The development-climate change nexus in Morocco through a cross-sectoral lens



Pilot domains

Agriculture-Biodiversity-Forests

Urbanization-Migration-Tourism

Water-Energy-Food

Deliverable 2 of Policy Supporting Research (PSR):

"How to better integrate the environmental dimension in the Belgian development cooperation in Morocco - Nexus development/climate"

February 2022

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Preface

The adoption of the Sustainable Development Goals (SDGs) and the Paris Agreement on Climate Change converged to consolidate an international consensus on the need for integrated development, environment and climate change agendas. Such an approach aims at addressing the embedded interlinkages and manage potential trade-offs that could result in unsustainable development trajectories and/or maladaptation. This is a complex governance mission that demands adopting an integrated and cross-sectoral approach in order to identify development efforts that are integrated and mutually supportive with climate change related strategies and actions (i.e., climate-smart development efforts), but also to anticipate and plan for climate change impacts on diverse development efforts (i.e., climate-proof development efforts).

Morocco clearly illustrates the imperative of conciliating development programmes and actions with the environment and climate change ones. According to the country's 'Projet de Stratégie Nationale de Développement Durable 2030', Morocco faces interconnected socio-environmental challenges, social vulnerabilities and rising inequalities in a context of acute climatic variability and change. The Belgian Development Cooperation has embarked on the challenge to work together with Moroccan actors towards addressing intertwining socio-environmental issues and giving a renewed relevance to its agendas in the country.

In this context, ADAPTtoDEVELOP, acronym for this PSR project, selected and analysed clusters of socio-economic sectors of high relevance to the development-climate change nexus in Morocco, here called as 'pilot domains'. The selected pilot domains are agriculture-forests-biodiversity, urbanization-migration-tourism and water-energy-food. The data collection for the analysis of the pilot domains was done mainly through literature review and exploratory in-depth semi-structured interviews (three interviews per pilot domain – see Deliverable 3). This cross-sectoral view in the development-climate change nexus in Morocco, together with the rest of the ADAPTtoDEVELOP analysis, will help the Belgian Development Cooperation to define strategic and operational steps to dive into Morocco's development challenges considering in a substantial way environmental and climate change aspects.

This document presents the analysis of the pilot domains in Morocco as a complex account of the sum of the collected data (desktop-research and interviews). Each pilot domain is analysed following the same structure, according to climate risk factors of exposure and vulnerability (including adaptive capacity) and offering a non-exhaustive discussion of key socio-economic and ecological adaptation needs and challenges in view of the development-climate change nexus, as well as selected entry points for building such an approach. Each analysis concludes with illustrative examples/case studies.

Colophon

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Acknowledgement

We thank our interviewees for sharing their expertise, their time, kindness and enthusiasm.

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Deliverable 2. The ADAPTtoDEVELOP 'pilot domains' in Morocco

Deliverable 3. Co-production of roadmaps on the development-climate change nexus in Morocco: Methods, results and lessons learned from ADAPTtoDEVELOP (methodology and workshops' results)

Deliverable 4. Development-climate change nexus in Morocco: Recommendations for the Belgian Development Cooperation

Deliverable 5. Synthesis Report ADAPTtoDEVELOP

Deliverable 6. ADAPTtoDEVELOP conclusions and recommendations (Outreach document)

All documents and project updates can be found in our ADAPTtoDEVELOP website here.

1. Agriculture-Biodiversity-Forests

Natural resources are key in the context of sustainable development and adaptation. This is particularly true for Morocco. Agriculture is a critical sector for national income generation, employment, and food security. In particular, the livelihoods of many populations – especially more marginalized groups – depend critically on agriculture, forests, and other local resources. Morocco has a markedly rich bio-cultural heritage with many endemic species and historically grown, culturally embedded resource knowledge and governance systems. This heritage holds high potential for supporting adaptation through an integration of sustainable agriculture, forestry, and nature-based livelihoods. However, due to a confluence of socio-economic and institutional factors, exacerbated by climate change, Morocco is losing its natural resources at a fast rate. High population growth, a growing but presently unsustainable agricultural, industrial, and tourism sector, high multi-dimensional poverty rates, inequality in access to resources, and what is often referred to as a 'rural exodus', create untenable demands on land and water and disrupt livelihoods and resource governance systems. The country has made important advances to tackle these issues, but remaining challenges are participatory decision-making, a political economy of land and water that pushes to maintain business as usual, and insufficient institutional capacities for effective local implementation and enforcement of policies and regulations. As such, the country faces a critical risk of falling into a "nexus syndrome" of degraded ecosystems, insecure jobs and livelihoods, and vulnerability to climate change. A way forward lies in integrated adaptation approaches that (i) meaningfully address trade-offs between agriculture, conservation, and biodiversity protection, and (ii) capitalize on the opportunities of *virtuous* cycles of sustainable agriculture, ecosystem restoration, secure livelihoods, and resilience to climate change.

This section offers a non-exhaustive discussion of key socio-economic and ecological adaptation needs and challenges in view of the development-climate change nexus, as well as selected entry points for building a more integrated approach for transformative adaptation in agriculture, forestry, and biodiversity protection.

1.1 The pilot domain in the context of socio-ecological change

1.1.1 Climate change and other drivers of change

Morocco is characterized by a high population growth, as well as high unemployment rates and a low human development index (HDI) compared to neighbouring countries. In combination with (i) high dependence of rural populations on natural resources for consumption and income generation; (ii) high (international) market premiums for natural resources; (iii) water-intensive agriculture and tourism models; the country faces high and growing demand for and competition over natural resources – importantly water, land, and marketable resources such as wood or oil seeds (cf. Box 1) (Schilling et al., 2012; The World Bank Group, 2021; Interviews). Competition over these resources arises between economic sectors (agriculture, industry, tourism, household consumption) and between different groups of users, resulting in higher rent-seeking behavior and politicization of access to such resources. The growing competition over and politicization of water, especially in urban areas, is for instance exemplified by the recent waves of 'thirst protests' over water security (Desmidt, 2021; François et al., 2016; Interviews). As a result, Morocco is experiencing high rates of ecosystem and biodiversity degradation. This pressure is exacerbated by insufficient control of (agri-)industrial pollution and poor waste management, and climate change. Higher average temperatures and less rainfall; more extreme events such as droughts, wildfires, storms, and floodings; acidification and warming of seas; and sea level rise further exacerbate existing issues of soil erosion, salinization of fresh water and soils, desertification, surface and

groundwater depletion, habitat fragmentation, and biodiversity loss (EO4SD, 2019; FAO, 2021; The World Bank Group, 2021).

1.1.2 Exposure

Water stress has always been high in the country, and agriculture continues to depend heavily on rainfall (about 85 %). Irrigated agriculture, applied to only about 15-20% of farmland, consumes 90 % of available water. This is partly explained by the country's agricultural policy, which continues to favour water-intensive export products (EO4SD, 2019; François et al., 2016; The World Bank Group, 2021). In addition to these general factors, specific populations and ecosystems are particularly exposed:

- Livelihoods based on agriculture and other natural resources – in particular those dependent on water-intensive crops or vulnerable species – are more highly exposed to increasing degradation of and competition over natural resources (François et al., 2016; Van Praag et al., 2021).
- In desertified or desertifying areas, populations and ecosystems are particularly exposed to additional loss of water resources and land degradation, as productive land and water are already very scarce and there is little margin for further deterioration. Nomadic herders for instance have increasing difficulties to find pasture land for their animals due to degradation and desertification (Dahan et al., 2012; Mokhtar et al., 2019).
- Forests are particularly exposed to climate-driven degradation (e.g., erosion), and to overexploitation due to high livelihood dependence (e.g. fuel, cooking), overgrazing, and clearings for agriculture and infrastructure (cf. Box 2) (The World Bank Group, 2021).
- Morocco's coastal wetlands are exposed to climate change due to their location, structure, and functioning (OffYourMap, 2018).
- Livelihoods of rural women tend to be more exposed to the impact of climate change and resource degradation. Women more often stay behind when husbands or children migrate to urban areas – leaving them in charge of the family farm – and are often involved in income generating activities that depend on the collection of local wild species (Montanari and Bergh, 2019a; Van Praag et al., 2021).

1.2 Vulnerability and adaptive capacity

1.2.1 General socio-ecological trends and factors for Morocco

Morocco's economy in terms of GDP, employment, and export revenue, as well as national and local food security, are highly dependent on agriculture, and thus vulnerable to productivity losses and volatility in this area. Because of a high-water poverty index, access to water is particularly vulnerable to further declines in availability. Low levels of literacy and educational attainment – in particular vocational skills – combined with insufficient job creation to match a rapidly growing population, reduce opportunities for diversifying incomes or shifting livelihoods away from agriculture and biological resources. Without alternatives, populations are pushed to overexploit local resources such as land, water, and pastures; further clear out forests for agricultural land; and overharvest local (wild) species either for own consumption or income generation (EO4SD, 2019; Schilling et al., 2012; The World Bank Group, 2021). As such, populations and territories are or risk to be trapped in a "nexus syndrome" of degraded ecosystems, low prospects of employment and livelihoods, and vulnerability to climate change (cf. Box 2) (Nilsson 2016).

Despite high ambitions and important policy advances in recent years, state-based (universal) social protection is in its infancy and not yet able to provide sufficient protection and coverage, especially for isolated and marginalized groups (Fonteneau et al., 2017). Many populations rely on community-based solidarity mechanisms to cope with shocks and set up highly fragmented, micro-level adaptation initiatives, often financed to a large extent through remittances from (inter)national migrants. Without external support and additional resources to connect and upscale such initiatives, however, their impact on addressing adaptation needs and systemic sources of vulnerability remains limited (de Haas, 2007; Van Praag et al., 2021; Interviews).

Finally, Morocco is characterized by an exceptionally rich biodiversity, with a high number of endemic species that have desirable properties for adaptation, such as drought resilience. This biodiversity is currently being lost at a fast rate. Similarly, many historically grown and culturally embedded communal institutions and knowledge on (sustainable) cultivation and use of local biological resources are being lost as well. Recent research argues that the erosion of these communal institutions and knowledge systems has further contributed to local overexploitation and conflicts over resources, and that the protection and restoration of the associated bio-cultural resources carries significant potential to promote local adaptive capacities (cf. Box 2) (Briones Alonso et al., 2018; Domínguez et al., 2012; Ouarghidi et al., 2017; Teixidor-Toneu et al., 2020a).

1.2.2 Public institutions and governance

Morocco's central government is highly aware of the importance of and need for adaptation, making political and strategic efforts to take into account climate risks in agricultural development and biodiversity conservation. Nevertheless, some important gaps in the internal and intersectoral coherence of policies and strategies remain to be addressed, and there seems to be an important gap between national-level policy making and (lower-level) implementation. For instance, Morocco's leadership on climate change mitigation and renewable energy stands in contrast with the continued promotion of water-intensive export crops. There are likewise many ambitious national-level policies and strategies on sustainable forest management (cf. section 2), but responsible institutions often lack capacities and tools to translate these to the regional and local level and to implement them (Dahan et al., 2012; François et al., 2016; Van Praag et al., 2021; interviews).

The political economy of land and water in Morocco seems to be an important obstacle to developing and implementing effective, integrated adaptation policies and strategies, and promoting more efficient resource use (interviews, land degradation paper). Land and water are heavily politicized resources, with land use and inheritance rules and practices being complex, embedded in religion, and politically sensitive. Economic and political elites tend to have strong control over access and use, which has been associated with the persistence of maladaptive 'traditional' ways of using and managing these resources even in a context of pressing degradation (Dahan et al., 2012; Desmidt, 2021; François et al., 2016; Interviews). Several institutional features contribute to the gap between national-level policy making and implementation in this nexus (Dahan et al., 2012; Van Praag et al., 2021; Interviews):

- the large size of the government apparatus and the "overabundance of administrative actors" involved in natural resource management (reform), with insufficient coordination and cooperation between different actors
- centralized decision-making creates particular administrative and procedural hurdles for adaptation projects on the agriculture-forests-biodiversity nexus, e.g., because obtaining

permissions to plant new species, install seedbanks, set up ethnobotanical gardens… take too long compared to planting and growing cycles

- insufficient presence and political weight of environmental authorities at different levels to steer and promote implementation, for instance through intersectoral cooperation across agriculture, forestry, and biodiversity protection
- insufficient institutional capacities of state institutions at different levels to effectively monitor and enforce policies and regulations, resulting in important information gaps on who uses biological resources, how much, for what purposes, …
- not all regions of Morocco are equally represented in decision-making, while the socio-ecological context and adaptation needs and challenges vary strongly across regions. Involving communities in decision-making is crucial when adapting local livelihoods dependent on agriculture and forest ecosystems, but this remains a challenge as well.

This socio-institutional set-up creates a context where state support for adaptation focuses strongly on large-scale infrastructure projects (e.g., renewable energy production), and on technical or technological agricultural innovations (e.g., drip irrigation, crop selection). Communities in contrast receive limited resources and support to coordinate, upscale, and accelerate local-level adaptation efforts (El Amrani, 2019; Mokhtar et al., 2019; Sowers et al., 2011; Van Praag et al., 2021; Interviews). This seems to be driven by a lack of adequate institutional structures for facilitating such multi-level governance and support, as well as limited consultation of citizens by the state and limited opportunities for civil society participation in decision-making (Dahan et al., 2012; Van Praag et al., 2021). Another reason highlighted in interviews is an insufficient support base for investing in adaptation among regional and local decision-makers, due to a lack of knowledge and awareness of adaptation needs and the opportunities that it brings for development (rather than presenting a constraint) – although this varies considerably across regions (see also e.g., Sowers et al., 2011).

1.2.3 Vulnerable groups, territories, and ecosystems

Beyond these general factors, vulnerability and adaptive capacity vary along a number of key socio-economic dimensions in spite of significant advances in recent years to mitigate these divides. Rural areas remain considerably left behind in terms of income, poverty, access to education and health care, access to decision-making process, and access to public and private financial resources, compared to urban areas (although unemployment rates are lower). This holds particularly true for mountainous areas due to their remoteness. Limited public investment significantly reduces available resources for building adaptive and coping capacity through e.g., social safety nets (François et al., 2016; EO4SD, 2019; The World Bank Group, 2021).

Similarly, the gender gap index in Morocco remains very high (World Economic Forum, 2021). Women still face important obstacles in accessing education, employment, land, finance, and decision-making processes through gender norms and cultural practices, with rural women often facing multiple and deep-rooted exclusion mechanisms (Montanari and Bergh, 2019a; Perry, 2020; cf. Box 1).

Indigenous groups tend to face compounded vulnerabilities as well. Amazigh peoples in particular often face high poverty rates, are politically disenfranchised, have limited access to education and social protection, and depend strongly on natural resources for their livelihoods (cf. Box 2; Cultural Survival, 2007; Perry, 2020)

Oasis ecosystems, currently disappearing at a fast rate, depend strongly on intricate interactions between human agricultural activity and ecology (e.g., through family-farm fruit tree cultivation, communal collection of dried palm leaves), and are thus particularly vulnerable to the combination of climate change and depopulation through out-migration. Oases often being the last frontier against desertification, the surrounding areas in turn become more vulnerable to desertification and environmental degradation (Aït Hamza et al., 2010; Bentaleb, 2015; Mokhtar et al., 2019).

Finally, forest territories, especially in mountain areas, are particularly vulnerable to the 'nexus syndrome' of degrading biological resources, insecure livelihoods, and vulnerability to climate change (Nilsson, 2016). Argan forests are of particular importance in the context of adaptation. Unique to Morocco, argan trees are highly drought-resistant, key in halting desertification and erosion, and key to supporting the livelihoods of local populations through e.g., husbandry and agroforestry. However, the populations depending on argan forests tend to be more highly marginalized and vulnerable to the trends described earlier. Combined with the recent boom in international market prices for argan oil, this ecosystem has come under severe pressure. Recent efforts to protect argan forests and associated livelihoods through integrated green development projects have high potential on paper, but carry high risks of perverse effects as well depending on how they are implemented (cf. Box 1; Montanari and Bergh, 2019a; Perry, 2020; Perry et al., 2019).

1.3 Institutions and policy programmes

Overall, three key observations emerge from the analysis of this domain (Van Praag et al., 2021; Interviews):

- At the national level, there is a clear recognition of the importance and need for promoting a resilient and sustainable agricultural sector, a more efficient use of natural resources, and forest conservation and restoration. This needs to trickle down further to the regional and local levels.
- There remains a need for innovation in conceptualizing, implementing and operationalizing integrated adaptation approaches and multi-level, participatory governance thereof.
- Current policies tend to favour repressive measures rather than incentives.

The recently published 'New Development Model' has been praised for recognizing the failure of past approaches to translate economic growth into higher well-being for citizens, and for moving beyond an overly focus on mitigation to give due attention to adaptation (CSMD, 2021). An important point of criticism is the fact that the new vision still relies on a top-down approach, where citizen consultation is included but not (yet) substantially developed, and it remains unclear what role there is for citizen participation (Interviews).

Morocco has many plans and strategies in place for forest conservation and restoration in particular, and has made important advances in the area of overall biodiversity protection. The country is for instance an active player in the Convention of Biological Diversity and emphasizes the value of biodiversity in its National Biodiversity Strategy and Action Plans (Convention on Biological Diversity, 2021). Nevertheless, there is a need for moving towards more integrated approaches and institutional set-ups that better consider socio-economic challenges, and the links with agriculture and rural livelihoods. An important step forward in this regard is the recognition that conservation also requires strategies to promote *sustainable use* by populations who depend on forests and other biological resources for their livelihoods and cultural patrimony (see e.g., the new strategy Forêts de Maroc) (Interviews). We list several selected examples of more integrated approaches (The World Bank Group, 2021):

- the National Action Program Desertification links efforts to combat desertification with poverty reduction and rural development

- the Water, Forests and Soil Conservation Directorate integrates biodiversity protection with livelihoods concerns by focusing on the regeneration of natural forests, the promotion of pasture management, and the management of hunting and inland fisheries

- the National Strategy for Integrated Coastal Zone Management (ICZM) promotes sustainable development in the coastal area through a regional collaboration with other countries of the Mediterranean basin. It aims to promote the protection of biodiversity and ecologically sensitive areas and attain sustainable biological resource management, among others through the implementation of trans-boundary pollution reduction, improved water resources management, and biodiversity conservation measures in priority areas. The ICZM was also designed and implemented to complement ongoing adaptation efforts from other sectors such as water, tourism, waste management, coastal zone development and housing, and agriculture (The World Bank Group, 2018).

The new agricultural development plan, Generation Green 2020-2030, shows promise as a more integrated approach. It aims to increase the role of forests as productive spaces for development, to ensure the sustainable management of forest resources, and to preserve biodiversity. As for implementation, however, critical reviews point to a number of unclarities, importantly how the plan will address the challenges of sharing scarce water resources and arable land. In addition, the plan does not clarify priorities, and in contrast to forestry plans gives limited attention to the demand side and resource *use (who uses the resource, how much, why, how efficiently?)*. This creates the risk of a continued focus on growth and exports, rather than promoting resilience and stability and an equitable distribution of the benefits of agriculture (interviews).

1.4 Case studies

Box 1: Arganiculture-reforestation programme as community-based green development?

Argan forests are the last barrier against desertification in the south, and an important component of a unique ecosystem and way of life of local communities.[1] In recent years, the international market price for argan oil has skyrocketed, creating large opportunities for value creation and income generation, but also putting considerable pressure on argan forests. In response, the national government in partnership with public and private investors, including international cooperation partners, started to invest heavily in programmes that aimed to simultaneously protect and restore argan forests and promote rural community-based development through argan commercialization. As argan collection and processing is traditionally by women through culturally transmitted knowledge and practices, many programmes also aimed to promote women's empowerment by requiring that argan commercialization be done through women's cooperatives. As such, programmes were presented as integrated approaches to climate change mitigation and 'green' development, contributing to forest conservation, rural community-based development, the preservation of cultural patrimony, and women's empowerment.

This constellation of factors resulted in a proliferation of women's argan cooperatives, many integrated in national or global argan value chains. Recent case studies of the impact of these

[1] Argan trees protect against soil erosion and resist drought through deep root systems, provide wood for fuel and construction, support farming and husbandry, produce valued edible and cosmetic oil, provide much needed shading, and naturally play a role in carbon capture (argan publication).

cooperatives, however, point to complex effects on community development and women's empowerment and some perverse effects. Cooperatives may be false, set up simply to access finances. In addition, rather than participating in decision-making, valorizing their knowledge, and sharing equally in benefits, many women in the studied cooperatives were deployed as a low-cost, informal, menial labour force with no social protection. Programmes failed to address deep-rooted inequalities and gender norms that prevented rural women with little education from capturing the benefits and obtaining decision-making power. Key questions are raised about who (should) control access to and use of argan forests and the associated cultural heritage, and whether communities are able to capture the benefits, and meaningfully participate in decision-making over livelihoods and the bio-cultural resources on which these depend (Perry et al., 2019; Perry, 2020; Montanari and Bergh, 2019a).

Box 2: The value of community-based bio-cultural resources and governance systems

Several areas in the High Atlas Mountains are experiencing high rates of biodiversity loss at the genetic, species and landscape levels, due to the processes described in section 1.1. In particular, increasingly severe and prolonged drought – combined with more frequent flash floods – affect agricultural production, disrupt plant life cycles, and contribute to soil erosion, while higher temperatures are changing the distribution of local species.

The Amazigh peoples that have traditionally inhabited these areas have managed local biological resources and landscapes such as pastures and forests for millennia through culturally embedded communal resource governance systems (knowledge, practices, beliefs, customs, …).[2] These systems served to ensure sustainable resource use and biodiversity protection, while nurturing social, cultural and spiritual relationships and traditions.

Although such communal governance systems can still be found across Morocco, they are generally being eroded. Key causes are high rates of rural-urban migration and the decreasing intergenerational transmission of knowledge to youth; the commodification of agricultural labour; the commercialization of different species; the privatization of land; and the growing insecurity of livelihoods based on biological resources. This complex scenario is closely interrelated with the ability of communities to conserve their cultural heritage and maintain agency over their way of life.

The Moroccan Biodiversity and Livelihoods Association implements participatory, community-based interventions in the High Atlas region to protect, restore, and strengthen such communal resource governance systems, and support Amazigh populations in building sustainable and secure livelihoods around local bio-cultural resources. Interventions can involve the (re)building of knowledge and capacities on sustainable resource governance; strengthening old and new governance systems based on participatory research and scientific insights; or the creation of community-based herbaria, agroforestry, plant nurseries, and seed banks to protect and restore local biodiversity and contribute to livelihoods. The association also supports communities in sustainably cultivating and marketing natural products through cooperatives, which reduces pressures on wild populations and supports the reintroduction of local species into the wild. Interventions are being upscaled and replicated in other areas on request of

[2] One of these systems is the *agdal*, which is found in some form throughout the Mediterranean region, and is today officially recognized as an *Indigenous and Community Conserved Area and Territory*, or ICCA). *Agdals* put temporary restrictions on the use of specific biological resources within a defined territory (e.g., communal pastures), with the intention of maximizing their availability in critical periods of need. Recent research suggests that these systems can have several benefits in terms of biodiversity protection and sustainable resource use, such as promoting the regeneration of grazing plants (MBLA sources).

local communities, and the MBLA identifies the participatory nature of their interventions as a key factor for success (MBLA, 2021; Teixidor-Toneu et al., 2020b; Domínguez et al., 2012; Interviews).

1.5 Reflections and pointers for future action

Although diversifying or shifting away **livelihoods from natural resources** can be a solid adaptation strategy in the face of severe environmental degradation, many populations in Morocco still derive their livelihoods from these resources today and might choose to or be forced to do so in the near future. In particular for severely marginalized groups, in a context of high unemployment and low educational skills, alternative livelihood formation may be a great challenge. In such contexts, it can be useful to capitalize on opportunities for building sustainable livelihoods around local biological resources that address both socio-economic and ecological adaptation needs (see e.g., Abourabi, 2020).

Morocco's rich biodiversity includes many species beyond the famed and widely publicized argan oil, that offer a host of nutritional and health benefits, and could be **sustainably cultivated and commercialized** through economic structures that promote fair access to benefits for producers (e.g., cooperatives). Demand for organic agriculture and artisanal or 'terroir' products is projected to grow in Morocco in accordance with the global trend. The Moroccan government is already engaging with this trend by creating quality standards and certificates, and by setting up so-called 'solidarity markets' that facilitate more vulnerable groups such as women and youth to sell their products, often through cooperatives. In addition, sustainable cultivation and commercialization of such local species can *promote* biodiversity protection and ecosystem restoration in several ways: by substituting for the collection of wild populations; by preserving genetic material and diversity; and by reintroducing species that have disappeared locally (cf. box 2). Women could play an important role in this respect, as they typically are important bearers of knowledge on socio-ecological systems and local biological resources at the community level. Valorizing this role and their knowledge could be a useful component in strategies to simultaneously promote gender equality and women's empowerment (MBLA, 2021; Montanari and Bergh, 2019b; Interviews).

However, the case of '**arganiculture**' (cf. Box 1) points to several important **risks** of such approaches. First, building programmes around one species or product through a system that is heavily reliant on **international markets and prices** makes it very vulnerable to (international) price fluctuations. This can have several types of perverse effects. Price volatility itself would compromise the security of livelihoods strongly dependent on the product. Price drops can endanger livelihoods, while price hikes can effectively exclude the poorest from accessing the product after it has been commodified. This is especially problematic for species with important economic, social, cultural value such as argan. Critics argue that building conservation and restoration efforts around monetary incentives (the commodification of nature) can result in an erosion of more resilient and powerful incentives based on the intrinsic value of nature (e.g., religious or spiritual meaning, or nature as having rights (Corrigan and Oksanen, 2021; Perry, 2020)). Finally, plantations set up through green growth projects like arganiculture development in Morocco do not necessarily match the ecological functions and resilience of natural habitats (see e.g., Pawson et al., 2013).

Diversification through ecosystem- or landscape-based approaches rather than reliance on a single species may be a better way forward, both for building more secure livelihoods, and for protecting ecosystem health and biodiversity. Examples are agroecology, agroforestry, ethnobotanical gardens, or protected areas where resource use is regulated in an integrated way.

A good practice in this sense would be to build on past or **existing governance systems**. As in many other contexts, historically grown, culturally embedded, 'traditional' governance systems in Morocco were effectively and often actively undermined through the top-down imposition of competing, often externally designed, institutions and land reforms by colonial and post-colonial governments (Domínguez et al., 2012; Perry, 2020). Although not a panacea, such local systems often have the advantage of being well adapted to local conditions and needs, and built on extensive local knowledge and understandings of socio-ecological interactions. Recent research has explored how such local governance systems can be restored, adjusted, and strengthened – for instance by combining local knowledge with new scientific insights. If anything, recent findings suggest that this avenue holds potential and remains vastly underused by governments (Berkes et al., 2000; Briones Alonso et al., 2018; Menzies, 2006). In Morocco, it would be useful to support existing efforts in this respect, and explore whether scientific insights and research can strengthen the adaptive capacity of historically developed systems such as *agdals* (cf. Box 2) (Domínguez et al., 2012; Teixidor-Toneu et al., 2020b).

A second key risk of building livelihoods around sustainable commercialization of natural resources lies in the tension between integration in (inter)national **value chains** on the one hand, and equitable revenue sharing and the protection of producers' rights, on the other hand. Markets and value chains exist in a context of distinct power relations, and professionalization of value chains can bring in commercial interests that do not align well with the objectives of sustainable and equitable livelihood development. When captured by political or economic elites or other powerful groups, natural resource-based development programmes can end up increasing local vulnerabilities and inequalities (Eriksen, 2021; Montanari and Bergh, 2019a; Perry et al., 2019). Critical questions to ask when considering such approaches are:

- who has access to the resource, who controls access to the resource, what determines access, how might the programme change this, and how might such changes affect marginalized groups and existing vulnerabilities?

- how are benefits shared, who decides this, how might the programme change this, and how will this affect marginalized groups and vulnerabilities?

Although **cooperatives** have a high potential as vehicles for producer empowerment, equitable revenue sharing, and social and solidarity entrepreneurship, the case of women's argan oil cooperatives shows that they are no silver bullet either (cf. Box 1). Democratic and inclusive internal governance and appropriate knowledge and skill sets of members seem key for cooperatives to work well. Achieving this may require substantial outside support by state or non-state actors. For cooperatives to promote gender equality and women's empowerment specifically, evaluations of argan cooperatives point to the importance of skills development (in particular numeracy), rights education, and community-level efforts to address harmful gender norms and discrimination (Montanari and Bergh, 2019a; Perry et al., 2019).

Integrated land use approaches and **nature-based solutions** can be particularly useful to increase efficiency in contexts of high competition for resources between sectors (Miralles-Wilhelm, 2021; The Nature Conservancy, 2017). In the Moroccan context, **coastal wetlands** are key ecosystems and biodiversity hotspots with high potential as nature-based solutions for protection against storms, floods, salinization, and coastal erosion; waste water treatment; biodiversity protection; and sustainable agriculture and tourism. Compared to 'grey' infrastructure such as concrete dykes, such nature-based solutions tend to offer large benefits and avoid important trade-offs, such as the displacement of populations or disruptions of livelihoods (OffYourMap, 2018; The Nature Conservancy, 2017).

A key entry point for an integrated approach to adaptation on the agriculture-biodiversity nexus is **knowledge, awareness and skills building.** According to interviewees, there is a two-pronged need.

First, Morocco' heritage of resource governance systems and knowledge has been degrading along with its natural resources (cf. supra), and many groups today appear to lack access to information and knowledge to adequately deal with environmental change and biological resource degradation in their territories. Technological innovations may be used incorrectly, resulting in (greater) resource efficiency. For instance, in some cases the roll-out of irrigation systems through (increasingly solar-powered) pumps has resulted in an overexploitation of groundwater resources. There is thus a **need for local experts**, who understand well local contexts, to disseminate useful knowledge among communities and households in an accessible and culturally sensitive way, and build the skills necessary to adequately apply new knowledge and technologies. In particular, there is a need for awareness, knowledge, and skill building among resource users and policy makers on (i) the value of local species, their different uses, and how to sustainably cultivate them; (ii) the potential of nature-based solutions to address a variety of issues in an integrated way and create important synergies (e.g. wetlands); and (iii) how everyday accessible sustainability practices in agriculture can promote local biodiversity and agricultural stability and long-term productivity. It is particularly important to reach and involve youth, so as to support the intergenerational transmission of knowledge and improve livelihood prospects (Interviews).

In any knowledge and skill building efforts, it is key to move beyond top-down approaches. **Inclusive participatory approaches** tend to be useful to understand what knowledge and skills already exist locally, or used to exist, and how this can be usefully integrated with new technologies and knowledge (Dechanet, 2020; Ouarghidi et al., 2017). In addition, participatory approaches are useful to translate abstract and possibly alienating discourses on 'climate change' or 'adaptation' to daily realities and challenges, which can ensure that new information, technologies, or practices are more easily accepted and adopted and thus have more traction (interviews). Finally, participatory approaches are a key instrument to track unintended negative effects of adaptation programmes and policies and understand how to address them – in particular for marginalized groups (cf. Box 1; Briones Alonso et al., 2021).

Secondly, interviewees highlight the need to **sensitize and inform local decision makers** about the value and potential synergies in adaptation in the agriculture-biodiversity nexus, also in terms of development and job creation. In particular, more awareness is needed on the benefits of nature-based solutions such as coastal wetlands over 'grey' infrastructure, also in terms of job and livelihood prospects (OffYourMap, 2018). Similarly, the high awareness at the national level on the large co-benefits in forest protection and restoration needs to be passed on to local levels.

Finally, any integrated adaptation approach needs a stronger focus on the **demand side of resource use**, and strengthened capacities for implementation, monitoring, and enforcement (Sowers et al., 2011; Interviews). Supporting political and policy dialogue on the political economy of resources, and on the space for communities and civil society to participate in decision-making processes and policy development, might be useful to address more deep-rooted drivers of inequalities and power asymmetries, and the resulting maladaptive outcomes.

2. Urbanization-Migration-Tourism

Migration, urbanization, and tourism are strongly connected in Morocco. Migration is intimately related to employment and livelihood prospects. Environmental degradation, exacerbated by climate change, increasingly pushes rural citizens out of natural-resource-based livelihoods, towards tourism and other employment in the country's coastal urban areas. This continued migration further boosts high rates of urbanization and littoralization, increasing already severe pressures on land, water, decent employment opportunities, decent housing, and public services. Although remittances from migrant networks play a significant role in supporting local livelihoods and adaptation efforts, this resource is not accessible to all and high out-migration itself may compromise the ability of rural communities and individuals to adapt to environmental degradation locally. Urban areas along the coast face major adaptation challenges as well, as they are highly exposed to the impact of climate change. These same impacts compromise the current model of international mass tourism, which currently further exacerbates competition over natural resources. In response to these adaptation needs and challenges, adaptation programmes are developed by the national government and at the grassroots level, but there is currently a disconnect between these different levels of adaptation action, as well as between national-level policy making and implementation of policies. Ways forward lie in stronger multi-level participatory governance of adaptation efforts and programmes, increased state support for grassroots and bottom-up adaptation efforts in both rural and urban areas, and a stronger promotion of the types of jobs, livelihoods, and skills that simultaneously benefit environmental protection and gain from it.

This section offers a non-exhaustive discussion of key socio-economic and ecological adaptation needs and challenges in view of the development-climate change nexus, as well as selected entry points for building a more integrated approach to transformative adaptation in the domains of urbanization, migration, and tourism.

2.1 The pilot domain in the context of socio-ecological change

2.1.1 Climate change and other drivers of change

Morocco is characterized by a rapidly growing population, and coastal cities continue to draw migrants from the interior. Both trends are translated into a high urbanization rate: between 1985 and 2025, Morocco's urbanized area will have increased six-fold, making it one of the most highly urbanized regions in Africa (The World Bank Group, 2021). As most of this urban growth is absorbed by the cities' peripheries, there is substantial urban sprawl, with a comparatively high urban footprint and high transportation costs for people and goods. Constraints to land access contribute importantly to this urban sprawl (Lall et al., 2019).

Internal migration is deeply connected to employment in Morocco: poverty and dwindling economic opportunities, exacerbated by environmental issues such as drought and land degradation, are continuing to push people out of rural areas. At the same time, job opportunities in tourism and other sectors (importantly agriculture, industry and construction) are continuing to pull people to coastal urban areas, continuing the past trend of high and growing littoralization. Especially young people often do not see a future in agricultural livelihoods and aspire to migrate to cities or abroad in search for educational and economic opportunities (Van Praag et al., 2021; Interviews).

The social and economic impact of Morocco's migration patterns is complex. Although urbanization in Morocco has not generated the same growth benefits as in many other countries with similar contexts, it has led to economic growth for urban and rural areas under certain conditions, although quite unequally

across rural areas. It has also contributed to problems in urban areas of rising informal employment, the expansion of slums, waste management challenges, pressure on physical infrastructure and health and education services, and growing competing demands on land and water (de Haas, 2007; Lall et al., 2019). Finally, the high out-migration from rural to urban areas, by many referred to as a 'rural exodus', is resulting in a depopulation of certain areas and territories. Although high out-migration rates may be compensated by in-migration from other rural areas, depopulation poses a real threat to the survival of certain socio-ecological systems (and the associated bio-cultural patrimony) today, notably of Morocco's oases and mountain areas. This depopulation is said to undermine historically grown culturally embedded communal practices in agriculture and husbandry, which have played an important role in sustainable resource governance systems such as oasis agriculture and argan-based agroforestry (de Haas, 2007; Perry, 2020; Interviews).

Tourism is a key and fast-growing sector in the Moroccan economy, and takes place primarily along the coastline – although the natural and cultural heritage of the interior is increasingly attracting tourists as well (Berriane and Moizo, 2009). The sector has been severely damaged by the COVID-19 pandemic as it is largely based on foreign visitors (interviews). Nonetheless, it contributes significantly to national income and job creation in urban areas, and is seen as a key strategy to diversify the Moroccan economy away from agriculture. At the same time, today the sector mostly involves large-scale or mass tourism that contributes little to local livelihoods and is not sustainable. Particular issues are a high water- and energy-intensity, and high rates of land conversion away from natural habitats and livelihoods The government along with international partners is promoting a different model of tourism (rural tourism, ecotourism, solidarity tourism, …) that should have a smaller negative environmental impact, help to preserve cultural-historical heritage, and bring larger benefits to local communities. However, the scale and actual implementation of this alternative model seems to remain limited (Alcalá et al., 2015; (Berriane, 2016; (Berriane and Moizo, 2009; François et al., 2016; Tekken and Kropp, 2015; Interviews).

In terms of natural resources and ecosystem health, the combination of high urbanization, migration, and littoralization rates, along with growing tourism development, are generating high and competing demands on land and water in coastal areas. This in turn results in high rates of land conversion and thus the destruction and degradation of natural habitats and ecosystems. In combination with high unemployment rates, especially of youth, and increasing pressures on livelihoods, conflicts over access to water and land are heightening in (peri-)urban areas and expected to grow more severe in the future (Desmidt, 2021; The World Bank Group, 2021).

Climate change puts additional pressure on livelihoods, human well-being, natural resources, and ecosystems in Morocco's cities and coastal areas. Rising sea levels and more extreme events such as storms will cause erosion and flooding (an estimated 42% of the coastline will be at high risk of erosion and floods by 2030). This will (i) reduce the available area for marine and terrestrial natural habitats; (ii) reduce the available area for human activity (housing, agriculture, tourism, industry); (ii) increase salinity of groundwater and soil, which undermines water and food security and ecosystem health. Higher temperatures will increase the frequency and severity of heat waves, increase mortality, and undermine quality of life especially in urban areas and southern oasis areas. This will also shorten the time span during which tourism is possible or desirable, and thereby risks to undermine the tourism-based livelihoods on which a growing share of urban residents depend (Desmidt, 2021; Schilling et al., 2012; The World Bank Group, 2021). Overall, there is a strong concern that rural-urban migration will become untenable given these climate risks.

2.1.2 Exposure

Morocco's population, ecosystems, and economic activity are particularly exposed to the impact of environmental change and climate change, as 60% of the population, 90% of industrial activity, a large share of tourism, and significant natural reserves and biodiversity hotspots are along its coast (OffYourMap, 2018; (Schilling et al., 2012; The World Bank Group, 2021. For instance, coastal erosion is already undermining the touristic potential of the country's beaches (Tekken and Kropp, 2015). Beyond these general factors, several territories and groups are particularly exposed to environmental change:

- Coastal cities and ecosystems on the Mediterranean coast such as Saïda, Tangier, or the Moulouya River and its delta (a biologically important estuary) are highly exposed to coastal erosion and flooding. Tangier Bay for instance is projected to lose 99.9% of its port infrastructure and 63% of the city's industrial zone (The World Bank Group, 2021).

- Morocco's coastal wetlands are particularly exposed to climate change due to their location and structure, while these are key ecosystems with high potential as nature-based solutions for protection against storms, floods, salinization, and coastal erosion; waste water treatment; biodiversity protection; and sustainable agriculture and tourism (OffYourMap, 2018).

- Coastal and urban populations are particularly exposed to the growing competition over limited and degrading resources – importantly safe drinking water and land for agriculture and housing. Within urban areas, better off neighbourhoods might be less exposed to the effects of climate change due to better access to drinking water, cooling technology, more green areas, and better flood protection (interviews; (Desmidt, 2021; Lall et al., 2019)).

- Livelihoods depending on coastal tourism or fisheries are particularly exposed to marine and coastal ecosystem degradation, biodiversity loss, coastal erosion, floods, storms, and rising temperatures brought about or exacerbated by climate change (The World Bank Group, 2013; The World Bank Group, 2021; Schilling et al., 2012).

- Women tend to be more exposed to the impact of environmental change on their daily lives and livelihoods, as they tend to stay behind to take care of the family farm and other natural-resource based livelihood activities, if only one household member is able to migrate (Van Praag et al., 2021).

2.2 Vulnerability and adaptive capacity

2.2.1 General socio-ecological trends and factors for Morocco

As most economic (industrial and service-oriented) activity, including a large share of tourism, takes place along the coastal zone, Morocco's national economy is highly vulnerable to the impact of climate change on coastal areas. The country is investing heavily in tourism as a strategy for diversifying the national economy and promoting rural development, which may mitigate its economic vulnerability to climate change – in particular through the heavy dependence on agriculture and natural-resource based livelihoods.

Yet, the tourism sector itself is sensitive to the impact of climate change, and may even undermine the adaptive capacity of local populations and territories. As tourism development policies have not yet managed to address the high-water intensity of the sector, it is highly vulnerable to declining water availability. This is especially the case for territories where water stress is already high, such as oases areas. The competing demands of tourism on water may further undermine access to water of local populations, and in particular more vulnerable groups. Nomadic populations for instance are observed

to settle around oases to ensure water access, putting further pressure on local water availability and entering in direct competition with settled groups and the tourism sector (Iinterviews; Tekken and Kropp, 2015).

Nonetheless, sustainable tourism also offers opportunities for sustainable jobs and livelihoods that do not depend on agriculture, and nature-based tourism specifically can create important incentives for conservation and restoration of ecosystems and natural habitats (interviews; Berriane and Moizo, 2009). There is ample interest in this approach at the local level, with citizens setting up many micro-level initiatives, sometimes supported by local or international NGOs, around sustainable or nature-based tourism. Yet, in the absence of additional systematic support, regulatory frameworks, and public investment, these initiatives so far remain very fragmented and their impact remains limited.

Aside from the composition of its economy, Morocco's population is vulnerable to climate change and other socio-economic challenges due to a high multi-dimensional poverty rate compared to the rest of the region and other middle-income countries (United Nations Development Programme, 2020; Schilling et al., 2012; (The World Bank Group, 2021). Poverty rates are markedly higher in the interior of the country, and in particular territories such as mountainous areas. Per capita household consumption is for instance 54 percent lower in rural areas than in urban areas, and uneven access to services and social protection amplifies these inequalities (Lall et al., 2019). Unemployment is also high, especially for youth and women, but is markedly higher in urban areas. For instance, unemployment rates for young men stand at 36 percent in urban areas vs. 8.4 percent in rural areas (Lopez-Acevedo et al., 2021). This lack of secure job or livelihood prospects strongly limits opportunities for diversifying or shifting livelihoods away from sectors under pressure. Finally, vulnerability and limited adaptive capacity are importantly related to low levels of literacy and educational attainment, as well as large inequalities in this area: there are still large divides in education between urban and rural areas, between men and women, and between different regions and ethnicities (Amaghouss and Ibourk, 2016; Lall et al., 2019; (UNESCO, 2021). These inequalities appear to have been amplified recently due to privatization waves in the education sector, and more recently due to the COVID-19 pandemic, raising serious concerns about Morocco's ability to safeguard the right to education (Abdous, 2020).

Beyond education and unemployment, rural and urban populations face a number of specific vulnerabilities and constraints to adaptive capacity. Rural populations are more remote and isolated, and therefore tend to have less access to relevant information, knowledge, and technologies. Public spending in rural areas remains low, with low levels of social protection. High poverty rates along with a lack of information and networks might lead some rural populations to become 'trapped' in their home regions, unable to migrate to find other opportunities, and thereby becoming even more vulnerable to the different pressures on their livelihoods at home. Urban residents, then, face risks of insecure informal employment, lack of access to necessary public services, decent housing, and adequate waste management, higher environmental pollution, and pressing competition for natural resources. Although urban areas are favoured in terms of public investment, within cities there can be large disparities in access to land, water, energy, public services, decent housing, green spaces, waste management facilities, and so on (Lall et al., 2019; Interviews).

Several additional dimensions of vulnerability, and inequalities herein, merit mentioning. In spite of a significantly higher commitment to gender equality in policy making since the ascension of King Mohammed VI in 1999, women remain a vulnerable group in Morocco across the board, having less access to land, financial resources, education, information, formal employment, and decision-making power (Montanari and Bergh, 2019a; The World Bank Group, 2021). In 2021, Morocco indeed still ranked 144 of 153 in the Global Gender Gap Index (World Economic Forum, 2021). At the same time,

due to their typically higher exposure, many women might have developed specific skill and knowledge sets and be better equipped to deal with environmental change (Van Praag et al., 2021). In terms of ethnicity, Amazigh peoples in particular face high poverty rates, are politically disenfranchised, have limited access to education and social protection, and tend to depend strongly on natural resources for their livelihoods (Cultural Survival, 2007; Freedom House, 2021). Finally, groups who cannot migrate, for instance due to insufficient income or a lack of migrant networks, and therefore remain locked in their territories are particularly vulnerable to the impact of climate change and a lack of social protection in Morocco (cf. box 3, Van Praag et al., 2021).

A final key point in terms of vulnerability and adaptive capacity relates to the capacity of Morocco's government to provide social protection. In spite of high ambitions and important policy advances in recent years, state-based (universal) social protection is still in its infancy and not yet able to provide sufficient protection and coverage, especially for more isolated and marginalized groups (cf. box 3). Generally, there are overall low levels of fiscal transfers to local governments and large gaps in access to public funds between the primary city and other urban and rural areas, limiting also the capacities of local governments to invest in adaptation programmes or social safety nets (Desmidt, 2021; Fonteneau et al., 2017).

2.2.2 Migration as adaptation, or as an adaptation need?

Migration patterns in Morocco are complex and are interwoven with vulnerabilities and adaptive capacity in complex ways. Migration importantly can create new types of vulnerabilities. Not all migrants find permanent jobs; many get temporary contracts, for instance in seasonal agriculture or construction, which can result in significant livelihood insecurity and precarious living conditions. Rural migrants might also lack the skills needed to find qualitative jobs in urban areas (for instance due to language barriers) or might face social barriers such as discrimination. Newcomers often have to settle in outskirts of cities with poor housing and little access to public services, water, or energy (cf. supra), and may be cut off from the communal solidarity networks on which they used to rely. The COVID-19 pandemic seems to have worsened issues of exclusion and marginalization in cities significantly. Finally, the depopulation of rural areas can limit adaptive capacities locally by undermining the social fabric and micro-level socio-ecological systems developed by previous generations (de Haas, 2007; Van Praag et al., 2021; Zaireg, 2020; interviews).

At the same time, migration itself can be seen as an adaptation strategy - although people tend not to see themselves as environmental migrants and motivations are multi-layered. Many migrants do find new economic opportunities, in particular those who migrate abroad. This usually brings about (substantial) financial remittance flows to their families who often (are forced to) stay behind. Financial remittances have huge importance in Morocco: they can be an important component of family incomes; provide a safety net for those who have lost their livelihoods, and can support adaptation initiatives in home regions. Recent research has also started to investigate the role of social remittances (i.e., knowledge, skills, or social networks), in climate change adaptation, in particular for returning migrants (cf. box 3). These social resources seem to potentially important roles as well in supporting communities to set up micro-level adaptation initiatives (de Haas, 2007; Van Praag et al., 2021). Without external support and additional resources to connect and upscale such initiatives, however, their impact on addressing adaptation needs and systemic sources of vulnerability remains limited. Overall, there is a strong concern that rural-urban migration will become untenable and will severely undermine the adaptive capacity of both rural and urban areas if not well managed.

2.3 Institutions and policy programmes

Morocco's national government is very much aware of the importance of and need for adaptation, and is making considerable political and strategic efforts to take into account climate risks in the development of affected sectors. We discuss a number of illustrative examples below.

The previous tourism strategy, Vision 2020, emphasized an increase of the size and revenue of the tourism sector. It also put forward the ambition for Morocco to become a role model for sustainable tourism, but implementation lags behind. The strategy did play a major role in the regionalization process to which Morocco committed in tourism, although it was not able to adequately address growing inequalities across and within regions in terms of tourism development (Hmioui and Leroux, 2019; (Roudies, 2013; Tekken and Kropp, 2015).

A new vision document explored different scenarios for Morocco's future tourism sector, of which one focuses on sustainability (Haut-Commissariat au Plan, 2011). The document refers to several environmental issues, such as water shortage, and to the *Plan Bleu*, an initiative to build a sustainable tourism sector for the Mediterranean region that looks at tourism through a lens of three pillars of sustainability: social, economic, and ecological. Nevertheless, the Moroccan vision seems to look at sustainability more from an instrumental perspective: how can the tourism sector adjust to increasing demands for sustainability from tourists, and to the reality of limited and degrading natural resources? There is thus ample room to further develop the notion of tourism as an integral component of adaptation to environmental challenges and climate change.

The National Strategy for Integrated Coastal Zone Management (ICZM) promotes sustainable development in the coastal areas as a way of enhancing the protection of ecologically sensitive areas and biodiversity, and ensuring that coastal resources are managed for the benefit of Morocco and the overall benefit of the countries bordering the Mediterranean. The ICZM was also designed and implemented to compliment ongoing adaptation efforts from other sectors such as water, tourism, waste management, coastal zone development and housing, and agriculture (The World Bank Group, 2013; The World Bank Group, 2018). Yet, it remains unclear what these adaptation efforts in the tourism and housing sector are, how they are turned into practice (The World Bank Group, 2021).

As the examples above illustrate, there is an important gap between national-level *policy making* and *implementation*. Ambitious national-level policies and strategies do not always clarify how sustainability should be operationalized or implemented, including at lower levels. In particular, translating national policies to the regional and local level remains a challenge. Strong centralized decision-making combined with a large government apparatus and limited coordination and cooperation among institutions creates a lack of flexibility and capacity to operate at local levels. State institutions also lack capacities and instruments to monitor and enforce strategies, plans, or specific regulations, for instance on water and energy use in touristic infrastructure, at local levels (The World Bank Group, 2013; Sowers et al., 2011); Van Praag et al., 2021; Interviews).

Another key issue relates to a large disconnect between national-level policy making and local or bottom-up implementation of adaptation projects (cf. box 3). Micro-level initiatives set up by citizens, with or without support from civil society organisations (CSOs), abound, but rarely grow into larger-scale programmes with broader impact (cf. section 2.1). CSOs are increasingly undertaking efforts to upscale such micro-level initiatives by connecting them spatially and conceptually, and promoting resource pooling and knowledge exchange. However, government support – which could be a key catalyzing force to expand local adaptive capacities – tends to be limited or non-existent. This seems to be driven both by a lack of adequate institutional structures for facilitating such multi-level collaborations and

support, and a perception among civil society that involvement of public authorities is time- and resource-consuming with little guarantee of positive returns (interviews). Limited consultation of citizens by the state, as well as limited opportunities for civil society participation in decision-making, might be an important cause for this disconnect (Bergh, 2017). Another reason highlighted in interviews is that there is a limited support base for investing in adaptation among regional and local decision-makers, due to insufficient knowledge and awareness of the need for adaptation and the opportunities that it brings for development (rather than presenting a constraint). Although the level to which regional authorities are sensitive to and taking action on adaptation varies a lot across regions (depending among others on the severity of risk and problems that the region experiences), there seems to be a general trend of insufficient state support for civil society action.

Urban planning and development illustrate this point well. Adaptative urban planning will play a critical role in managing Morocco's high rates of migration and urbanization, and maintaining cities livable, in the face of severe climate risks and environmental degradation. Yet, adaptation does not seem to play a prominent role in urban planning and development in Morocco, which is currently not well tailored to citizens' needs and pays insufficient attention to specific urban adaptation needs and challenges such as cooling. Past policies are criticized for investing too many resources in 'white elephant' projects that benefit a limited few. At the other end of the spectrum, civil society sets up many micro-level initiatives to improve quality of life at the neighbourhood level, e.g., in waste management or urban greening and agriculture. These however remain fragmented and have limited reach and impact. There is a clear need for comprehensive and sustainable strategies for resilient urban development – as migration to cities is expected to continue (Interviews; Lall et al., 2019).

The recent process of decentralization aims to address the ills of overly centralized decision-making, among others by having regions build regional development strategies. Yet, this process has not (yet) led to sufficient participatory governance and ownership at the regional and local levels. For instance, not all regions of Morocco are fully represented in decision-making. Similarly, municipal authorities have received more autonomy in decentralization reforms, but need additional resources, capacity building, and flexibility to manage urbanization trends sustainably (Bergh, 2017; Lall et al., 2019; Van Praag et al., 2021; Interviews).

2.4 Case studies

Box 3: The complexities of migration, adaptation, and environmental change in Tinghir

The region of Tinghir is highly affected by rainfall and temperature changes leading to drought, desertification, water scarcity, and a growing number of more extreme weather events. Beyond extensive state involvement in large-scale renewable energy projects, all other adaptation efforts consist of people setting up small associations – often funded through remittances – in a bottom-up way, without state support. This places a large burden on community-level projects which need to compensate for the lack of social protection, and thus have to deal with a wide range of needs, such as taking care of people with disabilities, disposing of waste, and setting up small agricultural projects.

Agriculture is not seen as an interesting future investment by many (young) people, and many (want to) leave agriculture behind because it is seen as unprofitable. Investments in modernization and adaptation are often limited because people have insufficient capital and resources to invest, and it is difficult to attract outside investment due to local heritage systems and constraints on land sales. Often only small innovations are made, such as changing crops or cultivation methods. When modernization is not possible, people often rely on their migrant networks to move elsewhere. This reduces the

development of alternative adaptation strategies for dealing with environmental issues locally. Those who still wish to have access to agricultural land or invest in this to complement other incomes, are often those who cannot migrate, for instance because they do not have migrant networks. These groups become particularly vulnerable to environmental degradation, climate change, and limited livelihood prospects.

Family members of migrants who stay behind receive remittances, which is often a key part of incomes. Remittances are invested in initiatives dealing with the degrading environment when they immediately impact individual or household livelihoods, but are rarely used to invest in structural organizational, logistic, and technological investments in agriculture or to reduce the harmful effects of drought and desertification at the community level. Social remittances may be more significant: through informal contacts and frequent visits to Tinghir, emigrants started to develop the idea to deal with adverse environmental changes locally, sharing and discussing climate change discourses and observations (Aït Hamza et al., 2010; Van Praag, 2021; Van Praag et al., 2021).

2.5 Reflections and pointers for future action

A key challenge for Morocco, especially in coastal areas, is the high and growing competition over land and water resources for housing, tourism, industry, agriculture, and ecosystem protection. **Nature-based solutions** built on integrated land use offer high potential for dealing with this challenge in a sustainable way that also capitalizes on synergies for other adaptation challenges. In addition, nature-based solutions tend be more cost-effective than 'grey infrastructure' in the long run, although they may be perceived as more risky investments in the short run (Miralles-Wilhelm, 2021; The Nature Conservancy, 2017). In the Moroccan context, coastal wetlands are of particular interest for adaptation in urban coastal areas, by offering integrated solutions for protection against coastal erosion, storms, and flooding; for waste water treatment; for biodiversity protection; for income generation through ecotourism; and for food production through integrated agriculture (OffYourMap, 2018). Nature-based solutions for qualitative high-density housing and urban design (e.g., through greening of public spaces and buildings, or urban agriculture) can counteract urban sprawling and reduce pressure on ecosystems, while simultaneously promoting current and future quality of life in cities through effects such as urban cooling and air pollution mitigation (Kabisch et al., 2017).

As nature-based solutions are often simply overlooked by decision makers, **knowledge building and awareness raising** on their viability as alternative options can already have a significant impact. Nevertheless, implementation can be challenging. Nature-based solutions typically have an integrated and multi-functional nature, and thus require dealing with various types of trade-offs. Different frameworks are therefore being developed to support effective implementation, also in the context of urban planning and development (see e.g., Bush and Doyon, 2019).

Overall, **key success factors** are inclusive multi-level governance, participatory decision-making, and sufficient institutional capacity at different levels (e.g., for long-term, integrative urban planning) (Frantzeskaki, 2019; Kabisch et al., 2017). These three factors are generally identified as areas that need further strengthening in Morocco (cf. section 2.3), and in particular are seen as important constraints to the effective implementation of (ambitious) national-level policies. This presents a challenge, but also creates opportunities for catalytic effects: improvements in these areas will support the creation of an enabling environment for many different types of adaptation solutions, initiatives, and programmes, above and beyond nature-based solutions, to work.

More specifically, across the domains of urbanization, migration, and tourism, observers remark that there is a clear need for stronger **multi-level and participatory governance**, both across different levels of governance within the state apparatus, and across the state and civil society (cf. section 2.3).

As for the first, a key attention point for urban planning and development is the further **empowerment of municipalities**, both financially and institutionally. Although the recent decentralization process has given municipal authorities greater autonomy, they still face mounting challenges that need to be addressed through a (large) expansion of investment and capacity building. This will also allow municipalities to take a greater role in urban and territorial planning. Currently, diffused and uncoordinated responsibilities for territorial planning and infrastructure provision contribute to urban sprawling and inefficient land use. Building on the ongoing decentralization reforms, there are opportunities to strengthen the pivotal role of local governments in planning for and financing integrated urban development that meets both socio-economic and environmental adaptation challenges (Lall et al., 2019; Interviews).

As for **state-civil society collaboration**, there is a clear need for greater participation of citizens and civil society in decision-making, and for greater support from state institutions to grassroots adaptation initiatives and efforts. Many existing grassroots initiatives, be it in the context of tourism or urbanization, could be considered adaptation projects, but are not recognized as such, and are thus not financed, stimulated, or exchanging and collaborating within an adaptation framework. The need for support thus goes further than financial resources: state institutions could play an important role in connecting, coordinating, and upscaling ongoing efforts. This would serve the double goal of relieving pressure from citizens and community-based solidarity networks to carry the burden of adaptation alone, and of building a more comprehensive, systematic, and integrated approach to adaptation.

For multi-level and participatory governance to work, however, all parties must be invested and convinced of its value. Interviews indicate that, depending on the context, decision-makers but also civil society may not consider such governance models viable options. To build a common support base, recent experiences point to the value of sharing **early success stories** through experimentation with participatory multi-level governance modes, for instance through regional multi-stakeholder exchange platforms. **Citizenship education and capacity building** of CSOs might also be useful to foster demand for and involvement in multi-level governance at the grassroots level (interviews).

Sustainable adaptive urban development in Morocco is also inextricably linked to rural-urban migration, and the key issue of employment and livelihood prospects in Morocco. Relying strongly on migration as an adaptation strategy carries important risks, as this strategy might deepen existing inequalities, and might put excessive pressure on cities. Although migrant networks and remittances can play an important role in supporting local adaptive capacity, high rates of out-migration can also undermine the adaptive capacity of the most vulnerable who stay behind.

At any rate, improving **prospects for sustainable and attractive livelihoods and employment** in rural areas has the potential to generate a variety of co-benefits. Livelihoods in sustainable nature-based tourism or built on natural resource conservation, for instance through payments for ecosystem services (The Nature Conservancy, 2017) or the sustainable cultivation and commercialization of local species (MBLA, 2021), can simultaneously raise awareness on and incentives for local environmental protection. Initiatives to professionalize and modernize natural resource-based livelihoods, for instance through the creation of cooperatives and digital marketing, might also be useful to make livelihoods more attractive and profitable (MBLA, 2021; Interviews).

Sustainable nature-based tourism is a particularly promising sector for job creation given Morocco's rich natural heritage, and the fact that tourism is an increasingly attractive sector for Morocco's youth. Pre-existing concerns about the social and economic costs of international mass tourism, compounded by the COVID-19 pandemic, have led to growing calls for alternative models of domestic tourism that benefit local communities and 'left behind' regions to a greater extent (Berriane, 2020); (Hmioui and Leroux, 2019). An important challenge will lie in breaking with the previous high-revenue model with vested commercial interests, and providing sufficient support for alternative models.

An additional source of employment and livelihoods lies in the need for integrated adaptation policies and programmes itself, which requires the presence of a labour force with appropriate skill sets. To ensure that citizens have the appropriate skills and there is equal access to skill development, especially for marginalized groups and migrants, there is a need to improve **access to education and (vocational) training**. This need has become particularly pressing given recent concerns about the inequality-enhancing impact of privatization waves in the education sector (cf. supra).

Finally, the COVID-19 pandemic presents major challenges for a sustainability transition, but the need for a **COVID recovery strategy** also provides opportunities. Morocco might be usefully supported by regional and international partnerships and knowledge exchange on how recovery strategies might promote a shift to more sustainable and equitable forms of domestic tourism; reorientations in skill building and vocational training towards local jobs in sustainability-enhancing sectors; a shift from water-intensive export crops to more resilient local species; or a rethinking of urban planning to make full use of available nature-based solutions.

3. Water-Energy-Food

Morocco is a water-scarce country. There is a strong link between food and water, and the water allocation requires trade-offs between competing uses and users. Many communities suffer from limited water resources to sustain livelihoods. Energy is also central to withdraw and transfer irrigation water, while the energy of water has been increasingly used for hydropower production. Hence, the water, energy and food (WEF) nexus represents massive socio-economic challenges in Morocco that are being exacerbated by climate change and other socio-economic and demographic drivers of changes. The concept of Water, Energy and Food nexus is increasingly advocated as an alternative governance thinking to the traditional sector-specific management of the resources. It recognises the inseparable interlinkages between the use of the resources to provide water, energy and food security. Such interlinkages involve possible synergistic pathways but also multiple trade-offs (Table 1). Yet, the water, energy and food sectors are still mostly managed and regulated using sectoral approaches, and often fail in adequately incorporating social and environmental implications. Here, we discuss the nexus in the context of socio-environmental changes in Morocco.

This section offers a non-exhaustive discussion of key socio-economic and ecological adaptation needs and challenges in view of the development-climate change nexus, as well as selected entry points for building such an approach, for the for the domain of water, energy and food.

Table 1. Main interlinkages between WEF sectors in Morocco, impairments and inconsistencies, and synergies and trade-offs in the nexus. The arrow indicates the direction of the interactions.

Water ⇔ Food	**Water ⇔ Energy**	**Food ⇔ Energy**
Interlinkages		
⇒ Crops and irrigation: food security, exportation ⇒ Food industry ⇐ Pollution, contamination, erosion, siltation ⇐ Surface and groundwater extraction and depletion	⇒ Hydropower (hydroelectric dams, pumped energy transfer station (PETS), and small hydroelectric power plants) ⇒ Cooling and cleaning of thermo and solar power production (Ersoy et al., 2021) ⇐ Desalinization ⇐ Water and wastewater treatment ⇐ Pumping and transporting drinking and irrigation water	Food chain: ⇐ Water pumping for irrigation ⇐ Harvesting ⇐ Food processing ⇐ Transportation ⇐ Cooking
Impairments / inconsistencies / risks		
⇐ Water pollution (pesticides, fertilizers) ⇐ Erosion, siltation leading to reduced water storage capacity of dams ⇐ Uncontrolled surface and groundwater extraction ⇐ Groundwater overextraction and depletion	⇐ Inefficient use of energy for drinking water withdrawal and transport	⇒ Excessive use of energy for agriculture that is energy inefficient, ⇒ Agriculture modernisation involves a high increase in energy consumption ⇒ Food industry is also a high energy consumer

⇐ Water demanding crops, not adapted to the water scarcity context	
Synergies and trade-offs	
Irrigation ⇔ Groundwater overexploitation	⇔ Small and medium dams built for hydropower can be used to provide irrigation water to downstream users (Sinan, 2020) ⇔ Competing use of water stored in dam, between irrigation and hydropower (Sinan, 2020)

3.1 The pilot domain in the context of socio-ecological change

3.1.1 Exposure and vulnerability to climate change and other drivers of change

The fundamental challenges related to the WEF nexus are becoming more complex in the face of the global climate changes and the changing socio-economic landscape in Morocco. While climate change is impacting the availability of the resources, national strategies, demographic evolution and urbanisation, modernisation and technological development, and macro-economy influence the demand for water, food and energy. This translates into numerous pressures on the natural resources, and ripples down to a range of socio-economic and environmental challenges. The main factors of exposure and vulnerability are listed in Table 2, and some of the biggest challenges are detailed hereafter.

Table 2. Exposure and vulnerability factors for the WEF sectors. Adapted from (Biggs et al., 2015).

Water	Energy	Food
Exposure		
Sanitation and hygiene Drinking water Pollution of water resources and ecosystems Agriculture and irrigation Industry	Income: household, GDP Employment Health Cultural activities (community connectedness)	Availability (market, relief, subsistence) Access to food Health and nutrition Production consistency Tourism
Vulnerability		
Water policy and allocation Siltation of dam infrastructures	Lack of qualified work force Infrastructure Access to credit and finance Knowledge transfer	Rural exodus with risk for decreases in workforce for agriculture Infrastructure Insurance and credit Investment and R&D

Observed and projected decreased precipitations and increased temperature and drought frequency caused by the changing climate represent an additional level of threat to the natural climatic variability and overall water scarcity in Morocco on the agricultural production and basic water needs. Decline in natural and artificial surface water and groundwater resources has already been attributed partially to climate change and repeated droughts over the past decade (Bahir et al., 2020; FAO, 2021), and it is expected to continue with the projected decreased water input from rainfall and increased water atmospheric demand. Both irrigated and rainfed agriculture are vulnerable to such decline in the storages and to the droughts. As an example, potential cereals yield lost have been

estimated to reach up to 40% (Bouras et al., 2019; Woillez, 2019). A decrease in annual river flow of up to 40% is projected to affect the Maghreb countries by 2100 which would directly affect water inflows to dam reservoirs and therefore compromise further the irrigation needs and the hydropower potential.

Drivers other than climate variability and change are also exacerbating the issue of water scarcity. Demographic increase, the change in diet and the exportation market involves an increasing demand for food and for crops that are more water demanding. Such demand has yielded to a sustained, uncontrolled over-extraction of groundwater, which has contributed to a widespread drop of groundwater level and the degradation of water quality through salt water intrusion (Agoubi, 2021; Media 24, 2018). This worrying phenomenon might have been exacerbated by the national program that aimed at converting conventional, surface irrigation to drip irrigation. The socio-economic and environmental impacts of such phenomenon are numerous. The cost of withdrawal and water production is higher, which discriminates less privileged users whose benefit margin from using the resource is smaller, for example, those whose soil fertility is lower or who lack access to the market and capital, to intrant, to technology and know-how. Export-oriented agriculture is also encroaching on possibility of providing safe drinking water to people in context of declining water availability, which is an additional source of vulnerability to water poverty. Other worrying impacts include the drying of wells and boreholes, the degradation of water quality and the salinization, and the reduction of resilience in the face of droughts (Montignoul et al., 2020). In the oasis, the lowering of the water tables is also leading to the drying up of many *khettaras* systems supplying water to the palm groves. This phenomenon added to the complex social management for the use of this traditional *khettaras* water distribution system leads individuals to have recourse to well digging. If uncontrolled, such transition from collective to individual management is likely to become another tragedy of the commons (Jouve, 2012). In addition to the problematic of overexploitation of groundwater level, water resources are also suffering pollution issues mainly from agricultural fertilizers and pesticides.

Water storage are also impacted by the widespread issue of soil erosion and consequential degradations and loss through the changing land cover and land use for agriculture, overgrazing, deforestation and urban expansion (Jazouli et al., 2019). Such degradations are aggravated by climate change (Simonneaux et al., 2015). They cascade to a diminished water storage capacity of the dams through siltation, hence reducing their capacity to optimally serve their purpose (Alahiane et al., 2016) as water reservoirs for irrigation, hydropower production, and buffers for flash floods. This issue is especially problematic as the role of dams might become even more crucial as the severity and intensity of drought events increase with climate change.

The significant demographic changes in Morocco also translate into a rapid growth of the urban population, and a phenomenon of poorly controlled urbanization in the peripheral areas of medium and large urban centers, to the detriment of agricultural land and natural structures that play an important part in water cycle and waste water treatment such as wetlands. The phenomenon affects the perimeters of irrigation located on the outskirts of urban centers, in particular the large hydropower perimeters of Gharb, Tadla and Haouz and the small and medium hydraulic market gardening perimeters located around the cities of Fez, Rabat, Salé, Meknès, Tétouan, Marrakech and Casablanca. On another hand, the decrease in rural population subsequent to rural exodus is also a likely to lead to a shortage in the workforce for the agricultural sector (Harbouze et al., 2019).

With urban expansion, the food insecurity issues that used to be more prevalent in the rural areas are becoming increasingly problematic in urban settings. Source of vulnerability to food insecurity also

lies in high international prices, and price volatility that is exacerbated by climate change. Food insecurity includes malnutrition and growth delay, but also overweight and obesity.

In addition to change in crop for exportation demand, the demographic evolution and economic and social changes too influence on the demand for food. Such changes represent an opportunity for increasing income, job creation, and economic development of farmers and all those involved in the food production chain. More workforce will be moving from the primary agricultural sector to food manufacture sector as food demand increases (Balineau et al., 2020). This ongoing transformation of the food chain also results in a range of challenges that are nutritional, socio-economic, environmental, and concern both urban and rural settings. In urban setting, the change in consumption habits is leading to a growing tension between a logic of modernization of the urban food systems and a logic of preventing the social and political destabilization that could result from it (Rousseau & Harroud, 2019). For example, while supermarket can be a compelling opportunity for farmers and food producers if they prioritize local products, it can also be a machine excluding those who cannot meet quality, quantity or production standards. Hence, the challenge lays in ensuring that that agro-food systems are accessible to all the producers, including the smallest ones, while providing a diverse and affordable food offer. They also naturally involve the risk of the degradation of the nutritional quality, and the challenges faced by the agricultural sector, including climate change, soil erosion, and water pollution. Another major factor is the food waste all along the food chain, which involve the need to limit the effect of an increase in food demand on waste production (Balineau et al., 2020).

The search for energy independency from imported fossil fuel and energy security have been driving an ambitious national strategy for renewable energy from hydroelectric, solar and wind power, placing Morocco as a regional leader in the deployment of renewable energy in North Africa (IEA, 2019). Although the production of renewable energy is soaring, its share in total final consumption (TFC) has decreased over the past decade as the electricity demand has witnessed significant increase due to population and economic growth, the increase in per capita consumption, and the continuous deployment of electrification projects (Gupta, 2009; UN, 2021). Some argue that, by making the withdrawal of groundwater more affordable, the development of renewable energy has contributed to exacerbating the already daunting issue of groundwater overextraction. On another hand, while access to affordable energy is an issue for some farmers, subsidized butane has also led to excessive energy consumption for agriculture (Sinan, 2020).

3.1.2 Adaptive capacity

Morocco has reached many development targets in the sectors of water, energy, and food, over the past decades. The country has developed a strong know-how and experiences, and has launched a number of ambitious and promising national initiatives and programs. Recent social and political changes in Morocco, including the influence of the 'Arab Spring', are leading to increasing transparency, decentralization and the empowerment of local civil society support the re-appropriation of water, livelihoods and power. In part due to an ideal geographical location, Morocco has also been involved in several international initiatives and regional projects facilitating synergies. For example, Morocco is an important player in the Euro-Mediterranean energy hub (Choukri et al., 2017). There are some ongoing efforts to create regional multi-service organizations to join efforts and assets regarding drinking water and electricity distribution, and water treatment, with the intention to reach economy of scale and coordinated actions.

However, the adaptive capacity exemplified by these progresses and initiatives are outweighed by a set of drawbacks. The relevance of the instruments developed to bring the sectoral plans to fruition

is often put into questions, due to the missing links between goals and practical implementation (Faysse, 2015). While water management is shining for its extensive technical know-how, infrastructure network, and the sustained effort to think solutions to converge towards water security (Ersoy et al., 2021; Hasnaoui et al., 2015; Hirich et al., 2016; El Jaouhari et al., 2018). It is often developed with a single objective in mind, which yields to unintended consequences. For example, studies have evidenced that the water efficient drip irrigation technique promoted under the Green Morocco Plan have served to extend the surface irrigated, not reduce water consumption. They have also evidenced that they have discriminated against less-educated farmers and smallholders (Jobbins et al., 2015). So far, these plans yield results on increasing availability and access on water but mostly fail to regulate a sustainable use (*who?, what?, how much?*).

More generally, WEF sectors are planned and managed in a fragmented, sectoral-oriented approach (Sinan, 2020), and a lot of barriers remain on the way of an integrated, coherent and sustainable management of the nexus. A critical weak point lays in the institutional fragility, inadequate governance, the multiplicity of institutions and actors and the lack of coordination between the various public institutions. Organisations such as the Higher Council for Water and Climate are reported to not comply their coordination role. The lack of autonomy and insufficient financial and human resources are said to undermine the effectiveness of the basin hydraulic agencies in charge of facilitating an integrated water management. At the local scale, the management is also conducted in a narrowly sectoral approach, by viewing the farm plot as disconnected systems that can be managed independently of anything else. The fundamental problem is often seen in terms of maximizing productivity, maximizing crop a drop on a farm, without thinking about it at the level of the water. Such approach can be partially attributed to the training of an older generation of engineers that is dominating the public sector. The energy sector too is lacking coordination and cooperation between the various stakeholders, political groups, and ministries, which hampers the consensus around the promotion of renewable energy (Choukri et al., 2017). Besides the coordination issues, the further development of renewable energy might be hampered by insufficient financial support for small scale projects and major technical issues related to the intermittent nature of this energy source. The difficulty for small-scale, community-based projects is also linked to the laws themselves such as the Act 13–09 law that tends to facilitate only large-scale projects (Choukri et al., 2017).

On the positive side, investment in renewable energy contributes to reducing CO2 emissions and hence to meeting Morocco's clean energy and Morocco's post-COP21 climate change commitments, in addition to helps increase Morocco's energy security.

Another weak point in Morocco is the issue of the data and studies that are not published. Among other things, the agricultural census from 2016-2017 was conducted but never published. This data sharing issue is a major problem.

In some sectors such as energy, the workforce is aging and facing waves of retirement, while there is not enough of operational young graduates to take over. There is also a scarcity of skills in new technologies, especially those related to renewable energy and energy efficiency (Agence Française de Developpement, 2021), which may jeopardize the development of the energy plan.

3.2 Institutions and policy programmes

The main institutions and programs on WEF in Morocco are listed in Table 3 and Table 4, respectively.

Table 3. Moroccan institutions in the WEF sectors.

Name of organisation and/or Programme	Main focus	Relevance to pilot domain
Ministry of Energy, Mines, Water and the Environment (MEMEE)		
Water Department (DE)	Research, assessment, planning, development, and management of water resources, as well as weather watch on climate change. It is made up of 3 directions: (i) the general directorate of hydraulics, (ii) the management of hydraulic installations and (iii) the direction of research and water planning.	WATER
National Office of electricity and drinking water (ONEE and ONEP)	Supply of drinking water and management of liquid sanitation.	WATER and ENERGY - WASH + ENERGY?
Agency of Hydraulic Basins (ABH, 9 in total)	Water management in Morocco is organized into nine large hydraulic basins, each of which have their "Basin Agency", a public administrative establishment endowed with legal personality and financial autonomy in charge of ensuring the integrated management of water resources.	WATER -management
Water services at the level of each province		WATER
The Moroccan Agency for Solar Energy (MASEN)		ENERGY - Solar
The National Agency for the Development of Renewable Energy and Energy Efficiency (ADEREE)		ENERGY - renewable ENERGY, ENERGY efficiency
The Energy Investment Corporation (EIS)		ENERGY
The Research Institute for Solar Energy and New Energy (IRESEN)	Carries out a broad range of energy RD&D activities in close collaboration with the private sector	ENERGY - R&D, private sector
Ministry of Agriculture and Fishery (MAPM)		
Offices Régionaux de Mise en Valeur Agricole (9, ORMVA)	Responsible for the development and agricultural development of the irrigated areas of the large hydraulics. Their three fundamental missions: planning, agricultural development and water service	FOOD and WATER - agriculture, irrigation, large hydraulics
Provincial Directorates of Agriculture (DPA)	Responsible for the implementation and monitoring of small and medium hydraulic perimeters outside the ORMVA action areas, on the basis of centralized planning at the level of the Rural Engineering Administration. They only intervene in the management of irrigation networks to carry out major maintenance work	FOOD and WATER - agriculture, irrigation, small and medium hydraulics
Agricultural Development Agency (ADA)	Responsible for the implementation of the strategy adopted by the government in the area of agricultural development.	FOOD - Agriculture development
Ministry of the interior - Water and sanitation directorate		

Name of organisation and/or Programme	Main focus	Relevance to pilot domain
Ministry of the interior - Management and Licensed Services Department		WATER
Consultative and intersectoral coordination bodies		
Higher Council for Water and Climate (CSEC)	Brings together the various stakeholders in the water sector, namely decision-makers, elected officials and users and public and private actors, and its fundamental mission is to formulate the general orientations of the national water and climate policy	WATER and climate - coordination, strategy development
The interministerial water commission (CIE)	Examines and implements the necessary measures to ensure a coherent and concerted development of the water sector, to monitor the implementation. recommendations from the CSEC. It is made up of representatives of all ministerial departments concerned with water issues	WATER and climate- coordination, strategy implementation
The High Commission for Water and Forests and Against Desertification		WATER
The National Environment Council (CNE) and its regional variations, the Regional Environment Councils (CRE)		
The Prefectural and Provincial Water Commissions (CPPE)		WATER
Agricultural water users' association (AUEA)	Aims to allow users to participate in the construction of the irrigation network and to make them responsible for its maintenance	WATER and FOOD - Agriculte, irrigation, community

Table 4. Strategies and programs related to the WEF nexus in Morocco.

Strategies and programs	Launch date / horizon	Institution	Objectives	Sector
Green Morocco Plan (Plan Maroc Vert PMV)	2008	Agricultural Development Agency, Ministry of Agriculture via the Regional and Provincial Directorates of Agriculture, the Regional Offices for Agricultural Development (ORMVA), and the National Office of the agricultural council (ONCA).	Ambitions to place agriculture at the heart of the national economy. The first pilar aims to accelerate the development of agriculture with high added value and high productivity. This Pillar requires many investments, among others in the industry related to the sector and in irrigation. The second objective is to fight against poverty and promote the maintenance of a certain population density in rural areas.	FOOD - agriculture
Generation Green	2020-2030	Ministry of agriculture, Fisheries, Rural Development, Water and Forest - Department of Agriculture	Aims to consolidates the outcomes of the PMV. It has a focus on the human dimension and aims to boost small and medium farms secure employment and revenues and spur agricultural entrepreneurship. It also aims to develop further the agricultural sector by doubling its share in the kingdom's GDP, reducing the trade balance by exporting more, and producing more products with high added value.	WATER and FOOD
National water strategy	2009; 2009-2020		Includes six axes around the management of water demand, water mobilisation through infrastructures and the use of unconventional water, environmental measures to protect the water quality and aquatic ecosystems, and reforms of the institutional and legal framework.	WATER - supply and demand management, protection
National Program for Drinking Water Supply and Irrigation	2020-2027	Ministère de l'Equipement, du Tranport, de la Logistique et de l'Eau Direction Générale de l'Eau	5 axes: - the development of the water supply (new large and small dams, seawater desalination, groundwater prospection and clearing, equipment and adductions) ; - demand management and water recovery; - strengthening the supply of drinking water in rural areas; - reuse of purified wastewater; - communication and awareness	WATER - supply and demand management, protection

National Program for Irrigation Water Saving (PNEEI)	2009; 2009-2020		Transversal measure in the PMV. Aims to increase the water use efficiency through the modernisation of the irrigation network, the conversion to localized irrigation, and the promotion and valorisation of crops with high added value.	WATER and FOOD - irrigation
Integrated water resources development master plan (PDAIRE)		Agencies of hydraulic basins	Established for each basin or set of hydraulic basins, taking into consideration the strategic orientations and prescriptions of the national water plan.	WATER management
National liquid sanitation and wastewater treatment program (PNA)	2005		Setting the objectives for 2020 and 2030 in terms of sanitation service and treatment rate	WATER - WASH and WATER treatment
Plan National de Protection Contre les Inondations (PNPCI)		Ministry of Regional Planning, Water and the Environment Secretary of State for Water Directorate General of Hydraulics Research and Planning Department the water		WATER - flood
National Energy Strategy	2009		Objective to increase the renewable energy and the overall energy efficiency. The targets was to reach 42% of the installed electric power in renewable in 2020, and 52% in 2030.	ENERGY - renewable ENERGY, private sector, PPP
National Strategy for nutrition	2011-2019	Health ministry		FOOD - health and nutrition
Blue plan		Non-governmental association “Plan Bleu pour l’Environnement et le Développement en Méditerranée”	Making the Mediterranean a space for cooperation for sustainable development.	

3.3 Case studies

Box 4: Decentralized groundwater management as a solution to adapt to expected increased water shortage due to climate change and other drivers?

Groundwater is a common good: its use is nonexclusive (it is not possible to exclude a user from using groundwater), but there is a rivalry in the use (the consumption by one user diminishes the quantity of water available for another user). When water withdrawal exceeds water refill, there comes the problem of overexploitation, diminution of groundwater level and all cascades into socio-economic and environmental costs. As such, groundwater overexploitation resulting from uncoordinated and uncontrolled individual extraction is a classic example of the tragedy of the commons. Montignoul et al., (2020) analysed the management of the Souss Massa basin in Morocco together with five other Mediterranean groundwater basins. The goal was to study how a tragedy of the commons can be avoided.

The Souss Massa groundwater is mostly used for the irrigation of exportation crops (citrus and vegetables). Groundwater has been increasingly exploited due to technical progress and national development programs. Numbers provided show that the withdrawn volume of groundwater is twice as important as the renewable groundwater volume. As a results, groundwater level data from 1949 to 2005 show a continuous decline that seems to exacerbate after 1990. Such decline has resulted in making the access to water more difficult or expensive, and to salinization. These issues jeopardize the overall water security in the region and are especially consequential for the most fragile portion of the population.

To control the groundwater use, various instruments were successively put in place, from repressive measures implemented in 1998 to a first water contract in 2004 that prove to be a failure, and a second water contract signed in 2015. This contract regulates the redistribution of powers to the benefit of users and facilitates the regularization of undeclared drilling.

The authors of the study concluded that the severe shortage on the Souss-Massa water is what has forced users to become aware themselves of the limits of the resource. This collective awareness, accompanied by firm measures on the part of the State, made it possible to initiate a process of user participation, a precursor to the 2015 groundwater contract. They conclude that it is easier to implement management measures when users are actually facing a shortage than in anticipation. However, they suggested that the effect of these measurements is likely insufficient to reverse the decreasing trend in water level. They highlight that the State is having difficulty enforcing the contract and recommended that, to make these contracts enforceable against third parties, it is necessary to define an intermediary organization where the users would have a more important place in the control, the definition of rules and the elaboration of sanctions.

Overall, the study highlighted that decentralized management, i.e., conducted by intermediate agents can only be effective if supported by economic instruments that encourage water saving, or the sharing of information.

Box 5: To what end? Drip irrigation and the water–energy–food nexus in Morocco

Drip irrigation has been long praised for being a water-efficient technology that reduces the pressure on the water resources while increasing the tolerance to drought and hence agriculture productivity and food security. By requiring less energy than flood irrigation with pumped groundwater, drip irrigation can also decrease the energy cost. Hence, drip irrigation represents a compelling case of the interlinkages between food production and water and energy use efficiency. The technique has been promoted and heavily subsidized by Morocco under the Green Morocco Plan since 2009. In spite of its promises for reducing the pressures on water resources, questions arise regarding the actual benefits and possible limitations and unintended consequences of such a conversion plan.

Jobbins et al. (2015) studied such implications through three study cases in Bitit and Ain Chega, Sebou, Lamzoudia, Tensift, and Guerdane and Issen, Souss Massa. They showed that several barriers are limiting the uptake of drip irrigation as well as unintended consequence of the conversion when it happens, hence preventing the conversion program to fullfill its objectives in terms of WEF security.

In summary, this study reveals the complex and at time unexpected dynamic that emerges when implementing such WEF programs, and shows that the adoption of technology offering water and energy use efficiency can be insufficient by itself to resolve the issues of scarcity. The results achieved can be different than the initial objectives. The results from this study suggest that productivity maximization and poverty reduction were found to be prioritized by the users over a reduction on the pressure on water resources. On the other hand, it also showed that this program can exacerbate social and economic inequalities. As stated by the authors, such nexus policy does not always lead to win-win but, instead, to winners and losers. Hence, they highlight the importance of a careful assessment of the socio-economical context when designing such nexus policies, and the need for these policies to target specific user groups in specific contexts. Importantly, the authors stressed that, "if the WEF nexus is to benefit small farmers, it should purposefully integrate ex ante evaluation of distributional impacts and engage with pro-poor development agendas." and that a careful anticipation of institutional barriers should be made when designing policy support such conversion program.

3.4 Reflections and pointers for future action

The WEF nexus in Morocco ripples down to critical socio-economic and environmental challenges that are being exacerbated by climatic, societal and economic changes. While there are a few encouraging initiatives and while a set of promising strategies and plans have been defined to meet these challenges, major barriers persist. The management remain mostly sector-oriented, and the instruments are lacking to translate the strategic objectives into impactful actions. The institutional landscape is scattered among multiple organisations that are lacking coordination. A persisting concern is the worrying drop in groundwater level and the overall degradation of water quality. Water is critical for agriculture, the main economic driver in Morocco, and other livelihood activities. But these activities most often don't account for the limited aspect of the resource, contributing to its depletion and degradation. The vital and economic nature of this resources makes its use extremely difficult to control and regulate in the face of lobby and individualistic uses. There is an urgency to enact a management that yields more resilience. A few recommendations for doing so are provided below:

- Manage water following an integrated management of the water resources (IWRM). Such management requires an extensive knowledge of the quantity and quality of the resource, and the current and projected needs by sometimes competing users, and up to dated, context-specific legal framework for water management, regulation and incentive, authority to enforce the law, decentralization processes through agencies, observatories for water monitoring and data

collection. The coordination and of all the organisations, from local to international, involved int water management is also crucial.

- Facilitate local experts on the ground who are trusted by communities to disseminate knowledge on how to apply adaptive technologies, what crops to grow, and how to use and store water efficiently.
- Have a strategic conversation about the economic collective efficiency of water and the role of water in the economy beyond agriculture and the big farms.
- Adjust agricultural strategies away from water intensive export crops. This requires a mind shift from thinking how to generate growth and then retrofitting sustainability issues, to what needs to be done to achieve sustainability and adapt to climate and environmental change, and then think about where opportunities lie for creating growth, jobs, etc.
- Think strategically about the role of water in the economy: integrating issues of climate risk, climate change, water management, as not a sectoral issue, not as environmental issues, they should be core economic development issues. One of the key ways of doing this is to look at tools like multi-donor trust funds, which are linked to economic development strategies.
- Assess each development cooperation projects in terms of the big picture: The project screening process should include questions related to the possible negative environmental consequences either in terms of climate mitigation, undermining climate resilience, exacerbating water insecurity, etc. How does it contribute to that?
- Make sure that the donor community is speaking with a single voice. One way to do so is to channel funding through multilateral organisations.
- Use COVID-19 recovery as an opportunity to rethink strategies.

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Annex 1 Salient numbers and facts on the water, energy and food sectors in Morocco

Water

A water-scarce country - Climate in Morocco is semi-arid to arid. Annual average precipitation is 346 mm with an important spatial variability ranging from 25 to 700 mm due to combined influence from mountains, sea and ocean, and the Sahara (Figure 3). With about 700 m^3 water / habitant / year, the country is classified as water scarce. Given the scarcity and spatiotemporal variability of the resources, its proper management is vital.

The spatial repartition of surface water is very inhomogeneous across the country, while groundwater is better distributed. No surface or groundwater fluxes enter the country apart from a small volume of water exported to Algeria, so there is no international dependency in terms of water and water-related challenges remain internal to the country.

The Law 10/95 on water constitutes the legal basis for carrying out an integrated management of water resources. It marked a turning point in the history of water management in Morocco. It lays down the elements of concerted management involving all stakeholders and recognizes for the first time the economic value of water through the introduction of the withdrawer - pay principle; polluter pays. Water management in Morocco is organized into nine large hydraulic basins, each of which have their "Basin Agency", a public administrative establishment endowed with legal personality and financial autonomy in charge of ensuring the integrated management of water resources.

86% of withdrawn water in Morocco for irrigation through the large hydraulic infrastructure and the small and intermediate hydraulic infrastructures. Given the overall scarcity of the resource and its important spatial and temporal variability, the country has long been investing in hydraulic infrastructures to facilitate the mobilisation and transfer of surface and groundwater. The effort chiefly started after its independence in 1956 with a continuous investment in a large network of small and big hydraulic infrastructures. The commonly called “big hydraulic” represents nine major irrigation perimeters mainly fed by dam water and represent priority areas for the agricultural development of the country. Besides the big hydraulic infrastructures, the “small and intermediate hydraulics” are scattered across the country and consist of a variety of smaller infrastructures and strategies for water mobilisation and use such as smaller dams, “hill dams”, ‘source capture”, groundwater pumping, flood water, etc. The FAO georeferenced database on dams[3] reported 152 dams in Morocco, 93 being used for irrigation, 56 for water supply, 28 for livestock rearing, 27 for flood control, 22 for hydroelectricity, 1 for recreation, and 2 for pollution control. Morocco is renowned for having such a reliable infrastructure network and an excellent technical mastery of its resources. In 2019, 86% of withdrawn water in Morocco were for irrigation. Irrigated areas represent 21% of cultivated areas each year.

In spite of these engineering solutions, water-scarcity issues remain remnant and are aggravated by demographic and economic development and climate change. In the late 2000, the water sector was revised through a series of national development strategies including the National Water Plan, the Green Morocco Plan, and the national plan for irrigation water saving. The various axes covered the quality improvement of the water service through the modernization of hydro-agricultural equipment, enhancing

[3] http://www.fao.org/aquastat/en/databases/dams

the value of water and building the capacities of farmers in irrigation, environmental measures to protect the water quality and aquatic ecosystems, and reforms of the institutional and legal framework. At the end of 2019, the collective reconversion yielded on the modernization of 22 pumping stations, 3 km of the irrigation network and 807 irrigation terminals between 2008 and 2019 (Ministère de l'Agriculture de le Pêche maritime du Développement Rural et des Eaux et Forêts, 2019). During that period, areas equipped with drip irrigation went from 160,000 ha to 585,000 ha (Media 24, 2020). Of this area, 750,000 ha benefit from Green Morocco Plan irrigation programs (Media 24, 2018).

>86 % of the population with access to at least basic sanitation and drinking water services in 2017. In terms of water hygiene and sanitation, the situation has improved significantly although critical challenges remain (UN, 2021).

94.6 % of anthropogenic wastewater was released in the environment without treatment in 2018, which represent an enormous environmental and sanitary risk 2017 (UN, 2021).

Overall, it was recognized that significant challenges remain for Morocco to reach the Sustainable Development Goal 6 (SDG6) on clear water and sanitation, but that it was on track to reach it (UN, 2021).

Food

World hunger index in 2018 indicated Morocco being in a situation of "moderate hunger"

Diet in Morocco is mainly based on cereals, although there has been an increased diversification of the consumed products. The prevalence of undernourishment has witnessed a general decrease between 2000 and 2015, from 6.4% average in 2000-2002 to 4.3% average for the 2017-2019 period (FAO Stat, (UN, 2021). The world hunger index in 2018 indicating Morocco being in a situation of "moderate hunger". The prevalence of stunted children is more worrisome. It has decreased from 23.1% in 2003 to15.1% in 2017, a high percentage that remains a critical challenge for the country 2017 (UN, 2021). On the other hand, the percentage of obesity (BMI >30%) in the adult population has witnessed a steady increase from 16.7% in 2000 to 26.1% in 2016 (FAOStat, UN, 2021), which constitute a major health problem in Morocco. (Benjelloun, 2002)

Agriculture and agro-industry are the motor of the Moroccan economy

National food production currently provides around 50 % of the needs. Results from the Green Morocco Plan include an increase of food self-sufficiency to 60 to 70% for cereals, 98 to 100% for meat and milk, 100% for fruits and vegetables, and 47 % for sugar (Media 24, 2020). Hence, food is tightly connected to the agricultural sector. This sector is the motor of the Moroccan economy, contributing to 13.6% of its GDP in 2017, and this contribution is currently rising in both absolute and relative terms. Morocco agro-industrial system is also on the rise, contributing to 3.9% of the GDP. Agriculture production and hence contribution to GDP is strongly influenced by the climate whose variability and hazards leads to large fluctuation to the agricultural production and hence contribution to GDP. In 2017, the agricultural sector employed 37.5% of the workforce nationwide, and 72.9 % in rural areas (Harbouze et al., 2019). Yet, Morocco is increasingly dependent on importation, in particular for cereals, sugar, and alimentary oils, while the country is self-sufficient when it comes to meat, fruits and vegetables, and most of its dairies.

The Plan Maroc Vert in 2008 to boost the agricultural sector and increase food security

In face of a food crisis in 2007, an insufficient agricultural productivity, and a negative commercial food balance, Morocco has launched the Plan Maroc Vert (PMV) in 2008 to boost the agricultural sector as a driver for the National economy. The first axis of the plan was about modernising the agricultural sector in the context of the global market. The second axis was about improving food security and consolidating the socio-economic fabric by accompanying the small farmers in securing and improving their income. The plan has led to an overall increase of food production per habitant, an increased productivity in cereal production, and a diversification of the exportation products (Media 24, 2020). Private investments and foreign investments (IDE) have also increased, in part as a result of the plan, and 1632 public-private partnership (PPP) projects have been implemented, the majority of which with farms smaller than 20 ha (Harbouze et al., 2019).

In spite of all the infrastructures in place, irrigation water needs are not fully met, and water still represents a limiting factor in the agricultural production.

Overall, it was recognized that major challenges remain for Morocco to reach the Sustainable Development Goal 2 on Zero Hunger, but that it was moderately improving (UN, 2021).

Energy

Morocco has full access to electricity for its population (100%) (UN, 2021). Electricity demand has witnessed significant increase at a 6.5 average annual rate from 2002 to 2015 due to population and economic growth, the increase in per capita consumption, and the continuous deployment of electrification projects. Population with access to clean fuels and technology for cooking reached 96.8% in 2016 (UN, 2021).

The CO2 emissions from fuel combustion for electricity and heating per total electricity output reached 1.8 MtCO2/TWh in 2018, which remains a major challenge for Morocco (UN, 2021)

No fossil fuel but huge potential for renewable energy

Critical characteristic of the country is that it does no hold any fossil fuel resources. It hence has long depended on the international primary energy: in 2011, the country imported 95.6% of its energy demand (Choukri et al., 2017; Leidreiter & Boselli, 2015). However, Morocco has a significant potential for renewable energy. In 2009, Morocco adopted a National Energy Strategy with the overarching goal to reduce the dependence of the sector on fossil fuels, and reach energy security through the development and increase of renewable energy and the boost of energy efficiency.

The initial target was to reach 42% of the installed electric power in renewable in 2020 (33%, 33%, 33%). Following the encouraging progress achieved during the first years of implementation, the target was upgraded to 52% (20% wind, 20% solar, and 12% hydropower energy) by 2030. To help reach these goals, Morocco opened its renewable energy market to the private sector with the Act No 13-09 for the production, purchase and commercialization of renewable energy, and by promoting and building PPPs. This National Energy Strategy is placing Morocco as a regional leader in the deployment of renewable energy in North Africa (IEA, 2019).

Hydro-electric plants were the dominant sources of renewable energy in 2015, with the installed hydro-electric power capacity reaching 1770 MW versus 797 MW and 180 MW for wind and solar, respectively. However, because of the limited hydro resources, the country has mainly developed

programs to boost solar and wind energy projects. The installed hydro capacity in 2030 is expected to be 3100 MW versus 5000 MW and 4800 MW for wind and solar, respectively (Choukri et al., 2017).

Overall, it was recognized that challenges remain for Morocco to reach SDG7 on affordable and clean energy and that it was moderately improving (UN, 2021).