521 |
| Willingness to buy | H (2, $N$ = 326) =1.1; $p$ =0.5769 |
| Willingness to work as a volunteer | H (2, $N$ = 326) =8.69; $p$ = 0.0130 |

Source: own elaboration.

After analysing these results, it can be concluded that the levels of only two variables, *Intentions towards charity store engagement* and *Willingness to work as a volunteer*, depend significantly on *Frequency of attendance.* Differences in the level of *Intentions towards charity store engagement* within the defined groups were examined using the Dunn *post hoc* test. The results of pairwise comparisons confirmed the statistical significance of lower values of the ITCSE variable for the group with a low level of FOA; differences in the level of ITCSE for groups with high and medium levels of FOA were not statistically significant.

Similar results of pairwise comparisons were obtained for the *Willingness to work as a volunteer* variable: lower values of the ITCSE variable recorded for the group with a low level of FOA were found to be statistically significantly.

Descriptive statistics for the variables *Intention towards charity store engagement* and *Willingness to work as a volunteer* grouped by *Frequency of attendance* are presented in Table 10.

To verify hypothesis 5, the Mann-Whitney U test was used. The results for each of the variables are presented in Table 11.

Table 10. Descriptive statistics for the variables *Intention towards charity store engagement* and *Willingness to work as a volunteer* grouped by *Frequency of attendance*

| Variable | Frequency of attendance | *N* | Mean | Median | *SD* |
|---|---|---|---|---|---|
| Intentions to engage in charity retailing | High | 118 | 2.34 | 2.00 | 1.39 |
| | Medium | 111 | 2.19 | 2.00 | 1.27 |
| | Low | 97 | 1.80 | 1.50 | 1.36 |
| Willingness to work | High | 118 | 1.38 | 0.00 | 1.88 |
| | Medium | 111 | 1.20 | 0.00 | 1.75 |
| | Low | 97 | 0.78 | 0.00 | 1.63 |

Source: own elaboration.

Table 11. Results of the Mann-Whitney U test

| Variable | Sum of ranks Female | Sum of ranks Male | *U* | *Z* | *p* | *N* Female | *N* Male |
|---|---|---|---|---|---|---|---|
| Past charity involvement | 37500.5 | 15800.5 | 10547.5 | 1.1102 | 0.2669 | 224 | 102 |
| Intentions towards charity store engagement | 38941.5 | 14359.5 | 9106.5 | 2.9364 | 0.0033 | 224 | 102 |
| Willingness to donate | 38464.0 | 14186.0 | 9035.0 | 2.8501 | 0.0044 | 223 | 101 |
| Willingness to buy | 35540.0 | 17761.0 | 10340.0 | –1.3732 | 0.1697 | 224 | 102 |
| Willingness to work as a volunteer | 39169.0 | 14132.0 | 8879.0 | 3.2247 | 0.0013 | 224 | 102 |

Source: own elaboration.

Only three variables, *Intentions towards charity store engagement, Willingness to donate and Willingness to work as a volunteer,* depend significantly on gender ($p < 0.05$).

Descriptive statistics for these variables grouped by gender are presented in Table12. The means of the analysed variables are lower for men.

Table 12. Descriptive statistics grouped by gender for the variables *Intention towards charity store engagement, Willingness to work as a volunteer* and *Willingness to donate*

| Variable | Gender | *N* | Mean | Median | Min | Max | SD |
|---|---|---|---|---|---|---|---|
| Intentions towards charity store engagement | Female | 224 | 2.29 | 2.00 | 0.00 | 6.00 | 1.42 |
| | Male | 102 | 1.78 | 1.50 | 0.00 | 5.00 | 1.14 |
| Willingness to work | Female | 224 | 1.36 | 0.00 | 0.00 | 6.00 | 1.90 |
| | Male | 102 | 0.60 | 0.00 | 0.00 | 6.00 | 1.34 |
| Willingness to donate | Female | 223 | 4.08 | 4.00 | 0.00 | 6.00 | 2.21 |
| | Male | 101 | 3.27 | 4.00 | 0.00 | 6.00 | 2.39 |

Source: own elaboration.

## 5. Conclusions

Out of consideration for future generations, it is important to find out what is people's willingness to support sustainable initiatives, also in the retail trade sector. The analysis of correlations between *Past charity involvement* and *Intentions toward charity store engagement* revealed the existence of a statistically significant relationship between these variables, which means that hypothesis H1 can be confirmed. It is quite surprising, however, that this relationship is not very strong. This may be a consequence of the main limitation of the study, i.e. the small number of experiences related to the charity shop format among the respondents and their resultant caution with regard to declaring an intention of engaging in such activities.

As regards the verification of hypothesis H2, it was shown that the variable *Intentions towards charity store engagement* was differentiated across the three groups; those with low, moderate and high levels of past charity involvement; and thus hypothesis H2 was confirmed.

The results relating to the preferred form of engagement in charity shop activities indicate that most preferred form indicated by young people is to donate something; this was followed by the option of buying something; working for a charity store turned out to be the least preferred form. Thus, the H3 hypothesis can be regarded as confirmed. This finding is broadly in line with the results obtained by Montgomery and Mitchell [Montgomery & Mitchell 2014: 1-13], who in their US study found that people aged 18-34 are more likely to donate something than to buy something. This may be connected with a tendency among young people to give priority to experiencing the reality over the accumulation of goods. In addition, young people tend to show a great interest in new arrivals on the market, which can also prompt them to get rid of goods which are no longer up-to-date.

Hypothesis H4 was partially confirmed. The levels of only two variables, *Intentions towards charity store engagement* and *Willingness to work as a volunteer*, depend significantly on religiosity measured by *Frequency of attendance*. This finding is quite surprising since previous studies found that religious involvement does have a positive influence on various forms of civic behaviour and charitable giving [Hodgkinson, Weitzman & Kirsh 1990: 93-114; Jackson et al. 1995: 59-78; Perks & Haan 2011: 107-129]. This may indicate a superficial character to respondents' religiousness, which does not translate into life decisions in the economic sphere. Research conducted in Poland shows that despite declared religiosity, religious commands are not considered to be particularly binding [Mariański 2015: 826]. However, the issue of the influence of religiosity on sustainable consumption,

including the tendency to make sacrifices, seems to be an interesting area for further research.

Hypothesis H5 was also partially confirmed. The levels of three variables, *Intentions towards charity store engagement*, *Willingness to donate* and *Willingness to work as a volunteer* depend significantly on gender. In the case of other variables (*Past charity involvement* and *Willingness to buy*), no such dependence was discovered. This finding is broadly consistent with the results of a study by Broadbridge and Horne [Broadbridge & Horne 1994: 421-437], who found that women become volunteers in charity stores more frequently than men (most often these are women over the age of 55). The results obtained in the present study also confirm the findings of a study on charitable giving conducted in 2016 in the United States [Women and Giving 2016], which showed that women donate to charity more often and in larger amounts than men.

The issue of attitudes and intentions with respect to alternative retail formats, including charity stores, remains a very interesting area for further research because of the multitude of determining and moderating factors involved. It would seem worthwhile to investigate the intentions of shopping in various alternative retail formats to identify any differences between the determinants of shopping in such places as second hand stores, charity stores and vintage stores; especially in countries with moderate levels of economic development where second-hand products can be perceived as inferior to new ones.

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## Zrównoważony rozwój w handlu detalicznym. Badanie intencji zaangażowania w działalność sklepów charytatywnych

**Streszczenie.** Celem artykułu jest przedstawienie związku między dotychczasowym zaangażowaniem w działalność charytatywną młodych konsumentów a ich chęcią angażowania się w działalność sklepów charytatywnych, a także rozpoznanie, które z potencjalnych form zaangażowania na rzecz sklepów charytatywnych są preferowane przez respondentów, oraz jak na ich deklaracje wpływają takie czynniki, jak płeć i religijność. W artykule wykorzystano wyniki badań bezpośrednich zrealizowanych w marcu 2018 r. techniką PAPI wśród 326 Polaków w wieku 16-24 lata. Przeprowadzona analiza wykazała, że wcześniejsze zaangażowanie w działalność charytatywną koreluje pozytywnie z chęcią angażowania się w działalność sklepów charytatywnych. Najczęściej deklarowanym przez konsumentów sposobem angażowania się w handel charytatywny jest przekazanie rzeczy do sklepu charytatywnego, a najrzadszym praca w takim sklepie.

**Słowa kluczowe:** rozwój zrównoważony w handlu detalicznym, alternatywny format handlu detalicznego, sklep charytatywny

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# Possibilities and Practices of Competences for Sustainable Development in Teacher Education at Yanka Kupala State University of Grodno

**Abstract.** The article discusses problems connected with effective learning in teacher education for sustainable development. The authors analyze educational goals, approaches to teaching, basic organizing ideas and the main constructs of an innovative model in teacher education for sustainable development. Basic strategies of learning are outlined, dominant methods and criteria for evaluation of educational results are briefly characterized. Students' activities are organized along a five-component structured model integrating knowledge, values, ethics, skills and evaluation.

**Keywords**: education of sustainable development, higher education, teacher education, competences

## 1. Introduction

The United Nations Decade of Education for Sustainable Development (2005-2014) requests that sustainable development issues be incorporated into education in a holistic and trans-disciplinary manner. This involves the embedding of sustainable development (SD) competencies into existing education programs.

The promotion of education for sustainable development (ESD) in higher education is, "considered crucial to building a sustainable future and to placing young people at the center of development" [Wals 2013: 5]. This responsibility and importance of ESD is shared by UNESCO [2005] and the United Nations Economic Commission for Europe (UNECE). Furthermore, the Lüneburg

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Declaration of 2001 reinforced the emphasis made within Chapter 36 of Agenda 21 (1992), that Higher Education should play a crucial role in supporting education's ability to address sustainable development challenges. The Declaration invites universities to sign the Declaration and commit to reorienting education towards sustainable development.

The implementation of an ESD strategy at the national and international level will allow setting goals and common objectives in the process of establishing ESD that can be agreed at the international level; propose innovative approaches and ways to achieve progress in the implementation of this international instrument. All this will allow introducing the subject of sustainable development and ESD into the public/political agenda.

Successful implementation of the strategy allows each country to ensure the transition from the simple transfer of knowledge and skills necessary for existence in modern society, readiness to act and live in rapidly changing conditions.

At the same time, for the success of the implementation of the ideas and methodology of ESD, such education must be continuous and take into account the needs, interests, values of all age and social groups.

In the Republic of Belarus, the task of developing education becomes more relevant in the context of the need to implement a national strategy for sustainable socio-economic development of the Republic of Belarus for the period up to 2030.

Trying to solve this problem we formulated several questions: in a swiftly changing world, how should the educational process be organized so that students can learn successfully throughout their lives for sustainable development? What pedagogical and social factors affect successful learning in teacher education? How should learning be evaluated? These questions build up the core of a successful society tomorrow. With these challenges in mind, we attempted to find some solutions.

## 2. Defining competences for SD

Competence-based and competence-oriented education is understood as a specific scientific management approach based on the foundations of the resource approach. It is consistent with the approaches of a higher hierarchical level: with the systemic philosophical and interdisciplinary general scientific approaches, as well as with the personal-activity concrete-scientific approach.

Consideration of the competence-based approach as an instrumental and managerial resource for the development of education makes it possible to combine in a common space the requirements for ensuring its continuity and manu-

facturability. The meaningful use of the competence approach as a resource of technologization and quality management of ESD allows to bridge the gap between education and non-educational social spheres by "leaving" representatives of the education sector to a reflexive, managerial position in relation to the mission, strategy, processes, structures in vocational education in a social context.

ESD in many countries transforms consistently in a connecting interdisciplinary notion, which combines natural, scientific and social aspects of teaching. In consequence this process set conditions for a necessity to revise old normative, legal, educational, methodical and didactic materials of educational process and work out new ones. This process negatively influenced a teacher's education as it is the most closely connected with tutorials. By the way, for a system of teacher training in Belarus a process of entering a new attitude to ESD turned out to be complicated and long.

For the educational system of Belarus, the introduction of SD as a necessary component of teaching in schools and institutes of higher education became a problem. During several years it was concentrated mainly in curricula on biology and geography in the form of separate topics, which had random spacing. 80% of information on SD themes still has a descriptive character and provides students shock data about an adverse state of the environment instead of purposeful forming of ecological consciousness and responsibility. The same problems are also mirrored in teaching practical work in institutes of higher education.

Based on our analysis, we can assert that at the end of the 2000s – to the beginning of the 2010s, ESD in Belarus schools was not integrated enough in the concept of general education and in practice it often revealed only ecological problems in teaching of separate subjects. Cognitive, natural-science, social, artistic and aesthetic aspects of ESD were also put aside. Humans are social beings and they should learn to live peacefully in their environment. For that they need to be able to analyse conflicts, consider their ways for solution, and weigh an opportunity of compromises and perspectives of further development.

A traditional paradigm of ecological education assumed destroyed, damaged or situated under threat environment as a basis for the whole scientific data. Then a new paradigm of ESD is based on the fact that the given environment is although an essential part but only a part of general project for sustainable development. In this connection educational aims also have changed, including Belarus. Education for sustainable development proceeds from a broader range of notions. It started, first of all, from the fact that humans are social beings and they should learn to live peacefully in their environment.

Now we can see an active process of discussing of competencies for SD as a value of sustainable development. Such authors as Wiek [2011], de Haan [2006], Reichmann [2012] have their opinion on the competences. We think that a model of De Haan is now one of the most importance models for education

for sustainable development (ESD). De Haan developed the concept of "formal competence" (*Gestaltungskompetenz*), which combines an integrated thinking, interdisciplinary approaches, the ability to solidarity. Environmental knowledge, the ability to act, a reflection of individual and cultural values are important in this concept too. The author emphasizes the need for "integrity" of education.

## 3. Sustainability for 21st education's needs at Yanka Kupala State University of Grodno

Yanka Kupala State University of Grodno takes part in the national and the European educational space. Yanka Kupala State University of Grodno is one of the top universities in Belarus, whose alumni work in all sectors of the economy; it has competitive study programs and tries to be in line with modern requirements for higher education. GrGU lecturers are involved in many educational programs, international exchanges, and leadership scholarships, constantly improving their own expertise and trying to emulate the Western European system of education.

Through its initiatives "Agenda 21" and through the Department of Ecology, Yanka Kupala State University of Grodno has been among the first Belarusian universities to view the institution as a whole and to attempt to initiate processes in all areas to foster the integration of sustainability.

Yanka Kupala State University collaborates actively in the framework of the Baltic University Program. Priority areas of this cooperation are such issues as: environmental protection; development studies and democratic transformations in the region through educational initiatives; strengthening the role of universities in society.

The staff is the University's most essential resource, and the personnel policy contributes to the goal of being one of the leading universities in our country.

The personnel policy is characterized by creating creative pedagogical teams capable of responding to the demands of modern times to solve the problems of personality formation based on culture, ideas of humanization, technologization and informatization of the learning process.

The content of education is intended to provide preparation for social, cultural, spiritual activities, to form a worldview, a system of values and ideals, which determine a certain position in the world and a system of relations with the world. The peculiarity of the educational process consists in applying, along with traditional forms, interactive learning technologies. These forms allow increasing the efficiency and quality of training, providing motivation for independent cognitive activity, contributing to the deepening of interdisciplinary connections through the integration of information and subject training.

## 4. Approaches to education for sustainable development and further possibilities to strengthen competences for SD at Yanka Kupala State University of Grodno

Education for sustainable development is an important part of teacher education. It is evident that any authentic education, by definition, works on sustainable development. Interpretation of education in the sphere of sustainable development as a chance to preserve (restore) traditional values of education as a part of universal culture gives an opportunity to introduce at the same time something new in this sphere. Accordingly, changes in the system of education at all levels which are recognized today in UNO (United Nations Organization) commissions need fundamental changes in the system of teacher training in institutes of higher education as well. First of all, it should secure a forming of high ecological culture of teachers to be and this ecological culture will allow him/her to influence efficiently on individual development of students.

Relevant aims and tasks of sustainable development demand a qualitative renovation of the contents of teacher training education. It should be accepted a priori that ESD penetrates mass consciousness more assertively, it gains mental character. That is why SD should be an important constituent of teacher training.

Skills development activity is extremely important. At the university students prepare a bibliography on the problem to be studied, make tables and graphs, photo essays, construct maps, visualize the significance, propose alternative strategies, preserve the collected information on CD. Every working team prepares a PowerPoint presentation, then the groups debate their solutions, refine them, construct meanings to the concepts and reach conclusions by consensus.

The obtained results help students arrive at meaningful decisions. This was the way to achieve competence to monitor the state of the environment. Students construct arguments to support their decisions. The last stage is pedagogical monitoring. Students assess each other and themselves and the teachers assess everybody. Each group is also assessed by the teacher.

Different studies have been looking at competences for SD from: (a) a general point of view, leading towards sets of general key competences for SD, to be applied in all higher education study programs; and (b) a narrow perspective, i.e. without connecting these competences for SD with other competence concepts already developed in higher education. At the university we specifically discusses the possibilities to connect competences for SD with other competence concepts.

The application of ideas of sustainable development in the educational process of the university is a global civilizational project. Studying sustainable development can contribute to reaching its key goals: fostering the thirst for knowl-

edge, developing intellectual skills, mastering the new knowledge tailored for individual capacities of the student and so on. Schools teaching practice for future teachers based on educational modeling contributes to two main directions of sustainable development: on the one hand, it helps to individualize the process of education, to adjust it to the capacities, and on the other hand – helps to cultivate educational independence through the skills of building models of new concepts. In the context of sustainable development, the experience of modelling is a valuable skill opening for the child the possibilities of independent cognition and continuing the education for life.

Over the past years, the university has integrated sustainability into their education, research, outreach, and operations. In accordance with this, in the current socio-economic conditions, the University sets itself the task of training specialists of a new type, possessing not only erudition and the necessary knowledge, but also the ability to solve organizational problems, production tasks in professional activities, possession of modern approaches to work, ability to manage innovation.

## 5. Conclusion

Education, in addition to being a human right, is also one of the prerequisites for achieving sustainable development ideas and an essential tool for effective management and sound decision-making. The vision of a strategy for ESD is a vision for the future. This is a vision of a region committed to the same values of solidarity, equality and mutual respect between people, countries and generations. Only in this case the sustainable development of the region is possible.

Yanka Kupala State University of Grodno is a base for training teachers and scholars in various specialties, focusing primarily on the needs of the labor market for highly qualified specialists and adhering to the path of sustainable development. The university has numerous contacts in the region with educational institutions of all levels, is the leader of teacher education in the region. The activity of the university is not limited to the borders of the Republic of Belarus; today, relations with universities in Poland, Lithuania, Latvia, Russia, and Germany are actively developing. The University was one of the first to successfully modernize its educational programs, providing the necessary changes to the curricula provided by the Bologna Agreement.

The university acts as a cluster of innovative development of educational and social spheres of the region. This was the beginning of a new stage in the development of education for sustainable development in the region, when a single educational space is coordinated and managed by leading experts in the field of

SD, while it is planned to create a dynamic base of education for sustainable development.

The main goal of the university's work in this direction is the promotion of knowledge in the interests of SD and the formation of ecological thinking of the population of the Republic of Belarus through the development of cooperation in education and education for sustainable development between various institutions, associations and structures operating in the region, as well as the active dissemination of best practices ESD strategies in the region.

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## Możliwości i rozwój kompetencji nauczycieli w zakresie nauczania zrównoważonego rozwoju – przykład Grodzieńskiego Uniwersytetu Państwowego im. Janki Kupały

**Streszczenie.** W artykule omówiono cele edukacyjne, podejście do nauczania, podstawowe idee organizacyjne oraz konstrukcję innowacyjnego modelu kształcenia nauczycieli na rzecz zrównoważonego rozwoju. Przedstawiono także główne strategie uczenia się i metody dominacji, a także kryteria oceny wyników edukacyjnych. Zajęcia studentów są zorganizowane według pięcioelementowego modelu integrującego wiedzę, wartości, etykę, umiejętności i ocenę.

**Słowa kluczowe:** edukacja na rzecz zrównoważonego rozwoju, wykształcenie wyższe, kształcenie nauczycieli, kompetencje

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# An Environmental Friendly Solution for Stimulating Protective Properties of the Soil

**Abstract.** The development of soil management at the local and regional level is faced with challenges associated with an increasing level of soil contamination in urbanized systems. Thus, intensive soil use in Ukraine in recent years has resulted in a significant loss of humus, which is accompanied by negative changes in agrophysical, physico-chemical and biological properties of the soil. The aim of the study was to model a stimulating process of natural protective properties of the soil complex thanks to the influence of biocomposite based on sewage sludge and phosphogypsum under conditions of sulfate reduction. The chemical fractions were extracted from contaminated soil before and after the treatment. Surface images of the treated soil were obtained by means of X-ray diffractometry and microscopic analysis. The mineral composition of soil samples after processing by biocomposite was also mapped. Finally, the technological concept of a two-stage process of soil remediation was proposed involving the stage of aerobic soil treatment with biocomposite and the phyto-remediation stage for additional treatment.

**Keywords**: protective properties, soil, heavy metals, biocomposite, phosphogypsum, sewage sludge

## 1. Introduction

The development of soil management at the local and regional level is faced with challenges associated with an increasing level of soil contamination in urbanized systems. Thus, intensive soil use in Ukraine in recent years has resulted in a significant loss of humus, which is accompanied by negative changes in agrophysi-

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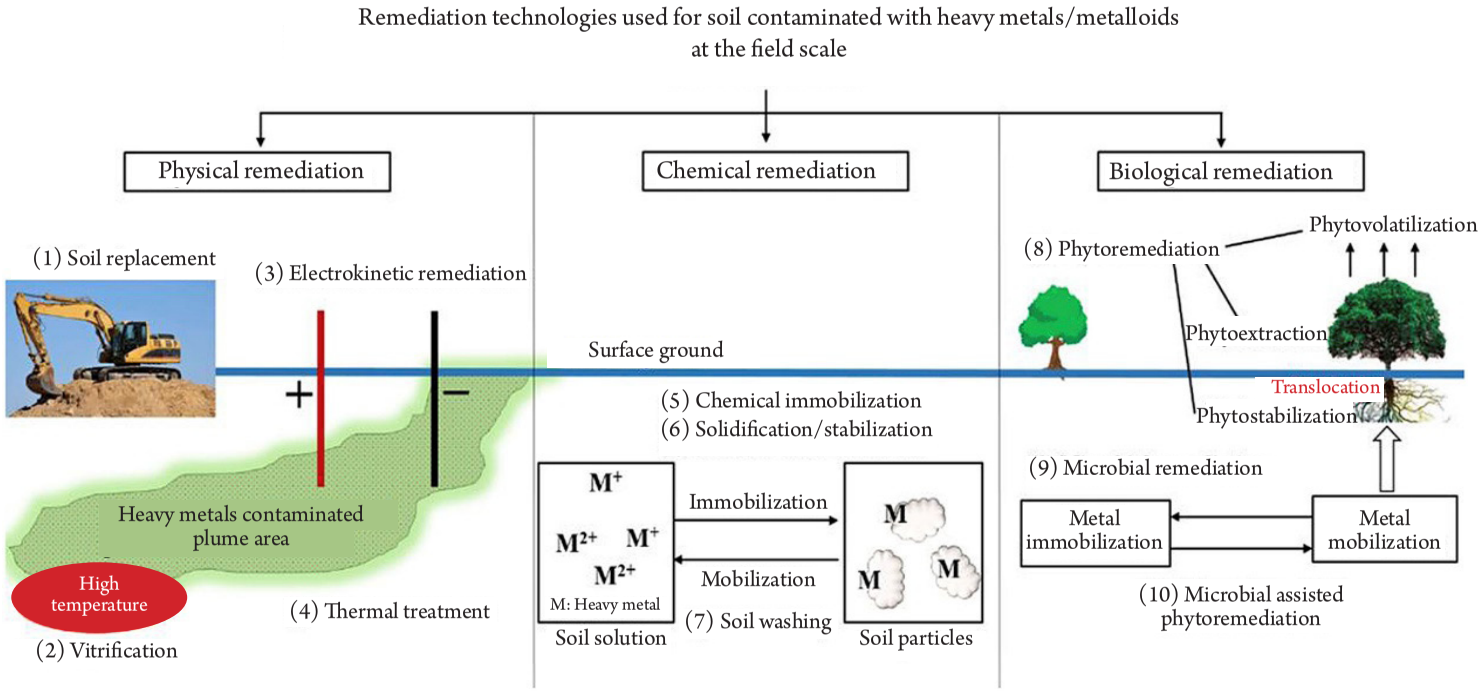



Figure 1. Remediation technologies for contaminated soil

Source: Yanyan Gong et al. 2018: 440-460.

cal, physico-chemical and biological properties of the soil. Correspondingly, the efficiency of agricultural methods and the productivity of agricultural crops are decreasing [Dadenko et al. 2013: 1274-1277].

Nowadays, it is still difficult to solve the problem of reducing levels of heavy metals in plant systems. Migration and accumulation of heavy metals is facilitated by the secretion of root exudates that moisten soil aggregates and bind cations of two- and polyvalent metals with the help of carboxyl and hydroxyl groups of polysaccharides, amino acids and carboxylic acids in complex compounds and concentrate these cations, resulting in the toxication of land ecosystems.

Among measures aimed at reducing the impact of pollutants on the soil one should highlight the following ones: chemical, physical and biological. Figure 1 shows various methods of soil remediation.

Many studies [Derome 2000: 79-88; Anderson et al. 2013: 1-21; Goulding 2016: 390-399] investigated the impact of liming and different kinds of fertilizer (phosphate, nitrogen, potash and organic fertilizers) treatments on heavy metal (Cu, Ni) and macronutrient (Ca, Mg, K) availability in the organic layer of soil. Widely used in the practice of agriculture has the technique of liming acidic soils [Derome 2000: 79-88], that not only helps to create better conditions for plant growth, but also reduces the flow of heavy metals from the soil into plants. The introduction of lime and lime materials is possible only on acidic soils. On alkaline soils, their enrichment with calcium can be carried out due to gypsum. For all types of soil, and especially for sandy and easily loamy, the enrichment of the horizon with organic fertilizers is quite important. However, in this case we mean manure, humus, peat, composts, pond silt and other types of local fertilizers.

From the point of view of biomineralization, bacterial metabolism affects the oxidation-reduction reaction in the soil medium and the rate of release of nutrients and deposition of heavy metals [Zachara et al. 2002: 179-207; Konhauser et al. 2012: 105-130], respectively, in the process of their fixation in a complex biogenic organomineral fraction of the soil. In the process of metabolic induced bio-mineralization, secondary minerals are formed as by-products of microbial metabolism containing metals in a chemically bound form, respectively, the extraction of the latter from the cycle of substances in the ecosystem [Chernysh 2017: 131-133].

The distribution of heavy metals in the soil is also regular, such as exogenous mainly in the soil surface between 0-5 cm; heavy metals are included to chelate complexes in the soil. Accumulation of the main part of heavy metals is observed mainly in the humus-accumulative soil horizon, where they are bound by aluminosilicates, and non-silicate minerals, organic substances due to various interaction reactions. Redistribution and migration in soil depends on the content of organic matter, particle size distribution, type of water regime, reaction of soil

solution, temperature of individual horizons. Thus, high content of humus and free iron oxides, which are the main carriers of heavy metals, weakly acid reaction of the soil ensures fixation of trace elements and their relative property in the soil profile. Quantitative indicators of the adsorption of heavy metals largely depend on the pH of the medium. The processes of adsorption of metals can change, namely, reduce the pH value of soil solutions. According to [Chang Pan et al. 2018: 012113], the causes of this phenomenon are the release of protons during the hydrolysis of heavy metal salts, the displacement of cations during the specific adsorption of metals.

Phosphogypsum is a mechanically destroyed rock, treated with sulfuric acid with the addition of lime mortar after extraction with $P_2O_5$; it has a significant content in the composition of the product of insoluble compounds (CaO, $SO_3$,

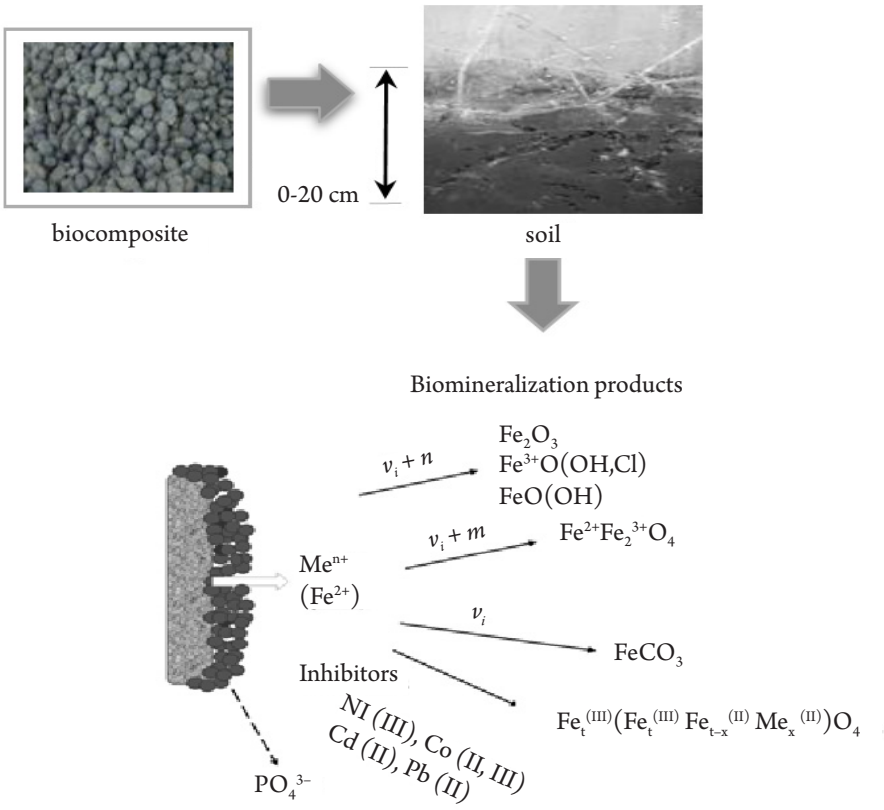



Figure 2. Schematic process of biocomposite introduction to soil

Source: based on Chernysh 2017: 131-133.

$Al_2O_3$, $Fe_2O_3$, $SiO_2$, MgO). The physicochemical properties of phosphogypsum affect the process of mineralization and humification of organic matter in the soil complex. A number of studies have revealed that when fertilizers are added with the addition of such qualitative transformations: the content of mineral colloids in the soil increases; soil aggregation increases; more moisture accumulates and remains; the remains of maize, sunflower and other plant waste that is difficult to degrade are more intensively decomposed. It has been revealed that phosphogypsum can be a stimulating additive for plant growth [Hentati 2018: 80-89].

Thus, the study of laws and mechanisms of the biochemical transformation of heavy metals in natural and artificial ecosystems for optimization and balancing of nutrition of crops remains relevant. The applied nature of this problem can also be considered from the perspective of the development of biotechnological systems and biotechnical means of natural mechanisms for stimulating soil complex protection while rehabilitating natural and anthropogenic landscapes contaminated by heavy metals. And the problem solving of phosphogypsum treatment is very important today.

Thus, the most important task of environmental research is to find ways to stimulate the natural protective properties of soils under condition of intensive anthropogenic load.

The study purpose is to research the effect of biotechnological treatment on the localization of heavy metals in the soil complex.

To achieve this aim it is necessary to solve the following tasks:

– study of the effect of organo-mineral biocomposite based on sewage sludge and phosphogypsum on soil detoxification;

– development of a technological scheme for the biotechnological treatment of soil remediation.

## 2. Materials and methods

### 2.1. Method of microfield experiment

In Chernysh [2018] was determined the features of quantitative and qualitative changes in the soil complex after biocomposite treatment (Fig. 2).

The experiment was carried out in plexiglass blocks with a perforated bottom area of 0.20 $m^2$ (0.5 × 0.4 × 0.5 m). The blocks were filled with gray forest soil taken from an area with a high level of anthropogenic load, containing 17.6-21.2 mg/kg (total form) of lead.

Perennial grasses were grown in blocks using increasing biocomposite doses. Natural vegetation which grew in blocks was mowed and removed from the soil

surface every season. The soil in blocks was dug over at a depth of 0-20 cm and partially removed from the blocks, mixed and put again into blocks at random. In this case, the perennial grasses used in crop rotation (alfalfa, clover, espartset, their mixtures with cereals) were applied. The ambient temperature in the room was maintained at 22-25 °C.

During the experiment biocomposite was introduced at an increasing rate of: 1) 2.5 kg/m$^2$; 2) 5.0 kg/m$^2$; 3) 7.5 kg/m$^2$. The biocomposite containing sewage sludge and phosphogypsum was mixed with the soil layer of 0-20 cm. The experiment was repeated three times. X-ray diffractometry of the mineral constituent were carried out. The analysis was carried out with the help of automated diffractometer DRON-4-07 (JSC RPE "Burevestnik", St. Petersburg, Russian). Elemental analysis of the samples (liquid and solid phases) after the experiments was carried out using the X-ray fluorescence analyser Elvax Light SDD (Elvatech, Kiev, Ukraine). Limits of detection of impurities are not less than 10 ppm. pH was analyzed by pX-meter pX-150 (ionometer) (Gomel Plant of Measuring Instruments, Gomel, Belarus).

Moreover, chemical fractions were extracted using standard methods of metal speciation [Chernysh et al. 2017: 129-140; Chang Pan et al. 2018: 012113; Hentati 2018: 80-89].

Microscopic analysis of the samples was carried out using a Remm-102 raster electronic microscope microanalyzer (JSC "SELMA", Sumy, Ukraine) under SEM-EDX scanning electron microscopy [Chernysh 2018].

## 2.2. The characteristics of the biocomposite

The organomineral product is produced in the process of anaerobic stabilization of sewage sludge and phosphogypsum under conditions of sulfate-reduction [Chernysh et al. 2018: 1269], which, after separation from the liquid fraction and drying, has a gray-brown color and resembles aggregated soil particles in a consistency.

The main components of the biocomposite were determined by means of diffractometric analysis such as: quartz or amorphous silica – $SiO_2$; potassium

Table 1. Percentage content of oxides in the biocomposite

| $SiO_2$ | $Al_2O_3$ | CaO | $K_2O$ | MgO | $Na_2O$ |
|---|---|---|---|---|---|
| 37.65 | 8.4 | 31.3 | 3.2 | 1.7 | 3.4 |
| $SO_3$ | ZnO | $Fe_2O_3$ | CuO | $P_2O_5$ | NiO |
| 9.5 | 0.01 | 0.45 | 0.003 | 0.5 | 0.0014 |

Source: Chernysh 2018.

hydroxide (potassium hydroxide) – KOH; brushite – $CaPO_3(OH)\cdot 2H_2O$; calcium – $CaCO_3$; ammonium sulfate (mascagnite), iron sulfides (marcasite), zinc (sphalerite), copper (kovelit) etc., which form a complex sulphide fraction. The content of the main elements in the organomineral composite is presented in the Table 1.

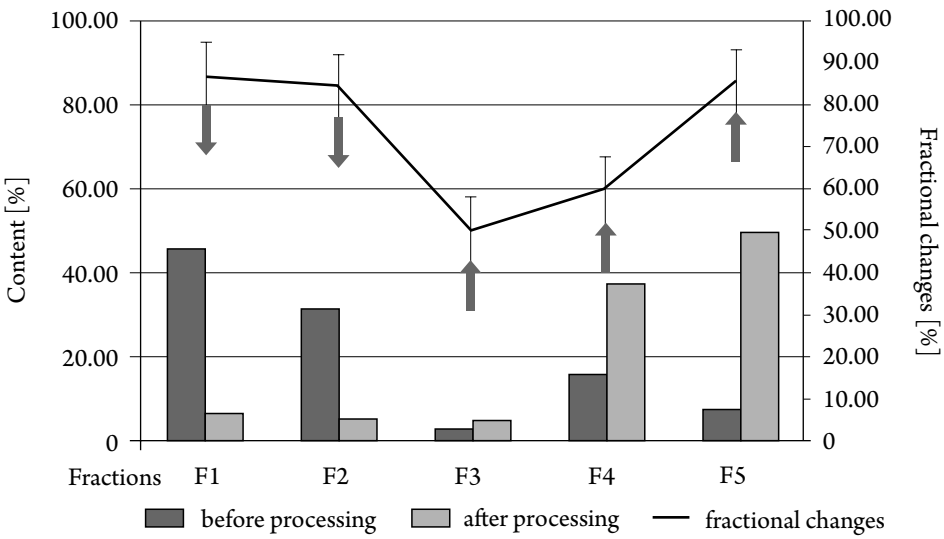
## 3. Results and discussion

### 3.1. Analysis of changes in the fraction composition of HM on the soil before and after the application of the biocomposite

Based on the analysis of the results, changes in the fractional metal composition is shown in the following diagram (Chart 1).

The largest portion of Pb and Cd (about 67%) before treatment was extracted as a portion of F1-Fe and F2-Fe, bound to amorphous oxides and hydroxide Fe: FeOMe, $(FeO)_nMe$, FeOMeOH, for example, $PbFe_2O_4$. The low portion of HM

Chart 1. Combined analysis of changes of fractional composition of metals in the soil before and after biocomposite introduction




F1 – oxides and oxyhydroxides of iron and manganese; F2 – exchange forms; F3 – carbonates, hydroxycarbonates; F4 – with organic substances; F5 – residue (silicates and sulphides).

Source: Chernysh 2018.

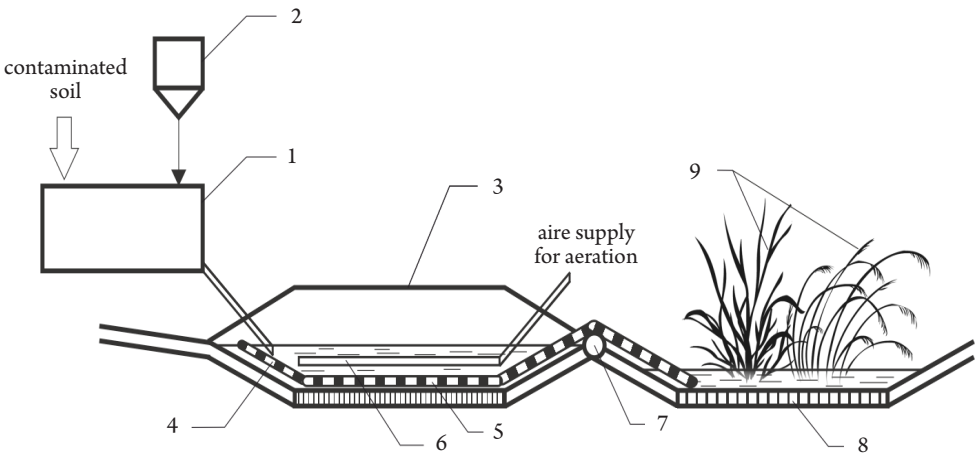
and Fe (i.e. <2% and <9.2% respectively) is extracted as bound to carbonate fraction. These results proved that Pb had main bonds with amorphous particles of iron oxide and ferrous hydroxide of soil, which is confirmed by diffractometry.

The diffractometric analysis showed traces of hematite, jarosite and scorodite, which are usual pyrite sedimentary products, which HM can generally bind to. The absence of residual mixed sulphide phases in soil may be connected with weathering of pyrite minerals.

During the extraction of $NH_2OH \times HCl$, under these acidic conditions of pH (about 4), about 76% of total lead was extracted. The mechanism of lead desorption from the surface of oxyhydroxide Fe because of the competition with OH-ions can explain a rapid increase in lead extraction. The remediation of Fe remains very low (about 0.2% of total Fe). Fe remediation may be controlled by Fe hydroxyxide precipitation.

These results suggest that the biggest portion of Pb and Cd present in the soil is sorbed onto Fe oxyhydroxides. The remaining portion (about 22% out of total HM) can be considered as a portion coprecipitated with Fe and/or bound to resistant compounds (predominantly silicates).

After treatment, five major fractions of metals in the "soil complex – biocomposite" system were generally compatible (86%): 37% were found in stable organic compounds and 49% were found in residual fractions, which had firm




1 - hopper for mixing ground soil and biocomposite; 2 - dispenser for biocomposite supply; 3 - bioreactor; 4 - scraper conveyor; 5 - isolated bottom; 6 - aeration system; 7 - electric drive; 8 - playground; 9 – phytoremediation plants

Figure 3. Biotechnological concept of soil remediation

Source: Chernysh 2018.

bonds with the matrix of mineralized sediments (silicates and sulphides) (Fig. 3). There were only 12% of metals oxyhydroxides. The low portion of HM and Fe were extracted as exchangeable and bound with carbonate fraction. Thus, it was determined that at least 90% of lead was bound in inaccessible form to plants: primary and secondary silicate minerals, slightly soluble metal compounds (sulphides) and organomineral complexes. It should be noted that the carbonate fraction increased by 2% and, correspondingly, it accounted for 4% of the total, which is related to the substitution of calcium by lead in carbonate compounds contained in the composite, as lead ions are similar in size to calcium ions.

The results extraction of Pb and Cd from the contaminated soil using $NaCH_3COO$ solution after the introduction of the biocomposite are also shown in Fig. 3. It was found that the extraction with the help of this solution has no significant effect on the release of Fe and HM. However, it showed an increase in calcium solubility (approximately 500 times at pH of about 5) and at the same time was observed for phosphorus adsorption on Fe oxyhydroxides according to the results of diffractometric analysis.

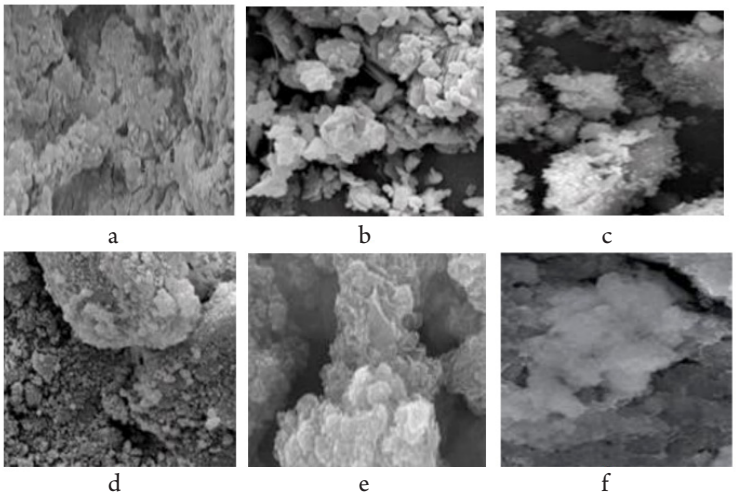
Thus, the accumulation of HM in soils and their distribution in fractions were also influenced by acid-base conditions. Thus, the restored soil had an acidity of 6.5 and the exchange fraction of lead decreased by 84%. The number of elements bound with hydroxides and oxides of Fe and Mn also decreased by 87%.

## 3.2. The technological concept of soil remediation

Technological processes that facilitate soil bioremediation will make it possible to reduce the processing time enabling the use of bioreactors, including fixed-bed reactors and slurry reactors with mixing [Barros et al. 2006: 1-10; Fulekar et al., 2012: 14-16; Napan 2014: 164]. The technological methods of intensifying the growth of microorganisms and improving the processes of soil bioremediation include: electro-kinetic activation, improvement of aeration conditions by blowing air through the soil etc.

The technological concept of an aerobic bioreactor for soil biodetoxification was developed (Fig. 3) based on the analysis of theoretical and experimental data.

The technological concept works as follows. The crushed soil contaminated with heavy metals is fed into the mixing hopper (1) together with the biocomposite from the dispenser (2). This mixture enters the bioreactor (3) through a pipeline, consisting of a trench with an insulated bottom (5) with a scraper conveyor (4), through which the soil moves. The aeration system (6) is arranged above the conveyor, which supplies air to the bioreactor in order to improve aeration conditions. The bioreactor is equipped with an electric drive (7). The previously




a – general view; elements: b – Fe; c – Pb; d – Ca; e – S; f – Si

Figure 4. SEM-EDX raster microanalysis map to 2 mm soil fraction (12X)

Source: Chernysh 2018.

cleaned soil is fed by the scraper conveyor (4) to a special platform (8) on which phytoremediation plants (9) are planted for further purification (phytoremediation), monitoring and control of pollutant content. Thus, the process of cleaning the soil from heavy metals and restoring its fertility, as a result of improving the development conditions of soil microbiota, is carried out in a two-stage process:

1. aerobic soil treatment with the biocomposite;
2. phytoremediation stage for additional treatment.

The map of the SEM-EDX raster microanalysis of 2-3 mm of the composite fraction was obtained by applying the biocomposite (Fig. 4).

In accordance with previous research [Chernysh et al. 2017: 129-140; Chernysh 2017: 131-133] the conceptual model of the influence of the proposed biocomposite on the protective function of the soil complex can be formulated. Contact of the organo-mineral biocomposite with the soil complex, aided by surface-sorption phenomena, can have protective properties and can lead to the formation of microaggregates consisting mainly of organic-mineral fine particles with the development of soil microorganisms on their surface. Subsequently, during the adaptation period a natural microbial association is formed in the aggregates, which develop into the system "biocomposite – soil – heavy metals" through the processes of microdiffusion and biosorption. Such a biotic component can play an important role in the conditioning and structuring of the environment, in particular, the mineral component (depositing of heavy metals)

and influence the gradual release of biogenic matter from the biocomposite. The micro aggregates are depleted in readily available organic matter, because during the process of soil mineralization such compounds are used by microorganisms-destructors and, accordingly, are more resistant to degradation than the primary biocomposite applied into the soil.

Therefore, the biogenic composite based on sewage sludge and waste phosphogypsum in the process of anaerobic fermentation under the conditions of sulphate reduction can stimulate the development of necessary anaerobic groups of microorganisms in the intra-aggregate space. In this case, sulphatisation contributes to the formation of macromolecules of biogenic composites.

## 4. Conclusions

The mineral composition map of soil samples after processing by biocomposite based on sewage sludge and phosphogypsum was created. The results of analysing the microstructure and mineral composition of the biocomposite samples show evidence of the process of biochemical binding in the biocomposite structure of metal ions and particles aggregation with biosorption on the surface of its aggregate structures of organic substance and precipitation of complex metal compounds. When restoring soils contaminated with Pb and Cd, a significant increase in the relative portion of resistant metal compounds (silicates and sulphides) was observed at all levels of acidity (pH from 2 to 7) from 5.6-9.05% to 45.3-51.7%.

A biotechnological concept for soil remediation was developed, which consists of two stages: 1. aerobic soil treatment together with the application of the biocomposite; 2. phytoremediation stage for additional treatment and control of toxicant content in the soil. The development of the method for the remediation of contaminated soils using biocomposite material based on phosphogypsum and sewage sludge of treatment facilities is aimed at achieving agricultural and environmental effect, which includes the development of useful environmental and trophic groups of microorganisms that constitute the soil biomes; humification intensification of organic matter; long-term protective function.

Thus, soil management is important, directly and indirectly, to crop productivity, environmental sustainability, and human health both at the local and regional levels. The influence model of the proposed biocomposite on the natural regulation of the buffer properties of the soil complex was developed. The biochemical aspects of the impact of the biocomposite on the growth of natural soil microorganisms and formation of favorable biochemical conditions for the restoration of contaminated soil require further research.

The environmental and biochemical aspects of the influence of organomineral biocomposite on the development of natural soil microorganisms and formation of favorable biochemical conditions for the restoration of contaminated soil require further research.

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## Przyjazny dla środowiska sposób stymulacji właściwości ochronnych gleby

**Streszczenie.** Rozwój gospodarki glebowej na poziomie lokalnym i regionalnym napotyka wyzwania związane ze wzrostem poziomu zanieczyszczenia gleby w systemach zurbanizowanych. Tak więc intensywne użytkowanie gleby na Ukrainie w ostatnich latach spowodowało znaczną utratę próchnicy, czemu towarzyszą negatywne zmiany właściwości agrofizycznych, fizykochemicznych i biologicznych gleby. Celem badań było modelowanie procesu pobudzania naturalnych właściwości ochronnych kompleksu glebowego z uwagi na wpływ biokompozytu na osady ściekowe i fosfogips w warunkach siarczanowania. Przeprowadzono ekstrakcję frakcji chemicznych zanieczyszczonej gleby przed i po obróbce. Zastosowano dyfraktometrię rentgenowską i analizę mikroskopową do tworzenia obrazów powierzchniowych obrabianej gleby. Opracowano mapę składu mineralnego próbek gleby po przetworzeniu przez biokompozyt oparty na osadzie ściekowym i fosfogipsu. Opracowano model technologiczny procesu remediacji gleb, który obejmuje dwa etapy: uprawę aerobową z użyciem biokompozytu; etap fitoremediacji w celu dodatkowego leczenia.

**Słowa kluczowe**: właściwości ochronne, gleba, metale ciężkie, biokompozyty, fosfogips, osady ściekowe

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