frontiers | Frontiers in Sustainable Food Systems

TYPE Original Research
PUBLISHED 07 February 2023
DOI 10.3389/fsufs.2022.1026432

OPEN ACCESS

EDITED BY
Paul Erik Kristiansen,
University of New England, Australia

REVIEWED BY
Henry Jordaan,
University of the Free State, South Africa
Sanju Deenapanray,
University of Mascareignes, Mauritius

*CORRESPONDENCE
Ahmad Abdel-Fattah
ahmad.abdelfattah72@gmail.com

†These authors have contributed equally to this work and share first authorship

SPECIALTY SECTION
This article was submitted to Climate-Smart Food Systems, a section of the journal Frontiers in Sustainable Food Systems

RECEIVED 23 August 2022
ACCEPTED 26 December 2022
PUBLISHED 07 February 2023

CITATION
Abdel-Fattah A and Al Hiary M (2023) A participatory multicriteria decision analysis of the adaptive capacity-building needs of Jordan's agribusiness actors discloses the indirect needs downstream the value chain as "post-requisites" to the direct upstream needs. *Front. Sustain. Food Syst.* 6:1026432. doi: 10.3389/fsufs.2022.1026432

A participatory multicriteria decision analysis of the adaptive capacity-building needs of Jordan's agribusiness actors discloses the indirect needs downstream the value chain as "post-requisites" to the direct upstream needs

Ahmad Abdel-Fattah[1]*† and Masnat Al Hiary[2]†

[1]Directorate of Local Development and Enhanced Productivity, Ministry of Planning and International Cooperation, Amman, Jordan, [2]Directorate of Socio-economic Research, National Agricultural Research Center (NARC), Al Baq'a, Jordan

Climate adaptive capacity-building initiatives and activities in developing countries, particularly those implemented by developmental agencies and international organizations, commonly focus on the upstream direct adaptive capacity-building needs of targeted vulnerable sectors. However, overlooking a holistic climate-adaptive capacity-building of a vulnerable sector down to the last link of its value chain renders inadequate contribution, jeopardizes the adaptation intervention, and prevents achieving a high level of buy-in of the chain actors for the results of the sought capacity-building programs. Thus, this study developed a hybrid system-wide and participatory (focus groups-based) multi-criteria decision analysis (MCDA) to conduct adaptive-capacity needs assessments for the actors of the agribusiness value chain of the developing country of Jordan. Our holistic approach enabled highlighting the sector's climate vulnerability along the value chain, conducting self-regulated adaptive training needs assessment (TNA) of the sector's actors and identifying and prioritizing their real adaptive capacity-building needs. This approach proved to be uniquely advantageous in comparison to the sector's commonly used questionnaire-based surveys that are limited-participatory, researcher-regulated, and subsystem-oriented approaches. The advantages of this hybrid hands-on and wide-ranging MCDA–TNA approach are evident from its revelation of unique results. The approach enabled actors of such a highly vulnerable sector to spontaneously identify and prioritize the indirect downstream climate adaptive capacity-building needs surprisingly over the direct needs. This is because the actors considered the indirect needs more important to their businesses and livelihoods than the direct needs, thus considering the indirect needs as "post-requisites" of the fate of the direct upstream needs. The hybrid approach also enabled the beneficiaries to formulate the intervention outcomes, unveil the factors ignored by the conventional researcher-controlled approaches, secure high buy-in of the self-attained results, and prioritize the actual adaptive capacity-building demands. This robust combination of qualitative research methods and tools could be straightforwardly applied to design and conduct efficient and cost-effective adaptive capacity-building programs, especially during time-restricted and resource-limited interventions. The results of such types of quick

and cost-effective qualitative investigations of adaptive capacity-building needs could be considered a preliminary and a first step toward deeper and more extensive quantitative studies, if needed.

KEYWORDS

participatory, multi-criteria decision analysis (MCDA), climate adaptive capacity needs, agribusiness, value chain actors, Jordan Valley

1. Introduction

Major international foreign aid and development agencies have been active in the developing country of Jordan since the 1950's, a few years following the nation's independence in 1946. This is because the country is heavily dependent on foreign aid (Fanack: Chronicle of the Middle East North Africa, 2021). Most of the economic support and development projects were directed at the agricultural sector, the backbone of Jordan's economy and development. Historically, the sector was the main provider of employment for more than one-third of the labor force (Kanaan and Kardoosh, 2002). Jordan is no different than many developing and developed countries in terms of the significance of agriculture, food production, and agribusiness to the national economy. Globally, the agribusiness industry is an unsurprisingly big business with a net worth of US $5 trillion, representing 10% of global consumer spending, 40% of employment, and 30% of greenhouse-gas emissions (Goedde et al., 2015). Still, food production will have to increase by 60% by 2050 (FAO, 2015a) to satisfy the growing demand driven by population growth and dietary changes. Thus, food production and agribusiness have massive socioeconomic footprints, in addition to environmental footprints.

Climate change threats to agri-food systems are considerable and are predicted to reverse the progress made so far in agricultural development and the fight against hunger and malnutrition (IPCC, 2014, 2022; FAO, 2015a; Cinner et al., 2022; Kalaitzandonakes et al., 2022; Kumar et al., 2022). As highlighted in the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), climate change augments and intensifies the risks to food security in most vulnerable countries (Porter et al., 2014). In the most recent IPCC's AR6, it was reported that the climate change impacts are stressing agriculture, increasingly hindering its efforts to meet human needs. Climate-related extreme conditions have affected the productivity of all agricultural and fishery sectors, with negative consequences for food security and livelihoods (Bezner Kerr et al., 2022). In IPCC's AR5, among the risks identified are loss of rural livelihoods and income, food insecurity, and the breakdown of food systems out of the eight key risks induced by climate change, which are believed to have direct consequences for food security. The loss of rural livelihoods and income is of critical significance since at least 70% of the very poor live in rural areas, with most of them depending partly (or completely) on agriculture for their livelihoods (IFAD, 2010). The most vulnerable countries are, *inter alia*, those of arid and semi-arid areas such as Jordan (FAO, 2015a). In IPCC's AR6, it is emphasized that climate change impacts everybody, but the vulnerable groups, such as low-income households, indigenous or other minority groups, and small-scale producers, are often at higher risk of malnutrition and livelihood loss among other impacts (Bezner Kerr et al., 2022). Most importantly, the said report warned that climate change will make some current food production areas unsuitable. The impact of the food value chain due to climate change will be altered in terms of availability, access, and stability of food security (Ickowitz et al., 2019). Nutrition-dense foods will become more perishable and thus more vulnerable to the limitations of food storage and transportation infrastructure. Climate change-related damages to food in storage (due to electricity failures and loss of cold storage) and transportation infrastructures (due to extreme weather events, damaging roads, and other infrastructure) could significantly decrease the availability and increase the cost of highly perishable, nutritious foods, such as fruits, vegetables, fish, meat, and dairy (Bezner Kerr et al., 2022). Thus, significant and immediate efforts to respond to climate change are still highly needed to safeguard the capacity of food systems to ensure global food security (IPCC, 2014, 2022; FAO, 2015a).

The impact of climate change on agriculture has been studied. It is fairly unclear how particularly prepared farmers are to deal with the impacts (Carey, 2018). Despite the increases that took place in the literature on adaptation and food production, since the advancement of relevant global knowledge works such as the IPCC's AR4, AR5, and the recent AR6, there has been a recent growing focus on the adaptation of food value chains and agribusiness, in particular (Carey, 2018; Bezner Kerr et al., 2022). Carey (2018) in an assessment of the adaptive capacity of Pioneer Valley's (Massachusetts) farmers concluded that, if farmers continue their same techniques over time, despite the experienced changes in weather, then the assumption is that they will have a less adaptive capacity for future weather variability. IPCC's AR6 (Bezner Kerr et al., 2022) stated that, even though many autonomous adaptation options have been implemented in both terrestrial and aquatic systems, on-farm adaptations are inadequate in meeting the Sustainable Development Goal (SDG) 2 of "*Zero Hunger*." Among the reasons why such a goal will not be met according to the said report is the limited adaptive capacities of the said systems. The AR6 Report highlights that among the measures that will enhance effectiveness and/or the feasibility of adaptation are supportive public policies including, inter alia, investment in sustainable value chains and support for capacity-building. In light of the overall findings of relevant studies (for example, FAO, 2015a) that climate change will increase crop yield variability in many regions, other climate-affected aspects of food systems, such as food reserve, storage, and distribution policies and systems, may need to be enhanced (IAASTD, 2009; Stathers et al., 2013; Porter et al., 2014; Bezner Kerr et al., 2022), along with a range of broader value-chain issues. Of particular interest, in this regard, among others, is building the adaptive capacity of the sector's actors (Porter et al., 2014; Bezner Kerr et al., 2022). Regarding the adaptation of the food value chains, the findings on the adaptation of IPCC's SRCCL (Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security,

and Greenhouse Gas Fluxes in Terrestrial Ecosystems) support targeting food value chains and intervention types to the needs of specific locations.

In a developing country like Jordan, primary and secondary agricultural production counts for 29 to 32% of the GDP (Rikken and Leeters, 2016). The sector contributes 25% to Jordan's total exports, overwhelmingly coming from the fertile Jordan Valley. The latter is a distinctive agroclimatic zone, favorable for year-long and outside-the-season crop diversity, both quantitatively and qualitatively, granting the Valley the titles of "*food basket*" and the food safety backbone of Jordan. However, Jordanian agribusiness is not only very vulnerable to climate and its actors lack adequate adaptive capacity over the entire value chain but also impacted by many nonclimatic bottlenecks, which could be categorized (CBI, 2018) into six main categories, namely *production*; *human resources*; *finance*; *marketing*; *policy & governance*; and *logistics & infrastructure*. Regarding the marketing category of obstacles, the sector is suffering from the lack of an effective national marketing strategy. This is further deteriorated by the recent marketing and export blockages due to the nearby Syrian and Iraqi civil wars. Jordan's agriculture exhibits the highest climate change vulnerability in comparison to other development sectors in the country. This led to this issue being addressed by some vulnerability assessments, adaptive capacity-building interventions, and research investigations tackling direct climate adaptive aspects (MoEnv, 2009, 2014; Al-Bakri et al., 2011; MDGF, 2011; Rajsekhar and Gorelick, 2017). However, there is still a complete lack of studies and research on mechanisms or frameworks for participatory and time- and cost-effective identification and assessment of holistic adaptive capacity needs of actors of vulnerable sectors along the entire value chain. We hypothesized thereof that overlooking the advantages of participatory capacity-building renders the assessment approaches unsatisfactory contribution, risks adaptation intervention, and prevents achieving a high level of buy-in of the value chain actors of the planned capacity-building programs. The commonly used approaches in the sector are limited-participatory, researcher-regulated, and questionnaire-based approaches of the training needs assessments or analyses (to be referred to herewith interchangeably by "*TNA*") is assumed to lack the superiority and advantages of participatory, self (i.e., actors)-regulated identification and prioritization of adaptive training needs of the sector's actors. The IPCC's AR6 (Bezner Kerr et al., 2022) emphasized that harnessing vital provisions of SDGs, such as indigenous knowledge and local knowledge, will support effective climate change adaptation to ensure resilient economies in food systems. The said report stressed that the adaptation strategies that address power inequities lead to co-benefits in equity outcomes and resilience for vulnerable groups. Indigenous knowledge and local knowledge facilitate adaptation strategies, especially when combined with scientific knowledge using participatory and community-based approaches. Similarly, we aimed from this research to contribute an integrated participatory adaptive capacity-building assessment framework or model in contrast to the commonly used questionnaire-based surveys in the sector that are based on limited participation and researcher-regulated (controlled) subsystem approaches.

The limitations of the questionnaire-based surveys in general research and adaptive capacity-building need studies, including those of the agrifood sector *per se*, have been repeatedly reported in the literature for many decades (e.g., Hyman, 1955) and still such limitations surface in the recent studies (examples, Kinross et al., 2017; Singh and Sagar, 2021). Such limitations encompassed, but were not limited to, frequent low-response rates (Bell, 1999) as low as 20% (Gilbert, 2001); incorrectly or illegibly filled out questionnaires or even missing answers (Beiske, 2002) will inevitably influence the quality of the data obtained and have the potential to further lower the number of useable questionnaires, abstaining from not offering the researcher the opportunity to follow up ideas and clarify the issue—one of the main strengths of interviews and focus groups. The questionnaires were also reported as time-consuming, expensive, and difficult for sampling and have potential biases from subject sampling, fatigue, and misinterpreting questions (Adams and Cox, 2008; O'Leary, 2014). Moreover, it is important to understand that questionnaires are limited to the questions asked. If the researchers miss important issues in their questionnaire design, they will not appear in the analysis and the importance of the situational or contextual issues will be missed if the single research approach is taken (Adams and Cox, 2008). This was the same conclusion of McLeod (2018) who stated that "*questionnaires still lack detail because the responses are fixed, there is less scope for respondents to supply answers which reflect their true feelings on a topic*." Einola and Alvesson (2021) in their "*Questioning Questionnaires*" study argued the validity of questionnaire-based surveys in research. They highlighted the inherent drawback of question misinterpretation when they noticed that many questions did not really work for several respondents. They stated that "*like all surveys, the validity of the Likert scale attitude measurement can be compromised due to social desirability.*" They arrived at a critical conclusion from their research that the interpretative nature of most research in social sciences is an important aspect that is highly overlooked.

More specifically, the questionnaire-based agrifood surveys of adaptive capacity also suffered from the same limitations. Carey (2018) attempted to evaluate, using a Likert Scale-based questionnaire, the climate adaptive capacity of Pioneer Valley (Massachusetts) farmers by assessing the farmers' knowledge and experience of climate issues directly impacting their farms and preparation. Specifically, Carey (2018) assessed three adaptive capacity components, namely "*combined knowledge,*" "*support & resources,*" and "*past actions*." Among the limitations the said study reported is the lack of good representation of the sampling groups where many farmers were unavailable for the interview or simply not able to be reached by email or telephone communication. This meant that farms had to then be selected in municipalities that may have already been used. This created an uneven distribution of towns represented between the counties. The researcher also had to eliminate farmers from the study who did not fully answer the questions and ignore them from the total scoring of the interview to compare across farms still accurately. The most important limitation of Carey's (2018) study is the inability to consider all adaptive capacity aspects, which include numerous components such as individual and collective knowledge, funding, political intervention, and community networks. The said study chose to focus only on one element of adaptive capacity, individual knowledge of farmers (and their responses based on their knowledge), as a predictor for the likelihood of capacity they would have to adapt to changes they experienced. This limitation was due to the lack of funding and time.

Another particular agrifood TNA and adaptive capacity assessment that was questionnaire-based and reported tied limitations is that of Lockwood et al. (2015), which provided a literature review and an appraisal of a range of adaptive capacity self-assessment procedures. The said authors utilized in their study a psychometric approach for measuring the dimensions of adaptive capacity focusing on the development of approaches that enable local actors and resource managers at the local scale to self-assess their capacity to respond to environmental changes using deductive approaches. The said authors stated that the studies they assessed provided little opportunity for local stakeholders to shape the assessment and that no objective self-report approaches have been used to identify the dimensions of adaptive capacity and their relative importance. The authors, however, mentioned some limitations of their study, including a low response rate (44%), and encouraged researchers to consider the face validity of all items generated, i.e., whether the item can be easily understood by the land manager and whether that land manager can distinguish between it and other items theorized to be related to that dimension of capacity. Moreover, the authors pointed out that the self-reported and the context-specific nature of their data mean that the results are conditioned by the degree of self-awareness of respondents and not necessarily generalizable to other populations or study areas. There are other agrifood sector–specific questionnaire-based TNA studies that highlight the limitations such as biases of interviewers (Limantol et al., 2016), a low response rate of the targeted population of the study (Roesch-McNally et al., 2020), and sample bias (Roesch-McNally et al., 2020). Roesch-McNally et al. (2020), for instance, disclosed their concern that given that their experiment was a convenience sample of small farmers, some of whom are already connected to Oregon State University's Extension networks, it is expected that there would be some self-selection bias on behalf of the respondents. Thus, they recommended to not generalize their results to the broader population of small farmers in the surrounding region.

In comparison, focus groups overcome the limitation of low response to the questions as the participants are purposely invited to express collectively their opinions *per se* and fully and explicitly answer the raised questions. Focus groups also provide a flexible and participatory method that contextualizes users' perceptions and experiences. As noted in our study, participants are far more likely to even release sensitive data (e.g., related to privacy and trust), which was emphasized by Adams and Cox (2008), which happens when participants form some rapport with the researcher in question. It is constructive to note that such participatory approaches allow the participants to sequence their responses themselves and these sequencings can be enlightening in themselves (Adams and Cox, 2008). Focus group-based studies allow designing the research in such a way that enough and reasonable time, in comparison to questionnaire surveys, would be allocated for the collection of authentic data when meeting directly with the respondents. Most importantly, our participatory focus on group MCDA methodology not only is anticipated to be time saving but also cost-effective as it only requires a few hours for each focus group session (ranging between two to 4 h depending on the ramification of discussions) and less money is spent (refreshments served and gas consumed for the transportation of participants and organizers/moderators to the meeting hall). Furthermore, while vulnerabilities can range from environmental, economic, social, and more, contrary to what Carey's (2018) study considered, the environmental vulnerabilities, our study's MCDA-based participatory approach is envisioned to enable participants to choose from a wider pool of criteria. Our method allowed us to effectively provide such flexibility in defining the participants' measurable criteria (through quantitative scoring) against which the options (needs) are assessed. The criteria that participants can consider are open to a wide range of qualitative impact categories but are not limited to socioeconomic, environmental, technical, political, cultural, etc. categories, which allow them to include issues related to their personal concerns such as those impacting their livelihood and social and financial stabilities.

With this in mind, the objective of our study in particular is to demonstrate the superiority of a hybrid participatory, actor-regulated MCDA approach as opposed to investigator-controlled, or limited participatory methods, such as the questionnaire-based approach criticized previously, to robustly conduct a self-run adaptive TNA of vulnerable actors based on their perceptions, thoughts, and concerns. We anticipated running the combined MCDA–TNA in the context of a system-wide approach, rather than the frequently used subsystem approaches to highlight the sector's climate vulnerability to the entire value chain. The MCDA approach has not been deployed in the agriculture and agribusiness sectors in Jordan before the attempts by the teams of this study. MCDA, the abbreviation of multi-criteria analysis (MCA), is both an approach and a set of techniques with the goal of providing an overall ordering of options, from the most-preferred to the least-preferred option. Globally, the approach has been utilized, mostly recently, in other sectors such as energy (e.g., Arsenopoulos et al., 2021) and rural development (e.g., Yuan et al., 2022). However, our framework is unique in combining multiple tools in a system-wide context. The ultimate goal of developing this holistic combined system of methods is advancing the agribusiness and agri-food sectors, like other fields, to a cost-effective and quick qualitative research-based framework that could be deployed in situations of limited resources and short timelines, as development projects and initiatives are not usually suited for conducting extensive quantitative experiments or large-scale surveys. Our framework is thus hypothesized to be a useful first step for providing directional information for future in-depth interventions. Such an efficient MCDA-based participatory approach is thought to be replicable in similar contexts and the broader community of similar concerns and to inform the national and international development agencies and other relevant entities in their efforts to identify and prioritize the comprehensive adaptive capacity needs of a vulnerable sector in a cost-effective and time-efficient approach. This is of particular importance to areas and organizations, where agriculture serves as the main pillar of the national economy and where adaptation and building the adaptive capacity in smallholder farming systems are crucial for food security, poverty reduction, and sustainable development.

2. Methods

The hybrid methodology for a system-wide and participatory focus group-based MCDA to conduct the adaptive capacity-needs assessment of the targeted beneficiaries of this study was organized in two major systematic steps. In the first step, an analysis of the climate change vulnerability and the impacts on the sector was conducted to inform and raise awareness about the nature and the scale of

the climate change problem in their sector to the participants of the focus groups. The enlightenment from the first step of climate vulnerability and impact implications along the entire value chain was fundamental to energize and effectively engage participants for the second step of the adaptive capacity-building process, which encompassed the self-regulated deployment of the MCDA tool. The orderly methodology led to disclosing and prioritizing their real adaptive capacity-building needs. The two steps are elaborated in the following sections.

2.1. Analyses of climate change vulnerability and the impact of the agribusiness value chain

The first step in this adaptive capacity-building needs assessment involved desk study and the analyses of available models to extract concrete and clear conclusions about the climate change vulnerability and its impact on the national agribusiness value chain and the socioeconomic framework of the sector. The aim was to disseminate such clear conclusions in comprehensible language to the actors during the focus group meetings. To that end, we reviewed and analyzed the recent climate change projections and vulnerability assessments conducted prior to executing the focus group sessions (late 2018 to early 2019), i.e., the studies available before 2018. Such studies included those conducted as part of the official Third National Communication Report (TNC) to UNFCCC (MoEnv, 2014), in particular, and the recent research studies conducted at the national level encompassing the targeted study areas, such as those of Rajsekhar and Gorelick (2017). The importance of highlighting such sectoral climate vulnerabilities and risks stems from the need to have a point of departure for the MCDA discussions involving the impacted demographic groups, with emphasis on the most vulnerable actors of the sector, particularly small-holders and poor farmers and later on the policy-makers who will be scientifically informed by the results. To the latter group, the sector is considered the major source of nutrition in the country and most importantly an imperative source of hard currencies originating from exports (FAO, 2015b). According to the Minister of Agriculture (Kayed, 2017), the sector reaped 63% growth in 2019 compared to 2018. In addition, about 25% of the total Jordanian poor live in rural areas reliant directly or indirectly on agriculture, which is a significant employer of such marginal communities (MoEnv, 2014).

Among the key messages disseminated to the focus groups from the said studies is the fact that agriculture is the most climate-sensitive economic sector because the existence of the sector itself and its production are directly dependent on and tied to climate as remarked by Trudge (2016). It was made clear that the climate risks are immediate and critical because most of Jordan's cultivation areas are rain-fed, making this sector more susceptible to climatic changes. The messages from the TNC's projections assessed the entailed information about the annual precipitation using the two Representative Concentration Pathways (RCPs), highlighting that it will likely suffer a significant variability in the next 30 years. The awareness messages included remarks from RCP 4.5 projection, which predicted a 20% decrease in the median precipitation values all over the country by 2055 reaching −35% in 2100. RCP 8.5's messages also predict that the precipitation decreases by 21% by 2050, leading the Standardized Precipitation Indices (SPIs) to progressively trend toward an intensification of winter and spring droughts. Regarding temperature, participants were made aware that temperature will increase during 2070–2100 and an RCP 4.5 average temperature could reach up to +2.1°C accompanied by a more consistent trend toward a drier climate. The maximum number of consecutive dry days would increase in the reference model (MoEnv, 2014) to more than 30 days for the same period and evapotranspiration would increase. Most importantly, the farmer groups were educated that all such predicted conditions will ultimately complicate water resources and supply management of the already fragile ecosystems in the country.

A specific evaluation took advantage of a more recent study by Rajsekhar and Gorelick (2017), who analyzed the surface water resources and agricultural water demand in Jordan up to 2100, contemplating two climate change scenarios: RCP 4.5 (optimistic case) and RCP 8.5 (business as usual). The study considered the collective impacts of climate change and land-use change stimulated by the Syrian political crises. It used regional bias-corrected climate simulations as inputs to high-resolution hydrologic models to assess three drought types, namely: meteorological (reflecting a decline in precipitation), agricultural (representing the deficit in soil moisture), and hydrological (as measured by reduced streamflow) under future scenarios. It considered 1981–2010 as a historical baseline to compare it with the future (2100) divided into three 30-year periods. After running their simulation, they found out that upon comparing the baseline period to 2070–2100, the average temperature increases by 4.5°C, rainfall decreases by 30%, and multiple drought-type occurrences increase from ∼8 to ∼25 in 30 years. The study also revealed a significant increase in the concurrent occurrences of multiple drought types along with an 80% increase in simultaneous warm and dry events. Watershed simulations of the future transboundary Yarmouk River flowing from Syria show that Jordan would receive 51 to 75% less water compared to the historical flow. The Yarmouk River is one of the major water resources for irrigation in the Jordan Valley. Moreover, Rajsekhar and Gorelick (2017) highlighted that the recovery of Syrian irrigated agriculture to preconflict conditions would produce twice the decline in the transboundary flow due to climate change. The adaptive capacity assessment of the study, particularly of extreme droughts, warned of an immense challenge exacerbated by the low awareness among the farmers of the climate change impacts. Table 1 summarizes the elements of climate change vulnerability and the implications of the impact extracted from the aforementioned desk study and the analyses of the available models that were provided as clear messages to the focus group participants.

Another key message disseminated is the notion that the agribusiness vulnerability, in particular, is in turn exacerbated by its fragile characteristics along the value chain. Currently, the sector is facing, in addition to climatic, many other environmental, socioeconomic, and geopolitical challenges. The climatic and environmental challenges are successive drought years; low and fluctuating rainfall; excessive and improper use of agrochemicals and unfermented manure associated with unpleasant odor and insects; and lack of resources for organic fertilizers, *inter alia*. The socioeconomic challenges are mainly tied to low educational levels and rural human resource capacities (Rikken and Leeters,

TABLE 1 Summary of the elements of climate change vulnerability and impact implications provided as messages to participants resulting from desk study and the analysis of available models.

Climate element	Vulnerability and impact implications	Source of information and data
Overall climate	➢ Agriculture is the most climate-sensitive economic sector	Trudge, 2016
Precipitation	RCP 4.5 ➢ 20% decrease by 2055 ➢ 35% decrease by 2100 RCP 8.5 ➢ 21% decrease by 2050 SPIs ➢ Drought intensification of winter and spring	MoEnv, 2014 (TNC to UNFCCC)
	RCP 4.5 ➢ 30% decrease by 2100	Rajsekhar and Gorelick, 2017
Temperature	RCP 4.5 ➢ 2.1°C increase up to by 2100 (a drier climate)	MoEnv, 2014 (TNC to UNFCCC)
	RCP 4.5 ➢ 4.5°C increase by 2100 (a drier climate)	Rajsekhar and Gorelick, 2017
Drought	➢ Maximum number of consecutive dry days increase to 30 days by 2100	MoEnv, 2014 (TNC to UNFCCC)
	➢ Multiple drought-type occurrences increase from ∼8 to ∼25 in 30 years	Rajsekhar and Gorelick, 2017
Water resources availability	➢ 75% less from Yarmouk River	Rajsekhar and Gorelick, 2017

2016). The geopolitical threats are related to the overall civil wars and conflicts in the regions, which closed the nearby regional markets. One particular message emphasized that, due to their greater dependence on agribusiness, principally, the rural poor will be affected disproportionately owing to their relatively lower ability to adapt. The participants were warned that this will jeopardize the costly sustainable-development progress made so far in relation to the poverty-eradication attempts and the harmful impact of food security and socioeconomic developments in such vulnerable areas. Predominantly, farming families and households in poverty pockets–dominant rural areas are expected to face the most severe consequences of climate change through the disruption of livelihood options that depend on agribusiness. Thus, the agribusiness communities deserve to be granted priority in designing the national adaptive measures and capacity-building programs. It was made clear that the expected impacts of climate change, particularly reduced agricultural productivity and water availability, threaten livelihoods and keep vulnerable people insecure. Thus, it was stressed that strengthening such adaptive capacities is highly needed especially to reduce agricultural costs at the farm level and to lessen challenges of transferring production and locked nearby markets, which have led to a remarkable decrease in agriculture exports due to such persistent regional political situation. We remind participants that, although Jordan enjoys some competitive advantage with regard to many agricultural crops, other crops still lose their ability to access foreign markets because of the weakness of competitiveness due to several reasons, most importantly, the political situation surrounding Jordan and to some degree the challenges in the liberalization of agricultural commodities trade.

In addition to the vulnerabilities and impacts highlighted previously to the sector's actors during the stakeholders' consultation and focus group sessions, some proposed adaptation measures and strategies in the analyzed vulnerability studies were assessed for further discussion with the actors. In particular, those measures important to the decision-makers with emphasis on adaptive capacity-relevant measures were given more attention. Among the messages disclosed from the assessments was that conservative agriculture requires extension and training programs (MoEnv, 2014). The final conclusions highlighted from the assessments also encompassed the concerns that such adaptive capacity-building needs were found to be overlooked in the process of transformation of strategies into on-ground action plans. The aforementioned vulnerability inferences helped greatly to better realize the rainbow of the identities of actors to be sampled and involved in the focus groups so that to systematically empower them to participate effectively in reconstructing the adaptive capacity of the sector.

2.2. A holistic, actor-controlled, system-wide, multicriteria adaptive capacity needs assessment of the agribusiness value chain

2.2.1. A system-wide approach

The term "*agribusiness*" meant in the context of this study emphasizes the "interdependence" of various sectors within the production chain (Ng and Siebert, 2009) and, thus, is believed to be better assessed through a system-wide approach to the food value chain, such as the approaches proposed in the general context of agri-food systems by Ng and Siebert (2009), Horton et al. (2016); and Horton et al. (2017). The latter source proposed a robust agenda for integrated system-wide interdisciplinary agri-food research, on which we based our conceptual model of the agribusiness sector's processes tailored for Jordan. The illustrations in Figure 1 serve as a benchmark for identifying the affected subsectors or "links" in the chain of actors in Jordan. This conceptual framework provided a "base map" to perform a systematic and thorough adaptive capacity gap diagnosis and thus enabled the spontaneous gap filling of vital adaptive measures during the stakeholders' engagement and

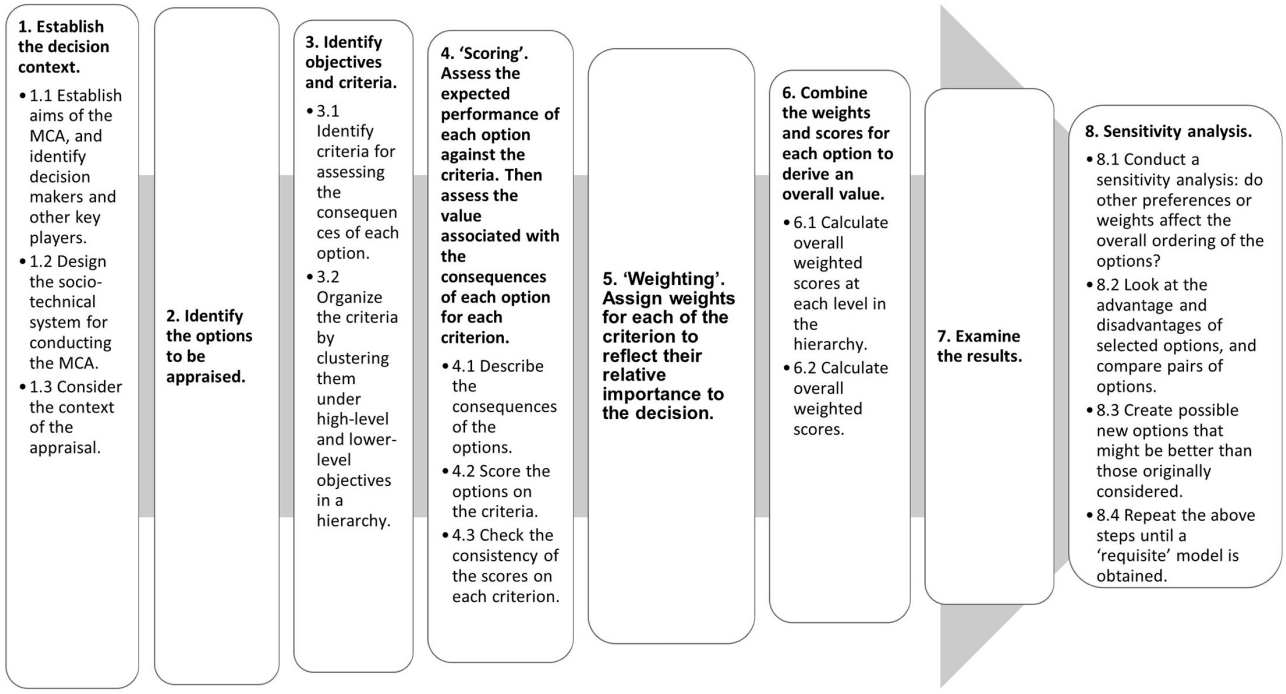

FIGURE 1
Flowchart (from left to right) of the MCDA tool (adopted from DCLG, 2009).

consultation sessions. Our approach aims at building the adaptive power of the most vulnerable actors of the wider chain. This approach is different than the common subsystem-based or single-disciplinary approach, which is mostly a questionnaire-based approach as the latter cannot enable full dissecting and diagnosing of the value chain's processes, actors, and stakeholders involved in comparison to the system-wide multidisciplinary participatory model. According to Gunderson et al. (2014), the agribusiness sector is comprised of interrelated subsectors working together to provide goods and services to consumers around the world, and organizations and managers engaged in the sector share many of the challenges that exist in other business value chains. We perceive that such agribusiness sector-specific challenges could be better diagnosed based on analyzing the entire value chain and key players. The process we followed to identify the actors of this study was based on the notion that the problem analyzed in our case was more related to specific segments of the actors of the wider value chain, who in turn are more affected by the climate change problem and thus have more power of right in the decision-making process. The aim was to build their adaptive capacity and to increase the added value of the products and export power, including developing the level of competitiveness for such vulnerable actors.

2.2.2. Selection of actors and sampling methods

The process of identification of the stakeholders of the agribusiness chain followed the subdivision adopted by the National Agricultural Research Center (NARC)—a national institution in charge of public agricultural research in Jordan—which is the same partitioning followed by international development and aid agencies active in this sector; e.g., The Netherlands Enterprise Agency (Rikken and Leeters, 2016). The latter resource followed a simple division of actors. The three main categories of actors assessed in our study (*farmers*; engineers & technicians; and *brokers & exporters of produce*) are the groups inclusive to the majority of actors mostly affected by the climate change problem. By *farmers*, we meant both the small farmers (on average around 3 hectares) and big farmers (up to 500 hectares) (Rikken and Leeters, 2016). The *Engineers and technicians* group encountered the general category of input material and service (such as seeds, seedlings, and fertilizers) suppliers, processors, technology transfers, and technical service providers as well as extension agents. By *brokers & exporters of produce*, we meant a general category of aggregators, distributors, traders, and exporters, which might include producers with a trade/export role and specialized traders/exporters. This structure of a simple agribusiness value chain is adopted by and is in line with the studies of experts in the field such as de Janvry et al. (2019)—researchers from the University of California at Berkeley. A minor overlap in the roles of actors is expected in any value chain such as the one we adopted here. However, as TNA decision-making is dependent on the collective voice of the group, this minor role overlap is not expected to impact the representative characteristics of the collective decision of the group as we followed a scientific sampling method to minimize actor overlapping and increase such representative power. The actors who play a determinant role in the profitability of farmers and control the market price through their self-imposed function in the chain are the middlemen (brokers). In addition to stakeholders who act (Figure 1) through a workflow of processes (from 1 to 4) utilizing the inputs shown in the squares in the bottom part to yield the outputs on the other side of the chain, there are the overarching external factors. The *geographic* and most importantly the *geopolitical* factors mainly due to the Syrian and Iraqi war crises influence the

Jordanian agribusiness chain rigorously as well explained in the following paragraph.

To increase the statistical representation of the samples (focus groups) of the targeted population and overcome the issues of generalization and quantifying of the analyses debated as limitations in the focus group method, we followed the recommended guidelines for conducting interrelated focus group-based qualitative research (e.g., Vicsek, 2010; Boettcher, 2016) to ensure capturing reliable data. Vicsek (2010) recommended applying the *Tentative Incidence Generalization*, which the author coined in lieu of the *Statistical Generalization* to overcome the *Generalizability* issue in focus group research. In the case of *Tentative Incidence Generalization*, when a researcher finds that certain perspectives or aspects are common to the research subjects belonging to a particular social category in small-sample research, the researcher infers it is likely that not only members of the sample but others belonging to the target population–consisting of people of the same social category–might share similar views (Vicsek, 2010). Thus, *Tentative Incidence Generalization* can be effectively applied in special cases; e.g., in the case of similar results with focus groups of different compositions (Vicsek, 2010). Practically, Boettcher (2016) recommended conducting at least three focus groups per unique segment, so data gathered from across three groups allows the researcher to observe consistent themes and patterns across groups and assess if there are any outliers or themes exclusive to one group that may not be representative of the unique segment as a whole. Among the other guidelines followed here from focus group research sources, particularly to overcome the limitation of numerical analyses of focus groups, is that emphasis should be placed on how the ranking (of priorities in our case) came about and what arguments the participants put forward rather than focusing on the numerical analyses of the results (Vicsek, 2010), which is limited in the case of focus group-based qualitative research.

In line with the qualitative research guidelines referenced previously, we have thus formulated nine representative facilitated workshops or focus groups (maximum of 15 participants in each group) from the four agroclimatic zones or districts of the Jordan Valley. The four zones assessed are the official administrative subdivisions of the Jordan Valley comprised of the *Southern Jordan Valley District*, the *Southern Shouneh District*, the *Deir Alla District*, and the *Northern Jordan Valley District*. The workshops incorporated agribusiness actors from the aforementioned three categories of actor groups, which are *farmers* (four focus groups(; *agricultural engineers & technicians* (four focus groups); *and brokers & exporters of produce* (one joint group of the four zones). Since few participants from the latter category were available in the four groups representing the four districts, the four groups were mixed into one larger group (Table 2) for efficiency and time-saving. This was done late upon observing the consistency of intergroup results, and the flow of outcomes from the focus groups' discussions took place ahead of this mixed group, i.e., the *farmers* and *technicians/engineers* groups, and due to the big conformity of the general results of ranked priorities presented in the *Results* section. The actors were selected randomly from a wide national pool of agricultural/agribusiness actors, i.e., purposive sampling. The population from which the sample was taken contains a national database of the said actors at NARC. The main demographic characteristics of the participants are presented in Table 2, while more demographic information is presented in Supplementary Table 1.

2.2.3. The participatory PRA-MCDA approach

The participatory aspect of the MCDA model followed the *Participatory Rural Appraisal* (PRA) method. The PRA method applied in this study is an approach that complements and supports projects where capacity building, subsidiarity, social justice, and fundamental issues of community development are the principal objectives as highlighted by Freudenberger (2008). Without stakeholder commitment, participation, and engagement, these projects have less chance of achieving their goals (Freudenberger, 2008). PRA offers an approach to project planning and implementation that integrally involves the stakeholders throughout the length of the process. The participants will first use PRA to assess their needs and customize the project interventions to their priority concerns and particular circumstances of their community. The MCDA we deployed is a tool used prospectively to appraise the options that are as yet only proposed. The general family of the MCA techniques can be used to identify a single most preferred option, rank options, short-list a limited number of options for subsequent detailed appraisal, or simply distinguish acceptable from unacceptable possibilities (DCLG, 2009). MCA in its intrinsic nature is a tool that describes any structured approach used to determine overall preferences among alternative options. Thus, it is a decision-making tool. It establishes preferences between options by reference to an explicit set of objectives that the decision-making body has identified and for which it has established measurable criteria to assess the extent to which the objectives have been achieved. It includes a full range of social, environmental, technical, economic, and financial criteria based on the quantitative analysis (through scoring and weighting) of a wide range of qualitative impact categories and criteria. Emphasis is put on the judgment of the decision-making body in establishing objectives and criteria, in estimating relative importance weights, and in judging the contribution of each option to each performance criterion. The criteria meant in the MCA are a reflection of the established objectives of the intervention. A summary of the MCDA's flow of processes followed in our methodology is depicted in Figure 2. One technique of MCA is MCDA. A full MCDA involves scoring each option on each criterion and then combining the scores by means of a system of weights to yield an overall ranking for each option. The MCDA tool tailored in our study to run the adaptive capacity-building needs assessment is based on a customized form of the tool documented in a hands-on guidance to MCA (Trærup and Bakkegaard, 2015). The latter resource systematically used the tool to evaluate and prioritize climate change technologies for adaptation and mitigation in developing countries as part of the global project entitled "*Technology Needs Assessment*" implemented by the *United Nations Environmental Program* (*UNEP*) and the *Technical University of Denmark* (*DTU*) called the "*UNEP-DTU Partnership*" (*shortly known as "UDP"*). The objective of the guidance of UDP's customized form of the standard MCA tool, the latter is best described theoretically in DCLG (2009), is to assist consultants, decision-makers, and technical experts on how to facilitate discussions for prioritizing adaptation and mitigation technologies and to support the stakeholders in identifying the

10.3389/fsufs.2022.1026432

TABLE 2 Main demographic characteristics of the study participants from the four districts of the Jordan Valley (bold values indicate sums of sub-values beneath).

Demographics	Southern Jordan Valley district		South Shouna district		Deir Alla district		Northern Jordan Valley district	
	Estimate	%	Estimate	%	Estimate	%	Estimate	%
Farmer focus group participants (total)	**17**	**100**	**11**	**100**	**22**	**100**	**20**	**100**
Farmer focus group participants (men)	16	94	**11**	100	18	82	19	95
Farmer focus group participants (women)	1	6	0	0	4	18	1	5
Technicians and engineers focus group (total)	**21**	**100**	**16**	**100**	**17**	**100**	**11**	**100**
Technicians and engineers focus group (men)	11	52	12	75	12	71	8	73
Technicians and engineers focus group (women)	10	48	4	25	5	29	3	27
Brokers and exporters of produce focus group (total participants and percentage)	**9 (100%)**							
Brokers and exporters of produce focus group (men)	8 (89%)							
Brokers and exporters of produce focus group (women)	1 (11%)							
All groups (144 participants) other demographic characteristics (total and percentage)								
1. **Age**	**144 (100%)**							
30–39	23 (16%)							
40–49	60 (41.3%)							
50–60	47 (32%)							
Older than 60	14 (10.7%)							
2. **Marital status**	**144 (100%)**							
Single	12 (8.7%)							
Married	132 (91.3%)							
3. **Educational level**	**144 (100%)**							
Elementary	52 (36%)							
Secondary	52 (36%)							
Community college (2-year Diploma)	14 (10%)							

(Continued)

TABLE 2 (Continued)

Demographics	Southern Jordan Valley district		South Shouna district		Deir Alla district		Northern Jordan Valley district	
	Estimate	%	Estimate	%	Estimate	%	Estimate	%
Bachelor degree	24 (16.7%)							
Master's degree	1 (0.7%)							
Ph.D. degree	1 (0.7%)							
4. **Other professions of livelihood besides farming/agribusiness**	**144 (100%)**							
Farmers	87 (60%)							
Private sector employees/independent business owners and farmers/agribusiness practitioners	10 (6.7%)							
Public sector employees and farmers/agribusiness practitioners	18 (13.3%)							
Retirees & farmers/agribusiness practitioners	29 (20%)							
5. **Income sources**								
Farming/agribusiness								
Mean	70.7							
Std. Deviation	31.36							
Nonfarming activities								
Mean	29.29							
Std. Deviation	31.36							
6. **Farming experience (years)**								
Below 10 years	12.7%							
10–20	54.7%							
21–30	22.7%							
31–40	4.7%							
More than 40 years	5.3%							
District total population[a]	**63,550**	18	**61,050**	17	**85,100**	24	**141,690**	40
Men	33,470	10	33,890	10	49,420	14	75,860	22

10.3389/fsufs.2022.1026432

TABLE 2 (Continued)

Demographics	Southern Jordan Valley district		South Shouna district		Deir Alla district		Northern Jordan Valley district	
	Estimate	%	Estimate	%	Estimate	%	Estimate	%
Women	30,080	9	27,160	8	35,680	10	65,830	19
Households	10,876	3	**11,372**	3	16,030	5	28,562	8
Working members in the household (16 years and over)[b] total	**3,257[c]**	11	**3,314**	11	**9,270**	31	**14,131[d]**	47
Permanent working men	186	2	1,284	17	2,712	36	3,284	44
Permanent working women	0	0	40	100	0	0	0	0
Seasonal working men	0	0	611	38	758	47	239	15
Seasonal working women	0	0	102	13	690	87	0	0
Incidental working men	1,572	11	788	6	3,463	24	8,459	59
Incidental working women	1,499	26	489	8	1,647	28	2,149	37

[a]Based on 2021 census data (DOS, 2021).
[b]Census includes Jordanian and foreigner workers (DOS, 2018).
[c]Reported data for Ghour As-Safi Area (DOS, 2018).
[d]Reported data for North Shouna Area (DOS, 2018).

appropriate criteria for the targeted analysis. We have found that the said UDP's MCDA tool is applicable to conducting our adaptive capacity-building needs assessment and was successful in this mission. The first author has proposed this hybrid method before, for the first time as well in Jordan, but in the field of climate, technology needs assessments (Abdel-Fattah et al., 2016a). The difference applied in this study is testing the tool from a different aspect of the adaptation process, the adaptive capacity, and following a system-wide approach of the value chain base not followed in the UDP's MCDA approach, utilizing a tailored global conceptual agri-food ecosystem model such as that of Horton et al. (2017), which is depicted, with slight modifications in Figure 1. The harmonization between the different methods to develop this hybridization of PRA-MCDA-TNA helped us conduct a more systematic and thorough climate adaptive-capacity gap diagnoses and, thus, a spontaneous identification and bridging of the capacity gaps for the sake of developing a holistic national program for climate adaptive capacity-building. The integration of multiple methods often collates more available information than what can be gathered by a solo method alone.

With that participatory PRA-MCDA approach in mind, the nine groups were invited successively from 28 November 2018 to 24 January 2019 to the sessions of live participative-filling of the MCDA matrices, which were displayed on a large screen during the exercise and conducted systematically for each group of actors facilitated and moderated by the two co-authors and assisted by another two consultants hired to provide logistics and facilitation (the nine multisheet *MS Excel* files of the MCDA tool run are available with this article as Supplementary material). The two co-authors carried out much of the modeling on the spot with the help of the *Excel* spreadsheets designed for the selected MDCA and with appropriate displays of the model and its results for all participants to see live. When launched, the workshops began with delivering the messages from the climate change vulnerability and impact assessments elaborated previously to the actors to initiate the actors' brainstorming and discussions about areas of risk. Then, this was followed by an open discussion to guide the participants to identify from their own context a random list of ambiguous-priority adaptive capacity-building needs for each category of actors based on a thorough diagnosis of each link of the value chain. The facilitators were open to modifications and additions to the options with the progress of the analysis. Then, this updating session was followed by brainstorming the criteria upon which the consequences of each option will be assessed. The criteria express the many ways that options create value. A broadly satisfactory requirement for MCDA is that the criteria should be chosen to represent the concerns of people as a whole and to allow the expression of informed preferences (DCLG, 2009). The criteria were then organized by hierarchically clustering them into higher- and lower-level objectives to facilitate scoring the options in the criteria and examining the overall results at the objective level. The most important trade-off between the objectives appears at the top of the hierarchy. This is often between costs and benefits. Thus, the very top objective is the overall result, taking both costs and benefits into account. The next level down would show costs as one objective and benefits as another. Then, the consequences of options against the criteria were described to the participants and discussed with them for insights. The approach that facilitated this was by writing a simple qualitative description of each option by considering each criterion and articulating it in the

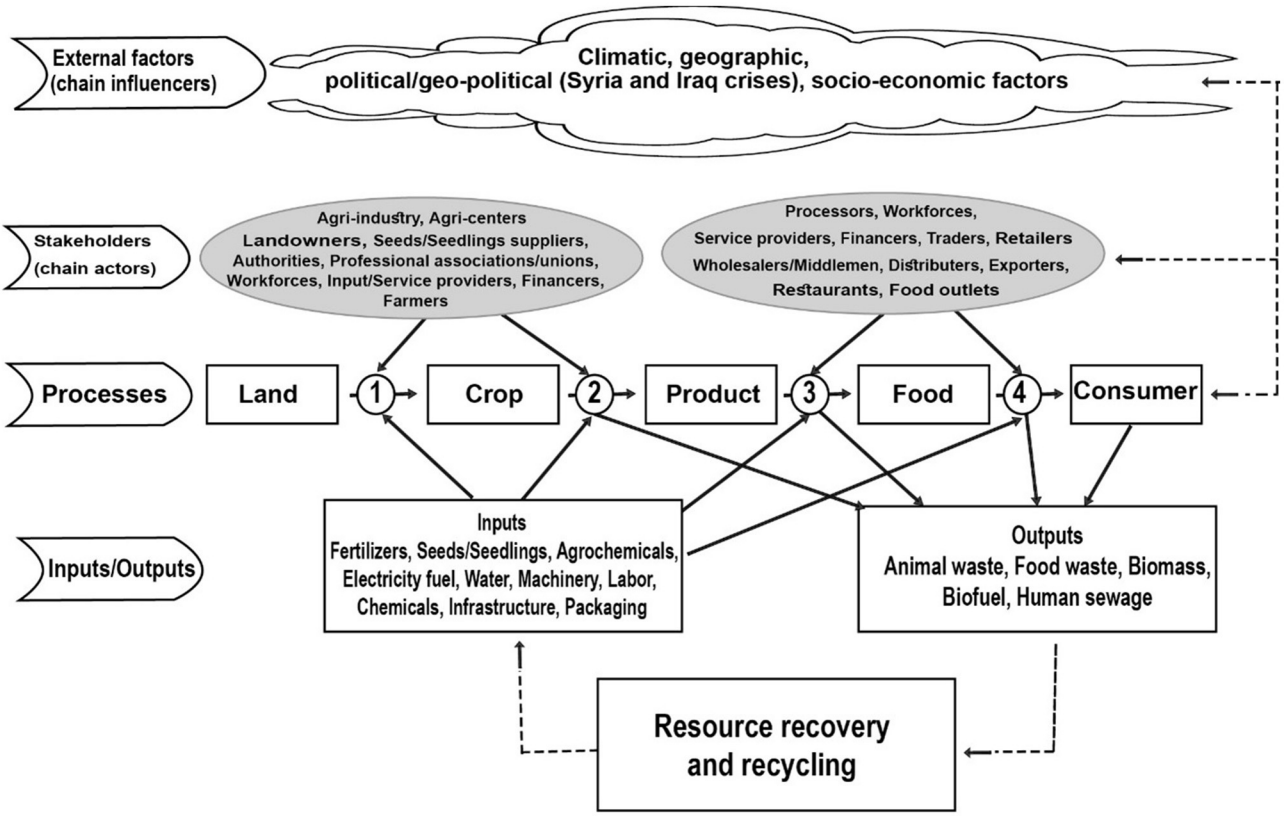

FIGURE 2
Jordan agribusiness value chain-tailored holistic conceptual model abstracted to initiate the focus groups' discussion and brainstorming systematic diagnoses of climate adaptive agribusiness capacity-building and training needs (adapted with modification from Horton et al., 2017).

performance matrices. The next major step was scoring the options in the criteria. The key idea is to construct scales representing the preferences for the consequences, weigh the scales for their relative importance, and calculate the weighted averages across the preference scales. These are simply scales anchored at their ends by the most and least preferred options for a criterion. The most preferred option is assigned a preference score of 100 and the least preferred a score of 0 (or it could be programmed to range from 5 to 0 as in our case). Next, we proceeded to reprioritize (ranking) the capacity-building needs through group (participatory)-scoring, assigning a score for the listed needs against weights (in percentage "%") for the selected multicriteria. Then, this step was followed by assessing weights for each of the criteria to reflect its relative importance to the decision followed by revising the assigned criteria's weights to re-adjust the final results based on the logic of results in light of the significance of each criterion. The final weight determination is informed by a group discussion. Then, the overall weighted scores at each level of the hierarchy are calculated. The overall preference score for each option is simply the weighted average of its scores in all the criteria as expressed by **Equation 1.** After finalizing filling all MCDA spreadsheets, the *Excel* sheet automatically calculates the weighted scores and produces a top-down ranking of options with the final weighted scores.

$$S_i = \sum_{j=1}^{n} w_i s_{ij} = w_1 s_{i1} + w_2 s_{i2} + \ldots + w_n s_{in}, \quad (1)$$

where the preference score for option *i* in criterion *j* is represented by *sij* and the weight for each criterion is represented by *wj*, and then, in the *n* criteria, the overall score for each option is represented by *Si*.

Notably, the training needs were first identified as general gap capacity-building categories at the overarching-theme levels, and whenever a subtheme is raised by a participant in a focus group, it was reassigned under its general theme. For example, when *harvesting*, *packaging*, *sorting*, and *grading* skills were raised as training needs, the moderators highlighted that such needs could be bundled under the "*post-harvest treatments*" capacity. Another example was the *agricultural operations* (*fertilization*, *prevention*, *control*, etc.), which were bundled under "*good agricultural practices (GAPs)*" and so on.

3. Results and discussion

The application of a hybrid participatory and system-wide MCDA tool to the food value chain engaging representatives from the four agroclimatic (administrative) zones of the Jordan Valley enabled full listing, scoring against the set criteria, and prioritizing the indirect and direct adaptive training needs. The results are displayed in Tables 3–5 for farmers, technicians/engineers, and middlemen/exporters of produce, respectively. This beneficiary-controlled hybrid model of methods helped to disclose the overlooked indirect adaptative factors that act as the chain's controlling bottlenecks, one of which is a marketing disadvantage that prevents exports to potential vital marketplaces, which was a

TABLE 3 The prioritized adaptive agribusiness training needs of the four investigated *Farmer Focus Groups* demographic category in the Jordan Valley (sorted ascending; the top three training priorities for each group marked in bold in the far-right column).

District : *Southern Jordan Valley*		
Rank	Training needs	Weighted final score
1	**Farm management skills**	**86.7**
2	**Postharvest treatments (with emphasis on dates, grapes, and vegetables)**	**85.0**
3	**Agricultural marketing and premarketing treatments (marketing-oriented picking, packaging, sorting, grading, transportation, storage, and marketing information)**	**83.3**
4	Formation of effective unions and federations of producers	66.7
5	Communication and negotiation skills	66.7
6	Good agricultural practices (GAPs)	65.0
7	Sustainable agriculture (such as *permaculture,* newly introduced in the country mainly by PRI[a])	48.3
8	Agricultural patterns	10.0
District: *South Shouna*		
Rank	Training needs	Weighted final score
1	**Agricultural marketing**	**92**
2	**Skills of formation of effective unions and federations of producers**	**80**
3	**Postharvest treatments**	**50**
4	Sustainable agriculture	42.5
5	Communication skills	35
6	GAPs	15
District: *Deir Alla*		
Rank	Training needs	Weighted final score
1	**Postharvest treatments**	**85.0**
2	**GAPs**	**83.3**
3	**Agricultural marketing**	**73.3**
4	Skills of formation of effective unions and federations of producers	58.3
5	Disposal of agricultural waste (increased resource use)	53.3
6	*Permaculture*	50.0
7	Farm management	43.3
District: *Northern Jordan Valley*		
Rank	Training needs	Weighted final score
1	**Sustainable agriculture**	**86.7**
2	**Agricultural marketing**	**77.5**
3	**GAPs**	**67.5**
4	Recycling of agricultural waste and compost manufacturing	67.5
5	Skills of formation of unions and federations of producers	52.5
6	Postharvest treatments	37.5
7	Hydroponics	32.5

[a]PRI: Permaculture Research Institute of Australia, introduced the Permaculture concept in the Jordan Valley about ten years ago through a demonstration site administered and promoted as "Greening the Desert Project" (PRI, 2022) https://www.greeningthedesertproject.org/ (accessed May 29, 2022).

TABLE 4 The prioritized adaptive agribusiness training needs of the four investigated technicians and engineers focus groups demographic category from the Jordan Valley (sorted ascending; the top three training priorities for each group marked in bold in the far-right column).

District: *Southern Jordan Valley*		
Rank	Training needs	Weighted final score
1	**Agricultural marketing**	**83.3**
2	**Farm management**	**73.3**
3	**GAPs**	**73.3**
4	Postharvest treatments	73.3
5	Communication skills	63.3
6	Statistical analysis skills for information and knowledge management	41.7
7	Sustainable agriculture	23.3
District: *South Shouna*		
Rank	Training needs	Weighted final score
1	**Skills of formation of active unions and federations of producers**	**76.7**
2	**Postharvest treatments**	**65.0**
3	**Agricultural information systems and marketing**	**55.0**
4	Communication skills	35.8
5	GAPs	28.3
6	Skills of technical writing for fundraising project proposals	10.0
District: *Deir Alla*		
Rank	Training needs	Weighted final score
1	**Postharvest treatments**	**90.0**
2	**Skills of formation of unions and federations of producers**	**78.3**
3	**Agricultural information systems and marketing**	**60.4**
4	GAPs	49.6
5	Communication skills	28.3
6	Skills of technical writing for project proposals attracting funding	2.5
District: *Northern Jordan Valley*		
Rank	Training needs	Weighted final score
1	**Agricultural marketing**	**85.0**
2	**Skills of formation of effective unions and federations of producers**	**80.0**
3	**Postharvest treatments**	**60.0**
4	Communication skills	30.0
5	Household agricultural (food) processing and storage	20.0
6	Farm management	20.0

common top-priority capacity-building need in almost all groups. The consistency of the results at both the intrademographic (the three tested focus groups in each demographic category) and interdemographic (the entire groups of all categories of agribusiness actors) levels supports the provision of specific guidelines of Boettcher (2016) we followed concerning the recommended number of focus groups to be run in such qualitative research. This allowed us to detect consistent themes and patterns across the tested groups and thus assess themes exclusive to some groups. A thorough look at the disclosed top-priority adaptive training needs identified both general consistency and category- and agroclimatic-specific capacity gaps explained later in terms of priority accordingly and discussed in the context of potential rational justifications of the dynamics of such frameworks of priority capacity-building needs. The consistency in the results of the options obtained could be further justified by the fact that the agribusiness value chain emphasizes the "interdependence" of the various subsectors within the production chain as noted by Ng and Siebert (2009). In our case, the closeness and interference in the official and, most importantly, personal relationships between the actors of the different links of the chain allow the coidentification and cocharacterization of mutual concerns and problems in the sector and automatically reach a consensus on such shared attitudes

TABLE 5 The prioritized adaptive agribusiness training needs of the investigated mixed-in-one four brokers and exporters of produce group representing the four geographic regions of the Valley (sorted ascending; the top three training priorities for each group marked in bold in the far-right column).

One mixed brokers and exporters of produce focus group representing the four geographic regions of the valley		
Rank	Training needs	Weighted final score
1	**Integrated pest management**	**82.5**
2	**Agricultural marketing**	**79.2**
3	**Postharvest treatments (with emphasis on dates markets)**	**49.6**
4	Strategic planning	33.3
5	Agricultural automation	5

and opinions. The adaptive capacity-building needs prioritized are explained hereafter.

3.1. Marketing

Within this unpredicted shift toward putting more weight on some indirect downstream adaptive capacity-building needs, it was not much unexpected that all nine focus groups considered *marketing* as a controlling factor of their produce viability. Thus, such an indirect adaptive measure always was one of the top three training priorities for each focus group (Tables 3–5). Three groups from both farmers and technicians/engineers (Tables 3, 4) unquestionably considered it their first priority while the third group (brokers/exporters) considered it their second top priority (Table 5). This result is in line with the key fact that the low marketing power of Jordanian farmers is not only in the international market domain (CBI, 2018) but even in the internal markets as well. In some seasons, farmers are the sole financial losers in the value chain economics mainly due to the lack of a national marketing strategy (CBI, 2018). This problem causes the absence of central planning toward demand-oriented production, weak transparent price-setting mechanisms, absence of a regulatory framework for quality and support to the export of fruit and vegetables, and lack of sufficient and up-to-date market intelligence (Rikken and Leeters, 2016). Such organizational problems are ultimately the result of parallel governmental intrinsic ignorance of the sector. Internationally, Jordan has substantial power to produce vegetables and fruits and even has horizons for expansion but suffers from the inherent absence of foreign marketing competitiveness (CBI, 2018). Jordan has customarily been exporting large quantities to its surrounding countries Iraq, Syria, Saudi Arabia, Lebanon, Eastern Europe, Russia, and the Gulf States (Rikken and Leeters, 2016). However, since 2011, border crossings in the north with Syria are almost completely closed or interrupted due to the civil war conflict, having a highly negative impact on reaching its normal markets and actual realization of exports. Therefore, powerful downstream marketing capacity-building is a critical indirect climate adaptive measure that actors in the agribusiness chain view as "*post-requisites*" (postcondition) to the fate of upstream direct adaptive farming activities and practices as well as support interventions, primarily those advanced by international development and aid agencies. Any intervention in the climate change adaptation context that overlooks the perceived risks from nonclimatic factors that the actors in the sector consider a big hurdle will most likely fail to achieve its set goals. Thus, building these vital indirect adaptive capabilities to explore and find new markets and complying with high-end market requirements are desperately needed as never before. Thus, training the sector-wide stakeholders on marketing skills and strategies toward national and international markets, securing alternative marketing solutions, and hunting for innovative marketplaces is crucially needed.

3.2. Postharvesting treatments

Postharvesting treatment is the second top priority and also an indirect, adaptive capacity need at the sector level. Seven focus groups from the three studied stakeholder categories identified it as a priority among the top three capacity-building needs. This result is in line with the report by Stathers et al. (2013), who emphasized that there has been less analysis and less assessment of the impacts of climate change on postharvest agriculture and pointed out that there are even still fewer discussions on these impacts in developing countries. The said study highlighted, in the context of food security, that many studies have focused on potential crop yield and the preharvest implications of different climatic projections but have overlooked the analysis of the need and ability to then protect this increasingly valuable harvest. In their study, Stathers et al. (2013) identified the adaptive opportunities for creating more climate-resilient postharvest agricultural systems and associated livelihoods. They presented a discussion on the factors influencing the attempts to strengthen the adaptive capacity of the postharvest systems of African smallholder farmers, e.g., such as its invisibility, its omission from training curricula, its innovation system challenges, and the policy bias toward preharvest agricultural spending. The authors concluded by recognizing the essential role of postharvest agriculture in helping communities adapt and cope with climate change and variability. Kumar et al. (2020) provided a bird's eye view of the postharvest technological solutions that could help reduce the effects of climate change. They listed some of the climate change impacts such as overdrying of grains in the field, fire hazards, reduction in seed viability, and higher intensity and frequency of pest attacks and mold growth in stored grains, entailing greater grain handling and management cost. They then presented some mitigation and adaptation measures such as energy and cost-efficient solutions involving the use of greenhouse technology, utilization of solar dryers for postharvest operations, the use of nonthermal processing like pulsed electric field and ultrasound, and irradiation technologies to ensure postharvest food quality preservation. They pointed out that postharvest loss

reduction can be achieved by advanced nanotechnology-based packaging, environment-friendly storage facilities, and supply chain management practices.

In the Jordanian context of the potential fields of postharvest technology, inputs, and infrastructure for cultivation, entrepreneurs in the sector still need much capacity building. Buyers are eager for new packaging and cooling techniques in particular, which will open new opportunities for getting fresh products through farm-to-end markets. A range of new films and plastics are having a huge impact on fresh fruit preservation, and continuous progress is being made in the field of controlled atmosphere containers (Rikken and Leeters, 2016). Postharvest techniques are also shifting the boundaries of transport and logistics, while EU buyers, for example, are interested in suppliers who keep up with these developments and their applications. This indirect adaptive capacity need is very logical as post-harvest losses are rising in low- and middle-income countries because of inadequate storage and inefficient transportation networks (Horton et al., 2017). Thus, recommended interventions in this direction should incorporate training on the introduction of advanced technologies and mechanization in farming and postharvest practices that are up to regional and international standards. This will increase productivity and quality and at the same time save labor costs and water. In this context, one particular crop that emphasized the need for this indirect adaptive capacity-building need in our study during the stakeholders' discussions was dates. Such a capacity gap was raised strongly by a farmer focus group representing a dates-famous region, namely the *Southern Jordan Valley District* (Table 3). The justification for highly prioritizing this crop is the promising potential such farmers anticipated from the market even though they have started growing dates relatively recently based on our discussions with them and with feedback. The great potential of dates for this group and the entire valley is due to the climatic conditions of the valley that are very supportive of elongated growing seasons accompanied by elevated temperatures and sunny days most of the year with warm to mild short winter. However, for the said district, this capacity need is a more important priority because their productivity is still behind the other three districts of the valley with 0.75 ton/dunam compared to 0.97, 1.12, and 1.25 ton/dunam of the *South Shouna*, *Deir Alla*, and *Northern Jordan Valley Districts*, respectively (Supplementary Table 1).

The brokers and exporters of the produce focus group highlighted the same conclusion (Table 5). Dates show a notable area of export expansion, which is expected to stay and augment in the near future. An important justification in addition to its market potential is its water efficiency ratio (D'Angelo and Quinn, 2012). For the next few years, the production capacity will double again (Rikken and Leeters, 2016). Dates have a short value chain that is greatly profitable along its segments. The *Medjool* variety (mainly planted in the Jordan Valley in the country) has the best prospects but other varieties, e.g., *Berhe* are also promising (FAO, 2015b). However, dates have ethnic markets across the world and all over Europe, and in particular, the share of ethnic consumers related to immigrants/refugees is growing fast. Due to globalization and, most importantly, historical and modern political crises-driven immigration waves, European consumers are becoming familiar with food traditions from other continents, in particular the Middle East, putting more demand for ethnic and exotic fruits and vegetables motivated by the steady population growth of ethnic minority groups.

3.3. Formation of active producer unions and federations

The need to have an environment that allows the establishment of robust producer unions and federations came as one of the top three priorities of the four focus groups. This indirect adaptive capacity-building need echoes the growing calls (for instance, Cinner et al., 2018) to strengthen the ability to organize and act collectively to minimize the impacts of climate change. Such calls emphasize that building connections across communities (bridging social capital) and people or organizations operating at larger scales (e.g., international NGOs and financial organizations) can help secure access to resources, scientific information, and technological innovations that facilitate adaptation as well as provide people a voice in higher-level adaptation policy and planning. This also includes strengthening institutions for collective action, for instance, comanagement. Agribusiness entrepreneurs worry about the lack of competence and leadership, the low level of cooperation within the sector and between the private and public sectors, and the negligible role played by the associations and cooperatives in the sector. The European market import experts emphasize that the supply lines in the fresh fruits and vegetables agribusiness are becoming shorter and more efficient. Thus, better control throughout the value chain is established by closer contact among farmers, traders, and retailers, which in turn builds expertise in specific products and helps comply with the strict delivery terms of large EU retailers, for instance (CBI, 2021). Thus, competitors must join forces and target strategic partnerships to acquire a stable position in the European market. Consequently, strengthening these vital capacity-building needs will help consolidate other tied important but second-priority needs identified otherwise by the actors at the lower levels of priority in relevance to other higher priorities, such as "*building agricultural information systems*," "*communication skills*," and "*skills of formulation of project proposals attracting funding*." In this regard, training needs that were of lower priority do not mean they are of no significance but they only form actions of less urgent priority under the current circumstances. For example, the need for building "*skills of technical writing of project proposals attracting funding*" is still demanding as, in poorer parts of the world, small-scale farmers suffer not only the lack of land but also the lack of access to credit (Horton et al., 2017).

3.4. Integrated pest management

This is one of the indirect upstream adaptive capacity-building needs discussed in the context of general "*farm management*" with emphasis on "*Good Agricultural Practices (GAPs)*." The latter category of capacity-building needs is considered this time as a prerequisite to the success of downstream indirect adaptive frameworks such as foreign market requirements. It was identified as a priority, particularly by brokers and exporters of produce, and occupied the fourth place in the order of importance. There were five focus groups who considered the aforementioned three other farm-management practices as their top three priority needs. This is in line with the findings of Lockwood et al. (2015) in their psychometry-based approach to measure the dimensions of adaptive capacity of rural

landholders in the Tasmanian Midlands. They have found that, in such agricultural landscapes in South-Eastern Australia, the most important dimensions influencing perceived landholder adaptive capacity are related to their management styles. The identification of "*integrated pest management*" as a priority capacity-building need is a result that is also in line with the requirements of strict foreign market compliance with MRLs (maximum residue levels) and microbial contamination. The latter two requirements are preconditions for entering the EU market (Rikken and Leeters, 2016), which explains why brokers and exporters of produce considered it their first priority over all their other needs (Table 5). This is also plausible considering, for example, the past decision of the *Ministry of Climate Change and Environment* in the United Arab of Emirates (Namrouqa, 2017) to ban the import of seven of Jordan's main vegetable exports as of mid-May 2017 to assure the quality of imports and eliminate pathogens such as bacteria and pesticide residues. The precautionary ban was put in place due to the increasing levels of chemical pesticide residues and would be implemented if exporters keep exporting produce that violates mutual agreements as declared by UAE officials. UAE is one of Jordan's largest importers of vegetables and fruits, with over 155,000 tons imported annually (Roya News, 2017). The ban created a financial burden on the Jordanian agricultural actors and further deteriorated the financial situation of the farmers of the Valley who have been severely affected in the two seasons that preceded this decision after the closure of the two largest markets, Iraq and Syria, as hundreds of tons of produce exports used to cross daily to such nearby markets. Heeb et al. (2021) emphasized how climate change is affecting the biology, distribution, and outbreak potential of pests in a vast range of crops and across all land uses and landscapes. They highlighted that up to 40% of the world's food supply is already lost to pests. Thus, the said co-authors warned that overlooking the reduction of pest impact is a threat than ever to ensure global food security. In this regard, they advanced a cross-sectoral approach of climate-smart pest management (CSPM) that aims to reduce pest-induced crop losses, inter alia, and strengthen the resilience of agricultural systems in the face of climate change.

3.5. Sustainable agriculture (permaculture)

One farmer group (*Northern Jordan Valley*) was interested in identifying the potentials of sustainable agriculture, particularly "*permaculture*" and what adaptation-mitigation co-benefits such sustainable farming system advances. Thus, the said group ranked *permaculture* as their top priority. The said farmer group realized *permaculture* as their top priority adaptive capacity need because this district of the Jordan Valley is more developed and advanced in readiness to try new sustainability-oriented farm initiatives than the other districts of the Valley. Consequently, this farming community became eager to test new sustainable farming systems to compare with traditional monoculture practices. *Permaculture* developed its evolving definition with time since the concept was first coined more than 40 years ago by its co-generators Mollison and Holmgren (1978) as "*an integrated, evolving system of perennial or self-perpetuating plant and animal species useful to man*" in comparison to the resource-hungry forms of commercial agriculture. Although it has not been explicitly presented in the context of response actions to climate change, as the climate change phrase was not "famous" and publicly known at the time the term *permaculture* was developing, *permaculture* turned out to be a holistic framework of adaptation-mitigation co-benefits with time and kept evolving in the coining-authors' following research work (Mollison, 1997; Holmgren, 2002). This evolution of the term progressed until it was mainstreamed in the climate change response literature (for example, Henfrey and Penha-Lopes, 2015). Energized by many modern descriptions of admiration, such as the one stating: "*popularly seen as a "cool" form of organic gardening, permaculture could be better described as a design system for resilient living and land use based on universal ethics and ecological design principle*" (Holmgren, 2018), it is not bizarre that this dynamic concept is still inspiring so many practitioners, investigators, and authors, leading to a vast collection of books illuminating on the theory and applications of the concept. While some consider it still far less widely understood, some authors (Henfrey and Penha-Lopes, 2015) highlighted that *permaculture* though is gaining prominence as a term.

The link between *permaculture* and the climate change response works is still evolving. While climate change is a foreboding call to reassess humanity's wrong development directions and urge it to transform global society in ways that allow our sustained survival, we believe *permaculture* is one of the best candidates for a package of solutions to serve as a positive sign for such sought transformational change toward inclusive sustainable development. Harnessing *permaculture* as both a guiding doctrine and a tool for collective practical action is common to many community-based responses to climate change worldwide. Some studies, one of which is Henfrey and Penha-Lopes (2015), have identified 17 key *permaculture*-based adaptation response strategies as a platform for "*growing global grassroots movement that is practicing adaptation to climate change through much wider and deeper transformations to sustainability. This movement is dynamic, holistic, self-organizing, and taking place outside of the mainstream sustainability discourse, which struggles hard to address climate change through an outdated paradigm*." Thus, we believe that *permaculture* not only operates active adaptation measures but also provides, *inter alia*, mitigation co-benefits that no other climate change-response approach can in one holistic bottom-up system like *permaculture*. Thus, *permaculture* will defiantly be vital in the transition process toward crops with the best possible farm management practices, resource use efficiency, and produce diversification toward a more resilient product assortment, especially in times of crisis such as the recent *COVID-19* Pandemic. During the latter unprecedented worldwide disaster, individuals and communities who were practicing full or partial forms of *permaculture* were believed to have fairly enjoyed not only resilience, security, and healthy food but also immune-boosting produce diversity (Iacuessa, 2021). Most importantly, *permaculture* formed an emergency "*Plan B*" of eating locally grown food at a time of broken food supply chains, suddenly closed supermarkets, and government-forced lockdowns. In a noncrisis situation, *permaculture* advances unique and healthy products and marketing advantages.

In the Jordanian vegetable subsector, it was foreseen that *permaculture* will grant a big opportunity for diversifying the assortment to become less dependent on tomatoes, the most common produce in the Jordan Valley. This zero-waste and low-emissions form of sustainable farming is a viable response to the challenges of "*How can food waste be reduced to ensure the most efficient*

functioning of the agri-food system?" (Horton et al., 2017) and the fact that new customers and markets will be available for those who develop low-emission and sustainable products (Dowling and de Wit, 2019). Nonland-based options in food and agricultural value chain management include reducing losses from food, water, and waste as well as postharvest, which in turn fosters and complements the "*post-harvesting treatments*" capacity-building need priority identified by some focus groups as discussed previously. *Permaculture* also augments access to new lines of green finance or subsidies, which helps the "*skills of technical writing of fundraising project proposals*" capacity-building need identified by some aforementioned focus groups. Thus, all such intrinsic and cross-cutting benefits of *permaculture* justify the need for a standard *Permaculture Design Course* (PDC) to be delivered systematically to Jordanian farmers. In fact, and in response to this study and the reach-out of the two co-authors (personal communications) to relevant authorities, the PDC is now newly being offered to regular farmers in the Jordan Valley through the "*Greening the Desert Project*" of the *Permaculture Research Institute* (*PRI*) of Australia (PRI, 2022) when it was available in the past mostly to sustainable agriculture enthusiasts and learners from outside Jordan. The PRI's PDC training offered in the Jordan Valley is delivered by Geoff Lawton, the successor of Bill Mollison (PRI, 2022) where Geoff Lawton and his wife, Nadia Abu Yahia, administer a similar twin site in Channon, New South Wales, Australia, named "*Zaytuna Farm*," which is the home of the PRI and a highly active global *Permaculture* demonstration site (Zaytuna Farm, 2022).

4. Conclusion

In light of results of the top adaptive capacity-building needs prioritized and discussed previously, the general notion conceived from Tables 3–5 supports the claim that an MCDA can yield surprising results that need to be digested before development-related decisions are taken and that it may be necessary to establish a temporary decision system to deal with unexpected results and to consider the implications of new perspectives revealed by the MCDA. It is clear from our study that, when farming and agribusiness actors are freely given the opportunity to discuss and decide the core list of their adaptive capacity-building needs, the list was almost void of classical direct upstream adaptive capacity-building needs, such as water resource management, water harvesting measures, treatment and reuse of reclaimed water; irrigation efficiency, water use diversification, and adaptive crop options, *inter alia*. Such nonholistic approaches that only promote common upstream adaptation measures will only help farmers to lessen the impacts of irrigation water shortages and thus minimize shrinkage in productivity but not help them satisfy the real needs attached to their businesses and livelihoods.

Even after demonstrating to the farming and agribusiness actors the climate vulnerability and impacts along the entire value chain, the beneficiaries-controlled MCDA approach revealed that actors of such highly vulnerable sectors spontaneously prioritized indirect climate adaptive-capacity needs, which they considered more important to their businesses and livelihoods, over the direct-capacity needs. Moreover, the actors of the Jordanian agribusiness still lack adequate adaptive capacity along the entire value chain that they pay more attention to the other nonclimatic obstacles. Farming and agribusiness actors are not enticing to the interventions of governmental and developmental agencies aimed at strengthening the sectors' adaptive capacity, if such interventions still overlook the risks from the nonclimatic factors. In this respect, this conclusion is an affirmation of our past perception gained during conducting research and assigning the management activities of the developmental projects, e.g., Abdel-Fattah et al. (2013, 2016a,b) and Abdel-Fattah et al. (2017), particularly during conducting stakeholder engagements and discussion sessions that the actors in the agricultural sector do not take the sector's vulnerability and the associated climate change risks very seriously. One justification of such a conclusion could be the notion that the actors of this sector are not considering themselves an effective part of the planning and implementation processes of adaptation planning proposed in the national and sectoral agenda as long as such initiatives still overlook such indirect nonclimatic factors, which turned to be significant adaptive requirements from the actors' points of view. Such incomplete strategies, thus, overlook the serious challenges farmers face later, for example, to market their reluctantly embraced climate-adaptive crops due to the deficiency to respond and adapt to uncertain market changes. Convincing a reluctant farmer, due to fear associated with the health and social concerns of the public, to utilize reclaimed water for irrigation, for instance, while neglecting the marketing potential of such "special-status" products, is inadequate adaptation intervention. The impact of such defective strategies will be even more serious when promoting unrestricted irrigation using reclaimed water, which has been permitted relatively recently in Jordan in 2016 and updated in 2021 (MoA, 2021) driven by the climate change stresses on water resources. This transformational change is still opposed and debated widely nationally.

The results of this study are one of the first to demonstrate how overlooking building a holistic climate adaptive capacity by actors of a vulnerable sector down to the farthest link of the value chain and disregarding its serious impact on the whole adaptation intervention effort is critical and detrimental to the fate of the direct upstream adaptive measures. The results emphasized the viability to complete the flawed interventions that aim at raising the awareness of the vulnerable sector's actors and workforces about the imminent climate impacts on the value-chain's upstream links without neglecting its downstream impacts and measures. The study proved that the downstream impacts might end up as the controlling factors of the destiny and success of such pricy intervention measures applied upstream mainly to those implemented by developmental agencies and international organizations in developing countries. For such incomplete development plans to not continue developing this way, actors–participatory decision-making-oriented initiatives, utilizing robust tools capable of fulfilling this obligation, such as MCDA, need to be further promoted in the sustainable development process. MCDA has shown the superiority of the participant-guided approach in enabling the beneficiaries to formulate the intervention outcomes, unveil the factors ignored by the researcher-controlled approach, secure high buy-in of self-attained results, and prioritize real capacity needs to formulate efficient and cost-effective capacity-building programs accordingly. In our study, the top three priorities of each group of actors were further considered by some local authorities

for taking subsequent actions and development of capacity-building (training) programs by the national entities in charge of this function in the country such as NARC. Accordingly, NARC has adopted the adaptive capacity-building package resulting from this study.

Therefore, as a final conclusion, assessments of the real adaptive-capacity-building needs of the involved actors of vulnerable sectors are recommended to follow holistic beneficiary-controlled rather than researcher-controlled approaches and make use of system-wide, multidisciplinary assessments rather than the traditional solo-sectoral methods. The latter methods, such as monodisciplinary questionnaires common in the sector's studies and research, failed to disclose the unnoticed indirect impacts on the value chain. Ultimately, this study demonstrated the advantages of a combined, participant (actors)-guided MCDA and an integrated system-wide interdisciplinary approach where participants' own meaning and perspectives are represented and not curtailed by the researchers' own perspectives and agendas. The fruits are robust identification and assessment of direct and, most importantly, indirect adaptive capacity-building gaps of the vulnerable sector's (such as agribusiness) value chain actors and workforces of a developing country, identifying downstream bottlenecks and contributing to the national adaptive capacity-building agenda of an underserved sector of such a vulnerable developing country. This approach has advanced a very efficient adaptive capacity-building planning tool, especially in situations of intervention initiatives with limited funding availability and tight time schedules. The results of such types of rapid qualitative investigations of adaptive capacity needs could be preliminary for further exhaustive quantitative studies. Such an approach is also believed to be applicable to similar developing countries.

5. Limitations of the approach

We do not of course argue that our focus group results are fully statistically representative due to the issues of generalization and quantifying the analyses debated as limitations in the focus group method even though we followed the guidelines recommended for such qualitative research to augment the representation of the results. However, the fact that there were strong consistencies and convergences in the results among many of the focus groups and similar clusters of opinion appeared over and over in the groups and support the assumption that the results have significance beyond their particular location.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and before the start of conducting the major qualitative component of this research, ethical approval was granted from the National Agricultural Research Center (NARC). The facilitated workshops or the focus groups-based MCDA approach is reported in accordance with the Consolidated Criteria for Reporting Qualitative Research COREQ (Tong et al., 2007). The patients/participants provided their written informed consent to participate in this study.

Author contributions

Both authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Funding

This exercise was conducted as part of the activities of an Adaptation Fund-sponsored Program in Jordan (Grant No. JOR/NIE/Multi/2012/1), addressing the adaptation of the agricultural sector to the impacts of climate change, entitled *Increasing the Resilience of Poor and Vulnerable Communities to Climate Change Impacts in Jordan by Implementing Innovative Projects in Water and Agriculture in Support of Adaptation to Climate Change* (Adaptation Fund, 2022). At the time of conducting the exercise, AA-F was serving as the National Manager of the said program implemented by the Jordan Ministry of Planning and International Cooperation (MoPIC) and MA was serving as the coordinator of one of the nine subprojects of the program, particularly the subproject concerned with grubbiness adaptation, entitled *Jordan Valley Water Sustainability and Agribusiness Competitiveness* executed by NARC.

Acknowledgments

This study is one of the knowledge products of the Adaptation Fund–sponsored program of Jordan, entitled *Increasing the Resilience of Poor and Vulnerable Communities to Climate Change Impacts in Jordan through Implementing Innovative Projects in Water and Agriculture in Support of Adaptation to Climate Change* implemented by the Ministry of Planning and International Cooperation (MoPIC) and Sub-Project 2.3 *Jordan Valley Water Sustainability and Agribusiness Competitiveness* executed by NARC to which, particularly its Director *Nizar Haddad*, the authors are very thankful for encouraging and supporting the research. Special thanks are due to the two consultants, Ahmad Al-Shadiadeh and Hazem Hasan from the Balqa Applied University, who provided logistics and facilitation during the execution of the focus groups.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of

their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2022.1026432/full#supplementary-material

References

Abdel-Fattah, A., Al-Qinna, M., Saifan, S., Al-Bakri, J., Boman, B., Fraisse, C., et al. (2013). A. *Policy-oriented National Priority Research Topics in Climate Change, Biodiversity, and Combating Desertification (2013-2020) with Guidelines, Procedures, Tools and Potential Funding Sources to Support their Implementation in the Hashemite Kingdom of Jordan. For UNDP, 2013, The Deposit Number at the National Library*. (2013). Available online at: http://www.moenv.gov.jo/ebv4.0/root_storage/ar/eb_list_page/arab-states-cca-0.pdf (accessed May 26, 2022).

Abdel-Fattah, A., Odeh, I., Khresat, S., and Noubani, A. (2016a). *Climate Change Technology Needs Assessment (TNA) Project-Jordan Report I: Technology Needs Assessment (TNA)*. For United Nations Environment Program (UNEP) and Technical University of Denmark (DTU). Available online at: https://tech-action.unepccc.org/wp-content/uploads/sites/2/2017/06/jordan-tna-report-march-2016.pdf (accessed May 26, 2022).

Abdel-Fattah, A., Odeh, I., Khresat, S., and Noubani, A. (2016b). *Climate Change Technology Needs Assessment (TNA) Project-Jordan Report II: Barrier Analyses and Enabling Framework (BAEF)*. For United Nations Environment Program (UNEP) and Technical University of Denmark (DTU). Available online at: https://tech-action.unepccc.org/wp-content/uploads/sites/2/2017/06/jordan-baef-report-august-2016.pdf (accessed May 26, 2022).

Abdel-Fattah, A., Odeh, I., Khresat, S., and Noubani, A. (2017). *Climate Change Technology Needs Assessment (TNA) Project-Jordan Report III: Technology Action Plans (TAPs). For United Nations Environment Program (UNEP) and Technical University of Denmark (DTU)*. Available online at: https://tech-action.unepccc.org/wp-content/uploads/sites/2/2017/10/jordan-tap-091017.pdf (accessed May 26, 2022).

Adams, A., and Cox, A. L. (2008). "Questionnaires, in-depth interviews and focus groups," in *Research Methods for Human Computer Interaction*, eds Cairns, P., and Cox, A. L. (Cambridge, UK: Cambridge University Press). pp. 17–34.

Adaptation Fund (2022). *Increasing the Resilience of Poor and Vulnerable Communities to Climate Change Impacts in Jordan through Implementing Innovative Projects in Water and Agriculture in Support of Adaptation to Climate Change*. Available online at: https://www.adaptation-fund.org/project/increasing-the-resilience-of-poor-and-vulnerable-communities-to-climate-change-impacts-in-jordan-through-implementing-innovative-projects-in-water-and-agriculture-in-support-of-adaptation-to-climate-4/ (accessed May 26, 2022).

Al-Bakri, J., Suleiman, A., Abdulla, F., and Ayad, J. (2011). Potential impact of climate change on rainfed agriculture of a semi-arid basin in Jordan. *Phys. Chem. Earth* 36, 125–134. doi: 10.1016/j.pce.2010.06.001

Arsenopoulos, A., Marinakis, V., and Doukas, H. (2021). Participatory multi-criteria decision analysis for sustainable energy planning. *Int. J. Multicriteria Decis. Mak*. 8, 276–290. doi: 10.1504/IJMCDM.2021.119451

Beiske, B. (2002). Research methods. *Uses and Limitations of Questionnaires, Interviews, and Case Studies, Munich, GRIN Verlag*. Available online at: https://www.grin.com/document/15458 (accessed May 26, 2022).

Bell, J. (1999). *Doing your Research Project: A Guide for First-time Researchers in Education and Social Science (3rd ed.)*. Buckingham: Open University Press.

Bezner Kerr, R., Hasegawa, T., Lasco, R., Bhatt, I., Deryng, D., Farrell, A., et al. (2022). "Food, fibre, and other ecosystem products," in *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, eds Pörtner, H. O., Roberts, D. C., Tignor, M., Poloczanska, E. S., Mintenbeck, K., Alegría, A., et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press). 713–906.

Boettcher, M. (2016). *How Representative is that Qualitative Data Anyway? Corono Insigh*t. Available online at: https://www.coronainsights.com/2016/07/how-representative-is-that-qualitative-data-anyway/ (accessed May 26, 2022).

Carey, A. (2018). *Assessing Adaptive Capacity of Pioneer Valley Farmers*. (Masters Theses). Amherst, MA, United States, University of Massachusetts.

CBI (2018). *Fresh Fruit and Vegetables - Jordan CBI Business Case 2018-2022, Center for the Promotion of Imports from Developing Countries, Netherlands Enterprise Agency*. Available online at: https://www.cbi.eu/sites/default/files/business_case_ffv_jordan.pdf (accessed May 25, 2022).

CBI (2021). *Which Trends Offer Opportunities or Pose Threats on the European Fresh Fruit Vegetables Market? (CBI, 2019)*. Available online at: https://www.cbi.eu/market-information/fresh-fruit-vegetables/trends/ (accessed May 26, 2022).

Cinner, J. E., Adger, W. N., Allison, E. H., Barnes, M. L., Brown, K., Cohen, P. J., et al. (2018). Building adaptive capacity to climate change in tropical coastal communities. *Nat. Clim. Change* 8, 117–23. doi: 10.1038/s41558-017-0065-x

Cinner, J. E., Caldwell, I. R., Thiault, L., Ben, J., Blanchard, J. L., Coll, M., et al. (2022). Potential impacts of climate change on agriculture and fisheries production in 72 tropical coastal communities. *Nat. Commun.* 13, 3530. doi: 10.1038/s41467-022-30991-4

D'Angelo, D., and Quinn, D. (2012). *Snapshot of the Business Enabling Environment for Agriculture-Jordan. AgBEE SNAPSHOT*. USAID's Enabling Agricultural Trade (EAT) Project. Available online at: https://www.agrilinks.org/sites/default/files/resource/files/USAID-EAT%20AgBEE%20Snapshot%20Jordan.pdf (accessed May 29, 2022).

DCLG. (2009). *Multi-Criteria Analysis: A Manual*. London: Department for Communities and Local Government Publication.

de Janvry, A., Sadoulet, E., and Trachtman, C. (2019). *Achieving Coordination in Agricultural Value Chains: The Role of Lead Agents and Multi-stakeholder Platforms*. Available online at: https://hal.archives-ouvertes.fr/hal-02287771/document (accessed May 26, 2022).

DOS (2018). *Numbers and Characteristics of Agricultural Workders 1994-2018*. Jordan Department of Statistics. Available online at: https://jorinfo.dos.gov.jo/Databank/pxweb/ar/DOS_Database/START__08/AGR_VEGWRK/table/tableViewLayout2/ (accessed June 25, 2022).

DOS (2021). *Population Estimates for the end of 2021*. Jordan Department of Statistics. Available online at: http://dosweb.dos.gov.jo/DataBank/Population_Estimares/PopulationEstimatesbyLocality.pdf (accessed June 25, 2022).

Dowling, C., and de Wit, E. (2019). *Climate Change and the Food and Agribusiness Sectors: Adaptation, Mitigation and Innovation*. Norton Rose Fulbright. Available online at: https://www.nortonrosefulbright.com/en/knowledge/publications/c7414616/climate-change-and-the-food-and-agribusiness-sectors-adaptation-mitigation-and-innovation (accessed May 31, 2022).

Einola, K., and Alvesson, M. (2021). Behind the Numbers: Questioning Questionnaires. *J. Manag. Inq*. 30, 102–114 doi: 10.1177/1056492620938139

Fanack: Chronicle of the Middle East and North Africa (2021). *Economy of Jordan*. Available online at: https://www.fanack.com/jordan/economy-of-jordan/ (accessed November 19, 2022).

FAO (2015a). *Climate Change and Food Security: Risks and Responses*. Food and Agriculture Organization. Available online at: http://www.fao.org/3/a-i5188e.pdf (accessed May 20, 2022).

FAO (2015b). *Jordan: Water Along the Food Chain. An Analytical Brief of Selected Food Chains from a Water Perspective*. Available online at: http://www.fao.org/3/a-i4608e.pdf (accessed June 23, 2022).

Freudenberger, K. S. (2008). *Rapid Rural Appraisal and Participatory Rural Appraisal: A Manual for CRS Field Workers and Partners*. Catholic Relief Services Available online at: https://www.crs.org/sites/default/files/tools-research/rapid-rural-appraisal-and-participatory-rural-appraisal.pdf (accessed June 4, 2022).

Gilbert, N. (2001). "Ethnography," in *Researching Social Life*, ed N. Gilbert (Sage Publications), 145–163.

Goedde, L., Horii, M., and Sanghvi, S. (2015). *Pursuing the Global Opportunity in Food and Agribusiness. McKinsey Quarterly. McKinsey and Company*. Available online at: https://www.mckinsey.com/industries/chemicals/our-insights/pursuing-the-global-opportunity-in-food-and-agribusiness (accessed May 20, 2022).

Gunderson, M. A., Boehlje, M. D., Neves, M. F., and Sonka, S. T. (2014). "Agribusiness organization and management," in *Encyclopedia of Agriculture and Food Systems*. Van Alfen, N. K. (Amsterdam, Netherlands: Elsevier), 51–70.

Heeb, L., Jenner, E., and Cock, M. J. W. (2021). Climate-smart pest management: building resilience of farms and landscapes to changing pest threats. *J. Pest Sci.* 92, 951–969. doi: 10.1007/s10340-019-01083-y

Henfrey, T., and Penha-Lopes, G. (2015). *Permaculture and Climate Change Adaptation: Inspiring Ecological, Social, Economic and Cultural Responses for Resilience and Transformation*. Bristol: Permanent Publications, East Meon and Good Works Publishing Cooperative.

Holmgren, D. (2002). *Permaculture: Principles and Pathways Beyond Sustainability*. Hepburn, VIC: Holmgren Design Services.

Holmgren, D. (2018). *RetroSuburbia: The Downshifter's Guide to a Resilient Future*. Hepburn, VIC: Melliodora Publishing.

Horton, P., Banwart, S. A., Brockington, D., Brown, G. W., Bruce, R., Cameron, D., et al. (2017). An agenda for integrated system-wide interdisciplinary agri-food research. *Food Sec.* 9,195–210. doi: 10.1007/s12571-017-0648-4

Horton, P., Koh, L., and Guang, V. S. (2016). An integrated theoretical framework to enhance resource efficiency, sustainability and human health in agri-food systems. *J. Clean. Prod.* 120, 164–169. doi: 10.1016/j.jclepro.2015.08.092

Hyman, H. H. (1955). *Survey Design and Analysis: Principles, Cases, and Procedures*. Glencoe, Illinois: Free Press. 425.

IAASTD (2009). *Agriculture at a Crossroads: Global Report*. International Assessment of Agricultural Knowledge, Science, and Technology for Development) (Project). Washington, DC, USA: Island Press. 95. Available online at: http://www.agassessment-watch.org/report/Global%20Report%20(English).pdf (accessed May 20, 2022).

Iacuessa, M. (2021). *Permaculture Garden Flourished During COVID*. The Potrero View. Available online at: https://www.potreroview.net/permaculture-garden-flourished-during-covid/ (accessed August 19, 2022).

Ickowitz, A., Powell, B., Rowland, D., Jones, A., and Sunderland, T. (2019). Agricultural intensification, dietary diversity, and markets in the global food security narrative. *Glob. Food Secur. Policy Econ. Environ*. 20, 9–16. doi: 10.1016/j.gfs.2018.11.002

IFAD (2010). *Rural Poverty Report 2011-New Realities, New Challenges: New Opportunities for Tomorrow's Generation*. International Fund for Agricultural Development. Available online at: https://www.ifad.org/en/web/knowledge/-/publication/rural-poverty-report-2011-print-version-5-0mb-?p_l_back_url=%2Fen%2Fsearch%3Fq%3DNew%2Brealities%252C%2Bnew%2Bchallenges%253A%2Bnew%2Bopportunities%2Bfor%2Btomorrow%25E2%2580%2599s%2Bgenerations%2B/ (accessed May 20, 2022).

IPCC (2014). "*Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*," in Field, C. B., Barros, V. R., Dokken, D. J., Mach, K. J., Mastrandrea, M. D., Bilir, T. E., et al. (Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press). 1132.

IPCC (2022). "Climate change 2022: impacts, adaptation and vulnerability. contribution of working group ii to the sixth assessment report of the intergovernmental panel on climate change," in Pörtner, H. O., Roberts, D. C., Tignor, M., Poloczanska, E. S., Mintenbeck, K., Alegría, A., et al. (Cambridge, UK and New York, NY, USA: Cambridge University Press). 3056.

Kalaitzandonakes, M., Ellison, B., and Coppess, J. (2022). *Climate Change & the Food System: Gardner Survey Results, Part 2*. Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, Champaign, IL, United States. Available online at: https://farmdocdaily.illinois.edu/2022/06/climate-change-the-food-system-gardner-survey-results-part-2.html (accessed November 20, 2022).

Kanaan, T., and Kardoosh, M. (2002). *The Story of Economic Growth in Jordan: 1950–2000, Amman*. Available online at: https://www.academia.edu/1648061/The_story_of_economic_growth_in_Jordan_1950_2000 (accessed November 19, 2022).

Kayed, M. (2017). *Agriculture Sector Reaps 63% Growth in 2019—Minister*. Jordan Times. Available online at: https://www.jordantimes.com/news/local/agriculture-sector-reaps-63-growth-2019-%E2%80%94-minister (accessed May 26, 2022).

Kinross, B., Santos, C., and de Boer, J. (2017). *A Literature Review of Training Needs Assessment (TRNA) Methodology*. A technical report for European Centre for Disease Prevention and Control (ECDC), Stockholm, Sweden. doi: 10.2900/6672

Kumar, K., Bhattacharjee, S., Vaikuntapu, P. R., Sharma, C. L., Jayaswal, D., Sharma, R., et al. (2020). "Climate Change Mitigation and Adaptation Through Biotechnological Interventions," in *Climate Change and Indian Agriculture: Challenges and Adaptation Strategies*, eds Srinivasarao, C., et al. ICAR-National Academy of Agricultural Research Management, Hyderabad, Telangana, India, 1–22.

Kumar, L., Chhogyel, N., Gopalakrishnan, T., Hasan, M. K., Jayasinghe, S. L., Kariyawasam, C. S., et al. (2022). *Climate Change and Future of Agri-Food Production*. Cambridge, MA: Academic Press.

Limantol, A. M., Keith, B. E., Azabre, B. A., and Bernd Lennartz, B. (2016). Farmers' perception and adaptation practice to climate variability and change: a case study of the Vea catchment in Ghana. *Springerplus*, 5, 830. doi: 10.1186/s40064-016-2433-9

Lockwood, M., Raymond, C. M., Oczkowski, E., and Morrison, M. (2015). Measuring the dimensions of adaptive capacity: a psychometric approach. *Ecol. Soc.* 20, 37. doi: 10.5751/ES-07203-200137

McLeod, S. A. (2018). *Questionnaire: Definition, Examples, Design and Types*. Simply Psychology. Available online at: https://www.simplypsychology.org/questionnaires.html (accessed November 24, 2022).

MDGF (2011). *Identify and Screen Adaptation Measures to Reduce Climate Change Impacts on Food Productivity- Jordan Final Report (Consultancy)*. Millennium Development Goals Fund. Adaptation to Climate Change to Sustain Jordan's MDG Achievements (Project/Joint Program: UNDP-WHO-FAO-UNESCO). Available online at: http://www.mdgfund.org/sites/default/files/ENV_STUDY_Jordan_Adaptation%20measures%20on%20food%20productivity.pdf (accessed May *26*, 2022).

MoA. (2021). *Instructions No.G/1 of 2021 Amending Instructions and Conditions for the Use of Waste and Treated Water, Saline Water and Brackish Water for Agricultural Uses Under Paragraph (c) of Article 15 of Agriculture Law No.13 of 2015 and its Amendments*. Ministry of Agricultural, The Official Gazette No. 377. Amman, Jordan. Available online at: http://extwprlegs1.fao.org/docs/pdf/jor204470.pdf (accessed August 19, 2022).

MoEnv (2009). *Jordan's Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC)*. Jordan Ministry of Environment. Available online at: http://unfccc.int/resource/docs/natc/jornc2.pdf (accessed May 26, 2022).

MoEnv (2014). *Jordan's Third National Communication on Climate Change to the United Nations Framework Convention on Climate Change (UNFCCC)*. Jordan Ministry of Environment. Available online at: https://unfccc.int/resource/docs/natc/jornc3.pdf (accessed May 26, 2022).

Mollison, B. (1997). *Introduction to Permaculture*. Tasmania: Tagari Publications.

Mollison, B., and Holmgren, D. (1978). *Permaculture One: A Perennial Agriculture for Human Settlement*. London: Corgi Books Transworld Publishers.

Namrouqa, H. (2017). *UAE Says Vegetable ban 'precautionary' as Jordan Reaffirms Commitment To International Standards*. Jordan Times. Available online at: https://www.jordantimes.com/news/local/uae-says-vegetable-ban-precautionary-jordan-reaffirms-commitment-international-standards (accessed May 31, 2022).

Ng, D. W., and Siebert, J. W. (2009). Toward better defining the field of agribusiness management. *Int, Food Agribus. Manag. Rev.* 12, 1–20. doi: 10.22004/ag.econ.92566

O'Leary, Z. (2014). *The Essential Guide to Doing Your Research Project (2nd ed.)*. London: SAGE.

Porter, J. R. L., Xie, A. J., Challinor, K., Cochrane, S. M., Howden, M. M., Iqbal, D. B., et al. (2014). Food security and food production systems. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. *Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* eds Field, C. B., Barros, V. R., Dokken, D. J., Mach, K. J., Mastrandrea, M. D., Bilir, T. E., et al. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. 485–533.

PRI (2022). *Greening the Desert Project. Permaculture Research Institute, Australia*. Available online at: https://www.greeningthedesertproject.org/ (accessed May 29, 2022).

Rajsekhar, D., and Gorelick, S. M. (2017). Increasing drought in Jordan: climate change and cascading Syrian land-use impacts on reducing transboundary flow. *Sci. Adv.* 3, e1700581. doi: 10.1126/sciadv.1700581

Rikken, R., and Leeters, J. (2016). *Export Value Chain Analysis Fruit and Vegetables Jordan*. Netherlands Enterprise Agency. Available online at: http://www.bureauleeters.nl/data/103-wsXTPO1yf418/export-value-chain-fruit-vegetables-jordan-2016.pdf (accessed May 20, 2022).

Roesch-McNally, G., Garrett, A., and Fery, M. (2020). Assessing perceptions of climate risk and adaptation among small farmers in Oregon's Willamette Valley. *Renew. Agric. Food Syst.* 35, 626–630. doi: 10.1017/S1742170519000267

Roya News (2017). *UAE Lifts Ban on Jordanian Agricultural Imports*. Available online at: https://en.royanews.tv/news/10949/2017-07-27 (accessed May 31, 2022).

Singh, S., and Sagar, R. (2021). A critical look at online survey or questionnaire-based research studies during COVID-19. *Asian J. Psychiatr.* 65, 102850 doi: 10.1016/j.ajp.2021.102850

Stathers, T., Lamboll, R., Brighton, M., and Mvumi, B. (2013). Postharvest agriculture in changing climates: Its importance to African smallholder farmers. *Food Secur.* 5, 361–392. doi: 10.1007/s12571-013-0262-z

Tong, A., Sainsbury, P., and Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. *Int. J. Qual. Health Care*. 16, 349–357. doi: 10.1093/intqhc/mzm042

Trærup, S. L. M., and Bakkegaard, R. K. (2015). *Evaluating and Prioritizing Technologies for Adaptation to Climate Change: A Hands on Guidance to Multi Criteria Analysis (MCA) and the Identification and Assessment of Related Criteria. UNEP-DTU Partnership*. Available online at: https://orbit.dtu.dk/en/publications/evaluating-and-prioritizing-technologies-for-adaptation-to-climat (accessed December 1, 2021).

Trudge, C. (2016). *Six Steps Back to the Land*. Why We Need Small Mixed Farms and Millions More Farmers. Cambridge: Green Books.

Vicsek, L. (2010). Issues in the analysis of focus groups: generalisability, quantifiability, treatment of context and quotations. *Qual. Rep.* 15, 122–141.

Yuan, Z., Wen, B., He, C., Zhou, J., Zhou, Z., and Xu, F. (2022). Application of multi-criteria decision-making analysis to rural spatial sustainability evaluation: a systematic review. *Int. J. Environ. Res. Public Health*. 19, 6572. doi: 10.3390/ijerph19116572

Zaytuna Farm. (2022). Available online at: https://www.zaytunafarm.com/ (accessed August 8, 2022).