Adoption and Economic Assessment of Improved Technologies

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Introduction

Because of the aridity prevailing in most of the Middle East and North Africa Countries, the Arabian Peninsula (AP) is the poorest in the world in terms of water resources, both globally and per inhabitant. Arid conditions in these countries act as a natural constraint for expansive agriculture. Only 1.7% of the total land area is arable in GCC countries. As a result, 60–80% of total food demand is currently met from external sources. The agriculture contributes only around 1%-4% of the GCC countries' GDP as compared to 10%-20% for their emerging market counterparts. Moreover, rapidly growing populations and rising per capita consumption becomes the key drivers for growth in food consumption. Indeed, increasing income levels and rising prosperity are leading to a shift in food consumption patterns with the demand for food products rising fast and contributing to more intensive land use.

The scarcity of arable land and water has limited the growth of AP agriculture. With the limited potential for an agriculture sector, optimizing use of these limited resources for technology transfer in agricultural development is one of the biggest challenges facing any decision-maker including the end users and growers. Thus, developing a sustainable and improved agriculture system would have a significant impact on helping these countries to shift their agricultural priorities from self-sufficiency to food security.

The development program for the region known as Arabian Peninsula Regional Program (APRP) implemented by the International Center of Agricultural Research in the Dry Areas (ICARDA) upon request from the AP National Research Systems has been operating since 1995, through the development of proven technologies to improve the agricultural productivity and contribute to reducing the food production gap in the AP region, which is already among the largest food importers and is set to witness a significant growth in the import of food products in the coming years. Several proven technologies and improved packages for different production systems have proven their worth at research stations, such as protected agriculture and its associated techniques, irrigated forages, on-farm water management, spineless cactus and rangeland rehabilitation. However, some of these technologies have not been widely adopted. While developing improved technologies is important for farmers in this region, new technologies can only affect livelihoods positively if they are profitable.

In light of these challenges, and in order to enhance the adoption and accelerate its process and scaling up of these proven and promising technologies, this chapter attempts to provide a more or less clear picture of the economic valuation (examination of the costs and benefits on using these technologies- trade-offs with respect to the conventional ones), and their level of adoption, with special emphasis on the main factors affecting the adoption of these technologies and limiting their adoption process in the GCC countries and Yemen.

We begin with a presentation of the methodological framework used. This is followed by the data and sources of data section. Results and discussion sections are presented in the third and fourth section. In the final section we summarize our findings and their implications for prioritizing interventions, especially in the context of planning for knowledge, promoting adoption, and ensuring scaling up and the widespread use of these technologies.

Material and methods

In order to achieve the outlined objectives, two methodological frameworks have been used. The selected evaluation criterion for this study was first the economic efficiency/viability measure using a cost benefit approach. The second method used in this research is the ADOPT (Adoption and Diffusion Outcome Prediction Tool) framework. This is an MS Excel-based tool that evaluates and predicts the likely level of adoption and diffusion of specific agricultural innovations with a particular target population in mind. This criterion used for the two methods was selected considering the main objective of this research. The following sub-section presents and discusses the two applied methods.

Cost – Benefit Analysis (CBA)

Cost Benefit Analysis (CBA) is a basic approach in neoclassical economics adapted by environmental economists for the evaluation of net social or private welfare from environmental remediation/projects. This is an evident indicator arguing that a technology generating higher net benefits is more efficient than a technology generating less or negative net benefits. This systematic framework was used to determine options that provide the best approach for the adoption and practice in terms of benefits in labor, time and cost savings, etc.

According to Harberger, (1971), the CBA is considered one of the basic postulates of applied welfare economics. There are many justifications for this, but according to Boardway (1974) the one that appeals most to 'objective' economists is that aggregate monetary gains and losses measure the efficiency of a technology. If the aggregate is positive, it implies that the gainers could compensate the losess and still be better off after the technology is undertaken and vice versa. De Graaff and Kessler (2009) argued that the eventual aim of CBA is a comparison between the present value of the streams of benefits (positive effects) and the present value of all investment and recurrent costs (negative effects). In a typical CBA, the costs of the inputs are assessed and compared to the monetary estimates of total benefits that the new technology is expected to provide. The essential theoretical foundations of CBA are benefits, defined as increases in human wellbeing (utility), and costs, are reductions in human wellbeing. For a new technology to qualify on cost benefit grounds its net benefits must exceed its net cost.

A CBA tool, in the context of this research, was employed to evaluate the on-site losses and gains associated with adopting the improved technologies in ICARDA's Arabian Peninsula Regional Program. The scale of the CBA in this study is farm level and the objective is a financial analysis of the gains and losses from the adoption of these technologies. CBA is used here as a decision tool after computing all cost and benefits valued in local currency for each country and converted to US dollars.

Adoption and Diffusion Outcome Prediction Tool (ADOPT)

The Adoption and Diffusion Outcome Prediction Tool (ADOPT) is an MS Excel-based tool that evaluates and predicts the likely level of adoption and diffusion of specific agricultural innovations with a particular target population in mind. The tool uses expertise from multiple disciplines to make the knowledge surrounding the adoption of innovations more available, understandable and applicable to researchers, extension agents and research managers. ADOPT predicts the proportion of a target population that might adopt an innovation over time. The tool makes the issues around the adoption of innovations easy to understand. ADOPT is useful for agricultural research organizations and people interested in understanding how innovations are taken up. The tool has been designed to: (i) predict the likely peak level of adoption of an innovation and the time taken to reach that peak; (ii) encourage users to consider the factors that affect adoption at the time that projects are designed, and (iii) engage research, development and extension managers and practitioners by making adoptability knowledge and considerations more transparent and understandable. This tool was used to evaluate and predict the likely level of adoption and diffusion of the improved technologies in ICARDA's Arabian Peninsula Regional Program. ADOPT predicts the proportion of a target population that might adopt an innovation over time. ADOPT users respond to qualitative and quantitative questions regarding twenty-two variables that influence adoption. Going through this process also leads to increased knowledge about how the variables relate to each other, and how they influence adoption and diffusion. ADOPT is structured around four categories of influences on adoption:

Learnability of the population - concerns the characteristics of the population that affect their ability to learn about the innovation. There are four questions regarding this aspect of adoption, which focus on group involvement in the community relevant to the innovation, whether or not the populations uses advisors to get relevant advice about the innovation, the relevant existing skills or knowledge in the population, and the awareness of the innovation in the population.

Learnability of the Innovation - refers to the characteristics of the innovation itself that determine a group's ability to learn about it. Three factors are used to determine this aspect of the adoption process: the ability to run small trials of the innovation, whether or not the innovation requires complex changes to the farmland for implementation, and the level of observation of the innovation.

Relative Advantage for the Population - attempts to determine whether the advantage that the population could gain from the innovation is sufficient to encourage the population to adopt the innovation. To assess this aspect, the program asks six questions which review the following: the number of farmers that could benefit from the innovation, the extent to which farmers use long-term planning, how much the farmers' decisions are motivated by maximizing profits, how much the farmers' decisions are motivated by protecting the environment, the community's level of risk aversion, and short-term financial restraints.

Relative Advantage of the Innovation - looks at the objective advantages of the innovation without considering the community's perception of the innovation. This part of the process is assessed through eight questions, which deal with the following: the initial costs of implementation, whether or not implementation can be reversed to allow for other innovation options, overall change in profit to the farms from the innovation, how long it will take for the change in profit to take effect, whether or not the innovation decreases farmers' vulnerability to seasons with difficult conditions, the advantages and disadvantages to the environment as a result of implementation, how long until the environmental effects are noticeable, and the non-monetary benefits of the innovation to the farmer.

Data and sources of data

For the cost-benefit analysis, it is worth stating that the unit of analysis in this study was formed by Heads of Household who were farmers with or without each one of the technologies indicated above. In a first step, this analysis was conducted only for Yemen. A rapid agro-economic survey was conducted on selected farms. A survey questionnaire was administered (by the researcher and field assistance) to selected farmers in target areas. Data on the following farm level issues were elicited from smallholder farmers within the target sites: labor resources; farm land characteristics; crop yield and prices; and crop production (i.e. investments on crop production). This survey obtained the necessary quantitative data for the financial CBA. The financial CBA aided the discussion on the costs and benefits associated with the adoption of the following technologies: Sorghum forage vs Clitoloria forage; Local Lipid forage vs Gaynda Lipid forage; Soil vs Soilless technology; and IPPM technology. Data solicited from farmers were analyzed (for the financial cost benefit analysis) using Microsoft Excel.

We used a focus group discussion (FGD) methodology (Krueger, 2002) to apply ADOPT (Kuehne et al., 2013) with group farmers. The number of farmers in the focus groups vary between the countries, and for the improved/tested technologies. We streamlined 22 discussion questions around four categories of influences on adoption, such as (i) characteristics of the innovation; (ii) characteristics of the target population; (iii) relative advantage of using the innovation, and (iv)learning of the relative advantage of the innovation. The format of the discussion group consisted of both analytical questions (i.e., they discuss and collectively decide what they believe the answer is), and clarifying questions (i.e., questions that help to clear up confusion and explain why they had chosen this answer). Farmers were asked to think about problems and challenges related to implementing water harvesting

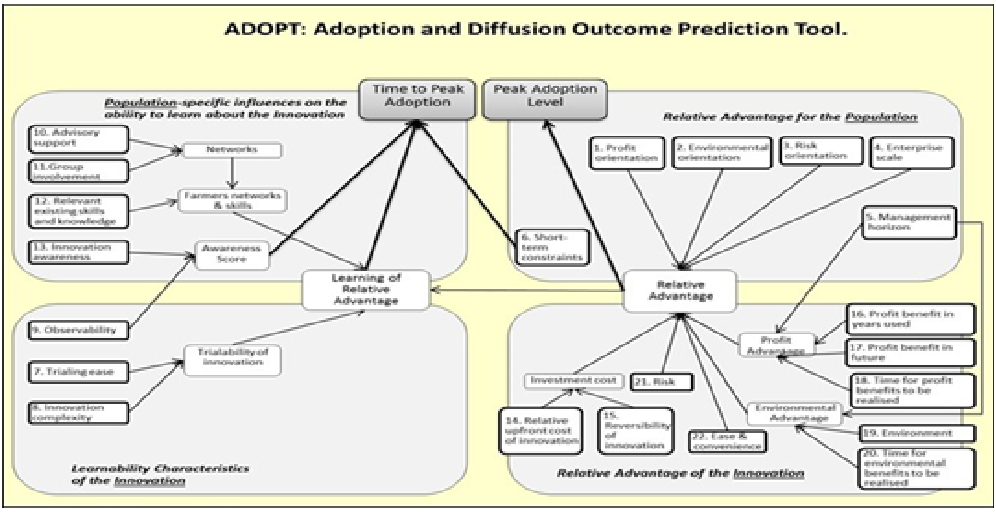

Figure 1 - Adoption and diffusion outcome prediction tool.
Source: http://aciar.gov.au/files/node/13992/adopt_a_tool_for_evaluating_adoptability_of_agric_94588.pdf.

Results and discussion

Cost Benefit Analysis (CBA) of the Adoption of the ICARDA's Arabian Peninsula Regional Program Improved Technologies

The results of the CBA for technologies implemented in Yemen are discussed in this subsection. The comparison between the costs and benefits between the sorghum and the improved forage named Clitoria indicates a clear profitability for the latter. Results indicate that, on average, the adoption of Clitoria implies a reduction of about 39% in total costs (Figure 2). The results also demonstrate an increase of about 207% and 479% on the revenue and the net return respectively. These findings are confirmed by the high Cost Benefit Ratio (CBR) when adopting Clitoria (7.97), in comparison with the farming of Sorghum (1.86). The major perceptible benefit, in addition to reducing total costs and increasing total revenue, is the amount of water saved when adopting this technology (reduction of about 48%). The visibility of these benefits could help public extension services enhance the adoption of this technology and encourage farmers to adopt it. This technology could be also scaled-up to other regions with similar socio environmental contexts across the AP region.

The empirical findings on the disaggregated costs and benefits assessment between the local libid (buffel grass, *Cenchrus ciliaris*) forage and an improved variety called gaynda are presented in Figure 3. The main appraisal indictors: net revenue, CBR and the Internal Rate of Return (IRR) indicated the high profitability when adopting the improved variety, libid. The corresponding CBR is around 22.32 among farmers who adopted gaynda against 18.35 among farmers adopting libid. Findings indicate that although we noted a slight increase in the total costs for the adopters of such technology, the net returns increased by approximately 126%. The major benefit of adopting this technology is the high level of revenue resulting from an increase in yield. Therefore, the tangible benefit from this technology is the high amount of forage produced per hectare, multiplied by its unit price during the period of analysis.

The third new technology evaluated is the soilless production system against the soil production system in protected agriculture. This technology was introduced to soil production system in protected agriculture. This technology was introduced to farmers in order to enhance the sustainability of their farming systems through an efficient use of resources, mainly water. The empirical findings indicate that CBR for the adopters of the soilless system for the cucumber crop is an average

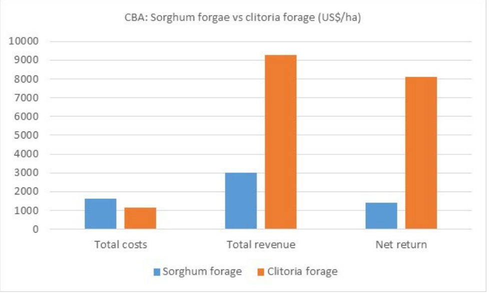

Figure 2: CBA – sorghum vs clitoria forage (US$/ha)

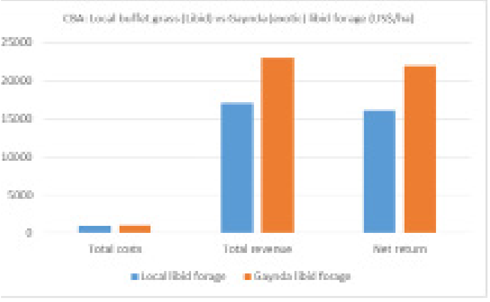

Figure 3: CBA – local buffel grass vs gaynda (exotic) libid forage (US$/ha)

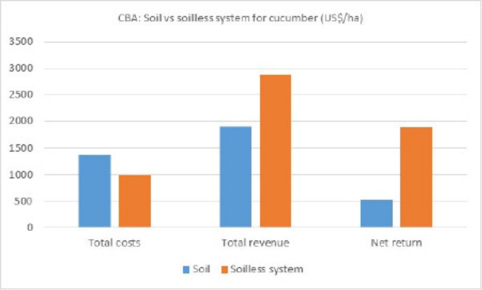

Figure 4: CBA – soil vs soilless system for cucumber (US$/ha)

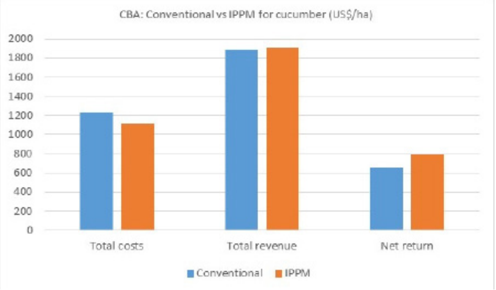

Figure 5: CBA – conventional vs IPPM for cucumber (US$/ha)

2.91, whereas this ratio is almost 1.4 for the farmers maintaining the soil production system. The tangible benefit gained from the adoption of this technology is, in addition to the high level of productivity and production, the conserved amount of water (around 200% saving in comparison with the soil production system). By applying this technology, the net return per hectare increased by 260% (Figure 4). This increase in income, in addition to the considerable amount of water savings that could accrue by adopting the soilless technology, highlighted the need to enhance the awareness of farmers regarding the profitability of using this technology (both economically and environmentally), in comparison to the soil system manual through an effective extension service to provide know-how and to facilitate the technology transfer on the use of this technology.

The interventions introduced by the project in using an integrated production and pest management (IPPM) production system were subjected to partial budgeting analysis, by comparing the adoption of the IPPM production system with the common practices of chemical pesticides or no pest control. The analysis showed that using IPPM increased yields by 15% per ha compared to yields with chemical

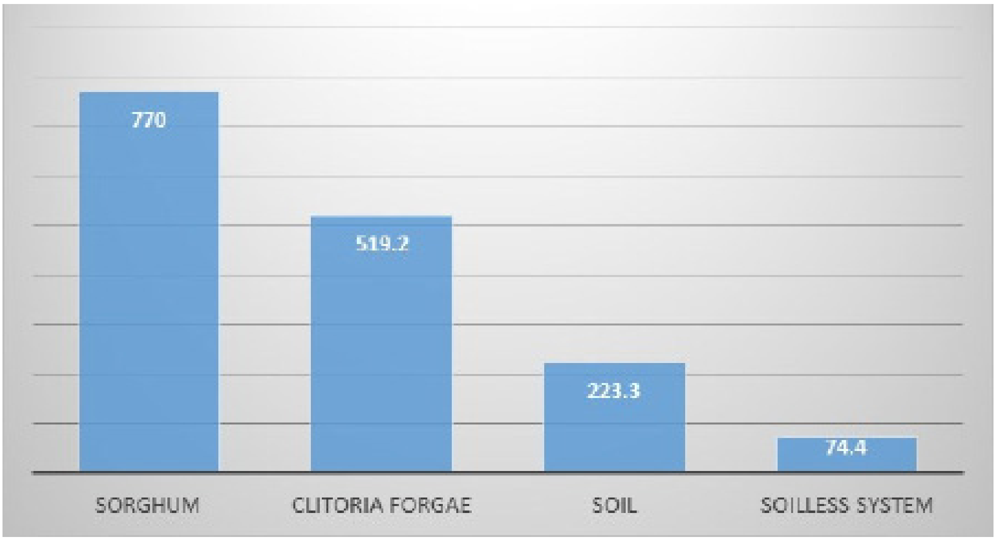

Figure 6: Water use efficiency by applying improved technologies (Clitoria forage and soilless system). The histogram represent the water used in m^3/ha

pest control, and gave a reduction in total costs of about 11% (Figure 5). Economic analysis showed that the net benefit to cucumber growers by applying IPPM technology was 1903 USD. These results are confirmed by the BCR indicators. BCR is around 1.72 among farmers who practiced the IPPM against 1.53 among farmers who did not practice it. The adoption of such technology offers an opportunity for arresting and reversing the downward spiral of resource degradation, protecting the environment (less chemical use), decreasing cultivation costs and making agriculture more efficient in terms of irrigation water-use (Figure 6).

In summary, there is clear evidence on the economic profitability of the four technologies. The project results suggested that sustainable increases in productivity of crops and forages can be achieved, the environment better protected, and a significant quantity of water can be saved if farmers/growers are encouraged to adopt the improved technology packages. The benefits of this technology must be clearly perceived by farmers, given their own socioeconomic conditions. However, the adoption of such technology needs to be accompanied by a supporting extension system and an enabling political environment to ensure the scaling-up and widespread use of this promising and profitable technology. In AP areas, increasing farmers' knowledge and perception of the merits of such technologies through better access to technical information, extension, and training will help them to develop a positive economic and environmental assessment of the proven technologies.

Adoption Levels and Factors Affecting the Adoption ICARDA's Arabian Peninsula Regional Program Improved Technologies

The use of new agricultural technologies has generally been found to be a function of farm and farmer characteristics and specific features of the particular technology (Feder et al., 1985; Marra and Carlson, 1987; Rahm and Huffman, 1984). A considerable set of literature has developed regarding factors that influence the adoption of new technologies by farmers through use of innovation theory (Feder et al., 1985; Griliches, 1957, and Rogers, 1995). Adoption and diffusion theory has also been widely used to identify the factors that influence an individual's decision to adopt or reject an innovation. Rogers (1995) defined an innovation as "…an idea, practice or object that is perceived as new by an individual or other unit of adoption. The perceived newness of the idea for the individual determines his or her reaction to it." The assessment of the adoption levels including the factors affecting the adoption of the outlined technologies implemented by the project are discussed in the following section. The analysis will be based on the following five characteristics of an innovation that affect an individual's adoption decision such as: (i) relative advantage on how the innovation is better than existing technology; (ii) the degree to which an innovation is seen as consistent with existing experiences, needs, and beliefs of adopters (compatibility); (iii) how difficult the innovation is to understand and use (complexity); (iv) the degree to which the innovation may be used on a limited basis (trialability), and (v) the degree to which the results of an innovation are visible to others (observability).

Predicted Adoption Levels and Factors Affecting the Adoption of Soilless Production System (SS) Technology

The results of the Focus group with farmers in Bahrain, KSA, Qatar and Yemen with respect to the adoption of soilless production system showed that the peak

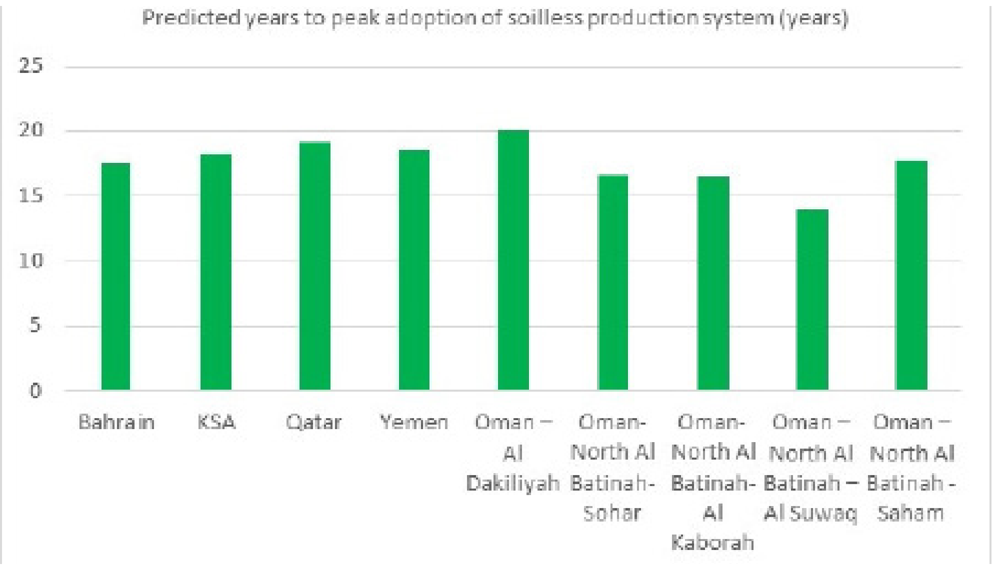

Figure 7: Predicted years to peak adoption of soilless production system (years)

adoption rate for this technology is predicted to be 95%, 91%, 8% and 86% after a period of 17.5, 18.3, 19.2 and 18.5 years, respectively (Figure 7). With respect to Oman, the findings indicate a slight difference between the regions on the predicted level of soilless production system. This difference is due to the socio demographic and economic conditions of the growers and to the farming system practiced in each region (Figure 8)

According to factors affecting both the peak of adoption and the time to reach this peak, results from the sensitivity analysis indicate that trialability of the technology in addition to its complexity where the effects of its use cannot be observed easily. In Bahrain, the adoption of the soilless system is affected negatively by the fact that it is not observable by the farmers who are yet to adopt it when it is used in their area.

In Yemen, in addition to the factors mentioned above, three factors are specific to the Yemeni growers that affect the technology of the considered technology. Such factors are the risk and investment cost and its profitability in the years that it is used. In Qatar, additional factors such as the need to develop substantial new skills and knowledge to use the innovation, are affecting adoption. This factor also influences the peak

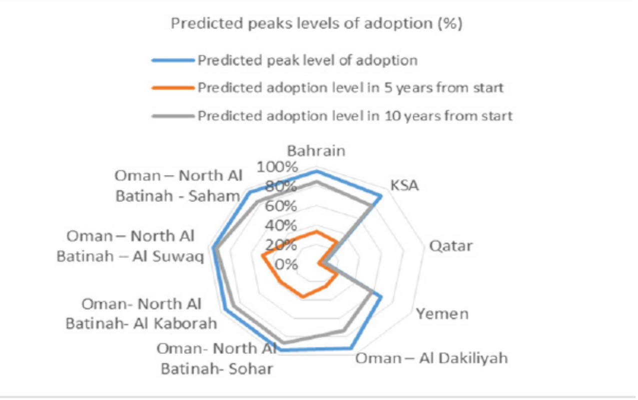

Figure 8: Predicted peaks levels of adoption of soilless production system (%)

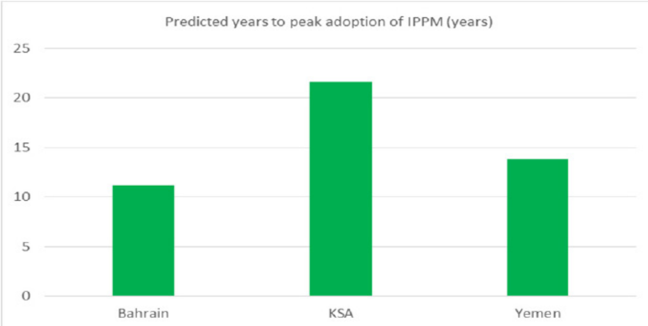

Figure 9: Predicted years to peak adoption of IPPM (years)

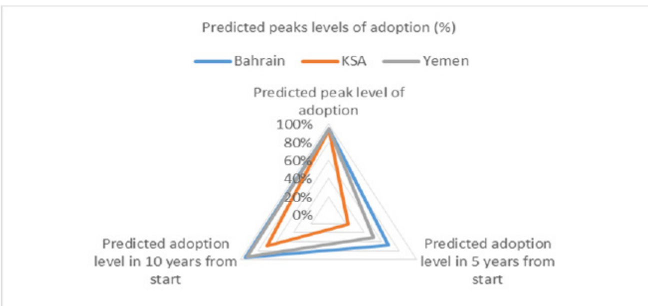

Figure 10: Predicted peaks levels of adoption of IPPM (%)

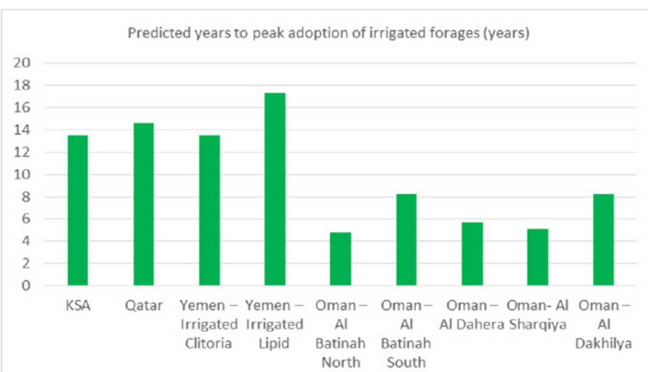

Figure 11: Predicted years to peak adoption of irrigated forages (years)

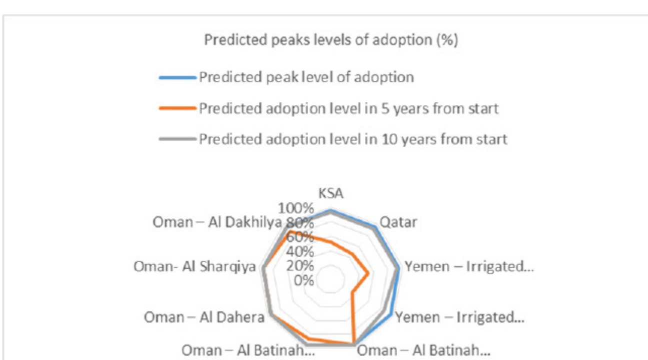

Figure 12: Predicted peaks levels of adoption of irrigated forages (%)

adoption time of soilless production in Oman (including the regional adoption across AP). This result highlighted the need to enhance the agriculture system to provide technical assistance for the users of this technology in all regions.

Predicted Adoption Levels and Factors Affecting the Adoption of Integrated Production and Pest Management (IPPM) System Technology

One of the major objectives of the ARPR is to include the IPPM technology. This technology aims to reduce costs, increase the productivity of small farmers, and protect the environment. The assessment results of the adoption of this technology with special emphasis on the main constraining factors affecting its adoption are displayed in the Figure 9. Results showed the peak adoption rate for Bahrain, KSA, and Yemen for this technology is predicted to be 95%, 94% and 85% after a period of 11.2, 21.6 and 13.8 years, respectively. After 5 years from the start, the predicted adoption level is quite acceptable for Bahrain and Qatar against KSA where this predicted level is very low. Furthermore, this level remains low after 10 years from the start of the adoption. This could be explained by the fact that many constraints are prohibiting the adoption and affects mainly the time to peak adoption level (Figure 10).

The discussion with farmers reveal that short term financial constraints of the farmers, the trialability of the technology, its complexity, lack of an effective advisory service, lack of know-how on the use of the technology and the up-front cost relative to the potential annual benefit from using this IPPM technology are the major constraints to adopt and widespread it. The outlined factors are also raised by the Yemeni farmers. Thus, for further expansion of this technology, there is a need for an enabling environment policy enhancing the use of organic sources and reducing the use of chemical in the indicated countries.

Predicted Adoption Levels and Factors Affecting the Adoption of Irrigated Forages (IF) Technology

The irrigated foraged and on-farm water management is an integrated technology introduced by the project and it is considered as a proven technology given its profitability both economically and environmentally. The aim is to reduce the quantity of water used for irrigation and to increase the profitability for the small farmers. Empirical findings from the identification and the analysis of the factors leading to the adoption of this technology, with emphasis to the predicted level of adoption and the time to peak such adoption after 5 and 10 years from the start are presented in the Figure 12. These results show a similarity in the years to peak adoption in KSA, Qatar and Yemen (for clitoria forage) where this peak (95%) is expected to be after 13.5, 14.6 and 13.2 years, respectively. In the case of Yemen (libid forage), this peak is predicted to be after 17.3 years (Figure 11).

In Oman, we note that this peak is very short in comparison with the rest of AP countries. It is expected to be around 5 years for the northern region and between 6 and 8 years for the southern region. This variability is due to the fact that environment of the northern region of Oman is characterized by availability of water and animal resources which enhance the adoption of this technology.

The results indicate that there are number of factors that influence the extent of adoption of technology such as characteristics or attributes of technology; financial factors, the change agent (extension system, professional, etc.); and the socio-economic and physical environment in which the technology take place. Thus, it is imperative to create favourable conditions so that a greater number of farmers can take advantage of these technologies. Furthermore, on the most important steps towards this goal is to identify the factors encouraging the adoption of high water efficiency irrigated forages. The results displayed in Figure 4 confirm that action should take into consideration only the factors that can step change only in time to peak adoption level. Factors such as severe short-term financial constraints, trialability of the technology before a decision is made to adopt it, complexity of the technology, observability to farmers who are yet to adopt it when it is used in their area, paid advisors capable of providing advice relevant to the innovation, need to develop substantial new skills and knowledge to use the innovation, and the size of the up-front cost of the technology relative to the potential annual benefit from using it.

Thus, farmers skill and networks, the trialability of the innovations, combined with the relative advantage of the innovations make up the population's ability to learn about the innovations, and this, combined with the factor of short-term financial constraints determines the time to peak adoption. In these countries, increasing farmers' knowledge and perception of the merits of irrigated less water consuming forages technology through better access to technical information, extension, and training. However, any intervention should take into consideration the most important factors influencing adoption, region specificities and farmers' preference.

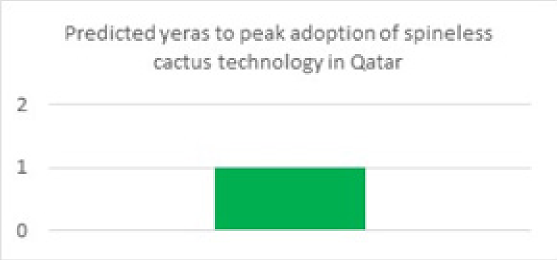

Figure 13: Predicted years to peak adoption of spineless cactus in Qatar (years)

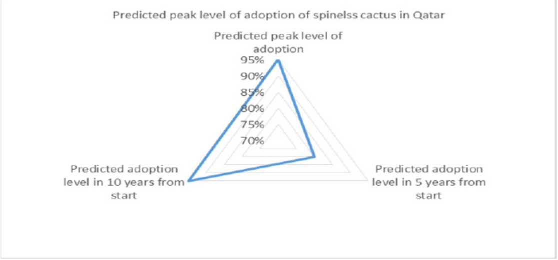

Figure 14: Predicted peak level of adoption of spineless cactus

Predicted Adoption Levels and Factors Affecting the Adoption of Spineless Cactus (SC) Technology

The peak adoption rate for spineless cactus technology in Qatar is predicted to be 95% after a period of 9.4 years (Figure 13). The predicted adoption level in 5 and 10 years from the starting period on the adoption of this technology is 80 and 90%, respectively (Figure 14). According to factors such as farmers' profit, and environmental and risk orientations, the number of farmers expected to benefit from the innovations, the environmental and profit advantages, the ease and convenience of implementation and use, and therefore, the level of peak adoption of the innovations is quite high. The farmer's skills and networks, the trialability of the innovations, combined with the relative advantage of the innovations make up the population's ability to learn about the innovations, and these factors determine the time to peak adoption. These results suggest that the expected adoption of this technology in the future is quite promising and therefore, its scaling-up should be accompanied by an effective and specialized extension system and an enabling policy environment, in addition to a financial supporting system given the high cost of rehabilitation.

Predicted Adoption Levels and Factors Affecting the Adoption of Rangeland Rehabilitation (RR) Technology

The analysis of the empirical findings presented in Figure 15 related to the predicted level of adoption for the rangeland rehabilitation technology indicates a huge difference between KSA and Qatar on the predicted peak of adoption of this technology. Although, the predicted years to peak adoption are around 18 years, the peak of adoption is expected to be 92% for KSA and 11% for Qatar (Figure 16). This predicted peak remains very low even during the first five to ten years in the case of Qatar.

The sensitivity analysis reveals that many factors are contributing/constraining the peak level of adoption, mainly for Qatar. These factors are the complexity of the

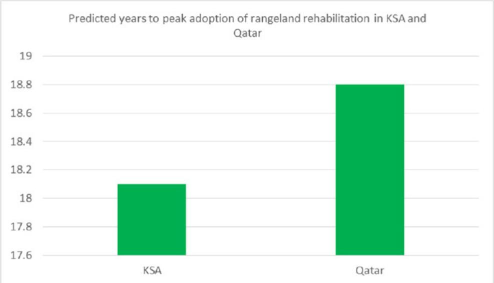

Figure 15: Predicted years to peak adoption of rangeland rehabilitation in KSA and Qatar (years)

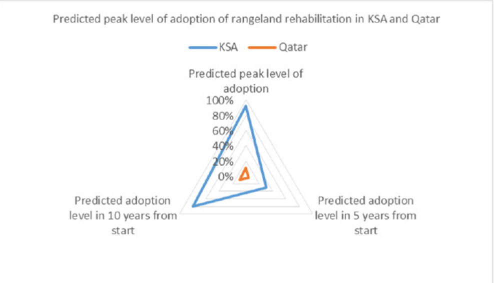

Figure 16: Predicted peak level of adoption of rangeland rehabilitation in KSA and Qatar (%)

innovation, its trialability, and the need for farmers to develop substantial new skills and knowledge to use the innovation. In addition, there are problems linked to the up-front costs of the investment relative to the potential annual benefit from using this technology. This implies that decision makers should take this into consideration when developing extension programs and effective extension services in Qatar.

Concluding remarks and policy implications

The economic evaluation and the identification and analysis of factors affecting ICARDA's Arabian Peninsula Regional Program (APRP) technologies implemented in the frame of improving food security and sustainable natural resources management through enhanced integrated agricultural production systems in the Arabian Peninsula project leads to the following results:

- There is a clear evidence on the economic profitability (reducing production costs and increasing =net return) if these technologies are applied appropriately (in the case of Yemen). Indeed, farmers are encouraged to adopt these proven and promising technologies.
- The project results suggest that sustainable increases in vegetable crops and irrigated forages productivity can be achieved.
- The project results suggest also that adopting integrated production and pest management and soilless production systems will contribute to a better protected environment (reduction of chemical products) and more efficiency in water-resources use.
- Although the adoption of some technologies is complex (case of rangeland management system), there is still interest from farmers/growers.
- The predicted level to peak adoption of these technologies is different between the AP countries and within the same country (case of Oman).
- The characteristics of the technology are a determinant on its level to peak The characteristics of the technology determine the peak adoption level and the time to peak adoption level (results suggest a low predicted level of adoption for the irrigated forages and high predicted level of adoption for the IPPM and rangeland rehabilitation).
- Technical assistance, substantial new skills and knowledge, up-front cost of

investment, financial resources and effective extension advisory services are considered the main factors influencing the adoption of these technologies.

- The action on these factors will affect only the time to peak adoption levels of the technologies.

The results from the present research study suggest the following:

- Given these technologies meet the technical, economic, and socioeconomic requirements, there is a need for a greater political and institutional input into these technologies. In particular, there is a need to design and develop alternative policy instruments (other than subsidies) and institutions for a well-developed agricultural extension system that will facilitate adoption of APRP technologies. There is a need also to create a new price policy that gives higher prices for the IPPM products (or organic products). Furthermore, raising awareness of farmers and decision makers on the environmental benefits of applying these technologies is needed to gain their support and confidence.
- The benefits (economic and environmental) of these technologies must be clearly perceived by farmers, given their own socioeconomic, cultural and economic conditions. In AP areas, increasing farmers' knowledge and perception of the merits of these technologies through better access to technical information, know-how, effective extension delivery system, credit services, and training will help them to develop a positive assessment of these technologies. This will ensure their scaling-up and widespread use.
- To accelerate the adoption process of these technologies, it is imperative to create favorable conditions so that a greater number of farmers can take advantage of the benefits of such technologies. The creation of a strong network among different institutions related to applying ICARDA-APRP technologies and the involvement of public and private financial institutions and support services could be an example of mechanisms to enhance adoption. More specifically, linking mechanisms between research and extension and extension education on ICARDA-APRP technologies would further extend the adoption of such resource-saving technologies to the farm level.
- Finally, there is a clear disparity at the regional scale on the level of adoption and on the factors affecting and encouraging the adoption of a specified technology (i,e. the case of soilless production systems and irrigated forage in Oman). Thus, scaling-up to other regions within the same country could be facilitated with interactive similarity maps that identify similar socio-economic and environmental contexts. Hence, only technologies with a high financial feasibility should be promoted, and therefore farmers should be encouraged to join established and strengthened associations through which training, technical assistance and help with access to extension information can be provided.