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Can farmer-to-farmer communication boost the dissemination of agroforestry innovations? A case study from Sulawesi, Indonesia

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Abstract Research agencies generate a vast number of agroforestry innovations, many of which have significant potential to increase productivity and to improve livelihoods. However, the dissemination of information related to these innovations and their adoption rate remains low throughout Indonesia, particularly in areas with a low level of infrastructure development, such as in Sulawesi, Indonesia. In areas such as these, interpersonal communication between farmers (*farmer-to-farmer interpersonal communication*) is a significant means by which farmers obtain information related to agroforestry innovations that they may utilize to improve the productivity of their plots. Given the significance of this channel of communication, further investigation is merited to assess how it might be leveraged to improve the dissemination of information related to agroforestry innovations and how it can complement the use of other communication channels. Thus, this study was conducted to identify how farmer-to-farmer interpersonal communication is used and the extent to which it is a preferred means by which information related to agroforestry innovations is disseminated in Sulawesi, Indonesia. Data was collected through semi-structured interviews involving 144 farmers (40 % female) from 12 villages in the provinces of South Sulawesi and Southeast Sulawesi, Indonesia. Results show distinct differences in terms of farmers' preferences for the various types of disseminators of information related to agroforestry innovations between provinces and genders. It was found that farmers play a significant role as reliable disseminators of information related to agroforestry innovations to a greater extent in areas where farmer's access to government extension agents is limited and where language barriers act as a constraint to the dissemination of information by these agents. Farmer-to-farmer communication is not the only communication channel for the dissemination of the information, but it is preferred by farmers who only speak local languages. Thus, to enhance the dissemination rate of agroforestry innovations, farmer-to-farmer communication channels should be utilized to complement the use of other channels. In areas where farmer-to-farmer communication channels are preferred, deliberate measures to improve expert farmers' and opinion leaders' access to information related to agricultural and agroforestry innovations will facilitate the effective dissemination of this information amongst a greater number of farmers.

Keywords Communication channels · Expert farmers · Extension agents · South Sulawesi · Southeast Sulawesi

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Introduction

Rogers (2003) defines an innovation as an idea, practice or object that is perceived as new to an individual or another unit of adoption. Most innovations are generated to solve perceived problems or needs, with expectations that the innovation in question will be adopted by those experiencing these perceived problems or needs. In agroforestry, innovations are generated both by farmers and researchers. On the whole, farmers are more likely to generate plot-level agroforestry innovations, while researchers are more likely to generate innovations intended to improve levels of agroforestry productivity from the plot level to the landscape level. Over the past 35 years, researchers have produced innovations in agroforestry to enhance plot-level production through improved germplasm and land management practices, improved market access, measures to diversify incomes, and through measures to increase the contribution of agroforestry systems to ecosystem services (Beer et al. 2005; Leakey et al. 2012). These innovations have had a positive influence in terms of improving livelihoods and the quality of the environment in rural areas. However, the level of dissemination of these innovations and their adoption by farmers is still low (Pattanayak et al. 2003; Mercer 2004; Mwase et al. 2015).

The dissemination of information related to innovations represents a specific stage in the innovation-decision process. This stage can be described as the *knowledge stage,* or the first stage by which the innovation becomes known to its intended users (Rogers 2003). The formation of an attitude towards the innovation; the decision to adopt or reject the innovation; the implementation of the innovation; and confirmation of the decision are the following stages in the process. The process of disseminating information related to innovations is an important stage, because when the intended users of the innovation know more about the innovation in question, this will reduce the level of uncertainty related to its advantages and disadvantages. In turn, this will lead to a greater chance that the innovation will be adopted. In general, the dissemination of innovations depends on at least two factors, these being: (1) the complexity of the innovation itself; and (2) the communication channels used to create awareness of its existence (Rogers 2003). Farmers are more likely to be interested in simple innovations that can be applied to their plots, or plot-level agroforestry innovations. Farmers usually become aware of such innovations from their peers. However, they may also become aware of these innovations from extension agents, mass media and other channels. In the case of landscape-level agroforestry innovations, extension agents and researchers are the most significant sources of information regarding the innovation.

Extension agents are expected to play a significant role in the dissemination of agroforestry innovations. However, in many developing countries, poor road conditions and other constraints have limited extension agents' access to isolated areas. These constraints have had a significant impact in a number of areas on Sulawesi, Indonesia (Martini et al. 2012). Farmers who cannot gain access to agroforestry innovations through extension agents often obtain information related to these innovations through internal systems involving communication with their peers (Pomp and Burger 1995; Isaac et al. 2007; Okwu and Daudu 2011). This channel can be described as *farmer-to-farmer interpersonal communication*.

The use of farmer-to-farmer communication to disseminate agroforestry innovations has been well-researched (Kiptot et al. 2006; Roshetko et al. 2007, 2013; Martini et al. 2008; Place et al. 2012; Matata et al. 2013; Mwase et al. 2015). Many researchers argue that farmer-to-farmer communication can further increase the dissemination of agroforestry innovations, with farmer-to-farmer communication complementing the use of other communication channels to disseminate agroforestry innovations. This study was conducted to determine the extent to which farmer-to-farmer interpersonal communication is the used and preferred for disseminating agroforestry innovations in Sulawesi, Indonesia, where most farmers depend on agroforestry system for their livelihoods (Janudianto et al. 2012; Khususiyah et al. 2012). Understanding how farmer-to-farmer interpersonal communication is used and why farmers prefer this channel of dissemination will assist in the development of cost-effective strategies for the dissemination of agroforestry innovations, particularly in areas with limited access to extension agents. The results of this study are expected to contribute to the development of an overall concept for the implementation of pluralistic extension systems in which farmers themselves play a significant role in the dissemination of agroforestry innovations.

Methodology

Study sites

Study sites were selected on the basis of varying levels of access to roads, electricity, and mobile phone signals. In particular; (i) South Sulawesi, the most developed region in Sulawesi, has relatively good access to roads, electricity, and mobile phone signals, which is characterized by a relatively high level of agricultural sector development; and (ii) Southeast Sulawesi, which is characterized by moderate to poor levels of infrastructure and agricultural sector development. The level of access to infrastructure, particularly road access, is one of the key aspects facilitating the achievement of a high level of agricultural sector development, specifically in terms of improving farmers' access to information and markets. In each of the two provinces, two districts in which agroforestry is the main source of local livelihoods were selected for this study. Specifically, these were the districts of Bantaeng (5°21′–5°35′S, 119°51′–120°5′E) and Bulukumba (5°20′–5°40′S, 119°50′–120°28′E) in South Sulawesi; and Konawe (2°45′–4°30′S, 121°15′–123°15′E) and East Kolaka (2°45′–5°00′S, 121°00′S–122°15′E) in Southeast Sulawesi (see Fig. 1). In each district, three villages were selected through purposive sampling, with a selection based on a consideration of the distance of the village to the district capital, which typically serves as the center for the dissemination of agricultural information. Selecting villages located at varying distances from the district capital was intended to facilitate an examination of a range of different situations in each district.

In both provinces, the predominant source of farmers' livelihoods is agroforestry systems involving the cultivation of cocoa, coffee, clove, fruits (durian

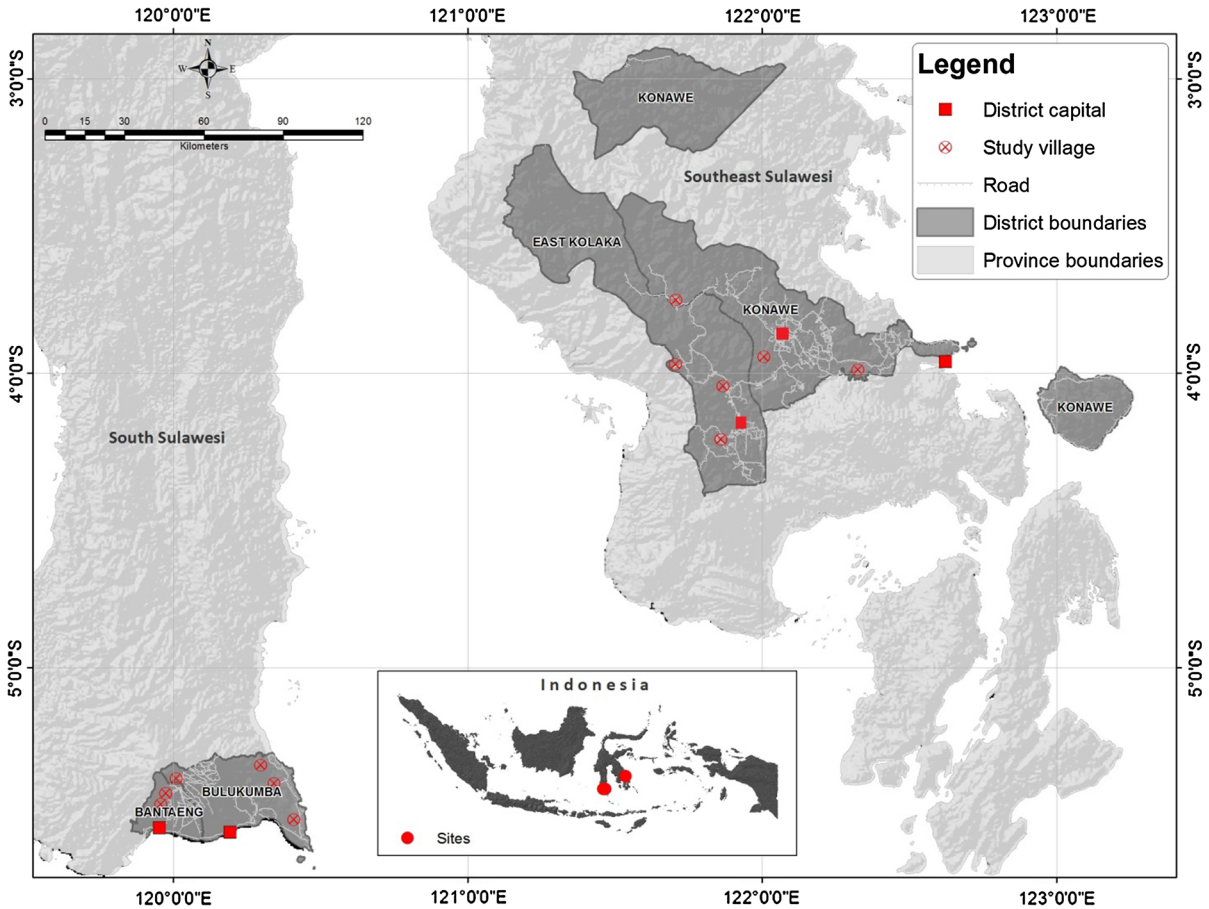

Fig. 1 Location of the study sites in South and Southeast Sulawesi provinces, Indonesia

and other tropical fruits) and pepper as the main commodities (Janudianto et al. 2012; Khususiyah et al. 2012). Each province has a different ethnic composition, with a more highly diverse composition in the districts in Southeast Sulawesi, with multiple ethnic groups, including migrants (Bugis, Makassar, Balinese, Sundanese, Javanese, Tolaki, Muna, Buton), compared to the districts in South Sulawesi, in which the vast majority of inhabitants consist of only two ethnic groups (Makassar and Bugis). In Southeast Sulawesi, communication between members of the varying ethnic groups is generally facilitated through the use of Indonesian, the national language. By contrast, with the limited level of diversity in South Sulawesi, with more communication between members of the same group, local languages are used to a much greater degree.

In both provinces, agricultural extension agents play a significant role in facilitating farmers' access to information and technology (Martini et al. 2012). However, government agricultural extension agents struggle with major challenges in their endeavors to improve their services. The most significant of these challenges are as follows: (i) the limited number and support of government extension officers; (ii) the lack of resources and facilities such as vehicles, research facilities, and resource centers; and (iii) limited budget allocations from central government for the implementation of extension activities.

Data collection

Data was collected in the period from October to November 2012 through semi-structured interviews. Data related to respondents' individual background, including data related to age, gender, education, ethnicity, social status, common language, and migration attitudes, were recorded during the interviews. In each province, interviews were conducted with 72 respondents from 6 villages, 12 respondents per village and 40 % of the respondents being female, with the primary occupation of all respondents being farmer. In addition, the interviews were used to collect information related to:

(a) *Dissemination of agroforestry innovations*: Respondents were asked to select the agroforestry innovations that they regarded as most important that they had become aware of and tested over the past 5 years. They were also asked to state the means by which they had learnt of these innovations.
(b) *Trusted and accessible sources of agricultural information in the village*: Each respondent was asked to list the five most frequently used sources of agricultural information and asked which of these sources they considered the most trustworthy and their reason for selecting it.
(c) *Farmer's preferences for farmer-to-farmer interpersonal communication for the dissemination of new agroforestry technologies:* Respondents were asked to rank in order of preference communication channels used for the dissemination of agroforestry innovations from a list including channels such as farmer-to-farmer, farmer-to-extension agents, farmer-to-researchers, and mixed channels. The provided list was obtained on the basis of direct observations and interviews with key stakeholders in each village before the survey was conducted.

Data analysis

Data related to respondents' personal characteristics, sources of information and communications media considered to be most accessible, farmers' preferences in terms of the channels of dissemination for agroforestry innovations, in the two provinces was analyzed through the use of descriptive statistics. A probit regression analysis was used to determine significant factors that affected farmers' preferences related to the channels used for the dissemination of information related to agroforestry innovations. All statistical analysis was conducted utilizing SYSTAT 11 software.

Results

Respondents' characteristics

An analysis of the data shows that the respondents were farmers of a productive age (average of 43 years old for men and 36 years old for women). The average level of educational attainment was higher in Southeast Sulawesi than South Sulawesi, mainly because migrants to Southeast Sulawesi had achieved higher

Table 1 Distribution of farmer's personal characteristics per district per gender in South and Southeast Sulawesi

Characteristics	Categories	Percentage of total respondents per gender per province			
		South Sulawesi		Southeast Sulawesi	
		Male (n = 42)	Female (n = 30)	Male (n = 42)	Female (n = 30)
Age (years)	20–35	21.4	50.0	21.4	60.0
	36–50	57.1	33.3	57.1	40.0
	51–65	19.0	16.7	19.0	0.0
	>65	2.4	0.0	2.4	0.0
Education	No school	19.0	13.3	0.0	0.0
	Elementary	35.7	60.0	38.1	30.0
	Junior HS	19.0	6.7	21.4	36.7
	Senior HS	16.7	13.3	33.3	26.7
	College	9.5	6.7	7.1	6.7
Common language	Local	35.7	43.3	0.0	0.0
	National	64.3	56.7	100.0	100.0
Ethnicity	Balinese	0.0	0.0	7.1	6.7
	Bugis	14.3	20.0	42.9	30.0
	Javanese	0.0	0.0	7.1	10.0
	Konjo	35.7	26.7	0.0	0.0
	Makassar	50.0	53.3	0.0	0.0
	Mixture	0.0	0.0	4.8	0.0
	Sundanese	0.0	0.0	0.0	3.3
	Tolaki	0.0	0.0	38.1	50.0
Social status	Common community	59.5	86.7	61.9	93.3
	Community leader	40.5	13.3	38.1	6.7
Migrants proportion	Local	76.2	80.0	21.4	30.0
	Migrant	23.8	20.0	78.6	70.0

levels of education in their place of origin. In South Sulawesi, 19 % of the male respondents and 13 % of female respondents had not participated in formal education at all, while all respondents in Southeast Sulawesi had participated in formal education at least to some degree (see Table 1).

As a result of the higher level of educational attainment and the greater degree of ethnic diversity in Southeast Sulawesi, the national language (Indonesian) was commonly spoken by all respondents. By contrast, only 60 % of respondents in South Sulawesi could speak Indonesian fluently, with the rest using local languages as their primary or sole means of communication (Makassar or Konjo). As stated previously, most of the population in the districts of South Sulawesi consisted of local ethnic groups (Makassar, Bugis and Konjo), while in Southeast Sulawesi, the level of ethnic diversity was considerably greater, with the indigenous group consisting of the Tolaki.

The population density of South Sulawesi stands at 176 persons/km^2, which is higher than the overall average population density for Indonesia, which stands at 135 persons/km^2. As a result of the relatively dense population in South Sulawesi, the average size of household agricultural land holdings is relatively small. It should be noted that there is a high level of migration from South Sulawesi to other areas of Indonesia where the population density is lower. By contrast, Southeast Sulawesi has a low population density, standing at 61 person/km^2. Thus, it is a target area for migrants from South Sulawesi and other parts of Indonesia with a relatively dense population, such as Java and Bali. Based on interviews with migrants to Southeast Sulawesi, the reasons for their migration to Southeast Sulawesi was to obtain better livelihoods (45.3 %); to contract a marriage (44.0 %); to join with parents (9.3 %); or to participate in a government transmigration program (1.3 %).

Dissemination of agroforestry innovations

In both study areas, farmers were generally familiar with agroforestry, with this system having contributed to local livelihoods for decades. However, farmers were not satisfied with level of income that they have derived from their agroforestry plots. Thus, they are constantly on the lookout for innovations to improve the productivity of their gardens to generate higher incomes. In Sulawesi, farmers tend to be prepared to directly test the new technologies of which they learn. In the past 5 years, farmers in the study sites have learned of and tested agroforestry innovations in areas such as: (1) intercropping new species in agroforestry systems; (2) vegetative propagation; (3) the development of nurseries to produce improved seedlings; and (4) the production and application of organic fertilizers. The first three innovations are related to the utilization of new commodity species in farmers' agroforestry gardens as a means of generating higher levels of income.

Farmers learnt of agroforestry innovations in these areas from a range of different channels of dissemination, including from other farmers, the staff of agroforestry projects (both government and non-government), extension agents, opinion leaders, family, agricultural companies/private sector operators and traders. In both provinces, farmers participate in agroforestry projects implemented by government and/or by nongovernmental (NGO) agencies. Government-run projects include those implemented by the forestry department, agricultural department, and estate crop department at both the district and national levels. According to prevailing regulations, government extension agents at the sub-district level are expected to play a major role in monitoring the progress of the implementation of these projects. However, due to a lack of coordination between government extension agents at the sub-district level (who work under the district-level government extension agencies) with other district-level departments, farmers do not frequently receive extension services from government extension agents. It was noted that the level of coordination between different government departments is better in South Sulawesi than in Southeast Sulawesi. Thus, in Southeast Sulawesi, extension agents' visit farmers less frequently, with this resulting in respondents in this province not listing extension agents as a significant channel of dissemination for agroforestry innovations (see Table 2).

Between the two provinces, there are distinct differences regarding farmers' sources of information related to agroforestry innovations (see Table 2). In South Sulawesi, where traditional cultural values are still highly respected strong, opinion leaders are the most significant channel for the dissemination of information related to agroforestry innovations. By contrast, in Southeast Sulawesi, where access to extension agents is limited due to poor road access and poor governance issues, other farmers serve as the most significant channel of dissemination. In both provinces, the respondents ranked government agroforestry projects in second place as significant channels of dissemination. In Southeast Sulawesi, where there is a greater number of active NGO agroforestry projects, particularly those focusing on improving cocoa agroforestry systems, farmers received agroforestry technologies from these projects to a significantly greater degree than do their counterparts in South Sulawesi. In Southeast Sulawesi, the role of opinion leaders is not as significant as in South Sulawesi. This is largely due to the high level of ethnic diversity and the great number of migrants from other regions, which tends to mean that traditional cultural values are less significant in this province, with no single dominant culture. However, family contacts were a more significant source of information in Southeast Sulawesi, particularly in the case of migrants from South Sulawesi, many of whom had family members who had some knowledge on agroforestry innovations.

In both provinces, there was a significant degree of variation in terms of gender and in terms of the channels of information preferred by the respondents (see Table 2). In South Sulawesi, men listed extension agents as the most significant source of dissemination for agroforestry innovations, while women regarded the role of opinion leaders as more significant. This was the case because in South Sulawesi in particular, agricultural extension activities tend to target men to a greater extent than women, due to cultural values that prioritize agricultural work for men and domestic work for women, with these values being particularly predominant in the Bugis and Makassar ethnic groups. Interestingly, when people from these groups migrated outside their place of origin, women benefited from agricultural extension services to a relatively greater degree. Another reason why women have limited access to extension agents is that most agricultural

Table 2 Farmers' preferences on disseminators of agroforestry innovations in South and Southeast Sulawesi

Category	South Sulawesi		Southeast Sulawesi	
All gender (n SS = 51; n SE = 57)	Opinion leaders (%)	23.5	Farmers (%)	29.8
	Government agroforestry project (%)	21.6	Government agroforestry project (%)	26.3
	Farmers (%)	15.7	NGO agroforestry projects (%)	19.3
	Extension agents (%)	15.7	Family (%)	12.3
	Private sector (%)	9.8	Opinion leaders (%)	8.8
	Traders (%)	7.8	Private sector (%)	3.5
	NGO agroforestry projects (%)	3.9		
	Family (%)	2.0		
Men (n SS = 29; n SE = 33)	Extension agents (%)	24.1	Farmers (%)	39.4
	Government agroforestry project (%)	20.7	Government agroforestry project (%)	30.3
	Private sector (%)	17.2	NGO agroforestry projects (%)	15.2
	Opinion leaders (%)	13.8	Family (%)	6.1
	Farmers (%)	13.8	Private sector (%)	6.1
	Traders (%)	6.9	Opinion leaders (%)	3.0
	Family (%)	3.4		
Women (n SS = 22; n SE = 24)	Opinion leaders (%)	36.4	NGO agroforestry projects (%)	25.0
	Government agroforestry project (%)	22.7	Government agroforestry project (%)	20.8
	Farmers (%)	18.2	Family (%)	20.8
	Traders (%)	9.1	Farmers (%)	16.7
	NGO agroforestry projects (%)	9.1	Opinion leaders (%)	16.7
	Extension agents (%)	4.5		

Percentage are per total respondents per category per province

SS South Sulawesi, *SE* Southeast Sulawesi

extension agents are men, with female farmers often being reluctant to engage in activities with male extension agents.

In Southeast Sulawesi, male respondents were more likely to list other farmers as being significant channels of dissemination of information related to agroforestry innovations than were women. This was because knowledgeable farmers were themselves mostly male, as a result of which female farmers were reluctant to seek information from them. Thus, by contrast, the female respondents were more likely to list family members as being significant channels of dissemination. In Southeast Sulawesi, women listed NGO agroforestry projects as the most significant channel of dissemination, mainly because NGO agroforestry projects are often implemented with particular consideration to gender equity in the selection of participants. As a result, women were more likely to be able to participate in NGO agroforestry projects and to learn about new agroforestry technologies through this channel.

Trusted and accessible sources of agricultural information

The previous section showed that availability of trusted disseminators is an essential prerequisite for the uptake of agroforestry innovations by farmers. In this study, we examine sources of agricultural information as the key to determine which disseminators are accessible to farmers and which are perceived as being trustworthy. It should be noted that agricultural issues cover a broad range of issues in addition to those specifically related to agroforestry.

Farmers responses are different if they are asked to describe the sources by which they obtain broader agricultural information rather than merely information related to agroforestry innovations (see Fig. 2). A significant proportion of farmers in Southeast Sulawesi, particularly male farmers, state that the most trustworthy source of information related both to broader agricultural issues and to agroforestry innovations is other farmers, particularly farmers from the

same village. However, female farmers in Southeast Sulawesi considered family as the most trustworthy and accessible source of information related to agriculture in general, with NGO projects being the least significant source of information, in stark contrast to their responses related to channels of dissemination for information related to agroforestry innovations. This is because the number of NGO projects focusing on broader agricultural issues is not as great as those focusing on agroforestry projects. Similarly, for broader agricultural information, government extension agents were considered to be in the top three most trustworthy and accessible sources of information, because based on their experience, farmers believe that activities implemented by agricultural extension agents yield significant benefits. Another reason is that the number of extension agents focusing on broader agricultural activates is greater than the number of extension agents specializing in agroforestry. Programs broadcast by organs of the mass media, particularly television and radio programs, are also listed as a trustworthy and accessible source of information, although the frequency of shows providing this type of information has declined over the past few decades.

In South Sulawesi, there were also significant variations in the responses related to preferred channels of dissemination for information related to agroforestry innovations and for broader agricultural information. Overall, respondents listed government extension agents as the most trustworthy and accessible source of agricultural information, with the main stated reason being that respondents believe that extension agents provided practical and useful information. Most male respondents believe that these extension offices were the most trustworthy and accessible source of information both for information related to agroforestry innovations and for broader agricultural information. However, female respondents tended to consider other farmers from the same village to be the most trustworthy accessible source of broader agricultural information, with the reason stated being that other farmers were more available than opinion leaders, whom the female respondents ranked as the second most trustworthy source of information.

The variations in the responses between the two provinces show that farmers' preferences for communication channels are not only influenced by the perceived reliability of the dissemination channel, but also by the availability of that channel in the village in which they are located. Another interesting fact is that farmers play a major role as a source of information on agricultural and agroforestry issues in areas where farmers' access to government extension agents is limited. However, in both provinces, government extension agents are still considered as an important channel of dissemination, as they are regarded as being well-trained and therefore able to provide reliable, practical information related to new agricultural or agroforestry technologies.

Preferred communication channels for disseminating agroforestry innovations

The information provided in the previous two sections has implications for the potential of a number of communication channels for the dissemination of agroforestry innovations. Farmer-to-farmer communication and farmer-to-extension agents are two of the channels described above. Other channels that have not been discussed but that also have potential include farmer-to-researcher channels and a combination of a number of different channels, with these methods being used for the dissemination of agroforestry innovations through plot-based garden demonstration trials.

The farmers in the two study provinces have different preferences regarding the type of communication channels used for the dissemination of agroforestry innovations (see Fig. 3). As described previously, farmers in South Sulawesi tend to prefer farmer-to-farmer channels. By contrast, farmers in Southeast Sulawesi farmers tend to prefer mixed channels (with demonstration plots used as an extension media). The very limited number of respondents stating that they preferred farmer-to-researcher channels is because this type of channel is not widely utilized in the study areas. The farmer-to-researchers channel is only utilized when researchers conduct participatory action research in the village to test farmers' responses of new technology they produced.

A probit analysis (Table 3) shows that only farmer-to-farmer communication channels display a significant difference between variables. The quality and availability of infrastructure is not a major variable differentiating farmers' preference for farmer-to-farmer channels. Rather, the language issue was more important in these terms. In general, farmer-to-farmer channels are preferred by farmers who only speaks the

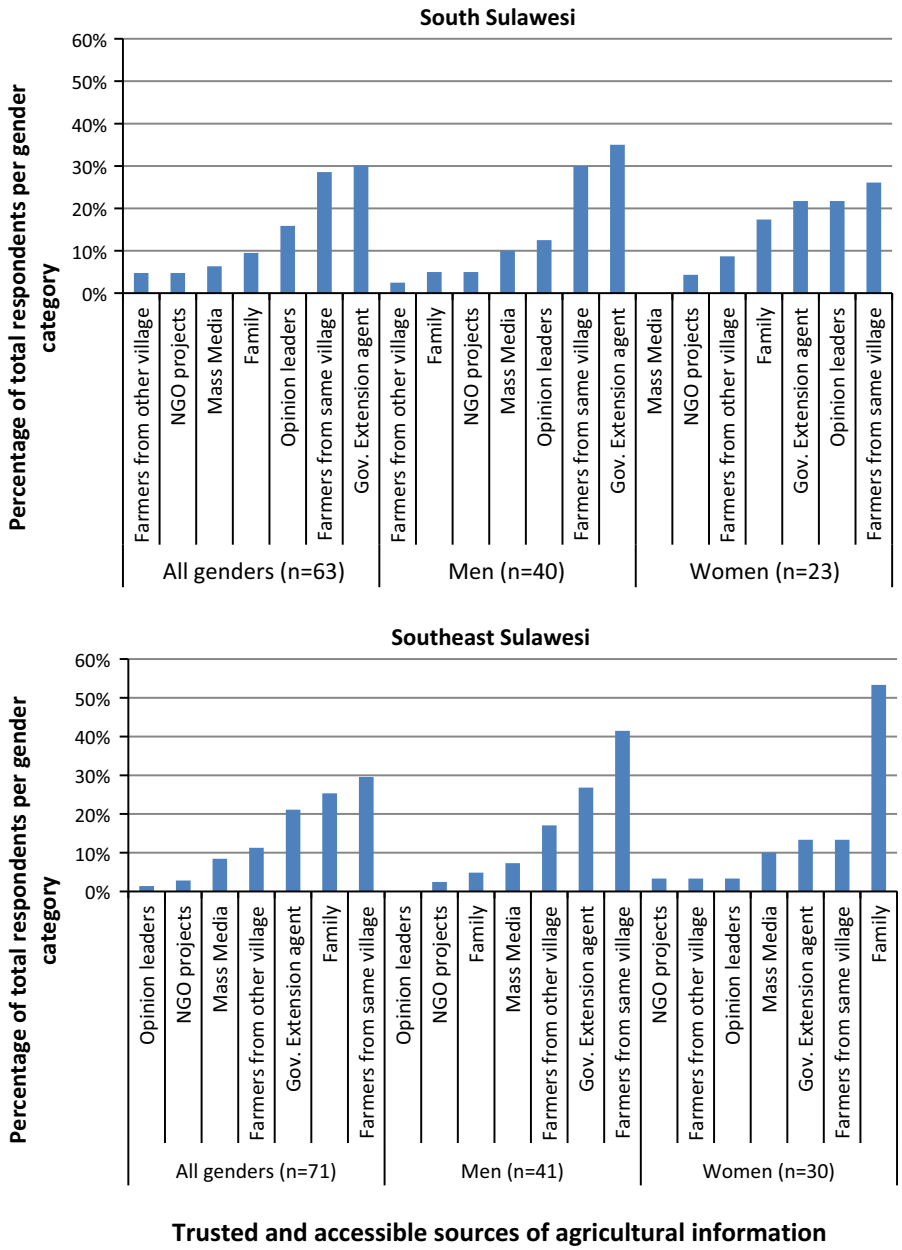

Fig. 2 Trusted and accessible sources of agricultural information in South and Southeast Sulawesi

local language and whose level of educational attainment is limited to the primary school level. Most of these cases were found in South Sulawesi (35.7 % of male farmers and 43.3 % of female farmers). A significant language barrier constrained the dissemination of agricultural information in South Sulawesi, where farmers or extension agents who can speak the local language were considered by respondents to be the most reliable source of information.

Based on the probit regression analysis, there was no statistically significant relationship between the other characteristics of farmers, including gender, age, education level, migrant status, and ethnicity, with farmers' preferences for the different types of interpersonal communication. In Southeast Sulawesi, men preferred the farmer-to-farmer channel to a greater extent than did women, while in South Sulawesi, there was no significant difference between the genders in

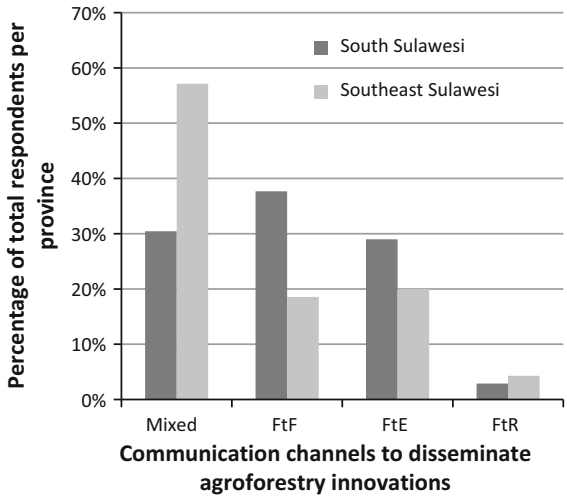

Fig. 3 Farmers preferences on type of communication channels for disseminating agroforestry innovations [i.e., Mixed channels, Farmer-to-farmer (FtF), Farmer-to-Extension agents (FtE), Farmer-to-Researchers (F-t-R)]

this regard. Young farmers (20–35 years old) in South Sulawesi and mature farmers (36–50 years old) in Southeast Sulawesi tended to prefer the farmer-to-farmer channel to a significantly greater degree. In both provinces, farmers with a level of educational attainment at or below the primary school level tended to prefer the farmer-to-farmer channel. In South Sulawesi, low levels of educational attainment are associated with poor fluency in speaking the national language (Indonesian), because the national language is learned and commonly spoken in schools. In South Sulawesi, there was no significant difference in terms of preference between the various ethnic groups. However, in Southeast Sulawesi, respondents who were members of the Bugis and Tolaki ethnic groups tended to prefer the farmer-to-farmer channel to a greater degree. In South Sulawesi, members of local indigenous groups were more likely to prefer the farmer-to-famer channel than were members of migrant communities in Southeast Sulawesi.

The fact that there was no statistically significant difference between respondents in terms of their preferences for types of communication channels (farmer-to-farmer, farmer-to-extension agents, farmer-to-researcher, mixed channels) shows that all of these channels can have the same level of importance for the dissemination of agroforestry innovations. Thus, for enhancing the dissemination rate of agroforestry innovations, those communication channels need to be implemented in a complementary manner.

Discussion

The results of the analysis show distinct differences in farmers' preferences for disseminators of agroforestry innovations between provinces and genders, with this difference being largely attributable to the availability

Table 3 Probit regression analysis on factors in farmers' preferences to communication channels for disseminating agroforestry innovations in Sulawesi, Indonesia

Variable	Farmer-to-farmer			Farmer-to-extension agents			Mixed		
	Estimated coefficient	SE	P value	Estimated coefficient	SE	P value	Estimated coefficient	SE	P value
Province	−0.175	0.63	0.779	−0.545	0.60	0.360	1.043	0.56	0.064
District	0.050	0.25	0.844	0.278	0.26	0.277	−0.386	0.24	0.103
Village	−0.012	0.04	0.766	0.017	0.04	0.662	−0.034	0.04	0.339
Gender	−0.050	0.26	0.848	0.177	0.27	0.507	−0.177	0.25	0.477
Ethnicity	−0.033	0.06	0.597	0.001	0.06	0.981	0.032	0.06	0.571
Age	−0.173	0.18	0.341	0.351	0.19	0.064	−0.101	0.18	0.566
Migrants	−0.063	0.32	0.843	−0.588	0.31	0.059	0.286	0.29	0.315
Language	−1.063**	0.37	0.004	0.154	0.38	0.681	0.703	0.39	0.068
Education	−0.197	0.10	0.055	0.041	0.10	0.666	0.032	0.09	0.719
CONSTANT	1.811	0.93	0.051	−1.868	0.95	0.050	−0.881	0.89	0.320

Probit analysis was not performed for farmer-to-researchers channel due to low number of responses

** $P < 0.001$

of trusted and accessible disseminators. In addition to other farmers as a channel for dissemination, farmers recognize extension agents as playing a major role in the dissemination of agricultural and agroforestry innovations. However, the constraints affecting extension agents often limit their visit to villages (Feder et al. 1999; Anderson and Feder 2004). The involvement of NGOs that promote agroforestry innovation also plays a significant role in the dissemination of the innovations (Franzel and Wambugu 2007). The mass media are another source of information that play a supporting role in the dissemination of agricultural innovations (Rogers 2003). However, in many areas in Indonesia where the quality of infrastructure is still poor, the level of farmer' access to mass media is limited. Also in Indonesia, the volume of agricultural information disseminated through mass media such as TV and radio is considerably lower than was the case 20–30 years ago.

There are significant variations in terms of preferences for channels of dissemination between the genders. Female farmers display a lower level of preference for extension agents or expert farmers as a channel of dissemination because most of these agents and farmers are male. Thus, female farmers prefer to obtain information from their family or from opinion leaders. They are also likely to prefer disseminators who give consideration to gender equity issues, particularly NGOs. This indicates that if extension services were to become more sensitive to gender equity issues, it would increase women's willingness to participate in activities implemented by agroforestry extension agencies.

Other farmers play a major role as trusted disseminators of agroforestry innovations, particularly in areas where farmers' access to government extension agents is limited. In areas where this access is limited, successful farmers and opinion leaders serve as the primary channels for the dissemination of agricultural innovations (Minh et al. 2011; Feder and Savastano 2006). Actors that play a role as disseminator include those who have a high level of access to agricultural or agroforestry innovations (Rogers 2003). Interactions between farmers and disseminators commonly involve interpersonal or face-to-face communication, which is the type of communication that farmers prefer (Pomp and Burger 1995; Glendinning et al. 2001).

Farmer-to-farmer communication is clearly not the only dissemination channel for agroforestry innovations, a view confirmed by Adhiguru et al. (2009). The level of development of infrastructure in a particular area is not the major factor determining farmers' preferences for farmer-to-farmer channels. Rather, language issues are a more significant factor. In addition to farmer-to-farmer channels, farmer-to-extension agents channels are also important. Lambert and Ozioma (2011) demonstrated that farmers with higher number of contacts with extension agents are more likely to adopt agroforestry innovations than farmers with the relatively low number of contacts with these agents. Regular contact with extension agents motivates farmers and exposes them to innovations, facilitating the provision of information that enables the adoption of new technologies.

Farmers prefer a combination of interpersonal interactions with different providers of information, with the combination of different providers enriching farmers' knowledge because the different sources give them different perspectives. These different perspectives provide a basis for farmers to justify decisions to improve their system of garden management (Winarto 2011). A demonstration trial can be used as a medium to facilitate the provision of information through a range of interpersonal communication channels (Martini et al. 2014). Extension agents are expected to play a role as initiators in the establishment of demonstration trials at village level.

In many areas, extension agents and researchers do not speak local languages because they are not natives of the area. Thus, even when extension agents and/or researchers have established channels of communication with farmers in villages, farmers who only speak the local language prefer to obtain information related to agriculture or agroforestry from other farmers. In areas where farmer-to-farmer communication is preferred, enhancing expert farmers and opinion leaders' access to agricultural and agroforestry innovations will enable a greater number of farmers to access the information (Kante et al. 2009).

Under Indonesian government regulations, expert farmers' role as extension agents is acknowledged as a means of complementing the services provided by formal extension agencies (UU No. 16/2006). The regulation stipulates that expert farmers should be supported by local government agencies to enable them to serve as volunteer extension agents through the provision of rewards such as increased access to training. For the local government, the cost of utilizing

farmers to serve as voluntary extension agents is far lower than the cost of hiring government extension agents (who receive monthly salaries and other benefits). Thus, the strategy of involving farmers in implementing extension services may be considered by government agencies with only a limited budget for the hiring of extension agents (Feder et al. 2010; Solomon 2011). This is an important consideration, given that limited budgets have restricted the number of government extension agents available to serve communities across Indonesia.

According to prevailing regulations governing agricultural extension systems in Indonesia, each village in the country should have a dedicated government extension agent. With a total number of 75,224 villages in Indonesia and a total of only 47,955 dedicated agricultural extension agents, this represents a gap of 27,269 extension agents (BP2SDMP 2013). To fill this gap, the Indonesian government currently engages 8000 volunteer extension agents (Syahyuti 2014), who are also farmers, to disseminate agricultural innovations. The government is also taking measures to improve the rewards systems for volunteer extension agents to ensure the sustainability and quality of the services provided by these volunteer agents. Kiptot and Franzel (2013) also state that improved systems of rewards are required to ensure the sustainability of the farmer-to-farmer extension approach, with these improvements being an integral component of required investments in human, social, and financial capital to motivate volunteers to work effectively. The Indonesian government's initiative could also be replicated in other countries or areas where interpersonal communication between farmers (*farmer-to-farmer*) is the preferred channel for the dissemination of information as a result of language barriers and farmers' limited access to external sources of agricultural information.

Conclusions

This study has demonstrated that farmers obtain information related to innovations in the area of agroforestry from a range of different sources, with preferences for various sources determined by which channels are available and perceived as being trustworthy. In areas where access to government extension agents is limited, expert farmers play a major role as disseminators of agroforestry innovation. In addition to expert farmers, opinion leaders are also important disseminators. Although farmers often rely upon expert farmers as a source of information, they also recognize agricultural extension agents as sources of practical information.

Various sources of agroforestry innovations influence the types of communication channels used to disseminate agroforestry innovations. Farmers preference for particular channels of dissemination, including farmer-to-farmer, farmer-to-extension agents, farmer-to-researchers, and a combination of those channels, is not greatly influenced by the quality and availability of infrastructure, but is significantly influenced by language barriers. In many areas of Sulawesi, particularly where language barriers prevent the effective provision of extension services, farmer-to-farmer communication channels enhance the dissemination of agroforestry innovations. However, farmer-to-farmer communication is not the only channel that may enhance the dissemination of agroforestry innovation.

The existence of different type of disseminators is an advantage, with the deployment of different types of disseminators leading to dynamic, pluralistic extension services in which a range of actors play different roles in the dissemination of innovations. A pluralistic system of extension services could be expected to reduce government costs. Thus, the Indonesian government is seeking to reduce the operational cost of providing agricultural extension services by implementing a more pluralistic system that involves farmers as volunteer extension agents. However, the role of farmers in disseminating agricultural or agroforestry innovations is still limited. To enhance the participation of a range of actors in the provision of agricultural extension services, it is vitally necessary that the government formulate and implement the appropriate policies to support the development of such a system.

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