



 السويد  
Sverige

# CLIMATE RESILIENT AGRICULTURE: TRANSLATING DATA TO POLICY ACTIONS

Case Study of AquaCrop Simulation in Morocco



Shared Prosperity **Dignified Life**





Shared Prosperity **Dignified Life**



### **VISION**

ESCWA, an innovative catalyst for a stable, just and flourishing Arab region

### **MISSION**

Committed to the 2030 Agenda, ESCWA's passionate team produces innovative knowledge, fosters regional consensus and delivers transformational policy advice. Together, we work for a sustainable future for all.



**Economic and Social Commission for Western Asia**

# **CLIMATE RESILIENT AGRICULTURE: TRANSLATING DATA TO POLICY ACTIONS**

## **Case Study of AquaCrop Simulation in Morocco**



**UNITED NATIONS**  
Beirut

© 2019 United Nations  
All rights reserved worldwide

Photocopies and reproductions of excerpts are allowed with proper credits.

All queries on rights and licenses, including subsidiary rights, should be addressed to the United Nations Economic and Social Commission for Western Asia (ESCWA), e-mail: [publications-escwa@un.org](mailto:publications-escwa@un.org).

The findings, interpretations and conclusions expressed in this publication are those of the authors and do not necessarily reflect the views of the United Nations or its officials or Member States.

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Links contained in this publication are provided for the convenience of the reader and are correct at the time of issue. The United Nations takes no responsibility for the continued accuracy of that information or for the content of any external website.

References have, wherever possible, been verified.

Mention of commercial names and products does not imply the endorsement of the United Nations.

References to dollars (\$) are to United States dollars, unless otherwise stated.

Symbols of United Nations documents are composed of capital letters combined with figures. Mention of such a symbol indicates a reference to a United Nations document.

United Nations publication issued by ESCWA, United Nations House,

Riad El Solh Square, P.O. Box: 11-8575, Beirut, Lebanon.

Website: [www.unescwa.org](http://www.unescwa.org).

# Overview

Within the framework of an initiative supported by the Swedish International Development Cooperation Agency (Sida) on “Promoting food and water security through cooperation and capacity development in the Arab region”, ESCWA prepared reports on the impact of changing water availability due to climate change on agricultural production in selected Arab countries.

A technical country team<sup>1</sup> was established and trained by ESCWA, the Food and Agriculture Organization (FAO) and the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) to assess the impact of projected climate change, expressed in terms of water availability, temperature and carbon dioxide (CO<sub>2</sub>) changes, on selected crops and locations in Morocco. The assessment findings, derived from a national case study report<sup>2</sup>, are used as a baseline to recommend adaptation measures to key actors in promoting water and food security under changing climate.

The assessments used the AquaCrop simulation programme developed by FAO. The assessments were carried out on selected irrigated and rainfed crops to identify the impact of climate change on crop productivity. The programme used the climate-variable projections of the Regional Initiative for the Assessment of the Impact of Climate Change on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR)<sup>3</sup>, while soil, yield and crop data were acquired from national sources. The climate change projections correspond to representative concentration pathways (RCP), i.e., greenhouse gas concentration trajectories adopted by the Intergovernmental Panel on Climate Change, of two levels: RCP 4.5: generally describing a moderate-emissions scenario; and RCP 8.5: generally describing a high-emissions or ‘business-as-usual’ scenario. In a way, RCP 4.5 and RCP 8.5 correspond to a more ‘optimistic’ and more ‘pessimistic’ scenario, respectively. The time horizons for the two RCPs consider the periods 2020-2030 (represented by 2025) and 2040-2050 (represented by 2045). Furthermore, to analyse the effect of elevated CO<sub>2</sub> on crop yield loss, two sets of projected CO<sub>2</sub> concentration changes, for each of the RCP scenarios, were simulated: one which considered the effects of increasing CO<sub>2</sub> concentrations; and another which kept CO<sub>2</sub> concentrations at the baseline level.

The present case study provides a general background of the assessment, and the main findings of the AquaCrop simulation undertaken to identify a variety of country-specific recommendations on adaptation measures in the agricultural sector.





# Table of Contents

<b>Overview</b>	PG.03
1. Country Background	PG.06
2. Selected Crops and Areas for AquaCrop Simulation	PG.07
3. Assessment methodology	PG.09
4. Description of Assessment Findings	PG.10
5. Analysis of Assessment Findings	PG.13
6. Recommendations for enhancing the resilience of the Agriculture Sector	PG.15
<b>Endnotes</b>	PG.20

# 1. Country Background

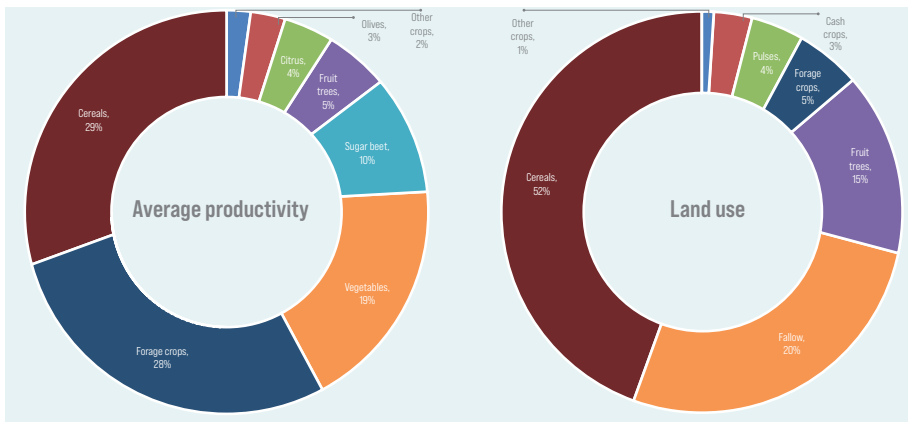
Morocco is characterized by an arid climate and 80% of the area has an average annual precipitation less than 250 mm. Two-thirds of the country's arable lands are in rainfed regions where agricultural production is considered adequate in terms of average productivity, while permanently irrigated lands currently cover around 1.5 million ha.

The Agriculture sector contribution to GDP is estimated at 14%, ranking third in importance after the service sector (57%) and industrial sector (29%). Despite relatively modest contribution to the national GDP, the agricul-

tural sector represents one of the main pillars of the country's economy. At the social level, agriculture contributes to the income of 80% of the inhabitants of the Moroccan countryside, estimated at around 18 million people, and provides a yearly average of 250,000 direct job opportunities.

Over the last decade, Morocco's efforts contributed to modernize and make resilient its agriculture within the "Morocco Green Plan" policy supported by consistent finance and a comprehensive climate policy where adaptation in agriculture has a prominent importance.

**Figure 1.** Land use and average productivity for most important crops in Morocco





## 2. Selected Crops and Areas for AquaCrop Simulations

The present study aims at shedding light on the impacts of climate change on water and crop productivity at the local level under different climate modeling scenarios.

Three major cropping systems were selected for the study:

- [1] Rainfed soft wheat, in **Marchouch region** in North western Morocco, and
- [2] Irrigated soft wheat in Zemamra area, **Doukkala region**
- [3] Irrigated sugar beet in Zemamra area, **Doukkala region**

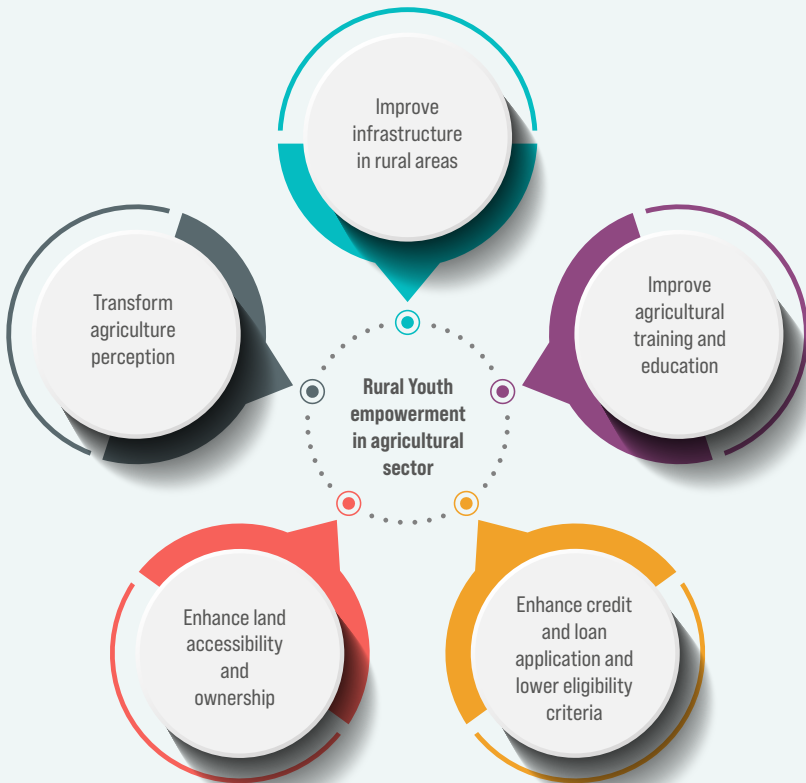
Soft wheat is the most widespread agricultural crop in all rainfed and irrigated areas of Morocco, with its cultivation covering an area of nearly 2 million ha in recent years. Sugar crops have benefited from the support mechanism put in place by the Morocco Green Plan, with their total area of cultivation increased in irrigated areas from 30,000 ha in 2011-2012 to 70,000 ha in 2015-2016 for sugar beet. Due to its growing population and sensitivity of agricultural production to high temporal variability of rainfall, Morocco has become a net importer of soft wheat. It is thus critical to identify the variability of crop yield in relationship to climate change and its impact on food security and economic growth of the country.

### Box 1. Rural Women and Youth empowerment

The Plan Maroc Vert strategy places agriculture as a cornerstone of economic growth in Morocco. The plan focuses on large and small agricultural holdings to create opportunities for rural women through value chains in the agri-food sector. Due to the increasing trend of men migration in pursuit of better living standards, women's role has increased whereby they represent around 23 to 35 % of the labor on family farms. Nonetheless women face many barriers to economic empowerment as gender inequality exists at level of access to land (Less than 5 % of landowners are women), credit and technology.

Policies need to be more gender-responsive to meet the needs of rural women such as recognizing their time and mobility constraints, and education level. Further, inheritance laws are to be revisited, and eligibility criteria for opening accounts and taking loans need to be lightened. In addition, women led initiatives should be encouraged especially in rural areas.

At the level of youth empowerment, there exists a wide segregation between rural and urban youth empowerment. Although active youth involvement in agricultural sector is a must to sustain agricultural systems, rural youth often face many challenges in terms of access to land credit and technical knowledge. For example, current financial support programs as the National Initiative for Human Development often dismiss rural youth issues.



Source: "ILO,2018. Young women's employment and empowerment in the rural economy, Morocco Country Brief"

### 3. Assessment methodology

The assessment aimed to evaluate the impacts of climate change on agriculture productivity using the AquaCrop simulation program (version 6) <sup>4</sup>, and the climate-variables projections of the RICCAR Initiative on Climate Change in the Arab Region, led by ESCWA, to assist in shaping evidence based agricultural strategies.

The steps involved in the use of AquaCrop were as follows:

- **Data collection** was required for climate, soil, and crop types. Climatic data, including precipitation and temperature, were collected from various daily data reports. Evapotranspiration file was created with the AquaCrop program by inputting each location's required specifications. Technical papers produced by researchers in Morocco were used as source of crop data. Further, soil data was obtained from field measurements and laboratory analyses of soil samples from the areas under study.
- **Calibration of AquaCrop** to simulate the productivity of the three selected cropping systems using data of wheat fields of five seasons (2012- 2017) in Marchouch, and of wheat and sugarbeet fields of 13 seasons (2000-2013) in Zemamra. Data included

soil characteristics, groundwater depth, irrigation scheduling, main farm management practices, climate data and crop yield. The objective of such calibration was to provide the model with actual parameters that can simulate the actual productivity of wheat and sugarbeet within an acceptable accuracy range.

- **Simulation** of the impacts of climate change on wheat and sugar beet productivity using the projections of the RICCAR project models (EC-Earth, CNRM-CM5, and GFDL-ESM2M) for two time periods: the 2020 -2030 period represented by 2025 and the 2040-2050 period represented by 2045, and for two scenarios RCP 4.5 and RCP 8.5. The reference period is the 1985-2005. Moreover, two sets of projected changes were implemented: one which considered the effects of both atmospheric CO<sub>2</sub> concentrations and associated climatic changes (temperature and water); and one which considered temperature and water changes only and no change in atmospheric CO<sub>2</sub> concentrations (i.e., keeping CO<sub>2</sub> concentrations at the reference level). This allowed to disaggregate the mitigating effect of elevated CO<sub>2</sub> on yield losses derived by adverse impacts of temperature rise and water scarcity, and accounting for related uncertainties.

## 4. Description of Assessment Findings

Overall results show that for the two sites the increase in atmospheric CO<sub>2</sub> concentration helps to increase crop yield, as it enhances the photosynthetic rate of plants while reducing transpiration. This, in turn, leads to better transpiration efficiency and to ultimately increase potential production. Nevertheless, the actual quantification of the 'increase' (biomass and yield) remain largely uncertain and may carry risks of over-estimation. The apparent marked rise in projected yield in the case of rising CO<sub>2</sub> concentration should be considered carefully as other non-linear limiting factors may counteract this positive effect.

Other impacts of climate change as shown in assessment of the two selected areas (table 1) indicate a rise in water requirement for irrigated crops by 7-12 % due to reduced soil moisture, a shortening of the growth cycle

of rainfed crops by 5-12 days due to higher temperature.

### • MARCHOUH SITE FINDINGS

The results of the calibration in Marchouch showed that the observed field and the simulated productivity of rainfed soft wheat differ by approximately 17% (0.26 ton/ha) with a coefficient of determination of 0.59.

### Climate variability projections

The expected climate variables projections for RCP 4.5 indicate a decrease in the average seasonal precipitation by 32.5 mm and 31.5 mm for the 2025 and 2045 periods, respectively. For RCP 8.5, the projected rainfall reduction is more severe than those predicted by RCP

**Table 1.** Change in crop yield and water productivity (%) for both areas, scenarios, and periods

Period	2020-2030	2040-2050	2020-2030	2040-2050
Change in crop yield (%)	RCP 8.5		RCP 4.5	
Rainfed wheat, Marchouch	-9.00%	-26.00%	-23%	-18%
Irrigated soft wheat, Zamamra	-1.04%	-6.73%	2%	2.57%
Irrigated sugar beet, Zamamra	-0.13%	-4.40%	0.58%	-0.86%
Change in water productivity (%)	RCP 8.5		RCP 4.5	
Rainfed wheat, Marchouch	-2.40%	-20.48%	-21.87%	-12.50%
Irrigated soft wheat, Zamamra	1.19%	-2.39%	3.01%	6.02%
Irrigated sugar beet, Zamamra	1.77%	-1.42%	3.21%	2.85%

4.5 as seasonal precipitation is expected to decrease by 50.1 mm and 69.6 mm for the 2025 and 2045 periods, respectively.

Temperature is expected to increase by 0.4 to 1.2 °C under RCP 4.5 and by 0.4 to 1.5 °C under RCP 8.5 for the 2025 and 2045 periods, respectively.

## Crop productivity projections

At fixed CO<sub>2</sub> concentration, the productivity of rainfed soft wheat, for RCP 4.5 scenario, is expected to decrease significantly by 23 and 18 % in the 2025 and 2045 periods, respectively, with a yield of 4.01 ton per ha for the reference period. In case of fixed CO<sub>2</sub> concentration, under both scenarios RCP 4.5 and RCP 8.5, the climate models used show an acute change in climatic parameters. Further impacts of the model in comparison to the reference period (1985-2005) are addressed in box 2.

The corresponding decrease in water productivity is expected to be 1.25 and 1.4 kg/m<sup>3</sup>, for the 2025 and 2045 periods, respectively [reference period 1.66 Kg/m<sup>3</sup>]. Similarly, for RCP 8.5 scenario, the decrease in crop yield is expected to be around 9 and 26 % for the 2025 and 2045 periods, respectively. The water productivity is expected to decrease to 1.62 and 1.32 kg/m<sup>3</sup> for the two periods, respectively [reference period 1.66 Kg/m<sup>3</sup>].

### • ZEMAMRA SITE FINDINGS

For the irrigated areas in Zemamra, data from only the last three years of the dataset available were used (2010-2013) as they were more complete and of better quality. Hence, a more robust calibration was derived and the difference between observed and simulated yield was almost null with a correlation factor of 0.999% for soft wheat and 0.74 % for sugar beet. These findings are consistent with those

## Box 2. Main Findings of AquaCrop Simulation in Marchouch

### • Under the RCP 4.5 scenario:

Seasonal precipitation (October-March) drops by 32.5 mm for the 2025 period and by 31.5 mm for the 2045 period, as compared with the reference period.

The productivity for rainfed soft wheat decreases significantly by 23% and 18% in the 2025 and 2045 periods, respectively, when compared to the reference period

Crop water productivity decreases from 1.6 kg/m<sup>3</sup> to 1.25 and 1.4 kg/m<sup>3</sup> for the 2025 and 2045 periods, respectively

### • Under the RCP 8.5 scenario:

Seasonal precipitation drops by 50.1 mm for the 2025 period and by 69.6 mm for the 2045 period, as compared with the reference period.

The productivity for rainfed soft wheat will decrease by 9% and 26 % for the 2025 and 2045 period, respectively, when compared to reference period.

Crop water productivity will decrease from 1.66 kg/m<sup>3</sup> [reference period] to 1.63 and 1.32 kg/m<sup>3</sup> for 2025 and 2045 period, respectively.

established by the national vulnerability map of the agricultural sector in Morocco.

### Climate variability projections

The expected climate-variables projections for RCP 4.5 scenario indicate a decrease in precipitation by 37 mm/year at the end of the 2045 period while temperature is projected to increase by 1-1.5 °C. For RCP 8.5 scenario, a much sharper decrease in seasonal precipitation is projected (53 mm/year), while temperature is projected to increase by 1.1-1.9 °C.

### Crop productivity projections

At fixed CO<sub>2</sub> concentration, yield and crop water productivity of irrigated wheat and of irrigated sugar beet are projected to remain nearly stable for the 2025 and 2045 periods, under both scenarios RCP 4.5 and RCP 8.5. Further impacts of the model are addressed in box 3 in comparison to reference period (1985-2005).

In the case of changing CO<sub>2</sub> concentration, a marked rise in yield and crop water productivity is projected for both crops. However, due to the high uncertainty of these results, these data are not considered in this study.

#### Box 3. Main Findings of AquaCrop Simulation in Zemamra

- **Under the RCP 4.5 scenario:**

Precipitation is expected to decrease by 37 mm/year at the end of the 2045 period.

- **Under the RCP 8.5 scenario**

Precipitation is expected to decrease by 53 mm/year. Average seasonal rainfall for wheat and sugarbeet may be reduced by more than quarter of its initial value by the 2045 period.

- **For both scenarios (RCP 4.5 and 8.5)**

Yield and crop water productivity for irrigated wheat and sugar beet are projected to remain nearly stable in the two future periods, under both scenarios RCP 4.5 and RCP 4.8 in the case of stable CO<sub>2</sub> concentration.

In the case of changing CO<sub>2</sub> concentration, an increasing trend is projected.



## 5. Analysis of Assessment Findings

Agricultural production in Morocco faces a greater risk of extreme volatility as a result of variable and decreasing rainfall caused by climate change. As two thirds of the country's arable land is rainfed, food security and economic growth are highly dependent on the annual rainfall variability. AquaCrop simulations have shown that the productivity of rainfed crops were the most vulnerable to climate change. Adaptation actions are imperative to alleviate the impacts of climate change on crop productivity especially rainfed crops.

For example, adopting and scaling up conservation-agriculture practices is essential in these areas, to modify seeding dates to account for shifting periods of rainfall, and to develop the use of new crop varieties that could easily adapt to expected climate changes.

With decreasing rainfall on the long-term and increasing variability of precipitations, farmers dependent on rainfed agriculture are at a very high risk of poverty. Employment in the agricultural sector in Morocco reaches 40% of its population where studies have shown that farmers dependent on rainfed agriculture receive limited income and support<sup>5</sup>.

This situation threatens the resilience of farmers that are tempted to change jobs and move to cities. It becomes thus important to ensure availability of social safety nets for the most vulnerable farmers and that various economic development venues are promoted especially in the rural areas where farmers rely on rainfed agriculture.

Although the effects of climate change are less pronounced for irrigated agriculture, adaptation measures in rainfed agriculture should be extended to buffer the impact of climate change on crop production in Morocco. Irrigation in Morocco depends significantly on water storage in dams. Since the early 1950s Morocco has implemented an irrigation policy based on largescale irrigation schemes and building of dams.

Promoting investments in irrigated areas for modernization of irrigation systems to increase land and water productivity should come hand in hand with establishing proper water accounting systems to monitor water

**Figure 2. Simulated length of Growing Period (LGP) for rainfed wheat in Marchouch area for three periods (a) reference period b) 2025 period, and c) 2045 period)**



resources availability and control water allocations to the irrigation sectors within sustainable limits of water consumption.

The adoption of the Green Morocco Plan in 2008 (and its second phase Green Generation 2030, launched in February 2020) aimed at improving productivity and food security relies on intensive investments in agriculture. The plan relies on increasing water use efficiency through minimizing canal losses, identifying proper timing and quantity of irrigation and minimizing evaporation losses.

Therefore, encouraging move towards irrigated agriculture promises a more stable income for farmers and reduce risks of output

volatility within sustainable limits of water consumption. This approach however should also come accompanied with sufficient programs to build capacity of farmers on issues related to water productivity and complexities and engaging them in innovative learning processes to achieve higher crop productivity and farm profitability.

Other crops and regions in Morocco require further analysis and simulation using AquaCrop to better identify the impacts of climate change on crop productivity. For this, data collection and availability are critical to enhance and expand the application of AquaCrop model.

#### Box 4. Economic Impact of Climate Change on Agriculture sector

Extreme agricultural output instability as a result of variable rainfall is a cause of concern as it jeopardizes the income of the most vulnerable farmers relying on rainfed agriculture and puts the country at a greater risk of macroeconomic volatility as the agricultural sector still constitutes a noteworthy portion of the country's GDP (14%). Cycles of booms and bust put the country's most vulnerable people at risk of losing their incomes, as they are generally the ones to suffer the most of consequences of a slowdown in economic activity.

Irrigated agriculture contributes between 35% and 70% of the total agricultural production in Morocco depending on rainfall, leaving a lot of uncertainty for the incomes of farmers depending on rainfed agriculture. General wheat production is very much dependent on rainfall as a large part of harvested areas are rainfed.

Simulation of the economic impact provides an indication of the magnitude of loss due to climate change and thus an estimate of the cost of no-action. Simulations done on the rainfed wheat in the area of Marchouch show a large decrease in its yield, reaching more than a quarter of the production by the period of 2040-2050 in the most pessimistic scenario RCP 8.5. This could mean losses of around 3.1 million US dollars for the area of Marchouch alone considering the most recent producer price for wheat in 2018. This effect is however mitigated in the case of irrigated agriculture, whereby decrease in yield of irrigated wheat and sugarbeet are relatively small and could be compensated for by projected increasing CO<sub>2</sub> concentration levels leading to considerable increase in the yield of both wheat and sugar beet.

Policy priorities should move towards decreasing the variability of agricultural production and securing a stable income for farmers, especially those relying on rainfed agriculture.

# 6. Recommendations for enhancing the resilience of the Agriculture Sector

The Moroccan agricultural sector faces many challenges; most of the agriculture areas are dependent on rainfall, however rainfall levels

are below 400mm over 93% of its area. Water scarcity already impacts many of its activities where volume of renewable water does not

Figure 1. Key Recommendations



exceed 844 m<sup>3</sup>/capita/yr with future projection will amount to 750 m<sup>3</sup>/capita/yr in 2025.

Further, climate change scenarios predict a decrease in precipitation and rise in temperatures. With Morocco predicted to be one of the countries most affected by climate change, the results of the present study have confirmed the expected higher temperatures, increased aridity, and reduced periods of rainfall. Accordingly, the AquaCrop model expected a decrease in productivity of rainfed crops.

Much work is required to improve resilience of the agriculture sector in Morocco, including data collection and sharing to expand the application of AquaCrop to other crops in the region and to different parts of Morocco,

providing experts and policymakers alike with a country wide assessment of impact of climate change on key and vital crops. It is also recommended to promote the use of new breed of drought resistant crops with shorter growing seasons and improve efficiency of conservation agricultural practices. While it is recommended to move towards irrigated agriculture, it is critical to establish water accounting systems and control water allocations to irrigation sector.

Table 2 lists the recommended actions for each key recommendation generated by this study in Morocco. Recommendations were identified based on the multiple dimensions they are connected to, including institutional, policy and financial arrangements, knowledge generation, and capacity development.

**Table 2. Key recommendations and actions**

## 1. Use of new crop varieties and modify seeding dates

### Institutional and Financial arrangements:

- Invest in innovative approaches and technologies use new crop varieties and/or modify seeding dates to maintain or increase crop yields under climate change conditions

### Technical Arrangements

- Adopt indigenous crop varieties that have better adaptability to local sever conditions and that are highlighted in Morocco's "Green" strategic plan for agriculture.

### Knowledge Generation:

- Encourage coordination and collaboration between universities, research institutes (National institute for Agronomic Research-INRA) and governmental agencies
- Provide the necessary financial resources for research institutes to perform related studies. Through programs for adaptation in the agricultural sector under the Climate finance instruments Green Climate Fund (GCF) led by Agency for Agricultural Development (ADA) in Morocco.

### Technical Arrangements

- Test crops with a shorter growing season, that adapt better to climate changes, as well as drought-resistant crops characterized by high productivity and shorter growing seasons
- Test the modification of seeding dates and crop sequence to account for shifting periods of rainfall

## 2. Adopt and scale up conservation-agriculture practices in rainfed agriculture

### Policy and Financial arrangements:

- Develop comprehensive policies encouraging conservation practices by providing incentives to farmers applying conservation agriculture practices/technologies
- Provide social safety nets (equitable micro-insurance schemes, subsidies to access renewable energy equipment) for the most vulnerable farmers especially farmers relying on rainfed agriculture
- Increase investment in water harvesting techniques for supplementary irrigation
- Enhance access to markets and finance for most vulnerable farmers
- Encourage economic development in areas where farmers rely on rainfed agriculture, so as to diversify the livelihood bases of the farmers by promoting off-farms activities.

### Knowledge Generation:

- Undertake research to compare yields, soil properties development and plant growth phases, under the conditions of conservation agriculture and those of traditional agriculture and publish results

### Capacity development:

- Build capacity of farmers on conservation agriculture practices as conservation is profitable, but farmers are unaware of the technology and its profitability, nor do they have necessary skills to implement it.
- Enhance information flow in both directions taking into consideration farmers' local initiatives and experiences to improve local ownership of management strategies

## 3. Modernizing irrigated agriculture

### Institutional and Financial Arrangements:

- Establish proper water accounting systems to monitor water resources availability and control water allocations to the irrigation sector within sustainable limits of water consumption (prevent salinization of irrigated soil and over abstraction of groundwater) by building on the new National Water Plan 2020-2035 launched in 2019 that improves sustainable groundwater management
- Enhance collaboration between different programs established to improve yields through efficient water use such as the National Program for Saving Water in Irrigation (PNEEI)
- Promote investments in irrigated areas for modernization of irrigation systems (e.g., localized irrigation technologies) to increase land and water productivity
- Implement sustainable energy solutions including renewable energy and solar desalination of brackish water and using energy efficient pumping equipment and networks

### Technical Arrangements

- Enhance irrigation scheduling and deficit irrigation
- Expand the use of modern agricultural technologies (conservation agriculture in rainfed areas and drip irrigation in irrigated areas as per “Green Generation 2020-2030 plan)
- Identify irrigated crops to be used in each region

### Capacity development:

- Build the capacities of the extension workers to be able to better advise farmers and cooperatives.
- Capacity building programs for farmer on water productivity and complexities especially regarding the different sources that may be used to satisfy the crop demand (surface, groundwater, and rainfall)

## 4. Improve data collection, monitoring and accessibility

### Institutional arrangements:

- Establish institutional coordination mechanisms to improve data collection and sharing between agencies of reliable agricultural and climatic data and linking it to regional and international data base research centers

### Technical Arrangements

- Improve agricultural and climatic monitoring and dissemination of this information to allow wider use
- Establish a database that provides reliable data required for calibrating and simulating AquaCrop model and allows for easy download and display of readily available data

### Knowledge generation:

- Produce interactive map using geographic information systems that represent the impacts of climate change on agriculture areas to display and download data as a tool to support and formulate future national and subnational agricultural and food policies and strategies
- Update the climate change data projection through cooperation between national, regional and international research and statistical institutions.

## 5. Promote further research and assessments

### Institutional arrangements:

- Identification of a national team that could follow up on the implementation and execution of established plans and collaborations such as the project for the Integration of Climate Change in the Plan Maroc Vert (PICCPMV)
- Promote partnership between research institutes and universities to perform studies on other crops and regions and agricultural environments using the AquaCrop and RICCAR climate datasets
- Establish a national network and join a Regional Network of AquaCrop practitioners and collaborate with the Near East and North Africa (NENA) Regional and Global Network of AquaCrop practitioners, established and managed by FAO
- Build on already established plans and collaborations such as the project for the Integration of Climate Change in the Plan Maroc Vert (PICCPMV)
- Identify focal point/coordinator to follow up on the implementation of assessment program for different crop types and different regions in the country



### Knowledge generation:

- Perform AquaCrop simulations and analyses on areas where rainfed agriculture/ irrigated crops are widespread, with their various geographical features, climates and soil types
- Assess optimization of water use in irrigation for the main crops in irrigated areas using Aquacrop model and analyze various irrigation methods and systems using Aquacrop model
- Encourage publication of research using AquaCrop model to provide more evidence-based adaptation measures for the agricultural sector under climate change conditions

### Technical Arrangements

- Establish a unified database between institutions (Agriculture – Water- Meteo – Statistics authority) to provide reliable data
- Apply model on different areas across the whole country that would be representative of the various agricultural environments and methods (irrigation, soil, climate) of all irrigated regions and of all major agricultural crops (vegetables, industrial oil and sugar crops, animal feed crops, cereals and legumes)
- Test various crops such as agricultural crops included in the Green Morocco Plan and those that are widespread in the region particularly lentils and chickpeas by applying the AquaCrop model

### Capacity development:

- Training of trainers on the application of AquaCrop and RICCAR Data sets through GIS for crop and water productivity assessments
- Training sessions and workshops at different institutions and universities that facilitate the use of AquaCrop and mainstream the Aquacrop simulation tool and methodology
- Develop training programs on the use of simulation tools (water deficit irrigation) linked to AquaCrop
- Disseminate the training material and methodology developed in the project to encourage further research and applications

# Endnotes

---

1. The country team comprised four experts from the Ministry of Agriculture; Fisheries, Rural Development, Water and Forests, and the National Institute for Agricultural Research
2. ESCWA. Assessing the impacts of changing water availability on agricultural production in Morocco. 2019, Available at <https://www.unescwa.org/sites/www.unescwa.org/files/uploads/national-assessment-report-morocco-arabic.pdf>
3. ESCWA, RICCAR Arab Climate Change Assessment Report, 2017. Available at [www.unescwa.org/publications/riccar-arab-climate-change-assessment-report](http://www.unescwa.org/publications/riccar-arab-climate-change-assessment-report)
4. Developed by FAO.
5. Sraïri, Mohamed Taher & Ghabiyel, Youssra. (2017). Coping with the work constraints in crop-livestock farming systems. *Annals of Agricultural Science*.



20-00577

