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Research Report

Climate Change, Transformative Adaptation Options, Multiscale Polycentric Governance, and Rural Welfare in Oum Er Rbia Basin, Morocco: Empirical Evaluation with Policy Implications

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Contents

Acronyms and Abbreviations

BPG	Broad Policy Goal
CC	Climate Change
GDP	Gross Domestic Product
ETV	Exogenous Trigger Variable
FPG	Final Policy Goal
ICAR	Indian Council of Agricultural Research
ITV	Impact Transmission Variable
IIWM	Indian Institute of Water Management
IWMI	International Water Management Institute
IPG	Intermediate Policy Goal
MAD	Moroccan Dirhams
MPG	Multiscale Polycentric Governance
PMV	Plan Maroc Vert
PNEEI	Programme National d'Economie d'Eau d'Irrigation
RW	Rural Welfare
TAO	Transformative Adaptation Options

Summary

Morocco has launched several transformative adaptation options (TAOs) to address climate change (CC) risks in their agricultural and water sectors. As part of the CGIAR Initiative on Climate Resilience (ClimBer), Morocco was one of six countries selected to pilot a framework assessing how multiscale polycentric governance (MPG)—which involves an improved coordination of institutions across sectors and scales, along with TAOs—could enhance the impacts on rural welfare through an impact pathways approach. The study considered three TAOs: shifting to high-value tree crops, contract farming and public-private partnerships, and converting to drip irrigation with system modernization.

The conceptual framework mapped 22 MPG elements (exogenous variables) and 30 impact transmission domains, linking TAOs (endogenous variables) to rural welfare through a system of 30 recursive equations. By using stakeholders' perception data on a scale of 1 to 10 from 178 respondents in the Oum Er Rbia River basin, and simultaneous regression estimation techniques, the study found that:

- Shifting to high-value tree crops is the preferred option, with a dominant share of total impacts across impact transmission domains, followed by contract farming/public-private partnerships, and drip-system conversion. However, given their strong functional relationship, implementing them together could bring large benefits.

- The MPG factors, particularly structural institutions and private actors, exert a significant influence on TAO performance, with the greatest effect observed on agricultural productivity, production, and sectoral performance transmission domains.

- Policies targeting all MPG domains that predominantly affect impact transition variables will have considerable spillover benefits on other domains, such as policy goals for enhancing farm and labor income, food availability and prices, and water security.

- Among the impact transmission domains, productivity and production contribute the most to food and income security. Since cultivated area and cropping pattern transmission domains significantly influence productivity and production, policy interventions targeting these domains can enhance food and livelihood security.

Therefore, prioritize policies targeting MPGs and TAOs that significantly impact transmission variables and select complementary policies that target these variables to generate higher impacts on the intermediate policy goals of food, livelihood, and water security, as well as the final policy goal of rural welfare.

Climate Change, Transformative Adaptation Options, Multiscale Polycentric Governance, and Rural Welfare in the Oum Er Rbia Basin, Morocco: Empirical Evaluation with Policy Implications

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Introduction

Climate change (CC) remains a major challenge worldwide with far-reaching ecological, economic, and social consequences. This is especially the case in countries such as Morocco. Although one of the fastest-growing countries in Africa, with 93% of its territory characterized by arid and semi-arid areas that rely on uncertain and irregular rainfall, Morocco is highly susceptible to climatic risks. For instance, the 2016 drought, said to be the worst in the past 30 years, reduced cereal yields by 70% and significantly slowed the overall economic growth (USAID 2016). With a 10-20% reduction in precipitation across the country in recent years, Moroccan agriculture has become increasingly vulnerable to significant consequences for food security, welfare, and economic growth.

The country's water sector is equally precarious, having experienced a 20% reduction in overall water availability, leading to a widening demand-supply gap and a decline in per capita water supply. Additionally, climate change is expected to reduce snowpack in the Atlas Mountains. This puts pressure on water resources, which are already stressed by other factors such as population growth, urban development, industry, and tourism. Furthermore, many coastal aquifers will become increasingly stressed due to coastal salinization. Several studies have evaluated the impacts of climate change on Morocco's water and agricultural sectors from different perspectives and contexts (Schilling et al. 2012; Tramblay et al. 2014; El Baki et al. 2021; Echakraoui et al. 2018).

Fortunately, Morocco is also one of the few countries that has already undertaken several major initiatives to counter the impacts of climate change on its agriculture and water sectors. The climate adaptation and coping initiatives undertaken in Morocco since 2009/2010 is notable not only for their transformative nature and scale of implementation, but also for their innovative and pioneering approach (ADA 2023). These initiatives are also unique as they have promoted several transformative adaptation options (TAOs) in a multi-sector context and as part of national-scale programs such as the Green Morocco Plan (Plan Maroc Vert [PMV]), implemented between 2010 and 2020, the National Irrigation Water Saving Program (Programme National d'Economie d'Eau d'Irrigation [PNEEI]), implemented since 2009/2010, and the ongoing Green Generation Plan (Génération Green 2020-2030) covering the period 2020-2030 (Hajjaji 2009; MAPMDREF 2020a).

Some of these TAOs include: (a) shifting of crop patterns towards less water-intensive but high value/tree crops (e.g., olives, oranges, and citrus); (b) conversion of flood and sprinkler irrigation systems into drip irrigation systems, (c) modernization of water and irrigation infrastructure; (d) contract farming/supply aggregation/value chain developments; (e) promotion of corporate farming and public-private partnerships in agriculture (via long-term lease of government and community lands); and (f) zero tillage farming technology, particularly in rainfed regions.

Given its innovative and comprehensive climate adaptation strategies, Morocco provides an apt context for a systematic empirical evaluation of how effective the TAOs are in improving the climate resilience of the agriculture and water sectors. The objectives of this paper are to:

- Develop an analytical framework that captures the role of multiscale polycentric governance (MPG) elements, or increased cooperation and collaboration of institutions across sectors and scales, in mediating and enhancing the impact transmission factors of an impact pathway to enhance economic and welfare benefits.
- Test the framework's effectiveness empirically in a suitable location in Morocco.
- Identify insights and policy lessons for Morocco itself to fine-tune its ongoing and future climate adaptation strategies and adjust its implementation process, as well as for other similarly placed countries in Africa and elsewhere in designing and implementing climate adaptation strategies.

It is on this rationale that Morocco was included as one among the six pilot countries selected globally under the CGIAR Initiative on Climate Resilience (ClimBeR).

The focus here is essentially on the impacts of climate change on the water and agriculture sectors. However, the same is true for other related sectors, such as livestock and non-farm, as well as market and trade, which are also treated both implicitly and explicitly. While there are numerous and varied impact pathways and variables, the coverage here is limited only to those that hold the most importance and relevance from a policy standpoint. Policy-wise, social welfare is defined in a restricted sense and primarily refers to rural welfare. Similarly, although the welfare consequences of climate change are far-reaching, this analysis focuses solely on rural welfare.

Policy Context

Morocco, officially the Kingdom of Morocco, is the westernmost country in the Maghreb region of North Africa. It has a total area of approximately 71 million hectares (Mha) with a population of around 37.9 million, growing at an annual rate of 1.2%. It is projected to reach 66.4 million by 2030 and 72.8 million by 2050. The urban population currently constitutes 62% but is expected to reach 69% and 77% by 2030 and 2050, respectively (World Bank Group 2021).

Morocco remains the fifth-largest economy in Africa and wields significant influence both within Africa and the Arab world. Although the service and industry sectors—including mining—dominate the gross domestic product (GDP) with shares of 50% and 25% respectively, the agriculture sector, with just a 14% share, is strategically very important. Moroccan agriculture is the largest employer, accounting for 43% of all employment and 78% of rural employment (World Bank Group 2021). However, the sector is highly susceptible to climatic risks. Irregular rain patterns, cold spells, heatwaves, and drought conditions severely affect agriculture in particular and the economy in general. Therefore, adaptation interventions to tackle the impacts of climate risks are paramount for Moroccan policy.

Therefore, it is essential to consider the policy context within which the pathway analysis for adaptation impacts is conducted, as well as its results, to ensure they are properly interpreted and understood. The pathway analysis also identifies the variables (policy instruments and impact domains) that require more focused attention. As noted previously, over the years, Morocco has undertaken three innovative initiatives to enhance the climate resilience of its agriculture and water sectors.

Although the PMV was a broad strategy with a larger mandate for combating climate change by switching to renewable energy, it also aimed to double the agricultural value added and create 1.5 million rural jobs by 2020, thereby transforming agriculture into a stable source of growth, competitiveness, and broad-based economic development. Considering the dualistic nature of Moroccan agriculture, PMV had two pillars—one targeting commercial farmers and the other targeting small farmers in marginal areas.

PNEEI, on the other hand, aims to modernize irrigation delivery systems by promoting the conversion of flood and sprinkler irrigation to drip irrigation systems in order to save water and improve water-use efficiency and productivity (Ministère de l'Agriculture et de la Pêche Maritime 2007; Finances News Hebdo 2022). This program provides a subsidy of up to 100% for adopting drip and micro-sprinkler irrigation, and up to 70% for sprinkler irrigation. The target is to shift 555,090 ha to drip irrigation, comprising 337,150 ha through individual conversion and 217,940 ha through collective conversion of family farms within large-scale irrigation projects. By 2020, PNEEI had promoted the adoption of drip irrigation in over 200,000 ha (60% of the target) of privately developed irrigation areas. However, the drip conversion process in large-scale irrigation project perimeters is ongoing, covering only 57,000 ha (25% of the target) due to delayed investments in irrigation networks (Finances News Hebdo 2022).

The Green Generation Plan, in contrast, has a larger mandate focused on the human and sustainability dimensions of rural development. On the human dimension, the Plan aims to create and strengthen the rural middle class, diversify rural employment opportunities, promote new production organizations involving young rural entrepreneurs, and enhance rural safety nets through crop insurance and stipends for low-income farmers. It aims to improve agricultural sustainability and climate resilience by promoting the adoption of TAOs and strengthening agricultural, water, and other rural institutions and infrastructures.

With their systematic implementation over the years, all three programs have enabled Morocco to register notable progress on several fronts. There has been a 45% increase in agricultural production and an 18% growth in agricultural exports since the launch of PMV in 2008. As a result, the agricultural GDP increased by 5.25% annually, compared to just 3.8% in other sectors. This resulted in an additional value of Moroccan Dirhams (MAD) 47 billion.[1] The value of agricultural exports also increased by 117%, i.e., from MAD 15 billion to MAD 33 billion. PMV has created 342,000 additional jobs in rural areas, resulting from an expansion in cultivated areas, crop diversification, and enhanced production. With this, working days/worker/year have also increased from 110 days/year to 140 days/year (MAPMDREF 2020b).

Notably, PMV has also facilitated further growth in agricultural value-added through both agricultural aggregation programs implemented in areas with commercial and high-value crops and public-private partnership (PPP) programs promoted on lands leased from the state and tribal communities (Belqat 2010). Both programs are being implemented under a dedicated and legally established incentive system. Under the aggregation program, PMV has implemented 63 projects covering an area of 177,000 ha and benefiting 55,000 farmers, 80% of whom are small-scale farmers with less than 5 ha. Under PPP, which involves leasing state-owned land, PMV has implemented 1,575 projects to cover an area of nearly 112,000 ha with a projected investment of MAD 22.3 billion. Of these PPP projects, 720 were allocated to small-scale farmers and entrepreneurs within the agriculture sector. More importantly, the large-scale tree plantations established on uncultivated public and community lands under the sustainability component, though still young, are also estimated to contribute to the process of carbon sequestration amounting to 1.9 million tons of CO_2 equivalent (MAPMDREF 2020b).

The policy context is very valuable for informed modelling and evaluation processes. It highlights the likely sets of TAO, MPG, and impact-related variables, along with policy goals that are to be selected and incorporated into a realistic model of CC-TAO-MPG-RW interactions. These sets of variables will be specified as we develop the system model and its underlying equation system.

[1] 1 (1 USD ≈ 10 MAD in July 2023).

Methodology and Data

Methodology

After a thorough literature review, the study team conducted fieldwork, including interactions with policymakers and stakeholders, to identify the TAOs and locations for detailed data collection. Based on these activities, the study assessed the impacts of three TAOs in the Oum Er Rbia basin of Morocco (Figure 1). The selected TAOs were: (1) contract farming and public-private partnerships, (2) shift to tree and high-value crops, and (3) drip system conversion and irrigation modernization.

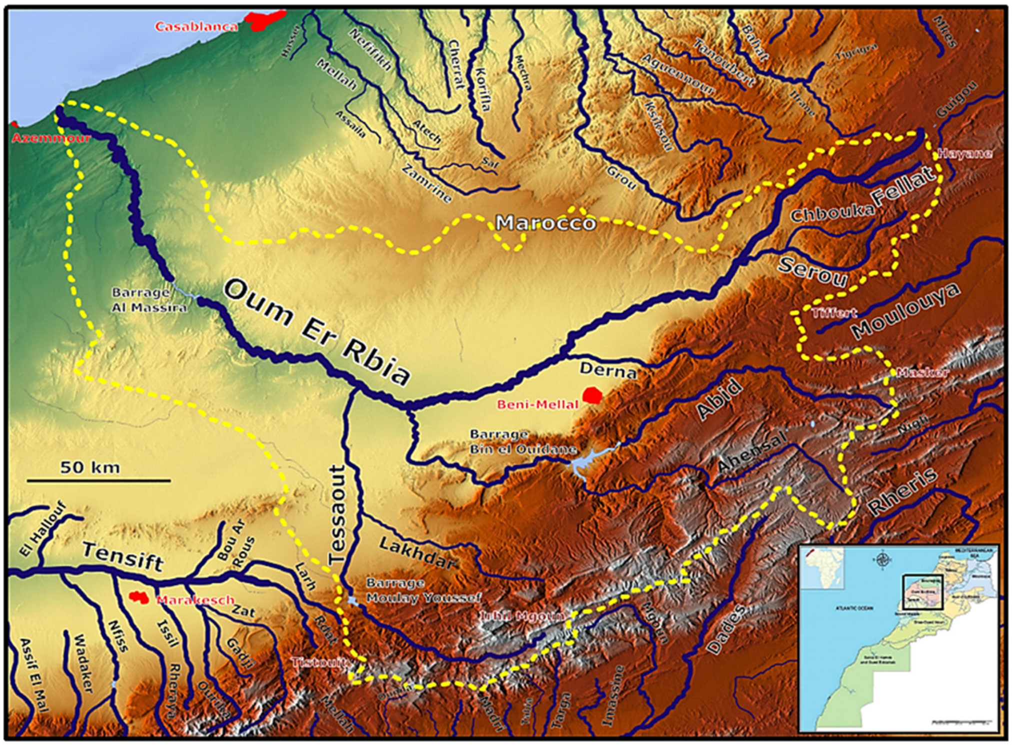

Figure 1. Oum Er Rbia River Basin, Morocco.

The Oum Er Rabia River basin, located in southwestern Morocco, is the second largest river in Morocco after the Sebou River. It has an average surface runoff of 105 m³ per second, equivalent to 3.311 billion cubic meters (Bm³) (MEMEE 2012). This basin has six major dams (including Al Massira, the second largest dam in Morocco with a 2.65 Bm³ storage capacity) and five minor dams. The combined storage capacity of these dams is estimated to be 5 Bm³. However, due to drought conditions and siltation, the actual storage in 2022 was only 7.6% of their total capacity (compared to 18.5% in 2021).

This basin accounts for 33% of the total harvested area in the country (Siebert 2013). Major crops grown include wheat and barley (largely under rainfed conditions) and maize, olives, almonds, sugar beets, oranges, dates, etc., (mostly under irrigated conditions). The basin holds the top share of most crops in the harvested area, except for wheat, which is the second highest after the Sebou basin. The Oum Er Rbia basin also accounts for 33% (0.48 million ha) of the country's total irrigated area (1.46 Mha). In terms of water footprint (both green and blue water use), the basin dominates with a volume of 7.7 Bm³, representing over a third of the total water footprint of Morocco (23.5 Bm³). This basin is highly susceptible to the impacts of climate change, including a high frequency and intensity of droughts. Historical data show that over the years, the basin has experienced a 20% reduction in rainfall and a 40-49% decline in annual flow (FAO 2015).

Figure 2 illustrates the conceptual framework developed to capture the pathways of impact transmission in the process of CC-TAO-MPG-RW interactions. Climate change impacts the water, agriculture, and environmental sectors through temperature and rainfall variability, and indirectly through the increased intensity of droughts, floods, and other extreme weather events (see line 1). General adaptation options enhance the coping capacity or result in incremental benefits (see line 2). However, when TAOs are supported by MPG—which increases cooperation and collaboration at various sectors and scales—they are likely to achieve sustainable impacts (see line 3).

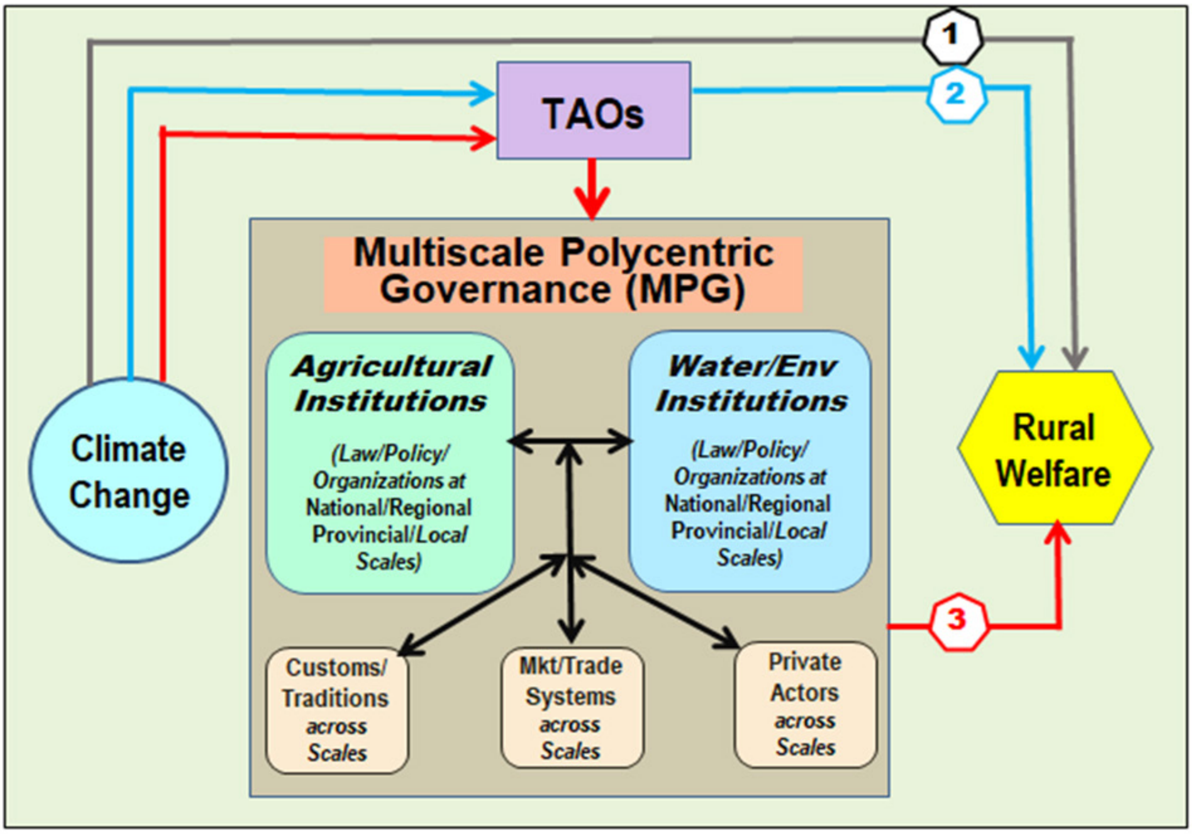

Figure 2. Conceptual framework for understanding CC-TAO-MPG-RW interactions

The analytical framework (Figure 3) captures the interactions between climate change, TAOs, impact transmission variables (ITVs), including cropped area and cropping patterns, land, water, and labor productivity, crop income, and markets. It also considers the intermediate policy goals, including farm and labor income, food availability and prices, water security, and the final policy goal of rural welfare. The framework was then mathematically translated into a unique evaluation methodology based on a system model with a set of equations defined by variables explaining different elements in the impact pathways.

In Figure 3, water, agriculture, and water supply are the most susceptible sectors to climate change impacts. Water sector performance, measured by water availability, is influenced by water institutions (national and regional level), water infrastructure, climate information systems, the performance of drip system conversions, as well as the shift to high-value crops. Climate change impacts water supply performance, which is also affected by water availability, water institutions, and water infrastructure. The performance of the agriculture sector is affected by the impacts of climate change, as well as water availability, water supply, agricultural input supply, agricultural and environmental institutions, climate information systems, agricultural production and marketing cooperatives, and land tenure. The water institutions, water infrastructure, agricultural marketing corporations, and rural service providers are linked to the conversion to drip irrigation and irrigation modernization. Land tenure, water institutions, agricultural institutions, agricultural credit institutions, and rural service providers affect contract farming and public-private partnerships. In turn, these very partnerships, along with drip system conversions, land tenure, water institutions, agricultural marketing and trade regimes, rural service providers, and corporate sector agencies, play a crucial role in facilitating the shift towards cultivating high-value crops. Linkages between most ITVs and TAOs, as well as ITVs, in an equation system are discussed in the next section.

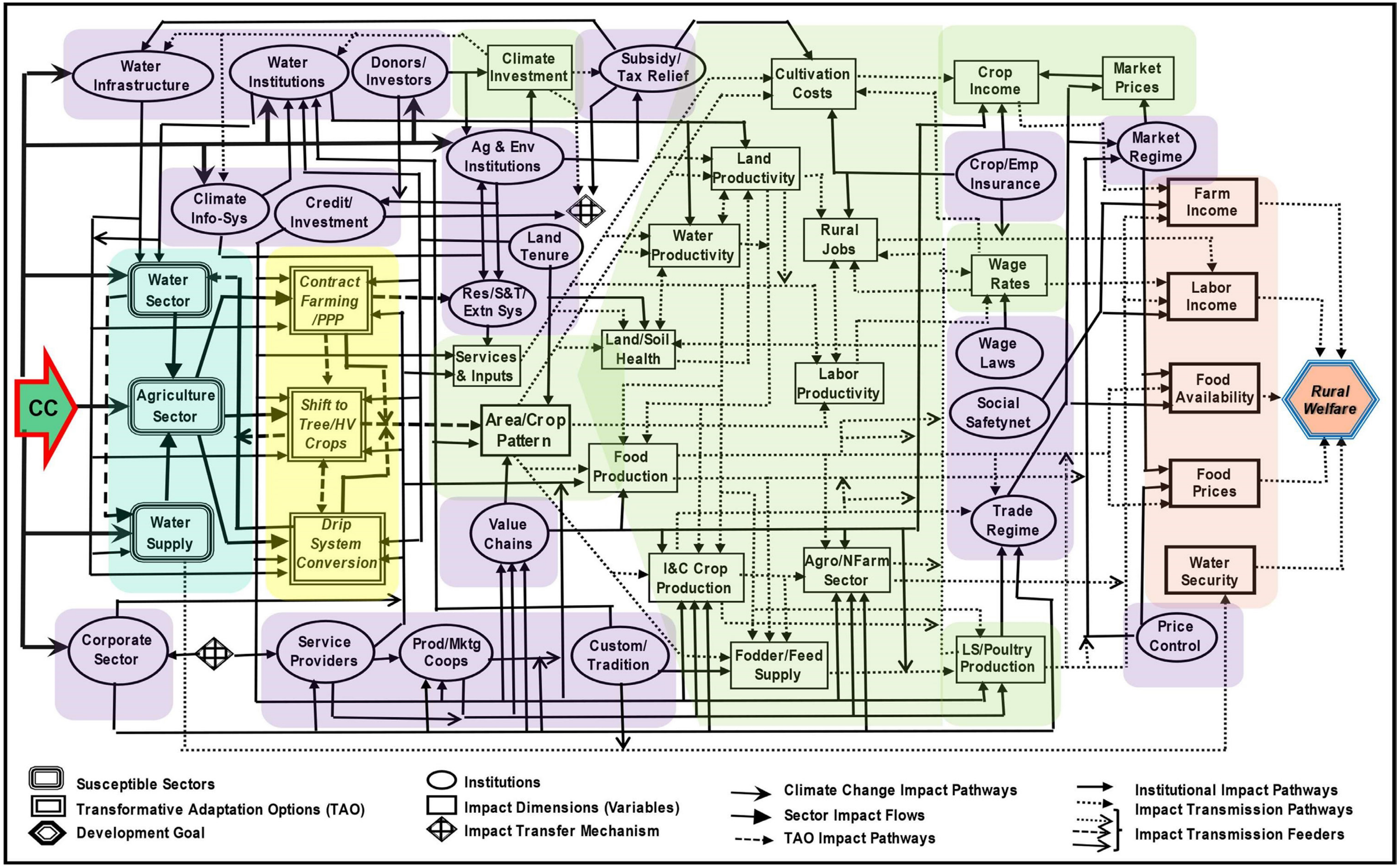

Figure 3. CC-TAO-MPG-ITV-IFG-FFG interactions within the impact pathway

Specification of the system model

For the specification of the system model required for pathway analysis, we define 52 variables and categorize them into the following analytical/functional categories. The 22 exogenous variables or independent variables (Xs) cover both climate change—the exogenous trigger variable (ETV)—and different elements of MPG domains (i.e., institutions, infrastructures, laws, policies, and private sector players) (Table 1). The remaining 30 variables are all endogenous or dependent in nature. Although all of them generate, capture, and/or transmit impacts, they exhibit distinct differences in their functional roles. The endogenous variables (Ys) represent not only the three TAOs and two MPG elements but also the 22 ITVs, six variables that capture the intermediate policy goals (IPGs), and the final policy goal (FPG) (Table 2).

Table 1. MPG categories and exogenous variables.

No.	MPG category or group names	Category codes	Exogenous variable	Related governance element
[1]	Exogenous trigger variable - climate change impact	ETV	X_1	Climate change
	MPG domains			
[2]	Structural institutions	MPG-G1	X_3 X_4 X_{19}	Land tenure Customary institutions Livestock composition
[3]	Agriculture-related institutions	MPG-G2	X_5 X_{10} X_{15} X_{14} X_{17}	Agriculture/environment Credit/investment Agricultural input supply Climate information and DSS Science/technology research, Extension
[4]	Market-related institutions	MPG-G3	X_8 X_{11} X_{12} X_{16}	Production and marketing Price regimes Trade regimes Value chains
[5]	Legal and policy-related institutions	MPG-G4	X_2 X_6 X_{18} X_{20} X_{21} X_{22}	Climate investment Agricultural subsidies and tax relief Agriculture and food price regulation Crop employment and insurance Agricultural wage laws and regulations Rural safety net policies
[6]	Private sector players	MPG-G5	X_7 X_9 X_{13}	International donors and investors Corporate sector and private players Agriculture value chains

Table 2. Endogenous variables (Ys), categorization to TAOs and ITVs, and the system model with 30 linked equations.

	Impact transmission category or group name	Category code	Endogenous variable name	Equations of endogenous variable		
1	MPG elements	ITV-G1	Water institutions	Y_1	=	$f_1\ (X_1, X_2, X_3, X_4)$
			Water infrastructure	Y_2	=	$f_2\ (X_1, X_2\ X_5, X_6, X_7)$
2	Transformative adaptation options	TAOs				
2.a	TAO-1		Drip conversion and irrigation modernization	Y_3	=	$f_3\ (Y_1, Y_2, X_3, X_8, X_9)$
2.b	TAO-2		Contract farming and public-private partnership	Y_4	=	$f_4\ (Y_1, X_3, X_5, X_9, X_{10})$
2.c	TAO-3		Crop shift to high-value crops	Y_5	=	$f_5\ (Y_1, Y_3, Y_4, X_3, X_8, X_9, X_{11}, X_{12}, X_{13})$
3	Impact transmission variables					
3.a	Water availability and water supply	ITV-G2	Water availability	Y_6	=	$f_6\ (Y_3, Y_5, Y_1, Y_2, X_1, X_{14})$
			Water supply	Y_7	=	$f_7\ (Y_1, Y_2, Y_6, Y_7, X_1)$
3.b	Area, land quality, and crop pattern	ITV-G3	Cultivated area	Y_9	=	$f_9\ (Y_3, Y_4, Y_5, X_3, X_4, X_{16})$
			Land quality/soil health	Y_{10}	=	$f_{10}\ (X_1, X_3, X_5, X_{17})$
			Cropping patterns	Y_{11}	=	$f_{11}\ (Y_3\ , Y_4, Y_5, Y_9, X_{11})$
3.c	Agricultural productivity and production	ITV-G4	Land productivity	Y_{12}	=	$f_{12}\ (Y_1, Y_6, Y_9, Y_{10}, Y_{11}, X_{15}, X_{17})$
			Water productivity	Y_{13}	=	$f_{13}\ (Y_1, Y_9, Y_{10}, Y_{11}, Y_{12}, X_{15}, X_{17})$
			Labor productivity	Y_{14}	=	$f_{14}\ (Y_9, Y_{11}, Y_{12}, X_{15})$
			Crop production	Y_{15}	=	$f_{15}\ (Y_3, Y_9, Y_{12}, Y_{13}, X_8, X_9, X_{10}, X_{18})$
			Fodder and feed supply	Y_{17}	=	$f_{17}\ (Y_9, Y_{11}, Y_{16}, X_4)$
3.d	Agricultural price, cost, and income	ITV-G5	Market price	Y_{19}	=	$f_{19}\ (X_6, X_8, X_{11}, X_{12}, X_{18})$
			Cultivation cost	Y_{21}	=	$f_{21}\ (Y_9, Y_{11}, X_6, X_{15}, X_{20})$
			Crop income	Y_{22}	=	$f_{22}\ (Y_9, Y_{11}, Y_{12}, Y_{19}, Y_{21}, X_{16}, X_{20})$
3.e	Rural jobs and wages	ITV-G6				
			Rural wages	Y_{23}	=	$f_{23}\ (Y_{14}, Y_{15}, Y_{16}, Y_{18}, Y_{20}, X_{21})$
			Rural jobs	Y_{24}	=	$f_{24}\ (Y_{12}, Y_{14}, Y_{15}, Y_{16}, Y_{18}, Y_{20}, Y_{23}, X_{20})$
3.f	Sectoral performance	ITV-G7	Agriculture sector	Y_8	=	$f_8\ (Y_6, Y_7, X_1, X_3, X_5, X_8, X_{14}, X_{15})$
			Industrial/commercial crops	Y_{16}	=	$f_{16}\ (_{Y9}, Y_{12}, Y_{13}, X_6, X_{11}, X_{12}\ X_{13}, X_{16})$
			Agro-based industries	Y_{18}	=	$f_{18}\ (Y_{15}, Y_{16}, X_{10}, X_{13}, X_{16})$
			Livestock production	Y_{20}	=	$f_{20}\ (Y_{17}, X_{10}, X_{11}, X_{12}, X_{13}, X_{19})$

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	Impact transmission category or group name	Category code	Endogenous variable name	Equations of endogenous variable
4	Intermediary policy goals (IPGs)	IPGs		
4.a		IPG-1	Farm income	$Y_{25} = f_{25}(Y_{18}, Y_{20}, Y_{22}, X_{22})$
4.b		IPG-2	Labor income	$Y_{26} = f_{26}(Y_{18}, Y_{20}, Y_{23}, Y_{24}, X_{20})$
4.c		IPG-2	Food availability	$Y_{27} = f_{27}(Y_{15}, Y_{16}, Y_{20})$
4.d		IPG-4	Food price	$Y_{28} = f_{28}(Y_{15}, Y_{27}, X_{11}, X_{18})$
5	Broad policy goals			
5.a	Water security			$Y_{29} = f_{29}(Y_{7}, Y_{1}, Y_{2}, X_{1}, X_{4})$
5.b	Income security		IPG-1 + IPG-2	
5.c	Food security		IPG-3 + IPG-4	
6	Final policy goal (rural welfare)			$Y_{30} = f_{30}(Y_{25}, Y_{26}, Y_{27}, Y_{28})$

These variables (see Table 1 and 2) are crucial for capturing the policy context in Morocco, as they encompass the prevailing adaptation options, governance elements, impact aspects, and policy goals. It is also important to note that all the variables selected to represent TAOs, MPG elements, and ITVs are essentially defined not only in an aggregate and notional form but also in a qualitative sense—in terms of extent and performance.[2] The formal mathematical representation of the more significant policy-related impact pathways are outlined in a set of 30 sequentially linked equations (see Table 2).

Sequentially linked equations not only show the distinct configurations of variables involved in different impact pathways but also capture the inherent structural linkages among them. These equations, taken together, constitute the system model of CC-TAO-MPG-RW interactions. When the system model is empirically applied with an appropriate dataset, it is possible to estimate the coefficients for all variables across all equations. The estimated coefficients for different variables capture their respective impacts associated with a marginal change. They indicate the size, direction, and significance of their respective impacts. From a practical and policy perspective, it is particularly valuable to trace and evaluate how the impacts of a change in each variable are captured in each equation, transmitted and mediated across equations, and ultimately reflected in variables representing various policy goals. This process is precisely what is being attempted in the pathway analysis.

Data Collection

Many variables and their impact on transmission processes within the system are inherently ex ante in nature. Therefore, it is challenging to obtain observed or quantitative information on many variables within the system. Even if we can observe information on certain aspects (e.g., production, productivity, price, costs, and income), they are most likely to relate to a past situation, making them less suitable for capturing either current or future conditions. Moreover, such observed information is also less likely to synthesize expectations or capture diversity.

Acquiring objective data on variables representing elements of TAOs and MPG structures is particularly challenging, especially given their diverse roles and impacts on performance both within and across impact pathways. Another major problem for data collection relates to the aggregate and notional way in which most variables are conceptualized and defined. For instance, climate change impacts (CLCIMPACT) is a composite variable that captures changes in various aspects, such as temperature and rainfall. Similarly, the variable of water infrastructure (WATRINFRA) encompasses a range of infrastructural elements, including water transfer, storage and conveyance structures, as well as flood control and water harvesting systems. The same is true for many other variables.

As it is difficult to obtain data directly pertaining to many indicators, we leverage the fact that the most highly relevant information is continually processed, coded, and stored as perceptions in the minds of those involved in the development process, either as planners, experts, evaluators, beneficiaries, or as informed observers. Such real yet latent information, as embodied in individuals, can be accessed through carefully designed and conducted stakeholder surveys. Notably, this form of information possesses many desirable properties that are often overlooked in objective or observed data. For example, unlike the observed data characterizing a past and static situation, perception-based data—if elicited carefully—can synthesize objective, subjective, and aspiration-related factors, as well as ex ante and dynamic elements. The use of such perception-based data for policy analysis has a strong theoretical foundation and a robust empirical tradition in current literature.[3]

The specified system model is empirically estimated using perception-based data collected from a purposively selected, representative sample of 176 respondents, dispersed both within and outside the study basin, with diverse characteristics and backgrounds, but with a knowledge of development in the Oum Er Rbia River basin. All relevant information on model variables is collected using a pre-tested questionnaire with 291 specific questions, each addressing different dimensions and angles of the variables. The data on these 291 sub-variables are recorded on a scale of 0 to 10, with zero denoting no effect and 10 denoting the highest possible impact. This is then appropriately averaged to derive summarized information on the 52 model variables.

Following the finalization of the model, several diagnostic tests are conducted on each of the individual equations of the structural model to assess their distributional and other econometric properties. After confirming

[2] For instance, water institutions are taken as a single entity, though it has many distinct elements (e.g., water rights, water law, water pricing, basin organization, etc.). Such conceptualization is inevitable given the need to capture a vast array of elements (encompassing climate change, sectors, TAOs, MPG-related elements, impact variables, and rural welfare) within just 52 variables, while also bringing them together within a single analytical framework. Although current and observed data on these variables may be limited, policymakers, experts, and stakeholders often have objectively derived, expectation-wise adjusted, and subjectively held but practically very valuable information on these and other similar variables (Saleth and Dinar 2008, 2009; Saleth et al. 2011).

[3] The theoretical legitimacy comes from the subjective nature of institutions (Douglas 1986; Ostrom 1990), stakeholders as 'agents of institutional change' (North 1990), and the human practice of 'adaptive instrumental evaluation' (Kahneman and Tversky 1984; Bromley 1985). The empirical precedence includes studies on institutional analysis (e.g., Gray and Kaufman 1998; Kaufmann et al. 2006) and impact assessment (e.g., Neubert 2000; Coudouel et al. 2006; Saleth and Dinar 2008, 2009).

the reasonable performance of individual equations, the system model—with 30 interlinked equations—is estimated using a 3-SLS procedure. This estimation assumes four different functional forms: linear versus logarithmic, and with constant term versus without constant term.

Impact Pathway Analysis

The estimated coefficients of the system model equations in Table 2 form the inputs for pathway analysis. Pathway analysis utilizes the key structural features of the equation system in the system model. That is, the estimated set of 30 equations, which represent different impact pathways, has functional and sequential linkages with each other. As such, a marginal change in any variable will have both local effects in the context of each equation where it appears as an independent variable, as well as downstream and system-wide impacts across all subsequent equations. Furthermore, as the impacts of a variable flow through the transmission process across equations, they are also moderated by both synergetic and discordant effects.

By tracking the impacts of each variable in both equation-specific and system-wide contexts, pathway analysis can help evaluate the relative roles and mediating efficacies of different MPG elements and ITVs. In this sense, pathway analysis can shed light on the analytics and mechanics of the impact transmission process.

From a policy perspective:

- All exogenous variables, except the climate change trigger (ETV), are treated as policy instruments.
- The ITVs are treated as policy domains (or impact domains), i.e., the sectors or contexts where policy instruments—either individually or in combination—are implemented, and their impacts evaluated.
- The IPGs and FPGs represent the outcome domains, where the relative impacts of policies across domains are finally reflected and evaluated.

However, given their downstream impacts, even most of the ITVs can also be treated as policy variables, as they can be manipulated—either directly through policies or indirectly through other policy instruments noted above—to achieve the desired level of change on one or more ITVs operating in downstream impact pathways. In other words, when one ITV is taken as a policy variable, its downstream ITVs can be treated as impact domains. Notably, this relationship is also equally applicable to TAOs. Despite being endogenous, TAOs can also serve as policy options, as their effectiveness and performance have downstream impacts on many ITVs.

With pathway analysis, it is possible to rank, prioritize, and appropriately combine and sequence the policy instruments (MPG elements, ITVs, and TAOs) in terms of their relative size and share of impacts both in equation-specific and system-wide contexts. Note that the same analysis can also identify the sectors or sub-sectors to be prioritized and the impact dimensions to be targeted. Thus, pathway analysis is highly valuable in prioritizing investments and policy efforts, as well as in maximizing their effectiveness in achieving policy goals.

Analytical framework for impact pathway analysis

Given the large dimensions of both the exogenous and endogenous variables in the analysis, pathway analysis is conducted by categorizing or grouping of both of variables (Tables 1 and 2). These categories are useful in interpreting pathway analysis results. First, these categories are based on important functional, operational, and logistical considerations. Second, within such a category-based analytical framework, the relative impacts and efficacy of variable groups will be evaluated in terms of their relative percentage share both in equation-specific and system-wide contexts. However, the group- and share-based analysis will also be complemented by examining the size and share of impacts specific to each variable across all relevant contexts.

Table 2 categorizes the endogenous variables and their corresponding coverage of variables, along with their respective symbols, which also represent the equation numbers in the system model. The endogenous variables are categorized into five analytically convenient and logically consistent categories. Each of these broad functional categories also has one or more sub-categories. For instance, ITVs are further categorized into seven sub-categories (ITV-G1 to ITV-G7), each of which covers variables under different institutional, sectoral, and impact domains. Similarly, the outcome domain is also distinguished in terms of IPGs and FPGs. The IPGs are also further categorized to highlight the three core components of rural welfare: income, food, and water security levels. The rationale for covering endogenous variables under each category and sub-category is sufficiently evident.

The six exogenous categories (in Table 1) show their variable coverage and corresponding names and symbols. Excluding the climate change trigger (ETV) (which is an exogenous variable but not a policy variable), all the remaining exogenous variables representing various MPG elements are under five MPG groups, which cover the five major governance groups: structural institutions and aspects (MPG-G1), agriculture-related institutions (MPG-G2), market-related institutions (MPG-G3), legal and policy-related institutions (MPG-G4), and private sector players (MPG-G5).

Aside from the livestock size and composition (LIVSIZCOM), the rationale and logic behind the coverage of variables under the five MPG groups are clear. Economic and resource conditions, including the availability of feed, generally affect the size and composition of livestock. However, it is treated as an exogenous policy variable within the structural category to investigate how its manipulation could improve food and income security.

Overall, the functional categorization of both exogenous and endogenous variables provides a more compact analytical framework for presenting and evaluating pathway analysis results. Besides its role in minimizing analytical and presentational complexities, the framework also has another major advantage. That is, it facilitates a more focused analysis of the relative efficacy of the policy instruments, considering their impacts both within and across impact and outcome domains.

Procedure for Impact Pathway Analysis

Pathway analysis is performed at two analytical levels:

- At the first level, the impacts of endogenous variables on all their downstream counterparts are to be evaluated to assess the relative level of downstream impact flows and thereby evaluate the relative strength of sequential linkages among them. The evaluation at this level is highly valuable for identifying the most effective configurations and for sequencing policy components within a climate adaptation strategy. The endogenous variables being evaluated here cover TAOs, ITVs, and IPGs.

- At the second level, the impacts of each of the exogenous variables (i.e., ETV and MPG elements) on all endogenous variables (i.e., TAOs, ITVs, IPGs, and FPG) are to be evaluated to understand the magnitude of the impact of climate change and the relative role and efficacy of each of the MPG elements. The analysis at this level is highly valuable in ranking and prioritizing policies based on their relative efficacy.

An appropriately reduced form for all equations is necessary to perform pathway analysis at either level. For instance, the reduced forms needed for the first level can be derived by redefining each equation in terms of only the relevant configurations of preceding Ys (i.e., TAOs, ITVs, IPGs, and FPG). In contrast, the reduced forms needed for the second level can be derived by redefining all equations only in terms of relevant configurations of Xs (i.e., ETV and MPG elements).

Given the functional characteristics and with estimated coefficients for the system model in Table 2, it is straightforward to derive the two sets of reduced-form equations required for pathway analysis (Annex A, Table A.2, Table A.3). By differentiating these reduced-form equations with respect to each of the variables relevant for the two levels, the results for the corresponding pathway analysis can be obtained.

In the first-level pathway analysis, the impacts of each endogenous variable (Y_i) on all its downstream counterparts (Y_{i+1}, Y_{i+2}, ..., Y_{29}) are evaluated. From a policy perspective, the variables represented by Y_i can be considered policy instruments, whereas their downstream counterparts can be treated as impacts or policy domains. The former are the column variables, and the latter are the row variables. Moreover, the column and row variables are grouped under five major categories, each with one or more sub-categories. Such a functional categorization can provide an analytical framework for a more compact and focused evaluation of pathway analysis results. And, finally, some variables are missing from both column and row variables due to modeling considerations.

For instance, among column variables, rural welfare (Y_{30}), which represents the last equation in FPG, cannot have any downstream variables. Similarly, the performance of the agriculture sector (Y_8) is absent because it is modeled only as an endogenous variable. Since four variables—water institution (Y_1), water infrastructure (Y_2), land and soil quality (Y_{10}), and agricultural market price (Y_{19})—are modelled to depend only on exogenous variables, they are absent among the row variables, though they appear as column or policy variables. As a result, Table A.5 will have only 28 column variables and 26 row variables.

In the second-level pathway analysis, where:

- The impacts of each exogenous variable (X_i) on all the endogenous variables (Y_1, Y_2, ..., Y_{30}) are evaluated.

- Variables X_is are policy instruments, and Y_is are impact or outcome domains. While the former are column variables, the latter are row variables.

- The column variables are grouped into six categories—one representing ETV and five others covering five different but closely related configurations of MPG elements. The categorization of row variables is similar to the one in Table A.5. Such a categorization facilitates a more compact and focused evaluation of the pathway analysis results.

Table A.6 has 22 columns, representing all 22 exogenous variables (Xs) and 30 rows, representing all 30 endogenous variables (Ys) in the model.

Results

Estimation of System Equations

Among the alternative estimates of different functional forms, the one with a linear form and no constant term was selected based on criteria such as model fit, explanatory power, and consistency of estimation (Annex A, Table A.1). The estimated results for this functional form and dataset are presented in Table 3.

Going by very high R^2 and X^2 values in the case of all model equations, the configurations of variables included in them are not only statistically significant but also explain all the variations in their respective dependent variables. Since these results are a testification to the realistic and robust nature of the system model, they can be legitimately used for a dependable pathway analysis.

Table 3. CC-TAO-MPG-RW interaction in Oum Er Rbia River basin, Morocco: equation-specific 3-SLS results.

Dependent variable- Symbol/name	Independent variables – symbol/ name		Coefficients	Standard error	z-value	P>|z|	(95% Conf. Interval)	
Y_1 Water institution	X_1	Climate change impacts	0.083	0.046	1.790	0.074	-0.008	0.174
	X_2	Climate investments	0.315	0.042	7.440	0	0.232	0.399
	X_3	Land tenure	0.138	0.051	2.720	0.007	0.039	0.238
	X_4	Customary institutions	0.398	0.044	9.060	0	0.312	0.484
Y_2 Water infrastructure	X_1	Climate change impacts	0.446	0.039	11.49	0	0.370	0.522
	X_2	Climate investments	0.141	0.048	2.920	0.004	0.046	0.236
	X_5	Agriculture and environment	0.194	0.056	3.470	0.001	0.084	0.303
	X_6	Subsidy and tax relief	0.224	0.051	4.390	0	0.124	0.324
	X_7	International donors/investors	-0.043	0.045	-0.950	0.342	-0.132	0.046
Y_3 Drip conversion and irrigation modernization	X_3	Land tenure	0.276	0.075	3.680	0	0.129	0.422
	Y_1	Water institutions	0.863	0.117	7.390	0	0.634	1.091
	Y_2	Water infrastructure	0.266	0.136	1.960	0.050	0.000	0.532
	X_8	Marketing/production cooperative	0.042	0.085	0.490	0.621	-0.125	0.209
	X_9	Rural service provider	-0.362	0.091	-3.960	0	-0.541	-0.183
Y_4 Contract farming and public-private partnerships	X_3	Land tenure	0.436	0.042	10.48	0	0.354	0.517
	Y_1	Water institutions	0.433	0.098	4.430	0	0.241	0.624
	X_5	Agriculture/environment	-0.044	0.069	-0.640	0.525	-0.179	0.091
	X_{10}	Credit and investment	0.204	0.045	4.540	0.000	0.116	0.293
	X_9	Rural service provider	-0.018	0.056	-0.310	0.753	-0.127	0.092
Y_5 Shift to tree and high-value crops	Y_4	Contract farming and PPP	0.975	0.101	9.610	0	0.776	1.174
	Y_3	Drip conversion/irr. modernization	0.134	0.049	2.760	0.006	0.039	0.229
	X_3	Land tenure	-0.066	0.060	-1.120	0.265	-0.183	0.050
	Y_1	Water institutions	-0.289	0.078	-3.710	0	-0.441	-0.136
	X_{11}	Marketing regimes	0.186	0.053	3.490	0	0.082	0.291
	X_{12}	Trade regimes	-0.028	0.060	-0.470	0.641	-0.145	0.089
	X_9	Rural service provider	0.207	0.056	3.690	0	0.097	0.316
	X_{13}	Corporate sector	-0.084	0.048	-1.750	0.080	-0.178	0.010
Y_6 Water availability	X_1	Climate change impacts	0.243	0.056	4.320	0	0.133	0.353
	Y_5	Shift to tree and high value crops	0.438	0.106	4.150	0	0.231	0.645
	Y_3	Drip conversion/irr. modernization	-0.094	0.050	-1.860	0.063	-0.193	0.005
	Y_1	Water institutions	-0.208	0.075	-2.790	0.005	-0.355	-0.062
	Y_2	Water Infrastructure	0.490	0.118	4.150	0	0.258	0.721
	X_{15}	Climate information system	0.038	0.048	0.790	0.431	-0.057	0.132

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Y_7 Water supply	X_1	Climate change impacts	0.248	0.068	3.670	0	0.116	0.380
	Y_6	Water Availability	0.711	0.099	7.190	0	0.517	0.905
	Y_1	Water institutions	0.237	0.070	3.400	0.001	0.100	0.373
	Y_2	Water infrastructure	-0.152	0.111	-1.370	0.170	-0.369	0.065
Y_8 Agriculture performance	X_1	Climate change impacts	0.174	0.073	2.400	0.016	0.032	0.317
	Y_5	Water Availability	0.838	0.131	6.400	0	0.582	1.095
	Y_7	Water supply	0.263	0.141	1.870	0.062	-0.013	0.539
	X_{15}	Ag input supply	-0.041	0.045	-0.920	0.359	-0.128	0.046
	X_5	Agriculture/environment	-0.068	0.046	-1.480	0.140	-0.159	0.022
	X_{14}	Climate information system	0.035	0.045	0.790	0.430	-0.052	0.123
	X_8	Production/marketing cooperatives	-0.067	0.060	-1.120	0.263	-0.185	0.050
	X_3	Land tenure	-0.097	0.042	-2.330	0.020	-0.179	-0.016
Y_9 Cultivated area	Y_4	Contract farming and PPP	-1.114	0.172	-6.460	0	-1.452	-0.775
	Y_5	Shift to tree and high value crops	1.611	0.173	9.330	0	1.273	1.950
	Y_3	Drip conversion/irri. modernization	0.365	0.087	4.200	0	0.195	0.536
	X_5	Agriculture/environment	0.093	0.062	1.500	0.133	-0.028	0.215
	X_3	Land tenure	0.103	0.089	1.160	0.247	-0.071	0.278
	X_{16}	Value Chain	0.084	0.066	1.270	0.203	-0.045	0.214
	X_4	Customary institutions	-0.158	0.068	-2.340	0.020	-0.290	-0.025
Y_{10} Land quality soil health	X_1	Climate change impacts	0.261	0.046	5.610	0	0.170	0.352
	X_3	Land tenure	0.143	0.049	2.890	0.004	0.046	0.240
	X_5	Agriculture/environment	0.181	0.050	3.600	0	0.083	0.280
	X_{17}	Research, extension systems	0.445	0.056	7.940	0	0.335	0.555
Y_{11} Cropping pattern	Y_9	Cultivated area	0.535	0.097	5.520	0	0.345	0.725
	Y_5	Shift to tree and high-value crops	0.336	0.133	2.530	0.011	0.076	0.596
	Y_4	Contract farming and PPP	0.008	0.106	0.080	0.939	-0.199	0.215
	Y_3	Drip conversion/irr. modernization	0.104	0.040	2.580	0.010	0.025	0.183
	X_{11}	Marketing regimes	-0.007	0.040	-0.180	0.856	-0.085	0.070
	X_3	Land tenure	-0.182	0.043	-4.220	0	-0.267	-0.098
	Y_{10}	Land quality soil health	0.219	0.069	3.190	0.001	0.085	0.354
Y_{12} Land productivity	Y_9	Cultivated area	0.140	0.143	0.980	0.325	-0.139	0.420
	Y_{11}	Cropping pattern	-0.450	0.137	-3.300	0.001	-0.718	-0.183
	Y_5	Water Availability	0.340	0.080	4.220	0	0.182	0.497
	X_{15}	Ag input supply	0.057	0.045	1.270	0.202	-0.031	0.144
	X_{17}	Research, extension systems	0.003	0.044	0.070	0.944	-0.084	0.090
	Y_{10}	Land quality, soil health	0.788	0.082	9.590	0	0.627	0.949
	Y_1	Water institutions	0.198	0.045	4.390	0	0.110	0.286
Y_{13} Water productivity	Y_9	Cultivated area	-0.668	0.151	-4.440	0	-0.963	-0.373
	Y_{11}	Cropping patterns	0.585	0.149	3.920	0	0.293	0.878
	Y_{12}	Land productivity	0.561	0.153	3.660	0	0.261	0.861
	X_{15}	Ag input supply	-0.179	0.050	-3.610	0	-0.277	-0.082
	X_{17}	Research, extension systems	-0.060	0.051	-1.170	0.242	-0.160	0.040
	Y_{10}	Land quality, soil health	0.605	0.134	4.520	0	0.343	0.868
	Y_1	Water institutions	0.139	0.049	2.820	0.005	0.042	0.236
Y_{14} Labor productivity	Y_9	Cultivated area	-0.528	0.197	-2.670	0.008	-0.915	-0.141
	Y_{11}	Cropping patterns	0.531	0.197	2.690	0.007	0.145	0.918
	Y_{12}	Land productivity	1.102	0.114	9.690	0	0.879	1.324
	X_{15}	Input supply	-0.174	0.064	-2.710	0.007	-0.300	-0.048

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Y_{15} Food production	X_{18}	Food price regulation policies	0.080	0.024	3.340	0.001	0.033	0.127
	Y_9	Cultivated area	0.096	0.073	1.320	0.188	-0.047	0.239
	Y_{12}	Land productivity	0.569	0.113	5.040	0	0.348	0.791
	Y_{13}	Water productivity	0.220	0.099	2.230	0.026	0.026	0.414
	X_{10}	Credit and investment	-0.095	0.028	-3.390	0.001	-0.149	-0.040
	Y_4	Contract farming and PPP	0.057	0.044	1.290	0.198	-0.030	0.144
	X_8	Production/marketing cooperative	0.063	0.037	1.690	0.092	-0.010	0.137
	X_9	Rural service provider	-0.056	0.036	-1.560	0.118	-0.126	0.014
Y_{16} Industrial/ commercial crop production	Y_9	Cultivated area	-0.058	0.079	-0.730	0.464	-0.214	0.098
	Y_{12}	Land productivity	0.338	0.160	2.110	0.035	0.024	0.651
	Y_{13}	Water productivity	0.523	0.160	3.260	0.001	0.209	0.837
	X_{11}	Marketing regimes	-0.010	0.054	-0.180	0.854	-0.116	0.096
	X_{12}	Trade regimes	0.090	0.058	1.530	0.125	-0.025	0.204
	X_6	Subsidy and tax relief	-0.175	0.058	-3.020	0.003	-0.288	-0.061
	X_{13}	Corporate sector	0.189	0.045	4.200	0	0.101	0.277
	X_{16}	Value chains	0.001	0.051	0.020	0.986	-0.099	0.101
Y_{17} Feed supply	Y_9	Cultivated area	0.403	0.149	2.700	0.007	0.111	0.694
	Y_{11}	Cropping pattern	0.686	0.179	3.820	0	0.334	1.037
	Y_{15}	Food production	-0.048	0.216	-0.220	0.824	-0.472	0.376
	Y_{16}	Industrial/commercial crop production	-0.087	0.184	-0.470	0.636	-0.448	0.274
	X_4	Customary institutions	0.006	0.044	0.130	0.896	-0.081	0.092
Y_{18} Agro-based, non-farm sector	Y_{15}	Food production	-0.843	0.213	-3.960	0	-1.260	-0.425
	Y_{16}	Industrial/commercial crop production	1.512	0.210	7.190	0	1.100	1.925
	X_{10}	Credit and investments	0.053	0.050	1.060	0.287	-0.045	0.152
	X_{16}	Value chains	0.203	0.076	2.680	0.007	0.055	0.352
	X_{13}	Corporate sector	-0.021	0.070	-0.290	0.768	-0.157	0.116
Y_{19} Agriculture market price	X_{18}	Food price regulation policies	0.011	0.034	0.330	0.744	-0.056	0.079
	X_6	Subsidy and tax relief policies	0.357	0.045	7.900	0	0.269	0.446
	X_8	Production/marketing cooperatives	0.132	0.050	2.620	0.009	0.033	0.230
	X_{11}	Marketing regimes	0.301	0.064	4.710	0	0.175	0.426
	X_{12}	Trade regimes	0.110	0.065	1.700	0.090	-0.017	0.236
Y_{20} Livestock and poultry production	X_{19}	Livestock size and composition	0.098	0.051	1.940	0.052	-0.001	0.198
	Y_{17}	Feed supply	0.623	0.066	9.490	0	0.495	0.752
	X_{10}	Credit and investment	-0.110	0.027	-4.050	0	-0.163	-0.057
	X_{11}	Marketing regimes	-0.005	0.048	-0.100	0.920	-0.098	0.089
	X_{12}	Trade regimes	0.195	0.047	4.170	0	0.103	0.286
	X_{13}	Corporate sector	0.162	0.033	4.850	0	0.097	0.227
Y_{21} Cultivation cost	Y_9	Cultivated area	0.251	0.149	1.680	0.093	-0.042	0.543
	Y_{11}	Cropping patterns	0.203	0.168	1.210	0.227	-0.126	0.532
	X_{15}	Input supply	0.190	0.048	3.980	0	0.096	0.283
	X_6	Subsidy and tax relief	0.179	0.055	3.290	0.001	0.072	0.286
	X_{10}	Credit and investment	0.123	0.045	2.710	0.007	0.034	0.212
Y_{22} Crop income	Y_9	Cultivated area	0.380	0.130	2.920	0.004	0.125	0.634
	Y_{11}	Cropping patterns	-0.232	0.129	-1.800	0.073	-0.485	0.021
	Y_{12}	Land productivity	0.159	0.133	1.200	0.232	-0.101	0.418
	Y_{21}	Cultivation cost	-0.051	0.122	-0.410	0.680	-0.290	0.189
	Y_{19}	Market price	0.656	0.130	5.030	0	0.400	0.911
	X_{16}	Value chains	-0.111	0.051	-2.180	0.029	-0.210	-0.011
	X_{20}	Crop and employment insurance	0.201	0.047	4.300	0	0.109	0.293

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Y_{23}	Y_{14}	Labor productivity	0.882	0.215	4.110	0	0.461	1.302
Rural wages	Y_{15}	Food production	0.473	0.261	1.810	0.070	-0.039	0.985
	Y_{16}	Industrial/commercial crop production	-1.563	0.345	-4.530	0	-2.240	-0.886
	Y_{20}	Livestock production	0.218	0.185	1.180	0.238	-0.144	0.581
	Y_{18}	Agro-based and non-farm sector	0.861	0.119	7.230	0	0.628	1.095
	X_{21}	Wage laws	0.100	0.055	1.820	0.068	-0.008	0.208
Y_{24}	Y_{12}	Land productivity	-0.251	0.179	-1.400	0.162	-0.603	0.101
Rural jobs	Y_{14}	Labor productivity	-0.131	0.171	-0.770	0.442	-0.467	0.204
	Y_{23}	Rural wages	0.482	0.075	6.420	0	0.335	0.629
	Y_{15}	Food production	0.843	0.252	3.350	0.001	0.349	1.337
	Y_{16}	Industrial/commercial crop production	0.108	0.246	0.440	0.661	-0.375	0.591
	Y_{20}	Livestock production	-0.148	0.142	-1.050	0.295	-0.426	0.130
	Y_{18}	Agro-based, non-farm sector	-0.072	0.095	-0.750	0.453	-0.259	0.115
	X_{20}	Crop and employment insurance	0.155	0.049	3.160	0.002	0.059	0.251
Y_{25}	Y_{22}	Crop income	0.794	0.080	9.920	0	0.637	0.951
Farm Income	Y20	Livestock production	0.322	0.091	3.540	0	0.144	0.499
	Y_{18}	Agro-based, non-farm sector	-0.041	0.066	-0.630	0.530	-0.170	0.088
	X_{22}	Safety net policies	-0.061	0.033	-1.850	0.064	-0.126	0.004
Y_{26}	Y_{24}	Rural jobs	-0.050	0.170	-0.290	0.769	-0.382	0.283
Labor	X_{21}	Wage laws	0.593	0.117	5.060	0	0.363	0.823
income	Y_{20}	Livestock production	0.418	0.080	5.220	0	0.261	0.575
	Y_{18}	Agro-based, non-farm sector	-0.256	0.071	-3.600	0	-0.395	-0.117
	X_{20}	Crop and employment insurance	0.254	0.058	4.350	0	0.140	0.369
	X_{22}	Safety net policies	0.011	0.035	0.320	0.750	-0.058	0.080
Y_{27}	Y_{15}	Food production	1.210	0.225	5.370	0	0.768	1.651
Food	Y_{20}	Livestock production	-0.168	0.175	-0.960	0.338	-0.512	0.176
availability	Y_{16}	Industrial, commercial crop production	-0.458	0.190	-2.410	0.016	-0.830	-0.086
	X_{11}	Marketing regime	0.230	0.068	3.390	0.001	0.097	0.362
	X_{12}	Trade regimes	0.148	0.087	1.700	0.090	-0.023	0.319
Y_{28}	Y_{15}	Food production	0.786	0.096	8.190	0	0.598	0.974
Food price	Y_{27}	Food availability	0.483	0.101	4.780	0	0.285	0.680
	X_{11}	Marketing regime	-0.273	0.070	-3.870	0	-0.411	-0.135
	X_{18}	Food price regulation policies	-0.043	0.038	-1.140	0.254	-0.118	0.031
Y_{29}	X_{1}	Climate change impacts	-0.555	0.092	-6.030	0	-0.735	-0.375
Water	Y_{7}	Water supply	0.774	0.122	6.360	0	0.535	1.012
security	Y_{2}	Water infrastructure	0.839	0.117	7.160	0	0.609	1.069
	Y_{1}	Water institutions	0.117	0.089	1.320	0.187	-0.057	0.291
	X_{3}	Customary institutions	-0.125	0.047	-2.670	0.008	-0.217	-0.033
Y_{30}	Y_{25}	Farm income	0.474	0.209	2.270	0.023	0.065	0.884
Rural welfare	Y_{26}	Labor income	0.302	0.153	1.970	0.048	0.002	0.603
	Y_{27}	Food availability	0.116	0.203	0.570	0.568	-0.281	0.513
	Y_{28}	Food price	-0.616	0.141	-4.360	0	-0.892	-0.339
	Y_{29}	Water security	0.637	0.097	6.540	0	0.446	0.828

The model estimates for each equation (see Table 3) show that:

1. Climate change impacts, climate investments, land tenure arrangements, and customary institutions significantly influence water institutions. These institutions are primarily perceived by survey respondents as national or regional entities. For example, policy planners and managers may view them as national and regional-level irrigation departments or river basin organizations, while farmers may perceive them as river basin organizations, irrigation departments, or water user associations.

2. Climate change impacts, climate investments, agricultural and environmental institutions (primarily national or regional agricultural and forest departments) and state tax policies significantly influence the performance of water infrastructure.

3. Water institutions and water infrastructure are the only two MPG elements that depend solely on other MPG elements. TAOs, on the other hand, depend on both MPG elements and preceding TAOs (equations 3–5).

4. Among the TAOs, land tenure, water infrastructure, institutional frameworks, and rural service providers have a strong influence on the adoption of drip irrigation and irrigation modernization.

5. Land tenure, water institutions, and agricultural credit institutions strongly affect contract farming and public-private partnerships.

6. Both TAOs—drip irrigation conversion and contract farming—along with water institutions, agricultural marketing regimes, and rural service providers, significantly influence the shift to high-value crops.

7. Climate change impacts, the shift to high-value crops, and water infrastructure have a strong positive influence on water availability for agriculture, while water institutions and drip irrigation conversion have a weaker effect. The positive perceived impact of climate change on water availability may reflect stakeholders' views that climate-related investments increase water availability. Conversely, they may perceive that current water institutions lack the capacity to improve availability, and that drip irrigation could reduce water availability due to expanding cropped areas (see explanation of equation 9).

8. The negative relationship with water infrastructure possibly reflects the perception of insufficient infrastructure to ensure an adequate water supply.

9. The negative sign of land tenure with agricultural sector performance may reflect the respondents' perception of the restraining effects of the current state of land tenure on improving sector performance.

10. The agricultural area is weakly influenced by the shift to high-value crops and drip irrigation conversion and negatively influenced by contract farming and customary institutions.

11. Climate change impacts, land tenure, and the contribution from agricultural and environmental institutions, and agricultural extension services show strong links to land and soil quality.

12. Expanding cultivated areas, shifting to high-value crops, adopting drip irrigation and modernization, and improving land and soil quality have a significant positive effect on changes in cropping patterns. However, restrictive land tenure arrangements act as a constraint, and larger landholdings under corporate farming (though statistically insignificant) do not favor diversified cropping patterns.

13. Land productivity is positively linked to irrigation through water availability, agricultural research and extension services, land and soil quality, and effective water institutions. However, greater crop diversity has an inverse relationship with land productivity. The weak link between agricultural input supply and land productivity highlights the need to strengthen its role in improving productivity.

14. Water availability, land and soil quality, and water institutions significantly enhance land productivity. In contrast, a larger cultivated area reduces water productivity, as water use is more efficient in smaller areas. Similarly, input supply systems that promote extensive production are not conducive to higher water productivity.

15. Cultivated area and agricultural input supply, which favor extensive systems over intensive production, have a negative influence on labor productivity.

16. Sound agricultural and food price policies enhance the contribution of land and water productivity to significantly increase crop production. However, the relatively weak impact of agricultural credit institutions on crop production warrants further investigation. Notably, the agricultural area has no significant impact on crop production, despite the emphasis on crop shifts.

17. Land and water productivity improvements, along with corporate sector involvement, strongly support higher industrial and commercial crop production, while state tax policies fail to provide adequate support.

18. Feed supply is positively associated with cultivated areas and cropping patterns but shows a (non-significant) negative relationship with food, commercial, and industrial crop production.

19. Industrial and commercial crop production and well-developed agricultural value chains strongly support agro-industries and the non-farm sector. However, respondents perceive that higher food production is a constraint on the expansion of agro-industries and non-farm activities.

20. Effective subsidy and tax policies, agricultural production and marketing corporations, and agricultural market and trade regimes significantly influence agricultural market prices.

21. Better feed supply, agricultural trade regimes, and corporate sector involvement have a positive effect on livestock production, while agricultural credit and investment institutions have minimal impact on livestock production expansion.

22. Besides the obvious factors like higher cultivated area, agricultural input supply, and credit and insurance driving the cultivation cost, cropping pattern changes show no significant effect.

23. Crop income seemed to be constrained by cropping patterns and agricultural value chain inefficiencies.

24. Rural wages are positively affected by labor productivity, food production, agro-industrial and non-farm sector development, and agricultural employment insurance, while industrial and commercial crop production has a significantly lower effect.

25. Rural jobs benefit from higher rural wages, food production, and crop and employment insurance.

26. Farm income is significantly increased by crop income, livestock production, and supportive subsidy and tax policies.

27. Labor income is positively linked to rural wages, livestock production, and crop and employment insurance, but negatively affected by agro-industries and the non-farm sector.

28. Food availability is positively influenced by food production and agricultural market and trade regimes, but negatively affected by industrial and commercial crop production.

29. Food prices are positively associated with food production and availability, while agricultural market regimes have a negative effect. Although this seems counterintuitive, considering the reverse causality reveals that higher food prices can, in turn, stimulate greater food production and availability. This underscores the importance of accounting for two-way feedback effects in impact pathways.

30. Water security is strongly determined by water availability for agriculture and household water supply, while climate change impacts and customary institutions negatively affect it.

31. Rural welfare is significantly influenced by farm income, labor income, food prices, and water security.

The description above illustrates the direct influence of MPG and ITVs. However, their indirect influence on downstream transmission domains through the sequentially linked system is illustrated through the impact pathway analysis.

TAOs as Policy Variables: Relative Performance

Given the pathway analysis results and evaluation framework, we now evaluate the relative impact performance of TAOs. This is possible by comparing their equation-specific and system-wide impacts using the information in Table 4, which shows the relative impact performance of TAOs evaluated in terms of:

a) Their relative size and share in total impacts.
b) Their share in column-wise and row-wise total impacts.

The column-wise shares indicate the distribution of impacts of each TAO across various impact domains. The row-wise shares show the impacts within a given domain as distributed across or contributed by TAOs. The former can identify the domains accounting for a major share of the impacts of different TAOs. The latter can identify the TAOs dominating impact generation at a given domain. Both hold policy value in identifying the appropriate set of impact domains for each TAO and the appropriate configurations of TAOs for each impact domain.

In terms of their relative size and share in total impacts, it is worth noting that TAOs have negative effects in a few cases. However, their overall impacts, both within and across equations, are mostly positive. The total impacts generated by the TAOs alone amount to 24.58 in absolute value terms (ignoring signs) and 16.98 in actual value (including signs). The discrepancy between these two values indicates the extent of negative impacts, which constitute approximately 31% of total impacts, thereby suggesting the predominantly positive net impacts of TAOs. Regarding the share of TAOs in the total impacts generated by all endogenous variables, it stands at 25% in absolute terms and 28% in actual terms. Of the total impacts generated by all TAOs, the shift to high-value crops has the most considerable impact (52%), followed by contract farming and public-private partnerships (25%), and drip conversion with irrigation modernization (23%). The relative impacts of TAOs vary significantly across equations.

Turning now to the most significant dimensions from a policy perspective, Table 4 shows the relative share of TAOs in both column-wise and row-wise total impacts (see Annex A, Table A.5 for actual values of the impacts).

Table 4. TAOs as policy variables: relative performance both within and across impact domains and categories

Impact domains	Category codes	Equation number	Column-wise share of impacts (%)			Row-wise share of impacts (%)			
			Y_3	Y_4	Y_5	Y_3	Y_4	Y_5	Total
Transformative adaptation options	TAO1	Y_3			1			100	100
	TAO2	Y_4			8			100	100
	TAO3	Y_5	2	16		12	88		100
Water institutions and infrastructure	ITV-G1	Y_1	16	7	2	56	28	16	100
		Y_2	5			88		12	100
Water availability and supply	ITV-G2	Y_6	1	7	3	4	47	49	100
		Y_7		5	2	4	47	49	100
Cultivated area and cropping pattern	ITV-G3	Y_9	11	7	13	22	17	61	100
		Y_{11}	8	9	9	21	26	54	100
Agricultural productivity and production	ITV-G4	Y_{12}	3	1	1	40	14	46	100
		Y_{13}	4	0	4	29	1	70	100
		Y_{14}	4	0	3	35	2	63	100
		Y_{15}	1	1	0	37	42	22	100
		Y_{17}	10	9	12	21	22	57	100
Cultivation cost and crop income	ITV-G5	Y_{21}	4	4	5	21	21	58	100
		Y_{22}	1	0	2	21	5	73	100
Rural wages and rural jobs	ITV-G6	Y_{23}	1	1	0	30	52	18	100
		Y_{24}	1	1	1	31	28	41	100
Sectoral performance (agriculture, industrial and commercial crops, agro-based and non-farm sector, and livestock)	ITV-G7	Y_8	1	7	3	4	47	49	100
		Y_{16}	3	1	3	30	6	64	100
		Y_{18}	4	2	4	25	14	62	100
		Y_{20}	6	6	7	21	22	57	100
Farm income	IPG-1	Y_{25}	3	2	4	22	16	63	100
Labor income	IPG-2	Y_{26}	3	4	4	19	25	56	100
Food availability	IPG-3	Y_{27}	1	1	0	4	37	20	100
Food price	IPG-4	Y_{28}	1	1	0	39	40	21	100
Water security	IPG-5	Y_{29}	0	4	2	4	47	49	100
Rural welfare	FPG	Y_{30}	3	4	5	17	24	59	100
Total			100	100	100				

Note: Equations Y_{10} and Y_{19}, representing land quality and soil health and agricultural market price, respectively, are excluded in the row because they are modelled as unaffected directly by TAOs.

The first aspect to note is the strong linkages between the shift to high-value crops and both the adoption of drip irrigation conversion and irrigation modernization, as well as contract farming and public-private partnerships, suggesting that their performances are interconnected. Despite the joint impact of drip conversion/irrigation modernization and contract farming/public-private partnerships, the shift to high-value crops is, however, mutually independent.

From the perspective of their column-wise distribution, TAOs differ in terms of the configuration of impact domains (i.e., equations) that capture the majority share of their respective total impacts. For instance:

- Six domains, i.e., water institutions (16%), cultivable area (11%), feed supply (10%), cropping patterns (8%), livestock production (6%), and water infrastructure (5%), account for the major share in the total impacts of drip irrigation and irrigation modernization (Table 4, column 4).
- Eight domains that account for the major share in the total impacts of contract farming are: shift to high value crops (16%); cropping patterns and feed supply (9% each); water availability, water institutions, and cultivated area (7% each); livestock production (6%); and water supply (5%) (Table 4, column 5).
- Six domains that have a major share in the total impacts of crop shifts are: cultivated area (13%), feed supply (12%), cropping patterns (9%), contract farming and PPP (8%), livestock production (7%), and cultivation cost and rural welfare (5% each) (Table 4, column 6).

The row-wise share indicates the relative share of TAOs in the domain or equation-specific total impacts. An analysis of this will help identify one or more TAOs that are more effective in enhancing the impact of performance of any given domain. For instance:

- In terms of its dominant row-wise share, a shift to high-value crops remains the most effective option (with the highest percentage share) for improving performance in 21 out of 28 impact categories (Table 4, column 9). These domains encompass a range including those focused on productivity and production, to those covering income and welfare.
- Contract farming and public-private partnerships are the most preferred options in the case of four impact domains—crop shift, food production, rural wage, and food price—where they have the dominant row-wise share (Table 4, column 8).
- The drip conversion with irrigation modernization is the preferred option for three impact domains—water institutions, water infrastructure, and food availability (Table 4, column 7).

From a policy perspective, two key points are noteworthy:

- First, shifts to high-value cops have a dominant share in total impacts both in column-wise (16%) and row-wise (88%) contexts. As the most preferred TAO, it deserves a higher priority in both implementation and resource allocation compared to its counterparts.
- Second, TAOs differ considerably in terms of their respective configurations of domains where they have a dominant share. Such a complementarity in their respective domain coverage, taken together with the strong functional linkages that the shift to high-value crops have with contract farming and drip conversion, suggests that it is better to implement them together in an appropriately prioritized climate adaptation strategy. The results in Table 4 suggest that Morocco has experimented with such a strategy with considerable success.

ITVs as Policy Variables: Relative Performance

The relative impact performance of endogenous variables, i.e., ITVs, is essentially evaluated in a group or category-specific context rather than in a variable-specific context. This is partly for analytical convenience and partly for practical consideration, i.e., in most cases, the variable-specific shares of endogenous variables in total impacts are too small to facilitate a focused analysis (see Annex A, Table A.4). More importantly, the group-specific approach also has a major advantage because it can help package closely related policy instruments and operationally cover closely connected impact domains.

For a better understanding of the distribution patterns of the column-wise and row-wise totals of impacts of exogenous variable categories, it is necessary to discuss the relative size and share of endogenous variable categories in the total impacts. This is because the column-wise shares of exogenous variable categories indicate their relative contribution to total impacts as policy instruments. On the other hand, the row-wise share indicates the relative extent to which exogenous variable categories capture the total impacts as impact domains.

First, consider the column-wise share. Annex A, Table A.4 shows that the endogenous variables, taken together, have generated a total impact of 86.91 in absolute terms, i.e., obtained by ignoring signs (57.58 in actual values). Of this total impact, ITV groups have a combined share of 72 %. While TAOs, as a group, account for a share of 25%. The IPGs, particularly IPG-3, which represents food availability, has a share of 3%. Of the total impact generated by all ITVs, ITV-G4 (covering agricultural production and productivity) has the largest share of 21%.

This is followed by ITV-G3 (covering cultivation area, land quality, and crop pattern) and ITV-G1 (covering water institutions and infrastructure), with shares of 19% and 12%, respectively. ITV-G2 (covering water supply and availability) and ITV-G7 (covering sectoral performance) have an 8% share each. The shares of the remaining two ITV groups are relatively small, ranging from 1% to 5%.

Regarding the relative impact shares among exogenous categories, the ITV group dominates, capturing a joint impact of 66%, followed by IPGs and the FPG (i.e., rural welfare), with impact captures of 24% and 10%, respectively. However, TAOs, as a group, account for just 3% of the total impact. The larger share of the ITV group indicates the strong functional and structural linkages among the exogenous variables that this group encompasses. It is also clear that TAOs with a larger column-wise share, but a low row-wise share is more optimal as policy instruments than as impact domains. Of the combined impacts captured by ITV groups, ITV-G4 (covering agricultural production and productivity) and ITV-G7 (covering sectoral performance) account for dominant shares of 19% and 18%, respectively. Notably, ITV-G6 (covering rural jobs and wages) also has a significant share of 10%. Among the intermediary outcome domains, all IPGs have an equal share in total impact capture (4% to 6%).

Tables 5a and 5b show the row-wise and column-wise distribution of total impacts, respectively. In Table 5a, for any given column, the row-wise share indicates the distribution of total impacts of each category of endogenous variables across impact domains (or equations). Overall, all ITV categories jointly account for 78% of the total impacts of TAOs, whereas IPGs account for only 12%. Both the TAOs and FPG account for 5% each. Although a similar pattern of impact distribution exists across domain categories, there are notable differences in the group-specific share for each domain category.

For instance, in the case of the total impacts of TAOs, within the ITV categories, ITV-G3 (cultivation area and crop pattern) has the highest share of 23%, which is followed closely by ITV-G4 (agricultural production and productivity) and ITV-G7 (sectoral performance) with a share of 21% and 19%, respectively. The ITV-G4 and ITV-G7 also have a dominant share in the total impacts of ITV-G1, ITV-G2, and ITV-G3. Therefore, it is clear that although the relative share of impacts captured by different domain groups differs, a notable pattern emerges. In other words, there are a few impact domains that consistently have a larger impact share across policy groups. They are ITV-G4, ITV-G7, and to some extent ITV-G6 (rural jobs and wages).

Table 5a. ITVs as policy variables: relative performance across impact domain categories

Endogenous variable / Impact domain categories	Category codes	Across impact domain categories (column-wise share in %)										
		TAO	ITV-G1	ITV-G2	ITV-G3	ITV-G4	ITV-G5	ITV-G6	ITV-G7	ISEC	FSEC	WSEC
Transformative adaptation options	**TAO**	**5**	**18**									
Drip conversion and irrigation modernization	TAO-1		11									
Contract farming and public-private partnership	TAO-2		4									
Crop shift to high-value crops	TAO-3	5	3									
Impact transmission variables	**ITV**	**78**	**52**	**60**	**79**	**58**	**46**	**37**	**52**			
Water availability and water supply	ITV-G2	7	13	11								
Area, land quality, and cropping pattern	ITV-G3	23	8		4							
Agricultural production and productivity	ITV-G4	20	13	18	40	15			1			
Agricultural price, cost, and income	ITV-G5	7	3	1	7	1	25					
Rural jobs and wages	ITV-G6	2	3	6	8	21		37	28			
Sectoral performance	ITV-G7	19	12	25	19	20	22		23			
Intermediary policy goals	**IPG**	**12**	**22**	**28**	**16**	**34**	**40**	**48**	**40**		**38**	
Farm income goal	IPG-1	4	1	0	3	2	30		7			
Labor income goal	IPG-2	4	2	1	3	8	1	48	20			
Food availability goal	IPG-3	1	2	3	4	11			9			
Food price goal	IPG-4	1	3	4	6	13			4		38	
Water security goal	IPG-5	2	14	20			9					
Broad policy goals	**BPG**	**12**	**21**	**29**	**16**	**34**	**39**	**48**	**41**		**38**	
Income security goal (IPG-1 + IPG-2)	ISEC	8	3	2	6	10	30	48	27			
Food security goal (IPG-3 + IPG-4)	FSEC	2	4	7	11	24			14		38	
Water security goal (IPG-5)	WSEC	2	14	20			9					
Final policy goal (rural welfare)	**FPG**	**5**	**8**	**11**	**6**	**9**	**13**	**15**	**8**	**100**	**62**	**100**
Total (TAO+ITV+IPG+FPG)	100	100	100	100	100	100	100	100	100	100	100	100

Table 5b. ITVs as policy variables: relative performance within impact domain categories

Endogenous variable / Impact domain categories	Category codes	Within impact domain categories (row-wise share in %)											Row total
		TAO	ITV-G1	ITV-G2	ITV-G3	ITV-G4	ITV-G5	ITV-G6	ITV-G7	ISEC	FSEC	WSEC	
Transformative adaptation options	**TAO**	**38**	**62**										**100**
Drip conversion and irrigation modernization	TAO-1		100										100
Contract farming and public-private partnership	TAO-2		100										100
Crop shift to high-value crops	TAO-3	80	20										100
Impact transmission variables	**ITV**	**17**	**11**	**13**	**17**	**13**	**10**	**8**	**11**				**100**
Water availability and water supply	ITV-G2	44	36	20									100
Area, land quality, and cropping pattern	ITV-G3	76	12		12								100
Agricultural production and productivity	ITV-G4	27	8	7	41	17			1				100
Agricultural price, cost, and income	ITV-G5	38	7	1	31	4	19						100
Rural jobs and wages	ITV-G6	5	4	5	16	42		6	22				100
Sectoral performance	ITV-G7	26	8	10	20	22	4		10				100
Intermediary policy goals	**IPG**	**13**	**10**	**9**	**14**	**30**	**6**	**3**	**13**		**2**		**100**
Farm income goal	IPG-1	27	4	1	15	11	28		14				100
Labor Iincome goal	IPG-2	18	4	1	11	27		12	27				100
Food availability goal	IPG-2	3	4	5	21	51			16				100
Food price goal	IPG-4	4	5	6	20	49			6		10		100
Water security goal	IPG-5	14	39	38			8						100
Broad policy goals	**BPG**	**13**	**10**	**9**	**14**	**30**	**6**	**3**	**13**		**2**		
Income security goal (IPG-1 + IPG-2)	ISEC	22	4	1	12	21	11	7	22				100
Food security goal (IPG-3 + IPG-4)	FSEC	4	5	5	21	50	1		10		6		100
Water security goal (IPG-5)	WSEC	14	39	38			8						100
Final policy goal (rural welfare)	**FPG**	**12**	**10**	**9**	**9**	**20**	**5**	**2**	**6**	**9**	**10**	**8**	**100**
Column-wise share (%)		25	12	8	19	21	3	1	8	1	1	1	100

Table 5b shows the column-wise share of total impacts at the row level. In Table 5b, the exogenous variable representing the impact of climate change is excluded because it is not a policy variable. Unlike the MPG elements, ETV is not directly under policy control, though its impact can be influenced through other policy instruments.

Since it informs how the total impacts captured by each domain (equation) are distributed across policy categories of endogenous variables, it can help identify one or more policy instruments that are more effective in improving performance in a given impact domain. From an overall perspective, ITV-G1 (water institutions and water infrastructures) contributes 62% of the total impacts identified by TAOs as the impacts domains, whereas TAOs—functioning as policy instruments—contributes 38%. As shown in Table 3, the breakdown of TAO contributions reveals that they are primarily related to the impacts of drip conversion with irrigation modernization, and contract farming with public-private partnership on the shift to high-value crops. Of the total impacts captured by all ITV categories, TAOs and ITV-G3 (cultivated area and crop pattern) contribute the most, with 17% each. The contributions of the remaining ITV groups are, to some extent, similar, ranging from 8% to 13%. As for the relative contributions of policy groups to the total impacts captured by IPGs within the outcome domain, ITV-G4 (agricultural production and productivity) has the largest share. This means policies improving agricultural production and productivity levels are likely to have the largest impact on IPGs in general, and food and income security, in particular. As a result, ITV-G4 also has the largest contribution to the impacts on the FPG.

However, it is worth noting that since the performance of ITV-G4 is highly influenced by ITV-G3 (cultivated area and crop pattern), policy elements targeting the latter are equally, if not more important. As can be seen in Table 5b, the ITV-G4 policy group contributes the most to the total domain level impacts of both ITV-G4 and ITV-G5 (agricultural prices, costs, and income) with a 41% and 31% share, respectively.

In terms of their relative share in the total impacts realized at the final outcome domain (i.e., FPG), ITV-G4 contributes the most, with a share of 19%. This is followed by TAOs (12%), ITV-G1 and food security (with 10% each), ITV-G2 (water availability and water supply), ITV-G3, and income security (with 9% each). These contributions establish a priority pattern that can be utilized in policy formulation and implementation. It is also intuitively clear that policies aiming to promote climate adaptation options, strengthen water institutions and infrastructure, expand cultivation area, and opt for cropping patterns are more likely to improve production and productivity, enhance farm employment, and boost rural income.

MPG Elements as Policy Variables: Relative Performance

Let us now focus on the relative performance of MPG elements as policy variables. Before proceeding, a few observations are warranted:

- First, the policy roles of the endogenous variables are evaluated based only on their downstream impacts, as our model does not account for the simultaneous or concurrent impacts among them.
- Second, unlike their dual role in the previous evaluation, the endogenous variables are treated only as impact or outcome domains. Likewise, the exogenous variables (excluding ETV) are treated solely as policy variables. The distinct roles of the two variable groups allow for a more precise delineation of impacts, as the column represents policy domains, and the row represents the impact and outcome domains.
- Third, since ETV is not a policy variable, it is excluded from evaluation.
- Finally, like the endogenous variables, the exogenous variables are also grouped into five categories by bringing together functionally and operationally connected MPG elements (see Table 2).

Table 6 presents the column-wise and row-wise distribution of the total impacts of exogenous variables. Taking the pattern of column-wise distribution (i.e., row-wise share of column-level impacts) first:

- The seven ITV categories, as a group, dominate their counterparts in terms of their relative share in total impacts across all institutional categories. However, their joint share varies significantly across institutional categories, ranging from 57% in the case of MPG-G1 (structural institutions) to 75% in the case of MPG-G2 (agriculture-related institutions).
- The TAOs, as a group, have the second-highest share of impacts in the context of both MPG-G1 and MPG-G5 (private sector players).
- But IPGs, as a group, have that distinction in the context of MPG-G2 (agriculture-related institutions), MPG-G2 (market-related institutions), and MPG-G4 (legal and policy-related institutions).

Therefore, from an overall policy perspective, the performance impacts of policies pursued in the realm of MPG, although predominantly captured by ITV domains, are also widely shared by other domains. This fact suggests that even when the MPG policies target predominantly the ITV domains, they will also have considerable spillover benefits on other domains, especially those related to IPGs. Another aspect with significant policy implications can also be noted:

- Looking at the relative share of impacts captured within the ITV categories, it is evident that the impact domains represented by ITV-G4 (agricultural production and productivity) and ITV-G5 (sectoral performance) have consistently a larger share in total impacts in the case of almost all MPG groups. ITV-G4 captures 30% of the impacts of agriculture-related institutions (MPG-G2), 15% of the impacts of structural institutions (MPG-G1), and 12% each of the impacts of market-related institutions (MPG-G3) and legal and policy-related institutions (MPG-G4).
- ITV-G5 captures 24% of the impacts of private sector players (MPG-G5), 16% of the impact of MPG-G3, and 16% of the impacts of MPG-G2.
- ITV-G5 (agricultural prices, costs, and income) accounts for 17% of each of the impacts of MPG-G3 and MPG-G4.

The pattern of relative impact captured by the domain categories can provide useful guidance for setting and prioritizing the target domain(s) for implementing different configurations of MPG-related policies.

Table 6. MPG elements as policy variables: relative performance both within and across impact domain categories

Endogenous variable / Impact domain categories	Category IDs	Across domains (column-wise share in %)					Within domains (row-wise share in %)					Row total
		Structural institutions	Agricultural institutions	Market institutions	Law and policy	Private actors	Structural institutions	Agricultural institutions	Market institutions	Law and policy	Private actors	
		MPG-G1	MPG-G2	MPG-G3	MPG-G4	MPG-G5	MPG-G1	MPG-G2	MPG-G3	MPG-G4	MPG-G5	
Transformative adaptation options	**TAO**	**28**	**6**	**4**	**8**	**17**	**49**	**14**	**7**	**15**	**16**	**100**
Drip conversion and irrigation modernization	TAO-1	10	1	1	5	10	47	3	3	23	24	100
Contract farming and public-private partnership	TAO-2	9	3	0	2	0	62	23	0	13	2	100
Crop shift to high-value crops	TAO-3	8	3	3	1	6	41	18	17	7	17	100
Impact transmission variables	**ITV**	**57**	**75**	**68**	**59**	**64**	**18**	**23**	**21**	**18**	**20**	**100**
Water institution and infrastructure	ITV-G1	8	2	0	10	1	37	13	0	47	3	100
Water availability and water supply	ITV-G2	5	3	2	3	7	27	24	12	17	20	100
Area, land quality and crop pattern	ITV-G3	12	11	12	4	12	27	29	23	8	13	100
Agricultural production and productivity	ITV-G4	15	30	12	7	12	19	49	15	9	8	100
Agricultural price, cost, and income	ITV-G5	4	4	17	17	4	9	12	36	38	5	100
Rural jobs and wages	ITV-G6	4	9	5	8	4	12	39	17	27	6	100
Sectoral performance	ITV-G7	9	16	19	11	24	13	29	26	16	17	100
Intermediary policy goals	**IPG**	**13**	**15**	**22**	**25**	**15**	**15**	**23**	**24**	**29**	**9**	**100**
Farm income goal	IPG-1	3	1	8	6	1	16	6	39	36	4	100
Labour income goal	IPG-2	2	1	3	7	3	16	10	20	44	10	100
Food availability goal	IPG-2	2	4	6	3	5	12	29	29	17	13	100
Food price goal	IPG-4	3	6	4	3	3	17	41	21	13	8	100
Water security goal	IPG-5	2	3	1	6	3	15	25	5	43	12	100
Broad policy goals	**BPG**	**13**	**15**	**22**	**25**	**15**	**15**	**23**	**24**	**29**	**9**	**100**
Income security goal (IPG-1 + IPG-2)	ISEC	5	2	11	13	4	16	8	30	39	7	100
Food security goal (IPG-3 + IPG-4)	FSEC	6	11	10	6	8	15	35	25	15	10	100
Water security goal (IPG-5)	WSEC	2	3	1	6	3	15	25	5	43	12	100
Final policy goal (rural welfare)	**FPG**	**3**	**4**	**6**	**8**	**4**	**12**	**20**	**23**	**37**	**9**	**100**
Column total		100	100	100	100	100						

In terms of the row-wise distribution pattern (i.e., the column-wise share of row-level total impacts), we can identify the MPG categories that are likely to be more effective in the context of different impact and outcome domains. For instance, in the context of TAO-related impact domains, Table 6 shows that MPG-G1 (structural institutions)—especially land tenure and customary institutions—are more effective, with a 49% share of the total impact. Its role is particularly strong in the context of contract farming and public-private partnerships. The MPG groups account for almost a similar share in the domain-level impacts of ITV groups as a whole but differ considerably in terms of their relative share of impacts across individual ITV groups. Thus, in the context of water-related institutions (water institutions and water infrastructure), legal and policy-related institutions (MPG-G4) and structural institutions (MPG-G10) are more effective with respective shares of 47% and 37% of domain-level impacts.

Understandably, agriculture-related institutions (MPG-G2) are relatively more effective in the context of four impact domains, i.e., cultivated area and crop patterns (ITV-G3), production and productivity (ITV-G4), rural jobs and wages (ITV-G6), and sectoral performance (ITV-G7). Their share of, or contributions to domain-specific impacts in the case of these four domains are: 29%, 49%, 39%, and 29%, respectively. However, in the context of the ITV-G5 (agricultural prices, costs, and income) impact domain, legal and policy-related institutions (MPG-G4) and market-related institutions (MPG-G3) are the more effective contributors with respective impact shares of 38% and 36%. These two MPG groups also have larger contributions in the case of outcome domains, i.e., IPGs. Such contributions are particularly important for meeting income goals. However, while agriculture and market-related institutions (MPG-G2 and MPG-G3) effectively meet food security-related goals, MPG-G2 and MPG-G4 contribute more to the impact on the outcome domain of water security.

Regarding the relative contributions of MPG categories with respect to FPG, MPG-G4 (which covers minimum wage, crop insurance, and safety-net policies) dominates with a share of 37%, followed by market-related institutions (MPG-G3) and agricultural institutions (MPG-G2) with shares of 23% and 20%, respectively. Overall, structural institutions contribute more to the context of TAO-related domains, whereas agriculture-related institutions contribute relatively more to most ITV and IPG-related domains. The contributions of other MPG groups are also significant to certain ITV and IPG-related domains.

Synergy, Discord, and Multiplier Effects Among Policy Variables

So far, the relative impact performances of both ITVs and MPG elements—as policy variables—are evaluated in separate contexts, i.e., 'Y on Y' and 'X on Y'. The first case evaluates the effects that each of the ITVs (i.e., endogenous variables representing various impact transmission pathways or channels) has on the impact domains as represented by all its downstream counterparts. The second case, on the other hand, evaluates the effects that each of the MPG elements (i.e., representing all exogenous variables except the climate change variable) has on all impact domains as represented by ITVs. Evidently, the effects of both sets of policy variables are captured by the same set of impact domains. This means that the impact domains can be used as a context to compare the relative performance of the two sets of policy variables. Such a comparison can provide relevant policy-wise insights, especially on the nature and levels of synergy, discordant, and multiplier effects between the two sets of variables across impact domains.

To gain a sound understanding of the implications of such a comparison, it is necessary to recognize the following points:

a) The impact domains can be defined in terms of either actual values or absolute values. As actual values account for signs and absolute values ignore the same, it is evident that the former is smaller than the latter. The gap between them indicates the extent of negative or discordant effects present in any given impact domain. Thus, it is possible to capture the discordant effects across impact domains by comparing the impacts of the two sets of policy variables.

b) As exogenous policy variables, MPG elements only have unidirectional effects on impact domains represented by ITVs. Since ITVs, as impact domains, capture and transmit such effects across domains, the initial impacts of MPG elements can either snowball or dwindle depending on the moderating effects during the impact transmission process. This suggests the scope for synergy effects between the two sets of policy variables.

c) Unlike the unidimensional role of MPG elements, ITVs have a dual role—both as endogenous policy variables and as impact domains. ITVs, as impact domains, are affected by the policy effects of MPG elements and those of all their upstream counterparts. Thus, ITVs, as impact domains, capture and transmit the impacts of three sources: MPG elements, upstream counterparts, and synergy effects of both. This implies the scope for multiplier effects.

d) It is clear from these points that the discordant effects can be calculated by comparing the impacts of each set of policy variables defined in actual values with the same defined in absolute values. The synergy effects, on the other hand, can be calculated by comparing the impacts of the two sets of policy variables in cases where both values are defined in the same impact domains. The multiplier effects can be calculated in terms of the ratio of the impacts of the two sets of policy variables. Based on these procedures, the synergy, discordant, and multiplied effects are calculated based on the impact domain categories.

Table 7 shows the relative levels of synergy, discordant, and multiplier effects between the two sets of policy variables across impact domains defined in both actual and absolute value terms. By first taking the case of impacts in actual value terms, we note that a simultaneous unit change in all MPG-related policy variables has generated a total impact of 30.38. However, a similar change in all ITV-related policy variables has generated a higher total impact of 57.58. The corresponding figures for absolute values are 39.91 and 86.91, respectively.

In either case, the difference between the total impacts of MPG- and ITV-related policy variables indicates the extent of system-level synergy. In both cases, however, the synergy level varies considerably across impact domain categories. For instance, across domain categories, synergy levels in terms of actual values vary from 0.08 in the TAO domain to 16.08 in the ITV domain.[4] Within the ITV domains, the synergy level of sectoral performance (ITV-G7) remains the highest (5.60), followed by agricultural production and productivity (ITV-G4) with 3.96, rural jobs (ITV-G6) with 3.87, and cultivated area and crop pattern (ITV-G3) with 3.27. Though magnitudes vary, the synergy levels reckoned in absolute values also exhibit a similar pattern of variations across domains.

Discordant effects represent the extent of negative effects evident across impact domains. They are determined by comparing the impact levels of each set of policy variables, measured in actual values with those obtained in absolute values. As can be seen in Table 9, the system-wide total of discordant effect is 9.53 in the case of MPG-related policy variables and 29.33 in the case of ITV-related policy variables, representing 24% and 34% of their corresponding total impacts. The higher discordant effects of ITV-related policy variables imply that their impacts are moderated considerably more by intermediate variables during Impact transmission as compared to the impacts of MPG-related policy variables.

[4] The negative figures observed in two cases (TAO and ITV-G1) basically indicate that the concerned domains are affected more by MPG-related exogenous variables than by ITV-related endogenous variables. This can be due to either lack of linkages among concerned ITV variables or dependence only on MPG-related exogenous variables.

Table 7. Relative synergy, discordant, and multiplier effects between the two sets of policy variables across impact domains

Endogenous variables / Impact domains (ITVs)	Category codes	Actual value		Absolute value		Discordant effects		Synergy effects		Multiplier effects	
		X on Y	Y on Y	X on Y	Y on Y	X on Y	Y on Y	Actual value	Abs. value	Actual value	Abs. value
		[1]	[2]	[3]	[4]	[3]-[1]	[4]-[2]	[2]-[1]	[4]-[3]	[2]/[1]	[4]/[3]
Transformative adaptation options	**TAO**	**3.04**	**2.96**	**4.21**	**2.96**	**1.17**	**0**	**-0.08**	**-1.25**	**0.97**	**0.70**
Impact transmission variables	**ITV**	**21.15**	**37.21**	**27.16**	**55.14**	**6.01**	**17.93**	**16.06**	**27.97**	**1.76**	**2.03**
Water institutions and infrastructures	ITV-G1	1.90		1.98		0.09		-1.90	-1.98	0	0
Water availability and water supply	ITV-G2	1.89	2.97	2.27	3.53	0.37	0.57	1.07	1.27	1.57	1.56
Area, land quality and crop pattern	ITV-G3	3.18	6.45	3.96	6.45	0.78	0	3.27	2.49	2.03	1.63
Agricultural production and productivity	ITV-G4	5.47	9.43	6.91	16.60	1.44	7.16	3.96	9.69	1.72	2.40
Agricultural price, cost and income	ITV-G5	3.09	3.26	3.32	3.89	0.23	0.63	0.17	0.57	1.06	1.17
Rural jobs and wages	ITV-G6	1.88	5.75	2.50	8.65	0.62	2.90	3.87	6.16	3.06	3.46
Sectoral performance	ITV-G7	3.75	9.35	6.23	16.01	2.48	6.66	5.60	9.78	2.50	2.57
Broad policy goals	**BPG**	**5.22**	**14.17**	**6.93**	**20.53**	**1.70**	**6.37**	**8.94**	**13.61**	**2.71**	**2.96**
Income security goal (IPG-1 + IPG-2)	ISEC	2.00	5.91	2.50	8.31	0.50	2.40	3.91	5.81	2.95	3.32
Food security goal (IPG-3 + IPG-4)	FSEC	2.23	4.82	3.20	8.75	0.98	3.93	2.59	5.55	2.16	2.73
Water security goal (IPG-5)	WSEC	0.99	3.43	1.22	3.47	0.23	0.04	2.44	2.25	3.46	2.84
Final policy goal (Rural Welfare)	FPG	0.97	3.25	1.61	8.29	0.65	5.04	2.28	6.67	3.37	5.13
Endogenous variables / Impact domains (ITVs)		30.38	57.58	39.91	86.91	9.53	29.33	27.20	47.00	1.90	2.18
As a respective % of total impacts		**52.76**	**100**	**54.08**	**100**	**23.88**	**33.75**	**47.24**	**54.08**	**1.90**	**1.85**

Notes: (a) Actual values account for negative sign, but absolute values ignore the same.

(b) 'X on Y' captures the total impacts of exogenous policy variables (MPG Elements) across impact domains (ITVs) and 'Y on Y' captures the total impacts of endogenous policy variables (ITVs) across impacts domains (ITVs).

A comparison of the discordant effects with the synergistic effects across impact domain categories reveals three key points, which have considerable implications for policy design and implementation. These points are:

- A strong association between the levels of synergy and discordant effects is evident across domains. That is, those impact domains with high synergy effects also display high discordant effects. Synergy effects also uniformly dominate over discordant effects across all but two impact domains, regardless of whether they are evaluated in terms of actual or absolute values.[5] This means there are substantial net synergy effects across impact domains.

- Synergy levels across domains are interrelated as they form part of the same impact flow. That is, the synergy at one domain is linked with the same in all preceding domains. However, from a policy perspective, it is still important to delineate not only the domains where they are more concentrated but also the domains preceding them. In this sense, relative synergy levels can be used to rank and sequence the policy-wise more important domains.

- The levels of multiplier effects capture an essential aspect of the relationship between the domain-level impacts of the two sets of policy variables. They can be obtained by dividing the impacts of ITV-related policy variables by those of MPG-related policy variables across impact domains. Therefore, the level of multiplier effects indicates the extent of change in the impacts of ITV-related policy variables caused by a unit change in the impacts of MPG-related policy variables in each domain context.

As shown in Table 7, the multiplier effect at the system-wide level is 1.90 (in actual values) and 2.18 (in absolute values). Understandably, levels of multiplier effects vary significantly across impact domain categories. For instance, as we consider the multiplier values in terms of actual values, the FPG has the highest multiplier value (3.37), followed by BPGs with a value of 2.71, and ITV with a value of 1.76.

Within the BPG category, water security (WSEC) has the highest multiplier value of 3.46, followed closely by both food security (FSEC) and income security (ISEC), with respective values of 2.96 and 2.16. Among ITV categories, rural jobs and wages (ITV-G6) have the highest multiplier value (3.06), followed by the sectoral performance (ITV-G7), and cultivation area and crop pattern (ITV-G3) with respective values of 2.50 and 2.03. For obvious reasons, the multiplier values in absolute terms are higher. They also lead to the same order of impact domains in terms of those obtained in actual value terms. The multiplier values play a significant role in identifying the domains that could yield better return on policy efforts. From this perspective, the domains that could provide better returns in terms of rural welfare are water security (WSEC), rural jobs and wages (ITV-G6), income security (ISEC), sectoral performance (ITV-G7), and food security (FSEC). To ensure such a welfare return, other domains that can receive policy attention include cultivation area and crop pattern (ITV-G3), agricultural production and productivity (ITV-G4), and water availability and water supply (ITV-G2).

[5] The exceptions here are the two domains with negative synergy figures (TAO and ITV-G1). As noted already, these domains are affected more by MPG-related variables than by ITV-related variables. They lack linkages as they are the upstream of the impact transmission process and depend only on MPG-related exogenous variables.

Conclusions and Policy Implications

An evaluation of the entire process of climate change, transformative adaptation, multiscale polycentric governance, and impact transition variables on rural welfare interactions in the Oum Er Rbia River basin in Morocco provided valuable insights. The policy lessons are relevant for Morocco to fine-tune its ongoing and future climate adaptation strategies as well as for other similarly placed countries in Africa and elsewhere in designing and implementing their climate adaptation strategies. Through the impact pathway analysis, it is possible to rank, prioritize, and appropriately combine and sequence policy instruments (MPG elements, ITVs, and TAOs) in terms of their relative size and share of impacts in system-wide contexts.

From a policy perspective of the adaptation options, two key aspects are important. First, the shift to high-value crops has the largest share of total impacts, followed by contract farming with public-private partnerships, and conversion to drip irrigation and system modernization. As the most preferred option, the shift to high-value crops deserves a higher priority in both implementation and resource allocation than its counterparts. However, taken together, the shift to high-value crops has a strong functional linkage with the other two TAOs—contract farming and public-private partnerships, as well as the conversion to drip irrigation with irrigation modernization. In fact, Morocco has been following such a strategy of implementing the three TAOs in its PMV. Implementing them together within an appropriately prioritized investment strategy, as suggested here, would accelerate the benefits to rural welfare.

Despite variations across impact transmission domains in terms of the relative share of impacts captured from different policy variables, a clear and notable pattern emerges. A few impact domains—including agricultural production and productivity, sectoral performance, and, to some extent, rural jobs and wages—have a consistently larger impact share across policy groups. Policies improving agricultural production and productivity levels will likely have the largest impact on IPGs in general and food and income security in particular. Notably, since the performance of the impact transmission category of agricultural production and productivity is highly influenced by cultivated area and crop pattern, policy elements targeting the latter are equally, if not more, important. These contributions establish a priority pattern that can be utilized in policy formulation and implementation. In fact, the analysis reaffirms what is intuitively clear: policies aimed at promoting climate adaptation options, strengthening water institutions and infrastructure, and expanding cultivation areas and cropping patterns are more likely to improve production and productivity, enhance farm employment, and increase rural income.

On the relative performance of MPG elements as policy variables, the impact pathway results provide interesting insights. The impact domains represented by all seven impact transmission categories captured the dominant share of the total impacts generated by each MPG category. The TAOs, as a group, captured the second-highest share of impacts only in the case of structural institutions and private sector players. IPGs, as a group, hold this distinction in the cases of agriculture-related institutions, market-related institutions, and legal and policy-related institutions.

However, from an overall policy perspective, the performance impacts of policies pursued in the realm of MPG, although predominantly captured by ITV domains, are also widely shared by other domains. This fact suggests that even when the MPG policies predominantly target the ITV domains, they will also have considerable spillover benefits on other domains, especially those related to IPGs.

Another aspect with important policy implications can also be noted. Examining the relative share of impacts captured within the ITV categories, the impact domains represented by agricultural production and productivity, and sectoral performance consistently account for a larger share of total impacts in the case of almost all MPG groups. This pattern of relative impact captured by domain categories can provide useful guidance for setting and prioritizing target domains for implementing different configurations of MPG-related policies.

Some MPG categories are more effective or contribute more to the overall impacts at a domain level across impact and outcome domains. For instance:

- In the case of TAO-related impact domains, structural institutions—particularly land tenure and customary institutions—are more effective, accounting for a significant portion of the total domain-level impacts. These impacts are particularly notable for the domain represented by contract farming and public-private partnerships.

- For water institutions and the water infrastructure impact domain, legal and policy-related institutions, as well as structural institutions, are more effective.

- Agriculture-related institutions are relatively more effective in the context of four impact domains—cultivated area and crop pattern, production and productivity, rural jobs and wages, and sectoral performance.

- In the case of agricultural prices, costs, and income impact domains, legal and policy-related institutions, and market-related institutions are more effective contributors.

- Legal and policy-related institutions, and market-related institutions, also have larger contributions in the context of outcome domains such as the immediate policy goal. Such contributions are particularly important for ensuring income security.

- However, agricultural and market-related institutions are more effective for food security, while water institutions, infrastructure, and structural institutions are important for water security.

- Two MPG groups: agricultural-related institutions, laws and policies—which encompass minimum wage, crop insurance, and safety-net policies—contribute more to the impacts in the outcome domain of water security.

- Regarding the relative contributions to the FPG, the MPG domain of laws and policies dominates. This is followed by market-related institutions and agricultural institutions.

MPGs, particularly structural institutions and private actors, have a relatively higher influence on TAOs. Policies targeting all MPG domains that predominantly affect impact transmission variable domains will have considerable spillover benefits on other domains, such as the intermediate policy goals of enhancing farm and labor income, food availability and prices, and water security. All MPG groups consistently have a larger share of impacts on agricultural production and productivity, as well as sectoral performance transmission domains.

Among the impact transmission domains, productivity and production contribute the most to food and income security. Since cultivated areas and cropping patterns of transmission domains significantly influence productivity and production, policy interventions targeting these domains can enhance food and livelihood security. Therefore, prioritize policies targeting MPGs and TAOs that significantly impact transmission variables, and select complementary policies that target these variables to generate higher impacts on the intermediate policy goals of food, livelihood, and water security, as well as the FPG of rural welfare.

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Annex A. Analytical Summaries.

Table A.1. CC-TAO-MPG-RW interactions model: system level 3-SLS results

Eqn. No:	Dependent variables	Sample size	Independent variables	RMSE	R^2	X^2	Probability
1	WATRINSTN	176	4	1.46	0.93	2,516.43	0.0000
2	WATRINFRA	176	5	1.36	0.96	4,508.55	0.0000
3	DCONVIMOD	176	5	2.25	0.88	1,523.49	0.0000
4	CONFAMPPP	176	5	1.20	0.96	4,327.62	0.0000
5	CROPSHIFT	176	8	1.08	0.97	7,926.31	0.0000
6	WATRAVAIL	176	6	1.30	0.96	5,315.73	0.0000
7	WATRSUPLY	176	4	1.33	0.97	5,449.97	0.0000
8	AGPERFORM	176	8	1.15	0.98	9,325.19	0.0000
9	CULTIAREA	176	7	1.82	0.93	4,305.78	0.0000
10	LANDSQLTY	176	4	1.41	0.96	4,224.83	0.0000
11	CROPATERN	176	7	0.82	0.99	12,643.72	0.0000
12	LANDPRODY	176	7	1.10	0.98	8,741.62	0.0000
13	WATRPRODY	176	7	1.26	0.97	7,999.77	0.0000
14	LABRPRODY	176	4	1.50	0.95	4,270.05	0.0000
15	FOODPRODN	176	8	0.92	0.98	9,247.54	0.0000
16	INDCPRODN	176	8	1.21	0.96	4,587.21	0.0000
17	FEEDSUPLY	176	5	1.40	0.96	4,507.75	0.0000
18	AGNFSECTR	176	5	1.74	0.89	1,948.44	0.0000
19	AMKTPRICE	176	5	1.07	0.97	5,636.33	0.0000
20	LIVSPRODN	176	6	0.82	0.98	11,949.34	0.0000
21	CULTICOST	176	5	1.25	0.96	4,441.61	0.0000
22	CROPINCOM	176	7	1.13	0.97	6,256.70	0.0000
23	RURALWAGE	176	6	1.79	0.91	2,635.12	0.0000
24	RURALJOBS	176	8	1.31	0.95	5,859.80	0.0000
25	FARMINCOM	176	4	1.11	0.97	6,287.63	0.0000
26	LABRINCOM	176	6	1.10	0.97	6,623.47	0.0000
27	FOODAVAIL	176	5	1.64	0.94	3,333.99	0.0000
28	FOODPRICE	176	4	1.32	0.96	4,423.77	0.0000
29	WATRSECUR	176	5	1.67	0.94	3,444.64	0.0000
30	RURWELFAR	176	5	1.09	0.97	6,695.78	0.0000

Note: Going by the high values of R^2 and X^2 (i.e., Chi-Square), the models behind all equations have explanatory power and also fit the data well.

The most important model diagnostic tests: predictive ability (F-test) (see Annex A, Table A.1) and first and higher-order autocorrelation (Durbin-Watson Test and Breusch-Godfrey Test), show better results. The high multicollinearity (Mean-Variance Inflation Factor) indicates that there is high interdependency of dependent variables. Higher heteroskedasticity (White's Test), and distribution normality (Skewness-Kurtosis Test) show skewed non-normal distribution of most variables. These can be expected with the number of variables considered in the model and the perception data collected on a 0-10 scale.

Table A.2. Reduced form equations (effects of Y_is on Y_{i+1}s)

Yi		Reduced form equation (Y_i on Y_{i+1}s)
Y_3	=	$0.86Y_1 + 0.27Y_2$
Y_4	=	$0.430Y_1$
Y_5	=	$0.249Y_1 + 0.036Y_2 + 0.134Y_3 + 0.975Y_4$
Y_6	=	$- 0.180Y_1 + 0.481Y_2 - 0.035Y_3 + 0.427Y_4 + 0.438Y_5$
Y_7	=	$- 0.043Y_1 + 0.579Y_2 - 0.025Y_3 + 0.304Y_4 + 0.311Y_5 + 0.711Y_6$
Y_8	=	$- 0.162Y_1 + 0.555Y_2 - 0.036Y_3 + 0.438Y_4 + 0.449Y_5 + 1.025Y_6 + 0.263Y_7$
Y_9	=	$0.233Y_1 + 0.155Y_2 + 0.581Y_3 + 0.457Y_4 + 1.611Y_5$
Y_{11}	=	$0.302Y_1 + 0.122Y_2 + 0.460Y_3 + 0.580Y_4 + 1.198Y_5 + 0.535Y_9 + 0.219Y_{10}$
Y_{12}	=	$0.302Y_1 + 0.122Y_2 - 0.138Y_3 - 0.048Y_4 - 0.161Y_5 + 0.340Y_6 - 0.101Y_9 + 0.689Y_{10} - 0.450Y_{11}$
Y_{13}	=	$0.182Y_1 + 0.055Y_2 - 0.196Y_3 + 0.007Y_4 - 0.466Y_5 + 0.191Y_6 - 0.412Y_9 + 1.120Y_{10} + 0.333Y_{11} +0.561Y_{12}$
Y_{14}	=	$0.081Y_1 + 0.154Y_2 - 0.215Y_3 + 0.014Y_4 - 0.392Y_5 + 0.375Y_6 - 0.355Y_9 + 0.876Y_{10} + 0.035Y_{11} +1.102Y_{12}$
Y_{15}	=	$0.110Y_1 + 0.115Y_2 - 0.066Y_3 + 0.075Y_4 - 0.039Y_5 + 0.235Y_6 - 0.052Y_9 + 0.639Y_{10} - 0.183Y_{11} + 0.692Y_{12} + 0.220Y_{13}$
Y_{16}	=	$0.095Y1 + 0.073Y2 - 0.183Y3 - 0.039Y4 - 0.391Y5 + 0.215Y6 - 0.249Y9 + 0.761 Y10 + 0.022 Y11 + 0.631Y12$ $+ 0.523Y_{13}$
Y_{17}	=	$0.288Y_1 + 0.134Y_2 + 0.569Y_3 + 0.582Y_4 + 1.507Y_5 - 0.030Y_6 + 0.794Y_9 + 0.053Y_{10} + 0.693y_{11} - 0.088Y_{12} - 0.056Y_{13}$ $- 0.048Y_{15} - 0.087Y_{16}$
Y_{18}	=	$0.051Y_1 + 0.012Y_2 - 0.221Y_3 - 0.122Y_4 - 0.559Y_5 + 0.126Y_6 - 0.333Y_9 + 0.612Y_{10} + 0.187Y_{11} + 0.371Y_{12} + 0.605Y_{13}$ $- 0.843Y_{15} + 1.512Y_{16}$
Y_{20}	=	$0.179Y_1 + 0.084Y_2 + 0.354Y_3 + 0.362Y_4 + 0.939Y_5 - 0.019Y_6 + 0.495Y_9 + 0.033Y_{10} + 0.432Y_{11} - 0.055Y_{12} - 0.035Y_{13}$ $- 0.054Y_{15} + 0.623Y_{16} + 0.098y_{18}$
Y_{21}	=	$0.120Y_1 + 0.064Y_2 + 0.239Y_3 + 0.232Y_4 + 0.648Y_5 + 0.360Y_9 + 0.044Y_{10} + 0.203Y_{11}$
Y_{22}	=	$0.019Y_1 + 0.052Y_2 + 0.080Y_3 + 0.019Y_4 + 0.276Y_5 + 0.054Y_6 + 0.022Y_9 + 0.057Y_{10} - .314Y_{11} + 0.159Y_{12}$
Y_{23}	=	$0.058Y_1 + 0.106Y_2 - 0.048Y_3 + 0.082Y_4 - 0.029Y_5 + 0.211Y_6 - 0.127Y_9 + 0.420Y_{10} + 0.166Y_{11} + 0.620Y_{12} - 0.200Y_{13}$ $+ 0.882Y_{14} - 0.259Y_{15} - 0.273Y_{16} + 0.136Y_{17} + 0.861Y_{18} + 0.021Y_{19} + 0.218Y_{20}$
Y_{24}	=	$0.080Y_1 + 0.084Y_2 - 0.072Y_3 + 0.064Y_4 - 0.096Y_5 + 0.183Y_6 - 0.109Y_9 + 0.486Y_{10} - 0.141Y_{11} + 0.537Y_{12} +0.107Y_{13}$ $+ 0.294Y_{14} + 0.783Y_{15} - 0.124Y_{16} - 0.027Y_{17} + 0.343Y_{18} - 0.004Y_{19} - 0.043Y_{20} + 0.482Y_{23}$
Y_{25}	=	$0.071Y_1 + 0.068Y_2 + 0.187Y_3 + 0.137Y_4 + 0.544Y_5 + 0.032Y_6 + 0.349Y_9 + 0.031Y_{10} - 0.118Y_{11} + 0.093Y_{12} - 0.036Y_{13}$ $+ 0.025Y_{15} - 0.079Y_{16} + 0.201Y_{17} - 0.041Y_{18} + 0.552Y_{19} + 0.322Y_{20} + 0.040Y_{21} + 0.794Y_{22}$
Y_{26}	=	$0.092Y_1 + 0.091Y_2 + 0.180Y_3 + 0.228Y_4 + 0.523Y_5 + 0.076Y_6 + 0.222Y_9 + 0.082Y_{10} + 0.233Y_{11} - 0.223Y_{12}\ 0.293Y_{13}$ $+ 0.508Y_{14} + 0.0100Y_{15} - 0.565Y_{16} + 0.342Y_{17} + 0.237Y_{18} + 0.054Y_{19} + 0.549Y_{20} + 0.569Y_{23} - 0.050Y_{24}$
Y_{27}	=	$0.069Y_1 + 0.092Y_2 - 0.055Y_3 + 0.048Y_4 - 0.026Y_5 + 0.190Y_6 - 0.032Y_9 + 0.419Y_{10} - 0.304Y_{11} + 0.558Y_{12} + 0.033Y_{13}$ $+ 1.215Y_{15} - 0.449Y_{16} - 0.105Y_{17} - 0.016Y_{19} - 0.168Y_{20}$
Y_{28}	=	$0.115Y_1 + 0.135Y_2 - 0.079Y_3 + 0.082Y_4 - 0.043Y_5 + 0.277Y_6 - 0.056Y_9 + 0.704Y_{10} - 0.290Y_{11} + 0.814Y_{12} + 0.189Y_{13}$ $+ 1.373Y_{15} - 0.217Y_{16} - 0.051Y_{17} - 0.008Y_{19} - 0.081Y_{20} + 0.483Y_{27}$
Y_{29}	=	$0.084Y_1 + 1.287Y_2 - 0.019Y_3 + 0.235Y_4 + 0.241Y_5 + 0.550Y_6 + 0.0774Y_7$
Y_{30}	=	$0.051Y_1 + 0.807Y_2 + 0.172Y_3 + 0.239Y_4 + 0.539Y_5 + 0.240Y_6 + 0.493Y_7 + 0.263Y_9 - 0.346Y_{10} + 0.158Y_{11} - 0.325Y_{12}$ $- 0.218Y_{13} + 0.154Y_{14} - 0.690Y_{15} - 0.127Y_{16} + 0.217Y_{17} + 0.052Y_{18} + 0.281Y_{19} + 0.349Y_{20} + 0.019Y_{21} + 0.376Y_{22}$ $+ 0.172Y_{23} - 0.015Y_{24} + 0474Y_{25} + 0.302Y_{26} - 0.182Y_{27} - 0.616Y_{28} + 0.637Y_{29}$

Note: Equations Y_1 (WATRINSTN), Y_2 (WATRINFRA), Y_{10} (LANDSQLTY), and Y_{19} (AMKTPRICE) are not in the list of reduced form equations, as they are modelled to depend only on exogenous variables Similarly, Y_8 (AGPERFORM) is not part of the explanatory variables, as it is modelled only as an endogenous variable.

Table A.3. Reduced form equations (effects of X_is on Y_is)

Y_i		Reduced form equation (X_i of Y_i)
Y_1	=	$0.083X_1 + 0.315X_2 + 0.138X_3 + 0.398X_4$
Y_2	=	$0.446X_1 + 0.141X_2 + 0.194X_5 + 0.224X_6 - 0.043X_7$
Y_3	=	$0.190X_1 + 0.309X_2 + 0.395X_3 + 0.343X_4 + 0.052X_5 + 0.056X_6 - 0.011X_7 + 0.042X_8 - 0.362X_9$
Y_4	=	$0.036X_1 + 0.136X_2 + 0.4956X_3 + 0.172X_4 - 0.044X_5 - 0.018X_9 + 0.204X_{10}$
Y_5	=	$0.037X_1 + 0.083X_2 + 0.430X_3 + 0.099X_4 - 0.036X_5 + 0.008X_6 - 0.001X_7 + 0.006X_8 + 0.141X_9 + 0.199X_{10} + 0.186X_{11} - 0.028X_{12} - 0.084X_{13}$
Y_6	=	$0.442X_1 + 0.011X_2 + 0.1223X_3 - 0.072X_4 + 0.0745X_5 + 0.108X_6 - 0.020X_7 - 0.001X_8 + 0.096X_9 + 0.087X_{10} + 0.081X_{11} - 0.012X_{12} - 0.037X_{13} + 0.038X_{14}$
Y_7	=	$0.514X_1 + 0.061X_2 + 0.120X_3 + 0.043X_4 + 0.023X_5 + 0.0425X_6 - 0.008X_7 - 0.001X_8 + 0.068X_9 + 0.062X_{10} + 0.058X_{11} - 0.009X_{12} - 0.026X_{13} + 0.027X_{14}$
Y_8	=	$0.680X_1 + 0.025X_2 + 0.037X_3 - 0.049X_4 + 0.001X_5 + 0.101X_6 - 0.019X_7 - 0.068X_8 + 0.098X_9 + 0.089X_{10} + 0.084X_{11} - 0.013X_{12} - 0.038X_{13} + 0.074X_{14} - 0.041X_{15}$
Y_9	=	$0.088X_1 + 0.095X_2 + 0.388X_3 - 0.065X_4 + 0.102X_5 + 0.034X_6 - 0.007X_7 + 0.024X_8 + 0.115X_9 + 0.093X_{10} + 0.300X_{11} - 0.045X_{12} - 0.135X_{13} + 0.084X_{16}$
Y_{10}	=	$0.261X_1 + 0.143X_3 + 0.181X_5 + 0.445X_{17}$
Y_{11}	=	$0.137X_1 + 0.112X_2 + 0.247X_3 + 0.036X_4 + 0.088X_5 + 0.027X_6 - 0.005X_7 + 0.019X_8 + 0.071X_9 + 0.118X_{10} + 0.216X_{11} - 0.033X_{12} - 0.101X_{13} + 0.045X_{16} + 0.097X_{17}$
Y_{12}	=	$0.323X_1 + 0.029X_2 + 0.125X_3 + 0.029X_4 + 0.143X_5 + 0.029X_6 - 0.006X_7 - 0.006X_8 + 0.017X_9 - 0.011X_{10} - 0.027X_{11} + 0.005X_{12} + 0.014X_{13} + 0.013X_{14} + 0.057X_{15} - 0.008X_{16} + 0.310X_{17}$
Y_{13}	=	$0.372X_1 + 0.062X_2 + 0.061X_3 + 0.136X_4 + 0.173X_5 + 0.009X_6 - 0.002X_7 - 0.008X_8 - 0.026X_9 + 0.001X_{10} - 0.100X_{11} + 0.013X_{12} + 0.039X_{13} + 0.007X_{14} - 0.1470X_{15} - 0.034X_{16} + 0.440X_{17}$
Y_{14}	=	$0.382X_1 + 0.041X_2 + 0.064X_3 + 0.086X_4 + 0.150X_5 + 0.028X_6 - 0.005X_7 - 0.009X_8 - 0.005X_9 + 0.002X_{10} - 0.074X_{11} + 0.011X_{12} + 0.033X_{13} + 0.0142X_{14} - 0.111X_{15} - 0.030X_{16} + 0.393X_{17}$
Y_{15}	=	$0.276X_1 + 0.08X_{18} + 0.047X_2 + 0.150X_3 + 0.050X_4 + 0.127X_5 + 0.0226X_6 - 0.004X_7 + 0.060X_8 - 0.042X_9 - 0.080X_{10} - 0.007X_{11} + 0.001X_{12} + 0.0035X_3 + 0.009X_{14} + 0.0001X_{15} - 0.004X_{16} + 0.273X_{17}$
Y_{16}	=	$0.299X_1 + 0.0367X_2 + 0.052X_3 + 0.085X_4 + 0.132X_5 - 0.162X_6 - 0.002X_7 - 0.008X_8 - 0.015X_9 - 0.008X_{10} - 0.083X_{11} + 0.101X_{12} + 0.222X_{13} + 0.008X_{14} - 0.057X_{15} - 0.025X_{16} + 0.335X_{17}$
Y_{17}	=	$0.090X_1 + 0.11X_2 + 0.314X_3 - 0.006X_4 + 0.084X_5 + 0.046X_6 - 0.006X_7 + 0.021X_8 + 0.098X_9 + 0.123X_{10} + 0.276X_{11} - 0.050X_{12} - 0.143051X_{13} - 0.001X_{14} + 0.005X_{15} + 0.067X_{16} + 0.025X_{17} - 0.004X_{18}$
Y_{18}	=	$0.219X_1 + 0.016X_2 - 0.048X_3 + 0.086X_4 + 0.093X_5 - 0.263X_6 - 0.0001X_7 - 0.062X_8 + 0.013X_9 + 0.108X_{10} - 0.121X_{11} + 0.152X_{12} + 0.311X_{13} + 0.005X_{14} - 0.087X_{15} + 0.169X_{16} + 0.276X_{17} - 0.067X_{18}$
Y_{19}	=	$- 0.357X_6 + 0.132X_8 + 0.301X_{11} + 0.110X_{12} + 0.011X_{18}$
Y_{20}	=	$0.056X_1 + 0.069X_2 + 0.196X_3 - 0.004X_4 + 0.052X_5 + 0.028X_6 - 0.004X_7 + 0.013X_8 + 0.061X_9 - 0.033X_{10} + 0.167X_{11} + 0.163X_{12} + 0.073X_{13} - 0.0007X_{14} + 0.003X_{15} + 0.042X_{16} + 0.015X_{17} - 0.002X_{18} + 0.098X_{19}$
Y_{21}	=	$0.050X_1 + 0.047X_2 + 0.148X_3 - 0.009X_4 + 0.043X_5 + 0.193X_6 - 0.00273525X_7 + 0.010X_8 + 0.043X_9 + 0.047X_{10} + 0.119X_{11} - 0.018X_{12} - 0.054X_{13} + 0.19X_{15} + 0.0302X_{16} + 0.0197X_{17} + 0.123X_{20}$
Y_{22}	=	$0.051X_1 + 0.012X_2 + 0.103X_3 - 0.028X_4 + 0.040X_5 + 0.235763X_6 - 0.002X_7 + 0.090X_8 + 0.027X_9 + 0.004X_{10} + 0.251X_{11} + 0.065X_{12} - 0.023X_{13} + 0.002X_{14} - 0.001X_{15} - 0.092X_{16} + 0.026X_{17} + 0.007X_{18} + 0.195X_{20}$
Y_{23}	=	$0.202X_1 + 0.030X_2 + 0.048X_3 + 0.040X_4 + 0.077X_5 + 0.068X_6 - 0.004X_7 - 0.018X_8 + 0.024X_9 + 0.063X_{10} - 0.005X_{11} + 0.019X_{12} - 0.032X_{13} + 0.008X_{14} - 0.082X_{15} + 0.165X_{16} + 0.194X_{17} - 0.021X_{18} + 0.021X_{19} + 0.1X_{21}$
Y_{24}	=	$0.207X_1 + 0.034X_2 + 0.090X_3 + 0.046X_4 + 0.088X_5 + 0.038X_6 - 0.003X_7 + 0.046X_8 - 0.039X_9 - 0.039X_{10} - 0.016X_{11} - 0.017X_{12} - 0.029X_{13} + 0.007X_{14} - 0.040X_{15} + 0.061X_{16} + 0.208X_{17} + 0.063X_{18} - 0.004X_{19} + 0.155X_{20} + 0.048X_{21}$
Y_{25}	=	$0.049X_1 + 0.031X_2 + 0.146X_3 - 0.027X_4 + 0.044X_5 + 0.207X_6 - 0.003X_7 + 0.078X_8 + 0.041X_9 - 0.012X_{10} + 0.258X_{11} + 0.098X_{12} - 0.008X_{13} + 0.001X_{14} + 0.004X_{15} - 0.067X_{16} + 0.014X_{17} + 0.008X_{18} + 0.032X_{19} + 0.155X_{20} - 0.061X_{22}$
Y_{26}	=	$0.077X_1 + 0.041X_2 + 0.246X_{20} + 0.057X_{21} + 0.011X_{22} + 0.118X_3 - 0.002X_4 + 0.039X_5 + 0.118X_6 - 0.004X_7 + 0.008X_8 + 0.038X_9 - 0.002X_{10} + 0.098X_{11} + 0.042X_{12} - 0.067X_{13} + 0.003X_{14} - 0.023X_{15} + 0.069X_{16} + 0.040X_{17} + 0.001X_{18} + 0.054X_{19} + 0.246X_{20} + 0.057X_{21} + 0.011X_{22}$
Y_{27}	=	$0.188X_1 + 0.029X_2 + 0.125X_3 + 0.022X_4 + 0.084X_5 + 0.096X_6 - 0.003X_7 + 0.074X_8 - 0.055X_9 - 0.087X_{10} + 0.232X_{11} + 0.076X_{12} - 0.110X_{13} + 0.007X_{14} + 0.026X_{15} - 0.001X_{16} + 0.175X_{17} + 0.097X_{18} - 0.016X_{19}$
Y_{28}	=	$0.308X_1 + 0.051X_2 + 0.178X_3 + 0.050X_4 + 0.140X_5 + 0.064X_6 - 0.005X_7 + 0.083X_8 - 0.060X_9 - 0.105X_{10} - 0.166X_{11} + 0.037X_{12} - 0.050X_{13} + 0.010X_{14} + 0.013X_{15} - 0.004X_{16} + 0.299X_{17} + 0.067X_{18} - 0.008X_{19}$
Y_{29}	=	$0.227X_1 + 0.202X_2 + 0.109X_3 - 0.045X_4 + 0.181X_5 + 0.221X_6 - 0.042X_7 - 0.001X_8 + 0.0527X_9 + 0.048X_{10} + 0.045X_{11} - 0.007X_{12} - 0.020X_{13} + 0.021X_{14}$
Y_{30}	=	$0.023X_1 + 0.128X_2 + 0.079X_3 - 0.070X_4 + 0.072X_5 + 0.246X_6 - 0.027X_7 - 0.004X_8 + 0.095X_9 + 0.079X_{10} + 0.310X_{11} + 0.040X_{12} - 0.018X_{13} + 0.009X_{14} - 0.010X_{15} - 0.009X_{16} - 0.145X_{17} - 0.026X_{18} + 0.034X_{19} + 0.148X_{20} + 0.017X_{21} - 0.026X_{22}$

Table A.4. Impact of TAOs on endogenous variables: relative size and share

Endogenous variables	Category IDs	Equation no.	Impacts of TAOs			Actual values		Absolute values	
			DCONIMOD Y_3	CONFAMPPP Y_4	CROPSHIFT Y_5	Row total	% of column total	Row total	% of column total
DCONVIMOD	TAO-1	Y_3			0.134	0.13	1	0.13	1
CONFAMPPP	TAO-2	Y_4			0.975	0.98	6	0.98	4
CROPSHIFT	TAO-3	Y_5	0.134	0.975		1.11	7	1.11	5
WATRINSTN	ITV- G1	Y_1	0.863	0.433	0.249	1.54	9	1.54	6
WATRINFRA		Y_2	0.266		0.036	0.30	2	0.30	1
WATRAVAIL	ITV-G2	Y_6	-0.035	0.427	0.438	0.83	5	0.90	4
WATRSUPLY		Y_7	-0.025	0.304	0.311	0.59	3	0.64	3
CULTIAREA	ITV-G3	Y_9	0.581	0.457	1.611	2.65	16	2.65	11
CROPATERN		Y_{11}	0.460	0.580	1.198	2.24	13	2.24	9
LANDPRODY	ITV-G4	Y_{12}	-0.138	-0.048	-0.161	-0.35	-2	0.35	1
WATRPRODY		Y_{13}	-0.196	0.007	-0.466	-0.65	-4	0.67	3
LABRPRODY		Y_{14}	-0.215	0.014	-0.392	-0.59	-3	0.62	3
FOODPRODN		Y_{15}	-0.066	0.075	-0.039	-0.03	0	0.18	1
FEEDSUPLY		Y_{17}	0.569	0.582	1.507	2.66	16	2.66	11
CULTICOST	ITV-G5	Y_{21}	0.239	0.232	0.648	1.12	7	1.12	5
CROPINCOM		Y_{22}	0.080	0.019	0.276	0.38	2	0.38	2
RURALWAGE	ITV-G6	Y_{23}	-0.048	0.082	-0.029	0.01	0	0.16	1
RURALJOBS		Y_{24}	-0.072	0.064	-0.096	-0.10	-1	0.23	1
AGPERFORM	ITV-G7	Y_8	-0.036	0.438	0.449	0.85	5	0.92	4
INDCPRODN		Y_{16}	-0.183	-0.039	-0.391	-0.61	-4	0.61	2
AGNFSECTR		Y_{18}	-0.221	-0.122	-0.559	-0.90	-5	0.90	4
LIVSPRODN		Y_{20}	0.354	0.362	0.939	1.66	10	1.66	7
FARMINCOM	IPG-1	Y_{25}	0.187	0.137	0.544	0.87	5	0.87	4
LABRINCOM	IPG-2	Y_{26}	0.180	0.228	0.523	0.93	5	0.93	4
FOODAVAIL	IPG-3	Y_{27}	-0.055	0.048	-0.026	-0.03	0	0.13	1
FOODPRICE	IPG-4	Y_{28}	-0.079	0.082	-0.043	-0.04	0	0.20	1
WATRSECUR	IPG-5	Y_{29}	-0.019	0.235	0.241	0.46	3	0.50	2
RURWELFAR	FPG	Y_{30}	0.172	0.239	0.593	1.00	6	1.00	4
Actual values	Column total		2.70	5.81	8.47	16.98			
	% of row total		22	25	52		100		
Absolute values	Column total		5.47	6.23	12.87			24.58	
	% of row total		22	25	52				100

Note: As per our Model, TAOs are assumed not to directly affect LANDSQLTY (Y_{10}) and AMKTPRICE (Y_{19}).

Table A.5. Down-stream effects of endogenous variables (effects of Y_is On Y_{i+1}s): actual size and share of impacts

Endogenous variables	Category IDs	Equation no.	Transformative adaptation options			Water institutions and infrastructure		Water availability and supply	
			DCONVIMOD	CONFAMPPP	CROPSHIFT	WATRINSTN	WATRINFRA	WATRAVAIL	WATRSUPLY
			TAO-1	TAO-2	TAO-3	ITV-G1		ITV-G2	
			Y3	Y4	Y5	Y1	Y2	Y6	Y7
DCONVIMOD	TAO-1	Y3				0.863	0.266		
CONFAMPPP	TAO-2	Y4				0.433			
CROPSHIFT	TAO-3	Y5	0.134	0.975		0.249	0.036		
WATRAVAIL	ITV-G2	Y6	-0.035	0.427	0.438	-0.180	0.481		
WATRSUPLY		Y7	-0.025	0.304	0.311	-0.043	0.579	0.711	
CULTIAREA	ITV-G3	Y9	0.581	0.457	1.611	0.233	0.155		
CROPATERN		Y11	0.460	0.580	1.198	0.302	0.122	0.000	
LANDPRODY	ITV-G4	Y12	-0.138	-0.048	-0.161	0.040	0.155	0.340	
WATRPRODY		Y13	-0.196	0.007	-0.466	0.182	0.055	0.191	
LABRPRODY		Y14	-0.215	0.014	-0.392	0.081	0.154	0.375	
FOODPRODN		Y15	-0.066	0.075	-0.039	0.110	0.115	0.235	
FEEDSUPLY		Y17	0.569	0.582	1.507	0.288	0.134	-0.030	
CULTICOST	ITV-G5	Y21	0.239	0.232	0.648	0.120	0.064	0.000	
CROPINCOM		Y22	0.080	0.019	0.276	0.019	0.052	0.054	
RURALWAGE	ITV-G6	Y23	-0.048	0.082	-0.029	0.058	0.106	0.211	
RURALJOBS		Y24	-0.072	0.064	-0.096	0.080	0.084	0.183	
AGPERFORM	ITV-G7	Y8	-0.036	0.438	0.449	-0.162	0.555	1.025	0.263
INDCPRODN		Y16	-0.183	-0.039	-0.391	0.095	0.073	0.215	
AGNFSECTR		Y18	-0.221	-0.122	-0.559	0.051	0.012	0.126	
LIVSPRODN		Y20	0.354	0.362	0.939	0.179	0.084	-0.019	
FARMINCOM	IPG-1	Y25	0.187	0.137	0.544	0.071	0.068	0.032	
LABRINCOM	IPG-2	Y26	0.180	0.228	0.523	0.092	0.091	0.076	
FOODAVAIL	IPG-3	Y27	-0.055	0.048	-0.026	0.059	0.092	0.190	
FOODPRICE	IPG-4	Y28	-0.079	0.082	-0.043	0.115	0.135	0.277	
WATRSECUR	IPG-5	Y29	-0.019	0.235	0.241	0.084	1.287	0.550	0.774
RURWELFAR	FPG	Y30	0.172	0.239	0.593	0.051	0.807	0.240	0.217
Actual values	Column total		1.57	5.38	7.08	3.47	5.76	4.98	1.03
	% of row total		2.7	9.4	12.4	6.1	10.1	8.7	1.8
Absolute values	Column total		4.34	5.80	11.48	4.24	5.76	5.08	1.70
	% of row total		5	6.7	13.3	4.9	6.7	5.9	1.2

Notes: (a) The four endogenous variables, i.e., water institution (Y_1), Water infrastructure (Y_2), land and soil quality (Y_{10}), and agricultural market price (Y_{19}) are modelled to depend only on exogenous variables. (b) The variable, i.e., AGPERFORM (Y_8), is modelled only as an endogenous variable.

Continued >>>

Table A.5. continued.

Endogenous variables	Category IDs	Equation no.	Area, land quality. and crop pattern, agricultural production, and productivity							
			ITV-G3			ITV-G4				
			CULTIAREA Y_{9}	LANDSQLTY Y_{10}	CROPATERN Y_{11}	LANDPRODY Y_{12}	WATRPRODY Y_{13}	LABRPRODY Y_{14}	FOODPRODN Y_{15}	FEEDSUPLY Y_{17}
DCONVIMOD	TAO-1	Y_{3}								
CONFAMPPP	TAO-2	Y_{4}								
CROPSHIFT	TAO-3	Y_{5}								
WATRAVAIL	ITV-G2	Y_{6}								
WATRSUPLY		Y_{7}								
CULTIAREA	ITV-G3	Y_{9}								
CROPATERN		Y_{11}	0.535	0.219						
LANDPRODY	ITV-G4	Y_{12}	-0.101	0.689	-0.450					
WATRPRODY		Y_{13}	-0.412	1.120	0.333	0.561				
LABRPRODY		Y_{14}	-0.355	0.876	0.035	1.102				
FOODPRODN		Y_{15}	-0.052	0.639	-0.183	0.692	0.220			
FEEDSUPLY		Y_{17}	0.794	0.053	0.693	-0.088	-0.056		-0.048	
CULTICOST	ITV-G5	Y_{21}	0.360	0.044	0.203					
CROPINCOM		Y_{22}	0.222	0.057	-0.314	0.159				
RURALWAGE	ITV-G6	Y_{23}	-0.127	0.420	0.166	0.620	-0.200	0.882	-0.259	0.136
RURALJOBS		Y_{24}	-0.109	0.486	-0.041	0.537	0.107	0.294	0.783	-0.027
AGPERFORM	ITV-G7	Y_{8}								
INDCPRODN		Y_{16}	-0.249	0.761	0.022	0.631	0.523			
AGNFSECTR		Y_{18}	-0.333	0.612	0.187	0.371	0.605		-0.843	
LIVSPRODN		Y_{20}	0.495	0.033	0.432	-0.055	-0.035		-0.030	0.623
FARMINCOM	IPG-1	Y_{25}	0.349	0.031	-0.118	0.093	-0.036		0.025	0.201
LABRINCOM	IPG-2	Y_{26}	0.222	0.082	0.233	0.223	-0.293	0.508	0.010	0.342
FOODAVAIL	IPG-3	Y_{27}	-0.032	0.419	-0.304	0.558	0.033		1.215	-0.105
FOODPRICE	IPG-4	Y_{28}	-0.056	0.704	-0.290	0.814	0.189		1.373	-0.051
WATRSECUR	IPG-5	Y_{29}								
RURWELFAR	FPG	Y_{30}	0.263	-0.346	0.158	-0.325	-0.218	0.154	-0.690	0.217
Actual values	Column total		1.41	6.90	0.76	5.89	0.84	1.84	1.54	1.34
	% of row total		2.5	12.1	1.3	10.3	1.5	3.2	2.7	2.3
Absolute values	Column total		5.07	7.59	4.16	6.83	2.52	1.84	5.28	1.70
	% of row total		5.9	8.8	4.8	7.9	2.9	2.1	6.1	2

Continued >>>

Table A.5. continued.

Endogenous variables	Category IDs	Equation no.	Agricultural price, cost, and income ITV-5			Rural jobs and wages ITV-6		Sector performance ITV-7		
			AMKTPRICE Y_{19}	CULTICOST Y_{21}	CROPINCOM Y_{22}	RURALWAGE Y_{23}	RURALJOBS Y_{24}	INDCPRODN Y_{16}	AGNFSECTR Y_{18}	LIVSPRODN Y_{20}
DCONVIMOD	TAO-1	Y_3								
CONFAMPPP	TAO-2	Y_4								
CROPSHIFT	TAO-3	Y_5								
WATRAVAIL	ITV-G2	Y_6								
WATRSUPLY		Y_7								
CULTIAREA	ITV-G3	Y_9								
CROPATERN		Y_{11}								
LANDPRODY	ITV-G4	Y_{12}								
WATRPRODY		Y_{13}								
LABRPRODY		Y_{14}								
FOODPRODN		Y_{15}								
FEEDSUPLY		Y_{17}						-0.087		
CULTICOST	ITV-G5	Y_{21}	0.656							
CROPINCOM		Y_{22}	0.021	0.051						
RURALWAGE	ITV-G6	Y_{23}	-0.004					-0.273	0.861	0.218
RURALJOBS		Y_{24}				0.482		-0.124	0.343	-0.043
AGPERFORM	ITV-G7	Y_8								
INDCPRODN		Y_{16}								
AGNFSECTR		Y_{18}	0.098					1.512		
LIVSPRODN		Y_{20}	0.552					-0.054		
FARMINCOM	IPG-1	Y_{25}	0.054	0.040	0.794			-0.079	-0.041	0.322
LABRINCOM	IPG-2	Y_{26}	-0.016			0.569	-0.050	-0.565	0.237	0.549
FOODAVAIL	IPG-3	Y_{27}	-0.008					-0.449		-0.168
FOODPRICE	IPG-4	Y_{28}						-0.217		-0.081
WATRSECUR	IPG-5	Y_{29}	0.281							
RURWELFAR	FPG	Y_{30}	0	0.019	0.376	0.172	-0.015	-0.127	0.052	0.349
Actual values	Column total		1.63	0.11	1.17	1.22	-0.07	-0.46	1.45	1.15
	% of row total		2.9	0.2	2	2.1	-0.1	-0.8	2.5	2
Absolute values	Column total		1.69	0.11	1.17	1.22	0.07	3.69	1.53	1.73
	% of row total		2	1.1	1.4	1.4	0.1	4	1.8	2

Continued >>>

Table A.5. continued.

Endogenous variables	Category IDs	Equation no.	Intermediate policy goals					Absolute value		Actual value	
			IPG-1 FARMIN COM Y_{25}	IPG-2 LABRIN COM Y_{26}	IPG-3 FOODA VAIL Y_{27}	IPG-4 FOOD PRICE Y_{28}	IPG-5 WATR SECUR Y_{29}	Row total	Column (%)	Row total	Column (%)
DCONVIMOD	TAO-1	Y_3						1.13	2	1.13	1.30
CONFAMPPP	TAO-2	Y_4						0.43	1	0.43	0.50
CROPSHIFT	TAO-3	Y_5						1.39	2	1.39	1.60
WATRAVAIL	ITV-G2	Y_6						1.13	2	1.56	1.80
WATRSUPLY		Y_7						1.84	3	1.97	2.27
CULTIAREA	ITV-G3	Y_9						3.04	5	3.04	3.49
CROPATERN		Y_{11}						3.42	6	3.42	3.93
LANDPRODY	ITV-G4	Y_{12}						0.33	1	2.12	2.44
WATRPRODY		Y_{13}						1.38	2	3.52	4.05
LABRPRODY		Y_{14}						1.68	3	3.60	4.14
FOODPRODN		Y_{15}						1.75	3	2.43	2.79
FEEDSUPLY		Y_{17}						4.31	7	4.93	5.67
CULTICOST	ITV-G5	Y_{21}						2.57	4	2.57	2.95
CROPINCOM		Y_{22}						0.70	1	1.32	1.52
RURALWAGE	ITV-G6	Y_{23}						2.82	5	4.70	5.41
RURALJOBS		Y_{24}						2.93	5	3.96	4.55
AGPERFORM	ITV-G7	Y_8						2.53	4	2.93	3.37
INDCPRODN		Y_{16}						1.46	3	3.18	3.66
AGNFSECTR		Y_{18}						1.50	3	5.65	6.50
LIVSPRODN		Y_{20}						3.86	7	4.25	4.89
FARMINCOM	IPG-1	Y_{25}						2.67	5	3.22	3.71
LABRINCOM	IPG-2	Y_{26}						3.24	6	5.09	5.86
FOODAVAIL	IPG-3	Y_{27}						1.47	3	3.76	4.33
FOODPRICE	IPG-4	Y_{28}			0.483			3.35	6	4.99	5.74
WATRSECUR	IPG-5	Y_{29}						3.21	6	3.47	3.99
RURWELFAR	FPG	Y_{30}	0.474	0.302	-0.182	-0.616	0.637	2.97	6	8.29	9.54
Actual values	Column total		0.47	0.30	0.30	-0.62	0.64	57.09			
	% of row total		0.8	0.5	0.5	-1.1	1.1		100		
Absolute Values	Column total		0.47	0.30	0.67	0.62	0.64			86.41	
	% of row total		0.5	0.3	0.8	0.7	0.7				100

Table A.6. Impact of climate change and governance variables on endogenous variables: relative size and share

Endogenous variables	Category IDs	Equation no.	Trigger	Structural institutions (MPG-1)			Agricultural institutions (MPG-2)				
			CLCIM PACT X_1	LAND TENUR X_3	USTI CNSTN X_4	LIVSIZ COM X_{19}	AGENIN STN X_5	AGCRIN STN X_{10}	CLIMIN SYST X_{14}	AGIN SUPLY X_{15}	ARESEX SYS X_{17}
DCONVIMOD	TAO-1	Y_3	0.190	0.395	0.344		0.052				
CONFAMPPP	TAO-2	Y_4	0.036	0.496	0.172		-0.044	0.204			
CROPSHIFT	TAO-3	Y_5	0.037	0.430	0.099		-0.036	0.199			
WATRINSTN	ITV-G1	Y_1	0.083	0.138	0.398						
WATRINFRA		Y_2	0.446				0.194				
WATRAVAIL	ITV-G2	Y_6	0.442	0.122	-0.072		0.074	0.087	0.038		
WATRSUPLY		Y_7	0.514	0.120	0.043		0.023	0.062	0.027		
CULTIAREA	ITV-G3	Y_9	0.088	0.388	-0.065		0.103	0.093			
LANDSQLTY		Y_{10}	0.261	0.143			0.181	-			0.445
CROPATERN		Y_{11}	0.137	0.247	0.036		0.088	0.118			0.097
LANDPRODY	ITV-G4	Y_{12}	0.323	0.125	0.029		0.143	-0.011	0.013	0.057	0.310
WATRPRODY		Y_{13}	0.371	0.061	0.136		0.172	0.001	0.007	0.147	0.440
LABRPRODY		Y_{14}	0.382	0.064	0.086		0.147	0.002	0.014	-0.111	0.393
FOODPRODN		Y_{15}	0.276	0.150	0.050		0.127	0.080	0.009	0	0.273
FEEDSUPLY		Y_{17}	0.090	0.314	-0.006		0.084	0.123	-0.001	0.005	0.025
AMKTPRICE	ITV-G5	Y_{19}									
CULTICOST		Y_{21}	0.050	0.148	-0.009		0.044	0.047		0.190	0.020
CROPINCOM		Y_{22}	0.051	0.103	-0.028		0.039	0.004	0.002	0.001	0.026
RURALWAGE	ITV-G6	Y_{23}	0.202	0.048	0.040	0.021	0.077	0.063	0.008	-0.082	0.194
RURALJOBS		Y_{24}	0.207	0.090	0.046	-0.004	0.088	-0.039	0.007	0.040	0.208
AGPERFORM	ITV-G7	Y8	0.680	0.037	-0.049		0.001	0.089	0.074	0.041	
INDCPRODN		Y_{16}	0.299	0.052	0.085		0.132	-0.008	0.008	-0.058	0.335
AGNFSECTR		Y_{18}	0.219	-0.049	0.086		0.093	0.108	0.005	-0.087	0.276
LIVSPRODN		Y_{20}	0.056	0.196	-0.004	0.098	0.052	-0.033	-0.001	0.003	0.015
FARMINCOM	IPG-1	Y_{25}	0.049	0.147	0.027	0.032	0.044	-0.012	0.001	0.004	0.014
LABRINCOM	IPG-2	Y_{26}	0.077	0.118	-0.002	0.054	0.039	-0.002	0.003	-0.023	0.040
FOODAVAIL	IPG-3	Y_{27}	0.188	0.125	0.022	0.016	0.084	-0.088	0.007	0.026	0.174
FOODPRICE	IPG-4	Y_{28}	0.308	0.178	0.050	-0.008	0.140	-0.105	0.011	0.013	0.299
WATRSECUR	IPG-5	Y_{29}	0.227	0.109	-0.045		0.181	0.048	0.021		
RURWELFAR	FPG	Y_{30}	0.023	0.079	-0.070	0.034	0.072	0.079	0.009	0.010	-0.145
Actual values	Column total		6.31	4.57	1.40	0.24	2.39	1.11	0.26	0.18	3.44
	% of row total		20.8	15.1	4.6	0.8	7.9	3.7	0.9	0.6	11.3
Absolute values	Column total		6.31	4.67	2.10	0.27	2.37	1.71	0.27	0.90	3.73
	% of row total		16	11.8	5.3	0.7	6.4	4.3	0.7	2.3	9.4

Continued >>>

Table A.6. continued

Endogenous variables	Category IDs	Equation no.	Market-related institutions (MPG-3)				Legal and policy aspects (MPG-4)					
			APMKT COOP X_8	AMKTRE GIM X_{11}	ATRDRE GIM X_{12}	AVAL CHAIN X_{16}	CLIMIN VEST X_2	STAX POLCY X_6	AFPR POLCY X_{18}	CREMIN SUR X_{20}	AGWA GELAW X_{21}	SNET POLCY X_{22}
DCONVIMOD	TAO-1	Y_3	0.042				0.309	0.060				
CONFAMPPP	TAO-2	Y_4					0.136	-				
CROPSHIFT	TAO-3	Y_5	0.006	0.186	-0.028		0.083	0.008				
WATRINSTN	ITV-G1	Y_1					0.315					
WATRINFRA		Y_2					0.141	0.224				
WATRAVAIL	ITV-G2	Y_6	-0.001	0.081	-0.012		0.011	0.108				
WATRSUPLY		Y_7	-0.001	0.058	-0.009		0.061	0.042				
CULTIAREA	ITV-G3	Y_9	0.024	0.300	-0.045	0.084	0.095	0.035				
LANDSQLTY		Y_{10}										
CROPATERN		Y_{11}	0.019	0.216	-0.034	0.045	0.112	0.027				
LANDPRODY	ITV-G4	Y_{12}	-0.006	-0.027	0.005	-0.008	0.029	0.029				
WATRPRODY		Y_{13}	-0.008	-0.089	0.013	-0.035	0.062	0.009				
LABRPRODY		Y_{14}	-0.009	-0.074	0.011	-0.030	0.041	0.028				
FOODPRODN		Y_{15}	0.060	-0.007	0.001	-0.004	0.047	0.022	0.080			
FEEDSUPLY		Y_{17}	0.021	0.276	-0.050	0.067	0.110	0.046	-0.004			
AMKTPRICE	ITV-G5	Y_{19}	0.138	0.301	0.110			0.357	0.011			
CULTICOST		Y_{21}	0.010	0.119	-0.018	0.030	0.047	0.193		0.123		
CROPINCOM		Y_{22}	0.090	0.251	0.064	0.092	0.012	0.236	0.007	0.195		
RURALWAGE	ITV-G6	Y_{23}	-0.018	-0.005	0.019	0.165	0.030	0.068	-0.021		0.100	
RURALJOBS		Y_{24}	0.046	-0.017	-0.017	0.061	0.034	0.038	0.063	0.155	0.048	
AGPERFORM	ITV-G7	Y_8	-0.069	0.084	-0.013		0.025	0.101				
INDCPRODN		Y_{16}	-0.008	-0.083	0.101	-0.025	0.037	-0.162				
AGNFSECTR		Y_{18}	-0.062	-0.120	0.152	0.169	0.016	-0.264	-0.067			
LIVSPRODN		Y_{20}	0.013	0.167	0.164	0.042	0.069	0.029	-0.002			
FARMINCOM	IPG-1	Y_{25}	0.078	0.258	0.098	-0.067	0.031	0.207	0.008	0.155		-0.061
LABRINCOM	IPG-2	Y_{26}	0.008	0.098	0.042	0.069	0.041	0.118	0.001	0.246	0.057	0.011
FOODAVAIL	IPG-3	Y_{27}	0.074	0.233	0.076	-0.001	0.029	0.096	0.097			
FOODPRICE	IPG-4	Y_{28}	0.083	0.166	0.037	-0.004	0.051	0.064	0.067			
WATRSECUR	IPG-5	Y_{29}	-0.001	0.045	-0.007		0.202	0.221				
RURWELFAR	FPG	Y_{30}	-0.004	0.310	0.040	-0.009	0.128	0.246	-0.026	0.148	0.017	-0.026
Actual values	Colum total		0.53	2.73	0.70	0.64	2.30	2.19	0.21	0.21	1.02	-0.08
	Column (%)		1.7	9	2.3	2.1	7.6	7.2	7.07	1	3	-0.3
Absolute values	Colum total		0.90	3.57	1.17	1.01	2.30	3.04	0.45	1.02	0.22	0.98
	Column (%)		2.3	9	2.9	2.5	5.8	7.7	1.1	2.6	0.6	0.32

Continued >>>

Table A.6. continued

Endogenous variables	Category IDs	Equation no.	Private sector players (MPG-5)			Actual values		Absolute values	
			DONINVSTR X_7	RSPROVIDER X_9	CORPSECTR X_{13}	Row Total	Column (%)	Row Total	Column (%)
DCONVIMOD	TAO-1	Y_3	-0.011	-0.362		1.02	3	1.76	4
CONFAMPPP	TAO-2	Y_4	-	-0.018		0.98	3	1.11	3
CROPSHIFT	TAO-3	Y_5	-0.002	0.141	-0.084	1.04	3	1.34	3
WATRINSTN	ITV-G1	Y1	-			0.93	3	0.93	2
WATRINFRA		Y_2	-0.043			0.96	3	1.05	3
WATRAVAIL	ITV-G2	Y_6	-0.021	0.096	-0.037	0.92	3	1.20	3
WATRSUPLY		Y_7	-0.008	0.068	-0.026	0.98	3	1.06	3
CULTIAREA	ITV-G3	Y_9	-0.007	0.115	-0.135	1.07	4	1.58	4
LANDSQLTY		Y_{10}				1.03	3	0.85	2
CROPATERN		Y_{11}	-0.005	0.071	-0.101	1.07	4	1.35	3
LANDPRODY	ITV-G4	Y_{12}	-0.006	0.017	0.014	1.04	3	1.15	3
WATRPRODY		Y_{13}	-0.002	-0.026	0.039	1.30	4	1.62	4
LABRPRODY		Y_{14}	-0.005	-0.005	0.033	0.97	3	1.44	4
FOODPRODN		Y_{15}	-0.004	-0.042	0.004	1.12	4	1.24	3
FEEDSUPLY		Y_{17}	-0.006	0.098	-0.143	1.05	3	1.47	4
AMKTPRICE	ITV-GS	Y_{19}				0.92	3	0.92	2
CULTICOST		Y_{21}	-0.003	0.043	-0.054	0.98	3	1.15	3
CROPINCOM		Y_{22}	-0.002	0.028	0.023	1.19	4	1.16	3
RURALWAGE	ITV-G6	Y_{23}	-0.004	0.024	-0.032	0.89	3	1.22	3
RURALJOBS		Y_{24}	-0.003	-0.039	-0.029	0.98	3	1.28	3
AGPERFORM	ITV-G7	YB	-0.019	0.098	-0.038	1.04	3	1.42	4
INDCPRODN		Y_{16}	-0.002	-0.015	0.222	0.91	3	1.63	4
AGNFSECTR		Y_{18}	0.000	0.014	0.312	0.80	3	2.10	5
LIVSPRODN		Y_{20}	-0.004	0.061	0.073	0.99	3	1.08	3
FARMINCOM	IPG-1	Y_{25}	-0.003	0.041	-0.008	1.04	3	1.34	3
LABRINCOM	IPG-2	Y_{26}	-0.004	0.038	-0.067	0.96	3	1.16	3
FOODAVAIL	IPG-3	Y_{27}	-0.003	-0.055	-0.110	0.99	3	1.50	4
FOODPRICE	IPG-4	Y_{28}	-0.005	-0.060	-0.050	1.23	4	1.70	4
WATRSECUR	IPG-5	Y_{29}	-0.042	0.053	-0.020	0.99	3	1.22	3
RURWELFAR	FPG	Y_{30}	-0.027	0.095	-0.018	0.97	3	1.61	4
Actual values	Column total		-0.24	0.48	-0.23	30.38			
	Column (%)		-0.8	1.6	-0.76		100		
Absolute values	Column total		0.24	1.72	1.67			39.64	
	Column (%)		1	4	4				100

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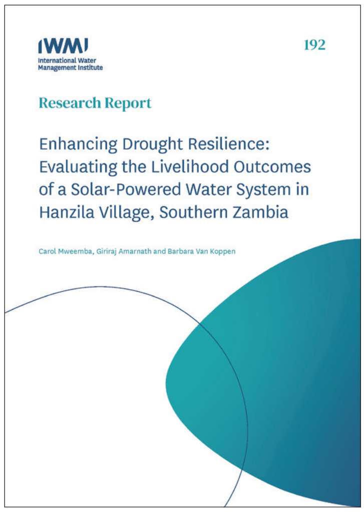

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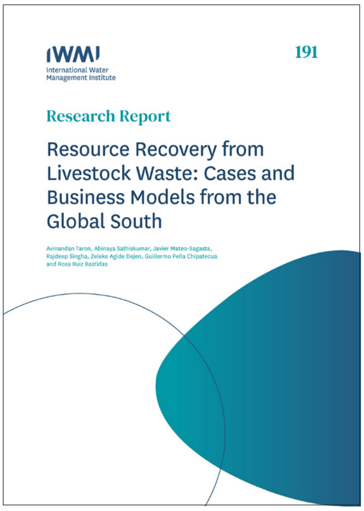

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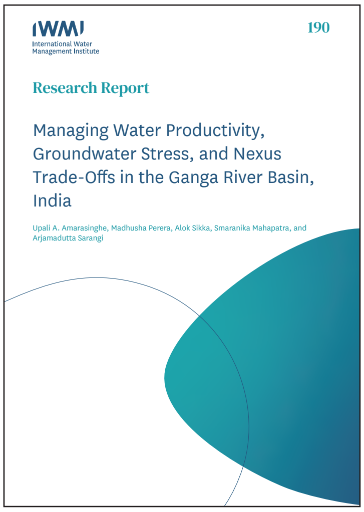

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