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Research Article

Promoting Adoption of Water Conservation; Soil Fertility and Health Improving Technologies through Agricultural Service Provision in Pakistan

Rani Mamoona Khan[1], Abid Hussain[2*], Abdul Hassan[3], and Abdul Majid[1]

[1]International Center for Agricultural Research in the Dry Areas (ICARDA), Pakistan Office, PARC-NARC Premises, Islamabad, Pakistan
[2]Social Sciences Research Institute (SSRI), PARC-National Agricultural Research Centre, Islamabad, Pakistan
[3]PARC-Social Sciences Research Institute, Agricultural Research Institute (ARI) Premises, Tarnab-Peshawar, Pakistan

Abstract: Agricultural service providers (Agric. SPs) play an essential role in the adoption of promising agricultural technologies by small and medium-sized farms. Similarly, agricultural service provision also generates substantial income for them. The study highlights the role of Agric. SPs in promotion of moisture conservation; soil health and fertility improving technologies at specific sites in Pakistan for three years i.e. from 2015 to 2017. It is based on primary data collected in the year 2018-19 from eighty sampled farmers, which were purposively selected to cover a range of selected technologies. It is found that Agric. SPs-induced adoption of these technologies has increased over time. They achieved considerable success in the promotion of the use of gypsum for moisture conservation and fertilizer placement drill in Pothwar-Punjab, ridge planting of crops in irrigated Punjab province, laser land leveling in irrigated areas of Sindh province, and use of biozote for improving soil fertility in both irrigated and rain-fed areas of Punjab province. These technologies have good income generation potential for Agric. SPs. The article also highlights factors hindering the large-scale adoption of the technologies in the country. Technical and entrepreneurship capacity building of the Agric. SPs in the provision of services to farmers in multiple technologies, and technical feasibility assessment of few technologies to use these for more than one crop are suggested for large-scale adoption of these technologies.

Keywords: Adoption, Agricultural service provision, Moisture conservation, Soil fertility, Soil health

1. INTRODUCTION

Agriculture sector plays a crucial role in the socio-economic development of Pakistan. Accelerated growth in the sector is required to fulfill the requirement of the increasing population for food and agro-based industrial products [1]. As the average size of operational holding is decreasing day by day due to population pressure, therefore, the ultimate way of increasing production is to raise the productivity levels [2]. Crop productivity can be raised through the adoption of promising water conservation; soil fertility and health-improving technologies. As adoption of these technologies makes it possible to obtain higher crop production with low use of costly productive resources. This would also result in increasing income of farmers, input suppliers, small entrepreneurs, and other relevant stakeholders. While, majority of the farming community in the country is constrained by a lack of information, farm machinery, and finances to adopt these technologies [3, 4].

In brief, adoption of moisture conservation, soil fertility, and health-improving technologies could result in saving of precious inputs, higher crop

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*Corresponding Author: Abid Hussain <abid@parc.gov.pk>

productivity and farm income, labour opportunities for rural poor, reduction in poverty, low food prices, improvement in food security, and environmental protection and sustainability [5]. Similarly, a robust and positive effect of agricultural technology adoption on farm household well-being is reported [6].

It suggests that there is a large scope for enhancing the role of agricultural technology in 'directly' contributing to poverty alleviation. In this regard, effective dissemination of appropriate agricultural technologies to end-users is being emphasized [7]. In the same perspective, the role of Agricultural Service Providers (Agric. SPs) in the farming is very important, especially for small and medium land holder farmers, who have limited access to costly agricultural technologies, practices, and inputs. Even farmers who can financially afford to adopt high-cost technologies mostly lack the necessary technical know-how due to a low level of education and ineffectual agricultural extension system. This necessitates the role of well-trained Agric. SPs, equipped with the necessary knowledge, machinery, and farm tools. It is reported by Mehmood *et al.* and Hassan *et al.* that the provision of quality and well-timed services at judicious prices significantly improves agricultural production [8, 9]. Similarly, a positive impact on livelihood and income of Agric. SPs have also been reported [9]. Thus, they can prove to be helping hand for the farmers at their doorsteps in acquiring these technologies. They also provide post-adoption services for the proper functioning of these technologies through the provision of technical guidance, and necessary repair and maintenance services. Thus, their role is very much required at the grassroots level for the development of the sector.

Though many studies have been undertaken on watershed management, adoption of water conservation as well on soil fertility, and health-improving practices; however, only a few of these highlight the role of Agric. SPs in promotion of these technologies. Thus, this study has been undertaken to fill the research gap. In this reference, a cadre of Agric. SPs was developed for dissemination of water and soil-related technologies through USDA/ICARDA funded projects called 'Pakistan water dialogue-Diffusion and adoption through partnerships and action of the best watershed rehabilitation and irrigation practices and technologies to help rural farmers (Watershed Rehabilitation and Irrigation Practice Project)' and 'Dissemination, diffusion, and adoption of the best soil fertility and soil health management practices and technologies for the farmers of Pakistan (Soil Fertility and Health Improvement Project)'. These projects were executed in two phases; Phase-I from 2013 to 2016 and phase-II from 2017 to 2018.

These projects were executed through technical partner institutes/ project collaborators including Pakistan Council of Research in Water Resources (PCRWR), Islamabad and its regional offices in Lahore, Peshwar, Tandojam and Quetta; Pakistan Agricultural Research Council (PARC) and its research establishments including Climate, Energy and Water Research Institute (CEWRI), Agricultural and Biological Engineering Institute (ABEI), and Land Resources Research Institute (LRRI) located in PARC-National Agricultural Research Centre, Islamabad; Barani Agricultural Research Institute (BARI), Chakwal; Soil and Water Conservation Research Institute (SAWCRI), Chakwal; Water Management Research Centre (WMRC), University of Agriculture, Faisalabad (UAF); Soil Fertility Research Institute (SFRI), Lahore; South Asian Conservation Network (SACAN), Lahore; Institute of Water Resources Engineering and Management (IWREM), Mehran University of Engineering and Technology (MUET), Jamshoro, and Agriculture Extension Department, Sakrand, Sindh. Under these projects, a series of training programs were organized by the South Asian Conservation Network (SACAN), Lahore to prepare a force of Agric. SPs throughout the country in selected water conservation and soil health/ fertility improving technologies/ practices.

As such participatory technical skill-enhancing training programs are always helpful for Agric. SPs in understanding practicality of a technology, increase adoption probability, improve their confidence level at farmers' field, and enable them to adopt service provision as a business [10]. In the first phase of the project, Agric. SPs were trained in selected technologies. So that after acquiring the required technical knowledge, they can help technical partners of the project to disseminate information and promote adoption. During the second phase of these projects, SACAN linked trained Agric. SP with private and public sector organizations to facilitate them in delivery of services and thereby develop them as sustainable entrepreneurs by making available subsidy/ credit arrangements for them. During this phase, SACAN also organized skill attainment training for Agric. SPs in 'On-farm soil testing using soil testing kit' in Punjab Province, as it was not included in Phase-I. This study is based on the data for the period (2015-2017), as the adoption of technologies and demand for services of Agric. SPs started after completion of training programs organized by SACAN and the development of demonstration sites by the technical partners in 2013-14. As already stated, the study is targeted to highlight the role of Agric. SPs in the adoption of selected water and soil-related technologies among the farming communities, and determine monetary gains acquired by Agric. SPs through the provision of these services. Specific objectives of the study are: to study adoption of the technologies by the farming community through assistance of Agric. SPs; to determine income generation potential of the services provided by Agric. SPs to farming community; to find out constraints faced by Agric. SPs in promotion of new technology/services; and to inquire Agric. SPs about their perceptions about the future adoption potential of selected technologies.

2. MATERIAL AND METHODS

The study is based on primary data collected through field surveys conducted in years 2018-19 by using a pre-tested questionnaire in all the provinces of Pakistan (Khyber Pakhtunkhwa, Baluchistan, Sindh, and Punjab). A list of the technologies for which services were provided to farmers throughout the country, under both water conservation and soil fertility/health improvement projects are given in Table 1. SACAN, Pakistan organized numerous training programs through which 410 farmers were also trained as Agric. SPs in five selected water conservation technologies, and six soil fertility/ health improvement technologies. Few farmers were trained in more than one technology. Out of these, 178 farmers were trained in drip/bubbler irrigation and gypsum application, 72 in bed planting, 76 in ridge planting of crops, 78 both inland laser leveling and bed planting of crops, 21 in use of zero tillage drill, 34 each both in sales or delivery of biozote and use of wheat fertilizer placement drill, and 12 in use of soil testing kit. A sample of eighty farmers was drawn purposively to cover all these technologies as per details given in Table 1. Mean annual adoptions of the technologies per Agric. SP over three years i.e. 2015-17 has been determined by using expression 1.

$$\frac{Number\ of\ Adoptions}{(Number\ of\ Agric.\ SPs)\times(Timer\ Period\ in\ Years)} \quad (1)$$

Closed-ended questions regarding the constraints in large-scale adoption of the technologies were asked from the sample Agric. SPs. The response was measured according to a 5-point Likert scale, where strongly agree scores 5 and strongly disagree scores 1. A score of 2.5 was considered as the cut-off point i.e. if the mean value of responses to a statement is greater than 2.5 it means that respondents have a positive attitude toward this statement i.e. they agree with it. While,

Table 1. Technologies Promoted by Agric. SPs

S. No.	Moisture Conservation Technologies/ Irrigation Practices	Sample Size	S. No.	Soil Fertility and Health Improvement Technologies	Sample Size
1	Gypsum sales in Pothwar-Punjab	02	1	Fertilizer placement drill in Pothwar-Punjab	01
2	Laser land leveling in Sindh	10	2	Pak Seeder in Rice-wheat zone of Punjab	01
3	Ridge planting of crops in Punjab	12	3	Fertilizer prediction model in Punjab	03
4	Bed planting of crops in Punjab	13	4	Soil testing kit in Punjab	04
5	Drip/Bubbler irrigation in Pothwar-Punjab	14	5	Biozote sales/delivery in Punjab	07
-	-	-	6	Zero tillage drill for wheat in Balochistan	13
	Total	51		Total	29

if the mean value of responses to a statement is less than 2.5, respondents have a negative attitude toward this statement i.e. they disagree with it. Mean scores close to 5 indicate strong agreement while, on the other hand, mean scores close to 1 indicate strong disagreement with a statement. Similarly, sample Agric. SPs were asked about adoption potential of the technologies on basis of a 5-point Likert scale. Data was analyzed through MS Excel for descriptive statistics and graphical presentation of results.

3. RESULTS

Agricultural Services Providers' induced adoptions of various moisture conservation/ irrigation practices as well as, soil fertility and soil health improvement technologies are presented in detail in Table 2. During the period (2015-17), annual mean number of adoptions per Agric. SP was the highest for use of gypsum for moisture conservation in rainfed areas of Pothwar-Punjab (39.3), followed by ridge planting of crops in irrigated areas of Punjab (4.0), and land laser leveling in irrigated areas of Sindh (2.2). Findings of use of gypsum are in line with that of [11], as they validated through on-farm participatory research in the rainfed-Pothwar, that gypsum is effective in moisture conservation and results in higher wheat productivity. They reported considerable improvement in adoption by developing linkages of farmers, input dealers/ Agric. SPs and gypsum suppliers. Moreover, it is comparatively a low-cost technology. While adoptions of bed planting of crops in irrigated areas of Punjab (0.8) and drip/bubbler irrigation (0.2) in Pothwar-Punjab through Agric. SPs were much low. The results are in line with [10], they reported that despite efforts made for a long time, drip irrigation technology could not get much popularity in rain-fed areas of Punjab due to the non-availability of installation services; its repair, and maintenance. They stressed that it is capital-intensive technology and need above-average returns on investment to pay it back. Thus to achieve high returns, it was emphasized that farmers should be inculcated to shift from subsistence to high-value crop farming. Furthermore, the use of quality material matters much to prolong the operational life of drip irrigation systems. It cuts down the cost of production and increases profitability [12].

In the case of soil fertility and soil health-improving technologies, fertilizer placement drill for wheat in Pothwar was most promising with the highest mean number of services (28.7) and mean adoption area (18.0 acre) from year 2015-2017, followed by biozote sales/ delivery (5.6). The positive impact of the use of fertilizer placement drills on wheat productivity has been reported by [13]. Many researchers including [14, 15] reported that the use of biozote resulted in better seed germination and healthier crops of wheat and

Table 2. Adoption of technologies by farmers through Agric. SPs

Technologies/Practices	Agric. SPs (No.)	Total Adoptions (2015-17)		Annual Mean per Agric. SP		Mean Area per Adoption (Acre)
		Farmers (No.)	Area (Acre)	Farmers (No.)	Area (Acre)	
Moisture Conservation/ Irrigation Practices						
Gypsum sales/delivery	02	236	392	39.3	65.3	1.7
Laser land leveling	10	66	385	2.2	12.8	5.8
Ridge planting	12	114	735	4.0	20.4	5.1
Bed planting	13	33	188	0.8	4.8	5.7
Drip/Bubbler	14	09	71	0.2	1.7	7.9
Total	51	488	1771	3.2	11.6	3.6
Soil Fertility and Soil Health Improving Technologies						
Fertilizer placement drill	01	86	1552	28.7	517.3	18.0
Pak Seeder	01	03	48	1.0	16.0	16.0
Biozote sales/delivery	07	118	489	5.6	23.3	4.1
Zero tillage drill	13	12	99	0.3	2.5	8.3
Total	22	219	2186	3.3	33.2	10.0
Fertilizer prediction model*	03	126	367	42.0	122.3	2.9
Soil testing kit*	04	10	11	2.5	2.8	1.1
Total	07	136	378	19.4	54.0	2.8

Source: Field Survey 2018, Pakistan *Data just for the year 2017 rice. However, they stated that the main hurdles in large-scale adoption of the technology are farmers' unawareness about the benefits of the technology, their low educational level, and its unavailability in local markets in Punjab province. Similarly, Agric. SPs' inability to maintain a cold chain in the delivery may result in the non-effectiveness of the product. They [15] stressed that input dealers/ Agric. SPs, local representatives, technical and extension institutions should be engaged in the commercialization of the technology. The fertilizer prediction model, and soil testing kit were in the first year of diffusion and adoption in the year 2017. The fertilizer prediction model also provided good business to Agric. SPs with 42 services per Agric. SP in just one year of business.

An increasing trend in the mean number of adoptions per Agric. SP for all the technologies over time has been observed. In the first two years of the second phase of projects (2015 and 2016). The adoption was quite low, as diffusion (dissemination of the information) of the technologies and capacity building of Agric. SPs through training was the prime focus of project activities (Table 3). Though adoption of the technologies gained a little hike in the year 2016. In the third year (2017), the institute that was responsible for the capacity building of Agric. SPs i.e. SACAN, Lahore, along with technical partner institutions put maximum efforts into the promotion of technologies. Consequently, a considerable number of adoptions of all the technologies were achieved. In the year 2017, the number of adoptions for soil moisture conservation technologies increased by about four folds and, that of soil fertility/ health-improving technologies by two and a half folds than that in the year 2015. Similarly, due to a consistent increase in the number of adoption, the area on which technologies were adopted by the farmers through services provided by Agric. SPs also increased over time (Table 4), specifically in the third year.

During the study period (2015-17), in the case of watershed rehabilitation technologies, the highest change in adoption rates by number (24.5 times) and area (58.0 times) were observed for laser land leveling in Sindh province over that of the year 2015, and among the soil fertility and soil health-improving technologies, the highest change in adoption rate occured for zero tillage drill in Balochistan province (9.0 times by number and 43.5 times by area over that of the year 2015).

On the whole, the area under the adoption of watershed rehabilitation technologies increased by six-folds, and that of soil fertility and soil health-improving technologies doubled during 2015 to 2017. Though, Pak-seeder for sowing wheat crop in the rice-wheat zone of Punjab could not gain much popularity and was adopted on a limited area, a registered increase of just 1.4 times over that of the year 2016. Similarly, changes in gypsum application area in Pothwar, ridge planting, and bed planting of crops in Punjab were comparatively small as compared to that in the year 2015 viz. 3.7, 4.5,and 4.6 times, respectively. Similarly, areas under application of biozote, and fertilizer place-

Table 3. Adoption rate of technologies

Technologies/Practices	**Mean adoptions per Agric. SP (No.)**			**Change over 2015**	
	2015	**2016**	**2017**	**No. per year**	**No. of times**
Best Watershed Rehabilitation and Irrigation Practices					
Gypsum sales/delivery	45	80	111	33.0	2.5
Laser land leveling	2	15	49	23.5	24.5
Ridge planting	14	35	65	25.5	4.6
Bed planting	4	11	18	7.0	4.5
Drip/Bubbler	1	3	5	2.0	5.0
All	66	144	248	91.0	3.8
Soil Fertility and Health Improvement					
Fertilizer placement drill	20	23	43	11.5	2.2
Pak Seeder	-	1	3	1.5*	3.0*
Biozote sales/delivery	20	48	50	15.0	2.5
Zero tillage drill	1	2	9	4.0	9.0
All	41	74	105	32.0	2.6

Source: Field Survey 2018, Pakistan

Over the year 2016*

Table 4. Adoption area of technologies

Technologies/Practices	Mean Area per Agric. SP (acre)			Change over 2015	
	2015	2016	2017	Area per year	No. of times
Best Watershed Rehabilitation and Irrigation Practices					
Gypsum sales/delivery	51	154	187	68.0	3.7
Laser land leveling	5	90	290	142.5	58.0
Ridge planting	92	228	415	161.5	4.5
Bed planting	23	59	106	41.5	4.6
Drip/Bubbler	4	24	43	19.5	10.8
All	175	555	1041	433.0	5.9
Soil Fertility and Health Improvement					
Fertilizer placement drill	400	501	650	125.0	1.6
Pak Seeder	-	20	28	8.0*	1.4*
Biozote sales/delivery	88	198	203	57.5	2.3
Zero tillage drill	2	10	87	42.5	43.5
All	490	729	968	239.0	2.0

Source: Field Survey 2018, Pakistan * Over year 2016

Table 5. Income of Agric. SPs through the provision of farm service in the year 2017 (Percent)

Technologies	Income Ranges (Rs.)					
	Nil	1000-50000	50001-100000	100001-150000	150001-200000	above 200000
Drip/Bubbler Irrigation	14	0	0	14	29	43
Gypsum	0	50	0	0	0	50
Bed Planter	7	31	31	23	8	0
Ridge Planter	0	0	42	25	8	25
Laser Land Leveler	0	0	30	20	10	40
Biozote Sales/Delivery	14	58	0	0	14	14
Pak Seeder	100	0	0	0	0	0
Zero Tillage	23	39	23	15	0	0
Fertilizer Prediction Model	0	100	0	0	0	0
Soil Testing Kit	0	75	0	0	0	25
Fertilizer Placement Drill	14	0	0	14	29	43

Source: Field Survey 2018, Pakistan

ment drill in Punjab province could not expand to great extent viz. just by 2.3 and 1.6 times over that in the year 2015, respectively.

Income earned by Agric. SPs through the provision of farm services to promote selected technologies under both projects in the year 2017 are categorized into different ranges in Table 5. Water-saving technologies, drip/bubbler irrigation, gypsum sales/delivery, and laser land leveling have good income generation potential, as income of more than forty percent of the sample Agric. SP was more than Rs. 200,000. Likewise, services in bed planting and ridge planting generated considerable returns as near about one-third Agric. SPs (31 % in case bed planting and 42 % in case of ridge planting) obtained income in the range of Rs. 50,001 to Rs. 100,000. These services have comparatively low-income potential compared to others, as these are seasonal in nature and limited only to crop sowing seasons. However, multi-crop ridge/ bed planters can be introduced through Agric. SP, these may result in better returns for them.

In soil fertility improving technologies, services in fertilizer placement drill has good income generating potential, as it generated income above Rs. 200,000 for 43 % Agric. SPs in the year 2017. Biozote sales/delivery, zero tillage, and fertilizer prediction model generated a low level of income i.e. Rs. 1,000 to Rs. 50,000 for most of the Agric. SPs (39 % in zero tillage drill, 58 % in biozote sales/ delivery and 100 % in fertilizer prediction model). Twenty-three percent of Agric. SP giving services of zero-tillage drill in Balochistan reported providing free of cost services to their fellow farmers due to their cultural norms and values. As they promoted the technology free of cost for the welfare of their community. Similarly, in the case of Pak Seeder in the rice-wheat cropping zone of Punjab, Agric. SPs reported providing services to their neighboring farmers without charging payments. Agric. SPs providing services for two or more technologies have more chances to earn a substantial income. Thus, their success in the business can be increased through capacity building by enhancing skills in effective entrepreneurship management to seek business in two or more technologies.

Income earned by Agric. SP through the provision of farm services in the year 2017, irrespective of technology types has been categorized in Figure 1. One-fifth of Agric. SPs earned income above Rs. 200,000. This is quite encouraging, as subsistence farmers (having land holding up to 2 ha) in the country earn income usually in the range of Rs. 200,000 to 300,000 annually. In total, forty-six percent of the Agric. SPs reported to earn income above Rs. 100,000 for the provision of farm services. Thus, service provision to fellow farmers by Agric. SPs have substantial income generation potential and help promote promising water-saving; soil fertility, and health-improving technologies/ practices in the country.

Constraints in promotion of technologies faced by Agric. SPs in the context of crop farmers' characteristics in the country are presented in Table 6. Lack of awareness in the farming community about promising water-saving; soil fertility and health-improving technologies, lack field experience, and hands-on training of Agric. SPs and their inability to cover farmers' demand specifically for technologies having seasonal nature of service are major constraints in the wider adoption of selected technologies.

While other factors, like lack of resources to invest in farming, social/cultural non-acceptance of technologies, traditional attitude, and small land holdings of farmers also hinder large-scale adoption. Mean of the sample Agric. SPs' Likert-scale responses by technology is four and indicate that adoptions of drip/ bubbler irrigation, bed planting of crops, use of fertilizer placement drill, and Pak Seeder are constrained much due to these farming issues than other selected technologies.

Moreover, constraints for wider adoption of individual technologies also vary. In case of gypsum and biozote (sales/ delivery); ridge planting and zero tillage drill inability of Agric. SPs to cover farmers' demand is a major constraint in large scale adoption. In the case of fertilizer placement drill; lack of awareness, limitation on resources to invest, and social/ cultural non-acceptance are main constraints in adoption. While, adoption of Pak-seeder is much limited, mainly due to small land holdings and lack of field expertise on the part of service providers. The use of fertilizer prediction models and soil testing kits is constrained by a lack of awareness. Adoption of laser land leveling technology is not gaining impetus for large-scale adoption due to a dearth of financial resources to invest on the part of Agric. SPs as well as farmers, and lack of expertise by Agric. SPs in service provision. Adoption of drip/ bubbler irrigation and bed planting of crops is constrained by all the factors listed in Table 6. According to Agric. SPs perceptions, ridge planting, laser land leveling, Pak Seeder, zero tillage drill, fertilizer prediction model, and fertilizer placement drill have great adoption potential. In the case of gypsum delivery/ sales and soil testing kit technology, one-half of the respondents expressed high optimism while

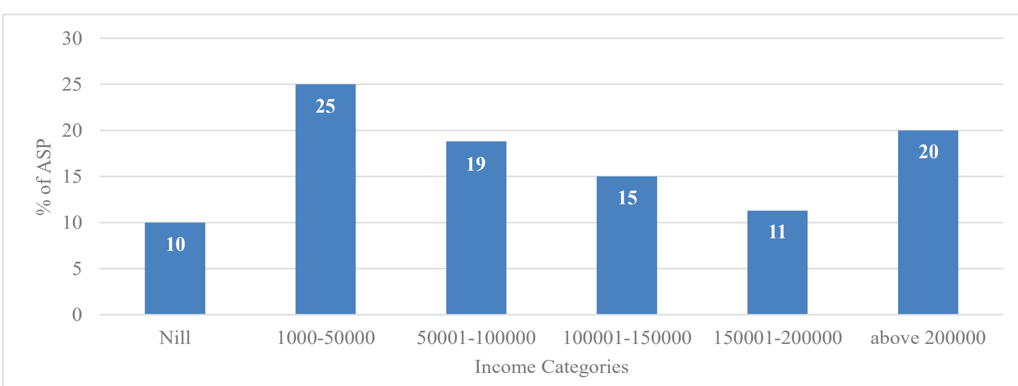

Fig. 1. Income earned by Agric. SPs through farm services Source: Field Survey 2018, Pakistan

Table 6. Constraints in promotion of technologies

Technologies	Lack of awareness	Lack of resources to invest	Sociocultural non-acceptance	Tradit-ional attitude	Small land holdings	Lack field experience and hands on training	Inability to cover demand	Average
Drip/Bubbler Irrigation	4	4	4	4	4	4	4	4
Gypsum Sales/Delivery	3	2	2	2	2	2	4	2
Bed Planter	4	4	4	4	4	4	4	4
Ridge Planter	3	3	2	2	2	4	4	3
Fertilizer Placement Drill	5	5	5	3	3	3	3	4
Biozote Sales/Delivery	5	2	3	2	2	3	4	3
Pak Seeder	4	3	3	3	4	4	4	4
Zero Tillage	4	3	3	3	2	3	4	3
Fertilizer Prediction Model	5	3	3	3	3	3	3	3
Soil Testing Kit	4	3	3	4	3	3	4	3
Laser/ land leveler	2	4	1	2	2	4	3	3
Average	4	3	3	3	3	4	4	-

the other half were highly affirmative about the adoption potential of these technologies. In the case of drip/bubbler irrigation half of the Agric. SPs (50 %) strongly agreed, more than one-third (36 %) agreed that the technology has the potential to be adopted on a large scale, while the remaining (14 %) were uncertain about the adoption potential of the technology. About one-third of Agric. SPs (62 %), providing services for bed planting of crops (rice and wheat) strongly agreed about the up-scaling potential of the technology, eight percent each was agreed and disagreed with the adoption potential of the technology, and twenty-two percent were uncertain about further adoption prospects of the technology. In biozote supply/sales more than half (57 %) strongly agreed, 28 % disagreed and 15 % were uncertain about the wider adoption of the technology.

4. DISCUSSION

It has been declared that the participatory skill development of farmers is a necessary condition for the promotion of water conservation and soil fertility-related technologies. In this regard, the necessary condition has been fulfilled in the country. However, sufficient condition needs to be fulfilled by further follow-up by technical institutions [10]. Thus, the linkage between Agric. SPs and technical institutions promoting these technologies are required to be further developed and strengthened. Similarly, strengthening agriculture research institutes and extension services have been suggested to improve the technical knowledge of service providers [9].

Thus, both horizontal and vertical coordination is stressed, as collaboration among Agric. SPs themselves allows access to technology at lower cost. While, cooperation of Agric. SPs-technical partners/ collaborators including technology suppliers in the private sector tends to reduce opportunistic behavior and market uncertainties [16]. In this reference, the imposition of a cap on rental charges by the government through a regulation mechanism has also been suggested [8]. In this way Agric. SPs can play a crucial role in knowledge dissemination and field demonstration, as well as in farmers' participatory research and training programs to popularize these technologies and enhance their adoption.

Agric. SPs reported barriers to the sustainability of work are low adoption rates, lack of public support, and enterprise-specific obstacles. Some of them have a plan for long-term sustainability such as training others or continuing to provide services without any type of support. They cited personal benefits such as self-improvement i.e. job experience and more earning, personal interest in the work being done, or seeing the community adopt new technologies. While, few researchers, including [17] also stressed improving the education status of the farming community to develop their behavior to augment the adoption of approved scientific technologies, enhance production and sustain food security in the long run. Similarly, the development of human capital characteristics for the adoption of sustainable agricultural practices is also emphasized [18, 19]. As it is stated that human capital-specific characteristics and entrepreneurial behaviour have a significant positive effect on the adoption of crop production technologies, specifically at small scale farms [18]. Thus, these human capital characteristics and coordination among stakeholders should be the prime focus, while devising programs to enhance the adoption of water conservation; soil fertility, and health-improving technologies. It is suggested to adopt the local service providers (LSP) model by involving local support organizations (LSOs) for agricultural advisory and related services. In the LSP model, local actors (farmers, business owners, breeders, etc.) are trained to provide services (knowledge, technology, training, etc.) to fellow farmers. Intangible benefits of the model are related to increased awareness and self-confidence of farmers to interact with Agric. SPs, and also in their problem-solving activities. This may enable farmers to express their technology needs and participate in designing, testing, and disseminating appropriate technologies. The system helps poor farmers being unable to afford inputs and services to put the advice into practice [20]. The most appropriate scale to adopt the model in the country is recommended at the Union Council level [8].

Similarly, it is reported that social organizations provided good quality extension and education-related services to the rural communities [21]. It is said that farmers rate LSO extension services providers high because they are accountable for the services they provide [22]. The increasing role of Information Communication Technologies (ICTs), especially mobile phones and the internet in this reference should also be considered [23]. To institutionalize the private sector for agricultural service provision on the model of metro cab system should also be envisaged. Where farmers can have better access to services well in time, and Agric. SPs may have more business. An added advantage of the system is an opportunity for the farmers to rate the services of Agric. SPs. Farmers' ability to get group deals to acquire services from Agric. SPs on low rates is another possibility. In this reference, a commission from helping farmers acquire the input/ services they need than having farmers pay for them seems a model with higher potential for financial sustainability [20]. It is always advisable to start with simple activities, having high chances of success, and quickly demonstrate success. Finally, as farmers' needs are constantly changing with time and socioeconomic attributes; thus, Agric. SPs need to periodically upgrade in knowledge, skills and attributes to keep pace with emerging challenges and dynamics of service provision.

5. CONCLUSION

Agriculture service providers (Agric. SPs) have contributed significantly to the dissemination and adoption of promising water-saving; soil fertility and health-improving technologies under USDA-ICARDA initiatives in the country. Demand for their services is increasing with time. Even, for a few technologies Agric. SPs are unable to meet the service demand of the farming community. Agric. SPs-induced adoption of selected technologies has sensitized the farming community about the economic importance of the adoption. Which will boost the adoption of these technologies in near future. Considerable adoptions through services of Agric. SPs are reported for use of gypsum for moisture conservation, biozote application for wheat and rice crops sales, fertilizer placement drill for wheat, and laser land leveling. Fertilizer placement drill and ridge sowing of wheat in Sindh was the most promising technologies and are adopted on a large area. Many socioeconomic factors affect the large-scale adoption of these technologies. Lack of awareness in the farming community about promising water-saving; soil fertility and health-improving technologies, lack field experience and hands-on training of Agric. SPs and their inability to cover farmers' demands well in time are major constraints in the large-scale adoption of selected technologies. Agric. SPs perceive that ridge planting, laser land leveling, Pak/ Happy Seeder for wheat, zero tillage drill for wheat, fertilizer prediction model, and fertilizer placement drill for wheat have great adoption potential in the country. Similarly, economic returns to sustain the livelihood of Agric. SPs are much essential to improve the delivery of services to the farming community. There is a need to technically access feasibility to use a few of the technologies for multiple crops like ridge and bed planters. The adeptness of Agric. SPs in service delivery can be enhanced through their capacity building by improving skills in effective entrepreneurship management, seeking more sales and services, provision of after-sale repair and maintenance services, and by seeking business in multiple technologies.

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7. CONFLICT OF INTEREST

There is no conflict of interest among the authors in the findings of the study and description of results.

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