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DESIGN THINKING IN THE VISUALIZATION OF ECONOMIC DEVELOPMENT PROJECTS IN THE AGRARIAN SPHERE: SCIENCE AND ART

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Abstract: The article represents an attempt to comprehend the possibilities of applying general methodological principles of design thinking in the process of planning and developing innovative economic development projects in the agricultural sector. The relations of design and visualization as the science and art processes in the economy are outlined. It is noted that smart agriculture uses advanced technologies such as sensors, devices, machines and information technology, robots, GPS technologies, which will allow farms to be more profitable, efficient, safe, and environmentally friendly. The authors claim that the goal of digitalization of agriculture is to achieve a significant increase in the efficiency and sustainability of its functioning through fundamental changes in the quality of management of both technological processes and decision-making processes at all levels of the hierarchy, based on modern production methods, and the further use of information about the state of controlled elements and subsystems, as well as states of the economic environment of agriculture. Based on a study of the use of visualization technologies within the framework of the philosophy of design thinking, it is shown that the introduction of digital technologies in the agro-industrial complex will dramatically increase labor productivity and reduce risks in agriculture. In modern conditions of intense competition, digitalization based on such projects will give the agricultural sector of any country (which is especially important for developing countries) great competitive advantages.

Keywords: agrarian sector; design thinking; theory and history of arts; economic process digitalization; innovative projects; visualization.

1 Introduction

The current stage of development of productive forces and production relations initiates the need for their qualitative transformation within the framework of the emerging model of innovative development of the country. This is reflected in the agricultural sector of the economy, where innovative activity becomes the dominant direction.

Meanwhile, low profitability of production and high risks of introducing innovations have made the agricultural sector of the economy unattractive for private investors, while local government support for investment processes does not make it possible to determine a system of strategic priorities for innovative entities in the agro-industrial complex. This proves the relevance and timeliness of scientific developments in the proposed direction.

Generalization and systematization of existing definitions of innovative activities of organizations in the agricultural sector make it possible to clarify the interpretation of this phenomenon. Leading experts believe that the investment process should be considered as a complex system characteristic capable of adapting to the changing influences of external and internal environmental factors, which is a constant and continuous process of transforming technical or technological ideas based on scientific developments into new technologies. In the prospect, these technologies should be used directly in production in order to obtain qualitatively new products and achieve economic, socially beneficial, and environmental effects [20].

It should also be taken into account that the complexity of agricultural production is the main factor when choosing methods for managing the innovation process, since, along with industrial means of production, biological organisms take an active part in the production process. Their development is determined by the action of natural laws and depends on factors such as climate, weather, heat, moisture, light, soil structure, etc. Such features predetermine the complexity and high level of risks of innovation processes in the agricultural sector. At the same time, it is necessary to take into account significant specifics in the assessment of innovative activity. Thus, the use of land as the main means of production requires the application of a dual approach to assessing innovation. Obtaining an economic effect, firstly, must be combined with replenishing soil fertility and preserving the environment and, secondly, the products of the complex must meet modern sanitary and environmental requirements. This gives grounds to define innovation, in relation to the agro-industrial complex, as a systematic process of using technical, technological, organizational, economic, social, and environmental innovations that ensure enhanced agro-industrial potential and increased socio-economic efficiency while maintaining and improving soil fertility and product quality.

A critical factor in the development of the agricultural sector today is digital transformation. Under the influence of digital transformation, agribusiness is changing quite quickly, while traditional boundaries and industry segments are blurring. Signs of the next revolution are already visible: robots and unmanned vehicles that are being developed specifically for agriculture, mechanized weed removal and fertilization or fruit picking. Robotic farming is now gaining momentum around the world, although just a few decades ago it seemed like a dim prospect. Precision agriculture is now based on soil maps, the use of satellites and drones, and information obtained through the Internet of Things. Drones, thanks to the advent of lightweight and powerful hyperspectral cameras, have made it possible to calculate the biomass and nutrient supply of plants, creating the basis for the development of more complex and accurate recommendations. Moreover, models based on decision trees that have been developed to date have made it possible to distinguish plant diseases based on visual information. “Virtual fence” technologies allow livestock to be grazed remotely using remote monitoring using sensors installed on the animals’ bodies [14]. For example, in Germany, the use of precision agriculture and smart farm systems has been practiced for almost two decades. Continuous improvement of hardware and software makes it possible to significantly improve the agricultural process, for example, for the optimal organization of the supply chain, from production to the flow of products to consumers [13].

Smart farming, as noted by Swiss scientists, reduces the harmful impact of agriculture on the environment through minimized or precise application of fertilizers and pesticides [10]. With modern ICT, near-constant monitoring of a farm using a network of sensors is entirely possible. Theoretical problems and practical issues of integrating information about the state of plants, animals, and soils with the needs for resources such as water and fertilizers have also been solved. Such goals are quite achievable even on a global scale.

The latest technologies make it possible to increase the volume of products produced, while using fewer resources and allocated space. Agriculture could soon become more precise, sustainable, and environmentally friendly. Combined together, these technologies have brought about revolutionary changes in agriculture in both more and less developed countries.

Digital technologies provide new opportunities for farm diversification. Like the “smart cities” that have been the subject of discussion and concept development, ICT capabilities are likely to lead not to a globally standardized and quickly adopted business system, but to a diversity of business systems. Management consulting will facilitate the contribution of technical innovation to diversification if it is reliable and transparent, even if farmers have no experience in growing a particular crop.

However, although the Internet of Things, applied to farm machines, animals, fields, plants, and trees, can be used to manage routine situations in agriculture, the farmer still has to be a researcher while keeping an eye out for an abnormal situation to arise. In addition, as in other sectors of the economy, competition is intensifying due to the development and implementation of the latest breakthrough technologies, in particular quantum technologies. In turn, there is an urgent need to apply the fundamentals of design thinking in projects in the agricultural sector.

Design thinking methodology has a creative component and borrows the work process of designers. David Kelly identified several basic principles of design thinking: idea generation, a team with diverse professional experience, maximum empathy towards consumers, and rapid prototyping using available tools [2]. Today, design thinking is actively used in the innovative activities of companies; the approach allows identifying the hidden needs of potential clients, understanding a person, his motives and values. Namely this feature of design thinking allows the team to focus its attention on the end consumer and, in the process of innovation, create a clearly valuable offer. One of the important areas of application of design thinking in the agricultural sector is the visualization of economic development projects. Design research allows identifying, interpreting, and visualizing information in a form accessible for further communication to all stakeholders.

It should be remembered that in the mid-20th century, the expression "industrial design" began to be used in relation to industrial production. However, by the end of the 20th century, the concept started to stabilize, and soon began to be pronounced simply as "design". Currently, the term "design" is used to express the nature of the artistic process or artistic and technical concept. Visual materials in the form of projects, sketches, layouts, various products, already completed projects, printed products, etc. can be called the final product here. Design and design thinking have become an integral part of the post-industrial economy. The very definition of the modern socio-economic formation - "karaoke capitalism" - indicates a paradigm shift in both economics and art; there is a kind of convergence of economic processes, digital transformation, and the development of visual art.

Design occupies an important place in the theory and history of art, since already starting from the 20th century, art has increasingly merged with design. The Bauhaus is the most famous and influential interdisciplinary school of art and design of the 20th century. The main concept of the school was to combine art with the practical skills and knowledge of the properties and capabilities of the material. The main task was to move away from the classical perception of art as separate forms, to bring together all its types, from painting to architecture and mechanisms. This school of design specialized in making products whose appeal was created not by extra work (such as external ornamentation, which takes time to apply), but by the inherent properties of the object. Interestingly, the creators of Apple used the basic principles of Bauhaus and believed that the design of every product should be beautiful and simple. But most importantly, if the product did not work or was too difficult for the user, then beauty did not matter.

Thus, design is not a simple field of activity. On the contrary, the design is complex in terms of structure. This includes the interrelationships of social and economic life, cultural and artistic activities, the manufacture of products and the formation of the necessary environment, as well as the description and optimization of economic processes. The visual display allows users to intuitively perform data sorting and classification operations and quickly understand the characteristics and category features of the data. But design thinking is a necessary condition for development of such visualization tools. Agrarian sphere is one of the fields where the above trends manifest to significant extent.

2 Method

The theoretical and methodological basis of the study consisted of the works, developments, and scientific recommendations of academic economists on the issues of innovative development of rural commodity producers, increasing the efficiency of their functioning, the formation of innovative infrastructure of the agro-industrial complex, the works of scientists on the problems of informatization and digitalization of agriculture and the use of information and digital technologies in agricultural management production.

The research carried out was based on a systematic approach to the objects and processes being studied. In the course of the work, dialectical, abstract-logical, monographic, and other methods of research were used.

3 Results and Discussion

Today, the philosophy and approaches of design thinking are actively used in innovative entrepreneurship - to create new businesses, as well as to generate business models [22]. There is a tendency to use the apparatus of design thinking to form desirable scenarios for the development of the future, because the activities of any organization will be determined to a greater extent by the holistic vision of the society it serves to build.

Design thinking is understood as an approach that is based on the designer's intuition and problem-solving methods, aimed at meeting people's needs in a commercially viable and technologically feasible way. In other words, design thinking is nothing more than innovation, the center of which is the person and his needs [10]. The words "design" and "innovation" are now becoming synonymous, and design thinking is characterized as a methodology for creating these innovations.

Design thinking takes advantage of the capabilities that exist in every person, but are not taken into account in standard problem-solving methods. Design thinking is human in its essence and is based on a person's ability to intuitively feel, to create ideas that carry not only a functional, but also an emotional component, to express oneself not only in words or symbols [1]. This is not about managing a project based on feelings, intuition, and inspiration, but about the need to move away from over-reliance on rationalism and an analytical approach [23].

The process of solving a problem from the point of view of design thinking consists of a number of successive stages, each of which requires compliance with the above principles. The Stanford School identifies five main stages - "Understanding", "Focus", "Idea", "Prototype", "Testing". In a number of studies, a larger number of stages is found only due to the fact that individual steps are divided into smaller, narrow tasks [24]. In general, the design thinking method consists of six key stages:

Stage 1 – empathy. The concept, which comes from psychology, is borrowed and effectively implemented into the mechanism of design thinking. It means the ability to hear and understand what exactly the client is saying, what wishes he expresses for the final product. But it is even more important to hear what the client did not say and, perhaps, did not realize himself, but at the same time what is really important and desirable for him. Empathy is associated with the ability to 'put oneself in the consumer's shoes'. And here the approaches developed and already actively implemented by modern companies within the framework of stakeholder theory become relevant. Dialogue with stakeholders is built "from a position of flexibility, differentiation depending on the interests of stakeholders, their tasks and goals, and is based on the principles of trust, mutual respect and feedback" [1]. Feedback is at the heart of the first stage of design thinking. In addition, important elements of this stage are observations, in-depth interviews, studying the environment surrounding a person, the context of his problem, one day in the life. The result of the research is an empathy map - a tool that helps understand the customer to whom the product is addressed. By creating such a map, the developer puts himself in the user's place [6]. Empathy maps can be used to test prototypes and during role-plays to better understand the needs of the audience.

Stage 2 – focusing. This is a transitional stage at which the received information is processed in order to eliminate everything unnecessary and secondary. At this stage, the client's problems should be formulated, which will subsequently become tasks. Focusing allows getting an explicit expression of the problem that needs to be solved based on the collected information about the needs of the person. The point of focusing is to formulate a question; the question should be related to the problem. In this case, the question should be formulated as specifically as possible, not about the problem as a whole, but about the problem of a specific person.

Stage 3 – generation of ideas. At this stage, there is a transition from defining the problem to creating a solution for the user. It is very important that this solution is truly created for a specific client, consumer, and not tailored to a standard option. Non-standard and individuality are the main postulates of this stage. To generate ideas, the creation of a prototype or layout, as well as bodystorming, is used. In the latter, the idea is to imagine what it would be like if the product existed and act as if it ideally existed in the place where it will be used.

Stage 4 – choosing an idea. To select an idea that best suits the needs of the consumer, it is necessary to develop selection criteria. Then, from a variety of possible scenarios, the ideal one is selected, which best meets the requirements and satisfies the selected criteria.

Stage 5 – prototyping. A prototype may look like a simple drawing, or a fully thought-out concept represented using a template, or a spreadsheet [15]. The prototype has several purposes. It is necessary as a tool for communication with the client, interaction for the purpose of the most fruitful and effective interaction. With the help of a prototype, it becomes possible to test a finished product or service, which will maximize the satisfaction of the customer's wishes. The prototype allows managing the solution development process and identifies changeable conditions.

Stage 6 – testing. Testing is about getting feedback on prototypes. Testing can take place in two scenarios. In one, the customer tests the prototype independently, while in the second, testing is carried out jointly with the contractor. Testing is aimed at solving several problems: improving the prototype, identifying its shortcomings, identifying unsolved problems and developing new solutions. Testing eliminates possible misunderstandings between the customer and the contractor. If to ignore this stage, then most likely the needs of the interested parties will not be fully satisfied and all previous work will be in vain, and therefore, the costs associated with it will not be covered by income [8; 24].

Since agriculture is dynamic, it exhibits both positive and antagonistic interactions due to the presence of contradictions in any sphere of human activity. Firstly, all objects in the agricultural economy are interconnected, secondly, they interact with each other, thirdly, interaction is a process of mutual influence, high communication and mutual relations between them. Agriculture is a production system whose purpose is to produce food products for consumption and raw materials for processing industries. This means that economic processes in agriculture are not the result of the interaction of two or more objects. The system determines the presence of many interconnected opposing elements that are in constant, enduring contradiction. Design thinking can help resolve contradictions and harmonize all elements.

As noted above, the goal of digitalization of agriculture is to achieve a significant increase in the efficiency and sustainability of its functioning through fundamental changes in the quality of management of both technological processes and decision-making processes at all levels of the hierarchy, based on modern production methods and the further use of information about the state of controlled elements and subsystems, as well as the state of the economic environment of agriculture.

Among the key basic areas of innovation, the following should be noted [19-21]:

1. "Smart" field - ensuring stable growth in the production of agricultural crop products through the introduction of digital technologies for collecting, processing, and using an array of data on the state of soils, plants, and the environment.
2. "Smart" garden - at least 90% of the area of perennial plantings in digitized form in a unified geographic information system; at least 40% of the area of industrial gardens must be provided with means of collecting data on the state of soils, plants, and the environment; at least 50% of the area of industrial gardens must be covered by a data transmission network to ensure the collection of Big Data; at least 60% of mobile technical equipment will be equipped with monitoring systems and included in a unified geographic information system; at least 30% of technical equipment will be robotic.
3. "Smart" greenhouse - development of modern integrated technology for "smart" greenhouses, based on the use of the Internet of Things for food production; ensuring stable growth in crop production in protected soil; obtaining highly competitive substrates and fertilizers; domestic innovative systems (microclimate, lighting, efficient energy supply, universal module, power supply, autonomy, etc.) for closed ground; methods of product quality control, increasing the nutritional value of vegetables.
4. "Smart" farm - the creation of digital technologies that ensure the independence and competitiveness of the livestock complex; creation and implementation of technologies to increase milk productivity of animals up to 13,000 l/year; reducing the incidence of mastitis in cows and, consequently, reducing the cost of antibiotics; creation and implementation of technologies for autonomous production (without an operator), energy efficiency and energy mobility in a "smart farm"; creation of safe and high-quality, including functional, food products.

The development of the modern agricultural sector occurs in several directions simultaneously, with the main focus being on the introduction of new technologies in agriculture. The use of best practices helps improve agricultural sustainability through smarter and more informed management decisions.

In addition, modern agricultural technologies to increase yields optimize the profitability of agricultural enterprises. Farmers successfully combine time-tested and new farming methods. For example, the sequence of crops in a crop rotation can be effectively planned using digital agriculture technologies to monitor field productivity based on satellite imagery.

It is necessary to develop the following end-to-end technologies: Internet of Things; RFID technologies; neural networks; big data; artificial intelligence; new production technologies; sensors and robotics components; Blockchain technologies; contactless and remote technologies [4; 7].

New technologies in the agricultural sector (agritech) cover a wide range of industries and technical means aimed at increasing the productivity of agricultural enterprises. Of course, the development of such technological solutions requires visualization.

The introduction of new smart farming methods based on projects that involve visualization within the framework of design thinking, taking into account all systemic connections and influencing factors, benefits all participants in the agri-food chain. The use of the latest technologies in agriculture to optimize and automate agricultural operations and field work can significantly save time and resources. Let us name the main advantages of using new agricultural technologies:

- Using irrigation water, fertilizers, pesticides, and other resources in smaller quantities allows agricultural producers to reduce costs and retain more of their profits;
- Reducing the volume of chemical runoff from fields and preventing pollution of water bodies mitigates the negative impact of farming on the environment and helps to increase the sustainability of agriculture;
- Increased productivity with reduced labor costs;

- Simplification of interaction between participants in the agricultural process and coordination of their actions using mobile devices, new specialized applications or web resources;
- Facilitating access to agricultural insurance and financial services, as well as market and technological data;
- Minimization of losses due to the invasion of field pests, natural disasters and unfavorable weather conditions in the fields using permanent agricultural monitoring systems at reasonable prices;
- Increased income of agricultural enterprises due to improved quality of agricultural products and strengthened quality control;
- Timely detection of nutrient deficiencies in plants and informing agricultural producers about the type and quantity of fertilizers and other agrochemicals needed to treat crops and increase their yield;
- Ability to predict potential problems in the field through new capabilities to visualize production patterns and laws resulting from the application of new methods for analyzing current and historical field data.

Agriculture 4.0 is born in the era of widespread automation and the use of digital technologies. The development of new agricultural technologies is becoming more integrated and networked, which makes it possible to optimize all stages of the production process and improve the processes of monitoring, control, and business management [19].

During the production process, farmers face a number of problems such as pest attacks and plant diseases. The weather factor in agriculture should also be taken into account: meteorological anomalies can cause serious damage to the crop. However, new digital technologies make it possible to minimize negative consequences. At the same time, with the help of new technologies, farmers can control those agricultural aspects that directly depend on them, and as a result, increase their profits. In particular, digital technologies in agriculture help to obtain a reasonable answer to the following questions [5; 10]:

- What types of crops to grow;
- How to optimally alternate crops in crop rotation;
- How often and in what volume to use water for precision irrigation;
- When to apply fertilizers and plant protection products, which one and how much;
- Which treatment is best suited for a given soil type.

The competitive advantages of agricultural enterprises are ensured by the use of modern software, remote sensing technologies (especially high-resolution satellite images), proximal sensors, new means of communication, and risk forecasting algorithms based on accurate data.

For example, one of the useful developments is CROP-monitoring, a high-tech agricultural tool that provides reliable analytics of field conditions for farmers, agricultural traders, and insurers.

In particular, EOSDA Crop Monitoring offers many useful features, such as graphs of precipitation and weather conditions. The user can analyze the values of accumulated precipitation and determine the level of humidity in a specific field. In this way, he makes reliable decisions regarding the need for irrigation and adjusts the timing of field work depending on meteorological phenomena. This allows avoiding excessive or, conversely, insufficient irrigation.

Visualization is one of the foundations of Crop Monitoring. For example, the Red Edge Chlorophyll Index shows areas of soybean field that need fertilizer (see Figure 1).

Figure 1. Chlorophyll Red Edge index, visualization (CROP Monitoring)

The normalized difference RedE indicates the photosynthetic activity occurring in the canopy and the estimated nitrogen concentration in the soybean plants in the selected field (see Figure 2).

Figure 2. Normalized RedE difference indicating photosynthetic activity CROP Monitoring)

Satellite photography can considerably improve variable rate seeding. The utilization of remote sensing data from the EOSDA Crop Monitoring satellite-based precision agriculture platform is one example. The scientists focused on vegetation and soil indices from several spectral bands. They were able to pinpoint areas of interest where agricultural tactics for precision planting variable rates should be readjusted due to drastic variations in those values (see Figure 3).

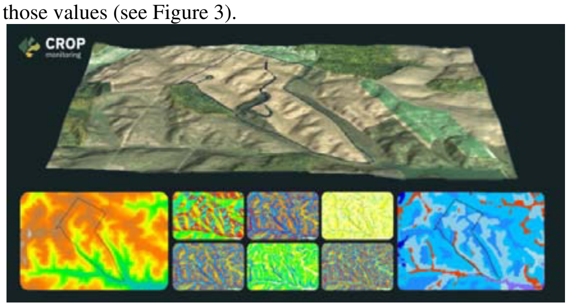

Figure 3. 3D visualization of the field with a digital elevation model, its derivatives, and a prediction map of the soil cover

General sample of visualization of agri-data tools for big data analytics is presented in Figure 4.

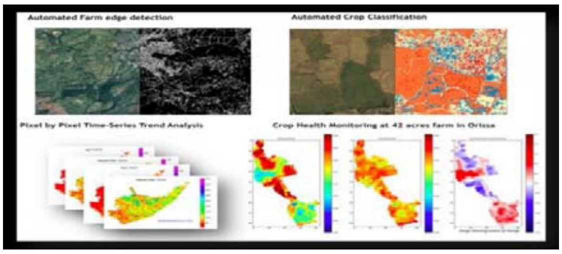

Figure 4. Visualization of agri-data based on big data analytics

Internet coverage, standard interception, interference, propagation losses, communication range, wireless connection quality, network growth, network management, communication protocols, latency, and throughput are the most frequent Ag-IoT network layer challenges. Because most farms are in rural areas, isolated locales, or mountain regions, getting internet connectivity to them is a big difficulty because these underpopulated areas have little internet infrastructure. Creating a local network, akin to a hybrid cloud, could be one approach. This system does not connect to the internet, but it does allow local servers to provide rudimentary IoT capabilities [3]. Because of recent advancements in low earth orbit (LEO) satellites, commercial internet connectivity via satellite, as shown in Figure 5, would be available shortly. In fact, Figure 4 is a 'classic' example of the use of design thinking in the visualization of economic development projects in the agricultural sector.

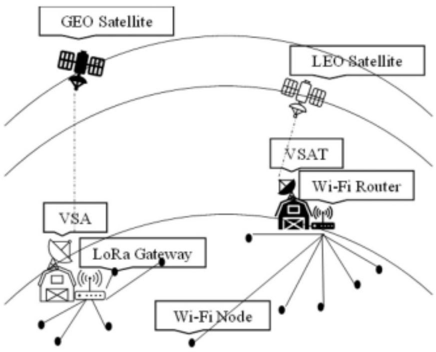

Figure 5. Future Ag-IoT system with satellite connected internet [3]

Moreover, VR and AR have emerged as transformative tools for stakeholder engagement, surpassing traditional communication methods and now are actively used for visualization of innovative projects in agriculture sector, enabling addressing the interests of all stakeholders and participants in frames of design thinking [9].

Plant Vision (formerly known as Huxley) is one such example. This crop management system entirely digitizes plant farming by utilizing artificial intelligence, machine learning, and augmented reality. To collect data, RGB and infrared cameras and sensors are being deployed in a facility. Crops are photographed every minute, and the AI scans the images to determine their health. A farmer can utilize wearables such as Google Glass to acquire augmented reality information such as temperature and plant health.

Irrigation, application of fertilizers, pesticides, and other agricultural inputs at large agricultural enterprises no longer occurs "by eye" or in equal quantities throughout the entire field. Thanks to new technologies in agriculture, agronomists can apply only what is required on a particular site, and also carefully select the right treatment for each crop.

It must be taken into account that AR/VR technologies are a tool, and the creation of cases and understanding of effectiveness is based on tasks and needs, which is determined when applying design thinking. In particular, AR/VR technologies are used to increase the investment attractiveness of agribusiness and to present agricultural enterprises to potential investors. In particular, in Ukraine, a unique comprehensive virtual tour was created for APK-Invest, one of the largest agro-industrial complexes in the country (it covers a significant territory of the Dnipropetrovsk region, almost 30 thousand sq. m.). As part of the project, digital platform company 3DTOUR created aerial panoramas, ground-based 3D panoramas, video inserts, and a corporate-style web interface for the presentation of the tour.

Despite the apparent external stability of the structure of the regional agricultural sector, it is in constant movement and development both in time (from the moment of sowing seeds to harvesting agricultural crops; from the birth of the offspring of farm animals to their rearing and fattening) and in space (movement of products agriculture within the territorial boundaries of the region and beyond).

Having defined time, space and movement as the main characteristics of the existence of processes and phenomena in the agricultural economy, as well as taking into account the presence of the unity of their three entities - the external environment, the object and the boundaries between them, we predetermined the need to study these categories from the point of view of the repeatability of economic processes, as well as objective the existence of opposites and contradictions in them. However, one should recognize the existence of the factor of chance as a reflection of external, insignificant, unstable, single connections of reality, the result of the intersection of independent causes and events. At the same time, there are several different options for turning possibility into reality, but only one is implemented. The effect of randomness has a destructive impact on cyclical processes in agriculture - these are natural and man-made risk factors, as well as economic factors (for example, the recent EU embargo on grain imports from Ukraine).

Therefore, the goal of the designing and development of innovative projects and digital platforms of the agro-industrial complex is to radically increase the efficiency of agricultural and agro-industrial enterprises through the widespread introduction into production processes of new digital, including end-to-end, technologies and innovative business models for market interaction of these enterprises based on the model "platform as a service", which involves complex visualization and the mandatory application of design thinking principles.

In each area of the agro-industrial complex, there are several markets, each of which can be equipped with its own digital platform. For convenience, if a certain market is part of another, larger market, then the digital platform supporting it will be called a subplatform in relation to the platform of the larger market. Each of these subplatforms may have its own subplatform. For example, a crop subplatform may contain grain subplatforms, which in turn may contain wheat subplatforms, corn subplatforms, etc.

Application modules (API) can be programmatically attached to each subplatform, which solve specific problems of the subplatform participants. In addition, sections of subplatforms may use the end-to-end technologies described above.

Thus, design thinking, including in agrarian sector, is actually a human-centered approach. This approach is capable of revealing new perspectives through interdisciplinarity, embodying the most original ideas, satisfying the most demanding stakeholders and leading to innovative solutions in the agricultural sector. Design paradigm helps in visualization of both production and economic processes in agrarian sphere, with AR and VR as the convergence of science and art. Combining data, design and artificial intelligence will create new breakthroughs in digital experiences.

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Primary Paper Section: A

Secondary Paper Section: AE, AH