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Original Research Article

An Assessment of Small-Scale Rice Farmers' Adaptability to Climate Change: Case Study in Central Java, Indonesia

ABSTRACT

Focus group discussions were carried out with rainfed rice farmers in Central Java, Indonesia to understand their rice production system and assess their adaptability to current and future climate. Results show that the farmers dealt with various stresses such as water shortage, weeds, insects, and pathogens and they spent a significant amount of money for the prevention or reduction of yield loss due to these stresses. As a result, their production cost ranged from 33% to 40% of revenue in the first season and hovered around 30% in the second season. The majority of funds used to prevent or mitigate crop losses from stresses was sourced from debts borrowed from commercial and non-commercial sources. The farmers were therefore vulnerable to any additional damage caused by stresses. Drought is one of the most damaging abiotic stresses but farmers do not have any effective countermeasures to mitigate its effects. This situation results mainly from their inability to access accurate and timely information on the type and start/end of the rainy season. This lack of information prevents them from selecting and planting the correct varieties and adopting the appropriate cultural management practices. Research needs to focus on this particular constraint to help rainfed farmers reduce crop losses from stresses, drought in particular, and to substantially move forward the process of designing more responsive and sustainable rice production models for Central Java and other similarly-situated drought-prone areas.

Keywords: climate change adaptation, cropping calendar, food security, seasonal climate prediction

1. INTRODUCTION

Rice is a staple for more than three billion people in the world and demand for it is anticipated to significantly increase in the future due to population increase in Asia where 90% of the crop is consumed and produced. To keep pace with demand, production must be increased at the required rate. Efforts toward this end, however, are challenged by the effects of climate change which have been worsening, and will continue to do so at ever-increasing intensity [1]. The need to cope with the effects of climate change on rice production have spawned advanced researches whose results can be used for the purpose. Some of these results are varieties that are tolerant of submergence, salinity, drought, and heat stresses [2], [4], [5], and the alternative wetting and drying and direct seeding management techniques [6],

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[7].

Rainfed rice is planted on 42% of the total rice area, with rainfed areas accounting for a larger proportion of total rice lands in Asia [8]. Unlike irrigated rice, it is heavily dependent on rainfall, which varies highly each year. Hence, the efficient use of rainfall is imperative for enhancing rainfed rice production.

Anticipating upcoming weather conditions, particularly the amount of rainfall, is crucial to achieving water use efficiency in rainfed rice production. Usual weather forecasts that are publicly available may be obtained from mass media but these are deterministic information given for a period of only one week, which is the theoretical limit for accuracy. At the field level, however, farmers need weather forecasts far beyond one week to determine the best time for sowing and/or transplanting. For instance, farmers in Lao PDR use 3-4 week old seedlings for transplanting [9]. If the rainy season starts late, seedlings become too old to grow efficiently after transplanting, thus requiring the preparation of a new nursery. Farmers in Central Java are also susceptible to rainfall fluctuations and thus face the risk of losing sown seeds because of drought at the beginning of the planting season and they are unable to capture monsoon rain. Mitigating the effects of rainfall fluctuations entails additional costs.

In stress-prone environments, such as those where weather fluctuations occur within seasons, farmers have adopted various adaptation measures based on their experiences. This study evaluated the local production system of small-scale rice farmers in Central Java, Indonesia, in terms of managing biotic and abiotic stresses, and thus their adaptability to climate change in producing rainfed rice.

2. MATERIAL AND METHODS

2.1 Site description

The study was conducted in the Boyolali, Pati and Rembang districts in Central Java, Indonesia. These districts account for 39% of the rainfed rice area in the country, with about half of the area being drought-prone. The Boyolali district, whose topography is undulating/rolling and whose soil is clayey, is located 130-250 meters above sea level. The Pati and Rembang districts, whose land is flat and soil is sandy, are located 11-17 meters above sea level. The long-term annual rainfall averages for the area are 1,506 mm, 1,243 mm, and 1,078 mm for Boyolali, Pati and Rembang, respectively. The amount of rainfall in Boyolali allows farmers to grow rice in two cropping seasons, with a third season devoted to corn, peanut, or soybean, depending on the amount of available water. Farmers in Pati and Rembang grow rice one or two times a year, depending on rainfall. The first rice is during the *Gogorancah* season from October to February and the second one is during the *Walik jerami* season from March to June. They try the third crops like mung bean if water is available. Crop establishment is done by direct sowing during the first season and transplanting during the second.

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2.2 Research method

The research conducted focus group discussions (FGDs) to gather information on the farmers' risk management practices in rice production. The FGD in the Boyolali district was conducted in September 2011 while that in the Pati and Rembang districts was held in March 2013. Three villages were chosen to represent Boyolali, namely, Bade and Jaten villages in the Klego sub-district, and Karangjati village in the Wonosegoro sub-district. Meanwhile, four villages were chosen to represent Pati and Rembang, namely Sidomukti village in the Jaken sub-district, Pelemgede village in the Pucakwangi sub-district, and Jadi and Megulung village in the Rembang sub-district. The characteristics of the rice ecosystems and some demographic data on the people in the study area are shown in Table 1.

The FGD participants comprised of 15-20 representatives from associations of farmers' groups in the chosen villages. The FGDs were facilitated by researchers from the Central Java Assessment Institute for Agricultural Technologies and staff from three to five extension agencies. The latter also helped in validating the information provided by the farmers. Each FGD was allotted three hours and a questionnaire was formulated to serve as guide during the discussions.

Table 1. Demographics and characteristics of the rice ecosystems of study sites in Central Java, Indonesia

	Bade	Jaten	Karangjati	Sidomukti	Pelemgede	Jadi	Megulung
Rice ecosystem	Rainfed lowland	Rainfed lowland	Rainfed lowland	Rainfed lowland	Rainfed lowland	Rainfed lowland	Rainfed lowland
Topograpy	Undulating/ rolling	Undulating/ rolling	Undulating/rolling	Undulating	Flat	Flat/ Undulating	Flat
Altitude (m a.s.l.)	250-350	250-350	130	17	11	15	15
Total population	1786	1331	2989	4192	2516	1681	944
Tiotal household	1253	517					
Total land area (ha)	321	283	466	212	332	460	140
Rice field (ha)	138	114	252	158	262	368	128
Rice area in wet season (%)	100	100	100	100	100	100	100
Rice area in dry season (%)	100	30	100	100	40	70	70
Number of farmers	712	443	1477	412	232	600	400
Average number of farm per farmer	1-2	2-3	1-2	1-2	1-2	4	1-2
Average size of farm (ha)	0.4	0.2-0.5	0.3-0.5	0.3	0.3	0.5-1	0.5
Average farming experience (year)	10-40	20-40	10-50	27	25<	30-40	30
Time allocation (%)							
-on farm	60	75	90	80	70	80	80
-off farm	40	25	10	20	30	20	20
Average family size	3	5	4-5	3	5	4	4

3. RESULTS

3.1 Rice cropping system

Tables 2-a, 2-b and 2-c show the common cropping system in the study area. Farmers in all the villages in the area used in general their land for rice during the first and second cropping seasons and another crop on the third season. The interval from one season to the next was very tight for Jaten village in Boyolali and Plemgede village in Pati. There was a one to two month break between the first and second

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crops throughout the study area.

All villages in Boyolali had access to irrigation (i.e., from gravity or water pumps), making them less prone to drought compared to the villages in Pati and Rembang which did not. This level of access to water determined crop establishment in the study area. Transplanting was a common practice during the first and second season in all villages in the Boyolali district while it was only practiced during the second season in the Pati and Rembang districts. During the first season, farmers in Pati and Rembang undertook direct sowing (dry seeding) since rainfall was uncertain. The seedling age for transplanting in the whole study area was usually more than three weeks, with the farmers in Pati and Rembang using older seedlings than those in Boyolali.

Table 2-a. Cropping systems in the study sites (first crop)

	Bade	Jaten	Karangjati	Sidomukti	Plemgede	Jadi	Megulung
Source of irrigation	**Tube well, water reservor**	**Irrigation canal**	**River, irrigation canal**	**None**	**None**	**None**	**None**
First crop							
Variety	Mekongga Ciherang Situ Bagendit Inpari 6	Ciherang IR 64 Umbul*	Ciherang IR 64	Cibogo Way Apu Buru* Inpari 6	Ciherang Mekongga	Ciherang	Ciherang Situ Bagendit IR 64
Type of seed	Registered seeds	Registered seeds	Registered seeds Certified seeds	Certified seeds	Certified seeds (blue)	Certified seeds Last harvest	Certified seeds Last harvest
Manure application	apply if available, <0DAT	apply if available, <0DAT	apply if available, <0DAT	10-12 t/ha, <0DAT	12 t/ha, 0DAT	5 t/ha, 0DAT	6 t/ha, 0DAT
Inorganic fertilizer (type)	15-15-15, Urea	15-15-15, SP36, Urea	15-15-15, SP36, Urea	Urea, KCl	15-15-15, Urea, KCl	15-15-15, Urea	15-15-15, Urea, KCl
Inorganic fertilizer (dosage)	300, 300 kg/ha	150, 300, 300 kg/ha	300, 150, 150 kg/ha	170, 60 kg/ha	100, 200, 40 kg/ha	100, 250 kg/ha	100, 150, 40 kg/ha
Inorganic fertilizer (timing)	10, 21, 28DAT	15DAT, 15DAT, 15 and 40DAT	15DAT, 15DAT, 15 and 35DAT	30, 55DAT, 10DAT	10DAT, 10, 25DAT, 25DAT	10-15, 25, 35DAT	10DAT, 10DAT, 25DAT
Planting method	Transplanting**	Transplanting	Transplanting	Direct seeding	Direct seeding	Direct seeding	Direct seeding
Seedling age (days)	20-25	25-30	21	-	-	-	-
Date of planting	November	End of September	October- November	December	October	November	October
Date of harvest	Feb	Feb	Jan- Feb	End of Feb- begin'g of Mar	Jan	Feb	Jan
Crop yield (tons/ha)	7	6-7	6	5.5	6	6	6

Table 2-b. Cropping systems in the study sites (second crop)

	Bade	Jaten	Karangjati	Sidomukti	Plemgede	Jadi	Megulung
Source of irrigation	**Tube well, water reservor**	**Irrigation canal**	**River, irrigation canal**	**None**	**None**	**None**	**None**
Second crop							
Variety	Mekongga Ciherang Situ Bagendit Inpari 6	Umbul* Cimanis*	Ciherang Mentik wangi	Ciherang Inpari 6	Ciherang Inpari 13	Ciherang	Ciherang Situ Bagendit
Manure application	None	None	None	Petroganic 60 kg/ha, 0DAT	Petroganic, 0-7DAT, 100 kg.ha	None	None
Inorganic fertilizer (type)	15-15-15, Urea	SP36, Urea	15-15-15, SP36, Urea	15-15-15, Urea, Zn, KCl	Urea, KCl	15-15-15, Urea	15-15-15, KCl
Inorganic fertilizer (dosage)	300, 300 kg/ha	150, 300 kg/ha	300, 150, 150 kg/ha	20, 100, 15, 15 kg/ha	200, 40 kg/ha	100, 250 kg/ha	100, 40 kg/ha
Inorganic fertilizer (timing)	10, 21, 28DAT	15, 40DAT, 15DAT	15DAT, 15, 35DAT, 15DAT	10DAT, 10DAT, 10DAT, 25, 40DAT	10, 25DAT, 25DAT	10-15, 25, 35DAT	10DAT, 25DAT
Type of seed	Registered seeds	Own seed stock/non certified seeds	Registered seeds, certified seeds	Certified seed	certified seeds	Own seed stock	Registered seeds, Own seed stock
Planting method	Transplanting,irregular spacing	Transplanting,	Transplanting,	Transplanting	Transplanting	Wet seeding, Transplanting	Wet seeding, transplanting
Seedling age (days)	20-25	25-30	21	25-30	25-30	25-30	25-30
Date of planting	End of Feb- March	End of February – (*methuk* system)	Feb- March (‘*methuk*’)	February	Second week of February	February - March	February
Date of harvest	May-June	End of may	June-July	May	End of May – starting of June	June	June
Crop yield (tons/ha)	5-6	6-6.5	5.2 – 5.5	6	5.5	4.5	5

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Table 2-c. Cropping systems in the study sites (third crop)

	Bade	Jaten	Karangjati	Sidomukti	Plemgede	Jadi	Megulung
Source of irrigation	**Tube well, water reservor**	**Irrigation canal**	**River, irrigation canal**	**None**	**None**	**None**	**None**
Third crop							
Variety	Corn (hybrid) Corn (local variety) peanut (local variety) soy bean (local variety)	Peanut (local variety) Corn (local variety) Sweet potato (local variety)	Corn (hybrid) Peanut (local variety) Fallow	Mung bean (local variety)	Sweet potato (local variety) Peanut (local variety) Mung bean (local variety) Corn (local variety) Corn (hybrid) Fallow	Mung bean (improved variety)	Mung bean (local variety)
Type of seed	Local market	Last harvest, local market	Local market	Local market	Last harvest, certified seeds	Registered seeds	Registered seeds, last harvest
Planting method	Hybrid corn: direct sowing 20cm x 70cm Local corn: direct sowing, random Soybean, peanut: direct sowing, 20cm x 20cm	Direct sowing	Direct sowing	Direct sowing	Direct sowing Sweet potato: stem planting	Direct sowing	Direct sowing
Date of planting	May-June	May-June	July	June	May-june	June	June
Date of harvest	August –September	August	Sept- Okt	August	August-September	August	August
Crop yield (t/ha)-corn	6 (hybrid), 4 (local)	1.8-2.0	5.4	0.8 – 1	0.8	-	-
Crop yield (t/ha)-peanuts	1.5	2.4	1.1	-	1	-	-
Crop yield (t/ha)-soybeans	1.5	-	-	-	-	-	-
Crop yield (t/ha)-mung beans	-	-	-	0.8-1.0	0.8	1.4	0.9
Crop yield (tons/ha)-sweet potato	-	8.4	-	-	1.4	-	-

During the first cropping, farmers in most of the villages used 3-4 varieties of rice, including landrace cultivars, with Ciherang being a common variety across the area. Fewer varieties were used during the second cropping and Ciherang was still widely used. Farmers purchased certified or registered seeds for both cropping seasons although farmers in the Rembang district used seeds from the last harvest in addition to certified seeds.

The application of organic fertilizer, in the form of manure, was a common practice in the Pati and Rembang districts unlike in the Boyolali district where it was dependent on the availability of manure. Farmers in Pati tended to apply larger amounts (i.e., 10-12 t ha^{-1}) of manure in first season than those in Rembang (i.e., 5-6 t ha^{-1}). Moreover, Pati farmers applied manure in both seasons while those from Rembang applied the organic fertilizer only in the first season. Organic fertilizer throughout the study area was applied during basal application (0DAT).

Meanwhile, the application of inorganic fertilizer was a common practice across the study area although the types of fertilizer used varied among the villages. Compound fertilizer (15-15-15) and urea were commonly used in all villages. Farmers in Jaten and Karangjati villages in Boyolali also used synthetic fertilizers such as SP36 (36% of P_2O_5) while farmers in Sidomukti village in Pati, and Jadi and Megulung villages in Rembang used KCL (16%) in addition to compost and urea. The amount of inorganic fertilizer applied tended to be larger in the Boyolali district than in the Pati and Rembang districts. The average dosages for nitrogen, P_2O_5 and K_2O in the first season were 153±35 kg ha^{-1}, 84±56 kg ha^{-1}, and 38±13

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kg ha^{-1}, respectively, in the Boyolali district while those in the Pati and Rembang districts were 105±26 kg ha^{-1}, 10±9 kg ha^{-1}, 15±6 kg ha^{-1}. The dosages in the second season were similar with those in the first season in all districts except that for P_2O_5 in Boyolali (66±29 kg ha^{-1}). In general, farmers applied more nitrogen and P_2O_5 in Boyolali than the national recommendation for the region. In Pati and Rembang, K_2O was in small dosages because it was applied as a supplement although farmers added a single type of fertilizer on top of compound fertilizer.

Despite the significant differences in the application dosages for inorganic fertilizer among the districts, grain yields (GYs) were almost similar. The GYs for the first and second season in the Boyolali district were 6.5±0.6 t ha^{-1} and 5.7±0.3 t ha^{-1}, respectively. These were 5.0±0.3 t ha^{-1} and 5.3±0.6 t ha^{-1} in the Pati and Rembang districts.

3.2 Water, weed, pest, and disease management practices

Table 3 shows the water, weed, pest, and disease management practices of farmers in the study area to control abiotic and biotic stresses during rice cropping.

Table 3. Farmers' water, weed, pest, and disease management practices in the study sites to

District	Boyolali			Pati		Rembang	
Village	Bade	Jaten	Karangjati	Sidomukti	Pelemgede	Jadi	Megulung
1. Water management							
Source of irrigation	Tube well Water reservor	Irrigation canal	River Irrigation canal	None	None	None	None
Mtethod of irrigation	Pump and gravity	Pump and gravity	Gravity	None	None	None	None
Irrigation ($US*/ha)	41	35	163-327	None	None	None	None
Number of time per crop season	3	3	2-4	None	None	None	None
Event of water shortage (1st crop)	Feb-Mar	Oct	None	Oct	Oct	Oct	Oct
Event of water shortage (2st crop)	Jun-Jul	May	Apr-Jun	Feb-Mar	Jun	Jun	Jun
2. Weed management							
Name of weed	Adasan Semanggi Jawan	Semanggi Bengok Kembangan Grinting	Jawan Genjer	Tuton Dengklekan Wewehan Drenjem	Tuton Dengklek Wewehan Drenjem	Tuton Dengklek Teki Dandangan	Tuton Dengklek Teki Dadangan Wewehan
Method of control	Manual weeding	Herbicide Manual weeding	Herbicide	Herbicide	Manual weeding	Herbicide Mechnical and manual weeding	Herbicide Mechnical and manual weeding
Yield loss w/ control (%)	5-10	10-15	10-15	10-25	10-25	10-25	10-25
Yield loss w/o control (%)	50	50	10-15	50	20-30	30-100	50

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control abiotic and biotic stresses during rice cropping

Table 3. Continued

3. Pest control							
Name of insect and pest	Brown plant l Stem borer	Brown plant l Grass hopper Stem borer	Grass hoppe	Brown plant hopper (BPH) Beluk (B) Sundep (S) Walang sangit (WS)	Beluk (B) Wereng (W) Sundep (S) Walang sangit (WS)	Walang sangit (WS) Wereng (W) Beluk (B) Sundep (S)	Beluk (B) Sundep (S)
Yield loss w/o control (%)	30-50 (BPH) <10 (SB)	100 (BPH) 100 (GH)	100 (GH)	30-100 (BPH 30-50 (B) 50 (S) 10 (WS)	40 (B) 30 (W) 10 (S) 0-10 (WS)	<100 (WS) 100 (W) 5-50 (B) 40 (S)	20-100 (B) 0-40 (S)
Method of control	Insecticide	Insecticide	Insecticide	Insecticide Reducing water (BPH)	Insecticide Reducing water (B)	Insecticide Reducing water (B)	Insecticide Reducing water (B)
4. Disease control							
Name of insect and pest	Grassy stunt (GS) Tungro (T) Leaf and neck blast (LNB)	Grassy stunt (GS) Tungro (T) Leaf and neck blast (LNB)	Yellow syndrom (YS) Tungro (T)	Cercorpora (Ce) HD bacteria (HDB) Neck blast (NB)	Pucakwangi (P) HD bacteria (HDB) Sheet blight (SB)	Xanthomona s (X) Leaf spots (LS) Neck blast (NB)	HD bacteria (HDB)
Yield loss w/o control (%)	30-50 (GS) <5 (T)	30-50 (GS) <5 (T)	100 (YS)	50 (Ce)			30 (X) 10 (LS) 30 (NB)
Method of control	None	None	None	Fngicide	Fngicide	Fngicide	Fngicide

*1USD=11,000IDR

Water shortage was a common phenomenon across the study area during both the first and second cropping seasons. In the first season, it was experienced mostly in October, which is the beginning of the season, except in Bade village in the Boyolali district where it occurred around February and March, the end of the cropping season. In the second cropping season, water shortage occurred in May, June or July, which are in the mid-end season in Karangjiati village in the Boyolali district and around the beginning of the season in Sidomukti village in the Pati district.

Farmers in the villages representing the Boyolali district applied irrigation during the period of water shortage, in the process incurring additional expense. The villages of the Pati and Rembang districts did not have irrigation sources and therefore had no means of mitigating the effects of water shortage.

Weeds, insects, and pathogens were also possible biotic stresses in the study area. *Table 3* also shows the control measures adapted by farmers to counteract the effects of these biotic stresses and the

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estimated yield loss in the event these control measures were not put in place.

Weeds, which cause substantial damage and yield loss in the study area, were more diversified in the Boyolali than Pati and Rembang districts but farmers in Pati and Rembang recognized more species than did those in Boyolali. There were two species (i.e., *Semanggi* and *Jawan*) that were commonly recognized in Boyolali while there were three (i.e., *Tuton*, *Dengklekan*, and *Wewehan*) in Pati and Rembang. The species *Drenjem* and *Teki* were also commonly recognized in Pati and Rembang, respectively. Herbicide application was a common practice for weed control across the study area, although weeding by hand or tools were resorted to in Bade village in Boyolali and in Sidomukti village in Pati. Meanwhile, farmers in Jaten village in Boyolali and in the villages of Jadi and Megulung in Rembang controlled weeds by a combination of herbicide application and manual weeding.

Farmers in the Pati and Rembang districts identified more pests than farmers in Boyolali. In Boyolali, brown plan hoppers (BPH) and grasshoppers were common across the villages. The pests in the Pati and Rembang districts, meanwhile, were BPH, *Walang sangit*, and *Beluk* for the Sidomukti, Jadi and Megulung villages, respectively. Pests in Pelemgede village in Pati brought significant damage on yields although it was not as serious as other villages where certain pests ruined the rice crop. Using insecticide was a common countermeasure against pest attack across the study area. Farmers in Pati and Rembang reduced water in their fields against particular pest attacks such as that by BPH.

Disease was also a common biotic stress in the study area, with farmers identifying a few diseases and estimating the damage these brought about to rice yields. Grassy stunt, Tungro, and leaf and neck blast were common diseases in the Boyolali district while HD bacteria and neck blast were common in the Pati and Rembang districts. Farmers in Boyolali did not identify the methods of disease control they used while those in Pati and Rembang applied fungicide. During the FGD, farmers in Pati and Rembang mentioned that diseases, which brought severe damage, could be attributed to the low amount of rainfall in the area and the application of less manure in sandy soil.

3.3 Production cost and profitability

Table 4 shows the total cost, revenue, and benefit-cost ratio (BCR) of rice production in the study area. In the first season, rice production was costlier in the Pati and Rembang districts than in the Boyolali district and this was mainly due to the high level of manure applied in the former. The mean average revenues earned per farm for the season in the area were US$1,773 and US$1,743 for the Boyolali district and the Pati and Rembang districts, respectively. Thus, the BCR for the first crop was higher in Boyolali than in Pati and Rembang. On the other hand, the second crop was costlier in Boyolali than in Pati and Rembang. Moreover, the average revenue in Boyolali remained the same while that in Pati and Rembang was significantly lower. This made the BCR for Boyolali for the second season significantly lower than that for the first season. The BCR in second season for Pati and Rembang districts, however, was significantly more due to lower total cost. For the two seasons in the whole study area, BCR was found to

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be profitable.

Table 4. Total cost, revenue, and benefit-cost ratio (BCR) of rice production in the study sites

Items	Boyolali			Mean	Pati		Rembang		Mean
	Bade	Jaten	Krgjati		Sidomukuti	P.Gede	Jadi	Mguung	
1st crop									
Total cost ($US)	653.5	719.4	651.8	674.9	1048.4	611.9	759	774.5	715.1
Basic cost (%)	9.2	8.3	23	13.5	4.8	11.4	5.3	9	8.6
Inputs (%)	39.4	41.6	29.1	36.7	64.1	35.2	51.7	48.8	45.2
Labor (%)	51.4	50	47.9	49.8	31.1	53.4	43	42.2	46.2
Revenue ($US)	2100	1950	1800	1950	2015	1815	1920	1920	1885
BCR_1st crop	2.2	1.7	1.8	1.9	0.9	2.0	1.5	1.5	1.7
2nd crop									
Total cost ($US)	729.7	678.9	872.2	760.3	526.9	550.8	528.0	546.5	541.8
Basic cost	8.2	10.6	17.2	12.0	9.5	12.7	7.6	12.8	11.0
Inputs	23.9	19.1	26.4	23.1	18.3	28	30.6	27.4	28.7
Labor	49.3	53	35.8	46.0	62	59.3	61.8	59.7	60.3
Revenue ($US)	1925	2000	1873	1933	1440	1800	1440	1500	1580
BCR_2nd crop	1.6	1.9	1.1	1.6	1.7	2.3	1.7	1.7	1.9
BCR_Mean	1.9	1.8	1.5	1.7	1.3	2.1	1.6	1.6	1.8

3.4 Information access

Table 5 shows the types of information needed by local farmers and the sources of information available in the study area. It indicates that farmers obtain information on a topic from various formal and informal sources, with their choice of which source to access being dependent on their purposes. For example, farmers went around different information sources to gather information on rice cultivation and weather while they went to the extension workers to consult on new varieties, new technologies, and similar topics.

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Table 5. Types of information needed by local farmers and the sources of available information in the study area

Number	Rice cultivation	New rice varieties	Rice pest control	Water management	Cultivation of non-rice crops	Soil nutrient management	Livestock production	Aquaculture	New technologies	Weather forecast
Experiences	6	0	2	0	1	4	2	0	0	3
Extension workers	6	7	6	1	5	5	4	1	6	0
TV, Radio	3	3	2	0	3	4	3	1	2	4
Farmers group	3	3	2	4	2	3	4	1	2	0
Neighbour, family	6	3	4	0	6	4	3	1	2	0
Agro-inputs shops	0	3	2	0	0	0	0	0	1	0
Other farmers	1	0	1	0	0	0	0	0	0	0
Local wisdom	1	0	0	0	0	0	1	0	0	2

4. DISCUSSION

Farmers mobilize their resources to maximize yields. The results of the FGDs conducted by the study showed that farmers in Central Java obtained high yields because of their intensive application of inputs such as inorganic and organic fertilizers. They also used various types of chemicals to minimize yield loss from different biotic stresses such as weeds, pests or diseases. Hence, the production costs in Boyolali were 33% and 30 % of revenues for the first and second cropping seasons, respectively while those in Pati and Rembang were 40% and 31%. These figures indicate that farmers in the study area finance a major part of their production cost, mostly by borrowing money from commercial and non-commercial sources. This, in turn, implies that these farmers are financially vulnerable in instances when additional damages are inflicted on their crops by biotic and abiotic stresses. The more damages to their crops, the more expenses they need to shoulder and this eventually increases their burden. Furthermore, borrowing money is not an easy and quick option for the farmers and, thus, they might not be able to take immediate countermeasures to deal with stresses which cause drastic yield losses. The inability of the farmers in the study area to undertake mitigating measures against stresses, mainly as a result of their difficulty in accessing affordable and available credit, leads to crop losses of enough magnitude to aggravate their poverty.

Drought is one of the most damaging abiotic stresses, especially in rainfed rice areas like Central Java. Although farmers in Boyolali had access to supplementary irrigation during droughts that visit the district, this resource costs, thus lowering the farmers' BCR. Farmers in Pati and Rembang, on the other hand, had no access to water to mitigate the effects of droughts. In cases of mid- and late-season droughts, water shortage hampers crop growth, thus causing substantial yield loss, if not total crop failure. Farmers would not be able to recover the funds they spent at the beginning of the season. There are thus no

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effective countermeasures to drought in the study area which prevent economic losses to farmers.

The study also showed that farmers in the study area accessed information from different sources to enable them to undertake countermeasures against stresses. Extension workers play a vital role as resource persons on new varieties, pest and disease control, and new technologies to secure/increase production. It is mainly through them that farmers were able to acquire their knowledge on mitigating the effects of various stresses that besiege their crops.

The farmers also obtained information on the weather through either traditional or modern sources of knowledge and information. One traditional method they resorted to was the use of the *Pranata mangsa,* a traditional calendar in Javanese that is used to guide the scheduling of land preparation, nursery operations, transplanting, and other farm activities. Some farmers also used natural signs such as some sounds of insects and characteristics of certain leaves, flowers or fruits. On the other hand, the modern sources of information on the weather consisted of the mass media, i.e., television, radio, and newspapers, which transmit weather forecasts from the Indonesian Meteorological, Climatological and Geophysical Agency.

It would seem that, as far as weather forecasting is concerned, tradition has not been spared assaults from climate change and its effects. While before the traditional or indigenous ways of foreseeing weather were considered in the past as adequate to guide the farming practices in the study area, the majority of farmers expressed the opinion during the FGDs that such ways were already outdated and not applicable under current climate conditions. And yet, despite this prevalent sentiment, the farmers also found the weather forecasts from government to be unsatisfactory, mainly as a result of faulty ones which had convinced the farmers that these were as unreliable as the traditional ways of weather forecasting. According to some testimonies from local farmers, the rainfall in 1993 was more than usual although weather forecasts predicted a dry spell for that year. The same inaccurate predictions were made in 2010. In both instances, crop failures resulted.

In rainfed areas, such as those in the study area, being able to accurately predict how much and when rainfall is forthcoming for a particular season is crucial for rice farmers as this will give them the information they need to be able to determine what kinds of varieties would be suitable and what management practices need to be adopted to increase yields and lessen crop losses. This ability is especially vital in areas, such as Cenral Java, where weather changes in the middle of a season and year.

5. CONCLUSION

Rice farmers in the study area of Central Java used various ways to increase their yield and the cost of inputs accounted for a large part of the total cost. This level of input use makes most of them vulnerable to additional damages caused by biotic and abiotic stresses from weather conditions because they

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finance majority of their expenses by borrowing from commercial and non-commercial sources. Drought is one of the most damaging abiotic stresses in the area but local farmers do not have any effective countermeasure to cope with it. What makes matters worse is that there are no available information to enable them to determine the amount of rainfall that would be available during, as well as the onset and end of, the rainy season, these information being crucial when weather fluctuates within a season and a year. They therefore do not have accurate bases by which to select a suitable type of variety to plant and the management practices to adopt so that yields may be optimized and crop losses minimized. This results in crop losses that aggravate poverty in the area. Research therefore needs to be undertaken to address these concerns and thus substantially move forward the process of designing more responsive and sustainable rice production system for Central Java and other similarly situated areas.

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