

PAPER • OPEN ACCESS

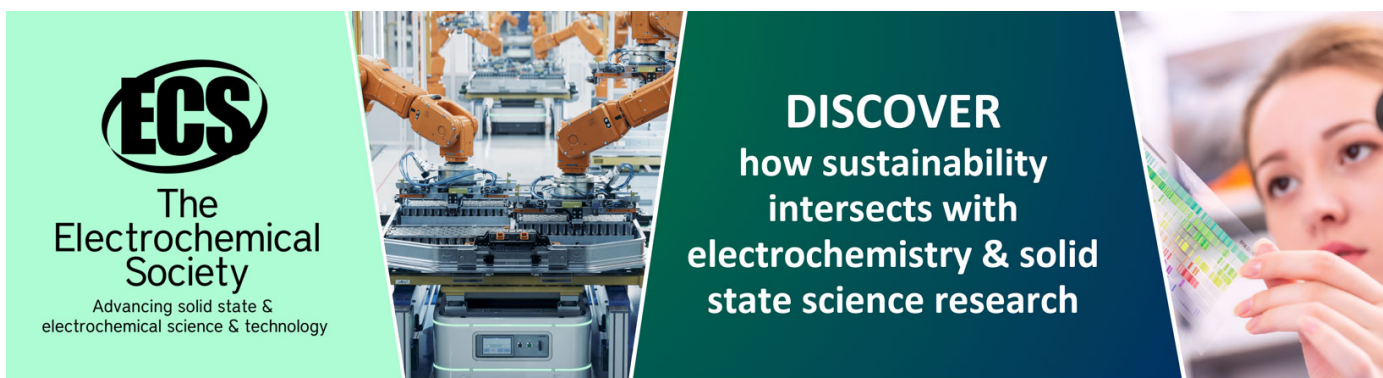
Digital technologies in the transformation of approaches to the management of natural resource capital in the agricultural sector

To cite this article: V Polyakov 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **1001** 012139

View the [article online](#) for updates and enhancements.

You may also like

- [Tools for assessing the level of development of digital technologies in Russia \(on the example of the Far East\)](#)
Nikolay Egorov, Grigoriy Kovrov, Irina Nikolaeva et al.
- [Impact of digital economy on urban land green use efficiency: evidence from Chinese cities](#)
Rou Wen and Hongyi Li
- [Relationship between the digital economy, resource allocation and corporate carbon emission intensity: new evidence from listed Chinese companies](#)
Pengyu Chen



ECS
The
Electrochemical
Society
Advancing solid state &
electrochemical science & technology

DISCOVER
how sustainability
intersects with
electrochemistry & solid
state science research

Digital technologies in the transformation of approaches to the management of natural resource capital in the agricultural sector

V Polyakov¹

¹Don State Technical University, Gagarin sq., 1, Rostov on Don, 344003, Russia

E-mail: polakoww@rambler.ru

Abstract. The article touches upon the impact of digitalization processes of economic entities and management bodies of the agricultural production system on the formation of a resource-saving paradigm of its development in the context of ensuring the reproduction of natural resource capital. Based on the position that natural resource capital and, especially, its element as ecosystem services largely form the primary basis for the life of both individuals and the entire human population, the need to find the most effective ways to eliminate the contradiction between the possibility of meeting the constantly increasing needs of modern society and reducing the level of natural capital expenditure, i.e. achieving the decoupling effect, is grounded. One of the key factors contributing to the emergence of conditions for the manifestation of this effect is the active introduction of digital technologies in the activities of agricultural enterprises. In this regard, we consider the development of "Agriculture 4.0" concept (Agriculture 4.0) and its basic directions of implementation are the active introduction of digital technologies (in particular, precision farming), eco-oriented solutions, as well as the use of alternative sources of resources. As an illustration of how digital technologies contribute to changing approaches to the formation of economic organizational and managerial relations that arise in the course of economic activity, we consider the formation of digital (platform) business models for the functioning of agricultural enterprises. It is stated that ensuring the reproduction of natural resource capital in the context of more effective provision of a complex of ecosystem services based on the use of digital technologies and it should involve the formation and use of a set of administrative and economic tools that encourage the introduction of resource-saving technologies and are aimed at reducing the costs of agricultural producers. In this context, we consider the practice of paying farmers so-called "payments for ecosystem services", which takes place in a number of foreign countries, and identify the most important factors in the development of ecosystem services markets.

1. Introduction

The processes of functioning of modern agricultural production systems are inherently associated, on the one hand, with the consumption of very significant volumes of natural resources, and on the other hand, with the provision of society as a whole and all individuals without exception, in particular, a significant number of ecosystem services, which largely lay the foundation for ensuring normal the life of mankind.

As a consequence, the search for the most effective ways to resolve the contradiction between meeting the constantly growing needs of modern society, which in the context of their food component



is precisely one of the ecosystem services of agriculture, and the need to reduce the level of expenditure of natural capital for these purposes, is becoming increasingly important.

One of the key factors contributing to the emergence of conditions for overcoming this effect is the use of the potential of the digitalization of economic relations and, in particular, the implementation of the postulates of the concept called "Agriculture 4.0".

2. Ecosystem services as an essential element of the natural resource capital of the agricultural production sector.

At present, an approach to considering the essential content of natural resources used in agricultural production as a form of capital is becoming more and more common, focusing not on the consumer properties of these resources, but on the features of the process of their reproduction, which makes it possible to ensure the achievement of sustainable socio-ecological and economic effect.

At the same time, it can be quite reasonably stated that natural resource capital and, especially, such an element of it as ecosystem services, to a large extent form the fundamental basis of the vital activity of both individual individuals and the entire human population, being the most important socio-economic category included in the system of reproductive relations. Speaking about the interpretation of the essential content of such services, we note that the most widespread in modern economic thought are approaches that identify them with a set of benefits and values provided by ecosystems, as well as with a complex of flows, diverse in their essential nature, formed by reserves of natural resource capital [1].

It is extremely important to emphasize that, while the reproduction of traditional forms of capital implies the creation of new value, the reproduction of natural resource capital is associated with the preservation of originally existing natural goods and services, but in the context of their involvement in the system of economic relations.

Individual elements of natural resource capital are characterized by heterogeneity of the parameters of the reproduction process. In particular, taking into account the specifics of the reproduction of ecosystem services, which are the producer of factors that form a favorable environment for human life and provide a long-term basis for sustainable development, is of great importance in modern conditions. The involvement of this element of natural resource capital in the system of reproductive relations was largely caused by a decrease in the level of opportunities for natural resource capital to satisfy the constantly growing needs of human civilization and the need, in this regard, to bear certain costs to ensure the reproduction of these opportunities.

Speaking about the content of ecosystem services, it should be noted that at present, various approaches to the implementation of their classification have been developed. The functional approach used by the United Nations Commission on Environmental Protection received the greatest recognition, within which the supporting (related to the use of products provided by ecosystems), regulating (related to the regulation of ecosystem functioning), supporting (related to ensuring the flow of the most important ecosystem processes) and cultural (ensuring the spiritual and aesthetic well-being of a person) services.

The international classification CICES identifies 59 types of ecosystem services, and this list is open and can be expanded after identifying other types of these services that have the potential to implement procedures for their assessment and accounting.

At the same time, according to M. Swinton, the agricultural production system is characterized by the receipt and provision of a complex of ecosystem services and anti-services, presented in Figure 1.

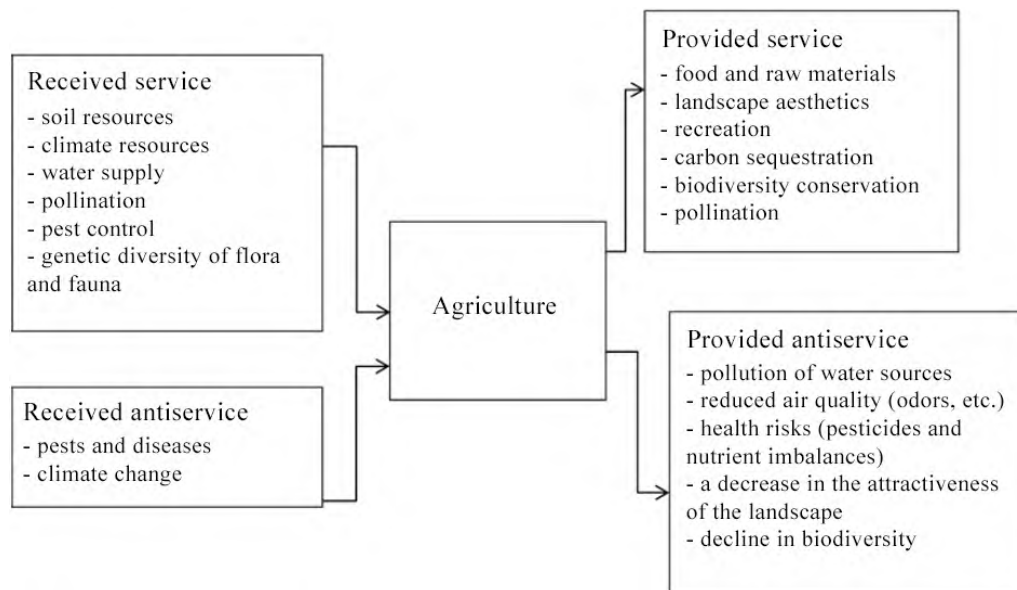


Figure 1. Set of ecosystem services and anti-services received and provided by the agricultural production system [2]

In their later work, Swinton and his co-authors include among the ecosystem services provided by intensive farming systems, the production of food and agricultural raw materials, pest control, the provision of clean water, climate stabilization and an increase in soil fertility [3].

Note that a group of British researchers has empirically shown the positive impact of improving agricultural land use systems in the context of providing such types of ecosystem services as absorption of emissions CO₂ and many other pollutants, improving the condition of green planting systems, preserving biodiversity, developing recreational areas, etc. [4].

However, in many cases, the development of the processes of intensification of agricultural production causes the manifestation of a tendency towards a decrease in values reflecting the quantitative parameters of natural resource capital due to the imbalance in the choice between environmental and economic targets of agricultural production in favor of the latter. In particular, in the agricultural sector, this is clearly manifested in a decrease in the ecological and economic efficiency of the interaction of elements within the framework of the complex system "man - land - land use".

In this context, more and more attention in the study of the problems of ecological and economic interaction in the process of agricultural production is occupied by the study of the decoupling effect, which means the elimination of the contradiction between the possibilities of meeting the constantly increasing needs of modern society and reducing the level of consumption of natural capital [5].

One of the key factors contributing to the emergence of conditions necessary for the manifestation of this effect is the active development of modern information and communication technologies, which laid the foundation for the formation and development of the digital economy.

3. Digital technologies as a tool for the development of modern agricultural production

Modern processes of the formation of the digital economy as a form of industrial relations, within which digital technologies dominate, and information flows functionally depend on the use of information and communication technologies [6], radically transform as the essential content of modern economic relations.

Regarding the essential content of the content of this definition, it is necessary to point out that at the present time in the scientific environment there is no uniform point of view regarding its interpretation. H.K. Chavula and A. Chekol characterize the concept under consideration as an economic system, the production and sale of products within the framework of which is carried out on

the basis of the use of electronic means [7]. The Australian Department of Communications and the Digital Economy of Australia refers to the digital economy as a global network of socio-economic activities that are implemented using Internet technologies and other forms of networking.

In turn, N. Negroponte described the formation of the digital economy as a transition from processing atoms to processing bits. Based on such a figurative definition, the digital economy is often defined as a "data economy", that is, an economic system in which digital data, as well as tools for their processing and further use, act as the most important production factors.

As a starting point for the development of digitalization processes, one can name 1991, when the excess of investment in the field of information technology over the amount of investment in the creation of production technologies was first recorded. Currently, as noted by the founder of the World Economic Forum K. Schwab, this process has advanced to the level of formation of modern "cyber-physical" systems, which are inherent in the characteristics of production, service, technical and even biological systems [8]. In this context, it has become customary to talk about the development of the so-called. "Industry 4.0", one of the main directions of which is the transition of business entities to the organization of their activities based on digital technologies. In relation to the field of agricultural production, this concept was called "Agriculture 4.0", and the basic directions of its implementation are the active introduction of digital technologies (robotics, precision farming, the Internet of things), eco-oriented solutions, as well as the use of alternative sources of resources [9].

Moreover, their development is an area of increasing attention from developers of innovative solutions. So, if as of 2010 there were about two dozen high-tech agricultural companies operating on a global scale, then by 2016 more than 1,300 start-ups were created in the agricultural sector, investment in which exceeded \$11 billion.

Digital technologies contribute to a change in approaches to the formation of economic, organizational and managerial relations that arise in the process of economic activity. Note that such a result is ensured through the use of a significant set of various tools that allow digitalization of all key aspects of the economic activities of agricultural enterprises.

In particular, due to the fact that in the process of agricultural production based on the use of digital technologies, it is necessary to operate with a huge amount of spatio-temporal and attributive data, one of the necessary tools for information technology support of this activity is geoinformation systems (GIS), which allow support the formation of separate information layers reflecting such parameters as the content of humus and nutrients in the soil, its agrophysical properties, weed infestation, etc. Analysis of the data presented in the specified information layers and presented on the corresponding thematic maps makes it possible to assess the agro-climatic conditions of reclamation activities, the features of fertilization, the possibilities of growing specific crops.

You should also point to such an important technological element used in the digitalization of agricultural production, as global positioning systems (GPS), designed for the most accurate determination of spatial coordinates at any point. The basic method used in determining the coordinates of an object is to determine the distance from a GPS receiver to several satellites at a given location. Based on constant tracking of the location of the object, the GPS-receiver determines the speed and direction of its movement. It was the emergence of global positioning systems that opened up fundamentally new opportunities in the context of the transition from traditional farming technologies to innovative approaches, within which it becomes possible to regulate the degree of impact on the agroecosystem based on taking into account factors reflecting the variability of key soil cover properties within a single field.

In general, the introduction of digital technologies makes it possible to reduce the dependence of the productivity and environmental sustainability of agroecosystems on weather factors, contribute to the greening of reclamation processes at the level of agroecosystems and individual technologies, leveling the negative impact on the environment, and reducing the cost of various types of resources, including natural ones. In addition, it forms a fundamentally new business model for agricultural enterprises, which can be called digital or platform.

4. Implementation of a digital business model in the activities of subjects of the agro-industrial sphere in the context of ensuring its resource-saving paradigm

The business model concept was first introduced by G. Hamel and K. Prahalad in their book *Competing for the Future*. From the point of view of these authors, the business model is considered as a link between the company's strategy and the business processes it implements.

Other authors, who considered the essential content of the business model as a management category, characterized it as a conceptual tool, business architecture, structural template, , forms of coordination of the goals of the enterprise and technologies for achieving them, driving force of business strategy [10]. At the same time, in the context of our research, it is extremely important to pay attention to the last definition, in which the concept of a business model is directly linked to technology and innovation.

In general, the business model can be defined as the conceptual basis of the company's activities, which, based on its strategic goals and technological capabilities, determines the ways to create the greatest value for the consumer.

At the same time, consideration of the concept of a business model is largely determined by the peculiarities of the theoretical approach from which it is carried out.

In particular, the resource theory of a firm operates with the proposition that the formation of a successful business model is determined by the presence of valuable, rare and irreplaceable analogs of resources and opportunities in the company. The embodiment of this maxim can be seen in the concepts of a firm based on knowledge, dynamic abilities, core competencies, etc. As a result, the concept of "business model" is currently described within the framework of the resource approach as a dynamic ability of a firm, which links its competencies with organizational results.

In turn, the approach focused on the concept of transaction costs considers a business model as a characteristic of a concept that reflects the content, structure and mechanism of transaction management at the organization level. Some authors, integrating the above two approaches, state that a business model is a certain combination of resources through which transactions generate additional value [11].

From the point of view of the proponents of the activity approach, the business model is a set of interdependent organizational activities that focus on the target firm, its partners, customers, suppliers, etc. At the same time, the business model should be designed in such a way as to match the key characteristics of the firm, which include its strategy and organizational design, as well as the business models of other firms that are closely related to the company [12].

Analyzing the direction of changing the essential content of business models in the digital economy, a number of researchers, as opposed to traditional models, form the concept of a platform business model, within which the formation of value for a client is carried out through the use of information and communication technologies that provide the possibility of interaction between economic entities in real time based on their equal access to high-quality and reliable information [13].

In this context, we can actually talk about the formation of a new type of economic activity - platform business. At the same time, according to experts from the World Economic Forum, up to 70% of the consumer value created in the global economy over the next decade will be generated as a result of activities based on the use of digital platforms.

Digital platform can be defined as an instrumental environment with a set of services and functions that allow direct interaction of participants in economic relations based on the implementation of certain economic operations. It helps businesses to significantly reduce costs by providing them with additional innovative functionality and helping to strengthen online interactions. From the point of view of the features of its architecture, the digital platform has a multi-level modular structure, which is formed by constant (forming the "core" of the platform) and variable (included in its "periphery") elements.

From a technological point of view, a digital platform is a collection of digital data and tools for their processing, integrated into a single automated system and placed in a concentrated form in a

specific subject area of the information space, designed to provide a customer with remote access to digital services hosted on the platform.

The attributive structuring of the digital platform as the basis of the platform business model can be represented as follows (Table 1).

Table 1. Essential content of the main attributes of the digital platform

Attribute	Content
Appointment	Concentration of information and its distribution
Object	Set of digital data, digital services
Subjects	Many interested users
Location	Information network space
Possession	Platform Creator
Access method	Remote
Economic sense of use	Reducing costs due to the use of digital services

The key differences between the platform business model and the traditional one includes ensuring effective interaction between economic entities, a lower level of transaction costs incurred by these entities, and the almost complete absence of barriers limiting the entry of participants.

The main components that determine the content of the platform approach to the formation of a digital business model of an organization are shown in Figure 2.

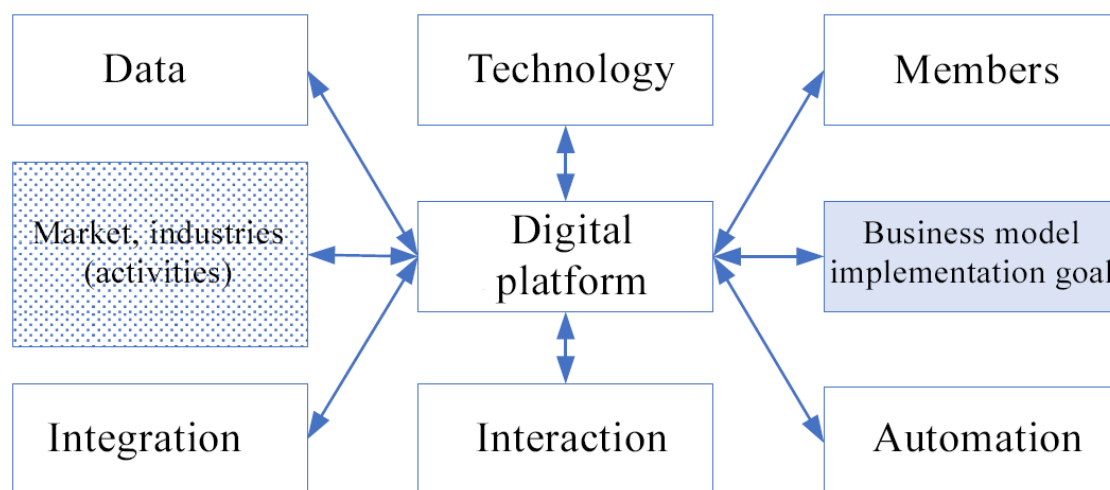


Figure 2. Components defining the content of the platform approach to the formation of a digital business model

Speaking about the relevance of using this approach in the field of agricultural production, we note that, in particular, in the Decree of the President of the Russian Federation No. 204 "On national goals and strategic objectives for the development of the Russian Federation for the period until 2024", adopted in May 2018, the task was determined qualitative transformation of priority sectors of the domestic economy, including agriculture, based on the introduction of digital technologies in general and platform solutions, in particular.

Currently, at the level of the Ministry of Agriculture of the Russian Federation, work is underway to form the National Platform "Digital Agriculture" as a single system integrated with digital sub-platforms for managing agricultural production at various territorial levels. The main purpose of its formation is determined to support the digital transformation of domestic agriculture through the introduction of platform solutions to ensure a technological breakthrough in the agricultural sector and increase the productivity of digital agricultural enterprises.

The concept of this platform, presented in February 2020 by Lanit-Integration company, assumes that it will include six sub-platforms, providing for the digitalization of the following directions for ensuring the development of domestic agricultural production:

- land use and land management;
- product traceability;
- agrometeorological forecasting;
- collection of industry data;
- information support and provision of related services;
- storage and distribution of information.

In total, the platform will include more than 50 services required to ensure digital governance of the industry. At the same time, various services, depending on their focus, can be managed by both state and non-state structures. However, from the budget funds it is supposed to finance only services focused on solving state problems related to the implementation of accounting, control and regulatory functions.

It is extremely important that the platform's services will allow operators to provide various services to agricultural producers throughout the Russian Federation. The organization of interaction of platform participants in digital form will lay the foundation for the implementation of qualitatively new approaches to agricultural production, focused on ensuring the reproduction of natural capital, in particular, such as precision farming.

It is precision farming that can be considered as an example of the implementation of a digital business model of an agricultural enterprise, focused on increasing the efficiency of using natural resources. This approach can be summarized as a system for managing agricultural land productivity, which is based on the use of a set of digital technologies.

As part of its implementation, on the basis of cartographic information and the results of a field survey carried out with reference to a coordinate system, it becomes possible to establish the reasons for the variation in the productivity of arable land within any given one. Accurate determination of coordinates, which is extremely important for high-quality, maximally differentiated performance of various agricultural practices on the ground, taking into account its specifics, help to produce GPS receivers, which are equipped with agricultural machinery.

The use of precision farming technologies, in particular the parallel driving system, allows field work to be carried out with maximum precision, even at night. In addition, precision farming technology provides the ability to monitor the level of soil moisture around the clock, ensuring rational automatic irrigation of only those areas where this operation is necessary.

At the same time, domestic scientists have accumulated some experience in developing original approaches to the implementation of the concept of precision farming, the success of which has been confirmed by their practical implementation. For example, the precision farming model developed at the Perm State Agrarian and Technological University is based on a step-by-step approach to its formation. The first stage in the implementation of this model, which consists in determining the actual area of sites and their boundaries, can be carried out either by using deciphered satellite images, or by mapping fields using specialized mobile complexes. At the second stage, the procedure for collecting information produced by a grain harvester is carried out, which is equipped with a GPS receiver, sensors for moisture and grain weight, as well as an on-board information system equipped with a mapping program, and compiling maps of yield and grain moisture. At the next stage, using the method of layer-by-layer imposition, an electronic map with several layers is formed, which is used to draw up task maps that are entered on the on-board computers' chip card. Checking the task maps, the vehicles move across the field using a GPS navigator. To minimize the resulting errors, a signal from a local base station is used, which is located at a minimum distance from the objects being mapped and controls objects that are in the line of sight from the station and equipped with rovers, which facilitates the coordination of work performed.

In general, precision farming as one of the examples of the practical implementation of the concept of "Agriculture 4.0" is a tool for the process of greening agricultural production oriented towards resource conservation and preservation of environmental parameters, carried out on the basis of the use of digital technologies and implying the implementation of an integrated approach that allows on the one hand, a more efficient reproduction of natural resource capital, and on the other, obtaining environmentally friendly products. In addition, as we have already noted, the focus on the implementation of the postulates of this concept implies the need to form a new business model for the functioning of an agricultural enterprise in the modern digital environment.

5. Payments for ecosystem services as a tool to stimulate the introduction of resource-saving digital technologies

It is quite natural that the introduction of precision farming systems and, in general, the digitalization of the activities of agricultural enterprises are associated with very significant financial costs, which are beyond the power of the absolute majority of agricultural enterprises, especially small ones.

At the same time, ensuring the reproduction of natural resource capital in the context of a more efficient provision of a complex of ecosystem services, based on the use of a complex of modern digital technologies, should imply the formation and use of a set of administrative and economic instruments that stimulate the introduction of resource-saving technologies and focused on reducing the costs of agricultural producers associated with improving the state of the elements of natural resource capital and, in particular, with the provision of a complex of ecosystem services to society.

In this regard, the mechanism for supporting producers of ecosystem services should inherently assume compensation for the opportunity costs of business associated with the introduction of resource-saving digital technologies and the provision on this basis of a larger volume of certain public goods. This can take the form of payments to agricultural producers of the so-called. "Payments for ecosystem services" [14]. At the same time, a number of foreign countries have already accumulated significant experience in using this tool.

For example, state programs for the conservation of wetlands, implemented in the United States, since 2004, provide for the government to pay farmers to implement measures aimed at reducing soil erosion. US banking organizations are actively involved in the implementation of the concept of payments for ecosystem services. Thus, more than 120 banks support the implementation of programs aimed at preserving the ecosystems of protected areas. Within their framework, they provide their clients with about 140 types of eco-oriented credit programs.

It is necessary to note the consistent steps towards the practical implementation at the national level of the main postulates of the concept of payments for ecosystem services, which is taking place in Costa Rica within the framework of a specialized program launched in 1996 aimed at encouraging land owners to conserve landscapes, ecosystems and biodiversity [15]. Various programs of a similar profile are actively implemented in Brazil, China, Australia and a number of other states.

The postulates set out in the 2007 Declaration on the Principles of Formation of Payment Systems for Ecosystem Services state that part of the benefits received by consumers of ecosystem services should be recorded and transferred to producers of these services in order to stimulate them to implement measures aimed at maintaining the stability of ecosystems and reproduction. natural capital. At the same time, the implementation of this process as an immanent condition presupposes the need to form and develop markets for ecosystem services.

The implementation of this task depends on the presence of several essential prerequisites. In particular, potential market participants should have access to information on the quality and volume of ecosystem services, as well as the ability to agree on the amount of fees for these services. In this context, the most important place is given to the process of assessing the value of ecosystem services as a basis for the subsequent formation of the objective value of ecosystem payments. It, first of all, should show how the costs and benefits from the implementation of changes that are manifested within agroecosystems will be distributed, which is the most important task in the process of ensuring the rationalization and sustainability of agricultural production.

In addition, it is necessary to form control and monitoring systems for the use of ecosystem services. It is the use of digital platforms, such as the currently designed National Platform "Digital Agriculture", that allows the most effective way to ensure the solution of these tasks.

6. Conclusion

The endowment of a specific agricultural production system with natural resource capital does not always act as a factor guaranteeing the success of its functioning. Only the use of modern management approaches, focused, on the one hand, at ensuring the decoupling effect, which involves eliminating the contradiction between the possibilities of meeting increasing needs and reducing the level of consumption of natural capital, and using the potential of digitalization, which implies not only a significant increase in the role of information technology in the activities of agricultural production entities, but also the transformation of business models of their functioning, on the other hand, lays the foundation for achieving a dual goal, which implies the effective performance by agricultural production of its function as a supplier of ecosystem services while ensuring sustainable reproduction of natural resource capital within the agrarian sector.

References

- [1] Balvanera S, Quijas S, Karp D et al. 2017 *Ecosystem Services, The GEO Handbook on Biodiversity Observation Networks* (Cham: Springer International Publishing AG) p. 39-78 DOI: 10.1007/978-3-319-27288-7
- [2] Swinton S 2011 Valuation of Ecosystem Services from Rural Landscapes Using Agricultural Land Prices. *Ecological Economics* **9** 1649-1659 DOI: 10.1016/j.ecolecon.2011.04.004
- [3] Robertson G P Gross K L and Hamilton S K 2014 Farming for Ecosystem Services: An Ecological Approach to Production Agriculture. *BioScience* **5** 404-415
- [4] Bateman I J, Harwood A R and Mace G M 2013 Bringing Ecosystem Services into Economic DecisionMaking: Land Use in the United Kingdom. *Science* **341** 45-50
- [5] *Decoupling natural resource use and environmental impacts from economic growth* 2011 (Nairobi: UNEP) p. 152
- [6] Tugui A 2015 Meta-Digital Accounting in the Context of Cloud Computing. *Encyclopedia of Information Science and Technology*. Hershey: IGI Global
- [7] Chavula H K and Chekol A 2011 *Information communication technology policy* (Addis Ababa: UNECA) p. 72
- [8] Schwab K and Davis N 2018 *Shaping the Fourth Industrial Revolution* (London: Penguin Random House) p 273
- [9] De Wilde S 2016 *The Future of Technology in Agriculture* (The Hague: Netherlands Study Centre for Technology Trends) p 118
- [10] Casadesus-Masanell R and Ricart J E 2010 Competitiveness: business model reconfiguration for innovation and internationalization. Management Research. *Journal of the Iberoamerican Academy of Management* **2** 123-149
- [11] DaSilva C M and Trkman P 2014 Business model: What it is and what it is not. *Long Range Planning* **6** 379-389
- [12] Zott C and Amit R 2017 Business Model Innovation: How to Create Value in a Digital World. *GfK Marketing Intelligence Review* **1** 18-23 DOI: 10.1515/gfkmir-2017-0003
- [13] Evans D and Schmalensee R 2016 *Matchmakers: The New Economics of Multisided Platforms* (Brighton: Harvard Business Review Press) p 272
- [14] Farley J and Constanza R 2010 Payments for ecosystem services: From local to global. *Ecological Economics* **69** 2060-2068 DOI:10.1016/j.ecolecon.2010.06.010
- [15] Porras I, Barton D N, Miranda M and Chacon-Cascante A 2013 *Learning from 20 years of Payments for Ecosystem Services in Costa Rica* (London: International Institute for Environment and Development) p. 76