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ORGANIZATIONAL-ECONOMIC MEASURES AND TOOLS FOR THE MULTIFUNCTIONAL USE OF AQUACULTURE FACILITIES IN UKRAINE

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Introduction. The world is aware of the importance of preserving natural resources and is shifting its focus to a social perspective, reflecting the acceptance of sustainable development principles. Aquaculture management must consider the impacts on the ecosystem and community, ensuring a balance in the use of water resources. Aquaculture can become a sustainable way to generate economic resources, and has recreational and cultural applications. This study examines the possibilities of using aquaculture in educational and cultural activities, public leisure, aesthetic education, and the development of park areas, as well as for other multifunctional purposes that contribute to improving water environment management and creating new ecological jobs.

Aim and tasks. The study aims to develop a conceptual vision of multifunctional aquaculture facilities as innovative and recreational centres for new jobs and the development of the local economy, considering socio-ecological and economic motivational mechanisms and effects that have not been previously investigated.

Results. The variability of directions for the development of aquaculture activities in the context of implementing marine strategies, Sustainable Development Goals, and reduction of the negative consequences of water pollution due to military actions. Socio-ecological and economic motivational mechanisms have been developed to form aquaculture facilities as centres of a green corridor or a concentration of ecologically safe zones to integrate them into urban and rural spaces. Measures for integrating aquaculture into tourism activities and the scientific concept of the concentration of ecologically safe territories with an aquaculture core in terms of organizational measures and possible effects are proposed.

Conclusions. A conceptual vision of multifunctional aquaculture facilities with the functions of reproduction, education and cultural-recreational enlightenment in terms of scientific and educational, decorative and circular facilities was proposed. The scientific concept of the concentration of ecologically safe territories with an aquaculture core in terms of organizational measures and possible effects was proposed.

Keywords: aquaculture, innovations, multifunctional, recreational.

1. Introduction.

The modern world is becoming increasingly aware of the importance of preserving natural resources and, therefore, shifts the focus from a commercial approach to a broad social perspective, reflecting the adoption of sustainable development principles. Aquaculture management should be carried out considering the possible impacts on ecosystems and communities. Impacts can be diverse, including water and habitat quality, carbon footprint, recreational, cultural and social components. It is necessary to balance the use of water resources for current and future generations by making decisions that consider all benefits and costs associated with the use of water resources. Aquaculture can play an important role in the development of urban and rural areas, so it is important to develop aquaculture as a sustainable way of generating economic resources.

This study aimed to investigate the possibilities of recreational aquaculture from different perspectives. The main research directions are educational and cultural activities, leisure and recreation of the population, aesthetic education, development of gardens, park zones based on natural or artificial water bodies, and stocking of local water bodies. Special attention has been paid to the use of aquaculture for multifunctional purposes, such as promoting new initiatives to improve the management of aquatic environments and create new ecological jobs.

2. Literature review.

The creation of integrated complexes combining fish farming with other aquatic activities, such as duck farming or vegetable production on pond dams, is a long-standing tradition in freshwater pond fish farming. Although the term “multifunctional” was not used in the past to refer to such practices, they were nevertheless common. The importance of multifunctionality has not received adequate attention, and the development of this type of fish farming has taken place without a clear plan. Owners and managers of pond fisheries have demonstrated innovation by granting access to previously restricted areas, providing fishermen with newfound opportunities to access high-quality fishing services.

Fishing services were the starting point for developing other tourist services such as catering and hotel services. Multifunctional pond fish farming became famous thanks to initiators who understood the social need for certain services provided by fish farms. Such initiatives contribute to the entertainment of aquatic ecosystems by achieving their sustainable use, promoting the consumption of fish and fish products, and responsible fishing, which are the most representative elements of leisure and are compatible with the preservation and respect of the natural environment (according to Goals 12 and 15). This stimulates partnerships between a wide range of stakeholders, according to Goal 17 (Fundación Biodiversidad, 2019; Zapata, 2020).

Multifunctional aquaculture facilities have many advantages, such as the use of low-quality soils, the possibility of being an ecological core to maintain the balance of the ecosystem, contributing to the formation of a green corridor, the concentration of green areas, and the creation of new jobs, as they require skilled labor and specialties. Aquaculture centers are an essential ecological point with nature conservation and recreational potential, as multipurpose reservoirs and their adjacent territories are always characterized by a high level of biodiversity (Zapata, 2020). Recreational fishing, in turn, is a form of leisure that does not involve profit or commercial interests. Its purpose is to satisfy personal needs in sports and recreation, and the catch obtained is used only for personal consumption and is not sold.

Recreational fishing takes many forms, including (Safran, 2002):

– Game fishing is a specialized form of fishing that targets easy-to-catch species such as salmon and trout.

– Match fishing is a form of competition where anglers compete with each other to catch the largest or heaviest fish.

– Put and catch is a form of fishing where fish are landed in a body of water to be caught and used for personal consumption.

– Catch and release is a recreational fishing practice in which, after the catch, the fish is quickly measured and weighed, followed by photography as proof of the catch, and then the fish is unhooked and returned alive to the water.

– Sport fishing is a form of fishing that is carried out to satisfy personal needs for sport and recreation. It can have a secondary purpose catching fish for own consumption, but not for further sale.

To achieve the goal of reducing the destruction of species, their preservation and reproduction, the formation of multifunctional aquaculture facilities that demonstrate the compatibility of recreational fishing with the preservation of the natural environment and aquatic ecosystems of the facilities becomes an important task for ensuring the sustainable development of fisheries and aquaculture, as well as for the preservation of biodiversity and natural resources.

3. Results.

3.1. Recreational aquaculture as a direction of biodiversity reproduction and Ukraine's achievement of the SDGs.

The Ukrainian Black Sea region suffers from military actions that have led to significant pollution of water resources and other negative consequences, such as the arbitrary introduction of exotic fish species, inadequate repopulation, exposure to electromagnetic radiation, and the detonation of explosive devices.

Additionally, climate change and overfishing or poaching can be highlighted. The consequences of these actions are so serious that fish populations may not recover, and their numbers are reduced to the point where there is a threat of disappearing forever. In addition, the low genetic variability of fish also threatens their survival. In order to preserve fish resources, it is necessary to take effective measures to protect them.

The development of aquaculture objects in Ukraine has recently led to a significant increase in production. Modern aquaculture farms ensure efficient processing and create value-added chains. Many of them have their own infrastructure for processing and marketing their products. Pond aquaculture is the most attractive and economically viable option for aquaculture enterprises, constituting approximately 30% of the market demand. Production in recirculating aquaculture systems takes the second place with a quarter of the market. Basin farms account for 17% of the market, and cage aquaculture makes up 13%.

To analyse the state and potential of recirculating systems, inquiries were sent to the relevant government authorities. The results of this study are presented in Table 1.

Research has revealed that information about aquaculture objects is not reaching many of the State Agency of Land Reclamation and Fisheries of Ukraine's offices in the form of reporting. This complicates the management and control of aquatic resources and harms the environment. The issue is particularly relevant for the Ukrainian Black Sea region.

Without adequate protection, control and reproduction measures, the environment undergoes changes that affect biodiversity. This can lead to environmental and socio-economic consequences.

One of the tools that help support and improve the quality of fish species is aquaculture. Fish culture can be an important tool for the restoration of endangered species, the restoration of populations, or for the production of decorative fish. However, it is important to observe preventive measures and good practices involving the introduction of these species into the environment.

Approximately 25% of the world's catch is discarded due to the wrong size or type of fish. To prevent this, new forms of fishing are emerging, such as urban aquaculture, which is gaining significant development in urbanized areas of the world. They make it possible to saturate local markets, increase control over fishing and, accordingly, reduce anthropogenic pressure on water resources. These methods consist in the use of innovative approaches to the use of aquatic biological resources.

Urban aquaculture helps to achieve the goal of ending overfishing by 2020, which Ukraine was supposed to achieve under Goal 14.4 (limiting overfishing, illegal, unreported and unregulated fishing and promoting the maximum ecological recovery of fish stocks). However, until now, the goal has not been achieved.

The field of aquaculture has several important functions, which are depicted in Table 2. They include the recovery of endangered species, promoting their conservation, supporting the life of fish in the natural environment, and preventing poaching and smuggling (Diia.Business, 2023).

Table 1 shows that the main goal of creating aquaculture facilities in urban and rural areas is the creation of natural ecosystems with reproductive, scientific, cognitive and leisure functions. Such facilities are multifunctional. They have environmental, economic (productive) and inclusive benefits.

Table 1. Availability and condition of aquaculture facilities in the field of aquaculture in Ukraine.

Office of the State Agency of Land Reclamation and Fisheries of Ukraine	Business entities	Characteristics of aquaculture facilities	Incoming letter from the Office of the State Agency of Melioration and Fisheries of Ukraine
Volyn	LLC "Company "Forel"	Growing pools with an area of 3,800 m2 and feeding pools with an area of 3,400 m2	No. 1-4-17/211-23 22.02.2023
	IE Kravets S.O.	Growing pools with an area of 28.8 m2 and feeding pools with an area of 36.5 m2.	
Zakarpattia	No usage reporting is provided aquaculture objects, their availability, condition, quantity, use		No. 1-3-16/213-23 23.02.2023
Ivano-Frankivsk	No information	No information	No. 1-4-17/139-23 24.02.2023
Lviv	There is no information on the use of aquaculture facilities		No. 1-3-16/196-23 22.02.2023
Rivne	LLC "Laursen Aquaculture"	Cultivation of clary catfish in a recirculation system.	No. 93.2-13/193-23 22.02.2023
Kchmelnytsk	There is no information on the use of aquaculture facilities		No. 1-3-10/298-23 27.02.2023
Chernivtsi	Farm "Ischkhan" (sturgeon and salmon species)	The area of the pools is 3,893 m2, of which the growing pools are 3,089 m2, the feeding pools are 804 m2	No. 1-16-12/173-23 24.02.2023
	LLC "Bookfish" (salmon species)		
	IE Fedorov Volodymyr Vasylovych (sturgeon species)		
	State institution "FTF "Lopushno " (salmon species)		
Odesa	PJSC "Odeskabel"	No information	Without an incoming letter
Central	The State Fisheries Agency of Ukraine does not have the requested information		No. 3-6.2.2-16/894-23 23.02.2023

Source: based on the State Agency of Melioration and Fisheries of Ukraine (2023).

Practical experience shows that the use of various resources and diversification in multifunctional pond farming leads to higher and more reliable incomes for farmers. In addition, such activities help preserve biodiversity, increase knowledge about nature, and promote social acceptance of fishing. Environmental services related to recreation and environmental educations are also important components of multifunctional pond farms.

From the above, it can be determined that the multifunctional use of aquaculture facilities is the improvement of the quality of work of aquaculture facilities through management interventions to increase or optimize economic and social benefits. This means that aquaculture facilities are used not only to enrich water resources, but also to achieve other useful goals, such as increasing the area's tourism potential or creating new jobs. This approach is highly effective and can be used to achieve various goals in the community's interests. The most important thing is that the multifunctional use of fishponds helps preserve the biodiversity of the territory and ensure sustainable development of the region.

Table 2. The role, functions and advantages of recreational aquaculture facilities.

Business entities	Role	Functions	Advantages
Public authorities	The facility of attention is the rational use of natural resources, repopulation, improvement, protection, restoration and improvement of people's quality of life.	Ensuring increased competitiveness of farms and adequate income for farmers. Conservation of genetic resources and the production of breeding fish, as well as the production of natural materials such as reeds, algae, molluscs, crustaceans and others. Conservation of habitat for animals, waterfowl, mammals, reptiles, amphibians, insects and plants, including aquatic species.	A sustainable food production system is being created, which guarantees quality and reliability. The mission is to ensure a sustainable ecosystem and guarantee the quality of natural resources, which will ensure the preservation of biodiversity and improve the quality of life on the planet. Prevention of excessive impact of human activity on water resources. Prevention of anthropogenic load on water resources, which can lead to pollution of water ecosystems and threats to the health of people and animals. Taking advantage of every member of society, not just economically active groups, and involving them in this process. Enrichment of the cultural and aesthetic environment of the region.
Research institutions	The object of fundamental and applied scientific research, as well as: – training and internship; – ensuring the availability of balanced nutrition at the level of scientifically based norms for all segments of the population; – achievement of policies related to the reproduction and preservation of the environment, biodiversity; – organization of children's camps and other events; – basis of activity of ethnographic and other open-air museums; – a basis for conducting pilot studies and experiments, as well as for conducting professional demonstrations and scientific meetings; – opportunities to contribute to the development of various industries and help ensure accessibility and equality.	Breeding of local breeds of animals, as well as maintaining gene banks in situ, allows the preservation of biodiversity and ensures the sustainability of natural ecosystems.	Scientific-educational and cultural-aesthetic enrichment of local landscapes, as well as support of the economic ecosystem for all levels of society.
Fishermen (federations, societies, associations) and non-governmental organizations	A source of information for including it in the process of making management decisions and forming local development programs.	Controlled consumption of services related to fishing, bird watching and other similar activities. Catching and consuming food products, in particular blue food and products of animal origin. Access to gastronomic and artistic events for all segments of the population in order to ensure their satisfaction and development.	A platform for promoting the best possible practices. A source of support and affordability for food prices.
Services sector	Creation of opportunities for the participation of all segments of the population in gastronomic, artistic events and other events by developing relevant services. Ensuring the availability and attractiveness of aquatic and marine products for consumption as a valuable source of nutrients necessary for maintaining and improving human health.	Production of animal and vegetable origin products, natural materials, vegetables and decorative plants, provision of tourist services such as bird watching, horseback riding, restaurant and hotel services. Focusing on promoting the sustainable use of these resources, instead of destroying fish stocks for entertainment and recreation.	Diversification of economic activities, such as specialty feed stores, UNESCO blue cuisine restaurant clusters, hotel and tourism sectors, aesthetic areas for social networks, etc. Formation of new workplaces, creation of corporate trainings, conducting familiarization tours. Promoting the consumption of aqua and marine products as nutrient-dense products necessary to maintain and improve health instead of destroying fish for recreational purposes.
Individuals	A place of rest, which includes, in addition to the leading three (economic, ecological and inclusive), functions: – educational; – informative; – cultural and educational; – aesthetic; – cognitive; – education, environmentally oriented thinking,	Dissemination of values and properties of water ecosystems among citizens.	Consumption of blue food and vegetables, consumption of fishing services, swimming, bird watching, cycling and horse riding tours, narrow gauge rides around the ponds, the opportunity to enjoy high quality restaurant and hotel services

Source: authorial development using by Fundación Biodiversidad (2019); Zapata (2020).

The effectiveness of the formation, development and functioning of multifunctional recreational aquaculture facilities are shown in the Figure 1. Aquaculture facilities play an important role in achieving the goals of the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) and the Global Framework for Biodiversity Post-2020 of the Convention on Biological Diversity.

The creation of these facilities contributes to the increase in the spread of knowledge among the population about the properties of water ecosystems and blue cuisine through corporate trainings and familiarization tours. In addition, it is a guarantee of the creation of new jobs and meets the sustainable development goals (Goal 8). One of the leading countries in the world in the field of recreational aquaculture activities is Spain. According to official data, 15,560 jobs are created in this field for every million inhabitants of the country, which is an impressive indicator.

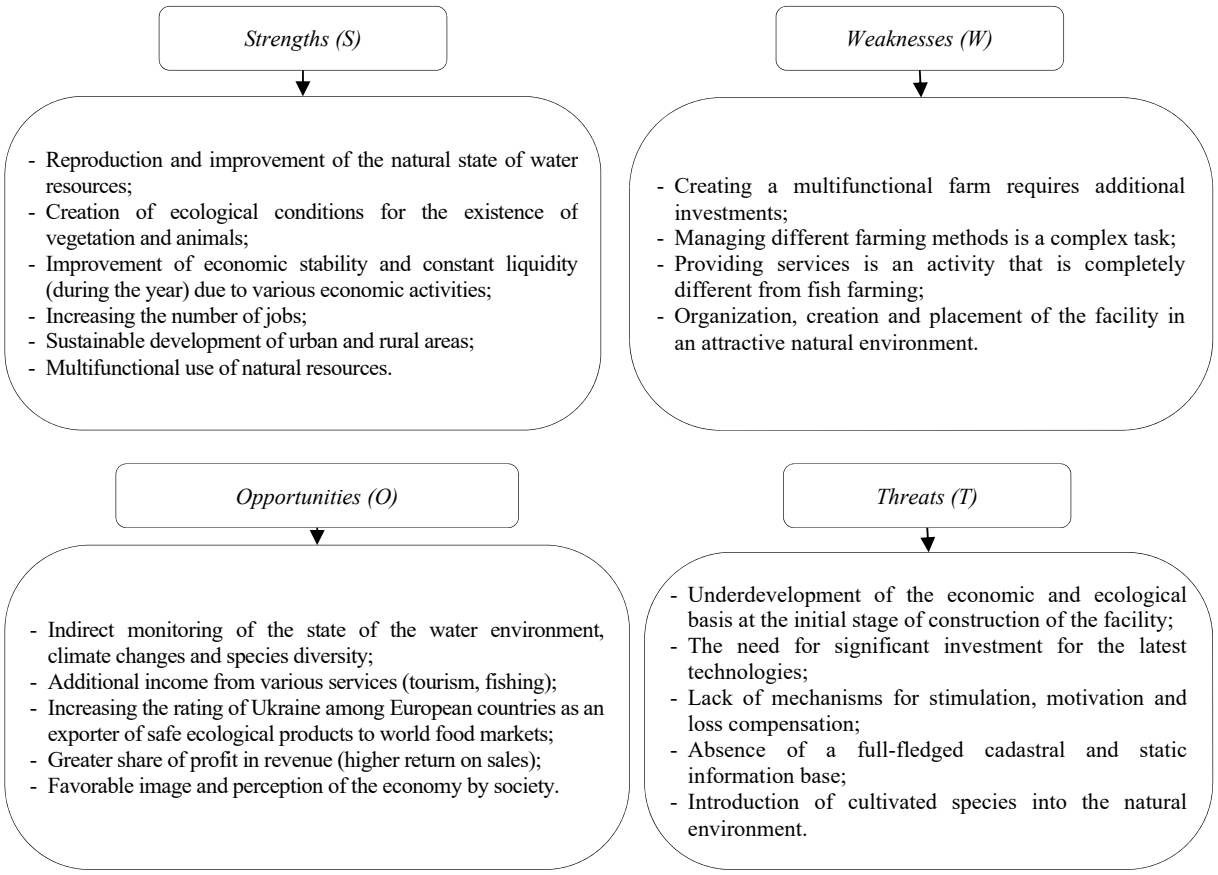

Fig. 1. SWOT analysis of the effectiveness of the formation, development and functioning of multifunctional recreational aquaculture facilities.

Source: authorial development using by Fundación Biodiversidad (2019); Zapata (2020).

The majority of Spain's budget allocated to the promotion of the national tourism product abroad is provided by the country's government.

The creation of multifunctional recreational aquaculture facilities in urban and rural areas allows increasing the tourist attractiveness of the country and ensuring economic growth and increasing the welfare of citizens. It also contributes to the development of territories, local culture and production of local products, which is one of the sustainable development goals (Goal 11).

Table 3 summarizes information about various innovative and technological systems of aquaculture activity that can be used to ensure affordable products on local markets. In particular, these systems include aquaponics systems, recirculating systems and hydroponic systems that allow fish to be grown efficiently and environmentally.

Combining the innovative technological systems shown in the table with recreational purposes can help ensure access to nutritious food in sufficient quantities throughout the year and develop aquaculture facilities with multi-functionality. Such a decision corresponds to the task of controlled fishing and the reproduction of aquatic biodiversity, contributing to the affordability of food prices and the fight against micronutrient deficiencies in vulnerable population groups (Goals 2 and 9). Combining reproductive and nutritional functions with recreational ones helps increase young people's interest in and participation in scientific research.

Table 3. Innovative technological systems of aquaculture activity in terms of recreational use.

System name	Properties	Characteristics	Recreational use
Stakes on the ground	– low primary costs; – great ability to maintain ecological balance; – are used on soils of low productivity.	Area from 200 to 2000 m^2 (or more), depth from 1.0 to 1.5 m, with slopes of 3:1, to avoid deterioration of quality.	Ponds on land can be used for recreational purposes such as fishing, photography, water skiing, camping, water skating, canoeing and other water sports, as well as for picnics and barbecues, recreation and wildlife watching.
Cement tanks	– more expensive than land ones; – long service life; – low maintenance costs; – resistance to large flows of water; – better sanitary conditions; – easy use; – greater carrying capacity.	Rectangular shapes take up less space but are less effective at cleaning, while circular shapes take up more space but are more effective at removing waste with a circular current.	Cement tanks can be used for recreational purposes such as fishing, water parks, and water sports.
Cages	– used in lakes, lagoons, reservoirs or large reservoirs. – require a constant and uniform flow of water and its complete renewal every hour; – fish are confined and move little, energy and protein consumption is low, and weight gain is high.	Nylon mesh is usually used for production, which can be of different sizes - from small (1.5 m * 1.5 m * 1 m) to cages with a diameter of 22 to 26 m and a depth of 2 to 4 m. They are placed along the course of the river , keeping a minimum distance of 3 meters between them and 4 meters from the bottom.	Cages can be used for recreational purposes, such as contemplation, environmental education, field trips.
Biofloc	Organisms, particularly bacterial communities, metabolize carbohydrates and use inorganic nitrogen, which reduces nitrogen levels and improves water quality. Other microorganisms, such as microalgae and zooplankton, use cultured species as a source of protein.	The aggregate consists mainly of organic matter, which is 60-70% of its mass, including a mixture of microorganisms such as fungi, algae, bacteria, protozoa and rotifers, as well as 30-40% inorganic matter, such as colloids, organic polymers, cations and dead cells Floccules (clots in suspension) have small size, irregular shape, high porosity and high permeability to liquids.	Biofloc can be used for recreational purposes, such as breeding various species of fish, including exotic ones, which may be of interest to aquarium enthusiasts.
Membrane reservoirs	Geomembrane is a material with low permeability, made of high density polyethylene. This material reliably protects against washing, has high resistance to ultraviolet rays and tears.		A recreational use of geomembrane tanks involves the creation of water attractions, such as water slides and trampolines. The tank can be filled for water activities at a certain time and level. In addition, geomembrane tanks can be used for fishing and other water sports, such as canoeing and kayaking.
Recirculation systems	Constant monitoring and control of physicochemical parameters and individualization of physical units of the production infrastructure are necessary to ensure the system's quality. Species cultivated under this system are utterly dependent on a balanced diet. The system must be tolerant of high density. The system must have mechanical and bio components to ensure effective filtration.	Leading closed systems of rational use of water (less than 10% daily of the total volume of the system).	Recirculation systems can be used for recreational purposes, such as aquariums, fountains, landscape design.
Aquaponics	Obtaining a larger amount of biomass in the same area is possible thanks to the joint placement of products of plant and animal origin. Fish farming waste, which is formed after the digestion and metabolism of the consumed balanced food on the water surface, is used. This makes it possible to attract resources more efficiently and reduce biomass production costs.	Integration of two production systems: agricultural (vegetable) and fish.	Aquaponics can be used for recreational purposes, such as creating a natural pool or pond in a recreational area. In this case, plants and fish interact in a balanced ecosystem that creates natural beauty and provides opportunities for fishing and picking fresh vegetables and fruits. Another option for recreational use of aquaponics is to create a water garden that serves as a place for relaxation and recreation.

Source: based on Zapata (2020); Tiutiunnyk and Kupinets (2020).

3.2. Socio-ecological-economic effects of aquaculture facilities.

Innovative recreation centres combine the functions of entertainment, production, environmental sustainability and new jobs. Thanks to the formation of such centres, there is an opportunity to use natural resources and create new opportunities for the development of the local economy and territories.

Innovative and recreational aquaculture centres are specialized multifunctional complexes equipped with innovations that combine elements of aquaculture (breeding of fish, seafood and other aquatic organisms) and recreation (fun games, active recreation, restaurants, hotels, etc.).

These complexes combine fishing and aquaculture with inclusive, recreational, economic and environmental education functions. They can be located in both urban and rural areas and use innovative technologies to grow fish and other aquatic organisms. In addition to aquaculture installations, these complexes have recreation areas for visitors. The purpose of these complexes is the production of aquaculture products, the provision of scientific and educational services, interesting and environmentally friendly forms of recreation for children and adults, which allow studying the diversity of aquatic biological resources, increasing environmental awareness and contributing to the achievement of the goals of the Strategy for Sustainable Fisheries and Aquaculture in the Mediterranean and Black Seas to 2030 year. Such centres may include aquariums, fish farms, maritime museums, attractions and other types of entertainment (Fig. 2).

They help to understand the need to act on multiple fronts and to ensure that fisheries are compatible with ecological and sustainable approaches to the management of marine resources (FAO, 2021).

One of these directions is the formation of scientific and educational aquaculture facilities, which aim to preserve and reproduce populations in accordance with Directive 2010/63/EU (European Commission, 2010).

These facilities provide an opportunity to study aquatic ecosystems and species of animals and plants living in seas, rivers and other bodies of water. The scientific platform allows you to collect information data, conduct research, and guarantee the transparency of investments made in one or another scientific development.

Facilities with decorative hydrobionts are another direction of aquaculture development, which has its own advantages. Unlike scientific and educational facilities, they can have not only a scientific, but also an aesthetic function, attracting the attention of a wide audience and causing interest in the study of aquatic ecosystems. The goal of creating facilities with decorative hydrobionts can be not only to satisfy aesthetic needs, but also to reproduce the populations of these species. In addition, such facilities can become a great place for photo sessions, especially in popular social networks and attract the attention of a children's audience.

Decorative aquaculture facilities reflect the results of the impact of digital transformation on modern business and competition in the service industry.

They meet the need to achieve the result of the blue transformation of the aquaculture industry, taking into account the ecosystem approach and the use of scientific and natural solutions, effective spatial planning tools, digitalization and innovation.

Circular aquaculture facilities are an effective way of reducing the negative genetic effects on mixed fish populations that may result from escapes from offshore and river farms (Burkynskyi et al, 2018; Office of Aquaculture, 2023). Recreational services offered at these properties include fish feeding and independent fishing for visitors to enjoy "fishing on the farm". This can be especially attractive to an adult audience, including anglers and tourists. In order to attract even more customers, various activities are held at such facilities, including the recreation of small-scale fishing and the promotion of blue cuisine.

Aquaculture facilities justify “no-kill” (humane) fishing and demonstrate the value we derive from consuming fish (Fig. 3).

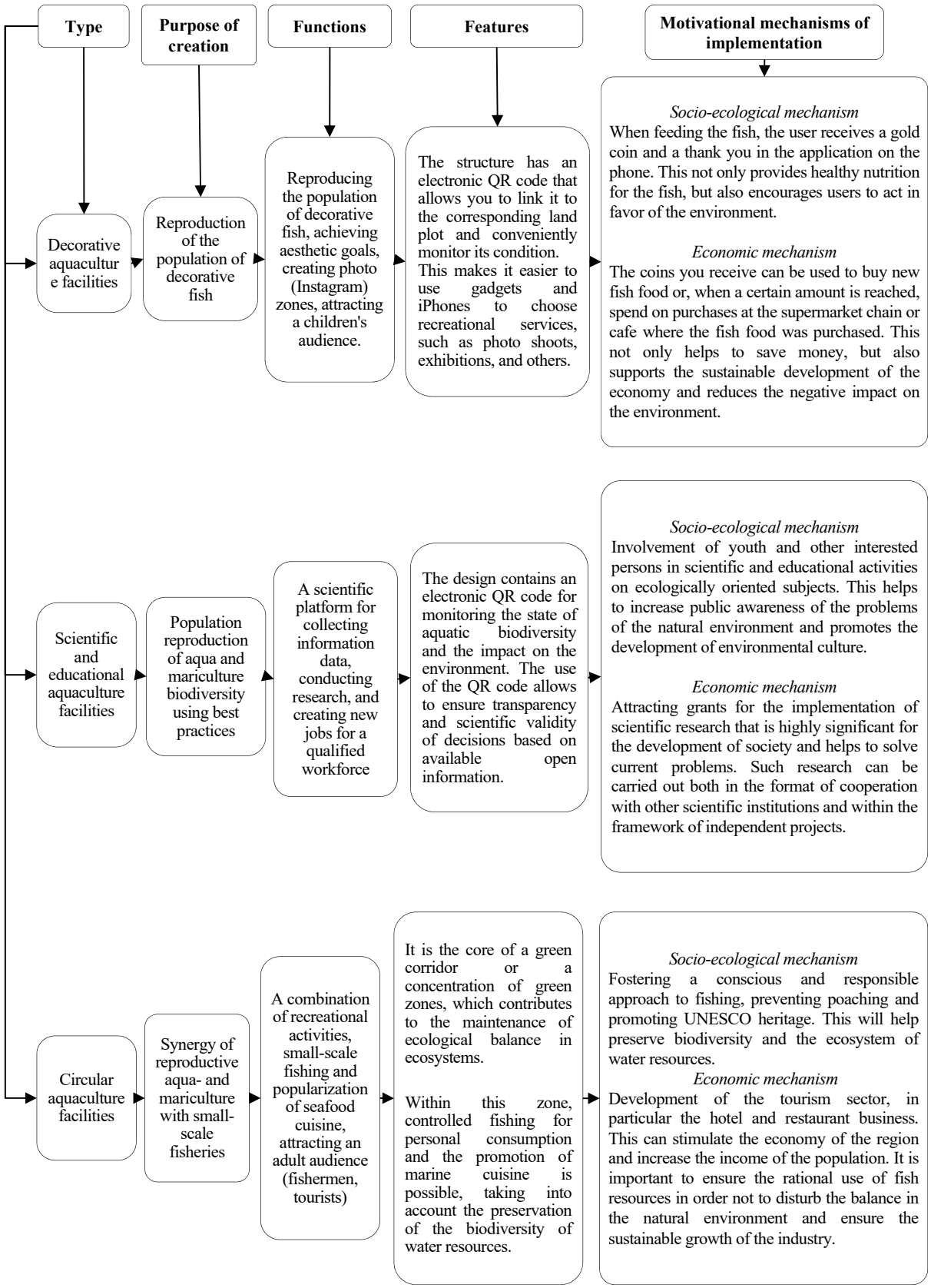

Fig. 2. Recreational aquaculture zones in urban (rural) spatial planning.

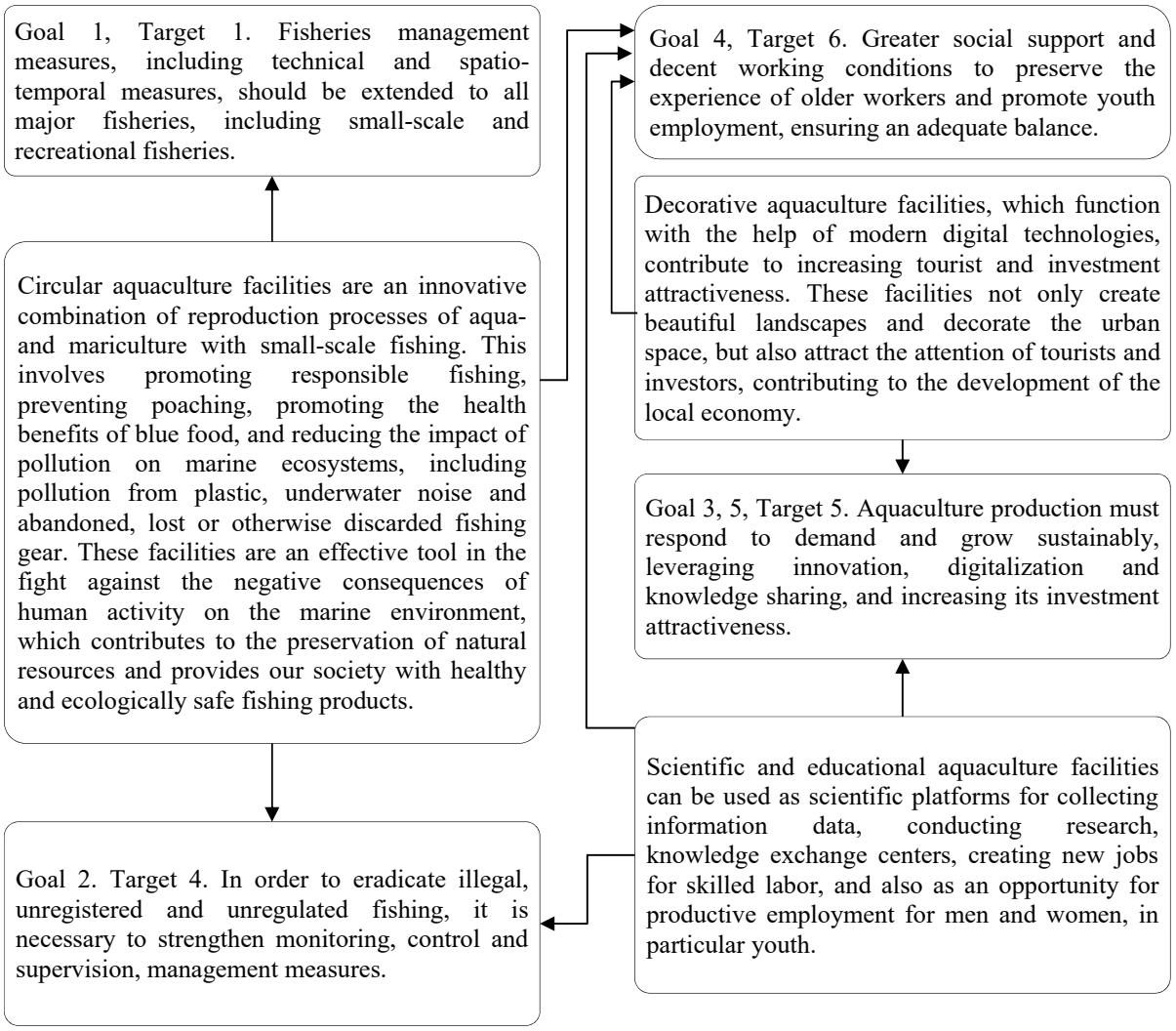

Fig. 3. Aquaculture facilities in the context of the implementation of the EU Strategy for Sustainable Fisheries and Aquaculture in the Mediterranean and Black Seas until 2030.

Source: authorial development with use by FAO (2021); European MSP Platform (2023).

3.3. Measures and proposals to increase the sustainable consumption of aquaculture for recreational purposes.

Recreational aquaculture can function alongside tourism activities both in synergy and separately. Water platforms are gaining great popularity in the world. The new industry attracted nearly €330 million in investment in 2018, including cash spent and local income. According to such results, it is envisaged to create 9 leisure platforms and 14 mariculture facilities at the national and regional levels (Melikh, 2019).

However, during the development of aquaculture and tourism, a number of conflicts of interest arise, which require finding a consensus and analysing possible negative consequences for both types of activity. It is important to consider the issue of adaptation of aquaculture activities to tourism (Fig. 4) in order to ensure their joint development and minimize the negative impact on the environment.

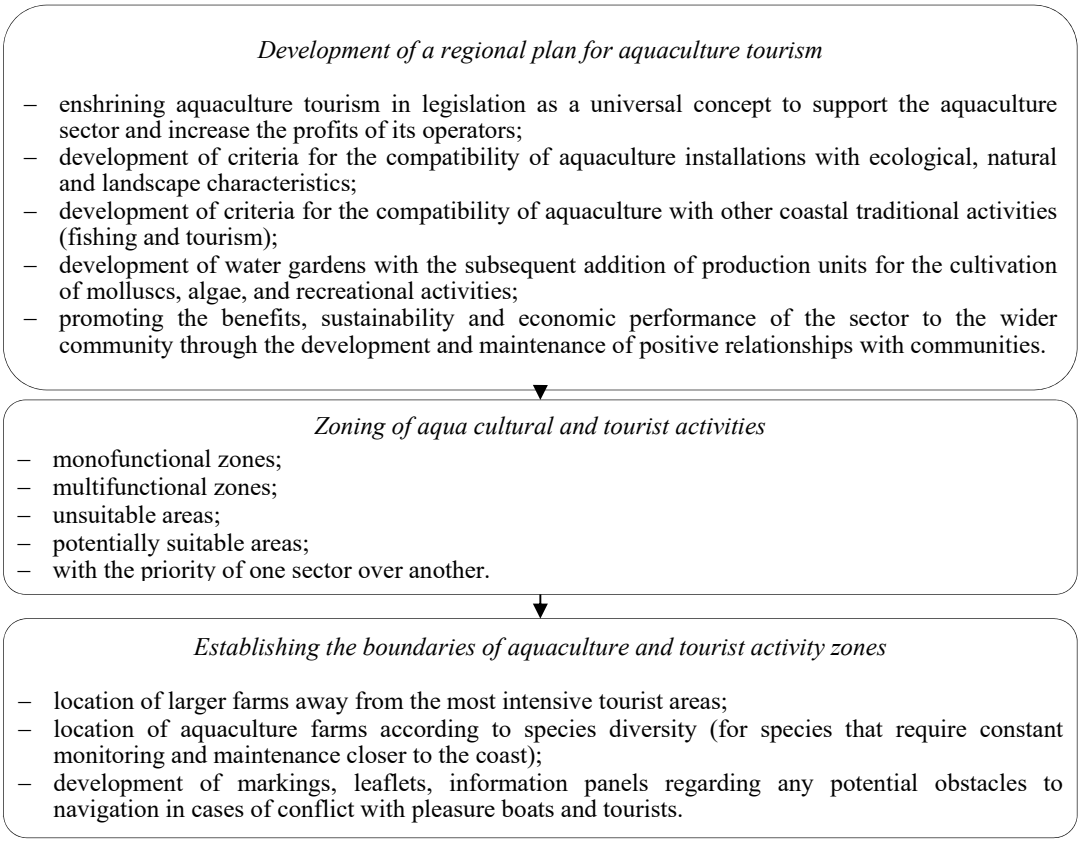

Fig. 4. Measures of integration of aquaculture into tourism activities.

Source: authorial development with use by Government of South Australia (2020); FAO (2021); European MSP Platform (2023).

According to the Resolution of the European Parliament (03.05.2022) on the EU's sustainable blue economy: the role of the fisheries and aquaculture sectors (2021/2188(INI)) (Parlamento Europeo, 2022), several measures are proposed for the development of Ukrainian recreational aquaculture:

– Development of aquaculture clusters on the basis of facilities that will become centres of cooperation between academic, research and innovation centres, state bodies and industry.

– This will enable the use of equipment, methods and practices based on the best scientific knowledge to increase the efficiency, safety and environmental sustainability of the aquaculture industry, and increase its economic potential and the country's competitiveness.

– Increasing attention to local culture and gastronomy in the development of coastal tourism by developing and popularizing beach and diving tourism, ecotourism, water sports and the cruise industry, recreational fishing tourism and small-scale fishing in specially designated aquaculture facilities.

– Formation of a platform for the exchange of knowledge of small fishermen with the scientific community on the basis of the formation of associations, cooperatives and other associations for the sustainable development purpose of aquaculture, prevention of poaching, increase of added value and cultural identity of local communities, as well as development of responsible fishing.

– Formation of a system of financial support for recreational aquaculture aimed at preserving and reproducing aquatic biodiversity.

– Development of a pricing system for fish that has been caught by recreational fishermen and includes fishing services, with the aim of affordability of prices for fish products for vulnerable sections of the population.

– Creation of centres and technologies for the processing of aquaculture by-products that will allow the conservation and use of unused resources, reduce waste and prevent fish kills. Such centres should provide for the processing, storage and sale of by-products, as well as research and development of technologies for the isolation of useful substances.

−Diversification of different species and, accordingly, increasing demand for their cultivation due to the possibility of the appearance of future methods of their use.

−Taking into account the non-market value and characteristics of aquaculture facilities.

−Promotion of new aquaculture products and obtaining added value from them (e.g. production of algae to capture carbon dioxide; cultivation of sea cucumbers to clean the seabed (ITSASNET, 2023); replacement of materials in various sectors of the economy; use of some species for human consumption as a result of their saturation with high-quality proteins and trace elements).

−The formation and concentration of green urban and rural areas with a blue core, as aquaculture facilities as a tool for the protection of the seas, the development of scientific and educational tourism, the creation of green corridors and the prevention of the formation of heat islands.

−Creation of a data monitoring system for recreational aquaculture that will include its impact on tourism, interaction with small-scale fishers, environmental impact and socio-economic importance. This will help determine the value of recreational aquaculture and its contribution to a sustainable blue economy.

−Development of a map of water and aquaculture facilities, on which the categories of facilities are drawn: water and aquaculture facilities that are leased at land auctions in the form of an auction; water and aquaculture facilities, on which work is being done to prepare lots for the purpose of their transfer at land auctions; open water and aquaculture facilities.

An important measure regarding the formation of aquaculture facilities to reduce the burden on the marine environment is the implementation of the main tool - spatial planning of sustainable development of aquaculture in urban and rural areas. This means adopting a specific and detailed zoning plan for the establishment and operation of aquaculture production units based on the following factors:

−Economic: the impact of different spatial planning options on income, jobs, affordability of prices, added value, production levels.

−Ecological: integration of fishing and aquaculture into the urban (rural) ecosystem.

−Social: conflicts of interest and opportunities.

−Institutional: legislative basis of spatial planning and management.

−Political: stakeholders, opportunities for current and future activities.

−Managerial: the influence of management scenarios.

−Physico-geographical: areas for certain types of aquaculture.

−Scientific: optimal practices of aquaculture in one or another area.

3.4. Measures for the adaptation of aquaculture activities in the socio-ecological and economic urban or rural ecosystem.

A separate issue is the measures to adapt aquaculture activities to the socio-ecological-economic urban or rural ecosystem and the further formation of a roadmap for the localization of aquaculture facilities, such as farms, gardens, ponds, etc. (Fig. 5).

The task of organizing and arranging the territory for the concentration of ecologically safe territories with an aquaculture core is to form such a strategy for the use of land massifs, which would maximally orient the actions of land users regarding the optimization, transformation and use of land to the natural conditions of the region (Tiutiunnyk and Kupinets, 2020).

Measures to create a "green" aquaculture zone are carried out directly by landowners or land users of economic enterprises. The organization of land use provides economic entities with the establishment of the composition, transformation (if necessary) of degraded and unproductive lands, which at the present stage has become the most effective factor in the ecological optimization of land use (Dobriak et al., 2009). In the system of these measures, the transformation of lands into ecologically safe ones is considered as an objectively determined element of effective land use or the placement of an aquaculture facility on land of low suitability.

When making a decision on the formation of ecologically safe land zones with an aquaculture core, it is necessary to clearly follow the sequence of transition.

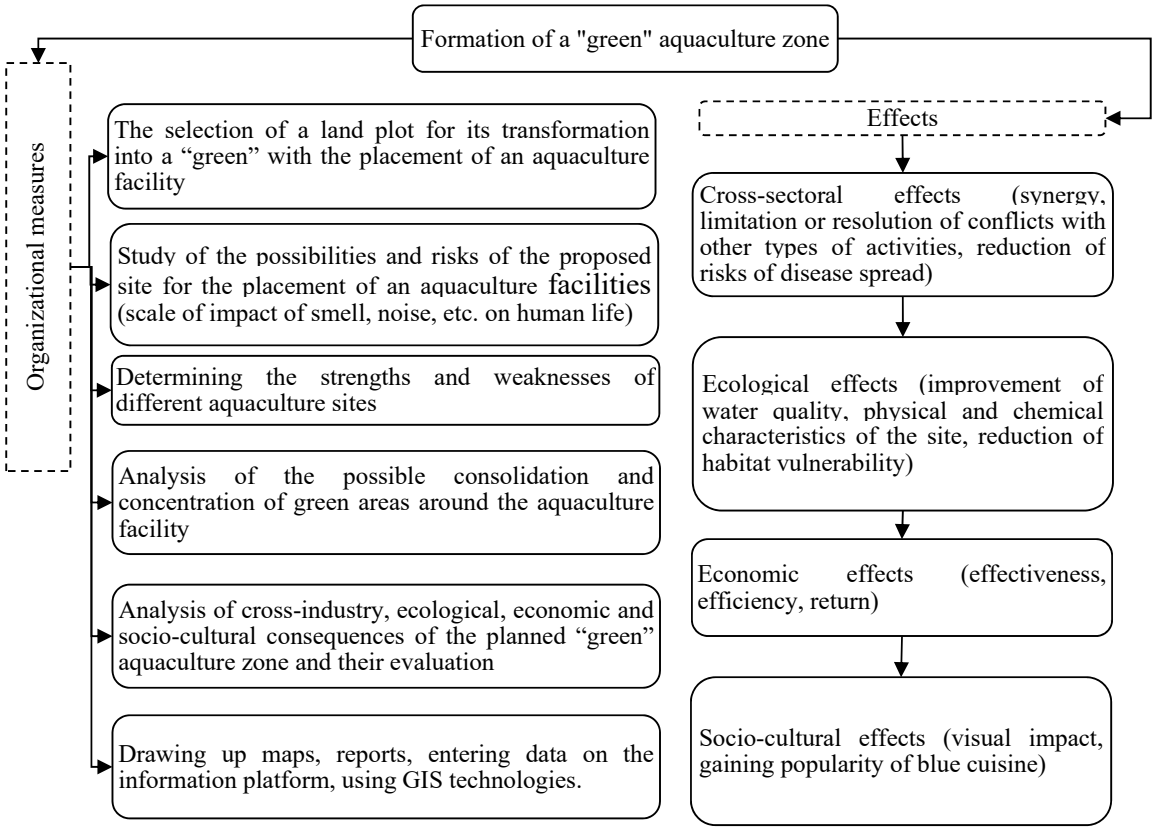

Fig.5. Formation and concentration of ecologically safe territories with an aquaculture core.

Source: authorial development with use by Tiutiunnyk and Kupinets (2020); Stelzenmüller (2013); FAO (2023).

The territory to be transformed requires the collection of information and the study of the characteristics of the facility – taking into account the location, geology, geomorphology of the relief, climatic conditions, soil conditions, and the state of pollution of natural resources. Based on these data, agroecological land types are determined (Tiutiunnyk and Kupinets, 2020). And accordingly, the type of aquaculture facility is selected. This type of aquaculture facilities, such as water gardens, which can attract not only representatives of science, government and business, but also tourists, is a small farm that can be built in the "backyard" (Government of Canada, 2023).

A backyard water garden is a small pond or water feature (including aquaculture, aquaponic) that is designed and installed in a backyard or outdoor space. This type of facility is usually used for decorative purposes to enhance the aesthetic appeal of the surrounding landscape, but can also be used for industrial purposes. For example, a water garden can become an additional source of growing aquaculture products, enrichment of local markets and additional income for vulnerable segments of the population, in particular pensioners.

The use of this type of facility also has an integral component: the cultivation of plant material. There are several ways to use this raw material, depending on the purpose of a specific plant. Plant raw materials can be used as food products, medicinal raw materials, decorative plants, or technical raw materials. In addition, this type of aquaculture facility can be used for recreational purposes. The development of these aquaculture facilities can help the development of small and medium-sized enterprises and the creation of jobs in the regions. It is also in line with the goal of inclusive development and can have a positive impact on the economy and the social sphere. The formation of a base, including an institutional one, for water gardening in combination with the use of recirculation systems or aquaponics can open up opportunities to supplement local budgets.

This will serve to bring local manufacturers out of the shadows of production and trade, who are in competition with wholesalers. In addition, it will become a support and lever for reducing the level of corruption. It will create additional jobs.

Aquaculture is also an effective tool for improving the performance of local markets, as it ensures a more balanced and stable supply of seafood to the market. Producers can form associations, consolidate and concentrate their land plots for efficient production of products, which is an important step in quality control and certification of products, as well as the protection of members of such associations.

Aquaculture has many advantages, one of which is the ability to control and increase the amount of seafood that can be grown and harvested in different areas. This allows efficient planning of deliveries and reduces the risk of excess or insufficient supply in the market. In addition, aquaculture provides stable prices for seafood, which allows to ensure the demand for them.

To increase income, you can create small markets on the allocated land plots for the sale of the grown products of aquatic gardening. This can become an additional source of income through the rental of these plots and market equipment such as scales. The presence of markets can also contribute to the development of local business, in particular tourism, which depends on the availability of fresh seafood (Fig. 6).

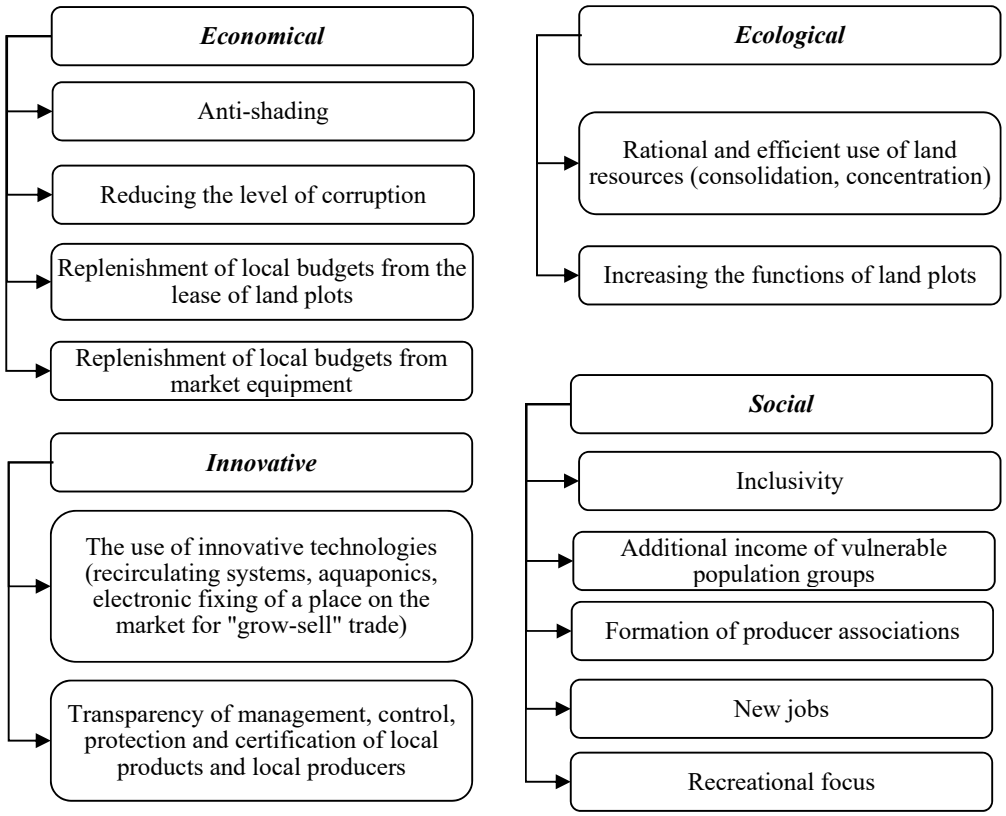

Fig. 6. The effects of water gardening as a tool for increasing the effectiveness of the functioning of local markets.

Possible benefits, best practices (management) are presented in Figure 7. However, to ensure the efficient operation of such markets, certain rules must be followed.

The stocking of ponds or water gardens must have documentary evidence, such as a stocking act, a set of veterinary certificates and documents on the purchase of fish, as well as an act of carrying out work on the reproduction of fish resources (Vdovenko, 2014). This will help ensure product quality and increase consumer confidence.

Aquaculture can be a useful tool to ensure sustainable economic activity for local communities that depend on aquaculture. Increasing the amount of seafood that can be grown in the area can create new employment opportunities and increase the income of local residents. Thus, water gardening can have a positive impact on the economy of the region and contribute to its sustainable development.

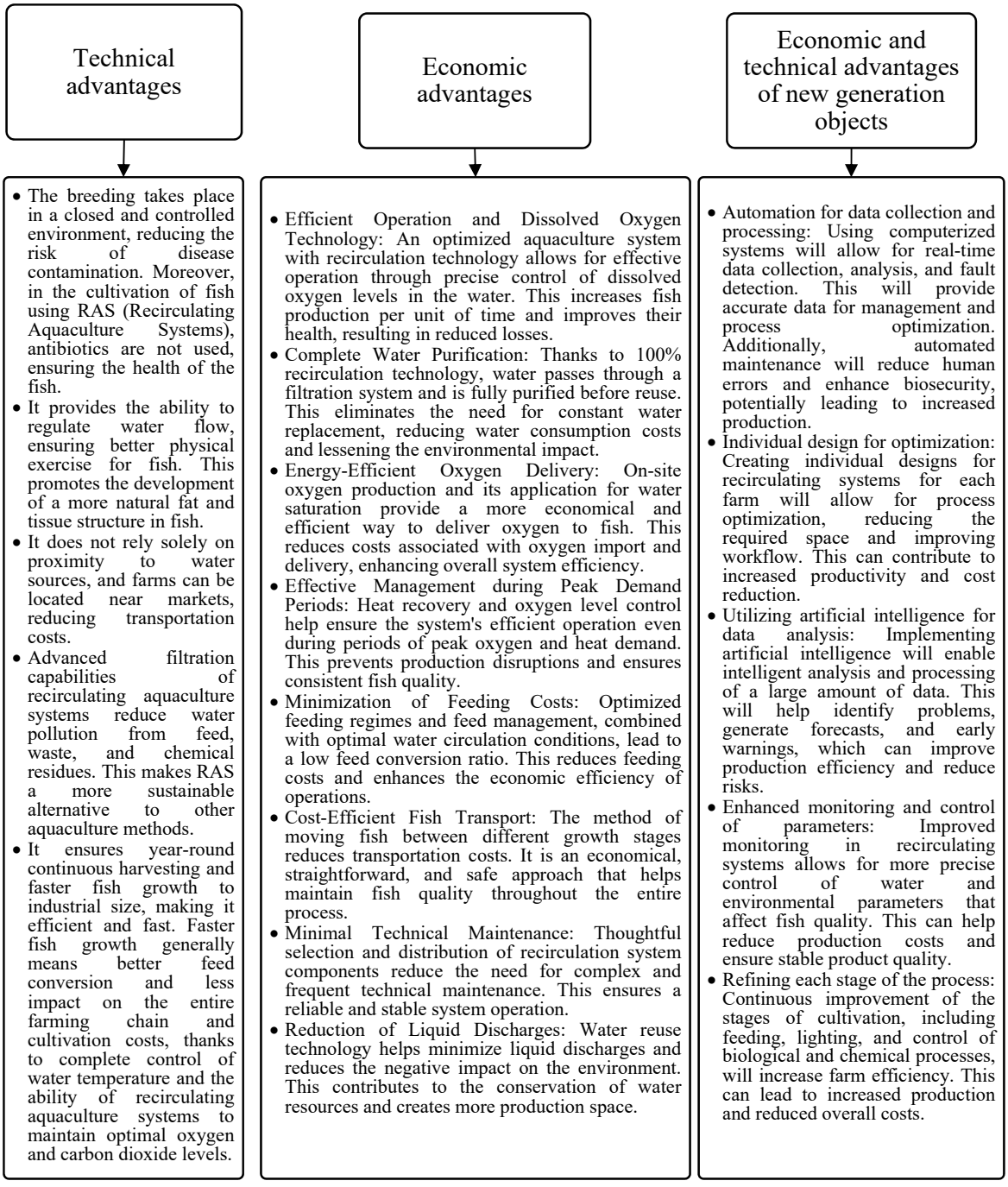

Fig. 7. Technical and economic advantages and benefits of introducing multifunctional facilities in the aquaculture industry.

4. Conclusions.

The study reveals the multifunctional use of aquaculture facilities to reduce the negative consequences of water pollution due to military actions, the implementation of modern marine strategies and the SDGs. The role, functions, and advantages of aquaculture facilities with economic, ecological, inclusive, and additional functions of reproduction, education, and cultural and recreational enlightenment are substantiated in the context of the interaction of the subjects of economic relations. Modern infrastructure systems for aquaculture biodiversity cultivation have also been investigated.

This study formulated a conceptual vision of multifunctional aquaculture facilities as innovative and recreational centers for new jobs and the development of the local economy, the core of green corridors, and centers of knowledge about the properties of aquatic ecosystems, production of local products, and replenishment of local budgets. With the help of a SWOT analysis, the strengths and weaknesses of the formation, development and functioning of multifunctional aquaculture facilities are determined. The socio-economic and ecological effects of the creation of recreational aquaculture zones in urban and rural spatial planning were determined, considering the compatibility of fishing with the preservation of the natural environment and water ecosystems. Various types of aquaculture water features are offered, such as decorative, scientific, educational, and circular features.

Socio-ecological and economic motivational mechanisms have been developed to form aquaculture water bodies as the basis of a green urban and rural corridor or a concentration of ecologically safe zones to prevent risks associated with restrictions on coastal areas.

Measures for the integration of aquaculture with tourism activities and for the development of Ukrainian recreational aquaculture are proposed.

The scientific concept of the formation and concentration of ecologically safe territories with an aquaculture core is presented in terms of organizational measures and effects, in particular inter-branch, ecological, economic and socio-cultural ones.

The establishment of marine gardens is justified as important inclusive aquaculture facilities that can provide sustainable income for local communities and retirees, who are vulnerable sections of the population.

The effects of marine horticulture as a tool for increasing the effectiveness of the functioning of local markets have been determined. It has been proven that small local markets on designated land plots can become an additional source of replenishment of the local budget through the rental of these plots and market equipment. The introduction of marine gardens can ensure sustainable economic development and enrichment of local markets, which in turn will lead to an increase in the quality of life of the local population.

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