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Post-Adoption Response of Farmers toward Agroforestry Based Soil and Water Conservation Measures for Watershed Management in India

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Abstract: Various watershed management programs were initiated in India with the main emphasis on soil and water conservation (SWC). It was imperative to study the post-adoption response of the farmers to assess the effectiveness of agroforestry based SWC technologies in watershed management. The present study was carried out in selected watersheds located in different agro-climatic zones of the India. Standardized structured data collection schedules were developed along with the relevant indices to measure continuity and discontinuity in adoption, observe technological gap and assess diffusion of the SWC technologies. Results revealed that two-third of agroforestry based SWC measures were continuously adopted, while one-third was discontinued by the farmers. Forty-six per cent of the agroforestry technologies were continuously adopted with the technological gap. About one-fifth of agroforestry based SWC technologies were also diffused to other farmers. Considerable number of farmers continuously adopted agroforestry SWC technologies with technological gap as well as discontinued them from their fields. This was due to lack of fund, non-availability of labor and requires huge amount of money to repair and maintain these technologies. Therefore, suitable mechanism of fund availability need to be explored for repairing, managing and maintaining agroforestry based SWC technologies that will help in continuous adoption even after withdrawal of public funded watershed development schemes. The paper explains post-adoption behavior of farmers regarding continued adoption, discontinuance, technological gap and diffusion of agroforestry based soil and water conservation technologies.

Key words: Post-adoption, agroforestry, soil and water conservation technologies, watershed management.

Soil and water conservation (SWC) measures are adopted worldwide for conserving and managing the natural resources. Agroforestry is extensible SWC practice in different parts of the world. These measures once implemented in community participation mode, need to be analyzed for their effectiveness and post implementation response. Post-adoption behavior is a decision of farmer regarding whether to continue the existing adopted technology with or without technological gap or discontinue for adoption of better available technology or diffuse the adopted technology due to satisfactory performance (Bagdi *et al*., 2015). Once the technology is implemented and perform satisfactory, farmer will continuously practice it or otherwise they will discontinue it for one or other reason (Rogers, 1995).

In present days, unlike past, factors other than meeting their basic needs play an important role in discarding an adopted technology. Adoption of better technologies will not provide satisfactory benefits in terms of agricultural productivity, natural resources management and poverty alleviation, unless the obstacles to their continuous adoption are not overcome (Oladele, 2005). In some instances, withdrawing subsidies of a schemes ultimately leads to the discontinuance of the farming innovations (Van Tongeren, 2003). However, the only effective way to increase productivity is broad-based adoption of new farming technologies (Minten and Barrett, 2008). Adoption of agroforestry is considerably more complex than traditional agriculture because it usually requires establishing a new input-output mix of annuals, perennials, green manure, fodder and other components, combined with new conservation techniques such as contour hedgerows, alley cropping, and enriched fallows (Rafiq *et al*., 2000). Unlike standard agriculture, there are few packaged agroforestry or farm-based, natural resource management (NRM) practices to deliver to farmers (Barrett *et al*., 2002). As a result, agroforestry and other NRM innovations are typically more knowledge-intensive than modern agricultural development packages based on improved seed, chemical, and/or mechanical inputs. Therefore, farmer education, experimentation, and modification are more important for agroforestry and NRM development than for conventional agriculture (Barrett *et al*., 2002).

Continuance and discontinuance of a technology depends on the effective implementation, proper management and resultants benefits. Discontinuance is a decision to reject an innovation after its adoption (Rogers, 2003). There are three types of technological discontinuance i.e. (1) replacement, (2) disenchantment and (3) forced discontinuance. Replacement discontinuance is a decision to reject an idea in order to adopt a better idea that supersedes it. Constant waves of innovations may occur in which each new idea replaces an existing practice that was an innovation previously. For example, Traditional agroforestry systems have been replaced by industrial agroforestry in India. Disenchantment discontinuance is a decision to reject an idea as a result of the performance dissatisfaction. The rate of discontinuance is equally important as the rate of adoption in determining the adoption level of an innovation and at any particular time discontinuance of an innovation is same as the first-time adopters (Leuthold, 1967). Forced discontinuance happens when farmers are forced to change or discontinue the existing practices because of the government policies. For example, Government of India has banned the burning of crop residue in view of harmful environmental effect and promoted the residue utilization through conservation agriculture. Inability discontinuance can also be the fourth type of technology discontinuance, when farmers discontinued an adopted technology because of his inability to maintain due to high cost or technology complexity (Bagdi *et al*., 2018). For example, a poor farmer may find difficult to maintain agricultural field bunds on sloppy land and repair of a breached concrete check dam.

Diffusion of technological innovations have been defined as the spread of 'successful' innovations as they combine with or displace existing 'inferior' alternatives (Sarkar, 1998). Thus, diffusion concerns the extent to which the new innovation is put to productive use. Early adopters are often referred to as innovators and the diffusion process as the spread of the innovation to other members of the population (Feder and Umali, 1993). According to Rogers' Theory of Diffusion of Innovation (1983) new ideas or technologies should be diffused to

Table 1. Centre-wise selected watersheds and number of respondents

Name of Research Centre (RC)	Name of selected watersheds with number of respondents in brackets	Total respondents
RC, Vasad	Navamota (50), Rebari (50), Sarnal (50), Antisar (50), Vejalpur-Rampura (50)	250
RC, Bellary	Joladarasi (50), Chinnatekur (50), PC Pyapli (54), Mallapuram (54), Chilakanahatti (58)	266
RC, Chandigarh	Aganpur-Bhagwasi (50), Mandhala (49), Johranpur (26), Sabeelpur (50), Kajiana (50)	225
IISWC, Dehradun	Fakot (50), Raipur (50), Sabhawala (51), Langha (60)	211
RC, Ooty	Salaiyur (50), Chikkahalli (50), Eramanaikkanpatti (50), Putthuvampalli (50), Thulukkamuthur (50)	250

the intended user. However, adopters of innovation tend to explore the new technology, and experience how effectively it would work in their areas before accepting or rejecting those technologies.

Soil degradation has raised some serious debate, and is currently an important issue worldwide (Gardner, 1996). It has been observed that erosion and soil degradation have disastrous effects on the agricultural productivity (Scherr and Yadav, 1996), while few opinioned that loss of productivity due to soil erosion and degradation is as low as five per cent (Crosson, 1995).

Agroforestry is a land use system which consists of combining agricultural and forestry practices to create integrated, diverse and productive systems (Garrett *et al*., 2000). In agroforestry symbiotic association occurs between tree, crops and livestock and each component is benefited from each other (Bandyopadhyay, 1997). The continued use of soil and water conservation measures (SWCM) technologies are mainly influenced by the actual profitability and the cost involved in maintenance and their use. Moreover, in places where scope exists for implementing SWCM in an integrated development mode, farmers maintained their resources in a better way and their replication rates were also higher (De Graaff *et al*., 2008). Moreover, if large number of farmers in a specific project area or village adopt natural resource management measure, farmers of the neighbouring villages may also adopt these measures without any project or funding assistance (spontaneous diffusion) (Bodnar *et al*., 2006).

Indian Institute of Soil and Water Conservation (IISWC) and its Centers have developed many watershed projects in different agroclimatic zones of the country and have implemented many agroforestry based soil and water conservation technologies for resource conservation and watershed management. Continued adoption or discontinuance of agroforestry SWC technologies viz., bamboo plantation in degraded ravine beds, agri-silviculture system and silvi-pasture system, sole tree plantation, grass based vegetative barriers and live hedge etc. depends on availability of resources with the farmers and also suitability to field conditions. Therefore, it was realized that the post-adoption response of beneficiary farmers who have practiced different agroforestry based soil and water conservation technologies for watershed management should be studied to assess the present status of continue-adoption, discontinuance, technological gap and diffusion. Keeping these points in consideration the present research study was framed with the main objective to measure the extent of post-adoption response (i.e. continue-adoption, discontinuance, technological gap and diffusion) of farmers with regard to the adopted agroforestry SWC technologies of watershed management.

Materials and Methods

Study area

The research study was carried out during 2012 to 2016 in eight states of India as core project at Indian Institute of Soil and Water Conservation (IISWC), Research Centre, Vasad, (Gujarat) as lead Centre along with IISWC headquarter Dehradun, Uttrakhand, and its Centers at Agra (Uttar Pradesh), Bellary (Karnataka), Chandigarh (Haryana), Datia (Madhya Pradesh), Kota (Rajasthan) and Ooty (Tamil Nadu). The already developed watersheds by IISWC and its Centers at least three years ago were selected for the study and four or five watersheds were selected at each

Centre. Hence, the watersheds developed by IISWC and its research Centers during 1990 to 2009 were selected under this study. Thus, in total 38 watersheds were selected from eight research Centers of IISWC in the country (Table 1).

Selection of respondents

The beneficiary farmers of selected watersheds who have adopted agroforestry based soil and water conservation technologies were selected as respondents in the study. At least 50 respondents were selected from each watershed comprising from all the existing categories of farmers in the watershed. A list of agroforestry based SWC technologies was prepared which were implemented during each watershed development programme. Agroforestry SWC technology-wise inventory of respondent farmers was prepared, who have adopted them, with the help of detail project report (DPR) or by organizing meetings with farmers. The inventory had the names of farmers along with size of land holding, who have adopted a particular technology in the watershed. Stratified proportionate random sampling plan was adopted to select respondents from different inventories or lists of farmers. At least 50 respondents were selected from each watershed comprising from all the existing categories of farmers in the watershed. Thus, total 1902 respondent farmers were selected in the study as sample size (Table 1). A detail structural interview schedule was developed by the investigators and data regarding personal, psychological and post-adoption behavior variables were recorded on developed structured schedule by interviewing the respondents personally.

Measurement of post-adoption response of farmers

To measure the extent of post-adoption response information about variables *viz.*, continue adoption, discontinuance, technological gap and diffusion was collected. A detail methodology consisting of data collection schedules, scoring procedure and data analysis with the following developed Bagdi *et al.*, 2015:

Technologies continue adoption index (TCAI) is the percentage of number of agroforestry based SWC technologies which continued adopted out of total initially adopted technologies by a farmer in his field under watershed area. It could be calculated as given below:

$$TCAI = \frac{\text{Number of Agroforestry SWC Technologies Continue Adopted by a Farmer}}{\text{Number of Agroforestry SWC Technologies Initially Adopted by Farmers}} \; x\,100 \qquad ...(1)$$

(ii) Overall technologies continue adoption index (OTCAI) indicate agroforestry SWC technologies which continued to be adopted by farmers of all selected watersheds in India as represented below:

$$OTCAI = \frac{\sum_{i=1}^{N} TCAI_i}{N} \qquad ...(2)$$

where, $\sum_{i=1}^{N} TCAI_i$ = Sum total of technologies continue adoption indices of i^{th} farmers; N = Total number of farmers

(iii) Discontinuance of technologies index (DTI) indicate the number of agroforestry SWC technologies discontinued out of total initially adopted technologies by a farmer from his field in watershed area and it could be worked out as given below

$$DTI = \frac{\text{Number of Agroforestry SWC Technologies Discontinued by a Farmer}}{\text{Number of Agroforestry SWC Technologies Initially Adopted by Farmers}} \; x\,100 \qquad ...(3)$$

(iv) Overall discontinuance of technology Index (ODTI): This index indicates the sum of the total of discontinuance of technology after initially adopted by the farmers.

$$ODTI = \frac{\sum_{i=1}^{N} DTI_i}{N} \qquad ...(4)$$

where, $\sum_{i=1}^{N} DTI_i$ = Sum Total of Discontinuance of Technology Indices of i^{th} farmers

N = Total number of farmers

(v) Technological Gap Index (TGI): This is with reference to the score that a farmer obtains on continuing a technology with a gap in relation to the total number of farmers adopted that particular technology with technological gap.

$$TGI = \frac{\sum_{i=1}^{N} \left[\frac{R-A}{R}\right]}{N} X100 \qquad ...(5)$$

where, R = Maximum possible score on complete adoption of a technology as per the design suitable in the watershed (i.e. 10).

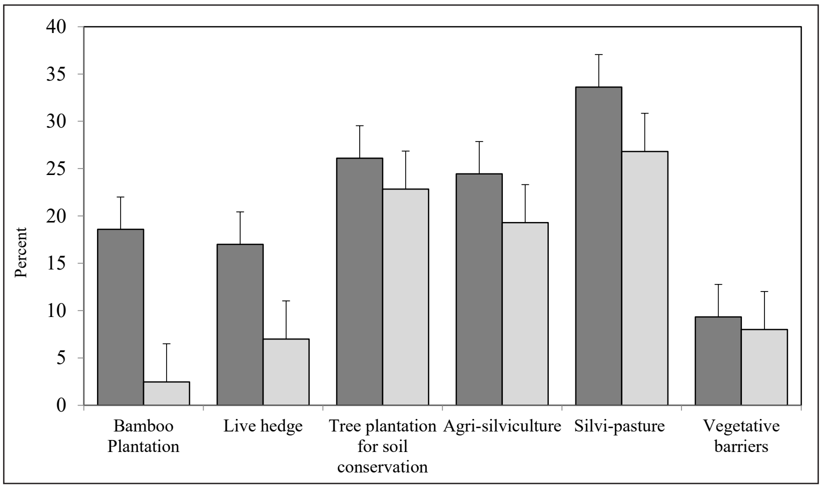

Fig. 1. Percentage of farmers initially and continuously adopted different agroforestry based SWC technologies.

A = Score obtained by a beneficiary farmer on his incomplete adoption of a technology

N = Total number of technologies adopted

(vi) Overall Technological Gap Index (OTGI): This is with reference to the score that a farmer obtains sum of the total of technologies with a gap in relation to the total number of farmers adopted that sum of total technology with technological gap.

$$OTGI = \frac{\sum_{i=1}^{K} TGI_i}{K} \quad ...(6)$$

where, $\sum^{K} TGI_i$ = Sum total of Technological Gap Indices of k^{th} farmers

K = Total number of farmers

(vii) Technology diffusion index (TDI): Number of agroforestry SWC technologies diffused out of total initially adopted technologies by a farmer from his field in watershed area and it could be worked out as given below

$$TDI = \frac{\text{Number of Agroforestry SWC Technologies Diffused by a Farmer}}{\text{Number of Agroforestry SWC Technologies Initially Adopted by Farmers}} \times 100 \quad ...(7)$$

(viii) Overall Technology Diffusion Index (OTDI): This indicates the ratio of sum of the total of the farmers involved in the technology diffusion to the total number of farmers that adopted the technologies.

$$OTDI = \frac{\sum_{i=1}^{N} TDI_i}{N} \quad ...(8)$$

where, $\sum_{i=1}^{N} TDI_i$ = Sum Total of Technology Diffusion Indices of i^{th} farmers

N = Total Number of farmers

Results and Discussion

Continuous adoption of agroforestry based SWC technologies

Continuous adoption of agroforestry SWC technologies by the farmers in various watersheds of the India is presented in Table 2. Overall, maximum (26.81%) of the farmers continuously adopted silvi-pasture practices for sustainable management of watersheds, compared to initial adoption (33.61% farmers) during implementation of watershed programs.

Tree plantation practice was continuously adopted by 22.83% farmers, while 26.10% farmers initially adopted these practices for soil conservation during implementation of watershed programs. Agri-silviculture practice was continuously adopted by 19.29% of farmers, whereas 26.44% farmers initially adopted these measures. Vegetative barrier, live hedge and bamboo plantation was continuous adopted by 8%, 9.33% and 2.47% farmers, respectively for soil and water conservation, whereas it was initially adopted only by 9.33%, 7% and 18.58% farmers, respectively. Among the implemented agroforestry measures in different regions, results further showed that maximum continuous adoption was observed for tree plantation for soil conservation and agri-silviculture in Dehradun, silvi-pasture

Table 2. Continue adoption of agroforestry SWC technologies by farmers in different watersheds implemented by IISWC and its Research Centres in India

Name of Technologies continued adopted in watersheds	Number of farmers					Mean
	Vasad	Dehradun	Chandigarh	Bellary	Ooty	
	Navamota, Rebari, Sarnal, Antisar & Vejalpur Rampura (n=250) %	Fakot, Raipur, Sabhawala & Langha (n=211) %	Aganpur, Bhagwasi, Mandhala, Johranpur, Sabeelpur & Kajiyana (n=225) %	Joladarasi, Chinnat-ekur, Pyapli, Mallapuram & Chilakanahatti (n=266) %	Salaiyur, Chikkahali, Ermanaikk-anpatti, Putthuvam-palli & Thulukka-muthur (n=250)%	
Bamboo Plantation	3.33 (43.33)	0.0 (8.33)	4.08 (4.08)	-	-	2.47 (18.58)
Live hedge of Thor, Vilayti babul, Sisal	7 (17)	-	-	-	-	7 (17)
Tree plantation for soil conservation	39.5 (47)	44 (47)	4.04 (6.06)	4.63 (6.48)	22 (24)	22.83 (26.10)
Agri-silviculture	2 (12)	50 (50)	-	3.85 (5.77)	21.33 (30)	19.29 (24.44)
Silvi-pasture cultivation	37 (52)	28.83 (33.33)	11.43 (17.14)	-	30 (32)	26.81 (33.61)
Vegetative barriers	22 (22)	-	-	0 (2)	2 (4)	8 (9.33)

Note: Figures presented in parentheses are also percentage of farmers adopted the technologies initially at the time of implementation of watershed programme.

cultivation in Ooty, bamboo Plantation in Chandigarh, and vegetative barriers in Vasad.

Discontinuance of agroforestry based SWC technologies

The data about the discontinuance of agroforestry SWC technologies recorded from various developed watersheds in the country are given in Table 3. Results showed that tree plantation practices were initially adopted by 26.10% farmers while discontinued by only 3.27% of farmers. Agri-silviculture practice was initially adopted by 24.44% farmers but 5.14% farmers discontinued. Silvi-pasture cultivation practice was initially adopted by 33.61% farmers, but was subsequently discontinued by 6.8% farmers.

As revealed in fig.2. Bamboo plantation, live hedge and vegetative barriers was discontinued by 16.11%, 10% and 3% of farmers respectively, whereas 18.58%, 17% and 2% farmers, respectively initially adopted these technologies for soil and water conservation for sustainable watersheds management. In

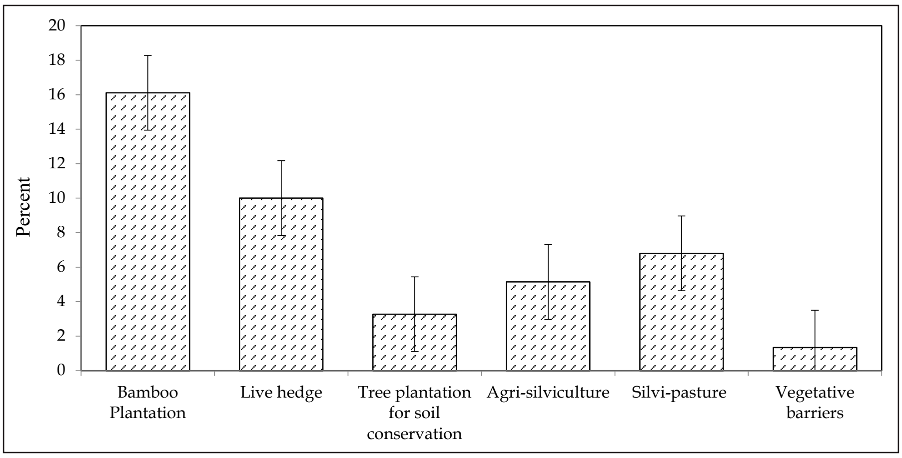

Fig. 2. Percentage of farmers discontinued agroforestry based SWC technologies.

Table 3. Discontinuance of agroforestry SWC technologies by farmers in different watersheds implemented by IISWC and its Research Centres in India

Name of Technologies discontinued in watersheds	Number of farmers					Mean
	Vasad	Dehradun	Chandigarh	Bellary	Ooty	
	Navamota, Rebari, Sarnal, Antisar &Vejalpur Rampura (N=250) %	Fakot, Raipur, Sabhawala & Langha (N=211) %	Aganpur, Bhagwasi, Mandhala, Johranpur, Sabeelpur & Kajiyana (N=225) %	Joladarasi, Chinnatekur, PC Pyapli, Mallapuram & Chilakanahatti (N=266) %	Salaiyur, Chikkahali, Ermanaikkanpatti, Patthuvampalli & Thulukkamuthur (N=250) %	
Bamboo plantation	40 (43.33)	8.33 (8.33)	0.0 (4.08)	-	-	16.11 (18.58)
Tree plantation for soil conservation	7.5 (47)	3 (47)	2.02 (6.06)	1.85 (6.48)	2 (24)	3.27 (26.10)
Agri-silviculture	10 (12)	0 (50)	-	1.92 (5.77)	8.67 (30)	5.14 (24.44)
Live hedge of Thor, Vilayti babul, Sisal	10 (17)	-	-	-	-	10 (17)
Silvi pasture cultivation	15 (52)	4.50 (33.33)	5.71 (17.14)	-	2 (32)	6.80 (33.61)
Vegetative Barriers	0 (22)	-	-	2 (2)	2 (4)	1.33 (9.33)

Note: Figures presented in parentheses are also percentage of farmers adopted the technologies initially at the time of implementation of watershed program.

different regions, maximum discontinuance was reported for tree plantation for soil conservation, agri-silviculture and silvi-pasture cultivation, bamboo plantation in Vasad region. The important reasons for discontinuance of agro-forestry technologies were scarcity of irrigation water, lack of maintenance, shade effect, animal grazing, less timber value with slow growth and tree cutting by local people as perceived by farmers of watersheds.

Technological gap in agroforestry based SWC technologies

Continued adoption of agroforestry SWC technologies with technological gap by farmers are presented in Table 4. Results revealed that out of 33.61% farmers, a maximum 17.68% farmers continuously adopted silvi-pasture cultivation practices with technological gap. Tree plantation practice with technological gap was adopted by 16.64% farmers out of 26.10% farmers (initially adopted) for soil conservation in their fields. In Fig. 3, it is clearly represented that Agri-silviculture technology with technological gap was adopted by 15.02% of farmers, compared to initially adoption by 24.44% of farmers for soil and water conservation. Live hedge, bamboo plantation and vegetative barriers measures with technological gap were adopted by 5%,

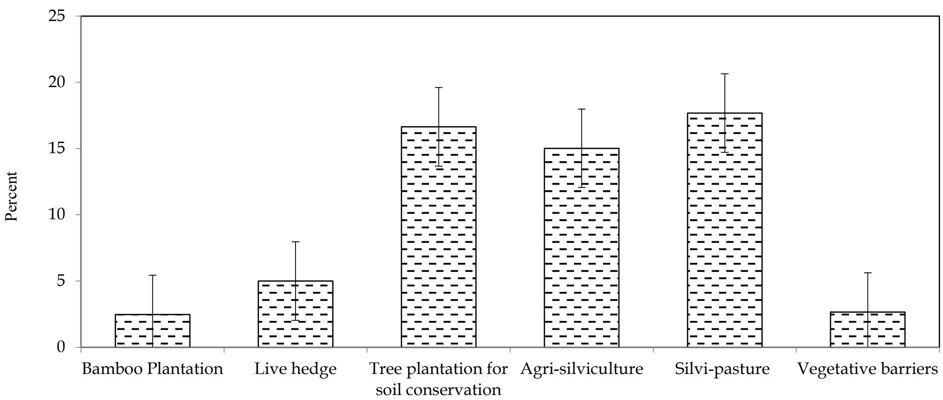

Fig.3. Percentage of farmers reported technological gap in different agroforestry based SWC technologies.

Table 4. Technological gap in agroforestry SWC technologies adopted by farmers in different watersheds implemented by IISWC and its Research Centres in India

Name of technologies adopted with technological gap in watersheds	Number of farmers					Mean
	Vasad	Dehradun	Chandigarh	Bellary	Ooty	
	Navamota, Rebari, Sarnal, Antisar & Vejalpur Rampura (N=250) %	Fakot, Raipur, Sabhawala & Langha (N=211) %	Aganpur, Bhagwasi, Mandhala, Johranpur, Sabeelpur & Kajiyana (N=225) %	Joladarasi, Chinnatekur, PC Pyapli, Mallapuram & Chilakanahatti (N=266) %	Salaiyur, Chikkahali Ermanaikkanpatti, Patthuvampalli & Thulukkamuthur (N=250) %	
Bamboo Plantation	3.33 (43.33)	0 (8.33)	4.08 (4.08)	-	-	2.47 (18.58)
Live hedge of Thor, Vilayati babul and Sisal	5 (17)	-	-	-	-	5 (17)
Tree plantation for soil conservation	31 (47)	44 (47)	3.3 (6.06)	0.93 (6.48)	4 (24)	16.64 (26.10)
Agri-silviculture	2 (12)	50 (50)	-	1.4 (5.77)	6.67 (30)	15.02 (24.44)
Silvi-pasture cultivation	17 (52)	23.42 (33.33)	10.12 (17.14)	-	20.2 (32)	17.68 (33.61)
Vegetative barriers	6 (22)	-	-	0 (2)	2 (4)	2.66 (9.33)

Note: Figures presented in parentheses are also percentage of farmers adopted the technologies initially at the time of implementation of watershed program.

2.47% and 2.66% farmers respectively, whereas 17%, 2.47% and 9.33% farmers respectively initially adopted it during watershed management programs.

Comparison of agroforestry measures in different regions showed that the maximum continued adoption of agroforestry SWC technologies with technological gap was observed for agri-silviculture, silvi-pasture and tree plantation for soil conservation in Dehradun, bamboo plantation in Chandigarh, and vegetative barriers in Vasad.

Diffusion of agroforestry based SWC technologies

Diffusion of agroforestry based SWC technologies from various developed watersheds is given in Table 5 and Fig. 4. Overall data revealed that maximum diffusion was of the silvi-pasture practices and 11.25% farmers promoted this practice to other farmers' fields within watershed or nearby villages for soil and water conservation for sustainable watersheds management in the country. Tree plantation technology was diffused from 4.63%

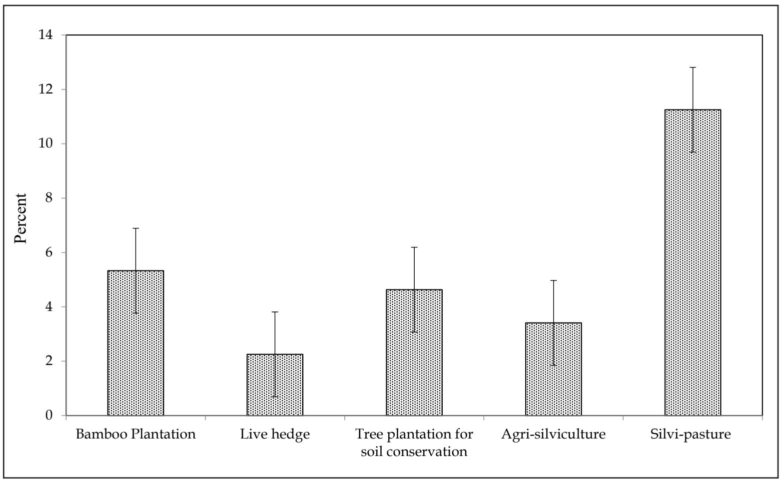

Fig. 4. Percentage of farmers diffused the different agroforestry based SWC technologies.

Table 5. Diffusion of agroforestry SWC technologies from farmers' field of different watersheds implemented by IISWC and its Research Centres in India

Name of Technologies diffused from watersheds	Number of farmers				Pool
	Vasad	Dehradun	Bellary	Ooty	
	Navamota, Rebari, Sarnal, Antisar & Vejalpur (N=250) %	Fakot, Raipur, Sabhawala & Langha (N=211) %	Joladarasi, Chinnatekur, PC Pyapli, Mallapuram & Chilakanahatti (N=266) %	Salaiyur, Chikkahali & Ermanaikkanpatti, Putthuvampalli & Thulukkamuthur (N=250) %	
Bamboo Plantation	5.33 (43.33)	-	-	-	5.33 (43.33)
Live hedge of Thor, Vilayati babul & Sisal	3 (17)	-	1.5 (9.39)	-	2.25 (13.19)
Tree Plantation for soil conservation	11 (47)	1.67 (47)	1.87 (3.38)	4 (24)	4.63 (30.34)
Agri-silviculture	2 (12)	6 (50)	2.63 (11.27)	3 (3)	3.41 (19.06)
Silvi-pasture cultivation	4 (52)	11.76 (33.33)	-	18 (32)	11.25 (39.11)

Note: Figures presented in parentheses are also percentage of farmers adopted the technologies initially at the time of implementation of watershed program.

farmers' fields to other farmers' fields for soil conservation. Agri-silviculture technology was diffused from 3.41% of farmers' fields to other farmers' fields. Live hedge and bamboo plantation technology was diffused from 2.25% and 5.33% of farmers' fields to another farmer, respectively. Regional performance of different measures showed that maximum diffusion of agroforestry SWC technologies was observed for silvi-pasture in Ooty, and agri-silviculture, tree plantation and live hedge in Dehradun.

Extent of post-adoption response of farmers towards agroforestry SWC technologies

The extent of post-adoption response of farmers towards different agroforestry SWC technologies adopted during various watershed development programs is given in Table 6 and Fig. 5. It was revealed that the overall **TCAI** value shows that 66.95% of agroforestry based SWC technologies were continued adopted by farmers in the watersheds. Accordingly, overall DTI value shows that 33.05% of agroforestry based SWC technologies were discontinued by farmers from their fields in the watersheds developed. The overall TGI data revealed that 46.08% of agroforestry SWC technologies were continuously adopted with technological gap by farmers in their fields in the watersheds developed. Diffusion of agroforestry SWC technologies were also studied with the help of Technology Diffusion Index (TDI) and it

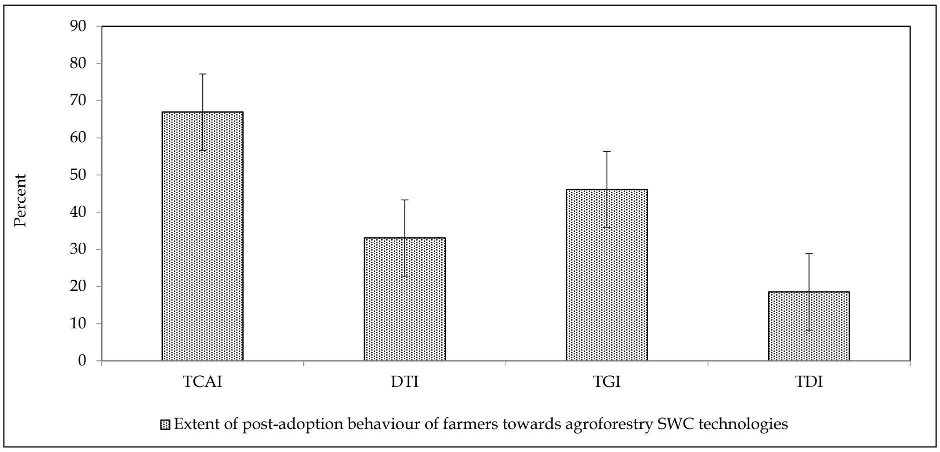

Fig. 5. Overall extent of post-adoption behavior of farmers towards agroforestry SWC technologies

Table 6. Extent of post-adoption behavior of farmers towards agroforestry SWC technologies in various watersheds implemented by IISWC and its Research Centres in India

Extent of post-adoption behaviour of farmers	Watersheds developed by Research Centres of IISWC in India					Overall Mean
	Vasad	Dehradun	Chandigarh	Bellary	Ooty	
	Navamota, Rebari, Sarnal, Antisar & Vejalpur Rampura (n=250) (%)	Fakot, Raipur, Sabhawala & Langha (n=211) %	Aganpur Bhagwasi, Mandhala Johranpur, Sabeelpur & Kajiyana (n=225) (%)	Joladarasi, Chinnatekur, PC Pyapli, Mallapuram, Chilakanahatti (n=266) (%)	Salaiyur, Chikkahali Ermanaikkanpatti, Putthuvampalli, Thulukkamuthur (n=250) (%)	
TCAI	57.33	88.58	71.66	59.51	83.7	66.95
DTI	42.67	11.42	28.34	40.49	16.3	33.05
TGI	33.27	84.68	64.15	16.35	36.52	46.08
TDI	14.78	14.91	-	24.95	42.37	18.52

was found out to be 18.52% for agroforestry based SWC technologies were diffused to other farmers' fields in nearby areas or villages from the fields of farmers' who were adopted these technologies during the watershed development programs implemented.

Soil and Water Conservation (SWC) practices have been successfully tested through various development projects in the India and other countries. It is imperative to create favourable conditions so that large number of farmers can take advantage from SWC practices (Asnake *et al.*, 2018). For continue adoption of SWC technology in the catchment area of watershed, farmers should have sufficient knowledge about the technology performance, benefits from technology, and need for its implementation of such as reduction in soil loss & runoff, increase in crop production, water conservation, and ground water recharge etc., as per the need of farmland for sustainable resource conservation and management. Agroforestry based SWC technologies should be adopted according to topographic condition, water availability, land slope and land erodibility in catchment area of watershed for the continue adoption. Moreover, before adopting any SWC technology in the catchment, farmers consider information about the technology, topography of the farmland, potential benefits and social interaction (Simon *et al.*, 2012).

Our results showed the medium levels of continuous adoption of agroforestry practices in the farmers' fields. Farmers' continue adoption of agroforestry practices depends on the environmental and economic benefits from the implemented practices. The medium level of adoption may be resulted from the incomplete knowledge about practice, interaction with the other practices, poor management and lesser potential benefits. Previous findings have also reported the medium level of adoption of forestry practices in India (Kandwal and Rampal, 2019). Similarly, Bagdi and Joshi (2018) also reported that three-fourth (76.02%) of farmers showed moderate level of participation in implementing SWC technologies for watershed management.

Results further showed that one-third agroforestry based SWC practices were discontinued by farmers from their agricultural fields. There may large number of reasons to discontinue a particular practice in the farm field. As agroforestry based SWC provides greater role soil and water conservation compared to other benefits. Therefore, greater intangible benefits and lesser tangible benefits may discourage farmers to discontinue the adopted practices. However, there may be other factors that discourage farmers to continue adopt a particular agroforestry based interventions. Woldeamlak Bewket (1998) reported that the major factors discouraging farmers from SWC technologies were labour shortage, land tenure insecurity and less effectiveness of technologies as per the farmers' requirements and to the farming system circumstances. Bagdi (1997) also reported that the reasons for discontinuance of agricultural technologies were the availability of alternative new or better technologies, negative consequences, non-availability of inputs and low profitability from technology. However, lack of information/guidance, non-availability of inputs and unwillingness were also considered as major reason for low/no adoption of different soil and water conservation (SWC) practices (Dhammu *et al*., 1998; Kadam *et al*., 2001 and Kumar, 2005).

Technological gap was also reported in the adoption of different agroforestry based SWC technologies. Lack of regular training, exposure visits and demonstration of and administrative and financial constraints may be reason for the technological gap in implementation of agroforestry based SWC. Das *et al*. (1998) has also reported that education, farm power, material possession, social participation, socio-economic status, extension contact, and mass media exposure has significant and negative association with the technological gap. Poor farmers are not taking proper care and maintenance of SWC structures after project withdrawal by PIA due to lack of money and resources. Therefore, financial provisions should be made for repair and maintenance of SWC technologies to adopt them in proper complete technology package without any technological gap after completion of watershed projects. Patil (1990), **Gupta *et al*. (1993) or Gupta and Sood, 1993**, Kalasariya *et al*. (1998), Singh (2007), Maraddi *et al*. (2008) reported that overall majority of the farmers belonged to medium technological gap category in adoption of agricultural production technology.

Once agroforestry based SWC adopted, it may be transferred or diffused to the another farmers by various means. This study revealed that out of total adopted agroforestry SWC practices, one-fifth of them were also diffused to other farmers' fields in nearby areas or villages from the fields of farmers' who have adopted these technologies during the implementation of watershed development programs. The diffusion of agroforestry technology might be increased among farmers who have adopted and who are potential adopters, and social networking could play an important role in spreading agroforestry as a sustainable practice. Silvopastoral systems may be included as a policy strategy for the mitigation of consequences of climatic change, such as burning and destruction of grasslands, decrease in milk production, and death of livestock (Roberto Jara-Rojas *et al*., 2020).

Conclusion and policy implications

It could be concluded from the study that in the government sponsored watershed development programmes, two-third (66.95%) of agroforestry based SWC technologies were continuously adopted for natural resources conservation, while one-third (33.05%) of them were discontinued due to their non-suitability or inability of farmers to continue the technologies. Out of the total adopted technologies, about forty six percent (46.08%) of agroforestry based SWC technologies were also continuously adopted with the technological gap. It could be inferred from the findings that on completion of government sponsored watershed development programme or on withdrawal of watershed project by Project Implementing Agency (PIA), farmers are unable to take care and maintain the agroforestry based SWC technologies implemented in their fields for management of watersheds due to paucity of funds and lack of laborers. It was also concluded from the study that about one-fifth (18.52%) of agroforestry SWC technologies were also diffused to other farmers' fields in nearby areas or villages from the fields of farmers' who initially adopted these agroforestry SWC technologies during the watershed development programmes implemented by IISWC and its Centres in the country for the cause of sustainable agricultural production along with conservation of natural resources like soil and water.

Important implications of the results were that, sensitization of farmers and watershed development agencies is needed towards to give more emphasis to suitability of agroforestry SWC technology to catchment area of watershed according to topographic condition, slope of land, erodibility of land, and water availability in catchment area of watershed for their longer continued adoption. In respect to mitigate the technological gap in adopted technologies the provisions of finance or farm equipments on custom hiring basis should be provided to poor farmers at the end of watershed development project from the fund of watershed project so that the agroforestry based SWC practices could be repaired and maintained by farmers in case of non-availability of fund or laborers for achieving the long-term sustainable benefits to farmers. Implication regarding more and wider diffusion of SWC technologies for watershed management, the agroforestry SWC technologies should be transferred in watershed catchment areas where reduction in runoff & soil loss, more moisture conservation and ground water recharge is required.

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