Policy Note

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Photo: A View of Mwea Irrigation District

How Could the Benefits of Climate Change Adaptation Be Incorporated into Economic Evaluation of Development Projects?

JICA Ogata Sadako Research Institute for Peace and Development*

Abstract

- Quantifying the economic benefits of climate change adaption may help attract more investments in projects with high adaptation benefits.
- Quantification often faces the challenge of representing uncertainties of many possible futures including those related to climate change impacts.
- There are methods available that help quantify the adaptation benefits of projects amidst uncertainties, and a case study of irrigation development projects in Kenya illustrates their usefulness.
- Using such an evaluation method, the analysis of this case study visually demonstrated that development of irrigation infrastructure and introduction of improved farming methods in the study area could reduce vulnerability of farmers' income and rice production there to future uncertainties, including potential negative impacts of climate change.

1. Adaptation and development

There have been decade-long discussions over how to distinguish adaptation to climate change from conventional development activities, because many activities targeting those objectives overlap with one another. A frequently cited answer to this question is that there is no clear line to divide them, and they blend into each other in continuum (McGray et al. 2007). What qualifies an activity as a climate adaptation action is not its specifications but rather its development process, which includes understanding the specific local context of the risks of climate change and making informed decisions on options to reduce them (Hamill and MacGray 2018). The development of adaptation actions can be implemented in many different forms and depths but

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[*] This policy note was authored by Daiju Narita (Graduate School of Arts and Sciences, The University of Tokyo/ JICA Ogata Sadako Research Institute for Peace and Development/ Kiel Institute for the World Economy) and Ichiro Sato (JICA Ogata Sadako Research Institute for Peace and Development).

some stakeholders would wish to find out to what extent an action or a project is effective in adapting and building resilience to climate change. That is a legitimate question from the perspective of, for example, financiers dedicated to supporting climate change adaptation projects who need to prioritize one project over others to be funded with their limited financial resources.

Critics of the current state of climate finance (i.e., financial support for climate change mitigation and adaptation actions) from developed countries to developing countries argue that funding is skewed towards mitigation actions while adaptation actions lack sufficient financial support (Buchner et al. 2017). Recognizing the gap in funding for adaptation, Parties to the Paris Agreement adopted a decision in 2021 that urged developed countries to at least double (relative to the 2019 level) their financing for climate adaptation measures by 2025. Quantifying adaptation benefits could increase the appeal of adaptation proposals to potential financiers and attract more climate finance. It could also mobilize more development finance (financial support to development efforts in developing countries) for adaptation by revealing the adaptation's value-add to the projects (i.e., benefits attributable to the reduction in future losses from climate change), beyond their conventional development benefits. Such a value-add would not be captured by standard project appraisal approaches such as cost-benefit analysis, and consequently some high-performing adaptation projects might be rejected because their net present values or benefit cost ratios do not reach the set criteria for investment. These constitute a business case for quantifying the effectiveness of adaptation actions; this policy note illustrates an approach to doing so, taking irrigation development as an example.

2. Irrigation as a measure to adapt to climate change

Negative impacts of climate change on agriculture and food security are already observed in many parts of the world, including Africa (IPCC 2022). It is imperative to take a range of adaptation measures to counter such negative impacts, and irrigation is one of the promising options to adapt to the changing climate. While irrigation could provide protection against variability of water availability for agriculture, Damania et al. (2017) argue it is not always successful in some dry regions and low-income countries. The authors further warn of the danger of maladaptation and call for good policies to make the best use of the irrigation infrastructure.

There are numerous challenges that planners, managers, and users of irrigation systems need to confront. In some cases, irrigation systems underperform because of technical problems such as excessive siltation of irrigation dams and canals, or water leakage or blockades of canals due to design failure and/or a lack of proper maintenance (Amede 2015; Appiah-Nkansah 2009; Plusquellec 2009). Social and institutional problems include lack of management over and discipline of water users who do not comply with the designated volume and schedule of irrigation, and their inadequate choice of crops and cropping systems that do not match water budgets (AHT Group AG Management and Engineering and UNICON 2013; Amede 2015; Bazin, Skinner, and Koundouno 2011; Tran et al. 2021; Van Huynh et al. 2019). Irrigation may also underperform because of periodic droughts (Yamashita and Hata 2021; Zwane 2019).

Many of those problems are avoidable or preventable through conventional measures for good infrastructure development and management, such as quality control of engineering design and construction of the infrastructure and effective policies and institutional arrangements to ensure smooth operation, sound financial management, rule enforcement, and proper maintenance.

However, there are types of problems that are particularly challenging to cope with: those that arise from unpredictable and uncontrollable external factors such as the future impacts of climate change and the long-term dynamics of the water demands of various water users in the watershed. Some of these unpredictable issues may be addressed through adaptive management approaches. For example, farmers in irrigation areas may decide to switch from cultivating one crop to another in response to unpredictable shifts in market demands or changes in temperature or irrigation water availability. Such adaptive management approaches are effective if the adaptive measures are not too difficult and expensive, and the impacts of unpredictable factors are not irreversible and serious. In the case of the development of irrigation infrastructure, it is usually expensive and difficult to redesign or remove it once it is built. Therefore, if unpredictable and uncontrollable external factors, i.e., uncertainties, put the future of the irrigation infrastructure at serious risk, an additional approach to address them is required. The uncertainties of the effects of climate change are also fundamental reasons why it is difficult to quantify the adaptation benefits of projects.

One of the useful frameworks to address the challenge of uncertainties is the Robust Decision Making (RDM) Framework (Lempert et al. 2003). The following sections demonstrate its usefulness, using a case of irrigation development project in Kenya.

3. Background and conceptual frameworks of the Mwea case study: Project evaluation subject to uncertainties

To obtain insights about the evaluation methods of adaptation benefits for irrigation infrastructure projects, JICA Ogata Research Institute (formerly JICA Research Institute) conducted a case study of the Mwea Irrigation Development Project (MIDP) in Kenya; for detailed methodological descriptions and results, please see Narita et al. (2020, 2022). MIDP is a development project carried out by the Kenyan National Irrigation Authority with a loan from JICA to construct an irrigation dam with a total storage capacity of 15.6 million m^3 (usable storage capacity of 11.2 million m^3) and enhance the irrigation system for farming in the Mwea Irrigation Scheme (MIS). MIS is located about 100km north-east of Nairobi, the capital of Kenya. The development of MIS dates back to 1954, and JICA has provided MIS with technical and financial support since the 1980s (for economic assessment of past irrigation projects on Mwea, see, for example, Kikuchi et al., 2020). Mwea is a major area of rice production in the country. Farming is performed mainly during the two local rainy seasons, the long rainy season from March to May and the short rainy season in October and November. The MIDP had already been initiated following a JICA internal feasibility study conducted in 2009, but the effects of climate change on project performance were not assessed in that prior study. The expansion of irrigation infrastructure by MIDP is designed to improve the quantity and stability of water supply, and as discussed above, its development could in principle have benefits for climate change adaptation.

A major challenge for quantitative evaluation of such adaptation benefits is that it must reflect the fact that any currently available forecasts of future climatic conditions are highly uncertain, at least in terms of predicting patterns for a specific locality – indeed, major global climate simulation models disagree even in terms of whether precipitation will increase or decrease in Kenya as the climate changes. Uncertainties that are dealt with in the context of the study are the lack of knowledge about future contingencies (the Knightian uncertainty), not the randomness that could be described by well-defined probabilities (the Knightian risk). In this sense, conventional frameworks of risk analysis based on probabilistic information (the probabilistic risk assessment) cannot be used for our case. Since a complete set of uncertainties is in principle unknowable and boundless, the focus of an evaluation analysis should be not to describe all future uncertainties but to identify how outcome indicators relevant for the project stakeholders will respond to possible climatic and socioeconomic changes in the future. To do this, the Mwea case study formulated the simulation scenarios and decided output metrics through a process of consultation with local farmers and government administrators, which took place in May 2017.

There are a number of analytical methods proposed for the investigation of problems subject to such uncertainty, grouped as the Decision Making under Deep Uncertainty (DMDU) approaches (for more information about them, see Narita et al. 2022). The analytical concepts the Mwea study adopted are those from the RDM framework, which is one of the DMDU methods. It deals with running simulations numerous times to stress-test proposed decisions against a wide range of plausible futures (Lempert 2019)

4. Simulation analysis of the Mwea case study

4-1 Simulation approach

Reflecting the local concerns expressed in the stakeholder interviews as mentioned above, we designed and conducted a simulation analysis focusing on the future rice yields and household income in the years 2030 and 2050 for a large number of scenarios representing a set of possible climate and local socioeconomic conditions, such as the local population and the market sales prices of crops. We made estimations by utilizing a combination of established climate, hydrological, and yield forecasting models and calibrating them with data from the above-mentioned feasibility study, the literature, and original local data collection. The scenarios are constructed by taking as given the existing local arrangements of water allocation and also by incorporating the possibilities of soft (i.e., non-infrastructure-related) measures for farming to enhance yields, income, and the capacity for climate change adaptation (e.g., water-saving cultivation to reduce vulnerability to droughts). For quantifying the impacts of potential soft measures, we employed the data and findings obtained by the RiceMAPP project, a separate technical cooperation project of JICA that set in Mwea to complement and enhance the effectiveness of MIDP, and studied the potentials of improved farming methods such as those incorporated in water-saving agriculture. Local climatic conditions are estimated by using the publicly available CMIP5 (Coupled Model Intercomparison Project Phase 5) outputs of global climate models to quantify future changes and a global database of weather reanalysis data (WFEDI data) to determine the current local weather conditions. They indicate a general warming of the area under future climate change while the precipitation trends are ambiguous at the locality. The simulated climatic variables are fed into a hydrological model (SHER model) and subsequently, to yield response functions consistent with a yield forecasting model (DSSAT model), the two models are both widely applied in various other studies (for more information, see Narita et al. 2020). See Table 1 for the framework of the analysis.

4-2 Results

The simulation results show that possible levels of household income and rice yields in the future spread over a broad range, differing even in sign (Figure 1).[1] Still, the general tendency that the income and rice yields are higher with MIDP than not (labeled as “donothing” in the figure) is clear. A noteworthy feature in the results is that the worst outcomes under the set of intervention options are much mitigated relative to those under the “donothing”

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[1] The denotation, “donothing”, refers to the option without MIDP or the introduction of farming methods proposed by the RiceMAPP project. All the other options are with MIDP. “RiceRice” denotes options with rice cropping in both long and short rainy seasons. “RiceUpland” denotes options with rice cropping in the short rainy season and upland cropping in the long rainy season. The “+” (plus) sign indicates the options adopt the improved farming practices and techniques proposed by the RiceMAPP project

case. Counterfactual simulations can also be run by assuming that the present climatic conditions will be unchanged in the future (i.e., counterfactual scenarios without climate change), and the residuals between the results with and without climate change could be utilized to identify the genuine impacts of climate change adaptation (Figure 2). Our estimates show that although the size of effects is different across scenarios, MIDP generally mitigates the negative impacts of future climate change (e.g., loss of the rice yield, as shown in Figure 2) relative to the counterfactual case without MIDP, i.e., it has the genuine benefits of climate change adaptation. Figure 2 also implies adaptation benefits of improved farming methods proposed by RiceMAPP, as the distributions of the outcome variable in the negative direction are significantly reduced for the options with "+" sign (indicating options with improved farming methods). In this way, these benefits of climate change adaptation could be quantitatively distinguished from the general development benefits that may occur regardless of the presence of climate change. Table 2 illustrates this point by comparing the distribution patterns of the residual of estimated annual household income for the two intervention options subtracting that of the "donothing" option under the same set of future scenarios with and without climate change effects, which indicates the distribution patterns are generally shifted upward for both intervention options in 2050 with the inclusion of the climate change factor.

5. Policy implications of the case study

The Mwea case study is a demonstration of quantifying the adaptation benefits of development projects. The analysis showed that the development of additional irrigation infrastructure, together with the improved farming methods proposed by RiceMAPP, could reduce the vulnerability of farmers in Mwea and of Kenya's rice production to future negative impacts of climate change and other uncertainties. The method of the study could be applied to other adaptation projects where the impacts of climate change on the projects are highly uncertain and potentially substantial. The limitations of the method include: the broad range of data and models required to evaluate the performance of the projects with many future scenarios; the method's incapacity to evaluate impacts of factors that are inconceivable and unquantifiable; and the amount of time required for analyses and stakeholder consultations.

The following implications are highlighted with the case study.

1) The DMDU approaches, such as the RDM Framework applied in our case study, provide means of incorporating climate adaptation benefits into the economic evaluation of development projects, despite the fact that these benefits are uncertain.
2) By facilitating the clarification of adaptation benefits in a financial sense, it may help promote a shift of the global climate finance, which is currently skewed to mitigation, towards adaptation.
3) Evaluation of adaptation effects of development projects could also be seen as a way to visualize potential benefits of conventional development projects in terms of climate change adaptation, which currently mostly remain implicit, thereby helping attract more development finance to adaptation.
4) Apart from the implications on the mobilization of finance, the case study also shows a practical way to quantify project benefits subject to large uncertainties, which are found not only in relation to climate change but also in many other areas such as the user demand for transportation-related infrastructure in competition with alternative modes of transport.

Figure 1: Estimated farmers' annual income in the Mwea Irrigation Scheme (MIS) in 2030 and 2050 under different project options. Reproduced from Narita et al. (2020).

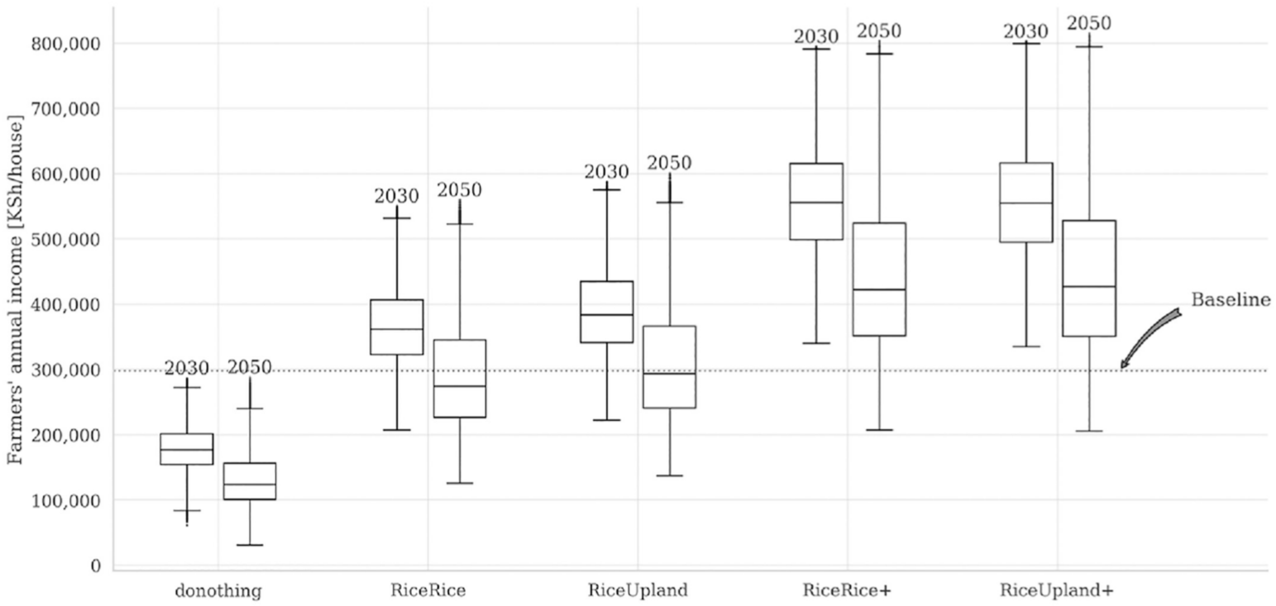

Figure 2: Impact of climate change on the rice yield in the Mwea Irrigation Scheme (MIS) (percentage changes under climate change relative to the levels without climate change). Reproduced from Narita et al. (2020).

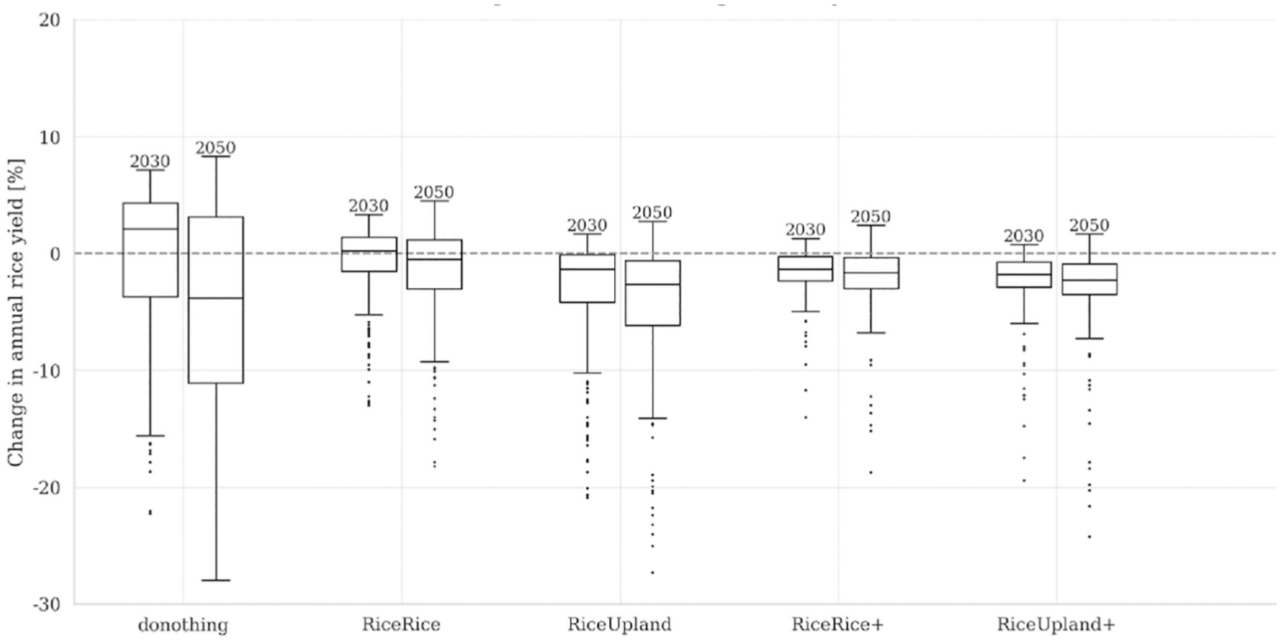

Table 1:
Framework of the analysis

Future uncertainties considered - Atmospheric CO_2 concentration - Temperature - Precipitation (annual, seasonal) - Number of households in MIS - Crop price (rice and upland crops) - Production cost - Discount rate	Options for interventions - No additional interventions after 2009 (do-nothing) - Implementation of MIDP (RiceRice) - Implementation of MIDP (RiceUpland) - Implementation of MIDP and improved farming practices/techniques proposed by the RiceMAPP (RiceRice+) - Implementation of MIDP and improved farming practices/techniques proposed by the RiceMAPP (RiceUpland+)
Models used - SHER model (hydrological model) - DSSAT model (yield forecasting model)	Metrics of outcomes - Rice yield in MIS - Farmers' household income in MIS

Source: Authors.

Table 2:
Relative benefits of project options, estimated as the difference in annual average household farming income (in thousand KSh per household) from that of the no-project ("do-nothing") option inclusive and exclusive of climate change-related effects (developmental and climate-related benefits of the project). Compiled using the data provided in Narita et al. (2022)

	RiceRice+				**RiceUpland+**			
	Year 2030		Year 2050		Year 2030		Year 2050	
	Without CC (developmental benefits)	With CC (developmental + climate-related benefits)	Without CC (developmental benefits)	With CC (developmental + climate-related benefits)	Without CC (developmental benefits)	With CC (developmental + climate-related benefits)	Without CC (developmental benefits)	With CC (developmental + climate-related benefits)
90th-percentile	240	249	222	235	322	335	297	317
Median	207	208	157	165	277	280	208	222
Mean	206	209	163	173	275	281	218	233
10th-percentile	173	170	116	122	230	231	158	165

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Contact:

JICA Ogata Sadako Research Institute for Peace and Development

10-5 Ichigaya Honmura-cho Shinjuku-ku Tokyo 162-8433, JAPAN
TEL: +81-3-3269-2357 FAX: +81-3-3269-2054
URL: https://www.jica.go.jp/jica-ri/index.html