EVALUATING MEASURES TO SUPPORT DRYLAND RURAL POPULATIONS UNDER HIGH CLIMATIC UNCERTAINTY AND RISK: THE EXAMPLE OF THE ARAL SEA REGION

Georgy Fomenko[1], Marina A. Fomenko[2]

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[1] Institute for Sustainable Innovation, Yaroslavl, Russia
[2] Cadaster, Scientific-Production Enterprise, Yaroslavl, Russia
info@npo-kad.ru

Abstract

Evaluating international technical assistance projects usually calls for assessing the efficiency and effectiveness of planned indicators. As climatic uncertainty and risk increase, there is a need to improve approaches to assessing the activities of such projects. Using the example of a project to adapt dryland dehkan households, cooperatives, and farms in the Aral Sea region (the Republic of Karakarpakstan in Uzbekistan) to climate change, this research methodically substantiates a set of indicators to assess the long-term effectiveness of adaptation measures. With regard to humanitarian support measures (which are strengthening the hydrometeorological monitoring network, creating early warning systems, raising public awareness about various climate threats and possibilities to reduce their negative consequences, and reclaiming the dried-up Aral Sea bottom to reduce dustiness) that pursue noneconomic goals, an assessment was made against previously established project performance indicators. With regard to ensuring the viability of dehkan households, cooperatives and farms over the long term, this research proves the need in evaluating the effectiveness of agronomic, water-saving, and landscape adaptation measures as a combination of private benefits (economic efficiency) and public goods (social and environmental efficiency). These evaluation indicators will help identify the most promising, effective and efficient practices to replicate in future projects.

Keywords: drylands, climatic vulnerability, climatic uncertainty, climate risk, climate change adaptation technologies, project effectiveness

I. Introduction

As climate uncertainty and risk[1] increase, international development technical support programs must increasingly focus on poverty-reduction strategies, with an emphasis on developing livelihood opportunities for the poorest people, primarily through the transfer of new knowledge and technologies. Thus, there is a demand to review the objectives and priorities of support programs and adjust the performance and evaluation indicators.

Research in this direction was carried out in the southern Aral region (in Uzbekistan, in the Republic of Karakalpakstan) in 2019 in five districts most vulnerable to climate change,[2] where a set of targeted measures[3] of climate-resilient and resource-saving agricultural practices have been

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[1] Risk is a kind of uncertainty when the probability of an occurring event can be determined.

[2] The areas have been recognized as the most affected by the environmental impact of the Aral crisis and, as a result, the most at risk of losing development capacity.

[3] The project activities in the pilot areas resulted in implementation of training activities and measures to reduce dusting in the Aralkum Desert, followed by the creation of 17 intensive gardens with drip irrigation

implemented through the transfer of adaptation technologies. The main objective was to develop a system of indicators for evaluating project activities (a set of agronomic, water-saving, and landscape adaptation measures) that reflected their effectiveness, long-term efficiency, and opportunities for further replication in other regions.

II. Materials and methods

Increasing climate uncertainty and risk are changing the households' lifestyle in the drylands. Such lands occupy 41% of the world's land surface [1] and are populated by more than 2.5 billion of the world's poorest, least healthy, and most marginalized people [2]. Drylands in poor countries are "investment deserts," except where valuable minerals attract targeted investments. The modern desertification paradigm (DP) focuses on the loss of ecosystem services when pastures are converted (due to mismanagement and exploitation of natural resources in drylands) into desert-dominated lands with low biological productivity and plants that are of little use for livestock. However, drylands have valuable assets that are often underestimated: for example, abundant solar energy, plant biodiversity, and significant potential to increase soil carbon storage. Moreover, these lands feed 50% of the world's livestock with the us of the latest technologies (hydroponics, laser land leveling, etc.) [3, 4].

This complex use of drylands under high climate uncertaintt and risk is based on the resilience paradigm of Human-Dominated Ecosystems (HDE). Some experts consider an HDE's ability to maintain its functional integrity by adapting to variable factors[4] as a property or a path to system stability under stress [5, 6].

For external targeted extra-economic (environmental, etc.) interventions in HDEs to have any chance of success after the completion of technical assistance projects, drylands need development tools that encourage the long-term sustainability of transferred innovations and technologies – tools such as domestic financial flows, support systems and infrastructure, a nurturing institutional environment, and climate risk insurance, among others. The useful method to assess efficiency of project activities is a multicriteria cost-benefit analysis (CBA), which provides for the use of the full economic value and wide use of expert assessments. They allow us to obtain aggregate indicators of the effectiveness of project and planning decisions in situations (1) where households and small producers lack (or have no) primary accounting; (2) where public goods (environmental, social) are being evaluated, since it is difficult to make in monetary terms. As for the measurement of sustainability/resilience of the development of a region, a set of relevant indicators is formed by the three components of sustainability capital: the economy, the environment, and the social sphere. In this context, the assessment of project activities in terms of improving the resilience of regions is carried out using the rapid impact assessment matrix (RIAM).

These assessments allow to represent the real impact of project practices and services on the resilience of agricultural systems [7, 8], as well as to compare different project options and

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over an area of 34 hectares; implementation of 17 hydroponics units with a total capacity of 8.5 tons of green fodder per day (in pasture cooperatives and large farms); and 24 mini hydroponics units with a total capacity of 1.92 tons of green fodder per day (for small commodity producers – owners of homestead lands, and *dehkan* households); transfer of 9 hydropumps to improve irrigation conditions in collective farms (pasture cooperatives); supply of agricultural equipment (14 laser sowers, 15 laser levelers, tractors, attachments for agricultural work, etc.); and the transfer of greenhouses to domestic and collective farms, beehives for organized apiaries, etc. The overall project will lead to the creation of growth points for a new environmental management system.

[4] At present, no scientific method can accurately predict the long-term evolution and spatial distribution of droughts and storm surges, and the impact on the infrastructure of society is not quantified. Modern risk analysis methods make it possible to determine the vulnerability of individual system components to an expected adverse event and to quantify the loss of system functionality due to that event.

development scenarios. Information on climate risks also adjusts data on expected net profits or losses, helps in the development of financial instruments for investing in ecosystem conservation.

III. Initial data and information

Research on measuring climate adaptation of rural populations in the drylands of the Aral Sea region was carried out under the United Nations Development Program (UNDP) project, "Developing Climate Resilience of Farming Communities in Drought-Prone Parts of Uzbekistan" (hereinafter "the project"). The research focused on developing a system of indicators to assess the efficiency of project activities in the process of transferring technologies for adapting to climate change to *dehkan* households, cooperatives, and farms, their efficiency at supporting life, and their long-term sustainability. The work was performed on five pilot sites in the Republic of Karakalpakstan: (1) in Muynak district – transfer of hydroponic facility for production of green fodder and intensive landscaping with a drip irrigation system to the pasture cooperative[5]; (2) in Kegeyli district – transfer of hydroponic facility for production of green fodder, intensive landscaping with a drip irrigation system and hydropumps for irrigation of green fodder to the pasture cooperative; (3) in Takhtakupyr district – transfer of hydroponic facility for production of green fodder to the *dehkan* household[6]; (4) in Kanlykul district – transfer of laser land levelling in combination with a moldboard-less seeder to the farm[7]; (5) in Chimbai district – transfer of greenhouse for year-round cultivation of vegetables and greenery and apiary to the *dehkan* household.

The research information base included (1) official statistical and non-statistical data; and (2) expert data, including results of interviews and focus groups with the individual beneficiaries of the adaptation technology and other stakeholders, information about and analytical and monographic materials related to the implementation of these technologies.

IV. Results

In accordance with the adopted research methods, a complex system of project assessment indicators was developed, consisting of three interrelated sets of indicators.

1. Performance evaluation indicators of the overall project

The first set of project assessment indicators, as shown in Table 1, contains four performance evaluation indicators, which are defined on the basis of the expected results of the project in relation to the beneficiaries and the relevant pilot sites in the following areas: (1) developed institutional capacity and established mechanisms for drought risk management and early warning; (2) climate-resilient farming practices applied in *dehkan* households; (3) adaptation measures to protect soil and retain moisture to improve climate resistance; (4) acquired and

[5] An agricultural cooperative (*shirkat*) is an independent economic entity with the rights of a legal entity, based on a shared and mainly family (collective) contract, a voluntary association of citizens for the production of commercial agricultural products. Law of Uzbekistan on agricultural cooperatives (*shirkat*), April 30, 1998, 600-I; Vedomosti Oliy Majlis of Uzbekistan, 1998, 5–6, Article 84; 2003, 9–10, Article 149; and 2004, 1–2, Article 18; Collection of Legislation of Uzbekistan, 2008, 52, Article 513; 2009, 52, Article 555; and 2013, 1, Article 1; and National Database of Legislation, 21.03.2019, 3/19/531/2799).

[6] A *dehkan* household is a small family-owned household that produces and sells agricultural products based on the personal work of family members on the land provided to the head of the family in the lifetime inheritance (Part 1 of Article 1 as amended by the Law of Uzbekistan, "On the *dehkan* household" , December 21, 2018, ZRU-506 - National legislation database, 21.12.2018, 3/18/506/2356).

[7] A farmis an independent business entity with the rights of a legal entity, based on the joint activities of members of the farm, with commercial agricultural production on the land provided in the long-term lease (Article 3 as amended by the Law of Uzbekistan "On Farming," April 18, 2018, ZRU-476 - National Database of Legislation, 19.04.2018, 03/18/476/1087).

widely available knowledge about climate-resilient agricultural production systems, including crop and livestock production in drylands.

The evaluation of the project's current performance showed that significant success has already been made to date in establishing a sustainable system to transfer knowledge and skills. This research found that project activities led to reductions in climate vulnerability for all individual beneficiaries, based on climate vulnerability index calculations performed in accordance with Hinkel's methodology [9]. The project results varied among the pilot sites, and the decrease in climate vulnerability was also uneven among pilot sites.

2. Benefits to individual beneficiaries and the community

The second set of project assessment indicators evaluate the effectiveness and viability of the project's long-term results. The assessment was carried out by comparing two options —with project implementation (expected) and without it (baseline), using the developed within the Project "Methodological recommendations for 'fast-track' assessment of the efficiency of pilot projects to ensure climatic sustainability of farms located in the arid regions of Uzbekistan" and a list of factors/criteria for assessing the effeciency of adaptation technologies at pilot sites. The assessment was carried out in points for the accepted indicators, according to the possible estimated values and the significance of each indicator (see Table 4). The results of assessing the efficiency of adaptation technologies at pilot sites (in terms of the aggregate of the economic benefits of individual beneficiaries and public goods – social, economic and environmental) are presented in Table 1.

Findings showed that drip irrigation led to maximum efficiency (111 and 112 points), allowing dryland farmers to obtain consistently high yields of agricultural crops and avoid increased soil salinization, which is very important due to the already saline soils of Karakalpakstan. Minimal efficiency was noted in a small greenhouse (65 points) at pilot site 5, mainly due to small volumes of marketable products.

2.1 Individual benefits to farmers

Although this research mainly concerns noneconomic benefits to individual farmers and communities, it still paid attention to the economic benefits of the technologies transferred to farmers and communities in the five pilot projects. Concerning the private economic profit to the individual beneficiaries within the total volume of private and public goods, it was found that the highest income resulted from apiaries and small greenhouses (38% and 36.9%, respectively), mainly due to the intense labor of the owner's family and collaborative workers, mutual trust among these family members and workers, and their respect for the requirements of the owner and their willingness to work whenever it's needed.

2.2 Public benefits and social good

In terms of the public good, the following observations were made. The hydroponic facility in the Muynak and Kegeyli districts had the greatest social effect (32.9%), making it possible to significantly increase and improve the quality of the feed base for livestock breeding and increase the number of livestock. High social benefit for the local community was recorded in the apiary (19%) transferred to the dehkan household (Chimbai district). In terms of the environmental public benefits, the drip irrigation systems transferred to the Muynak and Kegeyli districts were most efficient (57.1%). This was due to large savings in water for irrigating agricultural products (fruits) and, as a result, decreased pressure on the regional aquatic ecosystems.

3. Sustainability

The third set of project assessment indicators evaluates the sustainability of development of territories (in the pilot site areas) as a result of the project implementation, understood as a change in the total wealth (capital) of the territory (in economic, social, and environmental terms). Calculations were made using the Rapid Impact Assessment Matrix (RIAM)[8] [10, 11];

[8] This method was successfully applied during the implementation of the "Extended Berlin Geothermal Field Project" to increase electricity production by using geothermal sources; also it was used by the authors in

consequences (positive and negative) were assessed for two options – without implementation of the project activities and with implementation of the project activities. Results confirmed the undoubted viability of project activities for the sustainable development (resilience) of pilot sites at *dehkan* households, pasture cooperatives and farms in all three areas of measured impact: environmental, social, and economic.

Table 1: *Efficiency of Adaptation Technologies, Assessed at Pilot Sites*

Pilot Site	Pilot sites/transferred adaptation technologies	Assessment Estimates, in points			Total points
		Economic benefits to individual beneficiaries	Public goods		
			Social	Environmental	
1	**Muynak district – Azhiniyaz Jailolari pasture cooperative**	**46**	**66**	**101**	**213**
1.1	Hydroponic facility	*26*	*39*	*37*	*102*
1.2	Drip irrigation system for fruit production	*20*	*27*	*64*	*111*
2	**Kegeyli district – Kazanketken Jeylovi pasture cooperative**	**72**	**85**	**137**	**294**
2.1	Hydroponic facility	*26*	*31*	*37*	*94*
2.2	Drip irrigation system for fruit production	*20*	*28*	*64*	*112*
2.3	Hydropumps for irrigation of green fodder	*26*	*26*	*36*	*88*
3	**Takhtakupyr district – *dehkan* household hydroponic facility**	**16**	**15**	**28**	**59**
4	**Kanlykul district – farm, laser land levelling**	**26**	**18**	**44**	**88**
5	**Chimbai district – *dehkan* household**	**54**	**31**	**59**	**144**
5.1	Greenhouse for year-round cultivation of vegetables and greenery	*24*	*16*	*25*	*65*
5.2	Apiary	*30*	*15*	*34*	*79*
	TOTAL FOR ALL PILOT SITES	**214**	**215**	**369**	**798**

V. Discussion

The example of the Aral Sea region confirms the necessity of using three sets of mutually linked assessment indicators in conditions of high climate uncertainty and risk. Such a proposed system should include indicators for 1) assessing the attainment of the established project results, 2) assessing the effectiveness and viability of project results in the long term, in terms of economic benefits to direct beneficiaries and social, environmental, and economic benefits to the local community, and 3) systematically increasing the sustainability of the development of areas where pilot sites are located as a result of implementing such projects.

With regard to humanitarian measures (such as strengthening the hydrometeorological monitoring network, creating early warning systems, raising public awareness of climate threats and methods to reduce their negative effects, and recultivating the bottom of the dried-up Aral

developing a model for sustainable natural resource use of the Arkhyz territory (Russian Federation) and in assessing development options for water supply systems of the Plescheevo Lake basin.

Sea to reduce dust), all of which pursue noneconomic goals, it is appropriate to assess effectiveness, that is, to determine the extent to which measures to reduce climate uncertainty have been implemented and the planned results have been obtained.

In terms of measures to ensure the resilience of *dehkan* households, farms, and cooperatives, attention should focus on assessing the efficiency of agronomic, water-saving, and landscape adaptation measures as a set of private benefits to direct beneficiaries (economic efficiency) and the public good (social and environmental efficiency). Performance indicators (economic, social, and environmental) provide a better understanding of the motivation of specific users to adopt climate-saving practices that take into account adaptation risks and to assess the likelihood that such practices will be adopted, preserved, and provide livelihood opportunities for specific target groups in the long term after external intervention. Performance evaluation also includes indicators that characterize system changes more broadly, specifically in administrative areas where pilot sites for transferring adaptation technology are located. It is advisable to include indicators of sustainable development and a green economy; in the long run, such a system of indicators should be based on methodological approaches of environmental/economic accounting.

The proposed three sets of assessment indicators for evaluating project activities have a sufficiently high potential for use in conditions of increasing climate uncertainty and risk. It is easy to use and does not require significant labor and financial costs.

VI. Conclusions

Thus, complex design solutions that strengthen the resilience of human-dominated ecosystems deserve support if drylands are to be habitable for people in the future. Technical support measures alone are not enough, as new water-saving technologies can be widely and effectively applied only in an information and institutional environment which is suitable to them. For wide use of such technologies in the Aral Sea region it is necessary to establish pasture cooperatives, create a system of technical maintenance, organize sales of products and a reliable energy system. This causes the need for a comprehensive assessment of their effectiveness and efficiency and the use of the system of evaluation indicators developed by the authors. Aggregated evaluation data allow for prompt correction of project activities, in the process of distribution of adaptation technologies in other regions.

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Conflict of interests

The authors declare no conflict of interests.

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