Application of the FAO Ex-ACT tool for carbon balance accounting in the agroecosystems of Tajikistan

**Olga Golubeva[1], German Kust[2], Murod Ergashev[3],Olga Andreeva[4]*

[1]Environmental Land management proj., CEP, Tajikistan; Moscow University PhD student. golubeva190@gmail.com
[2]World Bank, Consultant; Moscow Lomonosov State University, Professor. gkust@yandex.com
[3]Environmental Land management project, Committee for Environmental Protection, Tajikistan. soil_m@rambler.ru
[4]Moscow Lomonosov State University, Associate Professor. andreevala@yandex.ru

Abstract

The FAO Ex-ACT tool was applied for the calculation of the carbon balance in the agro-ecosystems of Tajikistan. This method allows to make decisions on the use of low-carbon (low-emission) technologies in the agricultural sector. There were studied about 800 micro-projects implemented by local communities in the three macro-regions: Moist and semi-dry highlands; Moist foothills, and Dry downlands. It is shown that the Ex-Act can successfully define the groups of sustainable land management mini-projects by using the "carbon balance" criterion. According to this criterion the activities implemented by local communities in the highlands, are 10 times more effective than those in the lowlands. The highest specific efficiency for the formation of carbon stocks in soils and of the long-term sequestration in the above-ground biomass (per unit area) is typical for pasture management projects, horticulture, and deforestation control. Infrastructure projects (roads, greenhouses, etc.), on the contrary, contribute to increased CO_2 emissions and necessarily require appropriate compensatory measures.

Keywords: Ex-ACT, carbon balance, agricultural ecosystems, sustainable land management

Introduction, scope and main objectives.

There is no uniform opinion among scientists how to consider the role of agricultural sector in the carbon balance. Apparently, the most likely opinion should be considered that the various agricultural branches and technologies can contribute to both the emissions of greenhouse gases (GHG) and to reduce them. The last is linking with the absorption of carbon by formation of the soil humus (long term storage), and with the accumulation of the slowly mineralized biomass of wood and/or industrial crops.
For decision-makings on the use of low-carbon (low emission) technology in the agricultural sector it is important to know their effectiveness and the overall carbon balance, taking into account the above-ground and below-ground carbon pools in the complex of interrelated activities of the agricultural cycle. There is no single mechanism designed at the moment taking into account the absolute values of GHG emissions and carbon accumulation in agriculture, but there are mathematical models to assess the main trends in the carbon balance change within different land use and land management methods and approaches. The Ex-ACT modelling tool developed by FAO to assess the carbon balance is among these models, and is based on the 'estimated quantities' in agricultural and forestry projects ((Bernoux et al., 2010; Ex-ante Carbon-balance Tool - Ex-ACT). The method was used in our study to assess the "low-emission" efficiency of small-scale testing projects on sustainable land management. These projects are implementing in Tajikistan with the support of the World Bank, GEF and the Pilot Program for Climate Resilience within the project "Environmental land management and improving people livelihoods in rural areas". In the future, it is assumed that the carbon balance criterion will be used to recommend the most efficient technologies for dissemination. The tool can also be useful for the selection of project activities that provide the greatest benefits in economic terms and climate change mitigation, and evaluation results can be used during the financial and economic assessment of the projects (Cerri et al., 2010).

Thus, the purpose of our study was solved with the help of two interrelated tasks: (a) using the criterion of “carbon-reduction” to conduct a comparative assessment of agricultural technologies and complex of economic activities potentially considered to be sustainable in different natural and socio-economic conditions of a particular country; (b) to evaluate the possibility of using the Ex-ACT method to assess the perspectives of the carbon balance control at the level of communities and small farmers.
It is also important to note that the Ex-ACT method demonstrated good results in more than 20 project sites in Africa, Asia-Pacific and Latin America, but in Central Asia this tool was used at such a large scale for the first time.

Methodology

In total the Ex-ACT method was used for processing the information about 800 local projects implementing in the rural area Tajikistan in 2015-2016. We studied not only technologically different projects (cereal plants production, water management and irrigation, cattle breeding, pasture management, horticulture, road and canal rehabilitation, soil protection and eroson control, creenhouses, biofuel and alternative energy sources, etc.), but also compared the carbon balance of the similar activities implementing in different biophysical and economic conditions. In this respect, Tajikistan is very attractive country, because different natural zones are presented here: from high mountains with predominantly pastoral use, to the foothills with a rapidly developing horticulture and rainfed agriculture on slopes, upto the lowlands with well developed but devastated irrigation systems, where the current active search for effective cost-effective crop rotation (to replace the pre-existing monoculture of cotton using a water and soil conservation techniques) are taking place. The complexity as a combination of multicultural planting in the farms with cattle breeding is the main feature and at the same time a basis of the small private farms in Tajikistan. In combination with different climatic conditions a variety of impacts contributing to the carbon footprint provides a good platform for testing the functionality and applicability of the Ex-ACT method.
The Ex-ACT tool is a system for accounting carbon stocks and their changes in per unit area or yield, measured in equivalent tonnes of CO_2/ha per year. The carbon balance is calculated as the difference between the two scenarios of the development: "with" and "without" project activities. The Ex-ACT is based on the Microsoft Excel platform and consists of a number of modules, which describe the main directions of the agricultural and forestry sectors in terms of the carbon balance components, and works on the principle of "black box": after data entry in the relevant cells the output is the value of the carbon balance taking into account the capitalization time (we used the 20-years period). The main advantage of this approach is that it is accessible by trained users, who do not necessarily have a deep knowledge of the mechanisms of the carbon balance in the upper and below ground ecosystems (such as farmers, governmental field officers, NGOs, and others.). Therefore, the profile-based questionnaire was developed to collect primary data, where local farmers inserted the necessary information. Thereafter, it was checked for consistency and entered into a database for the purpose of further calculations. The coefficients used in some of the Ex-ACT modules were also checked (to be modified if need) on the basis of field and laboratory studies of the carbon balance in randomly selected sites.

Results

The application of the Ex-ACT tool for small areas (less than 1 hectare) it was discovered that the sensitivity of the method is low, because the values of the carbon balance do not exceed tenths or even hundredths tonnes of CO_2. In these cases the combination of similar projects in one can help, or alternatively more details in the description of the project are required, which is often beyond the scope of a standard questionnaire.
With these modifications the results obtained characterize the project activities as positive in terms of reducing carbon emissions. The most effective is the horticulture development (more than 34% of the total project activities, leading to carbon sequestration), the second is the perennial planting (about 24%), and the third is the rehabilitation of irrigation systems and canals, especially in arid regions (about 19 %).
More detailed results are given in the tables. Effective interventions are characterized by a negative carbon balance (absorption and long-term carbon sequestration), inefficient are characterized by positive balances (emission into the atmosphere).

Macro-Region	Number of subprojects	Gross carbon balance	Average carbon balance per project	% of the total carbon balance	Carbon balance per year
Moist and semi-dry highlands (Tavildara and Jirgatol districts)	186	-42083	-226	63	-2077
Moist foothills (Baljuvon and Khovaling districts)	218	-12987	-60	19	-641
Dry lowlands (Farkhor and Kulob districts)	380	-11702	-31	18	-578
Total	784	-66771	-85	100	-3296

Table 1: Carbon balance in the project's macroregions

Type of activity	Macroregion	Sequestration: t CO2-eq per hectare		
		Maximum	Mean	Minimum
Deforestation control	Midlands	-458	-255	-54
	Lowlands	-363	-312	-210
Horticulture	Highlands	-355	-176	-16
	Midlands	-183	-151	-64
	Lowlands	-153	-135	-92
Perennial meadows and pasture management	Highlands	-233	-63	-20
	Midlands	-44	-42	-32
	Lowlands	-26	-22	-16
New technologies for crop production	Highlands	-54	-39	-7
	Midlands	-54	-48	-44
	Lowlands	-30	-15	-4
Rehabilatation of irrigation canals	Highlands	-20	-19	-15
	Lowlands	-57	-24	-16
Water management	Highlands	-20	-19	-16
	Midlands	-21	-19	-17

Table 2: Specific carbon balance for some key activities

Discussion

The data obtained show that although the investments in the micro-projects are of the close scale, but in different macro-regions and invested in the development or application of different technologies they have different results in the carbon deposition: almost 60% of the effective carbon sequestration accounts for sustainable land management activities implemented in the highlands, primarily due to the micro-projects in horticulture and pasture management. Specific efficiency of the micro-projects evaluated by the carbon absorption criterion is almost 10 times higher in the highlands than in the valleys with irrigated agriculture. This is largely due to the fact that the local communities in the highlands invest the bulk of funds for the projects directly contributing to improving the state of natural resources (soil, forests, alpine meadows, pastures), and in the valleys farmers mostly invest in infrastructure projects (roads, greenhouses, water facilities and channels).

The specific values of carbon emissions (equivalent tonnes CO_2/ha per year.) are of particular interest. The data clearly shows that the most effective measures for carbon storage are: deforestation control, horticulture, and pasture management. The stabling activities and infrastructure development and rehabilitation as well as greenhousing promote the largest carbon emissions.

Conclusions

The results suggest that the mathematical models underlying the method of Ex-ACT are able to adequately describe the carbon fluxes within different land-use types, and can used for the planning of environmentally effective activities in different biophysical conditions.

The method helped to determine these most effective activities in the region (by the criterion of the annual carbon emission): deforestation control, horticulture, and pasture management. The stabling activities and infrastructure development and rehabilitation as well as greenhousing promote the largest carbon emissions.

Among the local communities, who have been granted an independent right to choose the direction of the project activities, the most effective in the development and application of low-emission and low-carbon technologies are those who live and operate in high-altitude regions. Their efficiency is 10 times higher compared with those communities living in low-lying valleys.

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EX-ACT - Ex-ante Carbon-balance Tool. Available at http://www.fao.org/tc/exact/ex-act-home/en/