







Communication

A Holistic Framework towards Developing a Climate-Smart Agri-Food System in the Middle East and North Africa: A Regional Dialogue and Synthesis

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Abstract: Agriculture and agri-food systems of the highly vulnerable Middle East and North Africa (MENA) region needs a radical transformation under a changing climate. Based on a two-year effort, initially we developed a mega hypothesis on how to achieve climate-smart agri-food transformation in the region. In the study, we hypothesized that “Climate-Smart Lifts” implemented in the enabling environments can rapidly facilitate agri-food transformation in the region. In order to gather the stakeholders’ perception about this, we organized a collective conversation among ~400 stakeholders that represent various scales and sectors within the agriculture sector in MENA. These “listening cum learning consultations” were conducted through a survey followed by a series of webinars. The webinar discussions were strategically guided based on our hypothesis, the responses from the surveys and the regional needs. These discussions provided a forum to bring-out the stakeholders’ perspective on what new knowledge, partnerships, instruments and projects were needed in the MENA. The deliberation focused on the opportunities of public–private partnerships focusing in all the four major agroecosystems in MENA (irrigated, rainfed, rangelands, and deserts). In result, we developed an effective framework for strategic resource mobilization in the region, keeping in view the strong regional needs for climate actions and the requisite long-term commitments for the SDGs implementation.

Keywords: climate preparedness; research for development Lifts; public–private partnerships; climate smart agri-food systems; MENA region

1. Introduction

The Middle East and North Africa (MENA) is highly vulnerable to climate change, which drives increasing socio-economic challenges in the region such as an exponential increase in food and water demand, increased dependence on food imports, changes in water supply, and increased heat and aridity [1,2]. As one of the world’s most dynamic regions, MENA is home to 6% of the global population, who are demographically, economically, and politically diverse [3]. Their food and water security situation is already the worst and beyond the hydrological resource capacity of the region, while the population is

further expected to be doubled by 2070, which would increase pressure on the resources and will bring more social unrest and conflicts [4].

Currently, the region has access to only 1% of the world's renewable water supply which is among the lowest in the world [5] and their average water availability is only 1200 cubic meters per year, compared to the worldwide average of 7000 cubic meters per year [6]. It has the highest percentage for renewable water resource withdrawal with seasonal water imbalances and limited rain frequencies. Climate change is further exaggerating this severe water scarcity [7,8]. According to the regional climate forecast, the region's temperature would rise by 2 °C in 2030, and countries in this region would be further subjected to water shortage with high inter-annual variability of precipitation [9–11]. Thereby, encroaching heat and desertification as a result of climate change are also contributing to the displacement of farming activities, declining soil fertility, and limiting future agricultural productivity in the region. As is obvious from Figure 1a, the mean annual temperature anomaly for the period (1980 and 2100) is extremely high in the majority of areas in the MENA, and the climate would be alarming in the next decades under RCP 4.5 and 8.5 scenarios. By the end of the century, these anomalies can reach as high as 5–6 °C under RCP 8.5 which may affect much of the agrifood systems in the region.

The MENA region supports diversified agro-ecological systems such as rain-fed, irrigated, agro-pastoral, and desert farming, and their distribution is shown in Figure 1b. However, food production is not sufficient to meet the dietary needs of the booming population, which compels many Arabic countries to import the majority of cereals, i.e., rice, wheat, maize, and barley from other countries. The domestic production of major cereals is mainly constrained by the demand from rapidly growing populations, lower crop productivity, shifting dietary patterns, and challenging policies, leading to heavy dependence on food imports [12,13]. The food imports dependency is exceeding in some MENA countries that determines their marked dependency on the other countries' water resources. For example, Iraq, Mauritania, and Oman's import ratios are 30% whereas in Yemen it is about 50%, and for the Persian Gulf Arab countries such as Kuwait and the UAE it may reach up to 70% [14]. Gradually, this region is plunging into food instability due to its growing dependency on international food markets. Although via certain policy interventions, they made staple food accessible at low prices, stability remains a challenge in some countries due to civil wars, political instabilities, and the outbreak of deadly diseases, which is upsetting the resource balancing in the MENA region. One of the recent examples is the geopolitical conflicts in Libya, Yemen, Syria, and Iraq which would take years to reach a normal state. In such critical situations, these countries have had the challenge of malnutrition, low food quality and high food wastage, and the collapse of the existing food supply and distribution systems. Meanwhile, with erratic climatic behavior, agriculture and agri-food systems in the region are already dwindling, which necessitates moving towards bringing a radical transformation in agri-food systems which is necessary to meet the food and dietary needs of the MENA region [15].

Water is an invaluable resource for agriculture in the arid MENA with 70–85% of food production depending on existing water resources that are continuously diminishing with changing climate. It is assumed that with the growing water scarcity, energy-intensive technologies such as water desalination would be the only alternative. Groundwater resource exploitation has reached up to 50–100% in many countries such as Egypt, Libya, Tunisia, and Palestine [17,18]. This water crisis could be a major threat to MENA's economies over the next ten years. These unsustainable trends leading to hydrological imbalances-related complexities would exacerbate if weak water governance and weak climate adaptation measures will continue.

The world bank reported that, by 2050, MENA could suffer from the greatest economic loss due to climate-related water scarcity. It is expected to severely constrain communities' livelihood and economic development in the next years. Unfortunately, the existing water resources management measures are incapable of bridging the water gap between the available water resources and rising water demand, most of the MENA countries have

over-exploited their groundwater resources and are heavily depending on non-traditional water resources such as desalination plants and wastewater treatment that are costing high in terms of fuel energy and has a greater environmental impact, this situation has affected mostly the agriculture sector, which is the largest water-consuming sector in all MENA countries [19,20].

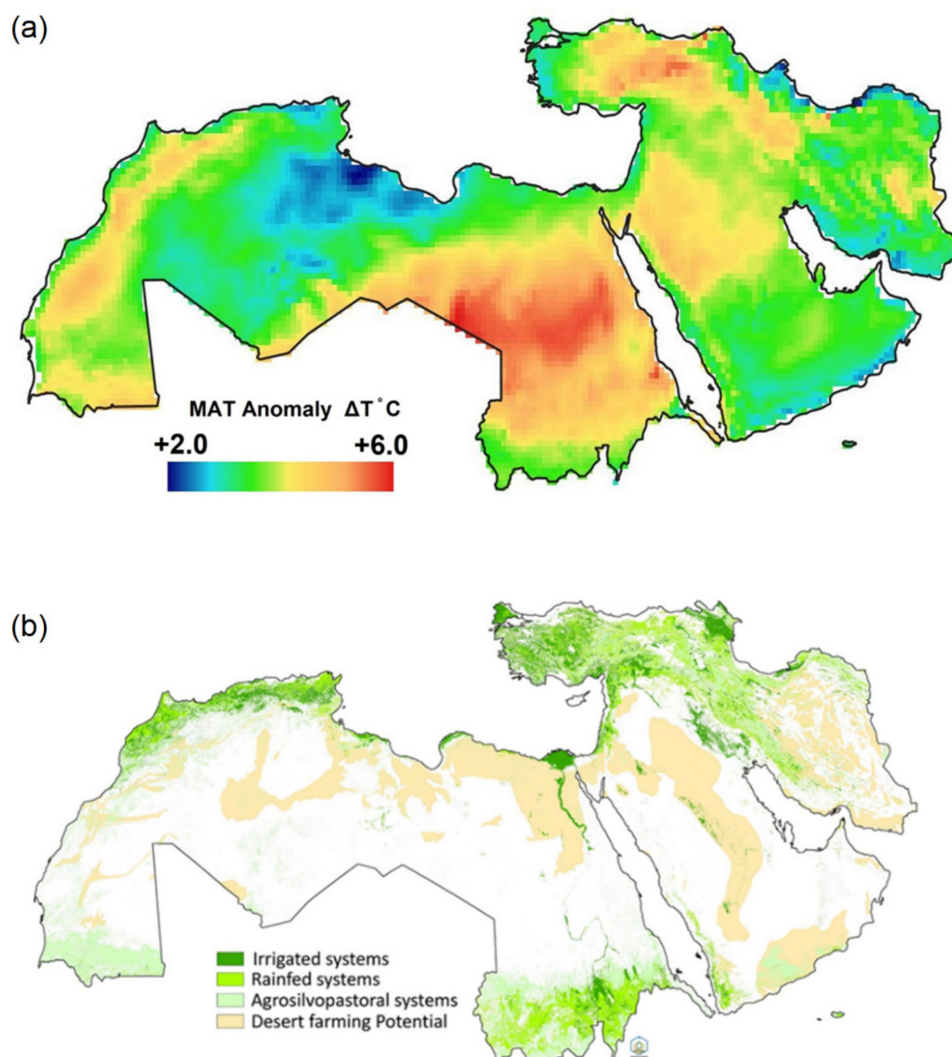


Figure 1. (a) The climate vulnerability map of the MENA region derived from the RICCAR climate product [16] by analyzing 1980–2100 for RCP8.5 and RCP 4.5 to show the temperature difference map (ΔT) of the mean annual temperature between 1980 and 2100 for RCP 8.5 which is business as usual climate scenario. (b) The spatial distribution of the four main agroecosystems in MENA viz. rain fed, irrigated, agro-pastoral rangelands and desert agriculture, developed using satellite remote sensing and spatial modelling.

Another challenge is the food security problems in the region, the existing food security measures are mainly focused on food availability which resulted in malnutrition and undernutrition in societies. This overlooked the significance of nutritional security in the chain of food accessibility, utilization, and stability. The MENA countries still requiring policies and programs to promote the availability and accessibility of nutritious food. Not only the accessibility of nutritious food but also the positive changes to the food consumption patterns are needed to add food diversity in the value chains. For example, Bahn et al. (2019) highlight the need for revising country-specific food-based dietary guidelines to include the dimension of sustainability, by trading off red meat consumption

with vegetables/beans because of providing both health and environmental benefits to populations [21]. MENA countries need to manage such dietary transformations through coherences and coordination in their technical, institutional, and policy instruments, and such efforts can uplift food security and nutrition in the region.

Because agriculture is the essential source of livelihood in the rural areas of MENA it plays a crucial role in providing economic stability, jobs, food security, and economic opportunities (despite the prevailing volatility in climate, markets, and geopolitics). However, it requires the inclusion of climate-smart agriculture interventions. Such transformation is important for meeting the needs of the growing urban population for nutritious and affordable food. Thereby, declining human capital by rural-urban migrations can be sustained but it requires quick actions in strengthening the agri-food businesses in the urban markets.

Digital technologies are thought to accelerate climate smartness of the countries and its stakeholders. However, the region's experience with digital technologies for their high-value production for domestic markets and rarely found in the middle-income MENA countries such as Egypt, Morocco, Tunisia, etc. [15]. The use of digital technologies in the agriculture value chain can improve the efficiency of the agricultural food production system to some extent, as reported in [22,23]. Unfortunately, the majority of marginal areas of the MENA region are deprived of these technical interventions, mainly due to systemic inefficiencies, inequalities, and the lack of transparency in resource flow, which demands fair-rule policies and governance in future public-private partnerships [24]. Positive technological changes can bring new opportunities in the farming systems of MENA countries and can harness the un-exploited agricultural potential which would lead to the revival of economic sustainability in the region. Moreover, agricultural production can also be increased by transforming their conventional cropping systems with a shorter duration and high-yielding crop varieties. The measures of enhancing rain-fed and irrigation water use efficiency of the existing cropping systems under limited water conditions will increase agricultural productivity as well as rural income. It requires more public investments in the domestic programs of rain-fed and irrigation water use systems and a strong regional commitment towards increasing the water productivity of the crops.

For the sustainability of MENA's agro-ecosystems, countries need to develop long-term initiatives that have a water-food-energy nexus spirit. Although there are some examples of nexus implementation in MENA, such as drip irrigation and solar-powered irrigation systems in Morocco, water storage and wastewater treatment in Jordan, and diversified cropping systems in Lebanon, they are not sufficient for regional needs and are not scaled up adequately. While these countries took such NEXUS approach across various sectors with the common goal of improving environmental, climate, human and political security, which is challenging for some MENA countries such as Palestine, Jordan, and Syria, that have transboundary water resources and agricultural production depends on shared water resources. This makes cooperative management of water resources very pertinent. This creates regional tensions and an elevated risk of conflicts in integrated policy negotiations and mutual agreements under the current water scarcity scenarios [25]. The weak implementation of the nexus approach is also due to the existence of rigid sectoral boundaries and insufficient incentives for integrated policymaking in the MENA countries. The lack of technical and infrastructural capacities, and practical experience to facilitate technology development and investment has made integrations challenging. Given the enormous pressure on the water and land resources in the MENA region, strong links for nexus implementation are needed through capacity building and the acceleration of shared experiences of the initial implementations with multi actors' collaborations from different sectors and scales [26]. On the other side, future policies require extensive quantitative analysis and a strong multi-actor consensus towards agri-food system development.

The Significance of Agri-Food Transformations in the MENA Region

From the above literature study and lesson learnt from various projects, the key climate related challenges are found in MENA, such as:

Biophysical. The region is already arid. Under a changing climate, much of the region is expected to get drier and hotter. Climate modelling estimates show that, by the end of the century, the mean annual temperature anomalies can reach as high as 5–6 °C under RCP 8.5 which may affect much of the rainfed or agro-pastoral agroecosystems, Figure 1a.

Socio-economic. Huge socio-economic disparities prevail in this region. Many countries have substantial income disparities (high Gini coefficient), and the socio-economic inequalities increase rapidly. Gender issues and youth unemployment are grim.

Population Growth. The population is growing at a much faster rate. This warrants sustainable agri-food systems' enhanced food security at affordable prices. Climate change and economic changes also encourage demographic shifts due to migration.

Poor Governance in a Changing Technological Context. The key challenge in the region is a fragmented and un-coordinated climate change planning platform with poor governance and institutions. Although technology in agriculture and related sectors is rapidly progressing, many MENA countries are far behind in adopting and adapting to new technological atmospheres. Thus, MENA's agri-food systems trail behind at the international level and needs a coordinated good governance, adept with changing technology.

Changing Dietary Patterns. Due to changing urbanization, income disparities and globalized economies, dietary patterns are rapidly changing [27]. Urban, and rural food quality demands are quite different and dynamic. Agri-food systems need to cope with this and be prepared to reduce dependency on imports.

Declining Water Resources. Although this is related to the biophysical aspect of climate change, this is a critical element that governs the mainstay of MENA's agri-food system. Socio-economic trends warrant increased urbanization and water use resulting in an enormous generation of marginal water with regard to a decline of natural water resources for the agricultural sector in terms of availability and quality.

The main issue is that small-scale farmers who directly depend on these fragile natural resources for subsistence agriculture are among the most vulnerable to the effects of climate change. Improving their adaptive capacity to withstand climate-induced shocks should thus be given due priority by enhancing the socio-ecological resilience of households through sustainable intensification, diversification, and effective market linkages facilitated through value chains that spread across the entire food system, i.e., the production, aggregation, processing, distribution, consumption and disposal of food products, is critical. It demands regional collaborations for combining such progressive implementation strategies and needs serious effort towards building a holistic framework for climate-smart agri-food systems development, transformations, and security.

2. Hypothesis of This Study

Since September 2018, a series of brainstorming events happened organized in the region which gave the opportunity for the regional Consultative Group on International Agricultural Research (CGIAR) centers to discuss together with the regional partners and stakeholders on how to address the MENA regions' climate crisis on its agri-food systems. Some of these notable events include the International Center for Agriculture Research in the Dry Areas (ICARDA) global meeting in Sept 2018, the Cairo Water week in 2019, FAO Land and Water Days in 2019, where ICARDA led the climate change section, and IWMI led the water scarcity sections, and the first regional conference "Improving Water Productivity in Agriculture", 2019, Tunis. This resulted in the convergence of a school of thought and consensus on how to make MENA's agri-food systems climate smart and the creation of a mega hypothesis. The emergence of the Two Degree Initiative (TDI) was the main impetus to draft this hypothesis to a MENA Global Challenge (GC) concept note. The MENA-GC consortia was led by a steering committee consisting of four CGIAR centers (ICARDA, WorldFish, the International Water Management Institute (IWMI) and the International Food Policy Research Institute (IFPRI)) and the Wageningen University and Research with the overall leadership of ICARDA.

Our hypothesis was that, if specific actions are holistically implemented in the MENA region with the appropriate enabling environments (e.g., integrated policies, gender mainstreaming, public–private partnerships and climate finance), it can make the region climate-smart and rapidly enhance the livelihoods of its people. This hypothesis is the crux of the MENA-GC which has four parallel and two cross-cutting research for development R4D “Lifts” (Figure 2).

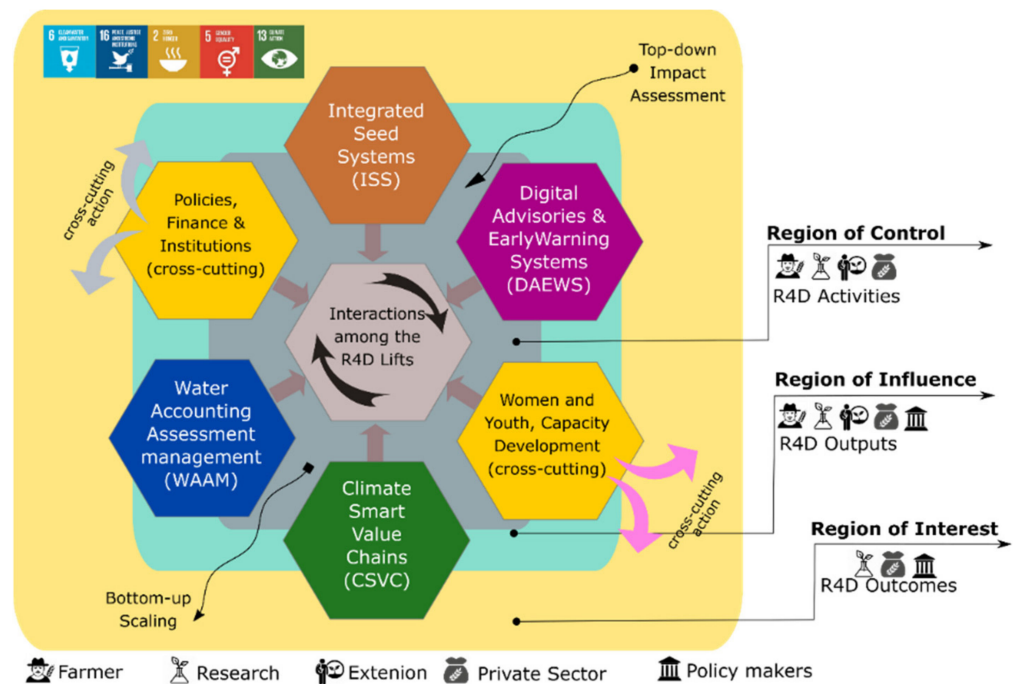


Figure 2. Theory of change diagram of the MENA Grand Challenge research vision, in which six R4D thematic actions (4 transversals and 2 cross-cutting) operating synergistically across the scales across the three regions (activities, outputs and outcomes) culminating in impact. The arrows depict “bottom-up” scaling efforts and “top-down” impact analysis. The region of interest (outcomes) addresses 13 SDGs.

Parallel Lifts:

1. Climate-Smart Value Chains (CSVC) Lift;
2. Integrated Seed Systems (ISS) Lift;
3. Water Accounting Assessment and Management (WAAM) Lift;
4. Digital Advisories and Early Warning Systems (DAEWS) Lift.

Cross-cutting Lifts:

1. Policies, Finance and Institutions;
2. Women and Youth and Capacity Development.

These lifts are planned to be operational holistically, multi-disciplinary, multi-scalar and tightly coupled to each other. The modus operandi behind this theory of change is that the MENA-GC focuses on the opportunities of public–private partnerships identified as potential major “Climate-Smart Lifts” (defined as a set of drivers, technologies and enabling environment, that can leverage mitigation and adaptation at scale) for food security and resilience of socio-ecological systems to climate change in the MENA region.

With the changing socio-economic scenario in the region, demographic trends and the nature of urban sprawl, on-farm enhancing crop productivity is not the only approach to solving climate change-related issues. Many regional stakeholders agree that diversified and sustainable farming systems are also needed to support healthy diets (including fish–vegetable combinations and aquaponics) [28]. Moreover, regions also need sustainable vegetable and fruits value chains for climate-smart agriculture interventions and they are

selected based on: vulnerability to climate change, their potential contribution to climate change adaptation and mitigation, food and nutrition security, and their ability to create employment and improve the resilience of family farmers and other value chain actors should be considered in the future strategies. This thought is developed within a dedicated theme called Climate-Smart Value Chains (CSVC) Lift.

Crop improvement to develop climate-smart and abiotic, and biotic stress-tolerant crop varieties are equally important climate change mitigation and adaptation measures in the agri-food sector [26]. Past research has developed a whole series of improved crop varieties and integrated crop management practices that are climate smart for existing and emerging climate change challenges [29,30]. Scaling up of improved technologies across the MENA necessitates the critical need for delivery systems [14] that could shape a dedicated Integrated Seed Systems (ISS) Lift, context-specific, given the diversity of the MENA region in agro-ecology, farming systems, crops, and farmers.

Because MENA is already an arid region with extreme water scarcity and increased probability of heat stress [31] and water-related issues, it needs great attention to make the region climate smart. There has been an increased thrust and consensus in the region to focus significantly on both water accounting (and water governance) and assessment (at large scales) and on-farm water management and strategies to enhance climate smartness by increasing water and agricultural productivity [32–34]. This motivated us to create a dedicated theme called the Water Accounting Assessment and Management (WAAM) Lift.

Access to information and knowledge is the key for the success in any large-scale intervention, in this regard, timely accessibility of relevant and multi-disciplinary advisories to the end-user is vital to rapidly achieve climate smartness in the MENA's agri-food system. With the increasing level of innovations and scientific progress happening on one side, and digital revolution with accessible and cheaper internet coverage, mushrooming of smartphone-based application development on the other, it is possible to develop effective digital advisories, e-extension and early warning systems, e.g., [23,35]. This is one of the key elements that can really make MENA's agri-food system climate-smart and can connect the smallholder farmers with the realm of value-chains adding weightage to the big picture of macroeconomics of the agri-food system. This plan leads to a dedicated theme called Digital Advisories and Early Warning Systems (DAEWS) Lift.

In addition to these four transversal Lifts, there are two cross-cutting Lifts (1): Policies: Finance and Institutions and (2) Women and Youth and Capacity Development. These two elements are present in all the four transversal Lifts in one way or the other and is explicitly considered when we examined the applicability of this mega hypothesis framework in the MENA context. These elements are given vital importance owing to the creation of enabling environments for the transversal Lifts to be successful. Policies, finance and institutional elements are considered in relation to partnership creation between various entities in the agri-food system (e.g., public–private partnerships) on one hand and policies that favour an inclusive finance and Lift specific interventions (e.g., seed policy, water rights and digital policies). The women, youth and capacity development action is the key to accelerate youth and women's involvement in value addition in various Lifts in the climate-smart agri-food transformation mission [36].

As a whole, MENA-GC will be built on the existing regional networks and initiatives (and the projects associated) within the different countries and in particular with important partners such as Food Agriculture Organization (FAO), Regional Water Scarcity Initiative (WSI), Family Farming, Hand in Hand and the CGIAR (DryArc initiative, Crops to End Hunger, Excellence in Agronomy, Water Land Ecosystem (WLE) and many other existing ones. The whole hypothesis under the MENA-GC challenge shaped the idea of consulting stakeholders that are already working under these domains, with whom the desired outcomes for a holistic framework could be tested by gaining stimuli of implementations.

3. Methodology

The first step of the MENA-GC mission was to develop a blueprint for MENA-GC which will eventually become a solid action plan implementation in the future. This warrants that we elaborately discuss with the regional stakeholders to understand their point of views on making MENA's agri-food system climate smart and how congruent the mega hypothesis is, according to their perspectives. It was very important to listen to a diverse pool of stakeholders that represents various sections of MENA from various organizational perspectives and various countries to validate this hypothesis in the broadest sense and to refine the action plan based on the responses we gather from the stakeholder's perception. In this regard, we set up a three-tier procedure (Figure 3); initially, we made an elaborate database of various stakeholders in the region based on our previous projects, already existing contacts and our regional intelligence. These stakeholders were initially informed about the Two Degree Initiative (2DI) and the MENA Grand Challenge and also an invitation to participate in a stakeholder consultation with the 2DI committee. We ensured that the contacted stakeholders were a good mix of action partners, boundary partners, civil society, national and regional donors, think tanks, corporate social responsibility (CSR) bodies, academic institutions, research organizations, banks, and the private sector, across all the MENA countries. The stakeholders were encouraged to participate in a detailed survey prior to the consultations, based on the hypothesis we made. This gave us a prior idea about the stakeholder's general perceptions and viewpoints of making MENA's agri-food systems climate smart even before the consultations and finding pathways to crystallize and if needed reorient a solid action plan based on the needs of the region and the current status of the enabling environments and constraints. The details of the important points gathered through this survey was analyzed and used in this study.

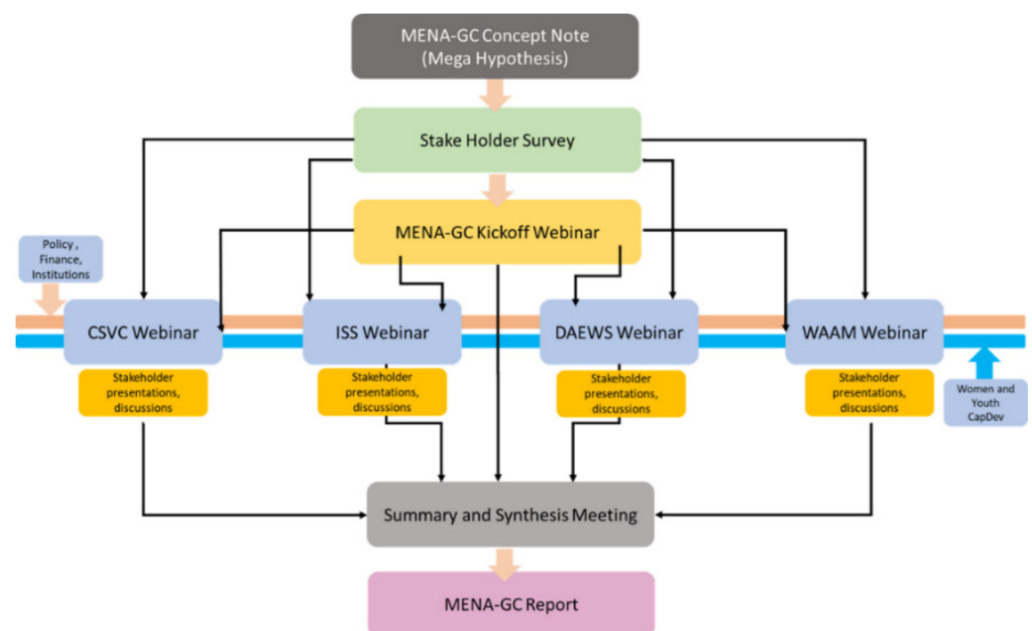


Figure 3. An illustration of the MENA-GC stakeholder consultation process to synthesize a “demand-driven” research agenda that could well capture the perspectives of a diverse stakeholder group.

3.1. Stakeholder Consultation

3.1.1. Stakeholders' Distribution

Around 400 stakeholders participated in the consultations (22–24 June 2020) that represented 19 countries (Figure 4). Depending on the scope of the stakeholders' organizations, their geographical areas of operations also often represented a certain sub region (for example, Arabian Peninsula or North Africa). There were also some stakeholders outside the MENA who had an interest in the region owing to their past and on-going

projects in the MENA region. The stakeholders who attended these consultations mainly represented organizations that have local, national or regional domains as their priority mandate areas (70%) and the remaining 30% constituted stakeholders who represented organizations having global interests (e.g., international organizations) and universities and organizations based outside MENA but having a strong interest in the region. We observed from the attendance, presentation of survey results, comments made in the chat box, and presentations by the different speakers that the LIFTs proposed under the MENA-GC are deemed relevant and comprise important responses for socio-ecological resilience in the region.

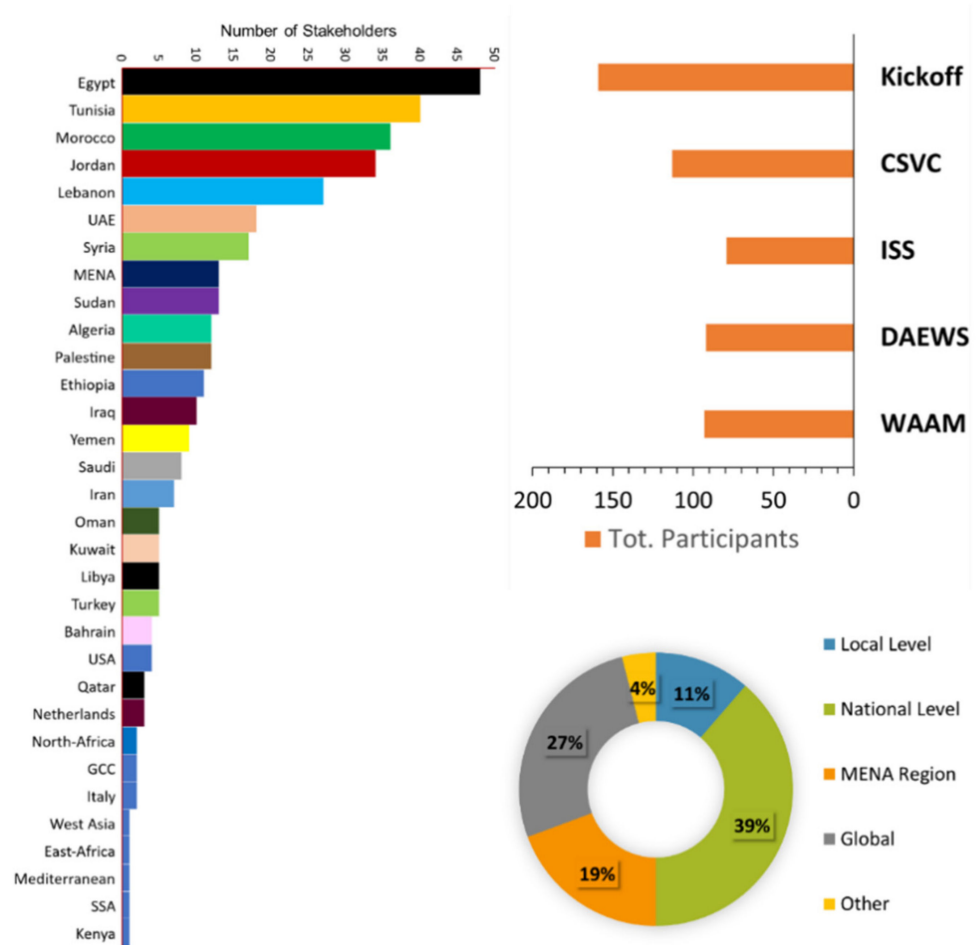


Figure 4. Analysis of stakeholder participants who attended the MENA-GC stakeholder consultation webinar series. The first figure shows countries represented and the second figure right panel shows the number of participants who participated in each webinar. The pie chart represents the geographical scale of interest of the stakeholders.

3.1.2. Stakeholders' Consultation Process

The main objective of the regional stakeholder consultations were to: (1) identify major climate change challenges affecting the agricultural sector and validate with stakeholders, (2) identify the prospects and hurdles in implementing climate-smart solutions across MENA, (3) identify plausible public–private partnerships and enabling environments, (4) explore the prospects of developing R4D projects and test cases which may have an impact on the ground, and (5) the prospects of holistic and synergistic action of the Lifts in MENA.

3.2. MENA Agri-Food Sector Division for Transformations

MENA is an extensive geographic region covering as much as 5896 million km² area that is home for 4567 m. The vastness of this region implies huge diversity in climate, soil, agroecosystems and cultures. Thus, relying on a unimodal solution to solving its agri-food sector problem will not be successful. We classified the global non tropical drylands into four main categories-based on the similarities in the agri-food system operations:

1. Rainfed agroecosystems;
2. Irrigated agroecosystems;
3. Agropastoral agroecosystems (rangelands);
4. Desert-based agroecosystems.

As MENA is an important component of the global non-tropical dryland (other than Central Asia, India, China and Sahel) that comes under the DryArc preview, we use this classification to design the operations in the MENA-GC of the global Two Degree Initiative. This classification of agroecosystems is particularly relevant for the MENA owing to their specificities and uniqueness. The implementation of the four Lifts has to be agroecosystem-specific and it is particularly important when we did the scaling of climate smart options in the MENA.

To alleviate the agri-food systems of already arid and climate vulnerable MENA region, the Grand Challenge of the 2DI in the MENA (hereafter “MENA-GC”) focuses on the holistic implementation of 6 R4D thematic actions (“Climate-Smart Lifts”) making use of the opportunities of public–private partnerships. The focus of discussions covers all the four major agroecosystems in MENA (irrigated, rainfed, rangelands and deserts).

4. Results and Discussions

4.1. Results of Pre-Consultation Survey and Discussions

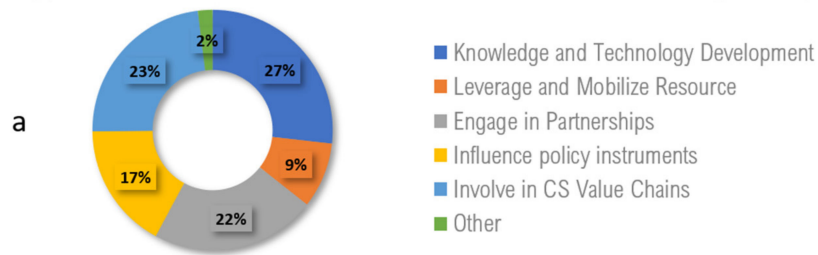
The MENA region is already arid and hot with the agricultural sector highly vulnerable to climate change. At the onset of the consultation process, it is very important to understand from the stakeholders about their perception of climate adaptation and mitigation in the agri-food sector (regional perception) because it represents the general climate-action priorities of the organizations they represent. As it was difficult to synthesize and summarize the lengthy narratives of all the respondents, we conducted a word cloud analysis of their collective narrative about this topic to crystallize the key messages. From the analysis, it was clear that “Water” stood out as a key element in both climate adaptation and mitigation actions from the general perception of the stakeholders at the regional level (Figure 5). Enhancing water productivity seemed to be a key approach in terms of climate adaptation in MENA whereas the use of novel technologies in irrigation and the element of water-energy nexus (with the enhanced use of solar energy) seemed to be a good climate mitigation action.

The enhanced use of climate-smart crop varieties also stood out in as a plausible climate adaptation and mitigation approach. The concept of precision irrigation also seemed to be an important intervention. Enhanced digital augmentation, agroforestry and desalination were other plausible climate-smart interventions that the stakeholders envisaged. These regionally generalized perceptions were very congruent with the postulates made in the MENA-GC hypothesis. The stakeholders who participated in the consultations were asked to identify their current dominant mode of pro-climate actions in the MENA’s agri-food sector (Figure 5a).

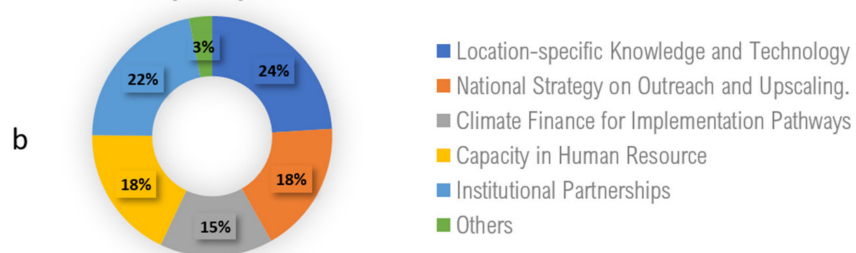
From the results of the survey, it was evident that most of them currently engage in knowledge and technology development (27%). This was followed by a cluster of stakeholders who are involved in various types of climate-smart value chains (e.g., mostly the private sector and those engaged in R4D projects where value chain perspective is dominant mode of action). When asked about their points of view on what are the needed mechanisms to achieve climate smartness in MENA’s agri-food sector, the general consensus was that the climate-smart interventions that are regionally implemented should have five pillars, more or less with equal prominence (Figure 5b). These include the development

of location-specific knowledge and technology, fostering institutional partnership where these technologies can be developed, enhancing the capacity of the national systems in all the domains (infrastructure, human resource, knowledge and other enabling environments) and to maintain adequate climate finance to achieve all these plans based on various means, such as large project funds, national funds, and the leveraging of private finance through public–private partnerships.

Type of climate smart actions actions the stakeholders are generally engaged in



Stakeholder perception on the mechanisms needed to make MENA climate smart



How the stakeholders like to engage in the MENA-GC actions

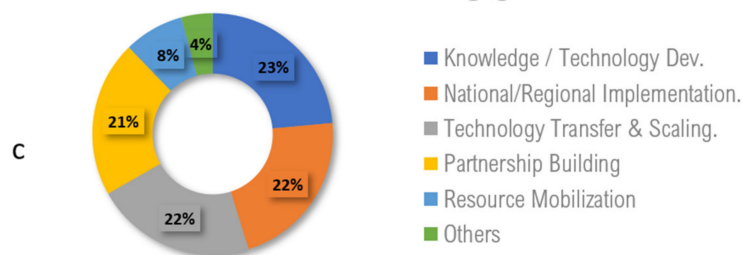


Figure 5. The pie chart represents the engagement of the stakeholders in different consultation tiers: (a) climate-smart actions, (b) perceptions about mechanisms required for making MENA climate smart, (c) stakeholders' likeliness to engage in MENA GC actions.

Finally, the national policies of MENA countries should be conducive enough for scaling and upscaling. This implies that there should be national strategies to scale climate-smart technologies across the countries using the case studies and success stories from selected benchmark sites. For example, in Sudan and Egypt, there are country-specific national strategies in order to upscale and out scale of mechanized raised bed planter technology as a climate-smart intervention in the agricultural sector. Similarly, there is a national mission in Morocco to upscale solar pump and solar technology use in the agricultural sector. Such national policies and strategies are critical to achieve climate smartness in the MENA. In the MENA-GC, we have already identified such a national mission which we will use to leverage to scale up various climate-smart initiatives in specific countries. We asked in what way the stakeholders would like to be involved in the future under the aegis of the MENA-GC (Figure 5c).

The collective response was more or less clustered around four main areas viz.

1. Engage in national or regional scale implementation of pro-climate projects (22%);
2. Engage in the development of location specific climate-smart technology or knowledge (23%);
3. Engage in the transfer of climate-smart technologies and help it scale and out-scale;
4. Engage in the development of strategic partnership building in order to develop the enabling environments to accelerate the climate smart transformation process.

The stakeholders did not in general want to be involved in resource mobilization (both financial and in-kind forms of resources). This implies that there is ample scope for donors and financial institutions to engage in the MENA-GC to mobilize and raise climate finance with a great potential to create the enabling environment through the stakeholder engagements 1–4.

Prior to the actual stakeholder consultations, along with the survey, we also gave them a detailed background of the MENA-GC mega hypothesis. This was an elaborate document that was developed by the MENA-GC committee, wherein each Lift was carefully crafted and narrated in a detailed manner considering the status quo science priorities and research needs. We encouraged the stakeholders as to what their general interests were among the four transversal Lifts (with the two cross-cutting Lifts implied in all the four Lifts). This was a way to validate (or invalidate) if the identified R4D actions were relevant, scalable, practically feasible or not in the MENA region from their perspectives.

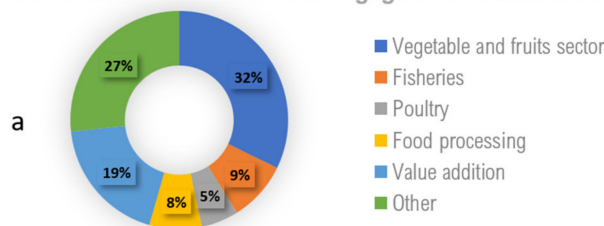
Understanding the importance of MENA-GC actions made the stakeholders greatly appreciate and concede to the CSVC Lift. The importance of climate-smart crop varieties adaptive to heat, drought, biotic and salinity stresses and scaling up these varieties across various countries and in the region is a very critical step thus the Integrated Seed Systems Lift was greatly appreciated as a vital component where the intricacies of private–public partnerships will be fostered to implement a pluralistic climate-smart seed systems will be the target in MENA. The rapid boom in digital technology and leveraging its capability to rapidly, efficiently, and precisely transfer quality information across various sectors and scales (scientist–stakeholder–policymaker–farmer–entrepreneur) is recognized as a critical element of rapid agri-food transformation. With the current plethora of smartphone-based technology and the potential for the development of newer context specific applications, engaging youth, women and the private sector has been elaborately discussed. This was particularly appreciated by the stakeholders as a solution to rapidly achieve climate smartness in the MENA and a dedicated R4D Lift was DAEWS was focused on these issues. The collective agreement on interconnectivity of four transversal Lifts achieved that have to be implemented together.

Analysis of the stakeholder response data showed that the general clustering of the regional interests is balanced across all four transversal Lifts, implying the fact that the region welcomes and embraces the relevance and importance of all of them. As the MENA region is extremely water scarce and it is the primary controller on crop growth and food productivity, the Water Accounting Assessment and Management (WAAM) Lift had the highest stakeholder clustering (33%). This was followed by Climate Smart Value Chains (CSVC) Lift (26%), Integrated Seed Systems (ISS) Lift (20%) and the Digital Advisories and Early Warning Systems (DAEWS) Lift (21%).

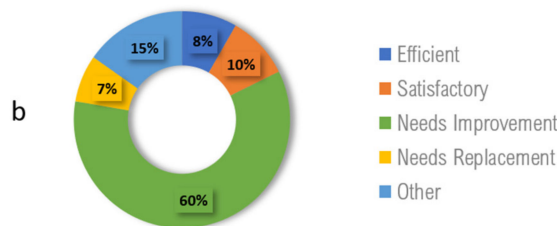
The implementation of the four Lifts has to be agroecosystem specific and it is particularly important when we perform the scaling of climate smart options in the MENA. We discussed what their thoughts were on the agroecosystem specificities of these four Lifts. Because the majority of the stakeholders represented local and national systems, most of their operational domains focused on location-specific actions and their thoughts would likely have a greater relevance in designing the plan. Figure 6 shows the general thoughts on the feasibility of implementing these four R4D Lifts in the different agroecosystems of MENA, based on general perceptions of the regional stakeholders who are very well known to the ground realities and the pros and cons of various actions.

Thus, it opines that the WAAM Lift will most likely be effective and influential in the irrigated agroecosystems and desertic agroecosystems where possibilities of irrigated farming are possible using ground water resources (e.g., the growing number of irrigated farms in Saudi Arabia and Libya). Irrigated agroecosystems and desertic agroecosystems are the places where the water productivity has to be enhanced via water saving techniques without compromising on the crop yield, research, public–private partnerships and scaling, rather than rainfed or rangelands that are already water scarce and other critical issues are relevant there. Irrigated agroecosystems are mostly located in places where there is availability of surface (Egypt and Sudan in the Nile River Basin; Iraq along the Euphrates-Tigris River Basin) or ground water resources. However, these resources are fast depleting and excessive use is driven by non-judicious use bolstered with enhanced evapotranspiration losses as a result of a changing climate.

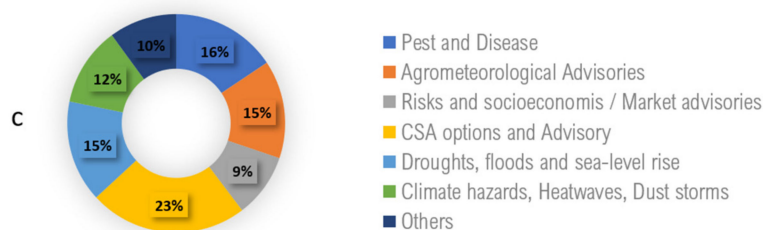
Current levels of stakeholder engagement in different value chains in the MENA



Stakeholder perception on the existing Seed Systems in the MENA



Current stakeholder engagement /awareness in various DAEWS in the MENA



Current stakeholder engagement in various WAAM actions in the MENA

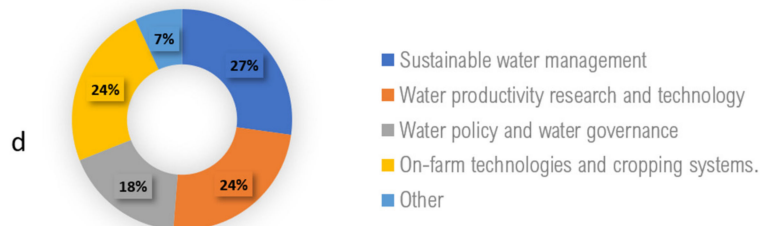


Figure 6. The pie chart represents: (a) the current level of stake holders’ engagement in different value chains in MENA, (b) perception on existing seed systems, (c) current awareness to the digital advisory early warning systems (DAEWS), and (d) current engagement in WAAM actions.

It was generally agreed that the ISS Lift will be most effective in the rainfed agroecosystems, which constitutes most of the arable lands in MENA. Farmers need climate-smart crop varieties that are tolerant to various abiotic and biotic stresses. However, this warrants the availability of seeds to the farmers that implies the effective seed systems that can pass various policy and partnership hurdles, apart from the seed science itself. While the applicability of the CSVC is evident in all agroecosystems, the agropastoral systems seem to have the biggest role where CSVC interventions are plausible. Because advisories and early warning systems are vital for rapid information transfer via multiple advisory modes (including e-extension), this R4D component is vital in all the Lifts. However, it is clear that stakeholders are less aware of the possibilities and prospects of this Lift probably being a newer approach in the food system. Nevertheless, this Lift is vital to rapidly achieving climate smartness in MENA's agri-food system and is also an effective mechanism to integrate all the other three Lifts in a holistic manner. Nevertheless, all four transversal Lifts have to operate with the spirit of tackling climate smartness employing a thematic focus that ensures the policy and institutional elements as well as the capacity development and gender and youth are well-balanced within each of the thematic domains.

When asked what financial models, policies and public-private partnership models that should be adopted in the region to make the various R4D Lifts operational in an effective manner, for example, in the area of WAAM Lift, it was opined that policies that encourage partnerships between various sectors are vital. This implies the urgent need for both national and international level partnerships that encourage water related issues in MENA agri-food sector. This includes transboundary water partnerships, national partnerships that encourage the role of PPP in water sectors, etc. Similar to WAAM, other Lifts are also thought to be positively governed by pro-PPP policies (e.g., CSVC).

Secondly, capacity development for women and youth is thought to be an important aspect of the CSVC and the WAAM Lifts where farmers, self-help groups, national research systems, extension agencies and the private sector are enhanced in their capacities of knowledge, technical know-how as well as in terms of enabling environments (e.g., technological and infrastructural capacities) with a special emphasis on women and youth, respondents' vote percentages are traceable from Figure 7.

4.2. Key Targets Emerging from Stakeholder Workshops and Consultations

After the series of workshops and consultations with stakeholders, some targets were defined to achieve climate-smart agri-food systems objective in the MENA region, as to solicit outcomes of the hypothesis. They include:

1. Identifying three–five clear medium-sized projects (e.g., each of them ~3 million USD over 3 years) in each of the R4D Lift areas of MENA-GC, implemented in the focal countries (Egypt, Morocco, Jordan, Lebanon, Tunisia). All efforts will be made to have multiple thematic projects operating in a given country to achieve holistic scaling and impact;
2. Identifying clear partnerships involving the national systems, international and regional donors, public and private sectors with sound synergies among the partners with a transparent business model in each of them that demonstrates synergies and complementarities;
3. Impact the livelihoods of 10 million farmers of MENA sustainably (i.e., sustained operation even after project phases). The plan is to ensure that impact is shared proportionately by all 4 + 2 R4D Lifts considered in the MENA-GC operating with a synergistic mechanism;
4. Ensuring that the impact reaches all agri-food system sections from smallholder farmers to large agritech industrial exporters with a major focus on the smallholder farmers.

The food system in the MENA region will be transformed significantly in the coming 10 years based on the principles of (1) climate-smart value chains and crop diversification (2) climate-smart crops (food-grains, forage, and horticulture), (3) a crop–fish–livestock mix for enhanced nutrition, (4) enhanced water productivity under a grim climatic situation

and (5) smallholder farmers thinking globally while acting locally via informed advisories that will enhance their income and livelihoods.

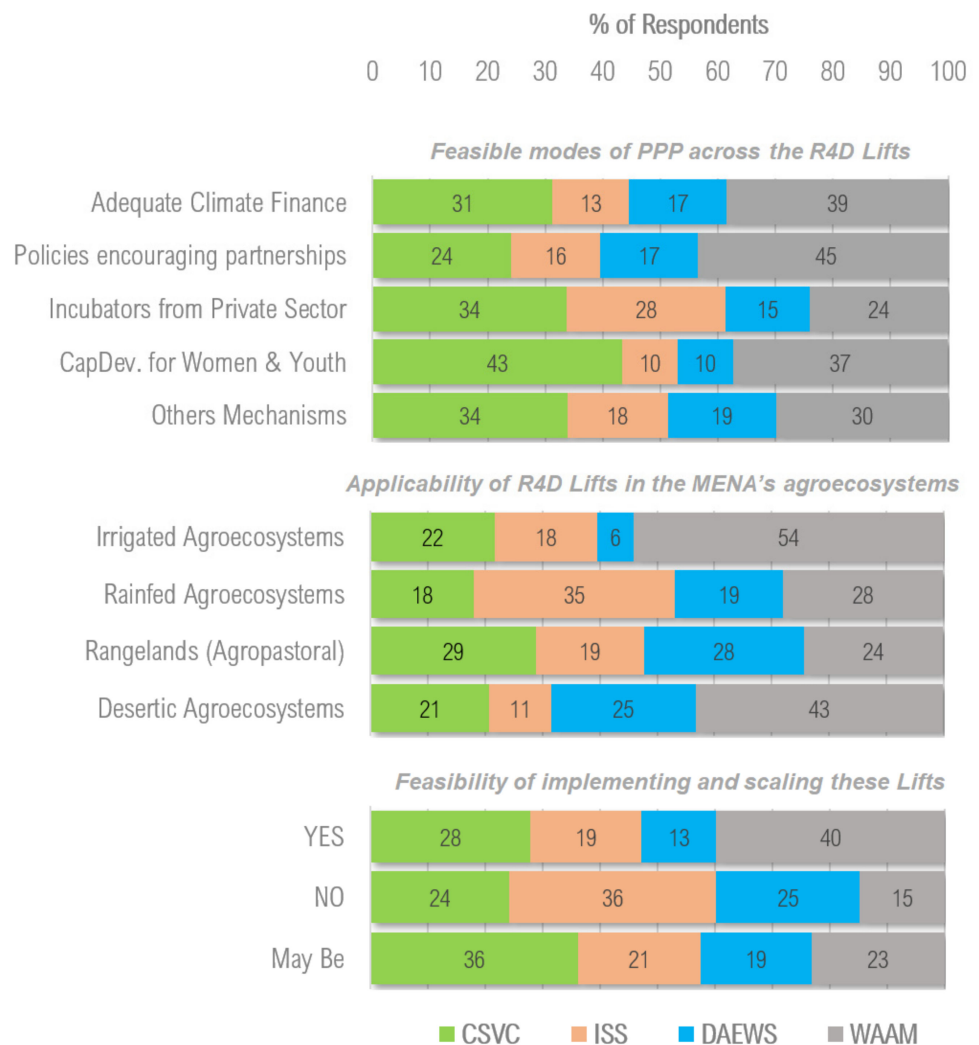


Figure 7. The bar chart represents survey results based on ~400 respondents’ viewpoints to the set of hypothesis questions.

In this regard, strategical designs for scaling of piloted projects that were proven at benchmark sites can create a solid and sustained impact on the ground upon implementation. This will take into account monitoring biophysical similarities, institutional elements, policy dimensions, and capacity development and fusing these in the scaling operation. Figure 8 shows the prospective countries where the pilot projects can be started and following its success, national-level scaling attempts can be implemented within the next 5–10 years. These countries were identified after holistically considering various factors involved in consultation with stakeholders and considering the donor landscape. After summarizing the existing challenges, priorities in all R4D Lifts and derived changes after consultations, a fundamental body of knowledge has been developed to set up this proposed holistic framework of climate smart agriculture in MENA region, the final worksheets are given as Appendices A and B.

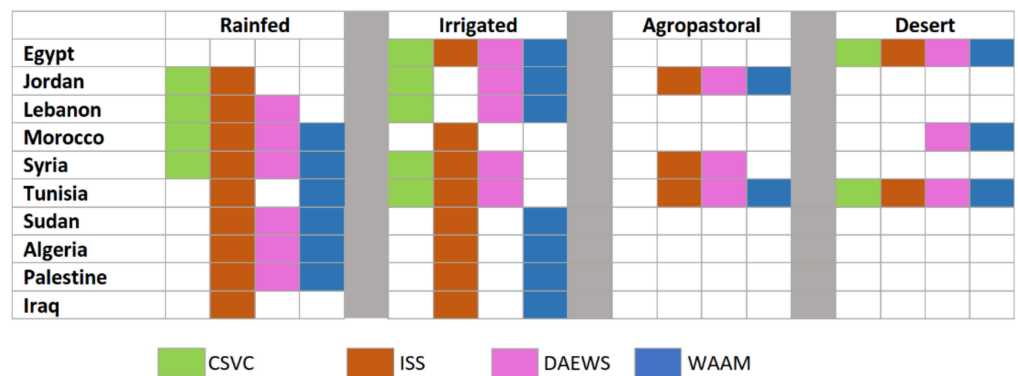


Figure 8. A pictorial representation for implementation of different R4D Lifts in various countries of MENA in different agroecosystems.

5. Way Forwards, Summary, and Conclusions

Under the MENA Grand Challenge process, we reached a clear investment blueprint to transform the agri-food system of MENA into a climate smart system, after the intensive consultations with the stakeholders and synthesis of the ideas we received. In future, we will piggyback on other ongoing regional initiatives and existing projects, either from the consortia centers (CGIAR) or our regional partners and try to align our future projects with these ones. Some examples are the DryArc initiative, the water scarcity initiative, etc. We will ensure to maximize synergies and complementarities and minimize duplication. The next step will be the development of medium sized projects with the analysis of funding opportunities from various donors in the region. These projects will be spread across the four transversal R4D themes (along with the two cross-cutting themes), and all efforts will be made to have these projects in the same countries so that holistic impact can be expected. With a clear idea on the projects that we want to run, the partners’ priorities, and a clear set of action plans in each of the projects, we will approach various donors (with concept notes) in the region who have an interest in funding climate change projects. We will also rely on large donors such as the Global Commission on Adaptation (via 2DI) to fund MENA-GC adequately, considering the importance of this region.

Effective implementation of the MENA-GC will address the following SDGs under the CGIAR Strategy in the region provided the region gets adequate funding (Figure 9). The MENA-GC is consistent with the CGIAR short-term strategies (to achieve 2030 goals) and the longer term priorities. Our mode of operation is congruent with the “One CGIAR” philosophy and the strategic plans of the MENA-GC lead centers (ICARDA, WorldFish, IWMI, IFRI, WUR). Thus, the MENA-GC consortia believe that it’s on the right path.



Figure 9. Sustainable development goals (SDGs) addressed under the MENA Grand Challenge.

Engaging with the Two Degree Initiative via the MENA-GC has given greater importance to climate change related issues (in the broadest sense) to the regionally active CGIAR centers. This is a great opportunity to link the MENA-GC with other prospective climate change initiatives in the region. Thus, in our resource mobilization efforts, we will synergistically make use of this nexus. We set one example of the Cairo Water Week 2020, wherein MENA-GC focused topics are discussed with rich scientific knowledge.

As for the final outcome of this study, the big picture of the MENA-GC agenda at the SDG level has not changed even after the stakeholder consultations. However, after the consultations, the planned outputs and activities have become more evident and targeted. With this statement, we conclude that these regional dialogues and synthesis in the study helped a lot in developing an effective mechanism for strategic resource mobilization in the region as one big achievement under the MENA Grand Challenge that advocates the strong regional needs for climate-smart agriculture and supports the requisite long-term commitments for the SDG's implementation.

Author Contributions: A.G., Z.U.N., J.W., B.D., A.E., Z.B., V.N., C.B. (Chandrashekhkar Biradar), K.A., G.A., C.B. (Clemens Breisinger), N.A.I., C.K., A.A.N. and M.T. contributed to this work since the MENA-GC thought process started in 2019. A.G. coordinated the MENA-GC and led this paper and J.W. provided the vision. A.G., J.W., B.D., A.E., Z.B., V.N., C.B. (Chandrashekhkar Biradar), Z.U.N., K.A., G.A., C.B. (Clemens Breisinger), N.A.I., C.K., A.A.N. and M.T. actively contributed to the MENA-GC consultation process, actively engaged in writing, analyzed the survey data, and prepared necessary graphics. This includes preparing the initial concept notes, preparing for the stakeholder consultations, and preparing Lift-specific post-consultation detailed reports from which this brief paper is distilled. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Thematic areas, priorities, and existing limitations identified for each Lift.

Priorities	Current Limitations
Climate-Smart Value Chains (CSVC)	
<ul style="list-style-type: none"> Promote sustainable intensification and integrated farming systems. Efficient, inclusive and profitable value chains around fish and vegetables. Effective engagement of stakeholders including producers, large agribusinesses, NGOs, civil societies, academia and research institutes. 	<ul style="list-style-type: none"> Research capacity to develop frugal innovations that are adoptable by smallholder farmers. Inclusive, timely and adequate access to information (agronomic and market). Institutional capacity to disseminate knowledge and mobilize and facilitate market opportunities. Technical knowledge on the application of integrated systems.

Table A1. Cont.

Priorities	Current Limitations
Integrated Seed Systems (ISS)	
<ul style="list-style-type: none"> Develop pluralistic, competitive and context specific integrated seed delivery system considering the diversity of MENA in terms of agro-ecology, farming systems, crops and farmers. Deploy agricultural technologies for impact at scale climate smart varieties of agricultural, horticultural, pasture and forage and tree crops. Design digital seed information tools with information on released crop varieties and their key traits relevant to climate change bundled to advisory services. Support policy and regulatory reforms including regional harmonization for ensuring the movement of varieties and seeds across national borders. 	<ul style="list-style-type: none"> Weak seed delivery system dominated by the public sector and a few major cereal crops, particularly wheat. Lack or absence of seed delivery systems for climate smart crops, particularly legumes and pasture and forage crops. Lack of diversification and low private sector participation due to a lack of knowledge, experience and skills in seed business development.
Digital Advisories and Early Warning Systems (DAEWS)	
<ul style="list-style-type: none"> Develop DAEWS tools for a diverse set of topics (pest and diseases, drought, irrigation, etc.) including e-extension. Develop DAEWS with a value chain perspective so that smallholders can link with the big market dynamics. Develop DAEWS with the view of connecting all the priority areas such that all the themes MENA-GC operate synergistically and break the thematic “silos”. 	<ul style="list-style-type: none"> Knowledge and technical capacity of the national systems to develop and use DAEWS needs to be enhanced. public–private partnerships for DAEWS systems in terms of data sharing, open access, start-up finance, support for upscaling needs to be enhanced. Support the national systems for the “digitalization” move needs to be augmented. Broadband internet coverage to rural areas needs to be enhanced.
Water Accounting Assessment and Management (WAAM)	
<ul style="list-style-type: none"> Accurate, co-designed and tailored WAAM framework for understanding hydrological processes, managing water fluxes, and informing multi-scale agro-food system policy dialogue and water governance and resource planning. Ensure WAAM is tailored to the local context and scale and acts as a pre-planning mechanism and implementation mechanism (where we will evaluate the implementation of the interventions, plans and investments). Assess status and opportunities for increased farm-basin and regional water productivity. Accounting of the water resources and ease allocation of the resources to support water managed as an integrated sector in a sustainable, equitable and accountable way. Support partner engagement in new technologies and services for water management at country, region and farm levels by deepening, expanding and replicating models for resolving tensions on water. 	<ul style="list-style-type: none"> Regional versus national disparities in water accounting and management is very variable between countries. The main obstacle to sustainable development is not a lack of research but a lack of political will or prioritization with governments to really reform and invest in sustainability. Lack of multi-stakeholder approach/platform in addressing the issue of climate change, i.e., poor governance, institutional fragmentation, poor coordination. Lack of resources, i.e., finances, knowledge and capacity (human and institutional). Lack of monitoring network across the MENA region and data sharing to develop an accurate water accounting (eg. weather stations, groundwater sensors, etc.).

Appendix B

Table A2. Thematic areas, priorities, and knowledge/capacity gaps identified for each Lift.

Original Priority	Changes after the Consultation
Climate-Smart Value Chains (CSVC)	
<ul style="list-style-type: none"> Adoption of multi-scale (large and small) and multi-criteria (water, income, nutrition, etc.) approaches and partnerships to maximize efficiency gains to sustainably and inclusively enhance resilience and improve livelihoods. Focus on fish and vegetable value chains. 	<ul style="list-style-type: none"> It is important to explore possibilities to expand the value chains considered to include other crops and livestock and link different value chains; Increasing need for ICT for market linkages and e-extension delivery The need to find the balance between economic and environmental sustainability The need to build local capacity including extension and CBOs that can aggregate and facilitate market outlets and use established agribusinesses as catalysts for change.

Table A2. Cont.

Original Priority	Changes after the Consultation
Integrated Seed Systems (ISS)	
<ul style="list-style-type: none"> Promote integrated seed system involving formal, intermediate and informal sectors. Promoting and scaling climate smart technologies. Policy and regulatory reforms to create enabling environment for seed systems. Use of ICT technology in the ISS was postulated but modalities were not detailed. 	<ul style="list-style-type: none"> Recognize the role of climate change on seed systems and design context specific seed system interventions for irrigated, rainfed, agro-pastoral and desert farming focusing on priority crops. Develop tools (or index) for scaling (varieties, i.e., with key traits for tolerance to drought, heat, salinity, and emerging pests; agronomic, i.e., water use efficiency, nutrient use efficiency; nutrition-dense and other preferences related to consumption and cooking time). Recognize the increased role of public–private partnership and emphasis for regional harmonization of regulatory reforms to ensure cross-border movement of varieties and seeds. Modalities of the use of ICT in ISS has been specified more clearly bundled with other advisory services.
Digital Advisories and Early Warning Systems (DAEWS)	
<ul style="list-style-type: none"> The original name of this Lift was called as EWA Early warning Systems and Advisories. The policy dimension of this Lift was earlier restricted to policy as a governing factor. Sustainability of the private sector involved in DAEWS after the project phase was not thought about. 	<ul style="list-style-type: none"> This Lift’s name is changed to DAEWS Digital Advisories and Early warning Systems to clarify the importance of both Digital Advisories and Early warning Systems to give due importance to both the segments. Now the policy element is dealt both as a (1) governing/enabling factor and as a (2) product that is delivered as an advisory via the DAEWS. We discussed about how to sustain the private sector after the project phase using the tools that they develop and promote.
Water Accounting Assessment and Management (WAAM)	
<ul style="list-style-type: none"> The WAAM Framework was initially designed for the sustainable use, management, and governance of water in MENA to minimize vulnerability under a changing climate and socio-economic pressures at farm–basin–national and regional levels. The focus was on water sector processes. Limited focus on political economy. Focus on use of WAAM on water management at the scale. 	<ul style="list-style-type: none"> As MENA region is reaching its sustainability limits in relation to water, it is important to understand, where are the limits? Where should we act and how? By co-designing, co-creating and effective partnerships across sectors and boundaries. Water sector is the connector and cannot be seen in isolation, need to bring in soil and land aspects. As political economy and water governance are critical elements, it is very important to understand the actors, their objectives and drivers towards multi-stakeholder approach for water governance. Beyond on-farm water management, upscaling of the water management practices requires major changes in water policy and practice supported by appropriate new instruments such as water accounting.

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