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INTEGRATING AGRO-ECOSYSTEM ANALYSIS INTO AGRICULTURAL EXTENSION AND ADVISORY SERVICES IN MARGINAL ENVIRONMENTS OF EGYPT: THE CASE OF SAHL EL-TINA, SINAI PENINSULA

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The agro-ecosystem includes not only the environmental setting, but also, the agricultural technology system, as well as, the social setting, which draw people's behavior towards natural resources. An intervention project named “Adaptation to Climate Change in Marginal Environments in the West Asia and North Africa through the Sustainable Diversity Crops and Livestock", which has been implemented in Sinai Peninsula (2010-2015). The project conducted four Farmer Field Schools (FFSs) in Sahl El-Tina region (village 4, 6 and 7). FFS activities included Agro-Ecosystem Analysis (AESA) to provide local smallholders with better understanding of the change drivers in the entire ecosystem. This is a descriptive study aimed to identify the awareness of the project participants with regard to 1) the ecosystem services; 2) the main drivers within Sahl El-Tina agro-ecosystem in terms of its impact and strength on the ecosystem services; 3) knowledge and practices that were participatory developed and gained; and finally 4) develop model for integrating AESA into agriculture extension and advisory system. Three Focus Group Discussions (FGDs) were conducted per each FFS totaling to 12 FGDs. Results of this study revealed that irrigation water is the most important ecosystem services as perceived by farmers. Regarding drivers, lack of subsurface drainage has severe negative impact on the ecosystem sustainability. The studied farmers were able to recognize 8 ecosystem services and 13 drivers. Similarly, they could recognize 45 of friendly agro-ecosystem practices in Sahl El-Tina as saline affected areas. These practices can be divided into five themes as follows: 1) soil salinity (10), 2) climate change (4), 3) animal production (10), 4) biological control (6), and 5) crop production (15). The previous findings may be regarded as a benchmark for future impact assessment study. Finally, this study proposed model form of the extension strategies to integrate AESA into extension programs at village level. To conclude, respecting AESA in extension programs in marginal areas increases farmers understanding of the dynamic relationship between controlling on change drivers and the ecosystem health and stability. Which may motivate them to adopt sustainable farm management practices in the future.

Keywords: soil salinity, fragile ecosystem, good practices, arid areas, climate change

Agro-ecosystem is an ecological system modified by human beings to produce agriculture commodities. It is often complex in its structure and dynamics as a result of the interaction between socio-economic conditions and ecological processes (Conway, 1987). The structure of agro-ecosystem includes not only environmental setting; e.g. climate, soil, various living organisms and other resources available in the entire ecosystem, but also, the Agricultural Technology System (ATS), as well as, the social setting (e.g. human values, institutions and skills), which draw people's behavior towards natural resources in the ecosystem. The ATS refers to community experience within the boundaries of the ecosystem landscape (including all crops, livestock, etc.) that people have developed for the purposes of agricultural production. This total package of technology assembles the cumulative knowledge that the community has developed to mold a given landscape into an agro-ecosystem. ATS is not homogenous but, it responds to both spatial and temporal changes (UNEP, 2009). Since, every agro-ecosystem has unique features as climate variabilities and water scarcity; these features may threat current livelihoods and resources. For instance, agro-pastoral environment is often inadequate and unsustainable, particularly with regard to drought effects and growing demographic pressure, in other word, population growth is a major factor in accelerating both degradation and desertification (UNEP, 1992). Therefore, sufficient quantitative knowledge about ecosystem responses to land use is essential to make decisions about the trade-offs between satisfying immediate demands of Ecosystem Services (ES) and maintaining its functions. As, responses vary according to the ecological and time setting and the land-use change (DeFries et al., 2004 and Kremen, 2005). Actually, both natural and human factors may induce ecosystem changes, these factors are called drivers. Proper ecosystem function and sustainable provision of ES demand understanding these drivers (Brock, 2012). Understanding the drivers in a particular ecosystem is essential for planning successful intervention, since, vulnerability diverse from place to place (Mearns and Norton, 2009 and Lescourret et al., 2015).

The ecological production function is a key step to understand the ES. It requires mapping the relationship from structure and function to services (Polasky, 2011); as shown in Fig. (1). Agro-Ecosystem Analysis

(AESA) may manifest the feedback loop between key ES and human well-being, identify the relevant drivers, and finally define the economic value of the services. It can be carried out at different scales; local-scale ecosystem within a landscape, or composite ecosystem (include more than one sub-ecosystem). Also, it can be conducted in both open and closed basins. Besides, AESA can be downscaled to cover a single field, a household farm, or more wider agricultural landscape of a village, region or nation (Marten, 1988 and Falkenmark and Galaz, 2007).

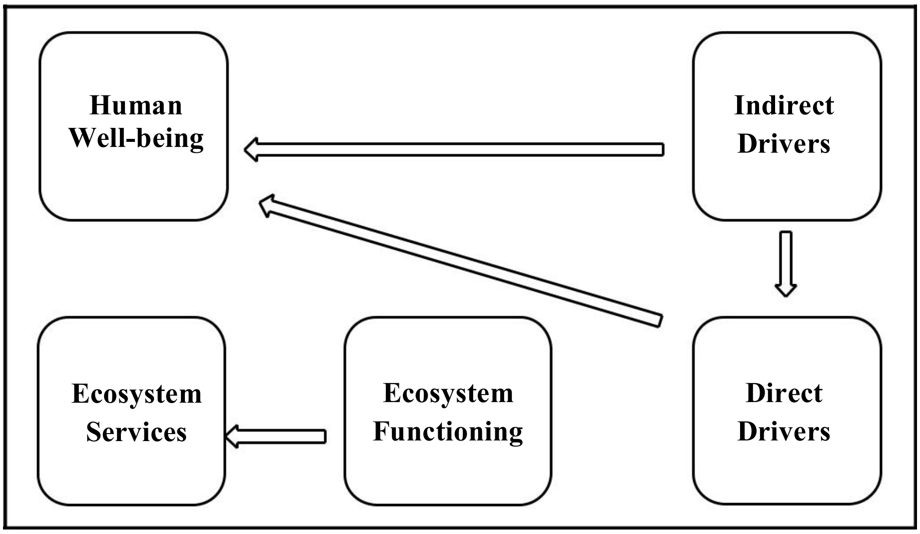

Fig. (1). The relationship among ecosystem structure, drivers, and services. Source: UNEP (2009)

Ecosystem drivers may be labeled as indirect and direct drivers (in other cases internal and external drivers). Indirect drivers affect direct ones and accordingly influence the ecosystem itself; e.g. changes in human population, economic activity, technology and socio-cultural factors (Brock, 2012). To illustrate, the expansion of agricultural subsidies (indirect driver) may lead to overexploitation of ES and accordingly induce more pressures. Similarly, technology changes increase production efficiency and the excessive use of fertilizers may bring about ecosystem pollution (Marten, 1988 and Lescourret, et al., 2015). Regarding direct drivers, changes in land use, Climate Change (CC), and pollution may derive more pressures on the ecosystem. For both types, drivers of ecosystem degradation are growing constantly and more efforts are needed to mitigate its effect. Therefore, developing in-situ socio–ecological framework is very important to maintain the function of the ecosystem (UNEP, 2009). Understanding ecosystem drivers demands the following steps: 1) identify main drivers in a particular ecosystem, 2) determine the relative importance of each on the ecosystem services, and 3) decide on the best way to influence the drivers to minimize ecosystem impacts and maximize the delivery of services (Hassan et al., 2005 and Prato, 2008).

According to the Millennium Ecosystem Assessment, there are four categories of services as follows: 1) provision services; e.g. food and water, 2) regulation services that maintain the function of the ecosystem processes; e.g. climate and water storage and disease regulation, 3) supporting services; including formation and guidance system, and 4) cultural services; such as recreational and spiritual benefit.

ES is the utilized aspects of the ecosystem to generate human well-being either actively or passively (Millennium Ecosystem Assessment Series, 2003). It may include ecosystem structure, process and/or functions when they have been consumed either directly or indirectly by humans. The functions or processes may be regarded as services, only, if humans utilized them. Therefore, structure, function, and services are not identical or synonymous. Nevertheless, ES are neither homogenous across the landscape, nor static across time. Equally important, the interactions between structure, process and service may generate additional complication, with respect to the fact that ES is hard to be measured or monitored directly (Fisher et al., 2009). Supply of ES refers to the capacity of a particular area to provide a specific bundle of ecosystem goods and services, while, demand is the sum of all ecosystem goods and services currently consumed within a given period of time (Burkhard et al., 2012).

The AESA is a methodology for analyzing agricultural systems in a particular area to propose convenient research and development plan, and extension programs. Also, clearly identify key issues or problems within the entire ecosystem, AESA apply systematic approach to gather both socioeconomic and biophysical data (Land Management Component, 2006).

Yet, developing comprehensive picture of an ecosystem functions, service delivery, and drivers of change necessitates new approach of knowledge generating and delivery (Jagger and Pender, 2003 and Brock, 2012). New approach should be adapted to deal with the complex and dynamic nature of ecosystems and the lack of knowledge or understanding of ecosystem functions and relevant measures to be regarded (UNEP, 2009). Being that, ecosystem sustainability became one of the emerged concerns of agricultural extension (Rivera and Alex, 2004). Any further development in the extension programs should concern utilizing natural resources more efficiently and repairing past ecosystem deteriorations (World Bank, 2005).

As a participatory approach, Farmers Field School (FFS) are comprised of small groups of people (10-20), with a common interest, who gather on a regular basis to investigate a particular topic in terms of how and why. Usually, FFS focuses on a particular crop in order to deepen the understanding of the principles of insect ecology, soil fertility and production economics etc. In fact, skills learnt in a given FFS about a given crop can be applied to other crops and other farm production systems (Braun and Duveskog, 2008).

Current community leadership and social structures has to be regarded in FFS' participants' selection. The participants are anticipated to outreach FFS' content to the wider community through knowledge dissemination during FFS' activities as a collective action (Feder et al., 2010). Equally important, the structure and process of the FFS make it possible to address many community issues relevant to the crop topic; e.g. equity, family health and community well-being (Luther et al., 2005). FFS provides a platform for improving decision making capacity of farming communities through awareness raising, education and training, as well as, stimulating local innovation for sustainable agriculture (Khisa, 2004). Additionally, it simplifies the scientific findings to match background and education level of local community as well as their indigenous knowledge (Medany, 2008).

It is one season-long training (seeds to seeds) and may extend beyond one season if necessary; e.g. post-harvest treatments and value addition practices. FFS meeting may be conducted weekly or biweekly and sometimes, at each distinct growth stages. The schedule should synchronize the crop growing stage. Also, there are no lectures in FFS, but, all activities are based on field work (learning-by-doing), besides, ecological principles, participatory training and non-formal education methods (Braga et al., 2001 and Braun and Duveskog, 2008).

The facilitator should be qualified with both technical and communication skills, so as to, he assumed to maintain even and active participatory discussion among his group (Gallagher, 2003). Initially, public extension staff leads FFS' activities to sharpen decision making and farm management skills through group interactions, leadership learning, communication and learning by doing among FFS' participants. Afterwards, some of the candidate participants may be qualified to receive more training to work as farmer-trainers in future training (Feder et al., 2010).

AESA is an essential component in FFS. It integrates observations, farmers' knowledge, experiences and decision-making into one activity together with new ecological concepts (Braga et al., 2001). It facilitates learning by discovery and guides farmers to critically analyze and make better decisions on their field problems (Gallagher, 2003). Promoting AESA skills among farmers demand providing them with good understanding of the agro-ecosystem, including, identifying both living and non-living organisms in the entire region, determine functions of each one in the ecosystem and how they interact with each other as a network of interactions. Also, how their decisions may make changes (Khisa, 2004).

During AESA, small group of 3-5 farmers move to the field to make observation notes about the crop, pests, natural enemies, diseases, weeds, soil and effects of weather on the entire agro-ecosystem. Then, each group brings their findings to the gathering area to develop a systematic report about their field observation. Indeed, the findings of the groups support and add accuracy to each other. Additionally, it promotes knowledge and experience sharing among farmers. A conclusion can be charted on a large sheet of paper to visualize the ecosystem understanding and managing farm health practices. Then, data can be listed in tables to enable other farmers to understand the results. Finally, a brief conclusion can be made about the relevant and immediate action that is needed (Luther et al., 2005).

Description of the Study Area

The ecosystem of Sahl El-Tina, Sinai Peninsula, Egypt, is considered a fragile system, whereas, access to water is mostly complex, seasonally dynamic, and highly determined by farm location. Equally important, the poor quality of ground water or using mixed Nile and drainage water (1: 1), contributed to impact the soil fertility and boost the salinity level. Further, CC implications have been witnessed and continue to affect temperature, rainfall, and sea level rise. Despite these circumstances, farmers are working to restore such marginal ecosystem into agriculture production. Sahl El-Tina is about 50.000 feddans (feddan = 4200 m^2 = 0.42 hectares = 1.038 acre) located at the eastern side of the Suez Canal as shown in fig. (2). Soil can be described as sediment fine to heavy clay, moderate to severe salt affected, and contain poor organic matter and nutrients. The government has accomplished infrastructure for irrigation, drainage, roads and electricity. It comprises of seven villages as follows: villages 1, 2, and 3 are almost 5000 feddans per each and allocated for large investors (more than 500 feddans); villages 4 and 7 are almost 4000 feddans per each and allocated for smallholders (less than 10 feddans), and finally villages 5 and 6 are allocated for medium and smallholders (less than 500 feddans). Sugar beet, wheat, barley and berseem are the dominant crops. The poverty and inappropriate management practices are common among local farmers, namely, Bedouins and smallholders, who moved recently from Nile Valley Governorates and almost apply conventional farming practices for old lands. In fact, they are confronting many challenges; drought, water salinity, poor soil and hot summer, besides, poor advisory services (Anon, 2012).

In an attempt to help those farmers; an agreement was signed between the International Center for Bio-saline Agriculture (ICBA), Dubai, and the Desert Research Center (DRC), Cairo to carry out the project titled "Adaptability to Climate Change in Marginal Environments in the West Asia North Africa (WANA) through the Sustainable Diversity Crops and

Livestock ". The project is comprised of various activities to develop and apply an integrated sustainable management practices. The project established four FFSs (2 FFSs in village 6, 1 in village 4, and 1 in village 7). AESA was embedded in FFS activities to improve smallholder farmers understanding of their agro-ecosystem as a marginal ecosystem. And so, farmers can gain insight of the strengths, weaknesses and consequences of different farm management choices and may adopt more conservative production pattern in a way to achieve their human well-being with regard to sustainability concept (Anon, 2015).

Fig. (2). Location map of Sahl El-Tina in North Sinai Governorate.

Based on the previous background, eco-based farm management practices differ from system to another, respecting both physical and socioeconomic conditions and there is no particular scheme to assess relevant knowledge. It worth to investigate smallholders understanding of their agro-ecosystem as a marginal area, that after participating in a particular project to be compared with knowledge of non-participant farmers for future comparison study. Chiefly, this study aimed at determine the participants' understanding of the following: 1) ecosystem services, 2) the main drivers in the ecosystem and its impact and strength, 3) knowledge and practices that were participatory developed and gained, 4) besides, develop model for integrating AESA into Agriculture Extension and Advisory System (AEAS).

METHODOLOGY

Focus Group Discussions (FGDs) is a method to collect qualitative data from a small number of individuals about particular topic(s). It provides convenient environment for research participants to express their perceptions, ideas, opinions and thoughts (Onwuegbuzie et al., 2009). Nonetheless, this study aimed only to provide an overview about knowledge and practices generated from farmers' participation in FFSs activities during AESA activities.

All FFSs were covered in this study as shown in table (1). Three FGDs had conducted per each FFS of total of 12 FGD, including about 96 stallholder farmers during the period from March to July 2014. Semi structured interview guide was developed to ask FFS' participants about their recognition capacity with regard to 1) ecosystem services, 2) main drivers, also, its impact (positive or negative) and strength (low, moderate, or high), and 3) knowledge and practices gained from FFS activities.

Table (1). Distribution of the members of FGDs by village and FFSs.

Village	Number of small holders	FFS	Number of participants in focus group discussions			
			FGD1	FGD2	FGD3	Totals
		1st	8	8	8	24
Village 6	332	2nd	7	8	8	23
Village 4	399	3rd	9	9	9	27
Village 7	278	4th	8	7	7	22
Totals						96

As early step in the organization of AESA, secondary data was utilized to identify ecosystem boundaries; community services, infrastructure and land use planning for each school of the four locations. Then, AESA has been carried out as a regular activity in each session along with other FFS activities in participatory manner of both farmers and multidisciplinary research staff to encourage learning and sharing practical knowledge.

The ecosystem drivers are the main components in the ecosystem structures, that any changes in such components may influence the ecosystem sustainability and may impact directly its stability. Actually, covering this point have taken long time of participatory discussions among multi-disciplinary researcher staff and farmers to identify the ecosystem structure and particularly main drivers, then elaborate how these drivers interact together and may impact the ecosystem, and finally, the strength of such impact on both current and future utility of agro-ecosystem.

In fact, same driver may have variant interactions and may be positive with regard to specific conditions and negative in another. Additionally, such relations may change from time to time. Therefore, farmers’ groups were asked to make conclusion only about their main interest of each driver with regard to their current and future utility of the ES. Farmers’ conclusions about the impact were assigned as follows: high positive (HP), moderate positive (MP), low positive (LP), high negative (HN), moderate negative (MN) and low negative (LN). Ecosystem services concern three types of services 1) provision services; e.g. food, raw material, and fresh water, 2) regulation services; e.g. biological control, organic matter decomposition, 3) habitat or supporting services provide the needs of an individual plant or animal needs essential to complete its lifecycle; food, water and shelter. Farmers were asked to assign ESs in order to identify its importance A conclusion of AESA findings were discussed afterwards during a plenary session, considering all locations have similar traits and located in the same agro-ecosystem. The proposed model for integrating AESA into advisory system was developed based on the practical knowledge the study findings.

RESULTS

1. Ecosystem Services

AESA aimed mainly to draw Sahl El-Tina farmers' attention to the services provided by the ecosystem, particularly, non-paid services and goods, which normally farmers do not consider. Hence, traditional practices may accelerate the decline of the ecosystem capacity of services provision. Especially, Sahl El-Tina is a marginal area and highly vulnerable to degradation. Table (2) demonstrates the findings of FGDs about farmers' perception of their agro-ecosystem services. Irrigation water was reported as first service perceived by farmers for its importance to soil enhancement and salinity treatment. The next service from the ecosystem was providing farmers with farmland, pastures, stockyards and housing parcels. The ecosystem also facilitates livestock and poultry production, which in turn, provide farmers with source of income, nutrition and job opportunity.

Table (2). Ecosystem services as perceived by FFS participants.

No.	Ecosystem services
1	Irrigation water improves soil salinity and prevent soil degradation
2	Ecosystem provide farmers with farmland, pastures, stockyards and housing parcels
3	Livestock provide households with source of meat, milk, hides and manure.
4	Poultry habitat and feeds for both commercial and domestic consumption
5	Farm outputs in monetary and nutrition forms and employment opportunities
6	Flora provides timber, energy and forages
7	Natural enemies are available in the ecosystem
8	Soil fauna and microorganisms fix and store carbon and other nutrients; and assimilate wastes

Source: Focus groups discussions

2. Ecosystem's Drivers

Table (3) indicates the ecosystem drivers as investigated by farmers during FFSs sessions and approved through FGDs. The location has minor negative impact as it increases transportation costs, yet, this impact still considered minor as farmers have good access to roads and transportations.
CC influences negatively the production system. That is, indirect impact resulted in salinity exaggeration as a result of increasing evaporation rate, besides, extreme weather events, which induced direct impact on plant growing in all phases. Although water is regarded the first ecosystem service, farmers see sever negative impact of water on the production process. The negative impact resulted in the frequent shortage of water particularly in summer, not to mention, the high demand for water to meet leaching requirements and high temperature.

In fact, the poor quality of water reduces the cropping variability options available for farmers and necessitates cultivating only saline-tolerant crops. Similarly, soil has negative impact also, yet poor soil fertility has moderate impact as farmers can enhance soil fertility through adding both chemical and organic fertilizers, while, soil salinity and diseases has sever negative impact as it demands long run and complicated treatments. With regard to plants i.e. crop, horticulture, and vegetables, all have strong positive impact on the sustainability of the ecosystem, as they provide farmers with different opportunities of livelihoods, as well as, meeting the demands relevant to domestic consumption. For the same reasons, farmers reported livestock and poultry have strong positive impact on the ecosystem sustainability. Regarding livelihoods and land use, crop-livestock production pattern has proven a good and strong positive impact. Other livelihoods have positive impact as well, nonetheless, it's still at minor volume to influence the ecosystem. On the other hand, fish farming activities exaggerate water logging and complicate soil salinity problem. Additionally, illegitimate pastoral activities by anonymous shepherds may provoke social conflict and tension with pastoralists. Similarly, but more importantly, farmers reported that farm labor have severe negative impact on farm activities and may enforce them to focus on chemical control instead of mechanical one. Lack of institutions and community services may also cause moderate negative impact. Finally, infrastructure may have moderate positive impact in general. However, lack of subsurface drainage is regarded as having severe impact on ecosystem suitability, since its absence frustrates other soil development activities.

Table (3). Ecosystem drivers as perceived by FFS participants.

No.	Driver	Perceived Impact	Strength
1	Location	Distance from urban, market and input suppliers	LN
2	Climate variability and extreme events	Increased temperature, causes evapotranspiration, leads to salinity intense, result in desertification	MN
3	Water shortage	Water fluctuation, pollution and salinity are common complains	HN
4	Soil characteristics	Poor organic matter, nutrients and microorganisms	MN
		High salinity, insects and diseases	HN
5	Ecological	Farmers cultivate crops, horticulture, vegetables and windbreaks	HP
		Pests, insects, rats, birds, reptiles, weeds are common problems	MN
6	Animal production	Livestock: goats, sheep, caws, buffaloes are common for commercial purposes	HP
		Poultry: rabbits, chickens, ducks and geese meet the domestic demands for protein	HP
7	Air	Pollution resulted from crop waste incineration	LN
8	Livelihoods and land use	Crop production is the main farm pattern	MP
		Crop-livestock production is common among progressive farmers and increase the value added	HP
		Seeds production provides extra income, but not common	LP
		Dairy processing is common for domestic consumption, but only few farmers produce for commercial purposes	LP
		Input suppliers and brokers are significant source of information	LP
		Nonfarm activities provide extra burden	LN
9	Socio-economic and demographic characteristics	Conflict with pastoralists and fish farmers limits the resources utility	LN
		Demographic dislocations induce poor coherence with the extended family	LN
		Poor farm machineries	LN
10	Labor	Shortage and high costs during annual calendar of farm activities	HN
		Family labor, neighbors' collaboration, and paid labor recover labor shortage	MP
11	Institutions	Lack of research, financial, and extension services	MN
		Newly established cooperatives promotes collective action	LP
12	Infrastructure	The area has good roads, canals, and bridges	HP
		The area has no subsurface drainage network	HN
13	Community services	Poor veterinary services, soil analysis, marketing, machinery, and extension	MN
		Poor drinking water, sanitation, electricity, security, transportation, and fuel	MN

HP = high positive impact, MP = moderate positive impact, LP = low positive impact, HN = high negative impact, MN = moderate negative impact, and LN = low negative impact.
Source: Focus group discussions

3. Knowledge and Practices

Knowledge and practices that were derived from farmers' FGD can be grouped into five themes namely: 1) soil salinity, 2) climate change, 3) animal production, 4) biological control, and 5) crop production.

3.1 Knowledge and practices on soil salinity

Table (4) points to farmers' perception of knowledge and practices to mitigate the impact of soil salinity on the ecosystem sustainability as a result of participating in FFS activities. Knowledge and practices cover drainage, irrigation, tillage and fertilization. And reflect famers' understanding of the interaction between soil salinity and farming applications.

Table (4). Ecosystem-based knowledge and practices to mitigate soil salinity implications.

No.	Ecosystem-based knowledge and practices to mitigate soil salinity implications
1	Maintain effective drainage is crucial recommendation for soil enhancement in the areas
2	Apply sub-soiling and two-dimensional tillage improves soil infiltration, temperature, moisture, aggregation, and organic matter content
3	Increase irrigation water of about 20% of the optimum amount to meet the leaching requirements
4	Maintain sufficient humidity in soil while excess salt is still in the root zone minimizes negative effect on plant growth
5	Soak seeds before planting to protect seeds from soil breaks
6	Apply crop residue or mulch over the soil to reduce evaporation
7	Compos crop residuals to provide cheap balanced fertilization and healthy food
8	Apply slow irrigation after sowing for watering and leaching purposes. Second irrigation take place one week after to lessen the salt concentration at the root zone
9	Don't overuse chemicals (fertilizers, pesticides, and herbicides) to reduce ground water pollution and salinity.
10	Analyze soil and water periodically to maintain reliable information for fertilization and irrigation management as well as animal water intake

Source: Focus group discussions

3.2. Knowledge and practices relevant to climate change

Findings in table (5) show the good practices to mitigate CC implications. Farmers indicated constant exposure to meteorology news as the main practice. It worth to mention that AESA drew farmers' attention to regard meteorology parameters in all farm applications; e.g. adding pesticide and fertilizers have to be amended to respond to rain, and wind speed and direction.

Table (5). Ecosystem-based knowledge and practices to mitigate climate change implications.

No.	Ecosystem-based knowledge and practices to mitigate climate change implications
1	Daily exposure to meteorology news to decide on the best times for different farm applications e.g. irrigation time and level
2	Water salinity may increase as a result of high evaporation induced by heat accretion
3	Windbreaks can mitigate climate change implications
4	Climate change may decrease the yield in some crops e.g. wheat and maize; and may increase the yield e.g. cotton

Source: Focus groups discussions

3.3 Knowledge and practices on animal production

The knowledge and practices relevant to animal production are focusing on the mitigation of CC impact, as mentioned by farmers. Table (6) shows participatory developed knowledge and practices, including, making silage to diminish feed shortage particularly in summer, also, animal drinking applications under heat conditions. Besides, medical precautions to mitigate the poor quality of drinking water and improve animal shelter conditions including airflow and animals number per unit area.

Table (6). Ecosystem-based knowledge and practices on animal production.

No.	Ecosystem-based knowledge and practices relevant to animal production
1	Silage processing increases feed storage time and improve farm management
2	Add protein from pasture or other additives in case of 100% long term feeding of Maize silage
3	Feeding animals on salt blocks during dry periods increases water intake and may depress the appetite and cause digestive upsets particularly with poor quality of drinking water
4	Both salinity and high temperature increase the water intake by animals
5	Animals prefer water at or below body temperature and avoid warmer water, so, cool water is preferred in hot conditions.
6	Using irrigation water (mixed fresh and drain water) for animals drinking is very risky and may bring parasite infection.
7	When saline water is used, livestock should be monitored for symptoms of health and productivity e.g. appear unwell, lack of appetite & reluctant to drink, frequent small amounts of concentrated urine, nasal discharge, and abdominal pain

Table (6) cont.	
8	Effective vaccination program helps to avoid death and infectious abortions in heifers.
9	Animals grazing in swampy areas and pastures resulting in high vulnerability for infection, so adding antibiotics and vitamins eliminate contamination probability
10	Improved husbandry practices increase folk/ herd adaptation to climate change

Source: Focus groups discussions

3.4. Knowledge and practices on biological control

The findings of the FGD as shown in table (7) produce number of practices and information regarding ecosystem sustainability at farm level applications. They reflect farmers' perception and understanding of different types of pests control; e.g. chemical, mechanical, biological and farm management. All mentioned applications give less interest to chemical control, and provide alternatives to replace it, such as, applying a crop rotation and disseminating natural predators and other parasitoids.

Table (7). Ecosystem-based knowledge and practices on biological control.

No.	Ecosystem-based knowledge and practices on biological control
1	Substitute chemical pesticides with releasing natural enemies (predators and parasitoids) into the agro-ecosystem to maintain its sustainability
2	Biological pest control reduces the risk of water pollution and risk to human health
3	Biological control demands constantly observing insects' population and propagation
4	Providing insect hotels near the field encourage the reproduction of beneficial insects
5	The diversified crop rotations eliminate the successive host crops for diseases, and so, reduce pests and diseases prevalence
6	Crop rotations may be regarded as biological control and fertility enhancement

Source: Focus groups discussions

3.5. Knowledge and practices on crop production

Table (8) presents a list of 15 knowledge and practices. It was all about farm management and agricultural applications. Most items are related to the cropping pattern including cover crops, crop rotation, intercropping and how to decide on the appropriate crops for soils in the area. That is, FFS focused on the physical convenience and the economic efficiency as two substantial characteristics for crop selection. However, among the recommended salinity-tolerant crops, farmers prefer pearl millet and sorghum for its salinity tolerance and good growth. Farmers also recommend the crop-livestock production system for income diversification, production stability and maximize value added. This system; as farmers reported; increases farm income at the same level of ES and maintain the ecosystem functions in favor of sustainability.

Table (8). Ecosystem-based knowledge and practices on crop production.

No.	Ecosystem-based knowledge and practices on crop production
1	The introduction of cover crops increases soil conservation, mitigate nitrate leaching and reduce evaporation from bare soil. However, it demands a higher labor and may induce pest infection.
2	Cultivating rapid growing crops reduces weed infestation and compete it for soil and light.
3	Planning for good crop rotation leads to optimal allocation of resources (e.g. land, time, energy, fertilizers, and water). Additionally, it improves profitability and productivity.
4	The subsequent crop's roots work as crop residues and stimulate biological activity and improves soil structure stability.
5	Although the intercropping system are generally considered harder to be managed, it’s assumed to have more potential in terms of land productivity, resilience, and sustainability.
6	Intercropping may bring mutual advantage, that, one crop serves the other one, e.g. earth worming or fixing the atmosphere nitrogen as wheat association with clover grass. Yet, it can be negative as well in the case of competition-based relationship between the associated crops.
7	Planting legumes and grains together with adding animals’ manure offer balanced fertilization.
8	Fodder crops and/or grains feed livestock, and in return, livestock provide the farm with manure for crops fertilization.
9	Crops-livestock farming system enhances natural biological cycles.
10	Cultivate both indigenous plants and proven good crops is preferable under saline conditions.
11	Salinity-tolerance is the main determinant for crop selection in Sahl El-Tina.
12	Millet is recommended as the first crop next to the leaching phase of saline soil prior cultivating other crops.
13	Early sowing of Millet resulted in better growing and feed quality.
14	Integrating alfalfa into crop rotation provides greater water retention and lower nitrogen fertilizers consumption. It supports also the integration between cereal and livestock production.
	Millet is a quick-growing summer forage and more salinity-tolerant than sorghum.

Source: Focus groups discussions

4. Integrating AESA into Agricultural Extension and Advisory Services

To develop more responsive extension programs, a comprehensive understanding of the entire ecosystem is substantial prerequisite. So that, AESA should take a part in each extension activity. Fig. (3) demonstrates extension strategies to integrate AESA into extension programs at local level. The provided model was developed based on the experience of this study in Sahl El-Tina as one of the marginal resources, and according to Millennium Ecosystem Assessment (2003). AESA has to be tailored to fit the process of developing extension programs according the following strategies:

Extension strategy to participatory preserve ecosystem provision capacity

- Increase farmers' awareness of ecosystem services, particularly non-perceived services.
- Promote farmers understanding of the interaction between human activities and ecosystem provision capacity.
- Draw farmers' attention to the trade-off between future costs of restoring deteriorated ecosystem and current rational and sustainable utilization on goods and services.
- Maximize the utility of each unit of the services and goods provided by the ecosystem.

Extension strategy to rational human demands and accomplish human will being

- Participatory prioritize local community needs of will being to be more rational and moderate with regard to maintain ecosystem sustainability.
- Investigate human activities that may influence the ecosystem supply capacity of goods and services.
- Promote social capital; e.g. establishing public private partnerships and farmers' associations to encourage collective action.

Extension strategy to participatory understand ecosystem drivers

- Participatory identify both direct and indirect drivers of the ecosystem.
- Participatory understand mechanisms and interactions among such drivers each other and between each driver and the ecosystem provision capacity.

Participatory shift the good practices into extension activities

- Participatory develop relevant and effective knowledge and practices to mitigate the negative impact and promote the positive ones.
- Develop extension activities to disseminate the developed package in the rural community.

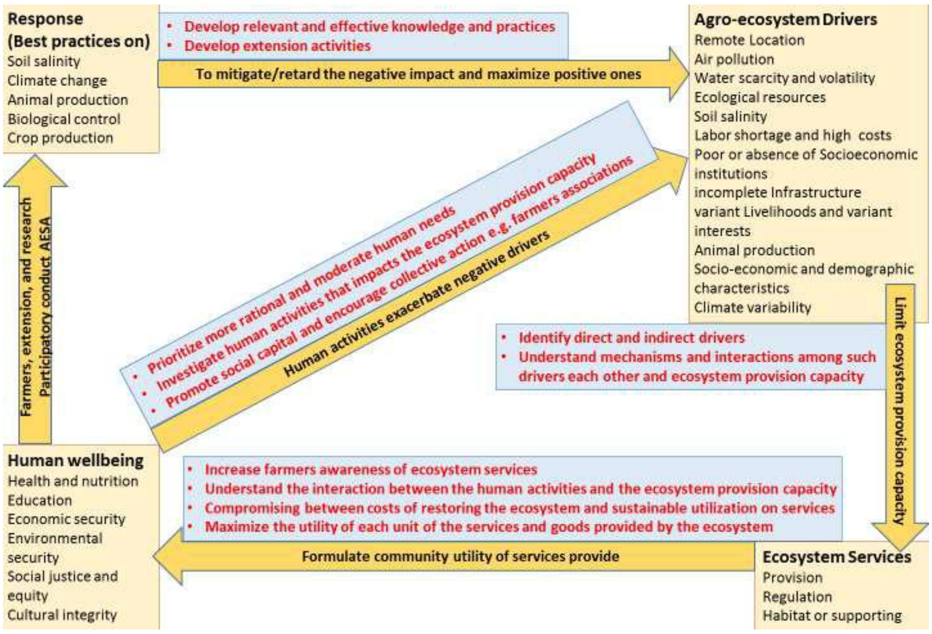

Fig. (3). A framework for integrating agro-ecosystem analysis into agricultural extension and advisory services in Sahl El-Tina, Egypt.

CONCLUSION

AESA may contribute in not only control the loss of the ecosystem provision capacity, but also, in restoring the degraded ecosystems. Hence integrating AESA into AEAS will broaden the interest of extension workers to apply more sustainable farm management. To achieve this purpose, AEAS has to increase the awareness of the main drivers of the ecosystem and worth the economic value of the provided service and goods, as well as, draw farmers' attention to the costs to be invested to restore or compensate current services in the case of its absence. The study revealed that, farmers were able to perceive number of ecosystem services, including, non-paid services and goods, which farmers don't usually count for. Also, farmers could recognize the ecosystem drivers that may influence the ecosystem capacity in the future to fulfill the community demands, besides, a list of 45 knowledge and practices. Such findings may be regarded as a benchmark for future comparison study with control group. To conclude, AESA enabled local farmers to invest their indigenous knowledge and integrate it into the provided package, as to generate reliable and valid knowledge and practices. AESA is highly recommended for extension programs developed for marginal areas to produce territory-based knowledge. Since, it may contribute in recharting rurals' mindset with regard to respecting the ecosystem circumstances across farm management practices.

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دمج نشاط تحليل النظام البيئي ضمن خدمات الإرشاد الزراعي في البيئات الهامشية بمصر: دراسة حالة على منطقة سهل الطينة بسيناء

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يمثل النظام البيئي الزراعي نظام بيئي معدل بواسطة الإنسان من أجل توفير السلع الزراعية، وبالإضافة إلى العناصر البيئية (الظروف المناخية، والتربة، والكائنات الحية)، يتضمن النظام أيضًا الخصائص الإجتماعية ونظام المعرفة الزراعية والتي تشكل بدورها سلوكيات أفراد المجتمع نحو الموارد الطبيعية. وتحتاج البيئات الهامشية بصفة خاصة لنظم معرفية وبرامج إرشادية مصممة خصيصًا لطبيعة النظام البيئي والبناء المعرفي السائد. وعلى ذلك يهدف مشروع "الأقلمة نحو التغيرات المناخية في البيئات الهامشية في غرب آسيا وشمال أفريقيا من خلال نشر حزم الإنتاج المستدام والمتنوع (محاصيل أعلاف - إنتاج حيواني) في منطقة شبه جزيرة سيناء" لإمداد صغار الزراع بحزم إرشادية مطورة لإنتاج محاصيل الأعلاف والإنتاج الحيواني، من خلال إنشاء عدد من مدارس الزراع الحقلية بمنطقة سهل الطينة، وتضمنت المدارس الحقلية تحليل النظام البيئي الزراعي كنشاط أساسي. حيث يساعد مشاركة الزراع في تحليل النظام البيئي في التوصل إلى حلول أكثر إستدامة لمشاكلهم المختلفة فضلًا عن زيادة إدراكهم للخدمات التي يحصلون عليها من النظام البيئي، وكذا أهم العوامل التي قد تؤثرعلى إستدامة هذه الخدمات. لذا هدفت هذه الدراسة إلى التعرف على مدى إدراك الزرع للعناصر التالية بعد مشاركتهم في أنشطة المشروع ١) خدمات النظام البيئي ٢) أهم محركات التغيير من حيث نوع الأثر وقوته ٣) الممارسات الزراعية المناسبة لتقليل أثر هذه المحركات ومعظم الخدمات التي يقدمها النظام البيئي ٤) وأخيرًا إقتراح نموذج لدمج تحليل النظام البيئي ضمن برامج الإرشاد الزراعي بالمناطق الهامشية. كدراسة وصفية تم عقد ثلاث حلقات نقاشية لكل مدرسة حقلية (٤ مدارس) بمجموع ١٢ حلقة نقاشية خلال الفترة من مارس إلى يوليو 2014، كما تم عرض النتائج ومناقشتها مع الزراع في إجتماع عام أثناء الحلقة الختامية لمدارس الزراع الحقلية لتأكيد وتوضيح النتائج. وقد أوضحت الدراسة أن مياه الري هي أهم الخدمات التي يقدمها النظام البيئي، وأن عدم توفر الصرف المغطى هو أهم العوامل ذات الأثر السلبي على إستدامة النظام البيئي، وأن رفع الزراع لمستوى الكومة السمادية إلى فوق مستوى الأرض بدلًا من الحفر من أبرز الممارسات المناسبة لتفادي إرتفاع مستوى الماء الأرضي. وإجمالًا إدرك الزراع عدد ٨ من الخدمات البيئية و١٣ من محركات التغيير، كما أوضحوا عدد ٤٥ من الممارسات البيئية المناسبة للبيئة المتأثرة بالأملاح كالتالي: ملوحة التربة (١٠)، التغيرات المناخية (٤)، الإنتاج الحيواني (١٠)، المقاومة الحيوية (٦)، وإنتاج المحاصيل العلفية (١٥). وتوصي الدراسة بتدريب المرشدين الزراعيين على المهارات الإتصالية والفنية اللازمة لإجراء تحليل النظام البيئي.