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DECOUPLING ECONOMY FROM NATURAL RESOURCES CONSUMPTION AND ENVIRONMENTAL PRESSURE: ANALYSIS OF KAZAKHSTANI CASE

Economic development has always been associated with a rise in the use of natural resources as well as an increase in environmental degradation. However, responsible production principles suggest the opposite. The need to separate economic growth from the consumption of limited natural resources and increasing environmental degradation gave rise to the concept of decoupling. The concept is highly relevant for achieving sustainable economic growth while diminishing the use of resources and simultaneously creating positive environmental impacts. This article aims to analyze the current decoupling state of the kazakhstani economy from natural resources consumption and environmental impact as well as decoupling trends over a certain period. The research was conducted in two stages: (1) statistical analysis of the resource decoupling in Kazakhstan on key natural resources (water, energy) as well as impact decoupling from such indicators as ecological footprint, waste generation, and emissions; (2) a regression model for evaluating dependence of economic growth in Kazakhstan on the consumption of natural resources and environmental degradation. The data was collected for the period from 2010 to 2021. The results show that economic growth in Kazakhstan is accompanied by an increase in waste generation, and emissions into the environment, in particular emissions of liquid and gaseous pollutants. This is in line with previous research which also didn't reveal the effect of decoupling from pollutants emissions. However, there was revealed an absolute decoupling from freshwater resources as well as a tendency for absolute decoupling from energy resources consumption. These findings can be used to define the current decoupling state and trends in Kazakhstan to monitor the effectiveness of the application of responsible production principles and the achievement of sustainable development goals.

Key words: decoupling, economic growth, resources consumption, environmental impact, responsible production.

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Экономиканы табиғи ресурстарды тұтынудан және қоршаған ортаға қысымнан айыру: Қазақстан кейсіне талдау

Экономикалық даму әрқашан табиғи ресурстарды пайдаланудың ұлғаюымен, сондай-ақ қоршаған ортаның деградациясының күшеюімен байланысты болды. Алайда жауапты өндіріс принциптері керісінше жағдайды білдіреді. Экономикалық өсуді шектеулі табиғи ресурстарды тұтынудан және қоршаған ортаның деградациясының күшеюінен ажырату қажеттілігі декаплинг ұғымын тудырды – бұл ағылшын тілінен аударғанда бөлу, ажырату дегенді білдіреді. Ресурстарды пайдалануды азайту және қоршаған ортаға оң әсер ету кезінде тұрақты экономикалық өсуге қол жеткізу үшін декаплинг тұжырымдамасы өте өзекті болып табылады. Бұл мақала табиғи ресурстарды тұтыну және қоршаған ортаға әсері тұрғысынан Қазақстан экономикасының қазіргі кездегі декаплинг жағдайын талдауға, сондай-ақ белгілі бір уақыт кезеңіндегі декаплинг тенденцияларын зерттеуіне бағытталған. Зерттеу екі кезеңде жүргізілді: (1) негізгі табиғи ресурстар (су, энергия) бойынша Қазақстандағы ресурстардың декаплинг деңгейін статистикалық талдауы, сондай-ақ негізгі экологиялық көрсеткіштер (экологиялық ізі, қалдықтардың түзілуі және шығарындылары) бойынша Қазақстан экономикасының декаплинг деңгейін статистикалық талдауы; (2): Қазақстандағы экономикалық өсудің табиғи ресурстарды тұтынуға және қоршаған ортаның нашарлауына тәуелділігін бағалауға арналған регрессиялық жылдан бастап 2021 жылға дейінгі кезеңді қамтиды. Нәтижелер Қазақстандағы экономикалық өсу қалдықтардың түзілуінің, қоршаған ортаға эмиссиялардың, атап айтқанда сұйық және газ тәріздес ластаушы заттардың шығарындыларының ұлғаюымен қатар жүретінін көрсетеді. Бұл нәтижелер алдыңғы зерттеулерге сәйкес келеді. Дегенмен, тұщы су ресурстары бойынша абсолютті декаплинг, сондай-ақ энергияны тұтыну бойынша абсолютті декаплинг үрдісі анықталды. Бұл тұжырымдарды жауапты өндіріс қағидаттарын қолданудың тиімділігін және тұрақты даму мақсаттарына қол жеткізуді бақылау мақсатында Қазақстандағы ағымдық декаплинг жағдайы мен тенденцияларын анықтау үшін пайдалануға болады.

Түйін сөздер: декаплинг, экономикалық өсу, ресурстарды тұтыну, қоршаған ортаға әсер, жауапты өндіріс.

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Отделение экономики от потребления природных ресурсов и экологической нагрузки: анализ Казахстанского кейса

Экономическое развитие всегда было связано с ростом использования природных ресурсов, а также с усилением деградации окружающей среды. Однако принципы ответственного производства предполагают обратное. Необходимость отделить экономический рост от потребления ограниченных природных ресурсов и усиливающейся деградации окружающей среды породила концепцию декаплинга – что, в переводе с английского, означает отделение. Эта концепция очень актуальна для достижения устойчивого экономического роста при одновременном снижении использования ресурсов и положительном воздействии на окружающую среду. Статья посвящена анализу текущего состояния декаплинга казахстанской экономики от потребления природных ресурсов и воздействия на окружающую среду, а также тенденций декаплинга за определенный период времени. Исследование проводилось в два этапа: (1) статистический анализ ресурсного декаплинга в Казахстане по ключевым природным ресурсам (вода, энергия), а также экологического декаплинга по таким показателям, как экологический след, образование отходов и выбросы; (2) регрессионная модель для оценки зависимости экономического роста в Казахстане от потребления природных ресурсов и ухудшения состояния окружающей среды. Данные собраны за период с 2010 по 2021 годы. Результаты показывают, что экономический рост в Казахстане сопровождается увеличением образования отходов, увеличением выбросов в окружающую среду, в частности выбросов жидких и газообразных загрязняющих веществ. Это согласуется с предыдущими исследованиями, которые также не выявили явления декаплинг по выбросам загрязняющих веществ. Однако выявлены абсолютный декаплинг по ресурсам пресной воды, а также тенденция к абсолютному декаплингу по потреблению энергоресурсов. Эти выводы могут быть использованы для определения текущего состояния и тенденций декаплинга в Казахстане с целью мониторинга эффективности применения принципов ответственного производства и достижения целей устойчивого развития.

Ключевые слова: декаплинг, экономический рост, потребление ресурсов, воздействие на окружающую среду, ответственное производство.

Introduction

Human well-being and its improvement, now and for a still growing world population in the future, is based upon the availability of natural resources such as energy, materials, water and land. Economic development so far has been associated with a rapid rise in the use of these resources (Wu et al., 2021). However, the reserves of natural resources on our planet are not inexhaustible. Many of them are becoming less abundant relative to demand, and some run the risk of critical scarcity in the near future. Moreover, undesirable environmental impacts can arise from any part of the life cycle of resources: in the phases of extraction, production/manufacture, consumption/use or postconsumption. These impacts may be caused by deliberate interventions into natural systems such as land cover change and resource extraction, or by unintended side effects of economic activities, such as emissions and wastes (UNEP, 2011).

In the context of limited natural resources and the growing environmental burden with the simultaneous need to ensure economic growth as well as implementation of responsible production principles, the concept of decoupling becomes relevant. A focus on decoupling requires attention both to the amount of resource use linked with economic activity, and to the environmental impacts associated with this resource use at all stages of the life cycle (UNEP, 2011: 21). The concept of decoupling is intended to answer the question of how to produce a sustainable economic growth while diminishing the use of resources and simultaneously creating positive environmental impacts (Scheel et al., 2020).

Decoupling economic growth from resource extraction and consumption has encouraged research interest among scholars and authorities around the world since, among other things, the call from the United Nations Environment Program (UNEP)'s International Resource Panel to decouple human well-being from resource consumption. Decoupling, itself, has become a nascent research field with its own decoupling theory and numerous and increasing research papers on the subject (Giampietro, 2019).

As for Kazakhstan the concept of decoupling economic growth from natural resources consumption and negative environmental impact is also undoubtedly important. The Concept for the transition of the Republic of Kazakhstan to a green economy defines such priorities as reducing the energy intensity of GDP, increasing the efficiency of using water resources, and mitigating pressure on the environment. However, despite the relevance of the concept of decoupling, in Kazakhstan there is a lack of comprehensive studies on assessment and analysis of the state and trends of decoupling economic growth from natural resources consumption and environmental pressure.

This paper aims to analyze the current decoupling state of kazakhstani economy from natural resources consumption and on environmental impact as well as decoupling trends over a certain period.

Literature review

The concept of decoupling is gaining increasing scientific interest due to its close connection with the concept of responsible production and resource efficiency. Searching in the Scopus database for the keyword "Decoupling" and then limiting it to such fields of knowledge as "Business", "Management and Accounting", "Economics", "Econometrics and Finance" and such keywords as "Decoupling", "Economic Growth" allowed to generate 433 publications on this topic, which indicates the relevance of the decoupling concept in the scientific community.

Zhang & Xiang (2000) first proposed the concept of decoupling in 2000. Then the OECD formally defined it becoming the first international organization to adopt the concept of resource decoupling, considering it as one of the main goals in its policy document "Environmental Strategy for the First Decade of the 21st Century". The OECD defines decoupling as breaking the link between "environmental harm" and "economic benefits" (OECD, 2002). Since then, the concept of decoupling has been globally recognized as an important concept for sustainable development (Chen et al., 2017).

International Resource Panel of the United Nations Environment Programme defines decoupling as a situation when resource use or some environmental pressure either grows at a slower rate than the economic activity that is causing it (relative decoupling) or declines while the economic activity continues to grow (absolute decoupling) (IRP, 2017).

Thus, international organizations when saying about the concept of "decoupling" refer to the end of the correlation between increased economic production and decreased environmental quality as well as expanded resourse use (Vaden et al., 2020).

A number of authors understand resource efficiency as decoupling. Kowalski defines decoupling as the use of fewer resources per unit of output and the reduction of the harmful environmental impact of the resources used or the economic activity undertaken (UNEP, 2011: 15). Liobikiene et al. (2020), Vaden et al. (2020) understand decoupling as a measure of resource efficiency.

Traditionally, there is a distinction between resource decoupling and impact decoupling. Figure 1 captures the essence of the two key aspects of decoupling as applied to sustainable development, namely resource decoupling and impact decoupling (UNEP, 2011: 15).

Figure 1 shows an increasing trend of human well-being and GDP as a result of pursuing SDGs. Also, according to Fig.1 relative resource decoupling takes place when increase in resource usage lags behind that of economic activity. In its turn, decrease in environmental impact while economy keeps growing means absolute impact decoupling (IRP, 2017: 22).

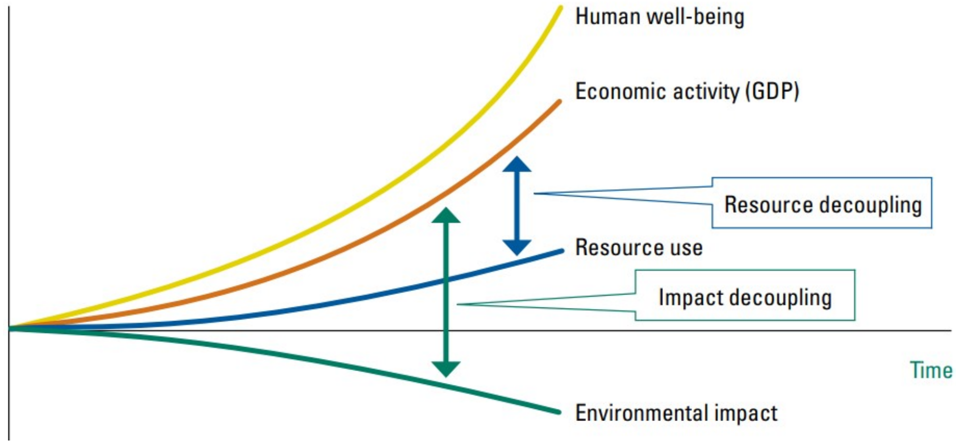

Figure 1 – Two aspects of decoupling
Note: UNEP, 2011

Plenty of scientific works are devoted to issues of assessing decoupling state as well as degree of decoupling in the context of countries, regions. Some scholars have evaluated impact decoupling using the ecological footprint (EF) indicator (Szigeti et al., 2017, Wu et al., 2021, Yang & Yang, 2019). Wu et al. (2021) proposed local ecological footprint (EF) accounts, including production-based biological accounts and consumption-based energy and build-up land accounts to measure the pressure on local natural capital. Decoupling effects of natural capital utilization were evaluated in 30 provinces of China during 2000-2016 using a modified three-dimensional EF model, sustainability reclassification method and decoupling index. Szigeti et al., (2017) through the relationship of the ecological footprint and GDP, examined the tendencies of eco-efficiency in the first decade of the 21st century. The relationship between GDP and EF were examined using scatter plot charts. The authors concluded that the average ecological footprint intensity of countries have improved significantly in the analyzed period. Yang & Yang (2019) evaluated the annual eco-efficiency of China based on the modified EF model from the perspectives of biological needs, resource consumption, and environmental pollution. Also in the above-mentioned article the decoupling status between resources consumption, pollution emissions and economic growth was explored.

Another context of measuring impact decoupling is analysis of pollutant emisssions. Xia et al., (2020) developed a decoupling model to analyze the effectiveness of the decoupling efforts related to air pollutants at city level. According to results eleven cities in Zhejiang Province have made significant decoupling efforts on the emission of three kinds of air pollutants, but there were found some differences in the trend of the decoupling effort index of different pollution sources in different cities. Zhang&Wang (2013) examined the occurrence of a decoupling between the growth rates in economic activity and energy consumption related CO2 emission in Jiangsu from 1995 to 2009. The study revealed that along with the rapid economic development, Jiangsu’s energy-related CO2 emission has grown rapidly.

Resource decoupling was measured by comparing resources usage namely energy, water resources with economic activity in the traditional dimension, namely GDP.

Decoupling relationship between energy consumption and economic growth was analyzed in studies of Wei et al. (2020), Dong et al. (2016), Kan et al. (2019). For instance, Dong et al. (2016) explored the decoupling status between energy consumption and economic growth in Liaoning Province. The combination of Tapio decoupling indicator and generalized LMDI (The Logarithmic Mean Divisia Index) method was utilized to study the decoupling status in Liaoning Province and reasons for it. Wei et al. (2020) calculated the decoupling index and decoupling states of energy consumption and economic growth in China’s provinces. The decoupling relationship between different energy sources namely coal, oil, natural gas and economic growth was defined. Kan et al. (2019) evaluate decoupling states of GDP from all types of primary energy use under consumption-based principle for world economy and eight typical economies during 2000–2011. As for each energy source authors defined decoupling of world economy from oil, but coupling with coal, natural gas and renewables.

Decoupling state related to water resources was explored in work of Zhang et al. (2021) who showed relative decoupling between water resources utilization and economic development in China in period 1997-2017. Authors have revealed a gradual decrease in the dependence of economic development on water resources while maintaining a serious water shortage, which indicates insufficient water use. Wang&Wang (2020) use the Tapio decoupling and LMDI decomposition methods to evaluate the decoupling performance between China's water consumption and economic growth at the national and provincial levels. Besides authors defined driving factors for decoupling occurrence.

Waste generation decoupling is another scientific area, which causes most scholars' attention. The reason for it is huge waste amounts associated with endless economic growth. Wang et al. (2021) use the Tapio elastic decoupling analysis method and an empirical model of the environmental Kuznets curve (EKC) to analyze the decoupling between municipal solid waste (MSW) generation and economic development in 285 of China's cities from 2002 to 2017. The decoupling analysis results show that the decoupling states in China's cities generally improved first and then deteriorated in 2002–2017. Cities with a higher economic development level generally had more serious deterioration states.

Decoupling issues in Kazakhstan were considered by Sansyzbayeva et al. (2020), Junissov et al. (2021), Xiong et al. (2015), Jiaxiu et al. (2019), Nguyen (2019). Using data for 2005-2018, Sansyzbayeva et al. (2020) determined the effect of decoupling by calculating the pair correlation coefficient between the gross regional product and 2 types of environmental pollution, namely emissions of solid pollutants and emissions of liquid and gaseous pollutants into the atmosphere. In 9 regions of the country, the effect of decoupling was not observed. Junissov et al. (2021) focuse on the decoupling between economic growth and energy consumption in each of five Central Asian countries – Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan – from 1990 to 2014. The Tapio decoupling model was implemented in order to determine the decoupling states for each country. According to results, in the period from 2001 to 2014 Kazakhstan's economy started to experience an expansive negative decoupling with some periods of strong decoupling. Xiong et al. (2015) applied an approximate relationship analysis, a decoupling relationship analysis, and a trend analysis to explore the relationship between energy consumption and economic growth using data from Kazakhstan for the period of 1993–2010. Results showed that in Kazakhstan the dependence of economic growth on energy exports gradually increased from 1993 to 2010. In the study of Jiaxiu et al. (2019) decoupling elasticity and decoupling index were employed to explore the relationship between economic growth and CO2 emissions in Kazakhstan and other Central Asian countries during 1992–2014. As for Kazakhstan, authors revealed dependence of economic development on high-carbon energies. Nguyen (2019) explored the relationship between economic growth, energy consumption and CO2 emissions of five Central Asian countries including Kazakhstan between 1998 and 2017. Results reflected that the economic growth in Kazakhstan was heavily dependent upon energy consumption.

The issues of the efficiency of the use of natural resources, in particular land, are considered by Yerseitova et al. (2018) who evaluates the use efficiency of agricultural land in the Republic of Kazakhstan in 2012-2016. Results showed that most agricultural land use metrics tended to have a positive dynamic. However, there was an insufficient land use performance compared to Russia, Belarus and Ukraine.

Thus, the literature review revealed a limited number of research papers on the comprehensive analysis and assessment of decoupling state of Kazakhstan's economy regarding both resource and impact decoupling. The available research on Kazakhstan is devoted only to decoupling of energy resources and CO2 emissions. However, there is an absence of studies combining the analysis and assessment of decoupling both on key natural resources as well as on waste generation and emissions into the environment.

Methodology and data

For the research purposes, statistical analysis with decoupling index calculation as well as regression analysis was applied. Decoupling index analysis is a traditional method of assessing the decoupling state of the economy. Statistical and regression analysis, due to their simplicity and clarity, can complement and refine the results of decoupling analysis.

The study was carried out in 2 stages:

- Stage 1: statistical analysis of the resource decoupling in Kazakhstan from key natural resources (water, energy) as well as impact decoupling from such indicators as ecological footprint, waste generation and emissions;

- Stage 2: hypothesis testing based on data regression analysis.

Statistical analysis includes decoupling index calculation based on the following formula 1:

$$DI_t = \frac{\Delta P_t}{\Delta Y_t} \quad (1)$$

where: DI_t – decoupling index in year t;

ΔP_t – change in the rate of resources consumption or pollutant emission between year t and year t-1;

ΔY_t – change in the rate of economic growth;

Thus, decoupling index (DI) refers to the ratio of (1) change in the rate of consumption of a given resource, or in the rate of production of a given pollutant emission; to (2) change in the rate of economic growth (GDP) within a certain time period (typically one year).

Decoupling Index Interpretation

The Decoupling Index (DI) may imply one of three scenarios as follows:

1. When DI>1, it means the increasing rate of resource consumption or pollutant emissions keeps pace with or is higher than economic growth. In this case, no decoupling is taking place. In other words, as the economy grows, resource consumption and environmental degradation increase rapidly.

2. When 0<DI<1, it means the rate of growth in resource consumption or pollutant emissions falls short of that of economic growth. In this case, relative decoupling is taking place.

3. When DI=0, it means the economy is growing while resource consumption remains constant. In other words, when the economy grows continuously, the amount of pollutants does not increase.

4. When DI<0, it means resource consumption or pollutant emissions/discharge decreases while the economy keeps growing. Here absolute decoupling takes place (UNEP, 2011: 111).

There are 2 hypothesis, which are going to be tested:

1) economic growth in Kazakhstan is accompanied by an increase in the consumption of energy and water resources;

2) economic growth in Kazakhstan is accompanied by an increase in waste generation, an increase in emissions into the environment and an increase in the environmental burden in the form of ecological footprint.

All data for statistical and regression analysis were collected from the official website of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan. The data are annual, the period from 2010 to 2021 was chosen. For the regression analysis model (2) the dependent variable chosen was GDP. The indicators presented in Table 1 were selected as independent variables.

$$Y = B_1 + B_2 \cdot X_1 + B_3 \cdot X_2 + \dots + u, \quad (2)$$

where: Y – the endogenous variable;

Xj – explanatory variables;

Bj – coefficients;

B_1 – fixed effects;

u – constant.

Table 1 – Dependent and independent regression variables

Notation	Variable
Y	dependent variable, gross domestic product
X1	The total amount of used fresh water
X2	Total primary fuel and energy consumption
X3	Emissions of liquid and gaseous pollutants
X4	Air pollutant emissions from stationary sources
X5	Waste generation
X6	Ecological footprint per person
Note: Compiled by the authors based on own research	

The dependent variable was gross domestic product. Waste generation includes the generation of production and consumption waste. According to Global Footprint network, ecological footprint per person is a measure of how much area of biologically productive land and water an individual, population, or activity requires to produce all the resources it consumes and to absorb the waste it generates, using prevailing technology and resource management practices. Table 2 presents descriptive statistics.

Table 2 – Descriptive statistics

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Y	12	21815517	83951588	48744628	19361683
X1	12	19999	22611	20912,98	756,6532
X2	11	54772	81500	69448,36	7483,714
X3	12	1587	1975	1813,833	118,2815
X4	12	124,26	142	132,67	5,53125
X5	6	320946,3	777764,9	487173,5	156365,4
X6	12	3,7	6,8	4,6167	0,85369
Note: Compiled by the authors based on own research					

Results and discussion

Analysis of decoupling economic growth from the consumption of key natural resources

Figure 2 shows the dynamics of decoupling GDP from the total amount of used freshwater in Kazakhstan from 2010 to 2021. According to the results, there is a constant GDP growth while freshwater consumption has a relative downward trend. This may indicate a situation of absolute decoupling, in which economic growth is accompanied by a reduction in water consumption. However, from the figure below it can be seen that freshwater consumption is characterized by somewhat unstable dynamics: from 2010 to 2012, there was a decrease in the amount of used freshwater from 22.6 billion cubic meters to 20.3 billion cubic meters. In 2013, there was a noticeable increase in freshwater consumption up to 21.8 billion cubic meters. Then, until 2016, there was a downward trend in freshwater consumption, followed by a period of growth and then a decline in freshwater consumption. Such unstable dynamics of freshwater use do not allow to make an unambiguous conclusion about the absolute decoupling of economic growth from freshwater consumption. It is necessary to consider the dynamics of the volume of available freshwater.

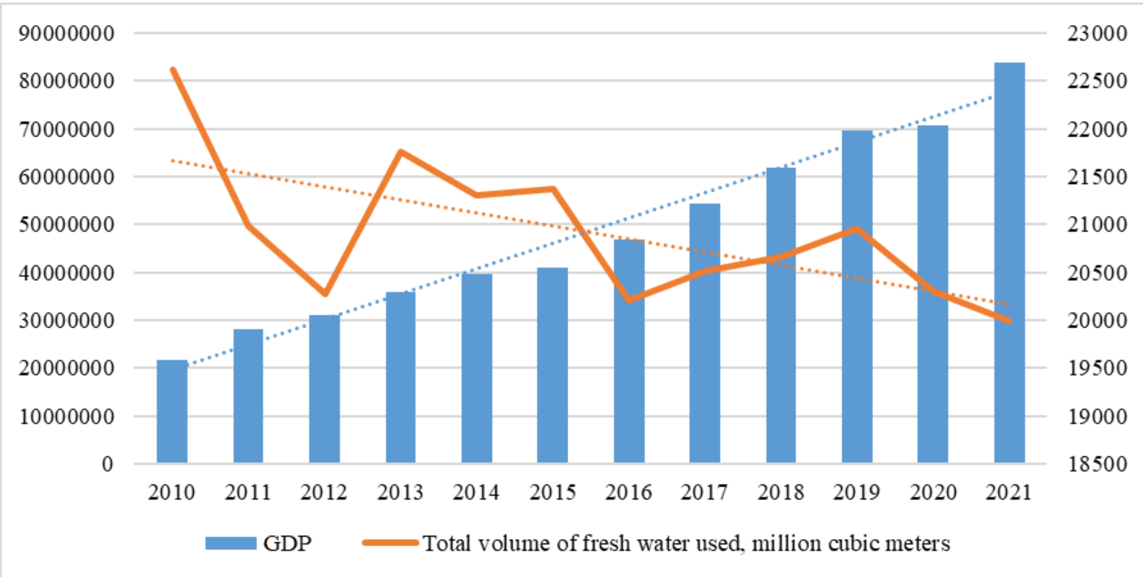

Figure 2 – Dynamics of decoupling GDP from used freshwater
Note: Compiled by the authors based on the data of the Bureau of National Statistics in the Republic of Kazakhstan

Figure 3 shows the dynamics of the available volume of freshwater. According to Figure 3 in the period from 2010 to 2012, when there was a decrease in the use of freshwater, the available volume of freshwater also decreased. It may indicate that during this period the reduction in water use could not have occurred through the application of responsible production principles and water-saving technologies, but because of the lesser availability of freshwater. From 2012 to 2014, the volume of available freshwater increased along with the increase in water use. However, in 2014, the use of freshwater slightly decreased, which, with a simultaneous increase in the available volume of water, may indicate signs of decoupling. From 2014 to 2016, the available volume of freshwater decreased again from 24,360 million cubic meters to 22,730 million cubic meters, which was accompanied by a decrease in the volume of water used. The next period on the graphs from 2016 to 2019 is also characterized by the coincidence of the growth in the available volume of freshwater and, although less intensive, still the growth in water consumption. In 2020 there was a remarkable increase in the amount of available freshwater with a simultaneous decrease in its use. In 2021, again, there is a coincidence of a decrease in the amount of available and used freshwater.

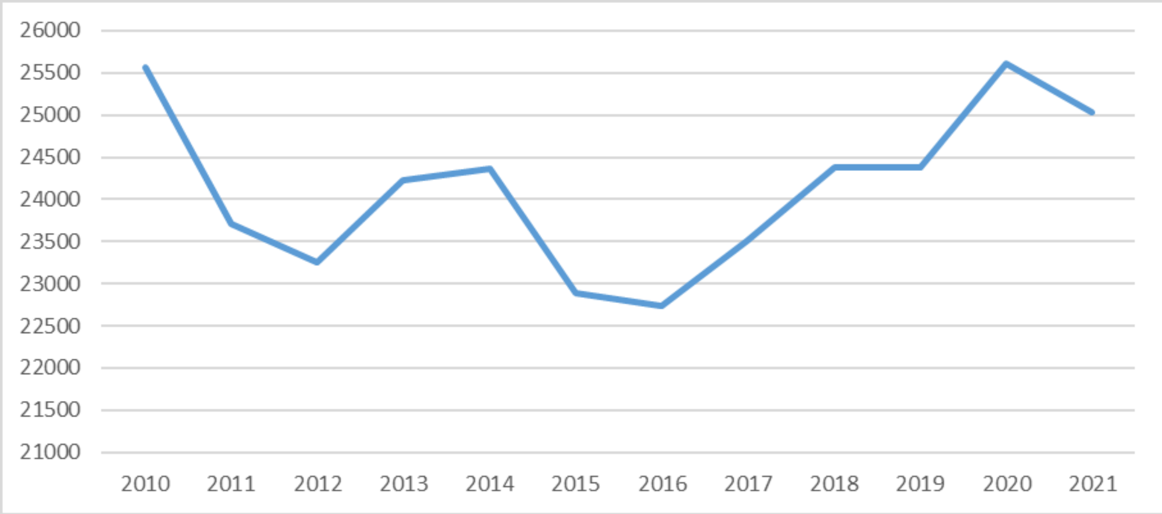

Figure 3 – Dynamics of total available volume fresh water
Note: Compiled by the authors based on the data of the Bureau of National Statistics in the Republic of Kazakhstan

Decoupling index dynamics from freshwater consumption from 2011 to 2021 is shown in Figure 4. The downward trend of the decoupling index indicates a trend towards absolute decoupling, in which freshwater consumption decreases while the economy keeps growing. The most favorable situation according to the figure took place in 2020, when the decoupling index was equal to -1.9. Thus, the dynamics of the decoupling index for 2011-2021 as a whole reflects the situation of absolute decoupling in Kazakhstan, in which economic growth is separated from water resources consumption.

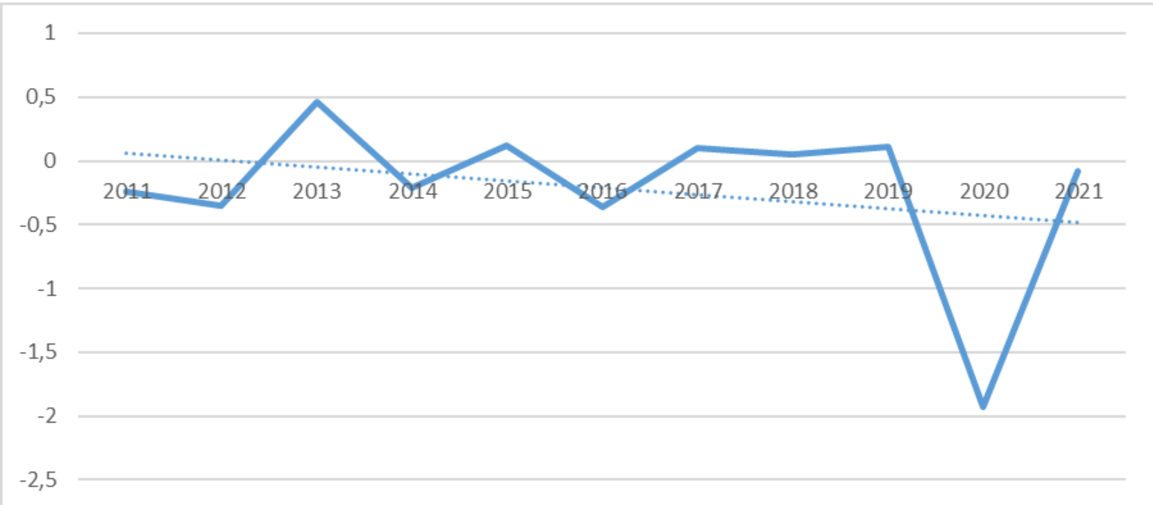

Figure 4 – Dynamics of decoupling index of GDP from used fresh water
Note: Compiled by the authors based on the data of the Bureau of National Statistics in the Republic of Kazakhstan

Figure 5 reflects the decoupling state of economic growth from energy consumption. Energy usage is characterized by unstable dynamics, generally characterized by a barely noticeable decline against the backdrop of stable GDP growth. A noticeable decrease in energy consumption occurred between 2013 and 2015 with a relatively small increase in GDP. A pronounced growth of the economy took place from 2016 to 2019, which was accompanied, although not so pronounced, still by an increase in energy consumption.

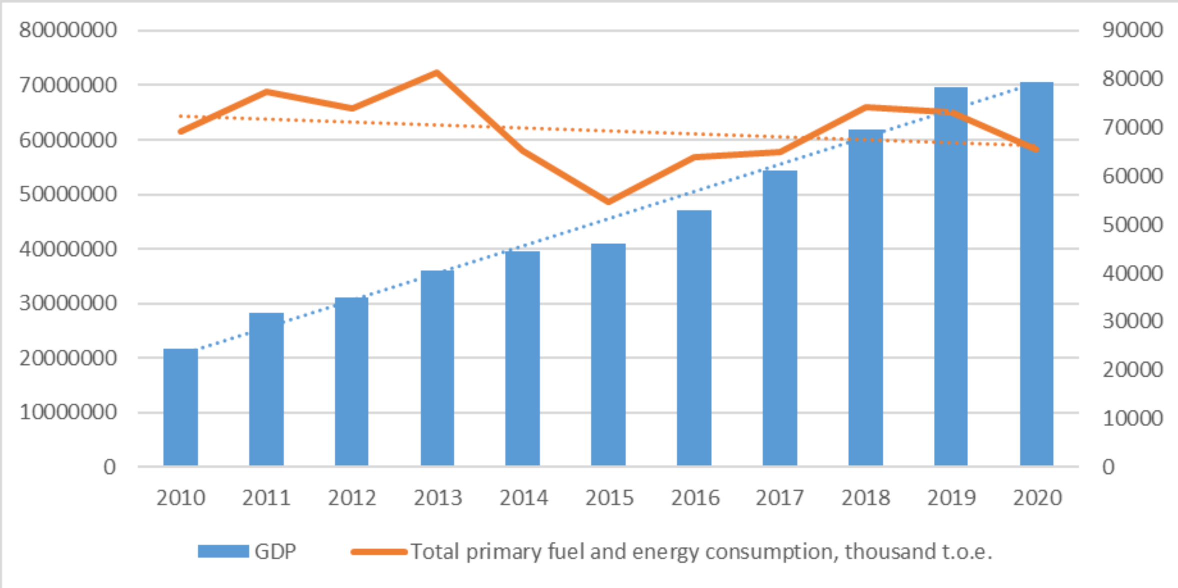

Figure 5 – Dynamics of decoupling GDP from total primary fuel and energy consumption
Note: Compiled by the authors based on the data of the Bureau of National Statistics in the Republic of Kazakhstan

The dynamics of the decoupling index for energy resources are shown in Figure 6 and are characterized by a downward trend, which reflects the intention to separate economic growth from energy consumption. However, there is instability in the dynamics, the values of the decoupling index vary from – 6 to +1. In 2015 and 2020, the decoupling index values reached the minimum values of -5 and -6.4 respectively, which indicates the achievement of absolute decoupling in these years. This is quite consistent with the figure above, which shows that in 2015 and 2020, economic growth was accompanied by a decrease in energy consumption. In general, given the unstable dynamics of energy consumption and the downward trend in the dynamics of the decoupling index, it can be concluded that there is a trend toward absolute decoupling in energy consumption.

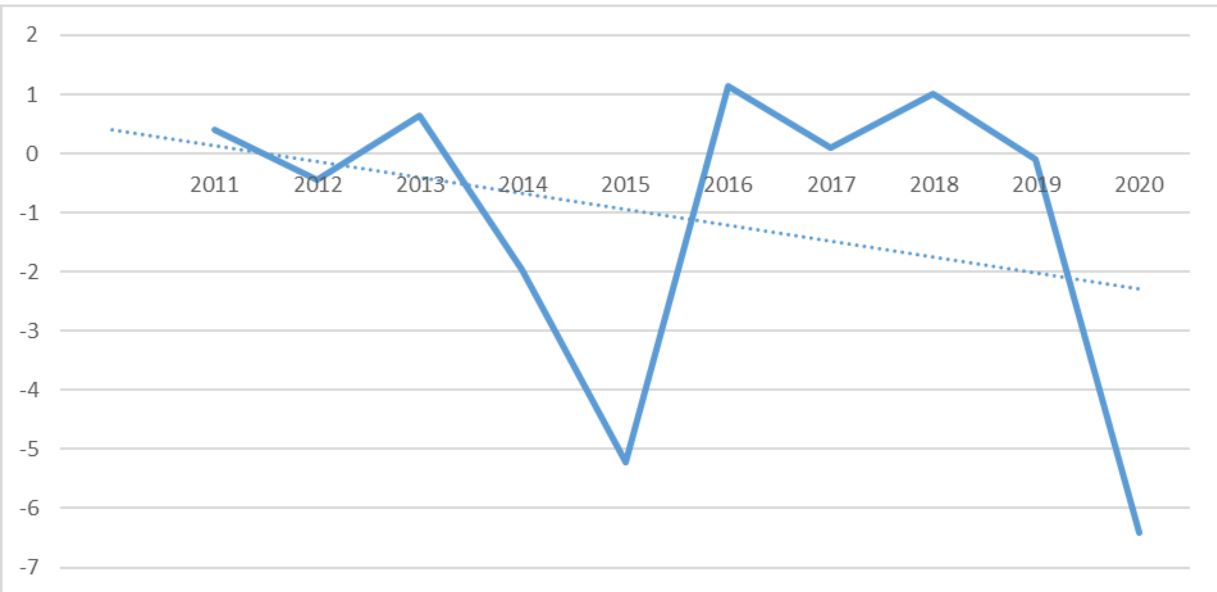

Figure 6 – Dynamics of decoupling index of GDP from primary fuel and energy consumption
Note: Compiled by the authors based on the data of the Bureau of National Statistics in the Republic of Kazakhstan

Analysis of decoupling economic growth from environmental impact

Figure 7 shows the decoupling state of economic growth from waste generation. Based on the data displayed in the graph, one can observe a joint growth trend in both GDP and waste generation from 2016 to 2021. However, it is worth noting a slight decline in waste generation from 2019 to 2020.

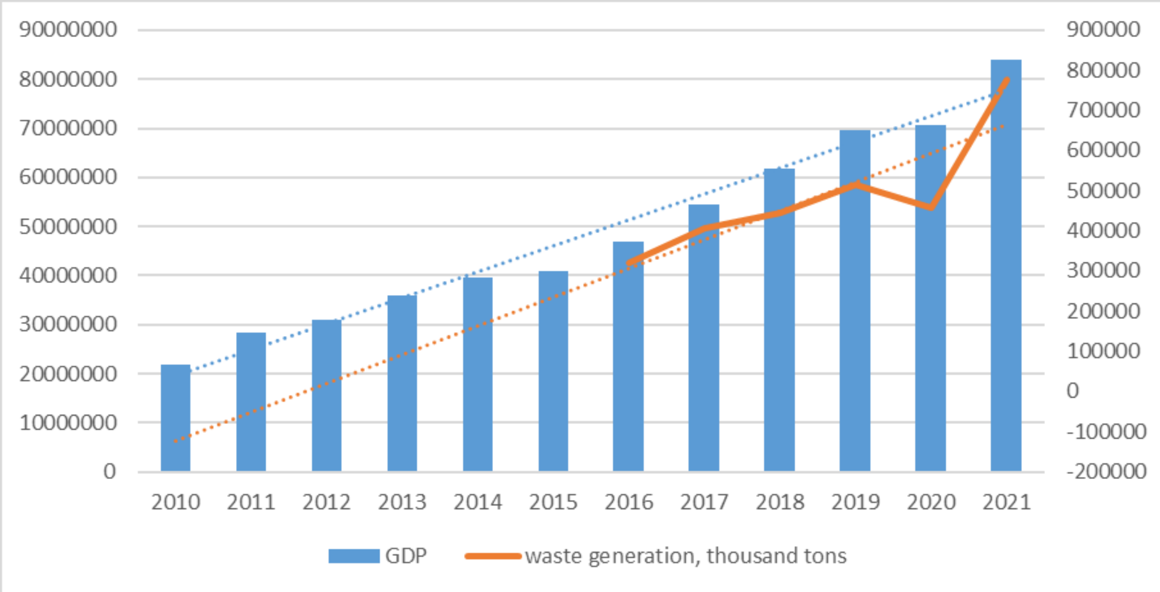

Figure 7 – Dynamics of decoupling GDP from waste generation

Note: Compiled by the authors based on the data of the Bureau of National Statistics in the Republic of Kazakhstan

Figure 8 shows the dynamics of the decoupling index of GDP from waste generation. If we analyze the decoupling index trend from waste generation, we can observe a barely noticeable downward trend which may reflect the aspiration of economic growth toward decoupling from waste generation. It should be noted that data on waste generation in official statistical materials are indicated starting from 2016 and onward. As can be seen in Figure 8, there is a stable trend from 2017 to 2019 between 0<DI<1, which is relative DI, after which there is a sharp decline to a value of -7 on the scale, reflecting transformation into an absolute decoupling index. This can be attributed to a decrease in waste generation in the respective years. Next, there is an increase in the decoupling index, along with GDP growth and waste generation starting from the year 2021. In general, most of the index values are in the range of about 1 and above which reflects the absence of decoupling.

Figure 9 represents the dynamics of ecological footprint per person, and it can be seen that until 2014 there were unstable dynamics. In 2010, the figure was 4.7 hectares per person, then increased to almost 7 hectares in 2011. In 2012, ecofootprint per capita fell to 4.9 hectares, increasing again in 2013 to 5.7 hectares. Starting from 2014 and up to 2021, the ecofootprint indicator has stabilized at around 4 hectares. In general, the ecofootprint dynamics for the period from 2010 to 2021 have a weakly pronounced downward trend. Given the more confident growth of the economy, such a ratio of GDP and ecofootprint dynamics may indicate a situation of absolute decoupling. However, for a more complete picture, it is necessary to consider the dynamics of the ecofootprint decoupling index.

Figure 10 shows the dynamics of the decoupling index for ecofootprint for the period from 2011 to 2021. The index trend has a weakly pronounced upward character, which indicates a trend of transition from decoupling to coupling. The period from 2014 to 2019 is characterized by relative stability in the dynamics of the decoupling index. In 2014 and 2015, the negative values of the index (-2.2 and -1.5 respectively) were replaced by positive values in 2016 and 2017 (0 and 0.3 respectively), thus characterizing the transition from the state of absolute decoupling to relative decoupling. In 2018 and 2019, the index again returns to negative values, that is, absolute decoupling again takes place. From 2011 to 2014, the index is characterized by sharp fluctuations: values greater than 1 are replaced by negative values and vice versa, characterizing drastic transitions from no decoupling to absolute decoupling. The sharp increase in the decoupling index in 2020 to a value of 6.7 may be because, against the backdrop of a slowdown in economic growth, there was a more noticeable growth rate of the ecofootprint. Thus, even though the ecofootprint decoupling state as a whole has a weakly pronounced uptrend, however, most of the index values are in the negative range, which indicates the predominance of absolute decoupling.

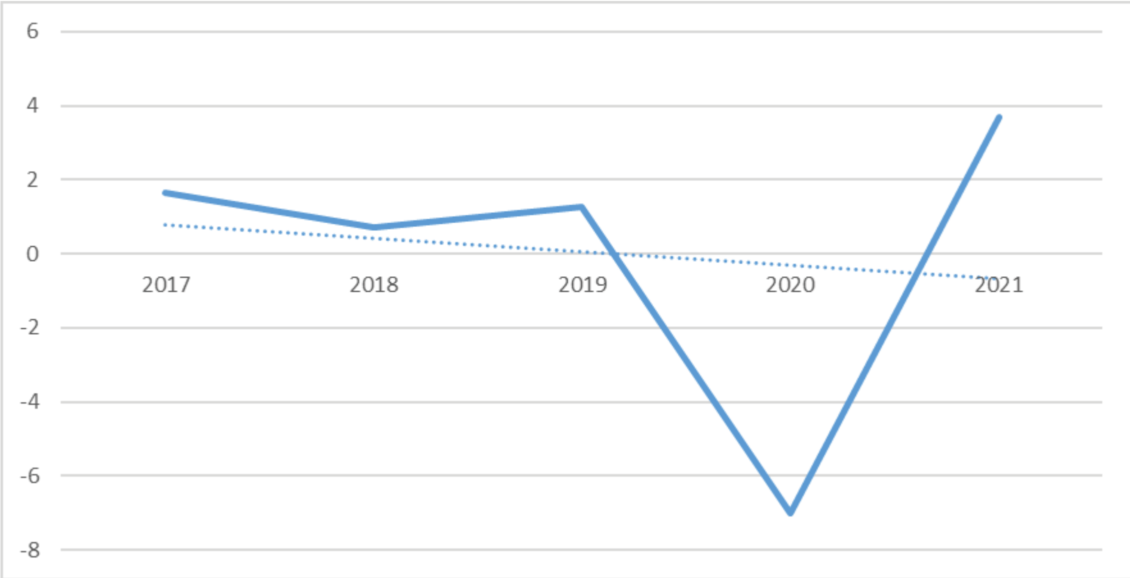

Figure 8 – Dynamics of decoupling index of GDP from waste generation
Note: Compiled by the authors based on the data of the Bureau of National Statistics in the Republic of Kazakhstan

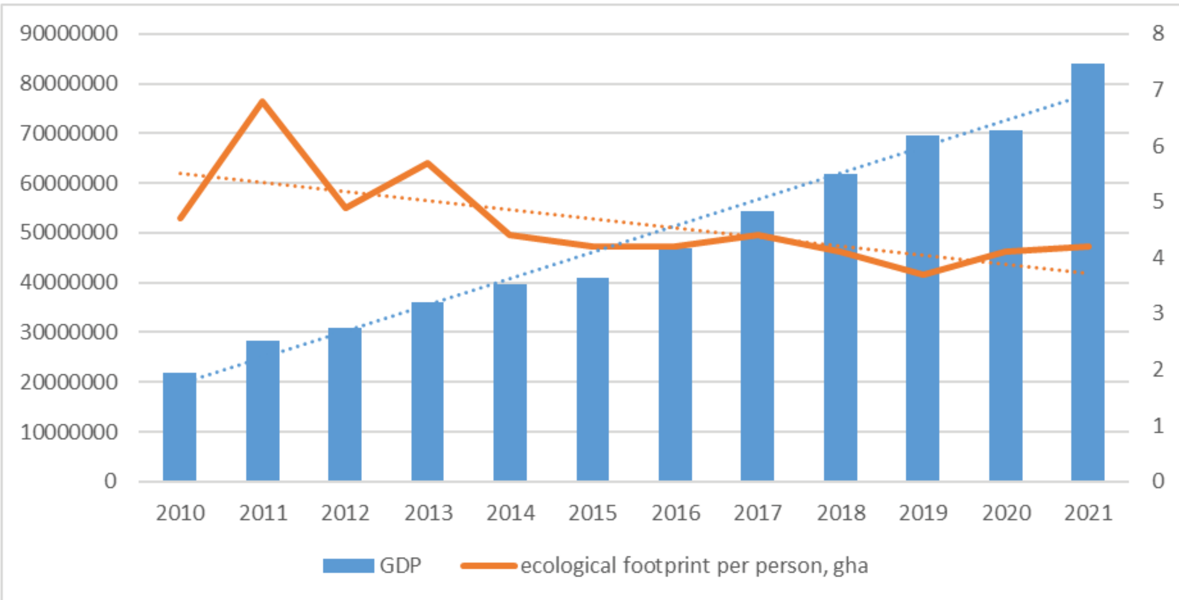

Figure 9 – Dynamics of decoupling GDP from ecological footprint per person
Note: Compiled by the authors based on the data of the Bureau of National Statistics in the Republic of Kazakhstan

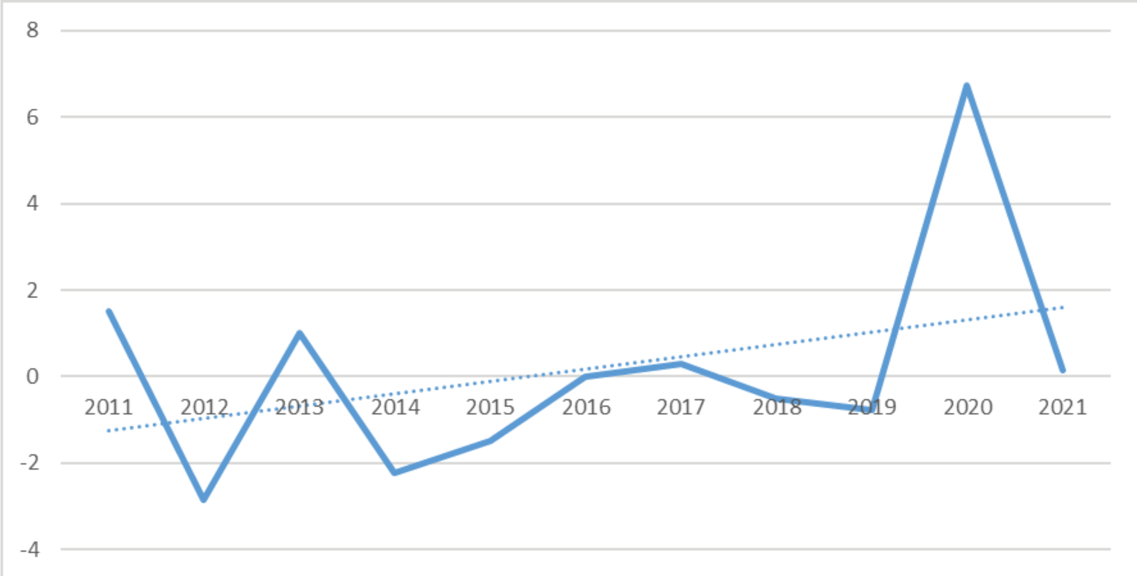

Figure 10 – Dynamics of the decoupling index of GDP from ecological footprint
Note: Compiled by the authors based on the data of the Bureau of National Statistics in the Republic of Kazakhstan

Figure 11 reflects the decoupling state of economic growth from emissions of liquid and gaseous pollutants. A barely noticeable uptrend of emissions is visible from the chart. Growth rates of emissions lag far behind those of economic growth indicating a relative decoupling situation.

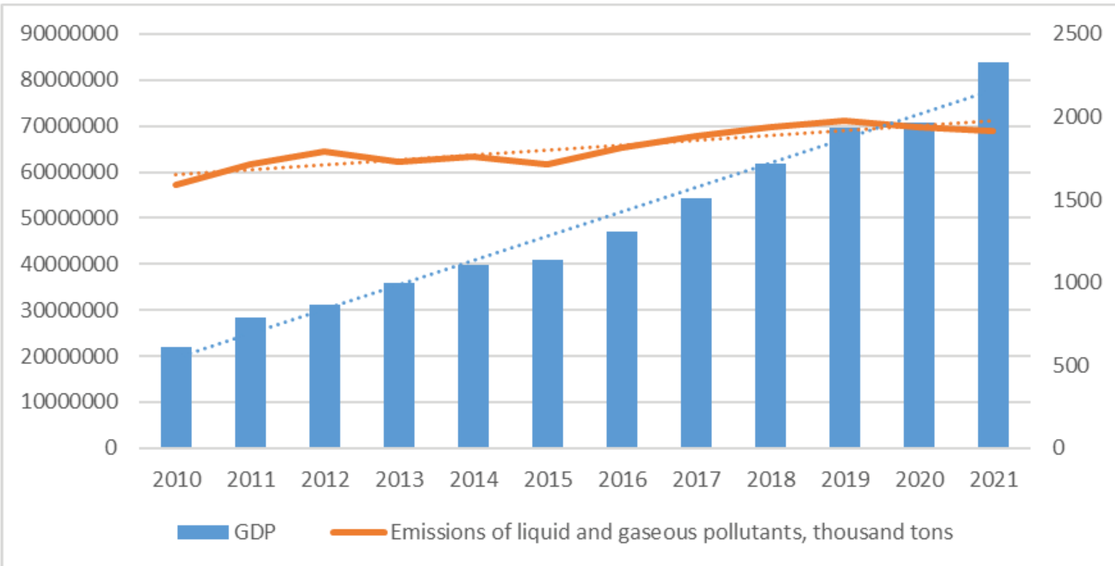

Figure 11 – Dynamics of decoupling GDP from emissions of liquid and gaseous pollutants
Note: Compiled by the authors based on the data of the Bureau of National Statistics in the Republic of Kazakhstan

Figure 12 shows the decoupling index trend from liquid and gaseous pollutants. The DI index range (0 < DI < 1) observed during the periods from 2011 to 2012 and from 2016 to 2019 indicates relative decoupling. This means that while the economy was growing, pollutant emissions were increasing at a slower rate. In contrast, during 2015 and 2020, there was an absolute decoupling, where economic growth was accompanied by a reduction in environmental pollution. In general, most of the index values are in the range from 0 to 1 indicating that there is a predominance of relative decoupling from liquid and gaseous pollutants.

Thus, the analysis of the decoupling state dynamics showed that for water resources there is an absolute decoupling of economic growth from water consumption, and for energy resources, there is a tendency to absolute decoupling.

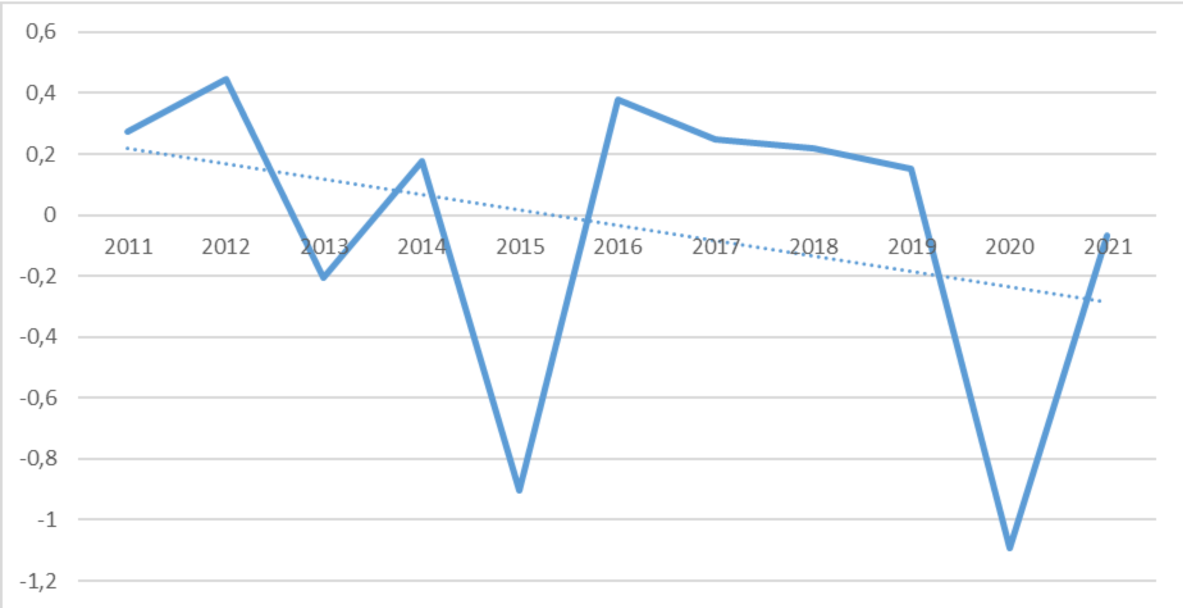

Figure 12 – Dynamics of decoupling index of GDP from emissions of liquid and gaseous pollutants
Note: Compiled by the authors based on the data of the Bureau of National Statistics in the Republic of Kazakhstan

As for impact decoupling, the analysis showed that economic growth in Kazakhstan is accompanied by an increase in waste generation, but the growth rates of the latter lag behind the pace of economic growth. There is also relative decoupling from liquid and gaseous pollutants.

Decoupling analysis of ecological footprint showed the predominance of absolute decoupling, in which economic growth is accompanied by a decrease in ecofootprint.

Regression analysis

For the purpose of regression analysis, four models were built with the dependent variable of GDP. The objective of regression analysis is to identify the degree of dependence of economic growth in Kazakhstan on resource consumption and environmental pressure. All variables were previously tested for multicollinearity. Within the framework of one model, there are used only variables with no close correlation between them. For the purposes of regression analysis, natural logarithms of values were taken. Regression analysis was conducted using the SPSS25 statistical software package. The correlations of independent and dependent variables are shown in Table 3.

The specifications of four models are shown in the Table 4.

From 4 specifications 3 are statistically significant according to the Fisher test. Moreover, all models containing environmental load factors, namely, emissions into the atmosphere, waste generation, and ecological footprint per person, are statistically significant. This suggests that economic growth in Kazakhstan is closely linked to environmental degradation. Within the framework of the second model, which includes such predictors as emissions of liquid and gaseous pollutants, and air pollutant emissions from stationary sources, all coefficients for independent variables are statistically significant. Moreover, emissions of liquid and gaseous pollutants are significant at the level of 1% and are closely and positively correlated with GDP. Thus, the hypothesis that economic growth in Kazakhstan is accompanied by an increase in emissions into the environment, particularly emissions of liquid and gaseous pollutants, is confirmed. In other words, economic growth is coupled with emissions of liquid and gaseous pollutants.

Table 3 – Correlations

	Y	X1	X2	X3	X4	X5	X6
Y	1	-0,596	-0,184	0,925	-0,532	0,942	-0,671
X1	-0,596	1	0,092				
X2	-0,184	0,092	1				
X3	0,925			1			
X4	-0,532			-0,212	1		
X5	0,942					1	
X6	-0,671						1
Note: Compiled by the authors based on own research							

Table 4 – Results of the regression analysis, dependent variable – GDP

Independent variable	Specification			
	1	2	3	4
The total amount of used fresh water	-6,255* (3,016)			
Total primary fuel and energy consumption	-0,446 (0,962)			
Emissions of liquid and gaseous pollutants		5,333*** (0,35)		
Air pollutant emissions from stationary sources		-3,345*** (0,531)		
Waste generation			0,664*** (0,118)	
Ecological footprint per person				-1,662** (0,581)
Constant	84,801** (30,931)	-6,034 (4,062)	9,293*** (1,543)	20,151 (0,886)
Number of observations	11	12	6	12
R2	0,372	0,973	0,888	0,45
Fisher test	F=2,367 [0,156]	F=164,021 [0,000]	F=31,602 [0,005]	F=8,191 [0,017]
Compiled by the authors based on own research				

Air pollutant emissions from stationary sources are less closely related to GDP, since correlation equals -0.532. A negative correlation value suggests a decoupling between economic growth and air pollutant emissions from stationary sources. Therefore, hypothesis number two is not confirmed in terms of air pollutant emissions from stationary sources.

The third model, which includes the independent variable "waste generation", is also statistically significant according to the Fisher test, the coefficient for waste generation is significant at the 1% level. A close positive correlation (0.942) was found between waste generation and GDP. These results suggest that as the economy grows, so does waste generation. Therefore, there is no decoupling between economic growth and waste generation, but conversely, there is coupling. The hypothesis that economic growth in Kazakhstan is accompanied by an increase in waste generation has been confirmed.

As for the fourth model with the ecological footprint independent variable, it is statistically significant, the ecological footprint coefficient is significant at the 5% level, and the correlation between the ecological footprint and GDP is noticeable and equals -0.671. The negative coefficient for ecological footprint, as well as the negative correlation coefficient between ecofootprint and GDP, indicate that economic growth in Kazakhstan is accompanied by a slight decrease in the ecofootprint indicator. This situation allows to assume the predominant presence of absolute decoupling regarding ecological footprint. Therefore, the hypothesis that economic growth in Kazakhstan is accompanied by an increase in the environmental burden in the form of an ecological footprint is rejected.

The first model with such predictors as the total amount of used fresh water and total primary fuel and energy consumption was statistically insignificant according to the Fisher test. The correlation between the total amount of freshwater used and GDP is moderately negative, which may indicate a decoupling between economic growth and water consumption. Therefore, the hypothesis that economic growth in Kazakhstan is accompanied by an increase in the consumption of water resources is refuted. The correlation between GDP and total primary fuel and energy consumption is weak and negative, and the coefficient on energy consumption is also negative. Therefore, the hypothesis that economic growth in Kazakhstan is accompanied by an increase in the consumption of energy resources is also refuted. It is worth noting that the regression analysis results are in line with statistical and decoupling analysis results which were conducted earlier within the current research.

Conclusion

Decoupling economic growth from natural resource consumption and environmental pressure is extremely important for Kazakhstan as well as for all economies all over the world. This paper attempted to analyze and assess current resource and impact decoupling state and trends in Kazakhstan. Resource decoupling was analyzed regarding water and energy resources and waste generation, ecological footprint per person, and pollutants emissions combined an impact decoupling analysis.

Resource decoupling analysis showed a presence of absolute decoupling from freshwater resources while dynamics of available freshwater volume were unstable. As for energy resources, there is a tendency for absolute decoupling of economic growth from energy resource consumption. Thus, the first hypothesis regarding accompanying economic growth with an increase in the consumption of energy and water resources is rejected.

Results of the impact decoupling analysis showed that economic growth was fully accompanied by waste generation growth. As for liquid and gaseous pollutants, there is a relative decoupling. Thus, the second hypothesis is confirmed related to waste generation as well as liquid and gaseous pollutants.

According to the results obtained, the ecological footprint per person decreases while the economy keeps growing reflecting a state of absolute decoupling. In other words, the second hypothesis is refuted regarding the ecological footprint indicator. Concerning air pollutant emissions from stationary sources the second hypothesis is also refuted.

Thus, according to the analysis results, it was revealed that economic growth in Kazakhstan is accompanied by an increase in waste generation, emissions into the environment, in particular emissions of liquid and gaseous pollutants.

To sum up, this study contributes to the scientific knowledge base by analyzing and assessing the decoupling state of the kazakhstani economy regarding key natural resources and environmental pressure. These findings can be used to define current decoupling state and trends in Kazakhstan, regions, and industries to monitor the effectiveness of the application of responsible production principles and the achievement of sustainable development goals.

The lack of data for some indicators of impact decoupling can be indicated as research limitations. Further research can cover the study of the best foreign experience in the field of achieving resource and impact decoupling and adapting it to Kazakhstan's realities.

Acknowledgments

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