Innovation Brief

CGIAR

INITIATIVE ON
Climate Resilience

Photo: Pierre Restoul / IWMI

Climate Change, Transformative Adaptation Options, Multiscale Polycentric Governance, and Rural Welfare in Oum Er-Rbia River Basin, Morocco: Evaluation Framework

Rathinasamy Maria Saleth[1], Upali A. Amarasinghe[2], Giriraj Amarnath[2], Abdelkader Ait El Mekki[3] and Youssef Brouziyne[4]

[1] Madras School of Economics, Chennai, India
[2] International Water Management Institute (IWMI), Colombo, Sri Lanka
[3] National School of Agriculture, Meknes, Morocco
[4] IWMI, Cairo, Egypt

Summary

This innovation brief presents a methodology that was developed and empirically applied in Morocco to support the "setting up (of) a multiscale polycentric governance framework for promoting transformative adaptation options for climate change" as part of the overarching goal of Work Package #4 (WP4) of the CGIAR Initiative on Climate Resilience (also known as ClimBeR). The empirical application to Morocco underlines the importance of the dynamic aspects of this process by bringing together all relevant elements, i.e., climate change, adaptation options, governance structure, impact transmission mechanism, and welfare into a single analytical framework for assessing the transmission of climate change impacts on rural welfare.

Context

The methodology of setting up a multiscale polycentric governance (MPG) framework for transformative adaptation options (TAOs) is rooted in an analytical approach that delineates the various possible pathways through which the impacts of climate change (CC) ultimately transmit on rural welfare at the grassroots level. Since various configurations of climatic, economic, policy, technical, institutional, infrastructural, and welfare-related variables characterize these impact pathways, this provides an excellent operational context not only for incorporating various elements of the MPG structure within a unified framework but also for evaluating their roles in mediating and enhancing the climate resilience impacts of TAOs both across regional scales and sectoral contexts.

In contrast with approaches prevalent in current climate adaptation literature, the impact pathway-based analytical framework enables the evaluation of the welfare impacts of climate-resilient coping and adaptation strategies in a more dynamic and interactive context. Clearly, the impact pathways, taken together, constitute the basic building blocks of the analytical framework underlying the evaluation methodology. By defining appropriate variables within relevant empirical contexts, these impact pathways can be formalized as an interrelated set of equations. Such an equation system can represent a mathematical analog of the analytical framework, which is capable of being empirically estimated with appropriate data. This innovation brief describes the empirical setting, which is critical for setting up the analytical framework for analyzing the interactions among climate change, multiscale polycentric governance, transformative adaptation options, and rural welfare (CC-MPG-TAO-RW), and the empirical application of the framework and key contributions to development policy in Morocco.

Empirical setting: Oum Er-Rbia River Basin, Morocco

For practical application and demonstration of this evaluation methodology, the study selected the Oum Er-Rbia River Basin (Figure 1), the third largest among 12 major river basins in Morocco.

Morocco is an ideal location for conducting this study for at least four important reasons:

(1) It is a fast-growing country in Africa and is highly susceptible to climatic risks since arid and semi-arid conditions prevail in 93% of the country. There has been a 10-20% decrease in precipitation across the country over the years. Reduced and irregular rain patterns, cold spells, heat waves, and drought conditions are frequent phenomena that severely affect agriculture in particular and the economy in general.

(2) With only 16% of the cultivated area being irrigated, and the rest of the country relying on highly variable and uncertain rainfall, agricultural and food production in Morocco is precarious and vulnerable with serious welfare and food security implications. For instance, the 2016 drought, the worst in 30 years, reduced cereal yields by 70% and significantly slowed down economic growth.

(3) Equally precarious and vulnerable is the water sector, in which the demand-supply gap is widening. Due to climate factors, there has been a 20% reduction in the overall water resources of the country. As against the average annual water demand of 14.7 billion cubic meters (Bm^3), water supply from all sources remains at only about 13 Bm^3. Water availability per capita has declined to just 730 m^3, far below the water stress threshold of 1,000 m^3/person.

(4) Finally, but more importantly, Morocco is one among a few pioneering countries that has undertaken major initiatives to counter the impacts of climate change on their agriculture and water sectors. Morocco has experimented with several TAOs under three major adaptation programs, i.e., the Green Morocco Plan [Plan Maroc Vert (PMV)] covering the period 2010-2020, the National Irrigation Water Saving Program [Programme National d'Economie d'Eau d'Irrigation (PNEEI)] promoted since 2009-2010, and the Green Generation Plan [Plan Génération Verte (PGV)] covering the period 2020-30. Some of these TAOs include:

   a. shifting the crop pattern to tree crops such as olives, oranges, and citrus;
   b. shifting from flood and sprinkler to drip irrigation systems;
   c. modernization of water and irrigation infrastructure;
   d. contract farming/supply aggregation/value-chain development;
   e. corporate farming and public-private partnership in agriculture (via land leased from the government and rural communities), usually by national/foreign private investors; and
   f. zero-tillage farming technology, particularly in rainfed regions.

Figure 1. The Oum Er-Rbia River Basin in Morocco.

To conduct a field study and gather perception-based data, the Oum Er-Rbia River Basin was chosen on the basis of the following rationale:

(1) Oum Er-Rbia is facing the most severe water deficit among the 12 major river basins of Morocco. Water storage has been declining, mostly due to frequent drought conditions and partly due to severe siltation. The five major dams in the basin have a combined storage capacity of 5 Bm^3 but actual storage is not only low but has declined from 18.5% in 2021 to 7.6% in 2022.

(2) Despite its water scarcity, the Oum Er-Rbia Basin plays a central role in agricultural and food production in Morocco. With a 33% share of the total harvested area in the country, this basin dominates in terms of the area share of most cereals—except wheat, in which its area share is the second largest.

(3) In terms of irrigated area too, this basin dominates with a 33% share. It accounts for a major share of the total water used (both blue and green) with a water footprint of 7.7 Bm^3 as against the national water footprint of 23.5 Bm^3.

(4) More importantly, the Oum Er-Rbia Basin is extremely vulnerable to the impacts of climate change, including high frequency and high intensity droughts. Historical data suggest that the basin has experienced a 20% reduction in rainfall and a 40-49% decline in annual flow. All these factors affect agricultural and food production with serious food and welfare implications within and beyond the basin.

Given the vast size of the Oum Er-Rbia Basin, field visits for this study focused on the Beni Mellal-Khenifra region, which is representative enough to capture the overall characteristics of the basin and also manageable enough from a logistical perspective. The basin covers, either fully or partly, three major regions of Morocco: Beni Mellal-Khenifra, Casablanca-Settat, and Marrakesh-Safi. Of these regions, Beni Mellal-Khenifra has five provinces (Azilal, Beni Mellal, Fquih Ben Salah, Khenifra, and Khouribga), and holds a major share of the agricultural area within the basin.

Although field visits were restricted to Beni Mellal-Khenifra, sample selection and data collection covered all regional scales and sectoral contexts, going beyond the study region per se. Similarly, identification of candidate TAOs and key elements of the prevalent MPG structure and impact transmission pathways was based on national, regional, basin, and sector-level reviews, relying on policy documents and published literature as well as interactions with experts, policymakers, and officials. All these aspects are essential to develop an analytical framework that reflects the realities of the study region in particular and the study basin in general.

Evaluation methodology

The evaluation methodology has three components: (a) an analytical framework, (b) a mathematical model, and (c) an empirical approach. Three contrasting scenarios form the conceptual foundation for the analytical framework (Figure 2). These are: (1) evaluating the impact of CC on the overall goal, rural welfare in this case; (2) evaluating the impact of climate change on rural welfare, considering the role of TAOs; and (3) evaluating the impact of climate change on rural welfare, considering not only the role of TAOs but also the mediating effects of the MPG structure. The analytical framework and evaluation methodology presented here are more relevant to scenario 3.

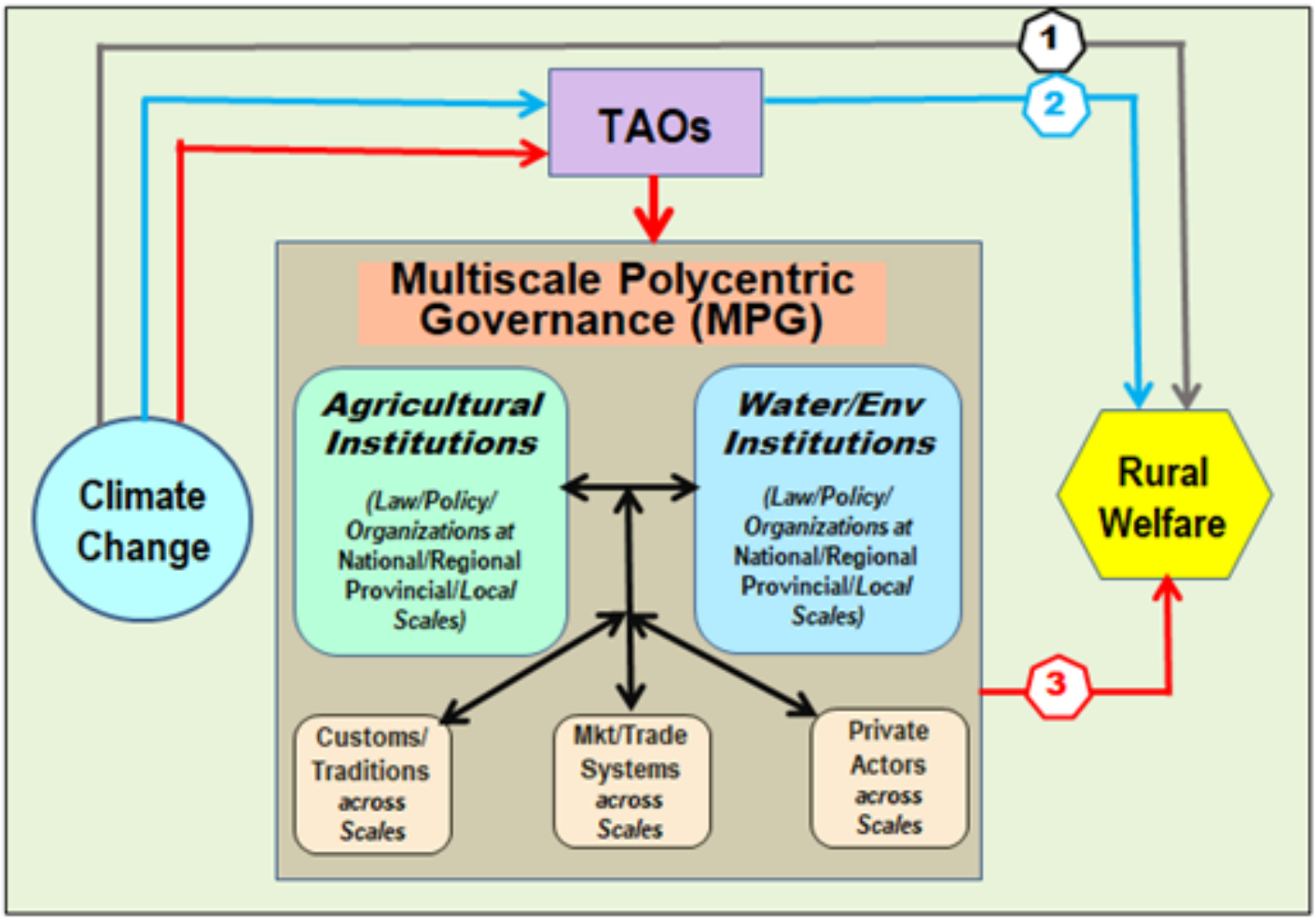

Figure 2. The conceptual foundation of the CC-TAO-MPG-RW framework.

Source: Saleth et al. 2023.

Analytical framework

The basic building blocks of the analytical framework are impact pathways and their underlying chains of variables. The framework includes the trigger element of CC and the policy goal of rural welfare (Figure 3). The outcome variables are on-farm and labor income, food availability and prices, and water security (shown in Figure 3 as brown boxes). In addition to these two, the analytical framework within the empirical setting of Morocco covers three sectors, three sets each of TAOs and MPG structure elements, and several impact or impact transmission variables.

- The three sectors are water, agriculture, and water supply (green boxes). Other sectors such as livestock and rural non-farm enterprises are covered implicitly as part of the impact variables.

- The three TAOs are (a) contract farming and public-private partnerships in agriculture, (b) the crop shift toward tree and high-value crops, and (c) drip system conversion and irrigation modernization (yellow boxes).

- The MPG structure is represented by three entities, i.e., institutions (laws, policies, and organizations), infrastructure (water, agriculture, and environment), and players (the state, corporate sector, service providers, and civil society organizations), operating across regional scales and sectoral contexts (violet boxes). The three governance elements are in turn represented by a total of 20 institutional, infrastructural, and player-related variables.

- The impact or impact transmission variables are mostly related to production, productivity, cost, and income-related aspects. These aspects are represented by 24 variables (light yellow boxes).

Altogether, the analytical framework captures the structural linkages and interactive effects of a total of 52 variables. It is the different configurations of these variables that characterize various possible pathways linking climate impact and social welfare.

Mathematical model

The analytical framework and the mathematical model of CC-TAO-MPG-RW interactions are closely linked. This is because by tracing all possible impact pathways and by defining each of them using the 52 variables, the analytical framework can be translated into a mathematical model with a set of 40 sequentially and simultaneously interlinked equations. These equations, which are defined by different configurations of variables, characterize most of the important layers operating in the process of CC-TAO-MPG-RW interactions in the study basin. The analytical framework and its mathematical representation constitute only two components of the evaluation methodology. The other, but more important, component relates to the empirical approach that is used to generate the data needed for the numerical estimation of the mathematical model involving a system of sequentially and simultaneously linked equations.

Empirical approach

The empirical approach involves major challenges as most of the 52 variables are inherently ex-ante in nature. Observed data on them are either absent or irrelevant as such data remain static, outdated, and devoid of any expectational considerations. Since the impacts of these variables not only vary by context but are also aggregate, composite, and notional in nature, there is a need to generate information on each of them from multiple angles and perspectives. Obviously, observed and single-point data are unrealistic to capture these variables. The lack of observed data on most variables does not mean there is a complete absence of information.


Photo: Pierre Restoul / IWMI

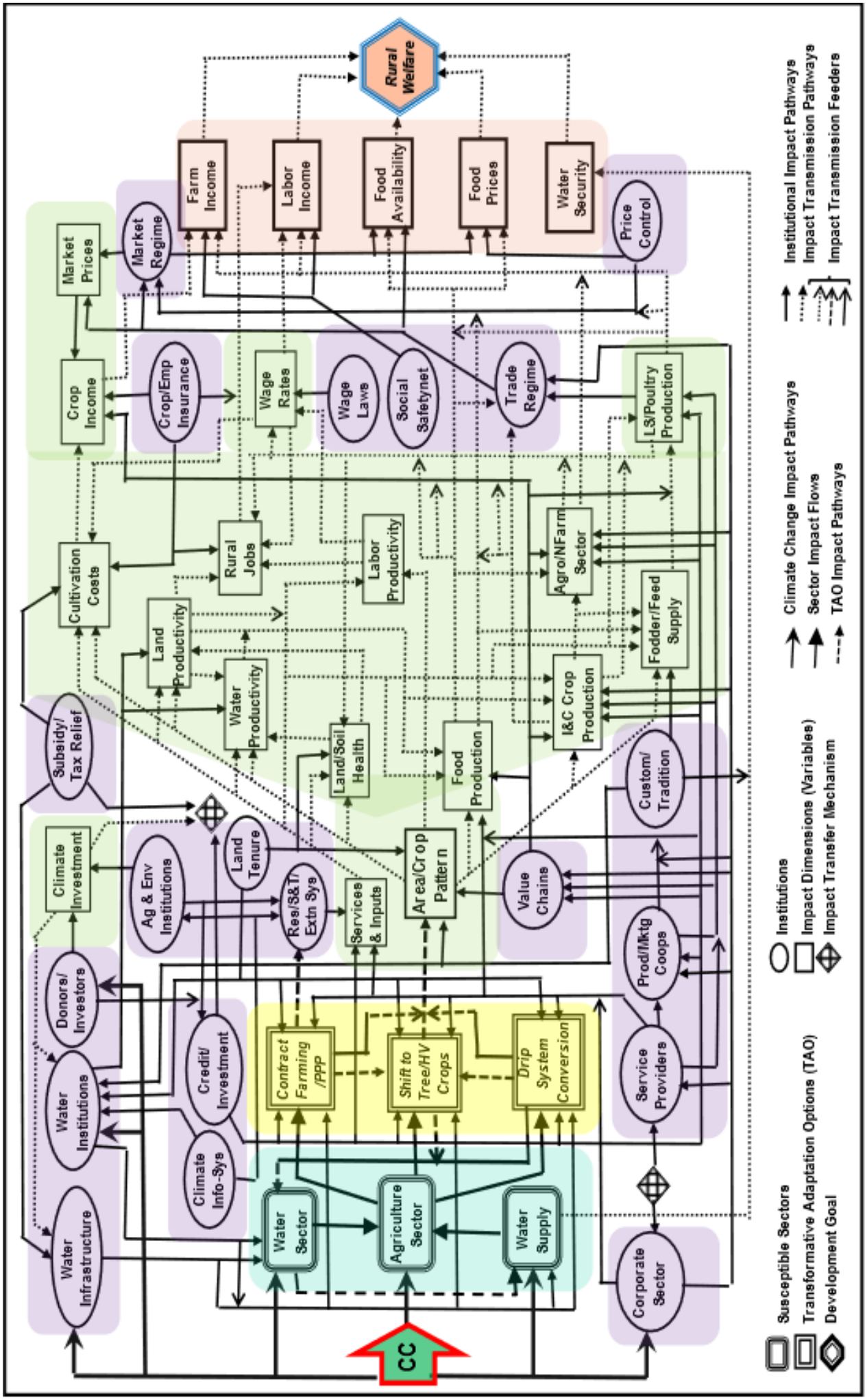

Figure 3. Analytics and pathways of the CC-TAO-MPG-RW interaction.

Source: Saleth et al. 2023.

Most highly relevant information is constantly being processed, coded, and stored as perceptions in the minds of planners, experts, evaluators, beneficiaries, and even informed common observers. The empirical approach underlying the evaluation methodology is, in fact, an effort to elicit such valuable information from a suitable sample of stakeholders using a well-designed questionnaire. While the stakeholder-based survey provides flexibility in conceptualizing, defining, and selecting more appropriate and specialized forms of variables, the perception-based data allow a synthesis of objective, subjective, and aspiration-related factors, and incorporates both the ex-ante and dynamic elements into the reckoning. Moreover, the use of perception-based data has a strong theoretical legitimacy, and their reliance on empirical application and policy analysis also has a long tradition.

Dataset and model estimation

We refer to Saleth et al. (2023) for details of the dataset and model estimation. Briefly, the dataset has information collected from 176 stakeholders with a field-tested questionnaire that covers a total of 300 questions. The first nine questions relate to identifier variables (respondent ID, gender, education, discipline, profession, experience, sector and region). The other 291 variables are specific questions directly aimed at getting information on the 52 model variables from different angles and perspectives. The perception-based answers are rated on a 0–10 scale, with zero denoting no effect and 10 denoting the highest possible impact. The analysis used a three-stage simultaneous least squares (3-SLS) model, with adequate diagnostic tests, to estimate the parameters.

The results of the analysis provide valuable insights into the significance of various variables included in the model. They also reveal the strength or weakness of the connections between governance variables and the impact they have across different pathways. The stakeholder-based survey provides flexibility in conceptualizing, defining, and selecting more appropriate and specialized forms of variables. The perception-based data allow a synthesis of objective, subjective, and aspiration-related factors, and the significance of coefficients helps to evaluate the relative importance of different policy, institutional, and impact variables that characterize different impact pathways.

Key contributions of the study

Using impact pathways as key building blocks of the evaluation methodology, the study has added dynamic aspects by bringing together all relevant elements, i.e., climate change, adaptation options, governance structure, impact transmission mechanism, and welfare, into a single analytical framework. The empirical approach also opened up new avenues, both in the way of conceptualizing and analyzing variables, and also in the way of using perception-based information as a valid and legitimate source of information. This is particularly useful in many difficult and deficient contexts in climate-welfare interaction in particular, and institutional and impact assessment in general. The empirical results presented in this study also clearly demonstrate not only the realistic nature of the evaluation methodology and empirical approach but also the practical and policy-relevant theoretical insights that one can gain on the process of CC-TAO-MPG-RW interactions in the study basin. Moreover, findings of the study will inform the national missions in Morocco on governance approaches in planning and implementation of transformative adaptation options in the country's Green Generation Plan 2020-2030.

Reference

Saleth, R.M.; Amarasinghe, U.A.; Amarnath, G.; El Mekki, A.A.; Brouziyne, Y.; Chandrasekara, S.; Ukwattage, U. 2023. *Climate change, transformative adaptation options, multiscale polycentric governance: Methodological framework for impact evaluation of rural welfare*. CGIAR Initiative on Climate Resilience.

Citation

Saleth, R. M.; Amarasinghe, U. A.; Amarnath, G.; Ait El Mekki, A.; Brouziyne, Y. 2023. *Climate change, transformative adaptation options, multiscale polycentric governance, and rural welfare in Oum Er-Rbia River Basin, Morocco: evaluation framework*. Innovation brief. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Initiative on Climate Resilience. 8p.

Disclaimer

This publication has been prepared as an output of the CGIAR Initiative on Climate Resilience and has not been independently peer reviewed. Responsibility for opinions expressed and any possible errors lies with the authors and not the institutions involved.


Photo: Pierre Restoul / IWMI

IWMI
International Water Management Institute

CGIAR
INITIATIVE ON
Climate Resilience

Ana Maria Loboguerrero Rodriguez, Initiative Lead, *a.m.loboguerrero@cgiar.org*

Jonathan Hellin, Initiative Co-Leader, *j.hellin@irri.org*

CGIAR is a global research partnership for a food-secure future. CGIAR science is dedicated to transforming food, land, and water systems in a climate crisis. Its research is carried out by 13 CGIAR Centers/Alliances in close collaboration with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector. *www.cgiar.org*

We would like to thank all funders who support this research through their contributions to the CGIAR Trust Fund: *www.cgiar.org/funders*.

To learn more about this Initiative, please visit *this webpage*.

To learn more about this and other Initiatives in the CGIAR Research Portfolio, please visit *www.cgiar.org/cgiar-portfolio*