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Original

Dual Role of Irrigation Schemes for NERICA Diffusion in the Central Highlands in Kenya: Sources of Supplemental Water and Technology Information

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Abstract. This paper considers the possibility of the diffusion of NERICA, new upland rice varieties, in the Kenya's central highlands, where few farmers have ever grown upland rice, particularly focusing on the role of irrigation schemes. The data we use were collected from 160 member farmers of 4 irrigation schemes and 80 non-member farmers living in the same command area of the irrigation through our own survey conducted in March 2012 at the beginning of the long rain season of 2012. We find that among the member farmers those who have more irrigation taps tend to adopt NERICA, implying that water availability from irrigation is an important factor that encourages farmers to grow NERICA. As for the knowledge about upland rice, we find that those who have heard about upland rice and/or have seen rice growing on upland are more willing to purchase or receive NERICA seed. If we compare farmers belonging to an irrigation scheme and farmers not belonging to any irrigation scheme, the former have better knowledge about upland rice. Thus, the irrigation schemes have a role of information dissemination among members, which may reduce the risk of the failure of new crop.

Key words: NERICA, Kenya, supplemental irrigation, farmers' group, dissemination

要旨　この論文は、陸稲を栽培したことのある農民のほとんどいないケニア中央高地における陸稲新品種のネリカの普及の可能性について、灌漑組織の役割に焦点をあてて検討する。使用するデータは、４つの灌漑組織に属する160名の農民とその灌漑の受益地に居住するが灌漑組織には所属しない80名を対象に、2012年大雨期の始まる2012年３月に著者らが自ら実施した調査により収集した。分析の結果、灌漑組織に属する農民の中では灌漑用水栓を多く持つ農家ほど、ネリカの採用に積極的であることが判明した。これは灌漑水が十分に利用できることがネリカの導入に重要な役割を果たすことを意味する。また、陸稲に関する知識については、陸稲のことを聞いたことがある農家、および実際に畑で育っているのを見たことがある農家の方が、ネリカを採用する傾向があることもわかった。そこで、灌漑組織に属する農民と属さない農民を比べると、前者の方が陸稲に関する知識が豊富である。つまり、灌漑組織は、所属するメンバー間で情報の交換が盛んであり、新しい作物を栽培することに対するリスクを軽減する役割を持っている。

1. Introduction

In sub-Saharan African countries, demand for rice has been increasing rapidly since 2000 when their long stagnated economies finally started growing. It led an increase in rice import, but an expansion of domestic rice produc-

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tion at the same time (Fig. 1). Kenya is not an exception. In terms of rice producing ecology, however, Kenya is special; 70% of rice field is irrigated and 80% of total domestic rice is produced in the irrigated ecology (Kenya Ministry of Agriculture, 2008). The figures are much higher than the average of sub-Saharan African countries where 17% of rice field is irrigated (Somado et al., 2008).

The Kenyan situation may have caused relatively low interest in the development of rain-fed rice. In the case of NERICA (New Rice for Africa), a group of new upland rice varieties developed by Africa Rice Center (formerly known as WARDA) in the 1990s, it had not been officially registered as new rice varieties until March 2009 in Kenya. On the other hand, in neighboring Uganda NERICA was formally released as early as in 2002 and the government began distributing NERICA seed widely in 2004 as in-kind credit (Kijima et al., 2006). Because rain-fed rice can be grown without irrigation facilities, NERICA was easily adopted by replacing other upland crops such as maize and beans, but it was easily abandoned at the same time. Fujiie et al. (2010) and Kijima et al. (2011) pointed out that erratic rainfall is one of the reasons of the discontinuation of NERICA production in Uganda. In addition, Fujiie et al. (2010) found that farmers belonging to farmers' groups tended to continue NERICA probably thanks to social leaning in the group (Conley and Udry, 2010). Thus, the objective of this paper is to explore how the new upland rice varieties are adopted and spread in the central highlands of Kenya, where farmers have never grown upland rice before.

Given the experiences in Uganda as mentioned above, this paper focuses on two factors that may affect the adoption of NERICA in Kenya. One factor is the role of supplemental irrigation facilities that have been developed in the central highlands in Kenya unlike in Uganda where no such irrigation is available for upland crops. The other factor is the role of farmers' groups, particularly the groups managing the irrigation facilities, in obtaining information on new crops. We hypothesize that supplemental irrigation will have a critical role in growing upland rice partly because it can reduce the problem of erratic rain. Since our dissemination of NERICA seed was conducted after farmers experienced severe droughts in 2010 and 2011 that affected the entire East Africa, they may be afraid that upland rice production will fail without irrigation. But another reason why we consider that supplemental irrigation is important is that it will allow farmers to plant NERICA seed a little earlier than the rain starts so that the upland rice can avoid cold temperature at the stages from panicle formation to flowering that may sterilize it. As for the farmers' group, we hypothesize that irrigation group members have better information through interaction with other members and hence are more willing to adopt NERICA (but only if the information is positive).

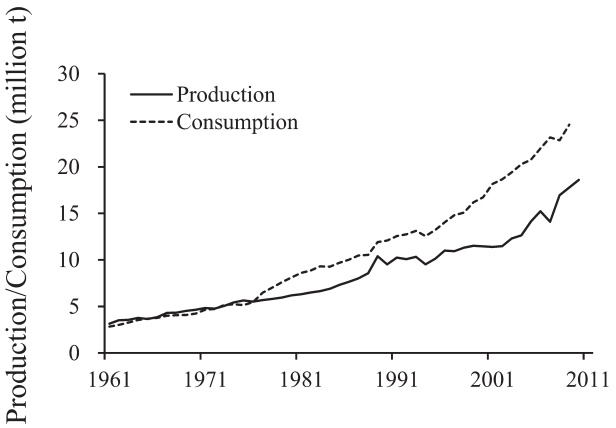

Fig. 1. Rice production and consumption in sub-Saharan Africa (paddy equivalent).
Source: FAOSTAT (7th August 2012)

2. Study site and data collection

As part of "Practical Study on Rice Promotion in the East African Highlands" implemented from 2009 to 2012 Japanese fiscal year, we selected our NERICA dissemination study site at altitudes between 1,200 and 1,500 meters above sea level in Embu county on the southeastern slopes of Mount Kenya in the central highlands of Kenya. Its capital city, Embu, is located approximately 120 km northeast of Nairobi; its coordinates are Latitude 0° 32' South and Longitude 37° 27' East; and its elevation is about 1,400 m. Annual average temperature and precipitation is 19.6 °C and 1,189 mm, respectively (Fig. 2). There are two rainy seasons in a year: "long rains" (March–June) and "short rains" (October–December). High altitudes receive more rainfall and there are many small rivers on the slopes of Mount Kenya. However, this area suffers from drought two or three times a decade, and erratic rainfall pattern affects the crop yield (Hirose, 1988).

Farmers conduct agriculture under rain-fed condition and harvest twice a year except for a few farmers who have access to irrigation water, as described later. Their main crops are maize, beans, banana (plantain), yams, cassava, millet, sorghum, vegetables, coffee, and tea. As mentioned in Introduction, upland rice had never been grown in this area until the recent introduction of NERICA. However, there are a few farmers who grow rice in rain-fed lowland probably influenced by the large irrigated rice field in Mwea located 25 km south of Embu. The Mwea irrigation scheme is the largest irrigation scheme in Kenya (7,860 ha) and produces about 50% of Kenya's total rice production according to Kenya's Ministry of Agriculture (2012). The influence of Mwea irrigation scheme may

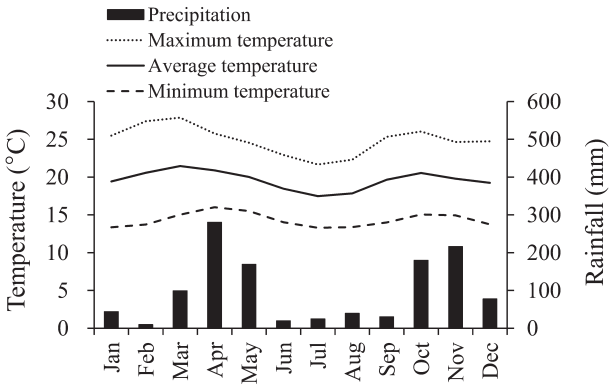

Fig. 2. Mean monthly rainfall and mean minimum, average and maximum temperatures (°C) in Embu.

be either positive or negative for upland rice production in the Kenyan central highlands: positive effects may be (i) upland farmers have ever seen rice growing at Mwea site and (ii) rice milling facilities are available around Mwea; but negative effects may be (i) upland farmers may consider that they cannot grow rice since rice grows only under irrigated condition and (ii) upland rice may not be competitive with lowland rice produced in Mwea in terms of productivity and quality.

Unlike the large-scale irrigation scheme in Mwea for lowland rice production, there are a number of small-scale irrigation schemes that distribute water in the streams to the upland plots of member farmers through pipes by gravity in Embu county.[1] In order to study the role of such small-scale, supplemental irrigation on the adoption of NERICA, we visited as many irrigation schemes listed by local agricultural offices as possible and interviewed the presidents and other responsible members in November 2011. Then, based on the information obtained by the interviews, we selected 4 irrigation schemes that showed general interest in growing upland rice. Then, in January and February 2012 we offered NERICA seed at 100 Ksh/kg (equivalent to 1.24 USD/kg as of February 2012) to the members of the selected 4 irrigation schemes taking the occasion of their member meetings.[2] Based on the results of NERICA seed sales, we randomly selected 20 member farmers who purchased NERICA seed and another 20 member farmers who did not purchased NERICA seed from each of the selected irrigation schemes. In addition, we randomly selected 20 non-member farmers from the command area of each irrigation scheme. Thus, the number of sample farmers amounts to 240, among which 80 members who purchased NERICA seed, 80 members who did not purchase NERICA seed, and 80 non-members living in the neighborhood. We conducted a household survey including questions about the knowledge and experience of rice production over the 240 sample farmers in March 2012.[3]

3. Irrigation schemes in the central highlands

In our study area, most farmers produce crops under rain-fed condition. But some farmers have access to irrigation systems to supplement water in cases of shortage particularly in the dry season (Photo 1). There are several

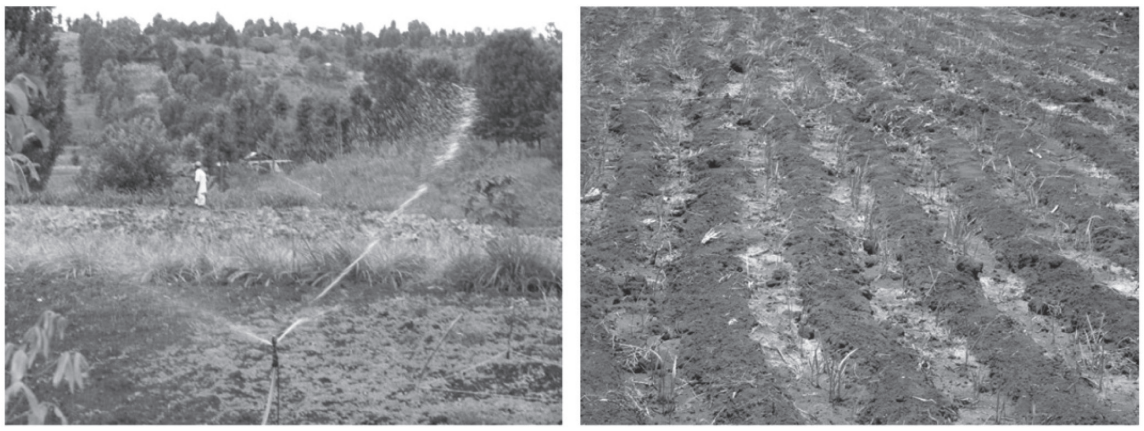

Photo 1. A sprinkler irrigation system to supplement water to farmer's fields in Embu (left), and NERICA seedlings grown under irrigated conditions (right).

[1] A small-scale irrigation scheme in the study site refers to a set of irrigation facilities and a farmers' group managing the facilities. Since an irrigation scheme includes a farmers' group, scheme members and group members are used interchangeably in this paper.

[2] We purchased "NERICA 4" seed from Mwea Irrigation Agricultural Development (MIAD) Centre in Mwea. They multiplied NERICA seed under irrigated condition to supply to farmers in the irrigation scheme. The seed were not certified because when we purchased the seed in February 2012, Kenya had not yet had a seed certification system for rice. Since our purchase price was about 75 Ksh/kg, our sales price of 100 Ksh/kg is considered to be closed to the market price that takes account of transportation cost.

[3] Due to some missing information, we use 157 member households and 76 non-member households in the following analyses.

ways to get water. Some farmers use private ponds constructed by themselves to store water and culture fish. Other farmers who live close to river fetch water from the river to water their fields. But being a member of an irrigation scheme is the most popular way to access irrigation water in this area. The irrigation schemes are organized and managed by farmers' groups to provide river water to the members through pipes.

3.1 The history

Since our study site is located on the foot of Mount Kenya, streams from the mountain usually have a plenty of water throughout a year. But only a few farmers could fetch water for crop production. Thus, in order to construct water distribution system from the river, farmers formed farmers groups called Self Help Group (SHG) during the 1990s, and registered under the Ministry of Gender, Sports, Culture and Social Services.

But a SHG was too small to collect enough money to install irrigation facilities, and hence they increased the number of members and finally formed a bigger organization, or an irrigation scheme (i.e., a group of farmers sharing irrigation facilities),[4] to be eligible to receive a financial assistance from donors.[5] As shown in Table 1, the number of members of sample irrigation schemes is between 200 and 400, which is much larger than a standard size of SHG (20–30 members). For the construction of irrigation facilities, each irrigation scheme got financial assistance from a different donor as shown in Table 1. As a result, the financing condition varies: Some received a grant, but others received a combination of loan and grant.

3.2 Fee and maintenance

Farmers must pay membership fee once when he/she becomes a member and maintenance fee each month. The membership fee does not differ much among the 4 groups as shown in Table 1.

The members pay a fixed amount to the irrigation schemes every month as a maintenance fee. The monthly payment varies as shown in Table 1, depending on the amount of loan and interest, since the maintenance fee is not only used for maintenance of the facilities but also allotted for loan and interest payments of the irrigation schemes. The irrigation schemes hire plumbers to maintain the piping system. If any accessory is stolen or damaged, the farmer who uses it is liable for the expense.

Although the gravity irrigation from rivers is cheaper than large irrigation systems that require dam and/or pump, the membership and monthly payment seem to limit the members to relatively wealthy farmers. However, its implication on poverty alleviation and income distribution is beyond the scope of this paper (for example, Burney and Naylor, 2012).

3.3 Water use regulations

The irrigation schemes set some rules to avoid water shortage. With respect to the watering methods, only sprinklers and dripping are permitted, and the use of drip irrigation is recommended. But actually, the farmers use other methods also. It does not come from farmers' ignorance of the rule, but rather they choose the best way depending on crops. For example, they use spot irrigation for bananas because bananas are sparsely planted. The sprinkler is said to be effective in spreading water widely, especially for french beans.

As for field size, each member is allowed to irrigate only one acre field (0.4 ha) for one membership even if he/she has bigger fields. As shown in Tables 2 and 3, average plot size under irrigation is 1.26 acres and average number of taps is 1.74. Almost half the sample households have two taps although some of them have only one acre plot under irrigation.

There are also restrictions in water use to avoid water shortage. First, members are not allowed to let non-members use water. Second, during a water shortage period, water use is limited. Farmers can irrigate only two or three days per week and are encouraged to use private ponds/reservoirs to avoid water shortage. Although this paper does not deal with water allocation problem among the members, it is always an important issue with any collective irrigation systems (Burney and Naylor, 2012; D'Exelle et al., 2012).

3.4 Penalty

If a member violates the rules/regulations, penalties will be applied. In case where a member fails to pay maintenance fee, his/her pipe will be disconnected, and eventually he/she will have to withdraw from the irrigation scheme. Then a new member will be placed to the vacant position once he/she pays membership fee.

If a farmer shares his water with a non-member or expands his/her fields over one acre, he/she will be charged a

[4] Irrigation schemes are different organizations from SHGs. SHGs still exist in the study site and some farmers belong to an irrigation scheme and one or several SHGs.

[5] In the case of GTZ-funded "Smallholder Irrigation Program," a farmers' group must pay an up-front contribution of 10% of total finance (loan and grant) before receiving the loan. In addition, the farmers' group must be registered as a cooperative society with a legal personality to receive the loan.

Table 1. Finance and management of irrigation schemes in Embu district

Irrigation scheme	Group A	Group B	Group C	Group D
Year of establishment	1992	2005	2003	1998
Number of members	300	255	378	220
Year financed	2002–2006	2008	2009	unknown
Donor	Plan International	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)	International Fund for Agricultural Development (IFAD)
Grant (M. Ksh)	29	31	30[1]	18
Loan (M. Ksh)	0	31[2]	30[2]	0
Membership fee (Ksh)	2,000	2,200	1,050	1,100
Maintenance fee (Ksh)	5,000 only once	500 per month	50 per month	200 per month
Maintenance	Group members	Consigned to an outside company	Group members	Hiring plumbers from outside
Penalties for misuse of water (Ksh)	None	10,000 fine and disconnection (500 for reconnection)	50,000 fine	1,000 fine

[1] Before receiving the fund from GTZ, the group received 3 million Ksh from Constituency Development Fund (CDF) in 2005.
[2] The loan carries interest.

Table 2. Plot size among members

Plot size in acres	Frequency	Percent
0.25	6	4.2
0.5	9	6.3
1	87	61.3
1.5	2	1.4
2	34	23.9
2.5	1	0.7
3	1	0.7
4	1	0.7
5	0	0
6	1	0.7
Total	142	100
Mean (SD)	1.26 (0.71)	

Table 3. Number of taps among members

	Freq.	Percent
1	59	42.1
2	66	47.1
3	11	7.9
4	2	1.4
5	0	0
6	2	1.4
Total	140	100
Mean (SD)	1.74 (0.85)	

fine and his/her pipe will be disconnected.

3.5 Crop production under irrigated conditions

The size of irrigated plot held by sample households belonging to an irrigation scheme is distributed from 0.25 to 6 acres (Table 2). Although the distribution seems to be wide, about 60% of members have 1 acre of irrigated plot, and the average size is 1.26 acres. As for the number of taps for irrigation, most farmers have one or two taps and only 10% of sample households have more than 2 taps (Table 3). Thus, in general, their plot under irrigation is not so large and it will be impossible for most of them to grow NERICA on a large scale, for example 1 acre, unless they are sure of its success.

Although the size is small, their use of irrigated plot is quite diversified. As shown in Fig. 3, maize and banana, staple foods in this area, are the most popular crops (more than 40% of farmers grow one of or both of them), but a lot of different types of vegetables such as beans, kale (*sukuma wiki*), and french beans are also grown under irrigated conditions. It is interesting to notice that 7.5% of farmers grew rice including NERICA using the irrigation systems in either long or short rainy season of 2011. Probably because the irrigation schemes had rice growers even before our intervention, some members already had information about upland rice and some of them already had seen it growing under upland conditions as discussed in the next section.

4. Adoption of NERICA

4.1 Sales of NERICA seed

We sold NERICA seed to the members of the selected 4 irrigation schemes. Among the 80 member farmers who

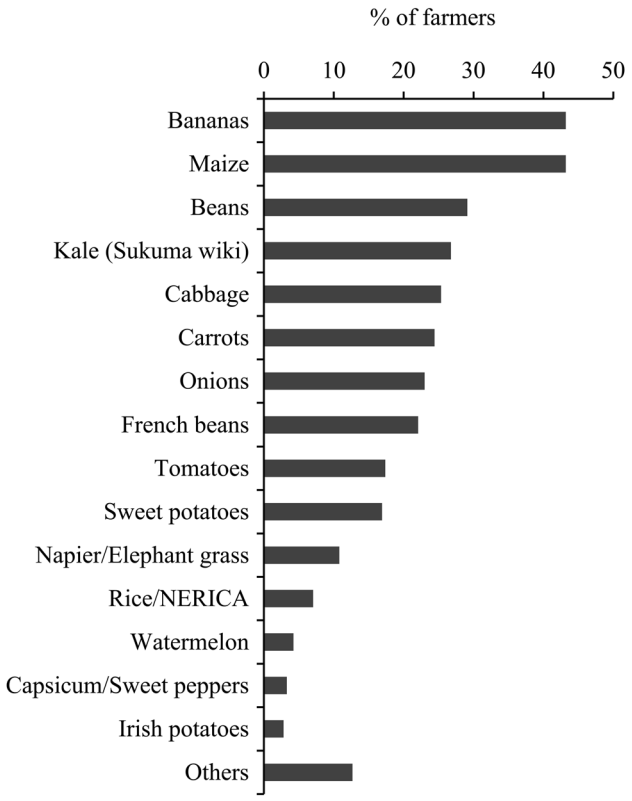

Fig. 3. Crops member farmers grew on their irrigated plots in 2011.

Table 4. Sources of NERICA seed among members[1]

Sources	Number of Farmers
JKUAT[2]	55
Irrigation scheme	12
Agricultural office	8
KARI[3]	1
Farmers group	2
Other farmer	1
Market	1
Total	80

[1] Total number of member farmers who specified the sources of NERICA seed is 75. But since 5 farmers obtained the seed from two sources, total number of seed sources amount to 80.
[2] Jomo-Kenyatta University of Agriculture and Technology.
[3] Kenya Agricultural Research Institute.

Table 5. Results of NERICA seed sales from JKUAT[1]

Amount (kg)	Number of Famers
0.5	12
1	42
2	7
3	2
4	0
5	1
unknown	3
Total	67
Mean (kg)	1.14

[1] As shown in Table 4, 67 member farmers purchased NERICA seed from JKUAT (55 cases are directly from JKUAT staff and 12 cases are indirectly through irrigation schemes).

purchased or received NERICA seed before the planting season in 2012, 67 farmers purchased from Jomo Kenyatta University of Agriculture and Technology (JKUAT) as shown in Table 4 (55 farmers purchased directly from JKUAT staff and 12 farmers purchased indirectly through an irrigation scheme). We expected that all the farmers had purchased NERICA seed from JKUAT, but some farmers purchased or received the seed from other sources as shown in Table 4. The seed received from Agricultural Office or Kenya Agricultural Research Institute (KARI) is the evidence that Ministry of Agriculture started NERICA dissemination in Embu county in 2012, which was unexpected for us. In such cases, farmers received the NERICA seed free. As for non-members, on the other hand, only 4 out of 80 farmers purchased NERICA seed in 2012.

Out of the 67 farmers who purchased NERICA seed from JKUAT, 64 farmers reported the amount of seed purchased. 42 farmers purchased only 1 kg of the seed (Table 5). And hence, the average amount is 1.14 kg, slightly above 1 kg.[6] Because standard seeding rate for NERICA is 20 kg/acre, 1 kg is only for 0.05 acre (or 0.02 ha) of land. As shown in Table 2, since most members have 1 or 2 acres of irrigated field, the land allocation to NERICA implies that it is just a small scale trial for most of the farmers. On the other hand, farmers received 1.75 kg of NERICA seed on average if they receive it free from KARI.

4.2 Who obtained NERICA seed?

Among the 157 sample farmers belonging to an irrigation scheme, 75 farmers purchased or received NERICA seed and 82 farmers did not, as described above. Now the question is whether the two groups of farmers are different.

In terms of the size of irrigated plot and the number of taps, those who obtained NERICA seed have a larger ir-

[6] The direct selling price and the indirect selling price of NERICA seed are the same (100 Ksh/kg) and hence the amount purchased does not differ much on average.

Table 6. Irrigation and obtaining NERICA seed among members[1]

	Farmers who obtained NERICA	Farmers who did not obtain NERICA	Significance level
Size of Irrigated Plot (acres)[2]	1.35 (0.85)	1.18 (0.51)	
Number of taps[3]	1.93 (0.99)	1.53 (0.63)	1%

[1] Means and standard deviations (in parentheses) are presented.
[2] The same data used for Table 2.
[3] The same data used for Table 3.

Table 7. Having heard about upland rice that were released recently?

		Purchased or received NERICA seed		
		Yes[1]	No	Total[2]
Having heard about Upland Rice	Yes	72	48	120
	No	1	32	33
	unknown	2	2	4
	Total[2]	75	82	157

[1] Total number of member farmers who purchased/received NERICA seed from any sources is 75 as shown in Footnote 1 of Table 5.
[2] Total number of member farmers whose data are used for the analyses in this paper is 157 as described in Section 2.

Table 8. Having seen rice growing on upland?

		Purchased or received NERICA seed		
		Yes[1]	No	Total[2]
Having seen Upland Rice	Yes	59	23	82
	No	14	56	70
	missing	2	3	5
	Total[2]	75	82	157

[1] Total number of member farmers who purchased/received NERICA seed from any sources is 75 as shown in Footnote 1 of Table 5.
[2] Total number of member farmers whose data are used for the analyses in this paper is 157 as described in Section 2.

rigated plot and more number of taps on average, as shown in Table 6. In fact, all the farmers whose plot size is above 2 acres and all the farmers who have more than 3 taps obtained NERICA seed. However, the difference is statistically significant only for the number of taps. Thus, having enough irrigation facilities seems to be an important factor to grow NERICA rather than the size of irrigated plot.

Tables 7 and 8 compare the knowledge about NERICA between farmers who obtained NERICA seed and farmers who did not. Tables 7 and 8 provide the knowledge about upland rice including NERICA, based on the questions "Have you ever heard about upland rice that has been released recently?" and "Have you ever seen rice growing under upland conditions?" respectively. Both tables show farmers who obtained NERICA seed tend to have more knowledge about upland rice. Their knowledge rates are statistically significantly higher than farmers who did not obtained NERICA seed at 1% significance level. Therefore, knowledge is also an important factor for farmers with irrigation to try NERICA. Although the analysis above can tell neither which knowledge nor what kind of information really matters, considering that upland rice is a new crop in the study site, knowing that such a crop exists seems to make farmers interested in it.

4.3 The role of irrigation scheme

As shown above, within irrigation schemes, knowledge is important for adopting NERICA. In this section we compare the members and non-members in terms of the knowledge of NERICA. Table 9 shows that 78.4% of the

Table 9. Knowledge of and interest in upland rice

	All the Members (N=153)	Members not purchasing NERICA (N=82)	Non-Members (N=76)	Total (N=229)
Having heard about an upland rice that has been released recently	120 (78.4%)	48 (58.5%)	16 (21.1%)	136 (59.4%)
Having seen rice growing on upland	82 (54.0%)	23 (28.0%)	5 (6.6%)	87 (38.0%)

Table 10. How did you know about NERICA for the first time?

Information sources	Members	Non-members	Total
SHG member	9 (8.2%)	2 (18.2%)	11 (9.1%)
Irrigation scheme member	93 (84.6%)	2 (18.2%)	95 (78.5%)
Neighboring farmer, but neither SHG nor irrigation scheme member	0 (0%)	4 (36.4%)	4 (3.3%)
Member of the same church	1 (0.9%)	2 (18.2%)	3 (2.5%)
Government extension officer	1 (0.9%)	1 (9.1%)	2 (1.7%)
Relative	3 (2.7%)	0 (0%)	3 (2.5%)
Radio	1 (0.9%)	0 (0%)	1 (0.8%)
Other	2 (1.2%)	0 (0%)	2 (1.7%)
Total number of farmers who know NERICA	110	11	121

members have heard about upland rice and 54.0% of the members have actually seen it, while only 21.1% of non-members have heard about it and 6.6% of non-members have seen it. As described in section 2, the 4 irrigation schemes we selected for our NERICA dissemination study are those had expressed general interest in growing upland rice, the better knowledge among the members may not be generalized for all the irrigation schemes. However, even if we use the members who did not purchase NERICA seed, the figures are still much higher than non-members. Thus, we could expect that the irrigation scheme members are likely to have better knowledge about upland rice than non-members. It implies that the two groups might have a different information source about new technology even though they live in the same area.

Table 10 shows how the farmers first heard about NERICA. Over 84% of the members obtained information through the members of irrigation scheme or SHG. Interestingly, 36% of non-members also obtained information through neighboring farmers, but they are neither SHG members nor irrigation scheme members. On the other hand, government extension officers and public media like radio are not popular sources of information among farmers. However, it does not necessarily mean that they have little role in information dissemination to farmers. Government extension officers tend to contact with only leaders of farmers' groups, hoping that the information should be transferred to member farmers. In the case of radio also, it may be only innovative farmers who catch new information from the radio, but they will transfer the information to other members. Therefore, in the case of NERICA information, we still do not know the exact role of government extension officers and radio. However, it is clear that irrigation scheme has a significant role in information dissemination.

5. Conclusions

In this paper, we focus on the role of irrigation schemes in NERICA dissemination in the central highlands in Kenya. It may be obvious that since farmers who can access to supplemental irrigation water would be able to reduce the risk of the crop failure, they are more willing to grow NERICA.

However, the role of irrigation schemes is not only to supply water during the water shortage period, but also to provide place for social learning to the members to community. By social learning in a community of the irrigation scheme they belong to, farmers might be able to minimize the risk of crop failure caused by insufficient information about a new crop. This may be another reason why members have more information and are more active to adopt a new crop like NERICA.

In order to be a member of an irrigation scheme, farmers have to pay intimal membership fee and monthly mainte-

nance fee. It means that only relatively wealthy farmers can have benefit from the irrigation water and the information shared among the members. Information may be spilled-over from the members somehow, but the presence of an irrigation scheme is critically important if upland rice is steadily produced. In this sense, irrigation schemes could be good targets of NERICA dissemination. In other words, promoting affordable small-scale irrigation facilities managed by a farmers' group can be an effective strategy to disseminate NERICA widely in the central highlands in Kenya.

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