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Abstract (for dissemination)	Water shortage, drought, and land degradation plague East Africa. As climate change is anticipated to worsen these challenges, sustainable best practices to offset environmental changes are needed. Statistics reveal that greenhouse gasses and temperatures will rise, rainfall patterns will be unclear, and climatic severe events will become more common. East Africa has explored BMPs to enhance agriculture and prevent climate change. Choose BMPs based on their technical appropriateness, environmental improvement potential, and economic viability. BMPs should also be cost-effective, flexible, and fulfill farmers' requirements and adoption factors. Deliverable D1.1.2 of WATDEV provides unique BMP standards for different settings and crop genotypes.
Keywords	BMPs, crops, varieties, environment

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Acronyms and Abbreviations

AICS	Italian Agency for Development Cooperation
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa, Uganda
AU-EU	Africa-Europe
CIHEAM	Centre International de Hautes Etudes Agronomiques Mediterranéennes, Italy
CNR	Consiglio Nazionale delle Ricerche, Italy
DG DEVCO	The Commission's Directorate-General for International Cooperation and Development
EU	European Union
FAO	Food and Agricultural Organization of the United Nations
HU	Heliopolis University, Egypt
ISRIC	International Soil Reference Center, The Netherland
KALRO	Kenya Agricultural & Livestock Research Organization, Kenya
R&I	Research and Innovation
WRC	Water Research Centre, Sudan
STI	Science, Technology and Innovation
SYKE	Finnish Environment Institute, Finland
WATDEV	Climate Smart WATer Management and Sustainable DEVelopment for Food and Agriculture in North and East Africa
WLRI	Water and Land Resources Institute, Ethiopia
BMP(s)/I(s)	Best Management Practice(s)/Innovation(s)

Executive Summary

WATDEV nations have complex political and socioeconomic backgrounds that impact their agroecological ones. Lack of scientific understanding sometimes leads to suboptimal farming techniques, but lack of cash may have hampered climate change efforts. Although Egypt has measures to combat soil pollution and salinization, gaps remain between government policies and farmer practices. Public ignorance may cause this situation. Despite government agricultural reforms in Ethiopia, political strife harmed the agricultural sector, lowering health and food security. The Kenyan government adopted measures to increase agricultural productivity, yet bad communications between policies and institutions still occur, fragmenting the government. Sudanese agriculture relies on the Gezira Irrigation System, but financial and bureaucratic authorities struggle to maintain it. This may be due to government policy and funding shortages.

1. Introduction

1.1 Overview

East Africa is characterized by issues related to water scarcity, drought, and land degradation. Sustainable best practices intended to lessen or mitigate the negative effects of environmental changes will be required, since climate change is likely to make these issues worse. Data show that greenhouse gasses emission and temperatures will increase, rainfall pattern will be uncertain, and climate extreme events will be more frequent as well (Kristjanson et al., 2012). BMPs have been studied as a tool to improve agriculture and to reduce climate change impact in East Africa (Nabirembe et al., 2020, Malacarne and Paul, 2022). By evaluating their technical suitability, environmental improvement potential, and economic viability, relevant BMPs should be selected (Atisa et al., 2014). Moreover, BMPs should be selected in a cost-effective and readily adaptable way, and they should meet farmers needs and the factors that may influence their adoption (Liu et al., 2018). In the frame of WATDEV project, in this Deliverable D1.1.2, specific guidelines on selected BMPs associated with different environments and crop genotypes are provided.

1.1.1 Countries socioeconomic issues

The African countries involved in WATDEV project have a complex socioeconomic and political assessment. Social inequality and a lack of effective financial services are commonplace in Egypt, Ethiopia, Kenya, and Sudan (Tchamyou, 2018).

Egypt experienced a disparity between environmental resources and human requirements as a result of population increase and a lack of agricultural land (Radwan et al., 2019). In addition, Egypt is a Country with a strong presence of military forces (Pratt and Rezk, 2019).

Ethiopia socioeconomic condition is currently affected by the Tigray conflict. In this scenario, health and food security are deemed to be negatively affected (Gesesew et al., 2021).

Kenya socioeconomic condition is characterized by a limited success in fighting poverty. In the last years, economic instability threats the improvement of the socioeconomic conditions (Eichsteller et al., 2022). A barrier to small farmers investing in agriculture is the high cost of arable land, the existence of large corporations with access to capital, as well as the considerable variety in soil type and agricultural potential across the entire country. Moreover, climate change scenario is exacerbating these conditions and extreme poverty is supposed to rapidly increase, and it is estimated as about 17% (Eichsteller et al., 2022).

Sudan citizens have a strong social structure and a govern with a robust hierarchical organization. The govern drives the availability of wealth facilities and natural resources (Sharkey, 2007). However, Sudan commercial agriculture profits are jeopardized by capitalist classes that control state power and citizen life, with possible increase in social inequality (de Wall et al., 2021).

1.1.2 Countries environmental issues

Egypt is one of the countries that face water scarcity the most, due to its geographical localization in the Sub-tropical climatic zone near Sahara Desert. Moreover, water and soils are reported to be often contaminated by pollutants or salt. Soil salinization has been documented to affect agricultural production with reduction up to the 35% (El-ramady et al., 2013). In this context, climate change seriously affects Egypt agricultural productivity, enhancing issues associated with water scarcity and desertification (Omar et al., 2021). Ethiopia is characterized by the presence of several lakes and the Nile River. Water distribution is regulated since 1959 by the Nile River Agreement, that limits water withdraw for the upper part of Nile basin, causing disputes between Egypt, Ethiopia, and Sudan (Jewaro and Diler, 2021). Moreover, water inequality issues involve also different ethnic groups within Ethiopian community (Jewaro and Diler, 2021). Kenya agriculture is characterized by a heterogeneity in farmers and farm patterns. Land degradation is increasing to the lack in adoption of sustainable land management practices. Kenya agricultural production would likely be significantly impacted by climate change, particularly due to rising rainfall variability, and solutions to drought have been suggested (Birch, 2018). Sudan agriculture is mainly based on Gezira Irrigation Scheme and, for this reason, on the crop pattern of the Scheme itself and the availability of water resources (Guvele, 2001). It is expected that Sudan agriculture production will significantly decrease by 2050 due to climate change scenario. As a mitigation measure, drought-driven policies have been established, introducing new food crops in Gezira Irrigation Scheme. However, food crops have shown fluctuated production and low market price, providing food security but not economic stability. In Sudan, the main issue is related to Gezira Scheme water distribution efficiency (Ahmed, 2020).

1.1.3 Constraints in improving environmental-friendly sustainable agriculture and water management in the frame of socioeconomic and political ISSUES

As previously described, the countries involved in WATDEV project have complicated political and socioeconomic backgrounds that affect their agroecological ones. While a lack of sufficient scientific understanding is frequently reflected by the use of unsuitable agricultural methods, a lack of finance may have affected the potential to fight climate change. In Egypt, although the govern has established policies to fight soil contamination and salinization, there are still gaps among government policies and farmers practices to be filled. This issue may be the consequence of the lack of public awareness (Kotb et al., 2000). In Ethiopia, although government has established agricultural reforms during the years (Gebru et al., 2018), the political conflict impacted the agricultural sector, reducing health and food security (Gesesew et al., 2021). In Kenya the govern established policies to boost agricultural production; however, issues related to the weak communications between policies and institutions still occur, leading to fragmentation of the governmental structure (Renner, 2020). In Sudan, Gezira Irrigation Scheme is the milestone of Sudanese agriculture, but financial and bureaucratic administrations face issues in maintaining the Scheme structure. This could be probably due to inappropriate policies and lack of funds allocated by government to ensure regular operations (Abdelgalil and Adeeb, 2015).

1.1.4 The D1.1.2 main objectives

By defining the final BMPs repository and comparing it with results from Local Brokerage, the D1.1.2 aims to provide guidance for the BMPs related to various environments and crop genotypes. With the help of BMPs gathered from various projects as well as BMPs established and assessed through local community analysis, the toolbox developed in the frame of WATDEV will be better able to choose which BMPs to utilize.

2 Methodology

2.1 DATA Collection

2.1.1 BMP SELECTION FROM REPOSITORY: METHODOLOGY

The BMPs were collected using the last version of the monkey survey during activity A1.1 and they have been reported in D1.1.1. These BMPs were used to generate a BMP repository. All project information and the answers of the Practice Evaluation Sheet were embedded in the BMP repository(https://cloud.watdev.eu/index.php/s/Mf7MEqDNaWeDgAT?path=%2FBMPs%20Stocktaking). The repository was filtered by purging BMPs showing missing values, and subsequently the BMP duplicates were removed. The next step was the definition and the assignment of minimum and maximum values (scores -1, 0, +1, depending on answers reported in the collected Practice

Evaluation Sheets) to BMP data and the subsequent detection and removal of outliers. Considering the different levels incorporated in the diverse sectors (CLT, POL, GOV, ECO, SOL, WAT, CRP, and ATM), BMP were evaluated for the putative presence of mislabeled ones. In the last step, valid data levels were defined for categorical data to provide a defined valid output. A total of 192 BMPs (D1.1.1) were evaluated and the process of scoring provided 73 BMPs with +1 score for at least one of the Practice Evaluation Sheet sectors (CLT, POL, GOV, ECO, SOL, WAT, CRP, and ATM). BMPs showing at least +1 score in the different socioeconomic sectors were:

- 35 for cultural sector (CLT)
- 26 for the policy sector (POL)
- 22 for the governmental sector (GOV)
- 31 for the economic sector (ECO)

From an environmental point of view, selected and scored BMPs were:

- 30 for the soil sector (SOL)
- 34 for the water sector (WAT)
- 37 for the crop sector (CRP)
- 13 for the atmosphere sector (ATM)

2.1.2 BMPs SELECTION FROM LOCAL COMMUNITY ANALYSIS: METHODOLOGY

The BMPs were defined and evaluated from local community analysis through local brokerages. Local brokerages were performed to assess local communities needs and gaps in a socioeconomic and environmental frame. In each Country involved in WATDEV, face-to-face or online meetings were organized with project partners and local SHs, representing agricultural, politic, and economic local organizations. Each brokerage planned a meeting to define the requirements of the community, assess the group, and visit the specific case-study locations. The need evaluation was performed through the Need Evaluation Sheet (Annex 1), with an open discussion on the perceived agroecological and socioeconomic issues of the community. The group evaluation was performed through the Group Evaluation Sheet (Annex 2) by a team of experts, in order to define the group and social dynamics in terms of collaboration, knowledge exchanges and attitude to cooperate with other groups. Both the Need Evaluation and the Group Evaluation Sheets were scored, considering the obtained answers from the SHs, with a scale from (-2) to (+ 2) (Tab 1). These results were plotted through spider plots (Section IV).

Table 1 - Need and Group Evaluation scores, based on brokerage outputs.

Score	Interpretation
-2:	No need (or change) is required (accepted)
-1:	Limited need (or change) is felt (possible)
0:	Equally accepted, but not considered as priority
1:	Relatively important where changes are welcome
2:	Priority where the need for change is felt and critical

3 Results

3.1 Group and needs evaluation for Egypt

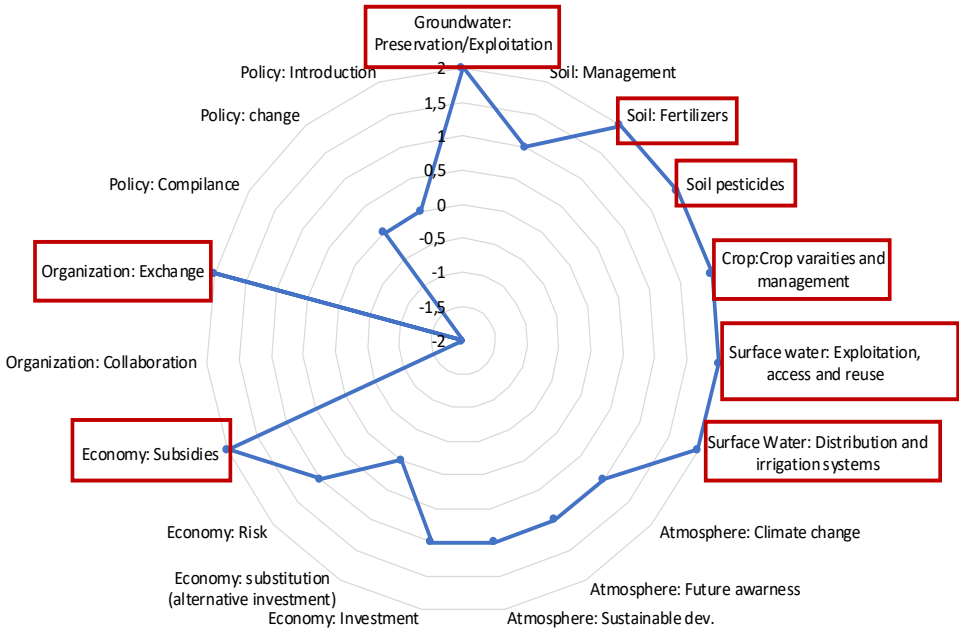

Figure 1 - Need Evaluation spider plot based on Egypt brokerage

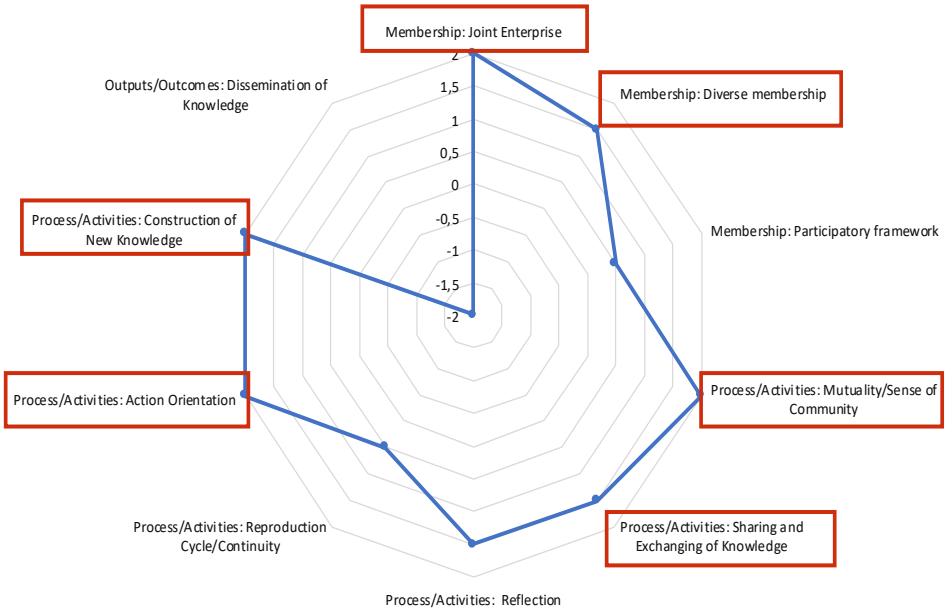

Figure 2 - Group Evaluation spider plot based on Egypt brokerage

In Egypt, brokerage outcomes revealed that local SHs perceived the socioeconomic current situation as the main aspect to improve. Particularly, one of the main aspects to be considered, based on brokerage discussion, was the current necessity of an improved organization, in term of SHs collaboration. The community was represented as a self-interest driven group in which farmers perceive themselves as facing issues in establishment of a hierarchical framework, thus local SHs highlighted the need to cooperate under a leading governmental institution. Based on brokerage results, communication among and within the local communities should be improved by the govern. Concerning environmental issues of Egypt, the main one was found to be related to the low content of organic matter in soil, thus suggesting a need in finding soil sustainable management practices to be applied. Local SHs also identified a need to increase irrigation system effectiveness, water distribution and availability. In this scenario, proposed BMPs were directly linked to socioeconomic issues and to agroecological ones.

3.2 Group and needs evaluation for Ethiopia

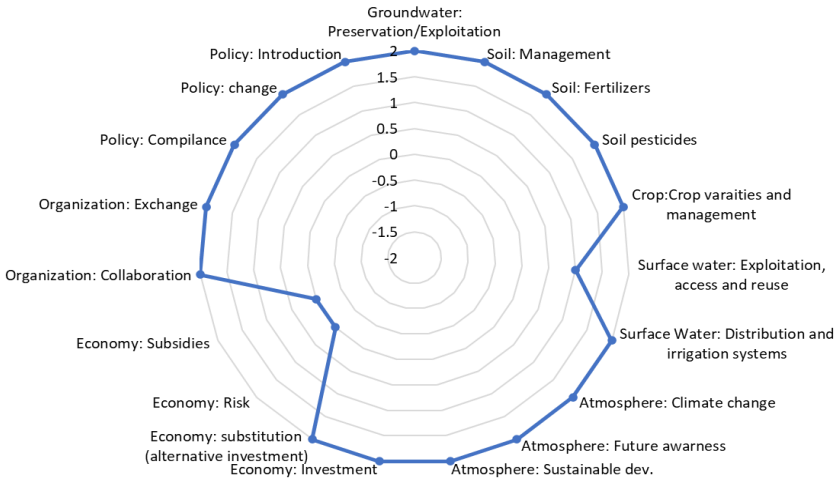

Figure 3 - Need Evaluation spider plot based on Ethiopia brokerage

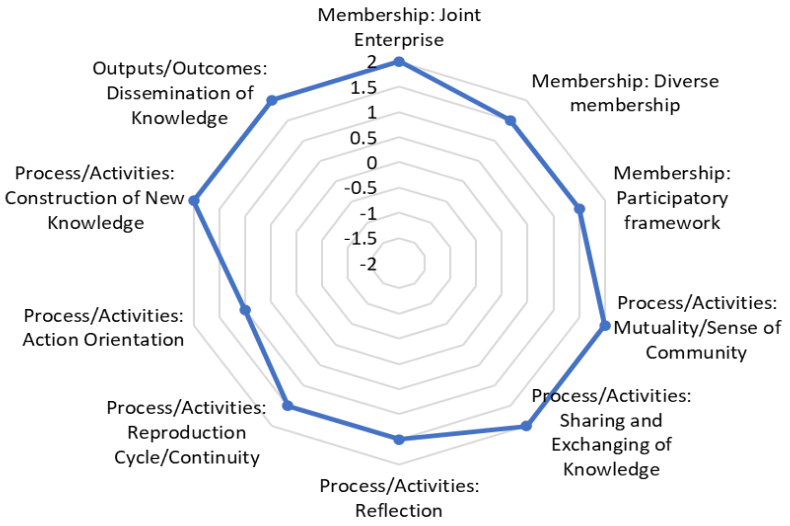

Figure 4 - Group Evaluation spider plot based on Ethiopia brokerage

From brokerage results from Ethiopia, spider plots highlighted high scores in almost all sectors, leading to the assumption that there was a need of an overall optimization or, alternatively, the presence of potential issues in governmental-driven initiatives. Lack in fundings or subsidies was not reported as a problem, but the extreme need in improving all raised points suggested a potential upstream problem that involves the govern and its communication with the local community. This aspect influences all the subsequent chain of socioeconomic and environmental aspects. A social aspect to be considered was that the local community perceived them-self as a restricted group, in which dissemination of knowledge occurs, but with low level of exchanges with other social groups. Several agroecological issues emerged from the discussion. Ethiopian soils seem to suffer of soil silting and soil contamination, probably due to an excessive and incorrect use of fertilizer and water. Local SHs affirmed that in Ethiopia there is a low technical knowledge on how to use pesticides and on what is their effects on the environment, as well as a low knowledge in term of market trend and seasonal agricultural products distribution. Moreover, SHs reported difficulties in a regular water distribution, probably due to the upstream river withdrawals that limits the availability of water that flows downstream.

From brokerage results from Ethiopia, spider plots highlighted high scores in some sectors, including soil management, crop varieties and management, climate change, and policy. SHs emphasized the need of controlling soil erosion and soil acidity in an environmental context. These issues were noticed by SHs, who showed a willingness to implement new, suitable BMPs. SHs emphasized the importance of improving agricultural rotation systems while modifying crop management. Due to the current availability of the same products on the market, with the ensuing imbalanced supplies, the market trend and food distribution were addressed as a problem. SHs emphasized the necessity for improved farmer communication as a counterpoint to this issue. The implementation of new practices

appears to be encouraged by SHs, who appear to view climate change as a problem. Concerning a socioeconomic frame, lack in fundings or subsidies was not reported as a problem. Local SHs underlined issues in a regular water distribution, probably due to the upstream river withdrawals that limits the availability of water that flows downstream. Consequently, the introduction of new policies associated to water distribution was reported as required. The Group Evaluation Sheet described a community where farmers appeared to share interests and were already members of cooperatives or associations. Farmer membership was represented by a variety of SHs, as women, researchers, private corporations, and different financial actors.

3.3 Group and needs evaluation for Kenya

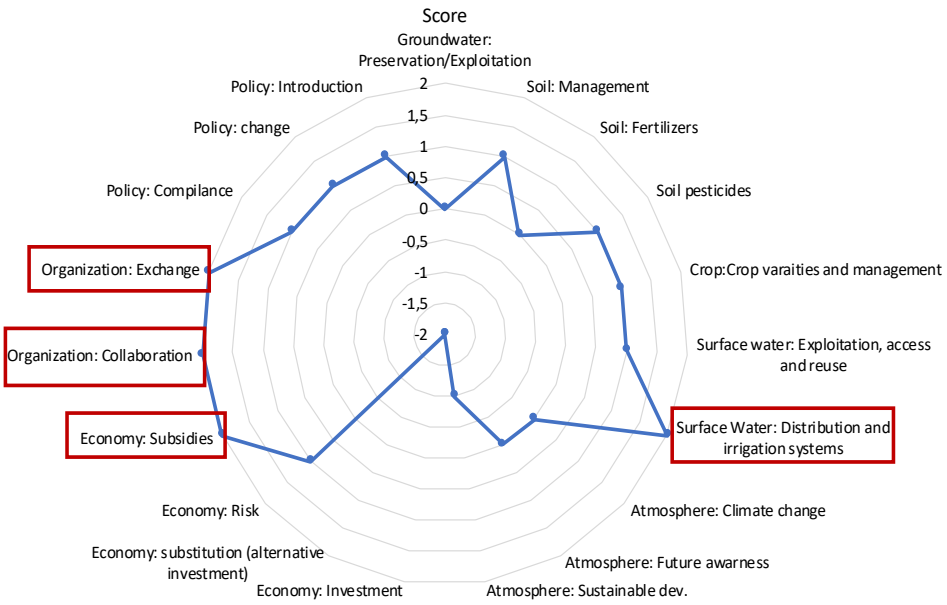

Figure 5 - Need Evaluation spider plot based on Kenya brokerage

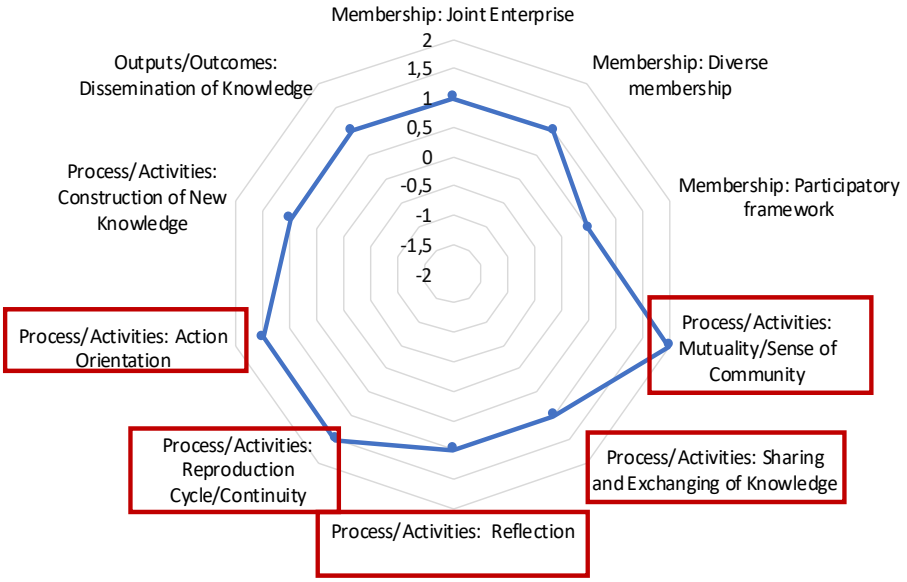

Figure 6 - Group Evaluation spider plot based on Kenya brokerage

In Kenya, the discussion highlighted the SHs needs in boosting socioeconomic aspects as the information exchanges, the attitude to collaborate and the availability of subsidies. Although the local community appeared to have a strong attitude in collaboration, SHs expressed the need to have a better managerial system to improve this aspect. Although the local SHs had an irrigation system, it was recognised that water management BMPs needed to be upgraded.

3.4 Group and needs evaluation for Sudan

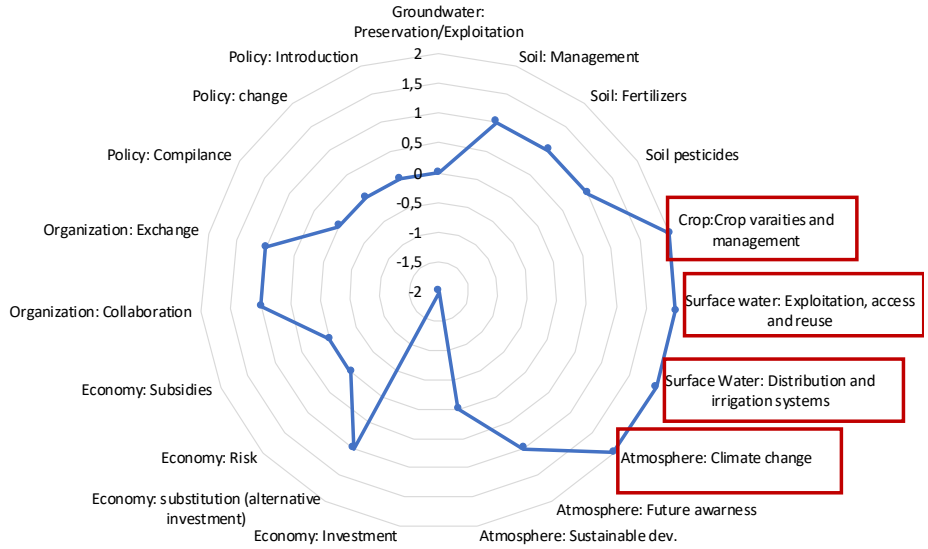

Figure 7 - Need Evaluation spider plot based on Sudan brokerage

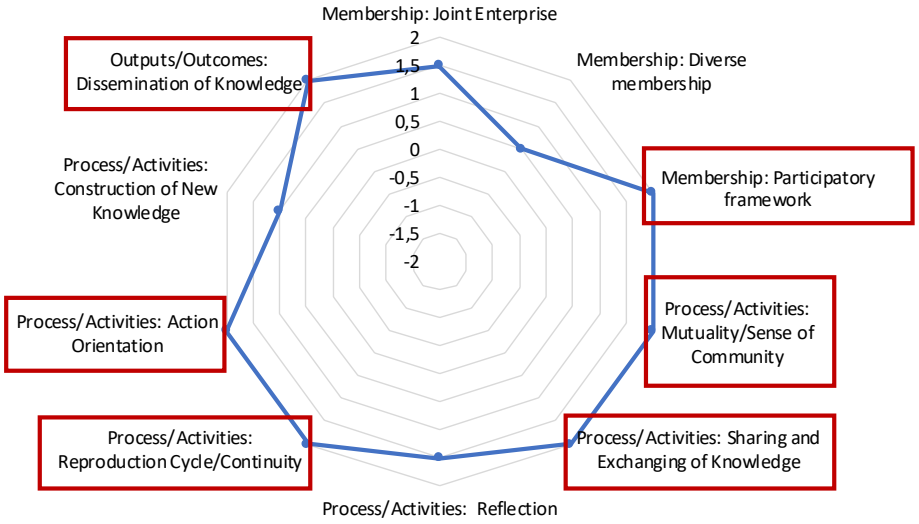

Figure 8 - Group Evaluation spider plot based on Sudan brokerage

In Sudan, results of brokerages showed that the local community had a strong sociopolitical and cultural structure and did not express the need in changing these aspects. The Group Evaluation Sheet results showed the presence of a good attitude in collaboration and organization. Sudanese

agricultural system is based on Gezira Irrigation Scheme and local SHs considered Gezira Irrigation Scheme as their main BMP to be improved, rather than in the definition and application of new potential BMPs. They appeared to be using a variety of BMPs, but there was a general lack of scientific understanding of their viability and field application, which is only applicable at the farm level. Although it appeared that the community had the technical know-how to keep the Gezira Scheme operating, sociopolitical and economic components of the country still needed to be improved. In order to modify the Gezira Irrigation Scheme's framework to meet local demands, certain SHs stated their desire to amend the agricultural crops scheme that is now governed by the government. Some farmers showed a positive attitude to the selection of novel cash crops. The community seemed to be open to new proposals, including the introduction of precision agriculture and the production of secondary products from crop wastes, in order to enhance value of the current crops. Climate change scenario was perceived as an issue by the local community. However, SHs do not consider themselves able to actively face this problem without a strong collaboration with governmental organs. Overall, the community needed an improvement in organization flexibility and delegation, as well as an enhancement of Gezira Scheme infrastructures, management, and organization.

4 Discussion

Brokerage outcomes, previously described through spider plots, and BMP repository data have been analyzed to assess a putative match between BMP selected from projects and BMP perceived as a need from the local community in each Country. Outputs of the matching process will be integrated in the modelling step of WATDEV project.

4.1 Matching between bmp repository data and brokerage outcomes in Egypt

Egypt Need and Group Evaluation revealed that local SHs need socioeconomic reforms and more collaboration. Local SHs discussed the importance of enhancing SOM and water content in soil. BMP repository data highlighted the presence of several BMPs able to improve soil organic matter, including the five-course rotation system, manuring and improvement in fertilizer use. In order to improve water distribution, the suggested BMP is the inclusion of the SHs in a Water Users Association, able to positively affect water distribution and also SHs collaboration and exchange.

4.2 Matching between bmp repository data and brokerage outcomes in Ethiopia

Brokerage outcomes showed that Ethiopian SHs underlined the need in new crop and soil management systems. To reduce soil erosion, possible BMPs from repository data could be crop

rotation, terracing, manuring. Local SHs did, in fact, emphasize their openness to implementing these particular BMPs. Proposed BMPs, able to counteract soil acidity, could be represented by an accurate balance between manure and organic fertilizers application and by the use of appropriate crop patterns. In a socioeconomic frame, local SHs indicated, as the main issue, the lack in appropriate policies able to improve soil and crop management and water distribution. These issues could be mitigated with the introduction of farmers corporation and association, able to improve the communication and organization within different members. In particular, to improve water distribution, BMPs repository data suggest the establishment of novel Water User Associations or the improvement of existing ones.of.

4.3 Matching between bmp repository data and brokerage outcomes in Kenya

Kenya SHs highlighted a desire to improve communication and cooperation within communities. During conversations with SHs, the need for improving the irrigation system became clear. Results from the data matching in the BMP repository indicated that the irrigation system might be enhanced by using the BMP for rehabilitation of the irrigation canals.Promotion of Water User Associations can also improve coordination and communication among SHs, as well as irrigation system management.

4.4 Matching between bmp repository data and brokerage outcomes in Sudan

Sudanese SHs underlined the need for strengthening the irrigation system and its management, as highlighted by Kenya demands. Similarly, they also showed the positive attitude in increasing collaboration among SHs. In this line, proposed BMPs can be irrigation canals rehabilitation and promotion of Water User Associations. Additionally, Sudanese SHs stressed the necessity for new cash crops and secondary product chains to be introduced in order to increase the value of agricultural products.Proposed BMPs could be the exploitation of spontaneous crops, as a source of secondary derived products, and the use of improved seed for new cash crops.

5 Conclusion

5.1 Countries common issues and needs

All countries seemed to be affected by a gap in the socioeconomic and policy sector. Sudan and Egypt needs were oriented in the establishment of a strong governmental organ able to control and improve socioeconomic and policy development. Communities in both countries acknowledged a need for better contact with governmental agencies. The necessity to improve SHs coordination and

communication was acknowledged by all the four Countries. Egypt, Kenya, Ethiopia and Sudan common environmental needs seem to be related to the water distribution.

5.2 Countries differences in socioeconomic and agroecological aspects

Egypt SHs highlighted the need in funding and subsidies, while this issue was not perceived by Kenya, Ethiopia and Sudan SHs. These last countries appeared to be focused on the improvement of the collaboration and communication. While Kenya and Ethiopia SHs acknowledged the willingness to improve collaboration and communication among the members of the community, the need for improved communication and cooperation between the community and the government was underlined by Sudan SHs. Ethiopian SHs, differentially from the other Countries, did not underline the need in improving surface water systems and, on the contrary, represented the only Country that highlighted the need of the introduction of new policies.

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