# AGRICULTURAL INPUTS USE FOR SUSTAINABLE DEVELOPMENT: THE INNOVATIVE COUNTRIES AND THE REPUBLIC OF SERBIA

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A B S T R A C T

Bearing in mind the increasingly pronounced world challenges such as the growth of population on the world, climate changes and pandemics, there is an increasing emphasis on healthy and safe food, as well as environmental protection. Organic production achieves the best ecological advantages compared to all other agricultural production methods. However, its application is limited due to lower yields, which requires increasing productivity. The aim of the paper is to differentiate between conventional and organic inputs (resources) and their impact on agricultural production, economic and sustainable development. Ordinary Least Square (OLS) panel regression did not show a significant difference between conventional and organic inputs for agricultural production, where it is only important to increase the amount of inputs for higher production, while the increase in total factor productivity of inputs has a positive impact on the economic and sustainable development of the observed countries.

## Introduction

Bearing in mind the increasingly pronounced climate changes, as well as the expected increase in the population to 9.7 billion by 2050, which would put additional pressure

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on agricultural land due to the increased demand for food, the impact and development of agriculture in accordance with the goals of sustainable development is increasingly pronounced (Arora, 2019). At the same time, the smart agriculture is one of the most important challenges for solving many problems of the agricultural sector, in terms of productivity, impact on the environment, food safety and sustainability (Kamilaris & Prenafeta-Boldú, 2018; Durkalić et al., 2019).

Organic agriculture excludes the use of chemical fertilizers, pesticides, but also genetically modified organisms, minimizing air, soil and water pollution, and optimizing health (Bengtsson et al., 2005, Scialabba & Müller-Lindenlauf, 2010). Organic agriculture is used as an indicator of sustainable agricultural development (Tomaš Simin et al., 2019). Organic production refers to sustainable agriculture with different environmental and health approaches, in conrast with conventional farming system that has degraded resources essential to agricultural production (Milić et al., 2022). Organic agriculture has low yields and productivity. However, organic agriculture has better results than conventional agriculture, because it provides important environmental benefits, such as stopping the use of harmful chemical inputs and their spread in the environment (Gomiero et al., 2011). Organic waste to energy conversion technologies have been successful in solving global challenges such as fossil fuel dependence, optimization of production costs, waste management, emission control and sustainable production (Stephen & Periyasamy, 2018; Pantović et al., 2023). Life cycle assessment (LCA) is the most commonly used method for environmental impact assessment. LCA was established to assess the problems of resource depletion, environmental and health impacts. Principle of LCA is the optimal relationship between inputs (resources) and outputs. Although organic agriculture generally emits less pollutants per unit of land occupied than conventional agriculture, it can also have higher impacts per unit of product (land occupation) due to lower yields per unit area (Van Der Werf et al., 2020; Andrei et al., 2023).

The productivity of organic agriculture depends on whether and to what extent it will be competitive with conventional agriculture. Some research shows that organic yields of certain crops are on average around 80% of conventional yields (De Ponti et al., 2012). There is much disagreement about what percentage of population can be fed by transforming the world's agriculture to organic methods. Considering productivity estimates in organic production, it is about half of the current world population (Connor, 2018). Some analyzes show that organic yields are lower than conventional ones by around 20% (De Pascale et al., 2017; Fowler et al., 2022).

Food quality and safety is one of the main challenges in developing and developed countries. Developed countries have problems with a high percentage of obesity, while developing countries face undernourishment. These challenges can be overcome with organic farming. A large percentage of organic producers come from developing countries. Food safety is a major concern in developed countries, while for developing countries it is food security. Organic agriculture can simultaneously contribute to the supply of food for the population, as well as to the reduction of the harmful effects of conventional agriculture on the environment. It is also promising since it can contribute to a significant increase in yields in developing countries. Even, organic agriculture has the potential to achieve higher yields than conventional agriculture in developing countries (Schoonbeek et al., 2013). The profitability potentional of organic agriculture is often significantly more successful than conventional agriculture in developing countries (Te Pas & Rees, 2014), which is mainly due to lower labor costs and cheaper organic manure. Lower production costs and higher net yield and profit, with ability of drought tolerance of certain organic crops, there is a possibility for higher profit in organic agriculture than in conventional agriculture (Shrestha et al., 2014).

**Table 1.** Significance of organic agricultural land by country, 2021

| Country | Organic area, in ha | Country | Organic producers |
|---|---|---|---|
| Australia | 35.687.799,00 | India | 1.599.010,00 |
| Argentina | 4.074.804,30 | Uganda | 404.246,00 |
| France | 2.776.553,93 | Ethiopia | 218.175,00 |
| China | 2.753.700,00 | Tanzania | 148.607,00 |
| Uruguay | 2.741.845,06 | Peru | 117.398,00 |

*Source*: Fibl Statistics, 2021

The largest number of organic producers come from developing countries (India, Uganda, etc.), although this is not the case in terms of the area of organic land (Table 1). This leads to the conclusion about the pronounced fragmentation of organic area in developing countries, as one of limitations in increasing the productivity of organic crops.

With the aim of sustainable agricultural development, innovative approaches and models such as organic agriculture, bioeconomy and circular economy in agriculture, conservation agriculture, precision agriculture, etc., are becoming more and more important. Organic agriculture contributes the most to the ecological goal of sustainable development, but it has lower yields than conventional agriculture. For the future development of organic agriculture important emphasis is on the increasing its productivity. Good combinations of organic and conventional methods, as well as other innovative agricultural systems (Reganold & Wachter, 2016), can greatly contribute to sustainable productivity in global agriculture (Meemken & Qaim, 2018). The integrated agricultural systems are a possible solution to the continuous increase in demand for food production, especially for small farmers with limited resources (Dar et al., 2018, p. 112), because the integral agriculture does not have such rigorous standards as organic, but still has stricter requirements than conventional. Organic agriculture, however, achieves significantly better environmental effects than integral and conventional agriculture (Pacini et al., 2003).

Given that agriculture improves productivity relatively quickly, the cost of doing so is high and is reflected in the excessive consumption of resources. The circular economy is therefore described as a very effective way towards the sustainable development of agriculture (Jun & Xiang, 2011). Given the importance of biomass, energy production technology, biofuels and materials from waste biomass within the circular economy and bioeconomy, it is important to make maximum use of the potential of agricultural waste (Rekleitis et al., 2020). The transition from a linear to a circular economy in the agri-food domain requires innovative business models (Donner et al., 2020; Melović, 2022).

Also, it is necessary to introduce approaches that, increase the productivity of inputs in addition to their ecological significance. In that sense, agriculture 4.0, which can reconcile both environmental and economic goals, refers to the use of artificial intelligence (AI), drones, Internet of Things (IoT), etc. in agriculture, thereby influencing increases in yields and reductions in costs, as well as the use of inputs and resources such as water, fertilizers and fuel. To grow food and meet the world's needs, agriculture need innovative solutions to produce in an ecologically, economically and socially sustainable manner (Yahya, 2018). Precision agriculture involves the use of information technology to improve the quality of products and production as a whole, so the use of wireless sensors and tools for agricultural management can lead to more efficient and environmentally oriented agriculture (Jawad et al., 2017), which can effectively manage resources. Precision agriculture can improve productivity and profits on farms, through better management of farm inputs, while leading to improved environmental quality (Tokekar et al., 2016).

The subject of the paper is the review of the used agricultural inputs and their importance for agricultural production, while the aim of the paper is to show the difference between organically used agricultural inputs and their contribution to the economic and sustainable development, in relation to conventionally used inputs, as well as the importance of productivity in their use. In line with this, the hypotheses were put forward:

H1: Countries with better agricultural indicators are characterized by a higher inputs use.

H2: Organic agriculture and inputs, which is in line with ecological standards, unlike conventional ones, can contribute to economic and sustainable development.

H3: The increase in efficiency and total factor productivity of inputs leads to economic and sustainable development.

## Materials and methods

The research was conducted for the period 1999-2019, on the sample of the Republic of Serbia and ten the most innovative countries (WIPO, 2020): Switzerland, Sweden, USA, UK, Netherlands, Denmark, Finland, Singapore, Germany and Republic of Korea. Table 2 shows the variables used for the research.

**Table 2.** Definition of research variables

| Label | Definition | Source |
|---|---|---|
| *Dependent variables* | | |
| Ag_out | Agriculture output | USDA, 2020. |
| HDI | Human Development Index | UNDP, 2020. |

| Label | Definition | Source |
|---|---|---|
| GDP_pc | Gross domestic product per capita (GDP per capita) | World Bank, 2020. |
| *Agricultural independent variables* | | |
| Ag_mac | Use of agricultural machinery | USDA, 2020. |
| Ag_fer | The use of mineral fertilizers - t | USDA, 2020. |
| Ag_land | Agricultural land | USDA, 2020. |
| Ag_labo | Labor force in agriculture | USDA, 2020. |
| Livesto | Livestock balance | USDA, 2020. |
| Feed | Livestock feed | USDA, 2020. |
| Org_area | Organic area | FiBL Statistics, 2020. |
| Org_liv | Organic livestock | Eurostat, 2020. |
| TFP | Total Factor Productivity | USDA, 2020. |
| *Control variables* | | |
| Ino | Innovativeness – Dummy variable (Republic of Serbia vs. the most innovative countries) | Authors' research. |
| GERD | Expenditure on research and development (% of GDP) | World Bank, 2020. |
| Cred | Domestic credit to the private sector (% of GDP) | World Bank, 2020. |

*Source:* Authors' research

The following research equations examined the impact and importance of agricultural inputs for agricultural production, economic and sustainable development of the observed countries:

$$Ag\_out_{i,t} = \alpha + \beta1AGRICULTURE_{i,t} + \beta2Ino_{i,t} + \beta3GERD_{i,t} + \beta4cred_{i,t} + \varepsilon_{i,t} \quad (1)$$

$$GDP\_pc_{i,t} = \alpha + \beta1AGRICULTURE_{i,t} + \beta2Ino_{i,t} + \beta3GERD_{i,t} + \beta4cred_{i,t} + \varepsilon_{i,t} \quad (2)$$

$$HDI_{i,t} = \alpha + \beta1AGRICULTURE_{i,t} + \beta2Ino_{i,t} + \beta3GERD_{i,t} + \beta4cred_{i,t} + \varepsilon_{i,t} \quad (3)$$

where agriculture refers to Ag_mac, Ag_fer, Ag_land, Ag_labo, Livesto, Feed, Org_area, Org_liv, TFP country i in the year t.

OLS panel regression was used to test the fitted equations. A random effect based on the Hausman test was used. Research models are set based on the multicollinearity of variables. Eviews was used for the research.

Based on the multicollinearity of the variables, the agricultural variables were separated into different models, where control variables were also used in addition to them, i.e., innovation that distinguishes the Republic of Serbia from highly innovative countries, GERD, considering that they lead to the emergence innovation, as well as domestic credit to the private sector that are significant from the aspect of financing the introduction of innovation and business in agriculture.

## Results

In the following two tables (Table 3 and Table 4), the impact of agricultural inputs on agricultural production was examined. Research results presented in different research models, which determined based on multicollinearity of variables and represent combinations of agricultural inputs with control variables.

**Table 3.** The impact of agricultural inputs on agricultural production in the Republic of Serbia and the most innovative countries - model 1 - 4

| Label | Dependent variable Ag_out | | | |
|---|---|---|---|---|
| | **Model 1** | **Model 2** | **Model 3** | **Model 4** |
| Intercept | **-14780665.55 (-2.32) | -1519822.53 (-0.35) | 1818759.96 (0.22) | 10995397.13 (0.20) |
| Ag_mac | ***44.56 (29.88) | | | |
| Ag_fer | | ***10.85 (46.86) | | |
| Ag_land | | | ***368.41 (10.63) | |
| Ag_labo | | | | ***-8459.55 (-2.86) |
| GERD | **1974397.66 (1.90) | *1573594.62 (1.47) | **1200235.09 (1.95) | -1204084.83 (-0.79) |
| Cred | 19334.67 (1.13) | **35967.97 (1.99) | **21978.28 (2.22) | 4467.62 (0.22) |
| Ino | 8260624.12 (1.19) | -2568250.65 (-0.50) | *15377258.18 (1.76) | 28836082.04 (0.51) |
| *Adjusted $R^2$* | 0.67 | 0.90 | 0.08 | 0.31 |
| *F-statistic* | ***88.09 | ***409.93 | ***4.54 | **2.38 |

*Source:* Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

**Table 4.** The impact of agricultural inputs on agricultural production in the Republic of Serbia and the most innovative countries - model 5 - 8

| Label | Dependent variable Ag_out | | | |
|---|---|---|---|---|
| | **Model 5** | **Model 6** | **Model 7** | **Model 8** |
| Intercept | -283589.65 (-0.08) | -2398893.97 (-0.56) | 4487010.16 (0.11) | ***4739394.75 (2.79) |
| Livesto | ***2007.70 (55.66) | | | |
| Feed | | ***0.29 (41.26) | | |
| Org_area | | | ***19.30 (12.35) | |
| Org_liv | | | | ***0.08 (3.44) |
| GERD | 903386.04 (0.97) | 833539.57 (0.94) | 479487.81 (0.49) | -128370.13 (-0.46) |
| Cred | 9292.14 (0.58) | ***41981.93 (2.84) | -11164.95 (-0.55) | -5090.02 (-1.46) |

| Label | Dependent variable Ag_out | | | |
|---|---|---|---|---|
| | Model 5 | Model 6 | Model 7 | Model 8 |
| Ino | -4551387.70 (-1.04) | -649087.98 (-0.13) | 23184305.58 (0.53) | ***8130326.41 (4.32) |
| *Adjusted $R^2$* | 0.91 | 0.64 | 0.49 | 0.03 |
| *F-statistic* | ***418.51 | ***76.53 | ***35.94 | *1.62 |

*Source:* Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

All examined models in Table 3 and Table 4 were statistically significant, and the inputs used in agriculture (agricultural machinery, fertilizers, agricultural land, livestock, livestock feed, organic area and organically raised livestock, represents respectively Models 1-3 and 5-8) had a positive and statistically significant impact on agricultural production, except the labor force (Model 4), which had a negative impact. This conclusion was imposed considering that a larger quantity of observed inputs led to higher agricultural production, i.e. output. This was not the case with the labor force, considering labor productivity as an important component, which meant that it is important to increase labor productivity by using digital technologies and agricultural methods. The following two tables (Table 5 and Table 6) examined the impact of all these inputs on the economic development of the observed countries.

**Table 5.** The impact of agricultural inputs on economic development of the Republic of Serbia and the most innovative countries - models 1 - 4

| Label | Dependent variable GDP_pc | | | |
|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 |
| Intercept | -4466.94 (-0.38) | -6601.56 (-0.56) | -6627.48 (-0.55) | 951.67 (0.11) |
| Ag_mac | **-0.01 (-2.28) | | | |
| Ag_fer | | -0.01 (-0.51) | | |
| Ag_land | | | *-0.09 (-1.58) | |
| Ag_labo | | | | ***-8.45 (-3.18) |
| GERD | ***6000.88 (3.31) | ***6039.37 (3.25) | ***6180.93 (3.32) | ***3990.29 (2.41) |
| Cred | ***224.79 (7.59) | ***215.25 (7.10) | ***221.27 (7.27) | ***211.61 (7.52) |
| Ino | 8602.56 (0.67) | 8166.79 (0.63) | 8551.87 (0.65) | 10997.38 (1.20) |
| *Adjusted $R^2$* | 0.35 | 0.33 | 0.34 | 0.38 |
| *F-statistic* | ***23.48 | ***22.45 | ***22.61 | ***30.37 |

*Source:* Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

**Table 6.** The impact of agricultural inputs on economic development of the Republic of Serbia and the most innovative countries - models 5 - 8

| Label | Dependent variable GDP_pc | | | |
|---|---|---|---|---|
| | Model 5 | Model 6 | Model 7 | Model 8 |
| Intercept | -6636.77 (-0.56) | -6348.13 (-0.53) | -6961.84 (-0.54) | -9895.60 (-1.29) |
| Livesto | *-0.16 (-1.42) | | | |
| Feed | | *-0.01 (-1.89) | | |
| Org_area | | | ***0.01 (4.75) | |
| Org_liv | | | | ***0.01 (2.63) |
| GERD | ***6274.06 (3.41) | ***6155.95 (3.28) | ***6652.70 (4.62) | ***6653.00 (2.84) |
| Cred | ***221.11 (7.35) | ***222.46 (7.25) | ***203.66 (6.10) | ***259.00 (7.56) |
| Ino | 8799.74 (0.68) | 9291.92 (0.71) | 2351.12 (0.17) | 9550.71 (1.02) |
| *Adjusted $R^2$* | 0.34 | 0.34 | 0.41 | 0.50 |
| *F-statistic* | ***22.39 | ***23.09 | ***29.16 | ***25.75 |

*Source:* Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

All models and variables (except chemical fertilizers) shown in Table 5 and Table 6 were statistically significant. Agriculture inputs had a statistically negative impact on economic development, except the organic area and organically raised livestock, where this impact was positive. The following two tables (Table 7 and Table 8) examined the impact of all these inputs on the sustainable development of the observed countries.

**Table 7.** The impact of agricultural inputs on sustainable development of the Republic of Serbia and the most innovative countries - models 1 - 4

| Label | Dependent variable HDI | | | |
|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 |
| Intercept | ***0.74 (34.04) | ***0.72 (33.74) | ***0.74 (33.98) | ***0.75 (38.39) |
| Ag_mac | *-0.01 (-1.71) | | | |
| Ag_fer | | -0.01 (-0.76) | | |
| Ag_land | | | *-0.01 (-1.33) | |
| Ag_labo | | | | ***-0.01 (-4.13) |
| GERD | ***0.03 (7.03) | ***0.03 (6.22) | ***0.03 (6.94) | ***0.02 (5.11) |

| Label | Dependent variable HDI | | | |
|---|---|---|---|---|
| | Model 1 | Model 2 | Model 3 | Model 4 |
| Cred | ***0.00<br>(5.72) | ***0.00<br>(5.48) | ***0.00<br>(5.55) | ***0.00<br>(5.80) |
| Ino | **0.05<br>(1.96) | ***0.06<br>(2.52) | **0.05<br>(1.97) | ***0.07<br>(3.11) |
| *Adjusted $R^2$* | 0.44 | 0.43 | 0.44 | ***0.47 |
| *F-statistic* | ***34.36 | ***33.71 | ***34.11 | ***44.30 |

*Source:* Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

**Table 8.** The impact of agricultural inputs on sustainable development of the Republic of Serbia and the most innovative countries - models 5 - 8

| Label | Dependent variable HDI | | | |
|---|---|---|---|---|
| | Model 5 | Model 6 | Model 7 | Model 8 |
| Intercept | ***0.74<br>(34.08) | ***0.74<br>(34.13) | ***0.75<br>(41.49) | ***0.77<br>(79.24) |
| Livesto | -0.01<br>(-1.01) | | | |
| Feed | | -0.01<br>(-1.20) | | |
| Org_area | | | ***0.01<br>(4.27) | |
| Org_liv | | | | ***0.01<br>(8.33) |
| GERD | ***0.03<br>(7.04) | ***0.03<br>(6.89) | ***0.03<br>(9.00) | ***0.01<br>(2.67) |
| Cred | ***0.00<br>(5.54) | ***0.01<br>(5.49) | ***0.01<br>(4.16) | ***0.01<br>(4.31) |
| Ino | **0.05<br>(1.97) | **0.05<br>(1.99) | **0.05<br>(2.26) | ***0.09<br>(6.59) |
| *Adjusted $R^2$* | 0.44 | 0.44 | 0.53 | 0.71 |
| *F-statistic* | ***33.71 | ***34.08 | ***46.50 | ***63.95 |

*Source:* Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

In the case of sustainable development, all the models shown in Table 7 and Table 8 were statistically significant. In this case, again, agriculture inputs had a statistical negative impact, except organic area and organically raised livestock, which had a statistically positive impact on sustainable development. Among the control variables it was important to point out innovation, i.e. that innovative countries had a positive impact, which should be a guideline for the Republic of Serbia. That is why it is important to introduce innovative approaches in agriculture, such as organic agriculture. However, the introduction of these approaches, must have been accompanied by an increase in input productivity.

**Table 9.** Importance of agricultural productivity for economic and sustainable development of the Republic of Serbia and the most innovative countries

| Label | Dependent variable BDP_pc | Dependent variable HDI |
|---|---|---|
| | **Model 1** | **Model 2** |
| Intercept | -6855.26<br>(-0.57) | ***0.74<br>(38.50) |
| TFP | **13211.99<br>(1.99) | **0.03<br>(2.26) |
| GERD | ***6312.44<br>(3.34) | ***0.03<br>(6.92) |
| Cred | ***213.37<br>(6.96) | ***0.01<br>(5.35) |
| Ino | 7096.27<br>(0.54) | **0.05<br>(2.17) |
| *Adjusted $R^2$* | 0.34 | 0.46 |
| *F-statistic* | ***23.07 | ***36.20 |

*Source:* Authors' research

Note: beta coefficients in front of parentheses, t-values in parentheses; *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively

Both models shown in Table 9 were statistically significant and in both models the productivity of inputs used in agriculture had a statistically positive impact on economic and sustainable development. Control variables had a positive impact both on the economy and sustainable development, which meant that allocation for research and development, innovation, and financing of farmers is very important. The growth of inputs can lead to an increase in agricultural production, while their productivity in use is much more important for economic and sustainable development.

## Discussions

In today's world with a growing population, it is very important to ensure the sustainability of agriculture and production. That is why it is necessary to increase productivity, which can be achieved by introducing modern technologies that increase production with a smaller amount of use of resources and inputs. Improved total factor productivity (TFP) can be achieved by adopting innovations (Steensland & Zeigler, 2021). Technical changes are important determinant of productivity growth in agriculture (Bustos et al., 2016).

The use of chemical inputs in agriculture is not only dangerous for human health, but also affects the ecological balance. Bio-fertilizer can act as a very good alternative, which leads to the sustainable development of agriculture (Mahanty, et al., 2016). It is important to motivate farmers to use organic fertilizers as an alternative to chemical fertilizers (Lu & Xie, 2018), due to its negative impact. The production and use of renewable energy for the operation of some types of agricultural machinery should be promoted, where possible, which can replace the use of fossil fuel energy and cause a minimal negative impact on the environment (Ridzuan et al., 2020). In order to achieve the sustainable development of the Republic of Serbia, it is important to use renewable energy sources more intensively and increase energy efficiency in all sectors, including agriculture, in order to reduce the use of non-renewable energy sources, environmental pollution and greenhouse gas emissions (Bošković et al., 2019).

Sustainable agriculture, which is in line with the Green Deal, includes different models, such as precision and organic agriculture. Organic model reduces pesticides and fertilizers (Poponi et al., 2021), in line with ecological goals. But, due to the limited yields of organic production, precision agriculture is being developed that better meet both the economic and ecological goals of sustainable development. Smart agriculture is fully in line with sustainable development, because, with the help of smart technologies, resources and inputs are optimally used in production, which increases productivity. This further reduces production costs. Also with reduces of inputs use, impact on the environment is also reduced.

The intensification of agricultural production has led to excessive use of non-renewable resources and a negative impact on the environment, which is considered unacceptable today. Namely, this obvious contradiction between the need to improve agricultural productivity for food security reasons and the urgent prevention of nature degradation due to the necessity of environmental restoration must be overcome (Lemaire et al., 2014). Regarding to negative impact of agriculture inputs, reducing the intensity of the use of natural raw materials and their rational use is necessary, as well as the introduction of modern technology and mechanization in agriculture in accordance with precision agriculture, which affects the increase in productivity while simultaneously preserving the environment. Innovative multipurpose agricultural machines are extremely important, in order to simplify and speed up the production process, with the reduction of the negative impact on the environment by agricultural activities (Bortolini et al., 2014). Emphasis should be placed on the possibility of automatic operation of agricultural machines and automatic navigation systems of agricultural machines, as a technology within precision agriculture (Li et al., 2019). Efforts to design and develop agricultural machinery, in this context, are preoccupied with numerous questions about initial costs, crop yields, and more (Banerjee & Punekar, 2020).

The main limitations of introducing precision agriculture are that its introduction is mostly expensive and unsuitable for small farms. Accordingly, financial measures and incentives for its adoption, as well as education in terms of promotion, are recommended (Ammann et al., 2022). Federal conservation programs can stimulate the adoption of precision agriculture. Productivity vary within fields suggesting conservation programs could be targeted to marginal field (Meng et al., 2022).

Developed countries have more intensive agricultural production than developing countries, which has a negative impact on the environment. Therefore, the effective use of chemical inputs is very important, such as fertilizers, pesticides, etc. Although they have strategies to reduce pollution and chemical fertilizers, they are still not implemented effectively. These countries use more fossil fuels and consume more resources than developing countries (Papież et al., 2022). That is why new technologies and agricultural mechanization should be adopted that enable efficient agriculture and higher productivity, as well as the energy transition between fossil energy and electricity (Vogt et al., 2021).

Excessive use of chemical fertilizers, fossil fuels, and other agricultural inputs are more intensive in developed countries with better agricultural indicators, which have an impact on higher yields and agricultural production. Given that negative impact of conventional inputs on the environment and environmental pollution, it is important to improve them in terms of increasing productivity, but also greater application of organic inputs and the use of renewable energy sources, in accordance with the preservation of the environment and sustainable development. That's why productivity should be increased along with environmental protection and conservation. Conventional inputs in agriculture negatively affect economic and sustainable development. That is why innovative solutions in agriculture and the introduction of modern technologies are needed, which will increase their productivity. The same applies to the use of chemical fertilizers, which can be replaced by organic ones that do not pollute the environment (Dimitrijević, 2023).

Low-input agriculture, precision agriculture and organic farming affects sustainable development. Organic production is based on the rational use of renewable resources and environmental protection (Bajagić et al., 2022). Today, the ecological dimension is increasingly taken into account when talking about the use of conventional inputs, such as fertilizers and others. There is a link between input use and yield growth, as well as economic development, increasing GDP per capita and decreasing agricultural labor. Agricultural productivity has a special role in these structural changes. Countries should not be based on avoiding fertilizers and conventional inputs for ecological reasons, but on the application of modern inputs that are in line with the green revolution and increasing agricultural productivity in line with structural changes. These complementary inputs can be of particular importance for increasing yields in economies with low agricultural productivity and a large share of the agricultural labor force (McArthur & McCord, 2017).

## Conclusions

The size of population on the world and the limited supply of energy represent major challenges for modern society. Therefore it is necessary to develop an agricultural methods that will be more energy efficient. Organic agriculture is able to significantly contribute to food production, without harmful impact on the environment and people. This type of agriculture can be applied more simply on small farms, as well as in developing countries, where the chances for the development of organic production are much greater due to the unavailability of expensive inputs for other types of agriculture. On the other hand, precision agriculture is a better option for large farms, bearing in mind the costs of its introduction, but also the economic and ecological benefits of its introduction.

The organic agricultural system is directed towards the protection of the human health and environment, while the conventional agricultural system degrades the environment. Although organic farming is an environmentally very sustainable option, it should also be economically viable for the farmers. Conventional agriculture is more economically viable compared to organic agriculture. At the same time, many consumers are not able to pay a higher price for organic products, which is why in the future the relationship between economic and environmental sustainability should be balanced as best as possible. That is why organic methods should be developed in the direction of increasing productivity and yield, because they are significantly different from all other agricultural production methods in terms of ecological characteristics.

The limitation of the work is that there is no record of the application of other innovative agricultural methods and inputs in production, which is why the research is based only on organic production. It is precisely the development of such databases, as well as the comparison of other innovative methods of production with organic, that are recommended for future research.

This research proved the research hypotheses, i.e. developed countries have better agricultural indicators and characterized by a higher input use, too. However, it is mostly the conventional inputs that have a negative impact on economic and sustainable development. Therefore, it is important to replace them with organic inputs and increase agricultural productivity, that have a positive impact on economic and sustainable development.

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**Conflict of interests**

The authors declare no conflict of interest.

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