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DEVELOPMENT OF A PERMACULTURE IMPLEMENTATION MODEL BASED ON THE EXAMPLES OF THE SIS, RANCHPAR, AND HOVTASHAT COMMUNITIES IN THE MASIS CONSOLIDATED COMMUNITY OF THE ARARAT REGION

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The results of the research pertain to the enhancement of the efficiency in utilizing the effluent waters from fish farms operating within the administrative boundaries of the Sis, Ranchpar and Hovtashat settlements in the enlarged Masis community. The study addresses the optimal utilization of agricultural lands and the development of a sustainable economic development model, aligned with the principles and requirements of Permaculture design. To achieve this objective, a comprehensive analysis was conducted on the groundwater effluents discharged from the aquaculture enterprises in the aforementioned settlements. The chemical composition and various quantitative parameters of these waters were examined. Additionally, the extent of waterlogged areas, their distribution zones, and the potential adverse effects on the fertility of agricultural soils and the surrounding environment were evaluated. In order to mitigate these negative impacts, a Permaculture-based remediation model was developed, and the feasibility of implementing this model was substantiated as a means of reducing the ecological negative consequences of aquaculture activities, while laying a foundation for the sustainable development of the economy.

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***Keywords*:** permaculture, efficient water use, aquaculture, groundwater, agricultural lands, efficient land use.

Introduction. Permaculture is a system for designing the surrounding environment and managing agriculture based on mimicking the characteristics of models observed in natural ecosystems or directly utilizing those models [1].

Permaculture is a means of recognizing, utilizing, and harmonizing the characteristics of landscape elements (relief, soil, water, vegetation, livestock) with human needs, as well as creating long-term effective and sustainable systems [2]. To achieve this goal, various models have been studied and implemented in international practice, the characteristics of which are mainly determined by the level

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of resource availability in a specific area and their quantitative and qualitative distribution. Summarizing the results of the works carried out by various authors in different countries, the main principles of permaculture design are summarized in the diagram below [3] (Fig. 1).

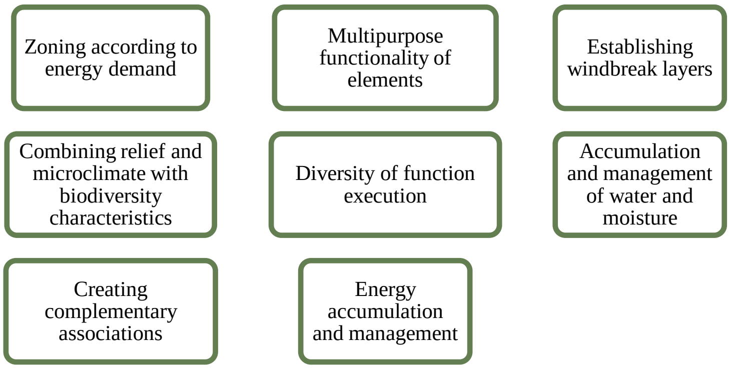

Fig. 1. Principles of Permaculture Design.

The system of permaculture implementation allows for:
– more efficient use of the symbiotic characteristics of plants and animals;
– utilization of plant compatibility and complementary features;
– cultivation of plants with mixed species, varieties, and dense planting;
– preservation and enhancement of biodiversity;
– accumulation and application of biological resources (compost and mulch);
– production of organic products [4].

Material and Methods. International scientific research on permaculture includes numerous studies focusing on soil restoration, water management, biodiversity, agroecology, and sustainable agricultural systems [2, 5–7]. According to various scientific and industrial research results, the efficiency of permaculture is primarily determined by soil restoration and the improvement of its properties. This system allows for an increase in organic matter content in the soil by up to 30%, which enhances soil infiltration capacity and carbon fixation [8, 9].

Permaculture technologies prevent soil erosion by up to 60%, contribute to solving water management challenges, restore groundwater reserves (by 20–40%), enable the production of ecologically clean products, reduce irrigation norms, increase biodiversity, and restore ecosystems [10].

Studies show that in permaculture-based farming systems, the efficiency of bees and other pollinators increases by 40–60%, which is crucial for the development of sustainable agriculture [11, 12].

Despite the positive results already recorded in international practice regarding this technology, a unified and effective model for the design and implementation of permaculture has not yet been developed from a social and economic perspective.

For the development of a permaculture model, the study was conducted in the enlarged community of Masis, specifically in the villages of Sis, Ranchpar, and Hovtashat. These settlements face several challenges due to their limited land and water resources, including:

- a decrease in the level of groundwater in the artesian basin;
- processes of soil salinization and degradation in irrigated lands;
- crop yields being directly dependent on the amount of fertilizers and pesticides used;
- declining soil fertility;
- monoculture-based agriculture leading to soil depletion and an increase in pests;
- wastewater from fish farms being almost entirely unused for irrigation, contributing to environmental degradation [13].

The implementation of permaculture in the villages of Sis, Ranchpar, and Hovtashat within the enlarged Masis community aims to address these issues. The foundation for this model is the utilization of artesian wastewater from fish farms.

Results and Discussion. For the development of the permaculture model, a study was conducted on the water-covered areas of the selected settlements. The NDWI (Normalized Difference Water Index) was used as the basis for the assessment of these areas, with its values for different months presented in Fig. 2.

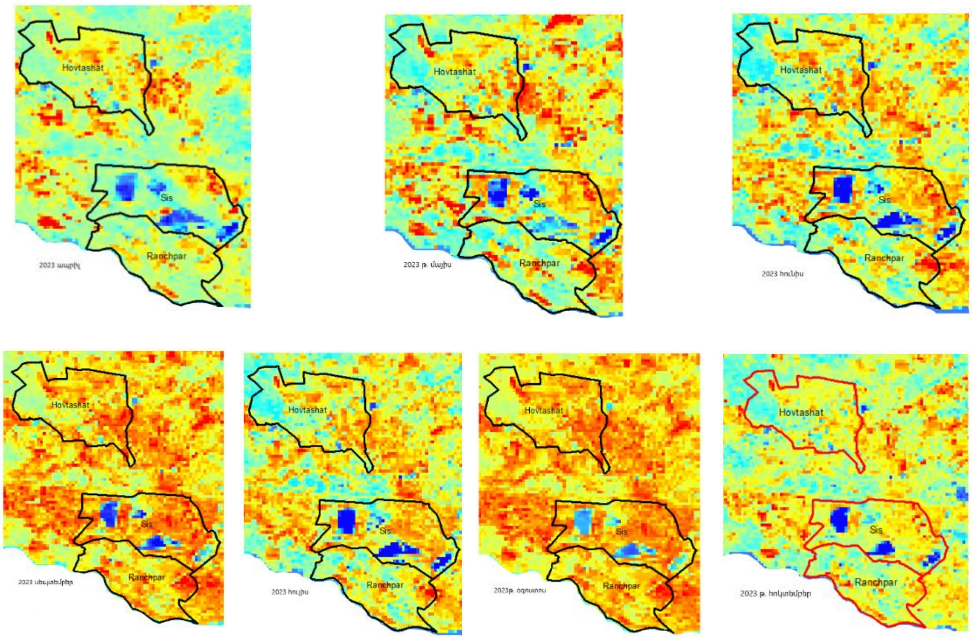

Fig. 2. Assessment of Water-Covered Areas within the Administrative Boundaries of Hovtashat, Ranchpar, and Sis Using the NDWI Index (2023).

Analysis of satellite images reveals that the water-covered area in the village of Sis is 18 000 m^2, in Ranchpar it is 1 500 m^2, and in Hovtashat it is 21 000 m^2.

The Normalized Difference Water Index (NDWI) effectively assesses the moisture content in a given area. For the Landsat 7 satellite, it is calculated using the following formula:

$$\text{NDWI} = \frac{\text{Band 2} - \text{Band 4}}{\text{Band 2} + \text{Band 4}},$$

for the Landsat 8 satellite:

$$\mathrm{NDWI} = \frac{\mathrm{Band\ 3} - \mathrm{Band\ 5}}{\mathrm{Band\ 3} + \mathrm{Band\ 5}},$$

where Band 2–5 are specific spectral bands from a particular satellite Landsat 8.

The NDWI values correspond to the following characteristics of the area are represented in Tab. 1.

Table 1

The NDWI values and characteristics of the area

NDWI values	Area characteristics
0.2–1.0	water surface
0–0.2	high moisture content / moist conditions
–0.3–0	severe drought, non-water surface
–1.0–0.3	drought, dry land surface

Table 2

Results of chemical analysis of return waters of the Sis settlement

Indicator	Meas. unit	Indicator value			The norm of the indicator according to FAO
		2021 February	2022 April	2023 September	
Hydrogen Index (pH)		7.7	6.89	7.1	6.0–8.5
Electrical conductivity	MSM/*cm*	622	635	619	0–3000
Mineralization	*mg/L*	423	410	420	2000
Sulfate ion	*mg/L*	77.2	78.5	75.1	0–960
Chloride ion	*mg/L*	59.1	59.9	55.67	0–1050
Fluoride ion	*mg/L*	0.251	–	0.139	1
Nitrate ion	*mg/L*	16.996	16.2	13.16	0–44
Ammonium ion	*mg/L*	0.683	0.022	0.248	0–6.42
Hydrocarbonate ion	*mg/L*	180	183.1	170.9	0–610
Phosphate	*mg/L*	0.311	0.39	0.493	0–6.1
Li	*mg/L*	0.01529	0.02	0.0176	2.5
Be	*mg/L*	0.00001	0.00001	$<10^{-6}$	0.1
B	*mg/L*	0.1847	0.18	0.3082	0.7
Na	*mg/L*	33.0321	35.3	30.44	69
Mg	*mg/L*	18.81	17.9	25.88	60
Al	*mg/L*	0.0046	0.004	0.003	5
P	*mg/L*	0.1309	0.03	0.1247	0–2
K	*mg/L*	3.4158	4.6	4.36	0–2
Ca	*mg/L*	39.899	40	55.12	400
Ti	*mg/L*	0.0062	0.01	0.0027	not defined
V	*mg/L*	0.0126	0.0134	0.0162	0.1
Cr	*mg/L*	0.0015	0.002	0.0141	0.1
Fe	*mg/L*	0.0136	0.0182	0.0526	5
Mn	*mg/L*	0.0033	0.0022	0.0068	0.2
Co	*mg/L*	0.00012	0.001	0.0001	0.05
Ni	*mg/L*	0.0022	0.0024	0.0016	0.2
Cu	*mg/L*	0.0007	0.0029	0.00054	0.2
Zn	*mg/L*	0.0014	0.0043	0.0005	2
As	*mg/L*	0.0041	0.0045	0.0044	0.1

Due to the operation of a single fish farm, the water-covered area in Ranchpar was recorded at 375 m^2, in Hovtashat at 1000 m^2, and in Sis at 947 m^2. From these water-covered areas, approximately 756 171 m^3 of irrigation-suitable water, rich in organic and mineral substances, is discharged annually into the external hydrographic network.

The number of deep wells is as follows: Ranchpar – 4 wells; Sis –19 wells; Hovtashat – 21 wells; total– 42 wells.

The average recharge area per well is 100 *ha*, with an average well impact radius of 564 *m*. Given that the administrative area of Ranchpar is 1250 *ha*, Sis is 1476 *ha*, and Hovtashat is 1510 *ha*, the recharge area per settlement is Ranchpar – 312.5 *ha*, Sis – 77.6 *ha*, Hovtashat–71.9 *ha.*

The average well impact radius for these settlements is: Ranchpar – 997.6 *m*; Sis – 497.1 *m*; Hovtashat – 478.5 *m* [14].

The results of chemical analyses assessing the quality of these return waters are presented in Tab. 2. Sampling was conducted from the return waters of three different fish farming ponds located in three separate communities, with a total of three samples collected. The water analyses were carried out in the laboratories of the Armenian National Agrarian University. Analysis of the provided data clearly indicates that these discharged waters are entirely suitable for crop growth and development. The presence of various microelements further supports the suitability of these waters as a basis for developing a permaculture model.

To implement permaculture in the villages of Sis, Ranchpar, and Hovtashat in the Masis community, the following actions are proposed:

1. Selection of areas within the impact zone of wastewater from fish farms and analysis of land-use conditions.
2. Choosing a 5–10 *ha* plot of land for permaculture implementation, considering soil quality, water availability, and sunlight exposure.
3. Conducting laboratory soil analysis to determine pH levels, organic matter content, and salinity levels.
4. Assessing water resources to determine water availability and quality.
5. Organizing meetings with local farmers and community representatives to explain the benefits of permaculture.
6. Implementing practices to increase organic matter in the soil.
7. Developing and applying green fertilization techniques.
8. Using artificial and natural mulching to minimize the physical water cycle in the “soil–plant–air–groundwater” system.
9. Applying green fertilizers (e.g., peas, soybeans) to enrich the soil with nitrogen.
10. Establishing a composting station for organic waste processing.
11. Organizing smart irrigation systems.
12. Installing solar-powered pumps for low-pressure drip irrigation systems.
13. Defining optimal water requirements for crops and planning an irrigation schedule.
14. Implementing filtration and biological purification systems for water recycling.

15. Utilizing companion planting systems (e.g., corn, beans, squash) for soil improvement and pest control.

16. Selecting drought-resistant local crops, such as pomegranates, grapes, and blackberries.

17. Practicing companion planting for pest control (e.g., basil near tomatoes, garlic near potatoes).

18. Using GIS systems for continuous soil fertility monitoring.

One of the best permaculture solutions in aquaculture is the implementation of aquaponics, which integrates fish farming and plant cultivation in a closed-loop system. In this system, nutrient-rich wastewater from fish tanks is directed to plant roots, where the plants absorb essential nutrients and purify the water before it is returned to the fish tanks. This reduces the chemical load in wastewater, decreases the need for chemical fertilizers, conserves water, and results in ecologically clean agricultural production (both plants and fish).

Chemical analysis of wastewater has shown that it contains nitrogen, phosphorus, and other elements that can be transformed into fertilizers. The effectiveness of the permaculture model, particularly for small-scale farms, is not primarily aimed at increasing profitability in the initial stages. Rather, its main objective is to restore the agro-ecological balance of the agro-landscape zone. The restoration of this balance is a time-consuming process, and its economic evaluation can only be addressed after the natural ecological equilibrium of the surrounding environment has been reestablished.

One of the key components of the permaculture model is vermicomposting, which involves using red worms to process organic fish farm waste into biohumus, a highly effective organic fertilizer. The development of liquid organic fertilizers is also recommended.

Hydroponic crops suitable for this system should be selected based on the local climate and economic conditions, taking into account factors such as temperature, pH, lighting, and the availability of essential nutrients (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, and trace elements) [15–17].

Conclusion. The introduction of permaculture in the Masis community can be based on a systematic approach, incorporating soil restoration, water resource management, biodiversity promotion, and community involvement.

Permaculture implementation in Masis can support sustainable agriculture, soil restoration, and economic development with minimal costs and long-term benefits. This process can be carried out step by step, involving farmers, local authorities, and educational institutions.

This initiative will contribute to the development of sustainable agriculture, soil restoration, water conservation, and economic growth in the Masis community. Active community engagement and education will be key to its success.

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ՊԵՐՄԱԿՈՒԼՏՈՒՐԱՅԻ ՆԵՐԴՐՄԱՆ ՄՈԴԵԼԻ ՄՇԱԿՈՒՄԸ ԱՐԱՐԱՏԻ ՄԱՐԶԻ ՄԱՍԻՍ ԽՈՇՈՐԱՑՎԱԾ ՀԱՄԱՅՆՔԻ ՍԻՍ, ՌԱՆՉՊԱՐ, ՀՈՎՏԱՇԱՏ ԲՆԱԿԱՎԱՅՐԵՐԻ ՕՐԻՆԱԿՈՎ

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Հետազոտության արդյունքները վերաբերում են Մասիսի խոշորացված համայնքի Սիսի, Ռանչպար Հովտաշատ բնակավայրերի վարչական տարածքի սահմաններում գործող ձկնաբուծարանների հետադարձ ջրերի օգտագործման արդյունավետության բարձրացմանը, գյուղատնտեսական նշանակության հողերի արդյունավետ օգտագործման և տնտեսության կայուն զարգացման մոդելի մշակման հարցերի ուսումնասիրմանը Պերմակուլտուրայի նախագծման և դրա տարածման սկզբունքներին և պահանջներին համապատասխան: Այս նպատակով Սիս, Ռանչպար Հովտաշատ բնակավայրերում գործող ձկնաբուծական տնտեսություններից հեռացվող ստորերկրյա ջրերը ենթարկվել են համակողմանի ուսումնասիրության, պարզվել են այդ ջրերի քիմիական կազմը և քանակական մի շարք ցուցանիշներ: Գնահատվել են ջրածածկ մակերեսները դրանց տարածվածության գոտիները և հնարավոր բացասական ազդեցությունը գյուղատնտեսական հողերի բերրիության և շրջակա միջավայրի վրա: Բացասական այդ ազդեցության չեզոքացման նպատակով մշակվել է Պերմակուլտուրայի ներդրման մոդել և հիմնավորվել է այս մոդելի կիրառման հնարավորությունները ձկնաբուծական տնտեսությունների գործունեության էկոլոգիական բացասական ազդեցությունը մեղմացնելու և տնտեսության կայուն զարգացման համար հիմնավոր նախադրյալ ստեղծելու նպատակով:

Г. М. ЕГИАЗАРЯН, М. В. ХАЧАТРЯН

РАЗРАБОТКА МОДЕЛИ ВНЕДРЕНИЯ ПЕРМАКУЛЬТУРЫ НА ПРИМЕРЕ ОБЩИН СИС, РАНЧПАР И ОВТАШАТ УКРУПНЕННОЙ ОБЩИНЫ МАСИС АРАРАТСКОЙ ОБЛАСТИ

Резюме

Результаты исследований касаются повышения эффективности использования возвратных вод рыбоводческих хозяйств, действующих на административной территории населенных пунктов Сис, Ранчпар Овташат укрупненного сообщества Масис, изучения вопросов эффективного использования сельскохозяйственных угодий и разработки модели устойчивого экономического развития в соответствии с принципами и требованиями проектирования пермакультуры и ее распространения. Для этого были проведены комплексные исследования подземных вод, сбрасываемых рыбоводческими хозяйствами, действующими на территории населенных пунктов Сис, Ранчпар Овташат, определен химический состав этих вод и ряд количественных показателей. Оценены водопокрытые поверхности, зоны их распространения и возможное негативное влияние на плодородие сельскохозяйственных угодий и окружающую среду. Для нейтрализации этого негативного влияния была разработана Модель инвестирования в пермакультуру и обоснованы возможности применения данной модели в целях смягчения негативного экологического воздействия рыбоводческих хозяйств и создания прочной предпосылки для устойчивого экономического развития.