Pond Aquaculture as a Measure for Development of Inclusive Green Economy on Rural Territories of Russia

Nikolay VOROBIYEV¹, Alexandra BOBICHEVA², Svetlana POPOVA¹, Tatiana RUDKOVA¹ and Konstantin KOZENKO³,*

¹Volgogral State Agrarian University, Volgograd, Russia
²Volgograd Regional Station of Animal Disease Control, Volgograd, Russia
³All Russia Research Institute of Irrigated Agriculture, Volgograd, Russia

*Corresponding author

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Abstract. The paper reviews a prospective measures of diversifying agricultural production through the development of low-cost pond aquaculture, allowing to create new production chains with high added value, unaffected by numerous weather and market risks inherent for agriculture, especially under risky conditions of southern Russia and its Volgograd region, where poaching catch of river crayfish decreased its natural population and made it a high-demand delicacy. Due to this, pond crayfish farming becomes a competitive direction of freshwater aquaculture, and for its implementing on rural territories paper proposes developed by authors’ project of small aquaculture enterprise based on breeding of crayfish and auxiliary production of carps. Being suitable for family farms and environment-friendly, this project could generate for farm up to $13,800 of profit yearly and thus become a basis for sustainable development of inclusive green economy within rural territories of Russia.

1. Introduction

Overcoming the socio-economic crisis of Russian rural territories and its transformation to sustainable development trend is quite a complex task, being difficult to achieve without buildup of diversified high-tech production chains in rural areas. In turn, it is unattainable without a development of scientific-industrial cooperation.

The crisis of sustainability of Russian rural territories economy is a system of negative factors, also being a subsystem of general crisis of national agriculture. Among factors of this crisis first of all should be highlighted an insufficient profitability of agricultural production in absolute and relative terms. Quite favourable conjuncture of export markets exerts its positive influence mostly on large agricultural enterprises that are not able to provide rural territories with a sufficient number of jobs [1].

As for state support of rural territories and agriculture, budget funds are flowing there through three main institutional channels.

Firstly, R&D financing of agro-industrial issues is carried out within a framework of state assignments for research institutions of the corresponding profile. Secondly, state supports agricultural production through various subsidies. Thirdly, there is a transfer of subsidies to rural territories, mainly being obviously unprofitable. However, a significant part of budget expenditures for R&D financing by state assignment does not form an appropriate budget and socio-economic effect due to the lack of implementation and commercialization of their results, while the economic activities of farmers are not effective enough due to the technical and technological backwardness of agricultural production.
Under these conditions, development of rural territories stops on doctrinal foundations and construction of certain socio-cultural objects, which in absence of financial flows that allow to create jobs with sufficiently high wages, possibility of self-employment and entrepreneurship, do not motivate young people to stay in rural areas. According to A.B. Yarlykapov, up to 60 percent of rural residents have real disposable income at the cost of living, and up to 35 percent - below it. Meanwhile, more than 30 percent of rural settlements are not connected to paved public roads. There is a steady tendency to reduce jobs in rural areas by about 1 million people for every five years [2, 3].

2. Results and Discussion.

For the Volgograd region, in addition to the general problems of the Russian agro-industrial complex, weather risks had historically made it a risky farming zone. At the same time, the current market conditions for agricultural products do not allow the formation of mechanisms for long-term and sustainable expanded reproduction of assets.

In this regard, the development of scalable and replicable technological solutions for rural areas that would diversify agricultural production is especially important. Among other forms of end-to-end scientific and industrial cooperation, a development of freshwater aquaculture is of particular relevance for rural territories. Technologies of pond breeding of aquatic organisms, being of relatively low capital intensity, thus are available to an ordinary agricultural producer. A farming diversified by aquaculture will allow to form expanded reproduction of assets in agriculture. In addition, a freshwater aquaculture, being systematically interconnected with the production of feed and other high-tech sectors of the agro-industrial complex, thus is closely connected with the scientific and production chains of agrobiotechnological research parks, buildup of which is a top importance matter for development of high-tech agriculture under Russian conditions.

Hydrobionts produced in freshwater aquaculture, mostly being presented by fish and crustaceans, are themselves a highly profitable commodity and a valuable food product. Content of lipids, amino acids and vitamins makes freshwater aquaculture production a necessary element of human diet. However, its current consumption is not sufficient according to scientifically based nutrition standards, which also indicates the presence of insufficiently satisfied demand for it in Russian market. So, according to A.I. Bogacheva, domestic consumption of fish and fish products did not exceed 20 kg per capita with the rational consumption rate of 22 kg approved by the Ministry of Health of the Russian Federation [4].

However, there should be noted a significant positive trend in consumption of these products over the past decade. According to S.I. Nikonorov, in 2008 population of Russia had consumed per capita no more than 8-9 kg of fish and fish products per year, while in 1991 a similar indicator was about 21 kg. For comparison, this author had cited similar indicators for a number of European countries. So, for the Netherlands, the average per capita consumption of fish and its processed products per year was 19 kg, for France - 25 kg, Denmark - 31 kg, Norway - 55 kg, Japan and Spain - 72 and 100 kg, respectively [5].

I. Yu. Kireeva notes a particular importance of fish and fish products in world food security, citing data from the 15th session of the UN Food and Agriculture Organization (FAO) in Morocco, where it was stated that fish and fish products account for up to 17% of animal protein consumption in worldwide scale [6].

In addition, according to FAO, the threshold of the global total allowable catch, which does not undermine the sustainable development of fish populations and other aquatic organisms, lies at 95-100 million tons per year. Meanwhile, consumption of fish, products of its processing products and seafood, has already reached 160 million tons and is increasing every year, so the development of aquaculture is critically necessary to fill in the missing volumes. Due to this, of special importance in Russian conditions is a development of pond aquaculture as the simplest way to reproduce hydrobionts in artificial conditions.
Russia has vast water resources, including over 25 million hectares of lakes and reservoirs, over 1 million hectares of agricultural reservoirs and up to 150 thousand hectares of specialized fishery ponds. However, a development of freshwater aquaculture in the Russian Federation remains low. So, in 2016 only 168,441 tons of aquaculture products were produced in Russia while 60% of this production volume was in North-Western and Southern regions of country [7].

Thus, for freshwater aquaculture development there is both a vast domestic market and significant reserves for production growth.

In addition, aquaculture farms not just produce valuable food products with a high protein content, but also are able to artificially reproduce valuable species of aquatic organisms, including crustaceans, and also act as commercial objects for amateur fishing, building up a basis for development of rural tourism.

There is a proven experience of diversifying agricultural production with combining crop production and aquaculture in one farm, including multilevel hydrobionts breeding, in southern Russian districts such as Astrakhan, Belgorod, Voronezh, Rostov regions. Therefore, in aspect of sustainable development of rural territories, it is advisable to consider not only diversification of agricultural production through aquaculture, but also a diversification of aquaculture itself with the cultivation of different aquatic organisms at different levels of one reservoir.

Thus, the cultivation of crayfish in fish ponds along with carps or other freshwater fish is of high economic and technological efficiency, and demands relatively low capital intensity.

Under conditions of Volgograd region where, in addition to the carp, optimal fish breeds for farming are reproduction of the white silver carp, the colorful silver carp, river catfish, grass carp. Of crayfish, it should be noted that annual decline in the population in the natural habitat, mainly due to poaching, and deeply insufficient development of artificial reproduction made them an expensive and highly demanded delicacy on regional market.

Moreover, it is autochthonous river crayfish that live in fresh water bodies of the Volga basin that are of special value as an object in aquaculture, since they have large body sizes, increased fecundity and vitality, and adaptability to new conditions [8].

Current issues of decreasing natural reserves of various types of crayfish has entailed a number of very relevant biotechnological studies carried out by Russian scientific institutions, such as State Institute of Fisheries (Volgograd), All-Russia Research Institute of Freshwater Fisheries (Moscow), Azov Research Institute of Fisheries (Astrakhan), Caspian Research Institute of Fisheries (Astrakhan), Krasnodar Research Institute of Fisheries (Krasnodar). For example, in State Institute of Fisheries there was developed an effective technology for two-level aquaculture of broad-fingered crayfish together with fish in ponds and lakes. In All-Russia Research Institute of Fisheries by E.N. Aleksandrova were developed resource-saving methods for growing planting stock of long-fingered and broad-fingered crayfish within cages in open reservoirs, as well as technology of pasture cultivation of marketable crayfish in small non-emptying reservoirs [9].

In general, among the modern methodological and technological developments in industrial crayfish breeding, could be distinguished some main directions. Firstly, this is a territorial distribution of pastoral crayfish farms and selection of natural reservoirs with optimal conditions for hydrobionts, what is related to application of the landscape approach, hydrochemical and hydrographic indicators. Secondly, these are technological schemes for a formation and maintenance of broodstock of crayfish at aquaculture facilities, what includes procedures such as scoring and selection of the highest quality crayfish from natural populations, creating optimal conditions for their wintering and mating in ponds, and spring catching of females with caviar for their placement in incubation-growth cages in ponds. Thirdly, these are low-cost technologies for growing crayfish larvae in cage devices, methods of introducing planting material into reservoirs and catching of grown commodity specimen. For example, the increase in the yield of second-stage larvae from planting females in comparison with the same indicator of eggs of the
same length, caught in spring in natural reservoirs, is up to 1.9 times, while a formation of crayfish broodstock by selecting the best quality females is up to 3.1 time.

Most common cage technology for growing crayfish larvae on the pleopods of females is low-cost, since it involves the use of low-cost equipment: a cage of small-cell nylon nets on a wooden frame. There is no electricity consumption. It is possible to optimize feed costs. In addition, when larvae are planted into a pond, shelter can be arranged at the place of their release, what allows to increase larvae survival and, therefore, the economic efficiency of the created artificial hydrobiocenosis [10].

Thus, at the current level of R&D in Russian science, there is a sufficient reserve of technologies that allows their replication and scaling even under conditions of small agricultural enterprises directly related to sustainable development of rural territories.

To achieve this goal, we have developed a project of a small aquaculture enterprise focused on pond breeding of crayfish and carps in the conditions of southern Russia. This project has a low capital intensity, which makes it affordable for small farms. At the same time it has a profitability sufficient for its expanded reproduction and the subsequent introduction of more high-tech production processes. The main production and economic indicators of this project are as follows. The costs of the project consist of excavation work on the arrangement of ponds, the purchase of equipment, planting stock (young specimen) of crayfish and carps, as well as the feed necessary for them to reach commercial maturity. Regarding a creation of ponds instead of using natural reservoirs, it should be noted some institutional and technological advantages of the first option. Ponds could be dug on almost any land plot, and, according to Russian reservoir-related laws, a pond located on a land plot owned by an individual or legal entity is the property of the owner of this plot; therefore, the creation by an owner of agricultural land within their borders of an artificial closed reservoir does not require any permits and approvals, which greatly simplifies the institutional aspects of creating small aquaculture enterprise.

Be a technological aspect, for optimal aeration, distribution of artificial feed and similar tasks, practice shows the optimality of rectangular ponds with a depth of 1.5 to 2.0 m and side slopes at an angle of 45 degrees. So, for growing crayfish, the minimum required total surface area of ponds will be 600 m², of which 300 m² is allocated to the main pond, 200 m² - the feeding pond, 100 m² - the pond for year-olds specimen. The cost on excavation when creating ponds of this shape and area will be up to $ 7500.

Investments in the equipment are formed by costs of aerators, oxidizers, filters and various measuring instruments for the operational control of quality of water in artificial hydrobiocenoses.

To determine required power of surface aerators, an oxygen demand of the created artificial hydrobiocenosis was calculated taking into account the oxygen consumption of fish and carps, as well as its biochemical absorption by water and soil. Based on the fact that 1 m³ of air contains about 290 grams of oxygen, and 1 m³ of water—about 5 grams, there is necessary minimum supply of 0.036 m³ per minute for 1 m³ of the reservoir. With a length of the main pond of 20 meters, a width of 15 and a depth of 2, the required capacity of aerators is 21.6 m³ per minute or 1049 m³ per hour at a pressure of 0.2 atmosphere. In this regard, at the bottom of main pond it will be most appropriate to install four JQT 2200-C aerators or similar samples with a capacity of 2.2 kW, the total capacity of which will be 263 m³ per hour. The market price of such a device is up to $ 800 per one aerator. A feeding pond and a pond for yearlings will require 4 more aerators, so their total cost for all ponds will be about $ 4000.

No less important equipment for breeding crayfish and carps are oxidators, which are compact generators for the production of atomic oxygen from hydrogen peroxide within inner container. Based on our calculations, ponds of this volume will require 10 oxidizers with a total value of about $ 3000. In addition, it will be necessary to install 15 water filters worth up to $ 7000, as well as an oximeter, salimeter and conductometer, which will require up to $ 500. In accordance with the generally accepted practice of business planning, it is advisable to postpone another 20% of the total cost of equipment for other expenses, so, reserving this amount of funds will increase total costs to $ 20 000.
For comfortable life conditions of river crayfish in an artificial hydrobiocenosis, they need a density of no more than 8 specimen per square meter, so, based on areas of the main and feeding pond of 500 m², it will require the purchase of 4,000 specimen of planting stock. Its cost is about $5 per 1 kg, the average weight of specimen about 150 grams, so it is necessary to purchase 570 kg of planting material worth $2850. Other expenses will amount to $3500. Thus, a cost of the project, taking into account the construction of ponds, their equipment and equipment, the acquisition of planting material for crayfish will be about $26,350.

Operating costs per year include: payment on electricity, purchase of compound feed and hydrogen peroxide for oxidizers, transportation and veterinary expenses, which, according to current average prices in southern regions of Russia, will total up to $3300.

The number of crayfish increases by 4 times per year. About ¾ of it during this time acquires marketable condition, which gives up to 12,000 marketed crayfish with a total weight of 180 kg. With a selling price of $9 per 1 kg, total revenue will be about $16,500 with annual profit of $13,200. Of labor costs it should be noted that such a pond could be serviced by part-time manual labor of 1-2 men, so for family farms these costs could be nullified.

It is optimal to integrate in such project a breeding of carps, which will harmoniously complement the created pond hydrobiocenosis and increase the economic efficiency of its operation. The optimal planting density of carps depends on pond volume and level of oxygen in water. Young carps are purchased with an average weight of 150 grams for planting in the spring, which allows the next year to get commercial specimen weighing 800 grams. Carps will be fattening in main and feeding ponds, with total area of 500 m² and a depth of 2 m. So, for 1000 m³ of pond volume, in a presence of a developed system of artificial enrichment of water with oxygen, the optimal planting density is one specimen per three m³, what will allow to plant about 333 young carp specimens. With their average weight of 150 grams, it will be summary about 50 kg of live weight. Based on the average market price of $8.5 per 1 kg of planting material, the cost of young carps will amount to $425, and annual cost of additional feeds for carp population be up to $350.

With an average survival rate of about 90% specimen under such conditions, on next year it is possible to obtain 300 carps with an average weight of 800 grams, which will make it possible to sell 240 kg of marketable products. At a current price of $4 per 1 kg, it will amount to $960 of additional revenue. Since the costs of creating a common pond ecosystem have already been taken into account to ensure the livelihoods of crayfish, minus cost of feed, breeding carps will bring the farm up to $610 of annual profit.

3. Conclusion

Also, depending on the location of the enterprise, its transport accessibility, there may be additional buildup of rural tourism segment with using of carp-stocked ponds for commercial sport fishing, which can provide additional profit. However, even without this segment, which is overly dependent on specific local conditions, analysis of the average market prices for equipment, marketable products and planting material for its reproduction allows us to conclude that the payback for breeding crayfish and carps with the parameters described above will be less than three years, and the annual cash flow generated by the project in the amount of over $13,800 will allow expanded reproduction of fixed assets and improve aquaculture production with the introduction of more high-tech technologies of aquaculture. Moreover, accessibility of this technology for small family farms and its environment-friendliness makes it relevant for practical implementing of inclusive green economy on rural territories of Russia.
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