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Adoption and Impact Assessment of Improved Technologies in Arabian Peninsula Countries: Towards an effective agricultural technology transfer system

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WORKING PAPER

Adoption and Impact Assessment of Improved Technologies in Arabian Peninsula Countries: Towards an effective agricultural technology transfer system

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Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is a non-profit, CGIAR Research Center that focusses on delivering innovative solutions for sustainable agricultural development in the nontropical dry areas of the developing world.

We provide innovative, science-based solutions to improve the livelihoods and resilience of resource-poor smallholder farmers. We do this through strategic partnerships, linking research to development, and capacity development, and by taking into account gender equality and the role of youth in transforming the non-tropical dry areas.

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The views and opinions expressed in this working paper are those of the authors. They do not necessarily reflect any other agency, organization, employer, or company's official policy or position.

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List of Acronyms

FFS	Framers Field Schools
APRP	Arabian Peninsula Regional Program
ICARDA	International Center for Agricultural Research in the Dry Areas
FGD	Focus Groups Discussion
AP	Arabian Peninsula
GCC	Gulf Cooperation Council
KII	key Informant Interviews
ICT	Information and Communications Technologies
SC	Spineless Cactus
IPPM	Integrated Production and Protection Management
KSA	Kingdom of Saudi Arabia
UAE	The United Arab Emirates
SPS	Soilless Production System
IF	Irrigated Forages
RR	Rangeland Rehabilitation
CGH	Cooling Green House
R&E	Research and Extension

KEY MESSAGES

Abstract

This study examined the sources of information on improved agricultural technologies introduced by the International Center for Agricultural Research in the Dry Areas (ICARDA's) Arabian Peninsula Regional Program (APRP) to the local farming systems. The study also assesses the various agricultural technology transfer methods used to enhance the widespread adoption of these technologies. The research uses primary data collected from 87 extension agents from the Arabian Peninsula (AP) extension systems (i.e. Kuwait, Qatar, United Arab Emirates (UAE), Oman, and Yemen). A descriptive statistical analysis supported by Kendall's W-test and a chi-squared distribution test is employed to identify and assess the effectiveness of the different technology transfer methods used by the AP extension systems. To study the AP extension agents' opinions and point of views regarding the use of the improved technologies; a qualitative approach was used based on the Likert scale.

Results show that mass media, farmer field schools (FFS) and neighboring farmers were perceived as the most productive agricultural extension methods to enhance adoption of the ICARDA-APRP introduced technologies, and the new agricultural innovations in general. The assessment of potential influencing factors on the effectiveness of these transfer methods reveals that each AP country has its own context, technology transfer method, and subsequent level of effectiveness. The most important influencing factors were found to include: the number of farmers per extension officer and category of farmers (i.e. farm size); the cost of extension methods; the target farmer and geographic location; age of extension officers; location and availability of extension offices; and leadership and supervision. The study recommends empowering national extension systems through both conventional and technology-led approaches using information and communications technologies (ICTs) and the mass media (particularly video and mobile phones) given their cost-effectiveness and impact on farmers' technology adoption decisions.

To make the extension system more efficient in the AP region, the study also recommends the following: (i) development of private advisory services to serve medium to large-scale farmers or farmers' associations in exchange for direct payment; (ii) amendment of extension policies toward more market-oriented approaches; (iii) fostering farmer organizations' involvement in extension activities and financing and improving extension infrastructure and equipment; and (iv) increasing the number of extension agents, experts and subject matter specialist working in extension.

Keywords

ICARDA-APRP agriculture technologies; extension methods; perception; extension agents; Kendall's W-test; Likert scale; Arabian Peninsula.

Highlights

- We identified and analyzed the potential factors affecting the performance of agricultural extension systems in AP countries.
- We assessed the most important agricultural technology transfer methods in AP countries.
- We analyzed the perceived effectiveness of the ICARDA-APRP technology transfer methods and identified their potential transfer methods.
- We highlighted the key factors affecting the ICARDA-APRP agricultural transfer methods for each separate AP country, and across the AP region.

1. INTRODUCTION

1.1. Background

The ICARDA project 'Improving agricultural production systems and conserving natural resources under climate change in the Arabian Peninsula (AP) region' aims to contribute to the national agricultural goals of AP countries through the development of more sustainable and resilient agricultural production systems. These systems should be adapted to climate change, enhance food security and reduce demand for imports.

In the frame of this project, ICARDA's APRP has been at the forefront of improved agricultural technology generation and transfer. This strategy is particularly relevant for AP countries, where the major challenge for policymakers towards increasing agricultural productivity while conserving natural resources – mainly water – is increasing farmer adoption of such innovative technologies. Thus, the influence that ICARDA has had in the AP is demonstrated by the uptake of technology packages developed jointly by APRP and NARS in rangeland rehabilitation, irrigated forages, on-farm water management, and protected agriculture. These packages proved to be successful at the pilot growers were shown to have positive impacts on the income and welfare of farmers in the region, and the management of natural resources.

1.2. Research problems

Although the programme's improved technologies have successfully catered to the needs of AP farmers, much still needs to be done to promote better and more effective methods of technology transfer to achieve increased output and higher incomes for small-scale AP farmers (Dhehibi et al., 2017). Technology does not stand alone but encompasses political, social, economic, and cultural factors that can impede the diffusion or transfer of technology. One of the major concerns in the transfer process is how to disseminate the ICARDA-APRP improved technologies effectively, while considering the viewpoint of farmers – particularly in addressing their questions of where, how, and what improved techniques are appropriate and available to them. Many farmers are well aware of the nature of their problems in the field, and with the support of research and extension workers' who know the local socio-economic conditions, can adopt the suitable technologies to pursue relevant solutions.

In the literature review, a technology transfer model involves the transfer of critical information from research and development, through extension personnel, and to the person on the ground who utilizes such information – the farmer (Dhehibi et al., 2019, 2020; Miller and Cox, 2006).). However, not all farmers demonstrate a willingness to adopt new technologies due to external factors relating to the local socio-economic, institutional, and environmental context (Corder and Foreman, 2009).

1.3. Research objectives

In line with the knowledge gaps described above, the following research objectives are proposed for consideration.

The objective of this research is to understand the most effective technology transfer process of these improved technologies. Such an understanding of the processes leading to the adoption of the ICARDA-APRP improved technologies by small-scale farmers will be essential to the planning and

implementation of successful research and extension programmes in AP countries. Within this framework, this study was designed to record and assess AP extension officers' perceptions regarding the use and effectiveness of transfer technology sources and approaches used to enhance the adoption of ICARDA-APRP technologies at a large scale:

1. Assess the effectiveness of the agricultural extension system in AP countries.
2. Identify and analyze the potential factors affecting the performance of agricultural extension systems in AP countries.
3. Identify the most important agricultural technology transfer methods in AP countries.
4. Analysis of the perceived effectiveness of the ICARDA-APRP technology transfer methods and identifying their potential transfer methods.
5. Finally, assess the key factors affecting the ICARDA-APRP agricultural transfer methods for each separate AP country, and across the AP region.

2. METHODOLOGICAL FRAMEWORK

2.1. Data collection and data analysis

To meet the objectives of the study, a questionnaire was conducted with the extension agents in five AP countries (Kuwait, Qatar, Oman, UAE, and Yemen). The survey aimed at gathering information related to the following elements: (i) agricultural extension agents' job satisfaction level in the AP countries; (ii) the effectiveness and factors affecting the performance of the agricultural extension systems in these countries; (iii) assessment of the technologies transfer methods used by the AP extension system (in general, and for each ICARDA-APRP technology); and finally (iv) understanding the potential factors influencing the effectiveness of these agricultural transfer methods. The number of surveys conducted in each AP country is displayed in Table 1, and the statistical analysis has been conducted using SPSS (v.20.0) software.

Table 1. Number of key informant interview (KII) surveys within each AP country.

Country	Number of implemented surveys
Kuwait	12
Oman	11
Qatar	7
UAE	32
Yemen	25
Total	**87**

Source: Authors elaboration (2020).

2.2. Analytical framework

To assess the effectiveness of different technology transfer methods used by the AP extension system, the research deployed integrated quantitative and qualitative approaches using the 87 KII surveys. A descriptive statistical analysis supported by Kendall's W-test and chi-squared ($\chi 2$) distribution test was applied to the data collected. The $\chi 2$ test is used to test the hypothesis of no association between two

or more groups, populations, or criteria. In this case, it was used for testing relationships between categorical variables in which the sampling distribution of the test statistic is a χ2 distribution when the null hypothesis is true. The null hypothesis of the χ2 test was that no relationship exists on the categorical variables in the population.

Kendall's W-test was used to rank the list of agricultural technology transfer methods among extensionist, from most to least important. It is a nonparametric statistic issued from a simple normalization of the Friedman test and ranges from 0 (no agreement) to 1 (complete agreement). It is a nonparametric statistic released from a simple normalization of the Friedman test (Corder and Foreman, 2009; Kendall and Babington, 1939) and goes from 0 (disagreement) to 1 (whole agreement)

The application of the test in this instance, therefore, indicates that if W = 1, then each extension agent assigned the same order to the list of methods, and if W = 0, there was no agreement among interviewees. Consequently, their responses were considered randomly (Kendall and Babington, 1939).

The null hypothesis is that there is independence of the rankings produced by the interviewed extension officers. This is a one-tailed test, since it only recognizes positive associations between vectors of ranks. The Kendall's statistical test was computed using the following formula:

$$S = \sum_{i=1}^{N}(Ri - R)^2 \qquad \text{(Equation 1)}$$

Where S is calculated as the sum of squares statistic over the row sums of ranks. Following Kendall and Babington (1939), Kendall's W-statistic can be obtained as follows:

$$S = \sum_{i=1}^{N}(Ri - R)^2 \qquad \text{(Equation 2)}$$

Where:

n is the number of concerns,

p is the number of judges,

T is a correction factor for tied ranks.

The W-statistic is an estimate of the variance of the row sums of ranks Ri divided by the maximum possible value the variance can take (R). This occurs when all respondents are in total agreement; hence $0 \leq W \leq 1$ (Shaibu et al., 2018).

Accordingly, Kendall's W-test was employed to rank the factors affecting the performance of the agricultural extension systems, the technology transfer methods used by the AP extension system (in general, and for each ICARDA-APRP technology), and the potential factors influencing the effectiveness of the agricultural transfer methods employed by stakeholders of the extension delivery system.

3. RESULTS AND DISCUSSION

3.1. Perception of extension officers about job satisfaction in AP region

A set of indicators was used to reveal job satisfaction among the AP extension staff, linking to the information they receive from management about what is going on their division/region. The real happiness of the team was found to relate to their level of involvement in work decisions. In terms of perceived salary and benefits, which came as ranker third (with mean rank of 4.31), perceptions were positive regarding this indicator, as were attitudes around access to opportunities and promotions within the agents' organizations. Overall, the positive perception of the extension staff concerning their outreach activities is a good indicator in terms of their ability to support and enhance adoption of the ICARDA-APRP technologies.

3.2. Perception effectiveness of the agricultural extension and delivery systems in AP countries

Consequently, the study proceeds to evaluate the effectiveness of the agricultural extension and delivery services in each of the five AP countries, both separately and when aggregated. The findings of this evaluation on the global perception of effectiveness in terms of performance in delivering and enhancing agricultural innovation adoption among end-users are outlined in Table 2 below.

Table 2. Effectiveness of the agricultural extension system in AP countries.

Global perception of effectiveness of the agricultural extension systems in AP countries	**Kuwait (n=12)**		**Oman (n=11)**		**Qatar (n=7)**		**UAE (n=32)**		**Yemen (n=25)**		**AP countries (n=87)**	
	FR	**%**	**FR**	**%**	**FR**	**%**	**FR**	**%**	**FR**	**%**	**FR**	**%**
Completely not satisfied	1	10.0	0	0.00	2	28.6	1	3.1	2	8.0	6	7.1
Somewhat not satisfied	2	20.0	2	18.2	0	0.00	3	9.4	1	4.0	8	9.4
It is satisfied but not very efficient	1	10.0	1	9.1	0	0.00	1	3.1	2	8.0	5	5.9
Somewhat satisfied, but there are some areas that can be improved	4	40.0	7	63.6	4	57.1	20	62.5	17	68.0	52	61.2
Completely satisfied	2	20.0	1	9.1	1	14.3	7	21.9	3	12.0	14	16.5
Total	**10**	**100**	**11**	**100**	**7**	**100**	**32**	**100**	**25**	**100**	**85**	**100**

Source: Own elaboration from AP extension staff KII surveys (2020).

The results displayed in table 2 reveals a moderate satisfaction from the interviewees on the effectiveness of the agricultural extension system in the AP countries. This perception scores vary between countries. It is for about 40%, in Kuwait and 60%, in Yemen. In general, this figure is around 61.2% in the AP region. Therefore, the interviewed extension officers reveal the need for improvement of the extension system. This could be achieved, among other strategies, through the involvement of private company to deliver extension services to the farmers and growers under government control, increasing the number of vehicles available for extension activities, and developing private advisory services to serve medium to large-scale farmers or farmers' associations against direct payment.

3.3. Assessment of potential factors affecting performance of agricultural extension and service delivery systems in AP countries

Empirical findings revealed a considerable satisfaction (52% of the total AP interviewees) regarding extension system delivery effectiveness. However, these figures vary between countries, ranging from 40% in Kuwait to 68% in Yemen. Around 16% of AP extension officers were not satisfied with the extension system and considered it inefficient. Several key factors have been discovered that affect the performance of AP extension and delivery systems. These potential factors in each country are displayed in the Table 3 below.

Across the target countries, the study identified four vital recurring factors, and several other minor elements, that could enhance the functioning of the extension system and contribute to broader adoption of the improved agricultural technologies. Again, the ranking of these factors differed between the countries. In Kuwait, for example, the involvement of private companies to deliver extension services to all growers under government control was ranked as the most reliable strategy. This is explained by the importance that government is playing by contracting the private sector to deliver extension to small scale farmers. The government has a role in extension services funding, quality control, arbitration, monitoring and in provision of quality infrastructure to lower private sector players' costs. This was followed by increasing the number of vehicles available for extension activities. The development and/or enhancement of private advisory services to serve medium- to large-scale farmers or farmer associations in exchange for direct payment was ranked third and amending extension policy towards more market-orientated approaches was listed fourth.

Similar results were found for the Qatar case: (i) developing and/or enhancing private advisory services to serve medium- to large-scale farmers or farmer associations against direct payment; (ii) amending extension policy towards more decentralization; (iii) and increasing the number of vehicles available for extension activities. The fourth-ranking factor was different and considered the importance of strengthening ICT availability to improve farmer access to information and education through, for example, email, SMS, online chat platforms, etc. In the literature, these methods are cost-effective and have a significant impact on agricultural technology adoption decisions among farmers (Azumah et al. 2018).

In UAE, although all extension services are provided free of charge to the farmers, the involvement of a private company to deliver extension services to the farmers and growers under government control was ranked as the first key factor to enhance the system. This policy strategy was followed by the development of private advisory services to serve medium to large-scale farmers or farmer associations. Another specific factor for the UAE case was the organization of farmers into the community and producer groups (ranked third) and changing the extension policy towards more market-orientated approaches. Similar factors were highlighted in Oman: (i) develop private advisory services to serve medium to large-scale farmers or farmer associations against direct payment; (ii) strengthen the involvement of agricultural input companies in extension activities; (iii) organize farmers into the community and producer groups. The difference concerning other AP countries was found in the fourth potential factor were increasing the number of experts and subject matter specialists working in extension is an essential country-specific factor.

In Yemen, the four factors identified to enhance the agricultural extension system are as follows (and in order of ranking): (i) involvement of a private company to deliver extension services to all growers under government control; (ii) change extension policies toward more market-orientated approaches;

(iii) increase the number of extension agents; and (iv) strengthen the involvement of agricultural input companies in extension activities.

Table 3. The four potential significant factors affecting the performance of agricultural extension systems in AP countries (by order of priority).

AP country	Potential factors affecting agricultural extension system in AP countries
Kuwait	1. Involve private company to deliver extension services to the farmers and growers under government control. 2. Increase the number of vehicles available for extension activities. 3. Develop or enhance private advisory services to serve medium to large-scale farmers or farmers' associations against direct payment. 4. Change the extension policy toward more market-orientated approaches.
Oman	1. Develop or enhance private advisory services to serve medium to large-scale farmers or farmers' associations against direct payment. 2. Strengthen the involvement of agricultural input companies in extension activities. 3. Organize farmers into the community and producer groups. 4. Increase the number of experts and subject matter specialists working in extension.
Qatar	1. Develop or enhance private advisory services to serve medium to large-scale farmers or farmers' associations against direct payment. 2. Change the extension policy toward more decentralization. 3. Increase the number of vehicles available for extension activities. 4. Strengthen ICTs for increased farmer access to information and education (via email, SMS, online chat platforms, etc.).
UAE	1. Involve private company to deliver extension services to all growers under government control. 2. Develop or enhance private advisory services to serve medium to large-scale farmers or farmers' associations. 3. Organize farmers into the community and producer groups. 4. Change the extension policy toward more market-orientated approaches.
Yemen	1. Involve private company to deliver extension services to all growers under government management. 2. Change the extension policy toward more market-orientated approaches. 3. Increase the number of extension agents. 4. Strengthen the involvement of agricultural input companies in extension activities.
Aggregated AP countries	1. Involve private company to deliver extension services to all growers under government management. 2. Develop or enhance private advisory services to serve medium to large-scale farmers or farmers' associations against direct payment. 3. Strengthen the involvement of agricultural input companies in extension activities. 4. Change the extension policy towards more decentralization.

Source: Own elaboration from AP extension staff KII surveys (2020).

Finally, assessment of the factors affecting agricultural extension systems across all countries in an aggregated manner, suggests that involving private companies to deliver extension services to all growers – under government control – is the most crucial consideration. Second is the development of private advisory services to serve medium to large-scale farmers or farmer associations against direct payment. Strengthening the involvement of agricultural input companies in extension activities was ranked third, followed by changing extension policy towards greater decentralization.

These findings recommend that extension staff should receive appropriate training to carry out their duties. They also reveal that available resources can be used more effectively through partnerships with the private sector and use of information and communication technologies where appropriate. It is critical to note that monitoring and evaluating the performance of extension service delivery, based on stakeholder feedback, is also crucial in ensuring that extension staff skills remain relevant to extension services' end-user's needs.

3.4. Assessment of agricultural technology transfer methods in AP countries

3.4.1. Perceived effectiveness of the agricultural technology transfer methods: A comprehensive assessment

Several extension methods have been used to transfer agricultural and livestock technologies with varying strengths and weaknesses relating to the technical characteristics of each AP country. Empirical findings suggest that mass media are ranked the most crucial innovation transfer methods used. These innovation transfer methods have been found to be common across all AP countries with few dissimilarities (Table 4).

The technology-led transfer approaches using ICTs and mass media such as video and mobile phones (social media) have been identified as potential ways to diffuse innovations in Oman, Qatar and UAE. This finding has been confirmed by Aker (2011) and highlighted the need for empowering the AP extension system to disseminate ICARDA-APRP technologies using these cost-effective methods, which have a significant impact on agricultural technology adoption decisions among farmers.

Dissemination among farming family household members has also been found to be of great importance in the diffusion of agricultural technology transfer strategies across AP countries. In this instance, farmers can receive business information from household members who have already successfully adopted the technologies. This method was ranked second in terms of its efficiency as a technology transfer method in Qatar and UAE while becoming fourth when aggregated all AP countries.

Table 4. Assessment of the four potentially most significant agricultural technology transfer methods in AP countries (by order of priority).

AP country	Ranking of the four agricultural technology transfer methods
Kuwait	1. Mass media – posters 2. Mass media – newspaper 3. Mass media – radio 4. Mass media – TV
Oman	1. Mass media – TV 2. Mass media – newspaper 3. FFS 4. Mass media – video
Qatar	1. Mass media – videos and mobile phones 2. Household member (family) 3. FFS 4. Mass media – posters
UAE	1. Mass media – newspaper 2. Household member (family) 3. FFS 4. Mass media – posters
Yemen	1. Mass media – newspaper 2. Mass media – video 3. Mass media – mobile phone (social media) 4. Mass media – posters
Aggregated AP countries	1. Mass media – newspaper 2. Mass media – radio 3. Mass media – posters 4. Household member (family)

Source: Own elaboration from AP extension staff KII surveys (2020).

3.4.2. Perceived effectiveness of the agricultural technology transfer methods of the ICARDA-APRP improved technologies

The perception from extension officers of the effectiveness of various technology transfer technologies was measured on a five-point Likert scale, five being most effective and one the least effective. The assessment was focusing on the transfer of five technologies among which, three related to protected agriculture: soilless production system (SPS), integrated production and protection management (IPPM), and cooling greenhouse system (CGHS) and two related to livestock feed resources – irrigated native forages (IF) and spineless cactus (SC). The computed ranked values derived from the AP extension officers' perceptions about a technology transfer method and specific ICARDA-APRP technology in each AP country are displayed in the table below (Table 5).

Empirical findings suggest that all extension methods used by the AP extension system had a potential variable perception index of influencing smallholder farmers to adopt the improved ICARDA-APRP technologies. This perception differs from country to country and between the diffused technologies. The index oscillates between 40% for the livestock feed resources to more than 60% for the protected agriculture technology packages.

Table 5. Perceived effectiveness of the ICARDA-APRP technology transfer methods, and the three potentially most significant transfer methods (listed in order of priority)

Kuwait	Oman	Qatar	UAE	Yemen	Aggregated AP countries
Technology I: SPS					
1. Mass media – posters 2. Mass media – video 3. Mass media – TV	1. Mass media – newspaper 2. Mass media – radio 3. Mass media – posters	1. Mass media – newspaper 2. School: lecture 3. Mass media – radio	1. Mass media – radio 2. Household (family) 3. Mass media – social media and newspaper	1. Mass media – newspaper 2. Mass media – mobile phone 3. Mass media – radio	1. Mass media – newspaper 2. Mass media – radio 3. Mass media – video
Technology II: IPPM					
1. Household (family) 2. Mass media – video 3. FFS	1. Mass media – radio 2. Mass media – newspaper 3. Household (family)	1. Household (family) 2. Mass media – video 3. FFS	1. Household (family) 2. Mass media – radio 3. Mass media – social media and newspaper	1. Mass media – newspaper 2. Mass media – mobile phone 3. Mass media – video	1. Mass media – newspaper 2. Mass media – radio 3. Household (family)
Technology III: GHCS					
1. Mass media – TV 2. Mass media – posters 3. Mass media - newspaper	1. Mass media – radio 2. Household (family) 3. Mass media – TV	1. Household (family) 2. Mass media – newspaper 3. Mass media – radio	1. Household (family) 2. Mass media – radio 3. Mass media – social media and newspaper	1. Mass media – mobile phone 2. Mass media – radio 3. Mass media – newspaper	1. Mass media – radio 2. Household (family) 3. Mass media – newspaper
Technology IV: IF					
1. School: lecture 2. Mass media – radio 3. Mass media – TV	1. Mass media – radio 2. Mass Media – TV 3. Mass media – newspaper	1. Household (family) 2. Mass media – newspaper 3. School: lecture	1. Mass media – TV 2. Mass media – radio 3. Household (family)	1. Mass media – newspaper 2. Mass media – mobile phone 3. Mass media – radio	1. Household (family) 2. Mass media – radio 3. Mass media – newspaper
Technology V: SC					
1. Mass media – radio 2. Mass media – TV	1. Mass media – newspaper 2. Mass media – radio	1. Household (family) 2. Mass media – radio	1. Household (family) 2. Mass media – radio	1. Mass media – mobile phone	1. Mass media – radio 2. Mass media – newspaper

3.	Farmer-to-farmer	3.	Household (family)	3.	Mass media – newspaper	3.	Mass media - newspaper	2. 3.	Mass media – radio Mass media – newspaper	3.	Household (family)

Source: Own elaboration from AP extension staff KII surveys (2020).

The extension methods perceived to most influence the adoption of ICARDA-APRP technologies were mass media (posters, newspapers, video, TV, radio, mobile phone). Other extension methods identified are FFS and household families. From Table 5, it can be seen that mass media such as posters, newspapers, radio, and video are considered potential methods to diffuse the SPS technology across the AP countries. For the dissemination of the IPPM technology, FFS combined with mass media and family members were identified as a potential agriculture technology transfer method.

The technology transfer approaches and methods used to diffuse GHCS differ from country to another. Mass media (TV, radio, and mobile phones) has been ranked as the most basic transfer method in Kuwait, Oman and Yemen. On the other hand, in the UAE and Qatar, household family members and neighboring farmers are ranked as the most important transfer option concerning this improved technology.

Concerning IF, the AP extension agents agreed that mass media (mobile phones, posters, newspapers, radio, etc.) is ranked as the topmost important transfer method, across the AP countries. However, in Kuwait and Qatar, school lectures were ranked first to improve the adoption of IF. The use of household family member is also claimed as an essential technology transfer method for the IF technology in UAE and across AP. This issue is explained by the importance of this family extension approach in disseminating forage seeds in these countries.

Except for FFS, mass media such as video, posters, newspapers and mobile phones (social media) and household family members are found to be potential ways to diffuse the SC innovation within and between AP countries. Although information transfer strategies have been initiated to improve new technology adoption by smallholder farmers, according to extension agents, the adoption rate of this low-water consumption technology remains significantly low. This issue consequently affects farm economic sustainability and performance (Anandajayasekeram et al., 2008). That's why farmer-to-farmer and household (family) transfer methods, considered as potential avenues for SC technology, could overcome this adoption constraint and therefore, this method should be adopted more as a potential ingredient to the scaling strategy of this technology.

3.4.3. Potential factors affecting agricultural technology transfer methods of ICARDA-APRP improved technologies

The results further highlight that several potential factors are affecting the ICARDA-APRP agricultural technology transfer methods and processes. Table 6 shows the four potential factors by order of priority in each of the separate AP countries and across the AP region.

Table 6. Potentially significant factors affecting the ICARDA-APRP agricultural transfer methods (by order of priority) for each separate AP country, and across the AP region.

AP country	Potential factors affecting the ICARDA-APRP technology transfer methods
Kuwait	1. Age of extension officers 2. Location and availability of extension offices 3. Economic conditions of the farmers 4. Socio-cultural conditions of the farmers
Oman	1. Number of farmers per extension officer and category of farmers 2. Age of extension officers 3. Location and availability of extension offices Leadership and supervision
Qatar	1. The geographic location of the Farmer 2. Number of farmers per extension officer and category of farmers targeted 3. Availability of resources (transport for extension officers, information technology and equipment, etc.) 4. Socio-cultural conditions of the farmers
UAE	1. Economic conditions of the farmers 2. Type of Farmer being targeted 3. Cost of the extension method 4. Leadership and supervision
Yemen	1. Number of farmers per extension officer and categories of farmers 2. Age of extension officers 3. Location and availability of extension offices 4. Leadership and supervision
Aggregated AP countries	1. Age of extension officers 2. Number of farmers per extension officer and categories of farmers 3. Location and availability of extension offices 4. The geographic location of the Farmer

Source: Own elaboration from AP extension staff KII surveys (2020).

According to the results, the factors affecting and influencing the ICARDA-APRP technology transfer methods differ from one country to another. In Kuwait, the age of extension officers, the location and availability of extension offices, the economic conditions of the farmers, and their socio-cultural conditions were found to be determinant factors affecting the success of the diffusion methods. In Qatar, different factors (ranked in order of most to least significant) were highlighted, i.e.: (i) geographic location of the farm; (ii) number of farmers per extension officer and categories of farmers; (iii) availability of resources (transport for extension officers, information technology and equipment, etc.); and finally (iv) the socio-cultural conditions of the farmers.

In the UAE, the four main factors affecting the proper functioning of the technology transfer methods and thus, uptake of the ICARDA-APRP technologies (listed in order of ranking), were: (i) economic conditions of the farmers; (ii) type of farmer being targeted (farm size and type of farming system); (iii) cost of the extension method (although in some countries such as UAE, there is no charge for agriculture extension services); (iv) and leadership and supervision provided by the extension officer.

In Oman and Yemen, a similarity was found in the significant factors influencing the effectiveness of the diffusion methods towards large-scale adoption of ICARDA's improved technologies. The number of farmers per extension officer and categories of farmers was ranked first as the primary performance determinant of the transfer method in these two countries. The second factor was the age of

extension agents, followed by the location and availability of extension offices. The fourth most important determinant was leadership and supervision.

Overall, in the region, the results suggest that the top four most important factors influencing the effectiveness of the diffusion methods, and widespread adoption of the technologies (listed by rank), includes:

- Age of the extension officers,
- The number of farmers per extension officer and categories of farmers,
- Location and availability of extension offices,
- The geographic location of the farm.

4. CONCLUDING REMARKS AND POLICY IMPLICATIONS

In this study, we examined (i) perceptions of the AP extension officers towards their jobs; (ii) the AP perceived effectiveness of the agricultural extension and delivery systems and the potential factors affecting the performance of these systems in AP countries; (iii) insights on the effectiveness of the agricultural transfer methods deployed for the diffusion of ICARDA-APRP technologies, in particular, and with respect to the new agricultural innovation in general; and (iv) the potential factors affecting agricultural technology transfer methods of these improved technologies.

From the study findings, the following conclusions are drawn:

- There is definite satisfaction among extension officers regarding the information they receive from management on what is going on in their division/region. The officers also appear to be satisfied with their involvement in the decisions affecting their work – and concerning the diffusion of new agricultural technologies.
- Several extension methods have been used to transfer agricultural and livestock technologies with varying strengths and weaknesses according to the technical characteristics/attributes (technology needs skill know; complexity; affordability; reduces farming costs; increases profits; reduces the risk in farming operations; environmentally benefit; implementation of the technology is easy; easy to monitor, to assess, and follow up; communicable; compatible, and finally, if the technology is divisible) in each AP country.
- There is significantly low patronage of using FFS mechanisms such as farmers' business schools and farm demonstrations for communicating information to AP farmers. In the literature, farmer field days and business schools are a useful transfer method for the diffusion of new or improved agricultural technologies in many areas around the world (Aremu et al., 2015). Their use as an extension transfer method has been found to generate positive results in terms of income improvement in many countries.
- Electronic and mass media mechanisms are robust platforms for the dissemination of agricultural knowledge and skills, and information on improved technologies to AP farmers. Thus, such media play an influential role in providing extension services to farmers, especially in countries where the public extension agencies are ineffective in providing these much-needed services.

- Extension methods used by the AP extension system have a potential variable perception index of influencing smallholder farmers to adopt improved ICARDA-APRP. This perception differs from country to country and between the diffused technologies. This index oscillates between 40% for the SC and IF technologies to more than 60% for the SPS, IPPM, and GHCS technologies.
- The most significant potential factors influencing the effectiveness of the ICARDA-APRP technology diffusion methods in the AP region are: the age of extension officers, number of farmers per extension officer and category of farmer, cost of extension method, the socio-economic condition of the target farmers, location and availability of extension offices, and geographic location of the farmer.

To satisfy the demands and expectations of the different stakeholders and partners in an extension model, the study recommends the following:

- There is a need to review, address, and adapt extension approaches in response to changes that influence practical service delivery and policy priorities.
- These changes include government budget availability, increased environmental and social concerns, the emergence of new communication technologies, and strengthening of the private sector.
- To meet these challenges and to adapt, there will be a need for the following:
    - Building on existing extension structures and strengths in different locations within the AP countries;
    - Establishing new programmes in ways that explicitly recognize the experimental nature of the reform and change process;
    - Recognizing the value of diverse approaches to farming activities; and
    - Reforming strategies and arrangements with partners and different stakeholders.
- Involving private companies to deliver extension services to all growers under government management.
- Changing the extension policy toward more market-orientated approaches.
- Increasing the number of vehicles available for extension activities.
- Strengthening ICTs to increase farmer access to agricultural information and education (i.e. via email, SMS, online chat platforms, etc.).
- Organizing farmers into the community or producer groups.
- Increasing the number of extension agents, experts and subject matter specialists working in extension.

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