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PROSPECTS OF IMPLEMENTATION OF BLOCKCHAIN TECHNOLOGY INTO AQUACULTURE SECTOR OF UKRAINE

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Introduction. The development of fish farming in aquaculture in a sustainable way ensures the sustainability of fisheries, which is associated with local problems in each region. Ukraine's fish production has been falling sharply over the last 30 years, and in 2021 the decline was more than 87 percent in comparison with 1990. In the Ukrainian aquaculture sector, there is a high degree of bureaucracy and risks of corruption, which need to be addressed in order to find a solution for the economy and businessmen. World reports show that Ukraine is among the world's leaders in illegal fishing. Thus, it is highly necessary to implement technologies for sector traceability and transparency, i.e., blockchain.

Aim and tasks. The main aim of this article is to research the possible mechanism of implementation of the transparent and efficient system of using the aquatic bioresources of Ukraine. A secondary aim would be to actualize the information regarding the use of blockchain technology in the aquaculture sector.

Results. This research shows that Ukraine's aquacultural sector is going through a crisis, which is being induced by the high level of corruption and poaching. The digitization of the aquaculture supply chain powered by blockchain technology has been proposed. The role of blockchain technologies is revealed through functions such as evidence, tamper-proof, transparency, and decentralization. It was investigated the positive impact of blockchain technology on aquaculture business, such as reduction in bureaucracy, quality assurance, improvement in information exchange, low cost of transactions, improvement in audit performance, easy recall process, product origin verification, and low probability of fraudulent activity. It would greatly reduce the time needed to gather all the documentation essential for work and reporting. The blockchain implementation roadmap has been developed, including the following stages: concept, legislation compliance, limited prototype, final vision, further research and optimization.

Conclusions. Blockchain technology fits Ukraine's economic goals in the long term perspective, such as continued digitalization of the country. Due to the blockchain technology, products of aquaculture would not enter the market unless registered in the unified system. That will influence the reduction of "informal economy" in the sector and the increase of market mechanisms. It will also have a positive influence on food security for the population and economic security for the producers. It will be a precedent for a fully transparent and digitalized field of economy.

Keywords: blockchain, aquaculture, innovation, traceability, supply chain.

1. Introduction.

In the Ukrainian culture and history freshwater fish have played an important role in dietary traditions and cultural practices for centuries, due to key location of the country nearby all key water basins and reservoirs. Traditionally, most aquaculture facilities in Ukraine are freshwater pond farms for common carp (Cyprinus carpio), silver carp (Hypophthalmichthys molitrix), bighead carp (Hypophthalmichthys nobilis), grass carp (Ctenopharyngodon idella) and Prussian carp (Carassius gibelio) that provide about 90% of total aquaculture production. Farming of other species-including European and African catfish (Clarias gariepinus), barracuda, walleye (Sander lucioperca), trout, sturgeon, and beluga-in pens, circulation systems, recirculating aquaculture systems etc., has increased slightly in recent years, but production still barely exceeds 10% of total production, so pond culture is the main source of farmed fish in Ukraine.

Aquaculture production peaked at 136.5 thousand tons in 1990 and then declined sharply. From 2018 to 2021 aquaculture production levels varied slightly, but in dynamic it can be seen the sharp decline over the last not just decades, but also over the last years (Figure 1). The production level fell by 21 percent since 2016, and in comparison with 1990 the production level fell by more than 87 percent in 2021 (State Agency for Land Reclamation and Fisheries of Ukraine, 2022).

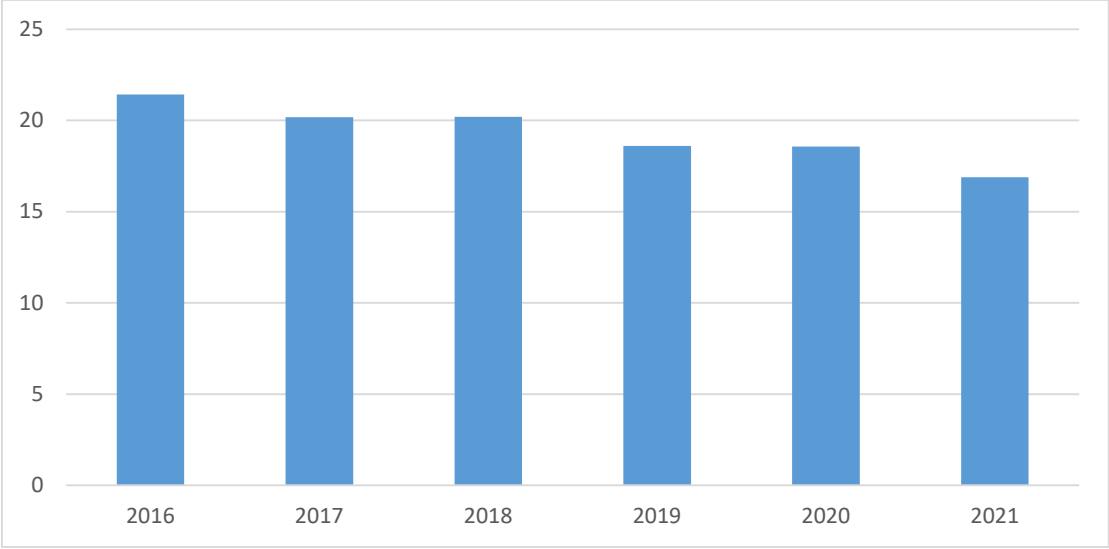

Fig. 1. Aquaculture production in Ukraine in 2018-2021, thousand tons.

Source: State Agency for Land Reclamation and Fisheries of Ukraine (2022).

Moreover, there is a high degree of bureaucracy and risks of corruption, which need to be addressed in order to find a solution for the economy and businessmen (Table 1). Factors mentioned in the table clearly show the problem Ukraine is facing right now: high level of bureaucracy and corruption. Other reports also show that Ukraine is among world leaders in illegal fishery, for example in the Illegal, Unreported and Unregulated Fishing Index, Ukraine is placed 7th in the World, and 2nd in Europe (IUU Fishing Index, 2022).

It should be remembered that in Ukraine the problem of poaching and so-called IUU fishing still exists in very high volumes, so approximately half of the products remain in the shadows, if not more, and do not enter official statistics. According to various estimates, 45-90 thousand tons can also be listed. National agency reports on the poaching of fish products in Ukrainian waters almost daily (Effective management office BRDO, 2019).

There is a clear need for improved traceability and transparency to distinguish honest companies and to support the United Nations (UN) Sustainable Development Goals (SDGs), e.g. Goal 9: Industry, Innovation and Infrastructure; Goal 12: Responsible consumption and production; Goal 14: Underwater life.

Blockchain technology has the potential to contribute to these goals, but it is relatively new, in the early stages of adoption, and faces many technical and socioeconomic challenges. However, there have been numerous reports documenting the use of pilots in a variety of sectors including agriculture, capture fisheries and aquaculture (Ge et al., 2017).

Table 1. Analysis results of regulation methods by the corruption risks.

Regulation tool (method)	Sum of points by corruption criteria	Risk level
Approval of the establishment of cultural fisheries	8,6	High
Agreement on acclimatization (reacclimatization), resettlement and breeding of new for the fauna of Ukraine or genetically modified aquatic living resources, stocking of reservoirs, etc.	7	High
Approval of the application for works on the introduction of aquatic bioresources into a fishery water body	9,6	High
Approval of the schedule for the introduction of aquatic bioresources	6	High
Underwater hunter's license	7	High
Permition for the right to engage in recreational and sport fishing	8,6	High

Source: Effective management office BRDO (2019).

2. Literature review.

The topic of aquaculture industry optimization is not new in the scientific articles, but in Ukraine researches are more closely connected to the standard ways of improving the efficiency, for example, the organizational and economic basis of the development of fisheries and aquaculture in Ukraine have been studied by (Vdovenko et al., 2020). In their work, the current state of commercial fish farming was analysed using the statistical information from the form 1A-Fish (annual), researching different aspects of statistics connected with types of fish and recommendations for its improvement. Some tried to take a look on the problem through the business factors (Dobrovolska, & Zubko, 2021). They have researched the factors influencing the status of the identified fish farm efficiency and possibilities for its improving, a comparison of the development of world and Ukrainian aquaculture enterprises was made. The world aquaculture sector is monitoring by the Food and Agriculture Organization of the United Nations.

The usage of blockchain technologies is mentioned in international studies, especially in developed countries, for example Wassenaer et al. (2021) have discussed the possibility of using the blockchains in food production and underlined the method of using it in the agriculture. The blockchain as a tool of tracing the products of food markets at all stages of production, processing and distribution have been researched by Cruz (2020).

Moreover, Sylvester (2019) in his study researched the fact, that blockchain technology can root out corruption and also provide transparency for the records and bookkeeping if the technology would be universally accepted. The technology itself provides more security than standard bookkeeping due to the fact that blockchain entries can’t be modified and altered after the fact of transaction, thus creating a transparent ledger from the production stage until the consumption or the shipping out of the country borders (García-Oliveira et al., 2022).

3. Aim and tasks.

The problem of transparency, excessive bureaucracy and illegal fishing activities is widely discussed both in Ukraine and in the world. Researches that are focused on implementation of blockchain technology into agricultural sector, including aquaculture, have been also provided.

There are examples of Spain and Netherlands, nevertheless there is a lack of such studies in Ukrainian reality. Such studies are of current interest considering the international rating of IUU index of the country and comments made by Ukraine officials regarding the volumes of poaching.

The main aim of this article is to research the possible mechanism of implementation the transparent and efficient system of using the aquatic bioresources of Ukraine. Secondary aim would be to actualize the information regarding the use of blockchain technology in the aquaculture industry.

4. Results.

As it can be seen from the analysis of the previous publications, Ukraine has issues in the field of fighting corruption and in bypassing the necessary bureaucratic procedures. In accordance with the requirements of legislation, to obtain the right to engage in industrial fishing, the fishing company must: obtain a quota to catch a certain amount of fish, permission for special use of aquatic bioresources, register an industrial log, obtain an industrial ticket, agree on the location of fish collection points, on the volume of extraction of aquatic bioresources and pay funds for the special use of aquatic bioresources. That is, the fisher/company should apply to the State Agency for Land Reclamation and Fisheries of Ukraine and its territorial bodies at least 6 times.

The presence of IUU fishing in Ukraine is characterized by the detection of cases of poaching, concealment of real catches in order to avoid payment for special use of aquatic bioresources, the presence in the reservoirs of prohibited tools and fishing gear, as well as representation of fish in the consumer market, that exceed official withdrawal statistics.

The blockchain technology is seen as an effective mechanism for overcoming the above-mntioned problems in the aquaculture sector of Ukraine. Blockchain is a distributed ledger technology used to securely record and verify information about subsequent events or transactions. Often associated with the financial services sector due to its use in cryptocurrencies, it also has potential applications in agriculture. In difference to standard methods of data storage, blockchain has decentralized the ability to keep the records within the system or verify transactions on behalf of users. Instead, every member of the blockchain platform has access to an automatically updated copy of all transactions. Every transaction is recorded in a new block in the chain.

Functions, which are helpful in monitoring the transactions during the production:

– Evidence. Each block contains several pieces of information: the data itself; a hash value or alphanumeric string determined by the encryption of the data; and the hash value of the previous block in the chain. Changing the data essentially changes its hash. Therefore, data tampering is obvious when the hash of a block does not match the network block record of the hash of the previous block.

– Tamper-proof. Every blockchain community member has access to an automatically updated copy of the blockchain. If data in one replica is tampered with, it will be inconsistent with other replicas and the community will not accept that chain as the consensus chain for events.

– Transparency. While each member of the blockchain community may not have permission to read the data in each lock, each member has access to an up-to-date copy of the ledger and can view changes and additions to the chain.

– Decentralization. Blockchains do not rely on a central authority to maintain data (Croft, 2021).

The World Wildlife Fund - New Zealand is running a test project to end poaching and criminal offences regarding illegal fishing in the tuna production industry located on the Pacific Islands. They work with various other organizations to track fish from boats to supermarkets. This blockchain supply chain traceability project leverages digital technologies in the Western and Central Pacific fresh and frozen tuna sectors to enhance supply chain management (WWF-New Zealand, 2019).

A simplified example of the digitization of aquaculture supply chains powered by blockchain technology is shown in the Figure 2. Firstly, there are physical processes that take place in the real world, and then users have to undergo online authentication and digital signatures; sensors and actuators; mobile phones.

The Internet/Web acts as the connectivity infrastructure (Zhang et al., 2021). Every action on the chain realized by using the abovementioned digital technologies and is recorded on the blockchain. An immutable way of storing information that is accepted by all involved parties. The information obtained in each transaction is verified by the business partners of the supply network and a consensus is formed among all participants. After each block is verified, it is added to the transaction chain (as shown in Figure 2) and becomes a permanent unchangeable record of the entire process (Kamilaris et al., 2020).

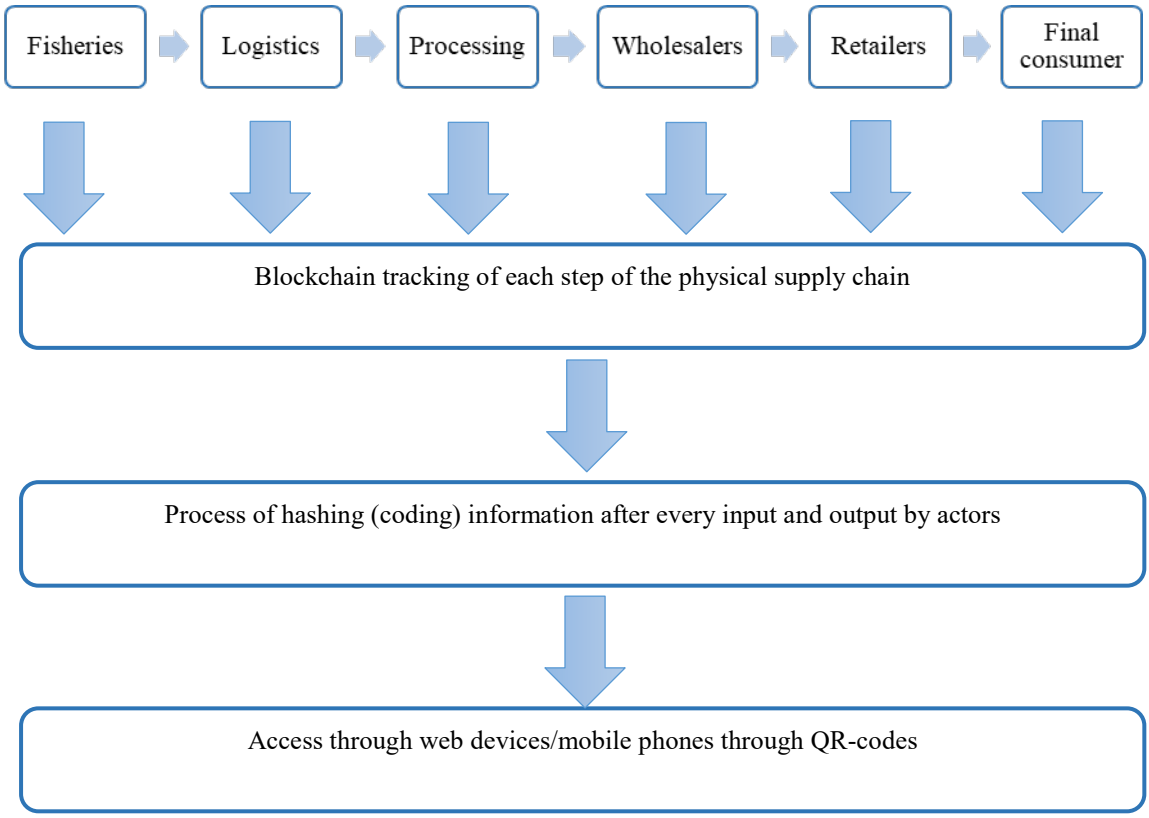

Fig. 2. Blockchain technology in aquaculture businesses.
Source: based on SourceTrace (2020).

Each stage of the fish journey (defined in Figure 2) involves different technologies and writes different information to the blockchain, the details of each stage are as follows:

1. Fisheries: information on populations grown, feed and chemicals used, machinery used, etc. Record transactions with producers/fishers.

2. Logistics: information about the conditions of transportation, time of movement from the fishery to the warehouse.

3. Processing: information about the conditions and location of the fish processing facility, the sanitary documentation and licenses, technical equipment used in the processing of the fish products.

4. Wholesalers/warehouses: shipping details, tracking track, storage conditions (e.g. temperature, humidity), shipping time for each shipping method, etc. All transactions between dealers and between the ultimate recipients (i.e. retailers) are recorded on the blockchain.

5. Retailer: the chain provides detailed information about each fish product, its current quality and quantity, storage conditions, and shelf life.

6. Consumer: in the final stage, the consumer can scan the QR code related to the fish using a mobile phone or web application connected to the internet/network and view all the information related to the product in detail. From the pond, where fish was caught, to distributors and retailers (SourceTrace, 2020).

Moreover, the other improvements from the implementation of the blockchain technology may be seen in the Table 2.

One of the key supply chain management goals expected to be impacted by blockchain technology is quality. Blockchain technology offers the possibility of a low-cost, detailed system for product identification and recording. Blockchain technology is not only a product identification system, but also has features that allow contracts and other important documents to be digitally signed throughout the supply chain, providing a common platform for supply chain financial management. Since all these operations are performed through a single system with open and easily auditable records, both the availability and quality of information can be improved. Improving the availability and quality of information is critical to improving other types of supply chain processes. The increased level of detail of the information available makes it possible to trace the material flow of defective or non-conforming products. In this way, the cause of the error can be quickly located and measures to improve production quality can be initiated by eliminating the cause. Quickly identifying and eliminating the cause of defects or product failures that could be dangerous to end users can prevent possible negative effects on a company or brand reputation.

Table 2. Objectives blockchain achieves.

Objective	Advantage	Argument
Quality	Decrease of bureaucracy level	All documents need to be signed only with a digital personal key, which should be registered in the system. All documentation can be viewed at any point in time, due to the cloud database (Mathisen, 2018).
	Quality guarantee	Provided information ensures that the product was registered in the system and therefore buyer or wholesaler can monitor all activities (Kshetri, 2018).
	Improvement in information exchange	Mistakes in decision-making process would be reduced due to the fact of full availability of information. Virtual prints are left on all transactions and communications (Turk, & Klinc, 2017).
Cost	Low costs of transactions	Some blockchain systems take as low, as 0.01$ per transaction.
	Improvement of performance at audits	All operations are transparent and are easily viewed in the blockchain system (Kshetri, 2018).
	Ease for recall process	All operations are saved in the blockchain system, therefore each individual buyer can easily view the batch that is purchased (Mathisen, 2018).
Sustainability	Product origin	Provenance of the commodity is slightly increased (Turk, & Klinc, 2017). Liability determination is easier (Mathisen, 2018).
	Low probability of fraudulent activity	The whole history of the transactions is available, therefore suppliers and consumers can both be confident in each other (Foerstl, Schleper, & Henke, 2017).

Source: based on Mathisen (2018), Kshetri (2018), Turk, Klinc (2017), Foerstl, Schleper, Henke (2017).

If blockchain technology is also combined with sensors, attributes such as temperature, pH and product contamination can be monitored. In these cases, the farmed fish connected to the sensor can be tracked as it moves from the aquaculture producer to the retailer's shelf (Garrard, & Fielke, 2020).

The sensor can be programmed to send data about the temperature of the fish to a blockchain-based logbook within a short period of time. When this data is stored on the blockchain, it is permanent and cannot be changed later. This means that any participant in the supply chain can access the temperature data of fish products through their unique blockchain identity and check whether the fish has exceeded a predefined acceptable temperature range. If the temperature at any point in the supply chain is outside the acceptable range, liability can easily be linked to the supply chain actor who owns the product at that particular point in time. In this way, overall process quality can be improved by quickly identifying and improving weak links in the supply chain (Mathisen, 2018).

Profit margins are usually low in a wholesale business or at a level of production. A small fraction of this resulting cost reduction can have a significant impact on a company's bottom line. For this reason, an expensive investment in a detailed traceability system for functional products is not attractive to functional product manufacturers. In other words, the benefits of using a traceability system for viable products have not outweighed the costs, resulting in lower profit margins.

The possibility raised by blockchain technology is a traceability system that brings a higher level of detail without the high ongoing costs. The combination of blockchain technology for records and technical solutions for product identification such as barcodes or QR codes makes blockchain-based records a viable option in companies where lean philosophy is an integral part of the supply chain. Attractive alternative strategies for detailed tracking mechanisms (IBM, 2018).

The Deloitte research highlights that while blockchain technology holds great promise for fisheries, the technology is still in its early stages; however, the elements needed to integrate a functioning ecosystem are already in place. A combination of investment and changes in business practices is required. In fact, the most tangible advancements to witness blockchain use cases are supply chain applications such as data integration and asset status tracking. Fisheries can learn from this experience (Blohmke, & Edgren, 2019).

Nevertheless, for implementing changes it would be needed either voluntarily support of all actors in the market, in order for it to be effective, or country would need progressive government regulation, which would guide the businesses through steps pictured in Figure 3.

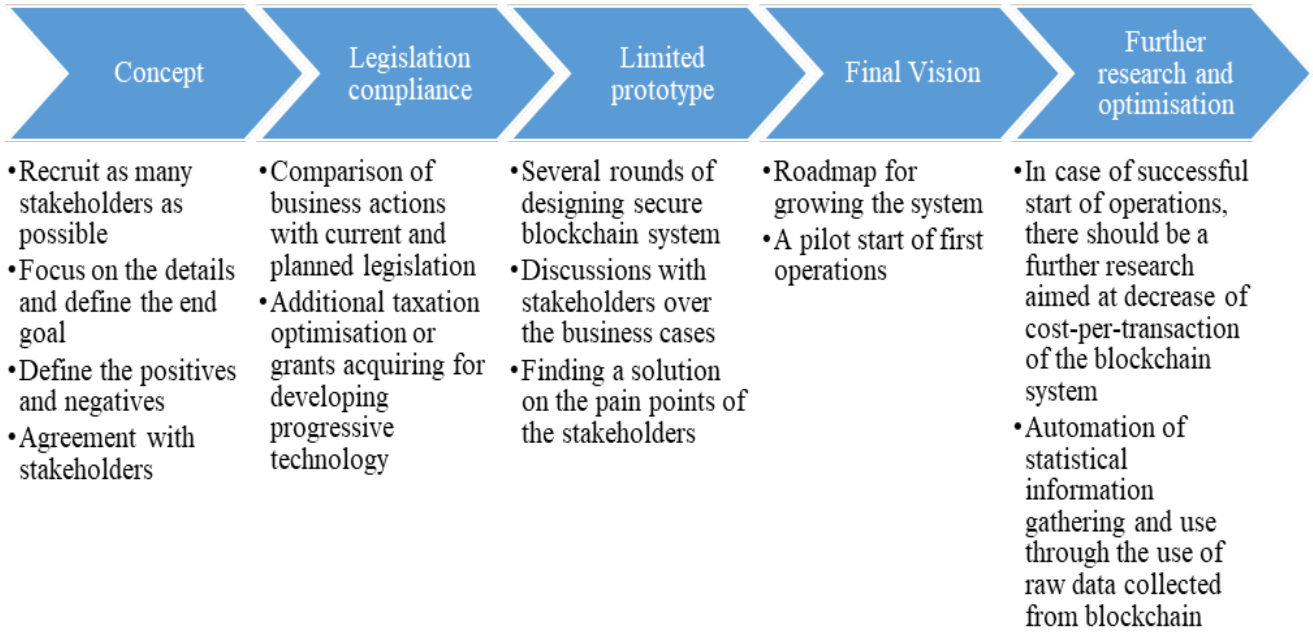

Fig. 3. Blockchain implementation roadmap.

Source: based on Blohmke, & Edgren (2019).

On the basis of this roadmap the program for the blockchain technology implementation into aquaculture sector could be developed at the national level. This meets the concept "the state in a smartphone", that is provided in Ukraine, and is the task for further research.

As a result of this study it was revealed that Ukraine's fish production has been falling sharply over the last 30 years, analysis show that official numbers on the industry show continuing decline, while international organizations and researchers underline the fact that corruption and illegal, unreported and unregulated fishing has been causing more losses for the industry.

Nevertheless, blockchain technology fits Ukraine's economic goals in the long-term perspective, such as continued digitalization of the country. Also, it was discovered that this technology can affect businesses in the field of growing and gathering aquacultures, because blockchain-based system would greatly reduce the time needed to gather all documentation essential for work and reporting, also it would increase the speed of work of fiscal inspectors, who would audit companies with much greater speed due to transparency of the system and reduced number of paperwork to review.

Also, it was researched the positive sides of blockchain integration in the field of growing and gathering aquacultures, at the same time underlining the fact that products of aquaculture would not enter market unless registered in the unified system, this would allow a possibility to return as many market actors from so-called "informal economy", thus increasing food security of the population, economic security of the producers and create a precedent of fully transparent and digitalized field of economy.

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