Feasibility assessment of installation of Recirculating Aquaculture System (RAS) in fish farms operating in Ararat Valley, Armenia

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Abstract

Inefficient water use, typical for low-intensity aquaculture systems in Ararat Valley, has become a key environmental issue in Armenia.

Main objective of the research is the assessment of the feasibility study and environmental analysis of investing water-efficient (Recirculation Aquaculture System) usage and intensification (increase in fish production) systems in an Ararat Valley fish farm. As a result of conducted research, it became clear that investment of Recirculation Aquaculture Systems is both economically and environmentally (it is possible to save about 788 m^3 water annually) viable

Introduction

Since the beginning of the 2000s, fish production has been in the list of the priority areas of the development and poverty reduction programs in Armenia, where a significant number of private fish farms have developed in the Ararat Valley. These farms typically use high quality potable groundwater resources as the main source of water for the fisheries. Because of unsustainable water use practices, water yield of more than 300 artesian wells has decreased by approximately

90%. Moreover, a devastating impact of increasing water scarcity on small and/or medium scale aquaculture has been observed. (ASPIRED 2016). To support current levels of fish production and to reduce the negative environmental pressure of aquaculture facilities in Armenia, more efficient and environmentally-friendly practices should be developed by protecting aquifers of the Ararat Valley from further depletion.

Model and Data

The research has been implemented in June-August of 2017 in fish farm which is located in the Hovtashat community, Ararat marz. In-Depth interview was conducted with fish farmer aimed at the collection of the data on the current production mode of the fishery and find out the possible farm intensification mechanisms to be applied there.

Inlet and outlet water samples were taken and analyzed periodically for proposing efficient water using techniques and farm intensification mechanisms. Inlet and outlet water samples were analyzed with 21 chemical, physical and biological quality parameters, which indicated that discharge water was completely clean and it can be used both for irrigation purposes and for intensification of the farms, such as installation of Recirculating Aquaculture System (RAS) in terms of water efficient usage. All analysis, including financial feasibility assessment were done with the help of the MS Excel.

Results

Analysis of the data obtained during in-depth interview indicates that the farm currently operates with total water volume of 1,400 m^3 by producing 7.14 kg/m^3 rainbow trout annually. From these results it is obvious that the farm has low intensive fish farming operation compared to the standards by FAO whish states that 15-25 kg of trout should be produced per m^3 of water in intensive fish farming (FAO, 2011).

Water quality analysis indicate that water leaves the farm in a virtually clean condition, as the water is used only for one cycle and small discharge water flows to the neighboring farm for irrigation purposes, the rest is discharged into drainage system. Besides water inefficient usage, one of the main problems is water over logging, soil salinization and alkalinisation, which in turns resulted environmental unsustainability.

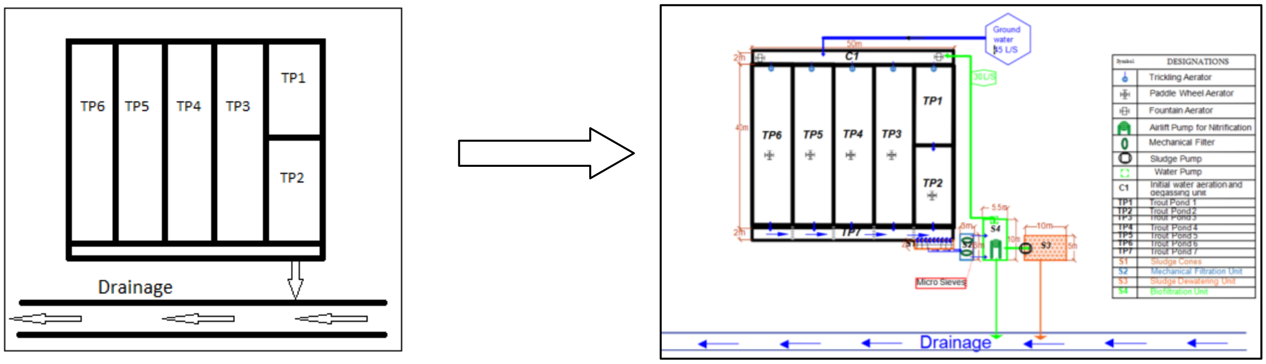
Analysis of the fish farm operational mode indicates that discharged water leaves the aquaculture system virtually clean and intensification and water recirculation or reuse in selected fish farm is possible, that in turns will lead the increase of the water efficiency in fish farm.

Description of proposed mode

In the scope of this research, a new intensive fish farming operational mode is proposed, which includes installation of RAS and production intensification along with aquaculture and agriculture integration. The system proposed to produce 25 kg/m3 rainbow trout (35 tons of fish production annually instead of previous 10 tons of production) in RAS configuration.

Old production mode

Proposed production mode



The system will receive 45 l/s pure groundwater and 35 l/s recirculated water, having 67% water recirculation rate. From both sources water will be pulled in a newly built basin (C1), where water will be aerated before entering the culture basins. Then water will move from C1 to TP1 and TP2 and subsequently to the basins TP3-TP6. Five trickling aerators will be placed with corresponding distribution outlets on the mutual wall of C1 and fish ponds aiming at simultaneous groundwater degassing from naturally occurring N_2 and CO_2 and aeration. Water from TP2-TP6 will eventually discharge into TP7. Finally, after leaving the culture system water will flow through the sludge and water treatment systems (S1-S4). In the current farm, sludge treatment system will include sludge cones (S1 in Fig. 1), drum filters (S2 in Fig. 1) and sludge dewatering and drying units (S3 in Fig. 1). The backwash sludge from both sludge cones and drum filters will be pulled together in the sludge collection channel (S3 in Fig.1), constructed parallel to rearing units. The sludge then will be pumped to specially designed screens, where it will be dewatered and dried to be used as a bio-fertilizer. To achieve water recirculation, a nitrification unit will be incorporated into semi-RAS system (S4 in Fig.1) (Timmons, 2013). Nitrification will be achieved using open containment moving bed biofilter, built from concrete parallel to Drum filter unit, and will be divided into 2 subunits (Pic. 4). The system will be shaded to avoid the growth of green algae. Adequate oxygen conditions, crucial for optimum filter performance (Timmons, 2013), will be achieved using an airlift pump aerator (S4 in Fig.1).

Feasibility assessment of proposed mode

For installation of the proposed model, approximately 12.7 mln AMD is required, which includes first year working capital. From this approximately 2.2 mln AMD is needed for constructing Aeration and degassing unit (C1), Unit for sludge cones (S1), Mechanical filtration unit (S2), Sludge dewatering unit (S3) and Bio-filtration unit (S4), approximately 10.48 mln AMD is needed for equipment acquisition, and approximately 1 mln AMD as a working capital.

With current production method and volume, the revenue and net income of fish farm are much lower than the same KOV in case of implementing proposed mode (See Table 1).

Table 1. Main KOV for both current and proposed modes

	Current mode	Proposed mode
Revenue	16,500,000	57,750,000
Total variable costs	11,829,560	47,180,354
Total fixed costs	2,926,258	6,715,096
EBIT	1,744,182	3,854,550
Interest	-	-
Tax (20%)	348,836	770,910
Net income	1,046,509	3,083,640

Although in case of implementing RAS model revenue is very high, table clearly shows that costs of proposed model are get higher as well. Highest costs that affect company's revenue are variable costs. In case of proposed model, the cost of electricity increases because of the usage of new equipment, such as aerators, which in its turn is needed for water nitrification and further processing. Despite all these costs, implementing the RAS model is very profitable, because farm is becoming intensive and production rate per m3 of water is higher than without RAS.

Four profitability criteria are used to assess the financial soundness of the project, using a discount rate of 36.21%. By all of the criteria, the project is profitable (see graph presented below). NPV is about 1.24 mln AMD (or 2.6 thousand US dollars), which indicates that the project over the 5-year period adds shareholder's value and shows that the project is financially sound. Similarly, the project earns internal rate of return which is about 40.23% higher than the cost of the capital it uses to implement the project. Additionally, profitability index (PI=1.091) also indicates that the Company is able to use investments wisely and generates high enough profit. In terms of payback period, the project is fast in returning the initial investment, about 2.63 years.

Conclusion

The proposed project aims at demonstrating increased environmental, social and economic sustainability of groundwater-based fish farms through introduction of an intensive aquaculture system simultaneously incorporating water recirculation and reuse methods.

The major improvement in the groundwater sustainability will result from estimated water recirculation rates of 67%. The reduction of groundwater abstraction form 70 l/s to 45 l/s will result in annual saving of pure potable groundwater of 788,400 m3. The proposed system configuration will also contribute to a high economic sustainability of the farm. Thus, it can be stated that overall, the project is valuable in terms of developing the RAS system in the fish farm, adopting new technology and generating attractive cash flows.

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ՀՀ Արարատյան դաշտում գործող ձկնաբուծական տնտեսություններում շրջանառու ջրամատակարարման համակարգերի տեղադրման տեխնիկատնտեսական հիմնավորում

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Ագրոբիզնեսի հետազոտությունների և ուսուցման միջազգային կենտրոն

Արարատյան դաշտում ցածր ինտենսիվությամբ ձկնաբուծության համակարգերին բնորոշ անարդյունավետ ջրօգտագործումը Հայաստանում դարձել է բնապահպանական կարևորագույն խնդիր: Սույն հետազոտության նպատակն է գնահատել Արարատյան դաշտի ձկնաբուծարանում ներդրվող ջրի արդյունավետ օգտագործման (շրջանառու ջրամատակարարման համակարգ) և ձկնաբուծարանի ինտենսիֆիկացման (ձկան արտադրության ավելացում) համակարգի տեխնիկատնտեսական գնահատում և էկոլոգիական վերլուծություն:

Հետազոտության արդյունքում պարզ դարձավ, որ շրջանառու ջրամատակարարման համակարգերի ներդրումը և' էկոլոգիական (տարեկան հնարավոր է խնայել մոտ 788 հազար մ3 ջուր), և' տնտեսական առումով ձեռնտու է:

Технико-экономическое обоснование внедрения системы Замкнутого Водоснабжения в рыбоводческих хозяйствах на территории Араратской равнины

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Неэффективное использование воды, типичное для малоинтенсивных рыболовных хозяйств на территории Араратской равнины, стало серьезной экологической проблемой в Армении. Целью данного исследования является оценка целесообразности и экологический анализ эффективного использования воды (через внедрение системы циркулирующего водоснабжения) и интенсификации производства (через повышение объемов производства рыбы) в рыбоводческих хозяйствах Араратской долины. В результате исследования было выявлено, что внедрение систем циркулирующего водоснабжения обосновано как в экологическом (можно сэкономить около 788 тыс. м^3 воды ежегодно), так и в экономическом контексте.