SECURING WATER FOR FOOD

Aybar Performance Evaluation

Broadbed and Furrow Maker in Ethiopia

AUGUST 2019

SECURING WATER FOR FOOD: A GRAND CHALLENGE FOR DEVELOPMENT

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TABLE OF CONTENTS

ABSTRACT

Aybar Broad Bed and Furrow Maker was a Securing Water For Food (SWFF) supported agricultural innovation project targeting the pressing challenge of waterlogging in Vertisols of Ethiopia. This report presents impact analysis results conducted in July and August, 2019, in West Shewa Zone of Oromia National Regional State in Ethiopia. Farmers have been using the innovation for four years.

A total of 50 end users (46 male and four female) of the innovation were individually interviewed from nine villages in West Shewa Zone. In consultation with West Shewa Zone Bureau of Agriculture, the lists of innovation adopting villages were identified. Accordingly, nine villages were purposively selected from the zone and used for this performance evaluation study. Data was collected on farm information, income, expenditures, and perceptions on the innovation. Gender observations and questions raised by respondents also are included in this report.

Wheat and Teff are cereals mainly grown in the study area. However, Aybar Broad Bed and Furrow Maker (Aybar BBM) is solely used for growing wheat. Following adoption of the innovation, row-planting of Teff is practiced. The mean farm size of sampled respondents is six acres with minimum and maximum sizes of 1.23 acres and 14.82 acres, respectively. After the innovation, the average yield of wheat increased by 115 percent (from 0.26 MT/acre to 0.57 MT/acre). The average annual farm income of end users before the innovation was 10,313 Ethiopian Birr (ETB) (approximately USD 362). It increased to 24,155 ETB (approximately USD 847) after the innovation. Despite reduced waterlogging, no crop diversification is practiced due to the innovation. Reducing the unit price of Aybar BBM (currently USD 12) and an adequate supply of the innovation that can be used for other crops other than wheat are requested by end users in the study area. Strong commitment is needed by the innovator and higher officials in the Ministry of Agriculture to resolve the indirect and controlled supply of the innovation to end users in the study area. Otherwise, continued dissemination of the innovation is challenging.

INTRODUCTION

Ethiopia has a total population of 112,078,730 and is ranked 12th in the world and 2nd in Africa after Nigeria, with a population of 200,963,599. Oromia National Regional State has the largest population in Ethiopia with an estimated population of 38.36 million in 2019 (World Population Prospects, 2019). Rainfed mixed-agriculture by smallholders constitutes the dominant share of Ethiopia's economic sectors in foreign exchange earnings and employment opportunities for the growing population. The country achieved a 10 percent increase in public investment in agriculture, a target set by the African Union Comprehensive Africa Agricultural Development Program (CAADP) and marked as among major successes (The World Fact Book, 2016).

Less than three percent of farmers have access to small-scale irrigation in Ethiopia. This figure is less than one percent for cereal acreage. Land degradation and the erratic nature of rainfall are exacerbating the impacts of climate on smallholder rainfed subsistence farmers in the country. Increasing the application of fertilizers to 95 percent of wheat farm lands increased yield per hectare only by 3.38 percent. Low quality and insufficient quantities of fertilizers are the challenges in Ethiopia (Mann and Warner, 2017). According to Minot et al. (2015), 4.7 million farmers grow wheat on 1.6 million hectares of land, constituting 18 percent of the total cropped area in Ethiopia.

Lower productivity of crops in Ethiopia is due to waterlogging on Vertisols, inadequacy of inputs, soil degradation, and declining soil fertility. Central highland Vertisols in Ethiopia cover about 7.6 million hectares, and vulnerability to water logging is a challenge among smallholder farmers (Adamu, 2018). The Aybar BBM was developed to address the Vertisols waterlogging problem in the central highlands of Ethiopia. Due to waterlogging of Vertisols, less than 2 million hectares of the approximately 7.6 million hectares of the highlands are cultivated. The innovation reduced water logging by constructing broad beds and furrows that drain excess water from the fields. As a result of excess water draining from the fields, the Aybar BBM increased crop yield.

An impact assessment was carried out by a Field Evaluator in July and August, 2019, by interviewing 50 farmers that are using Aybar BBM in West Shewa Zone of Oromia National Regional State in Ethiopia. The Fulcrum mobile application, supported by GPS system, was used to store interview responses. The main purpose of this assessment was to identify the benefits, limitations, and impacts for farmers using Aybar BBM innovation.

BACKGROUND

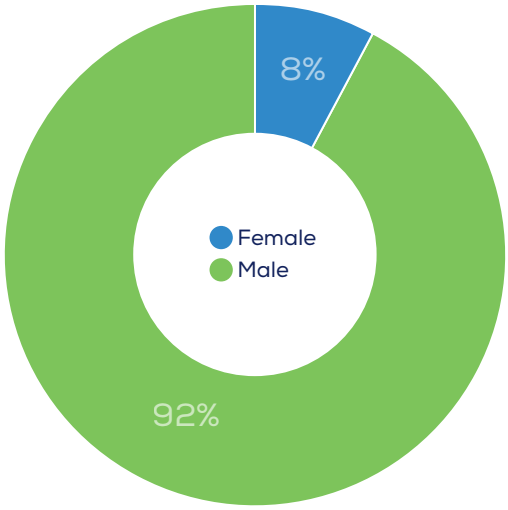
A total of 50 interviews were conducted from nine villages in West Shewa Zone of Oromia National Regional State, Ethiopia. All interviews were conducted individually, with no group interviews used for this study. In consultation with the West Shewa Zone Bureau of Agriculture and considering the proportion of Aybar BBM innovation end users in each village in the study area, availability sampling technique was used to select sample respondents. Accordingly, 80 percent of the respondents were selected from four major Aybar BBM adopting villages: Sarawa Debissa (24 percent), Chalalaka Bobe (22 percent), Qella Imbortu (20 percent), and Simbo Goro (14 percent). The Fulcrum mobile application, supported by GPS system, was used to store interview responses. Due to respondents' refusal for audio recording, photos are used for documentation in this study.

The survey questionnaire has four major parts and one other component. These are farmer information, income and expenditures, and perceptions on the innovation. Each section has its respective questions. The last section mainly constitutes three issues. These are poverty, gender observation, and questions/requests by the respondents. Information gathered from each section was used to achieve the objectives of this field report.

Gender

From a total of 50 respondents, 92 percent (46) are male and eight percent (four) are female. This is in accordance with information obtained from the West Shewa Zone Bureau of Agriculture in which the number of male Aybar BBM end users is significantly higher than female end users. Clear reason for this disparity was not provided (Figure 1).

FIGURE 1. GENDER DISTRIBUTION OF THE SAMPLED RESPONDENTS (%) IN THE STUDY AREA N=50



Farm Size

The local land measurement unit in the study area is called 'Qarxii' and has different conversion rates to hectare (ha). Three types of land conversation rates are identified during the survey in the selected villages. These are 4 Qarxii = 1 hectare, 5 Qarxii = 1 hectare, and 6 Qarxii = 1 hectare. Each village's respective conversion rate is used to record the farm size in hectares for this study. The mean farm size of sampled respondents is 2.42 hectares [six acres] with minimum and maximum farm sizes of 0.5 hectare [1.23 acres] and six hectares [14.82 acres], respectively (Table 1).

TABLE 1. FARM SIZE OF SAMPLED RESPONDENTS: DESCRIPTIVE STATISTICS

	OBS	MINIMUM	MAXIMUM	MEAN	STD. DEV	VARIANCE
Total land (in ha)	50	.50	6.00	2.42	1.36811	1.872

A t-test statistic is estimated to identify mean farm size difference between male and female end users of the innovation. The mean farm size owned by female respondents is 2.125 hectares [5.25 acres], and it is lower than the sample average of 2.42 hectares [six acres]. In contrast, the average farm size owned by male respondents is 2.445 hectares [6.04 acres], and it is higher than the sample average. Statistically, there is no significant difference in farm size between female and male respondents (Table 2).

TABLE 2. FARM SIZE COMPARISON: TWO-SAMPLE T-TEST WITH EQUAL VARIANCE

GROUP	OBS	MEAN	STD. ERR	STD.DEV	[95% CONF INTERVAL]	
Female	4	2.125	.590727	1.181454	.2450432	4.004957
Male	46	2.445	.205185	1.39163	2. 032388	2. 858917
Combined	50	2.42	.19348	1.368114	2.031186	2.808814
diff		-.320652	.719081		-1.766462	1.125158
diff = mean (Female) - mean (Male)						t = -0.4459
H_0 : diff = 0				degrees of freedom		= 48
H_a : diff < 0	H_a : diff !=0		H_a : diff > 0			
Pr (T < t) = 0.3288	Pr (|T| > |t| = 0.6577				Pr (T > t)	= 0.6712

Farmer's Experience

All the respondents indicated that farming is their primary occupation. Farming experience with the innovation ranges from two to four years in the study area. Those who adopted the innovation for three years constitute 42 percent (21), followed by two years by 36 percent (18), and four years by 22 percent (11). Chalalaka Bobe, Sarawa Debissa, Qella Imbortu, Jamjam Lega Batu, and Kataa Handodee villages are the first end users of this innovation in the study area (Table 3).

TABLE 3. FARMING EXPERIENCE WITH AYBAR BBM INNOVATION BY END USERS (IN YEARS)

	USING AYBAR BBM			
NAME OF THE VILLAGES	2-YEARS	3-YEARS	4-YEARS	TOTAL
Chalalaka Bobe	3 (6%)	3 (6%)	5 (10%)	11 (22%)
Sarawa Debissa	9 (18%)	2 (4%)	1 (2%)	12 (24%)
Qella Imbortu	3 (6%)	5 (10%)	2 (4%)	10 (20%)
Fincha'a Godeti	-	3 (6%)	-	3 (6%)
Jamjam Lega Batu	-	1 (2%)	2 (4%)	3 (6%)
Kataa Handodee	-	1 (2%)	1 (2%)	2 (4%)
Simbo Goro	3 (6%)	4 (8%)	-	7 (14%)
Goru Kurkufa	-	1 (2%)	-	1 (2%)
Ejersa Lafo	-	1 (2%)	-	1(2%)
Total	**18 (36%)**	**21 (42%)**	**11 (22%)**	**50 (100%)**

Other Occupations or Sources of Income

All the sampled respondents have only one source of income from farming, and they are not engaged in other occupations.

Family Size

The mean family size of sampled respondents is six with a median value of six. The minimum and the maximum family sizes are two and 13, respectively (Table 4).

TABLE 4. FAMILY SIZE OF RESPONDENTS: DESCRIPTIVE STATISTICS

	OBS	MEAN	MEDIAN	ST. DEV.	VARIANCE	MIN	MAX
Total land (in ha)	50	6.02	6.00	2.607	6.796	2	13

METHODOLOGY

Sample Selection

Due to unavailability of lists of the end users from the innovator, it is not possible to apply a random sampling technique for this impact evaluation study. This is mainly due to an approach followed to disseminate the innovation to final users in which the innovator does not directly distribute to the beneficiaries. This mandate is from the Regional Bureau of Agriculture and Rural Development that distributes the innovation to each Woreda as well as respective villages, even though it is difficult to identify the criterion used for distribution.

After desk reviews, it is evident that the Aybar BBM is mainly disseminated in Oromia National Regional State of Ethiopia. Within Oromia region, the innovation is particularly distributed in central highland areas where water logging is a major constraint to crop production among smallholder farmers. In particular, the central highland areas are covered with Vertisols characterized by poor infiltration that exacerbate water logging. Information from the Ministry of Agriculture and Rural Development also indicates that the innovation is exclusively used for improved wheat growing.

West Shewa Zone is among the major wheat producing areas in central highlands of Ethiopia and mainly covered with Vertisols. Besides, the Aybar BBM is mainly introduced in West Shewa Zone and the zone is purposively selected for this study. In consultation with West Shewa Zone Bureau of Agriculture, the list of innovation adopting villages was identified. Accordingly, nine villages were purposively selected from the zone and used for this study. The proportion of respondents from each village was determined by considering both the proportion of innovation end user and applying random availability sampling technique. The randomization is applied to avoid selection bias.

A total of 50 end users of the innovation were individually interviewed from nine villages in West Shewa Zone. Due to the upcoming national election and farmer training, it was not possible to find all respondents in their field for the interview. Instead, for those who were not available in their field, farmer training centers were used to individually interview respondents. This was one of the major challenges for this survey. The other challenge was unwillingness of respondents to be audio recorded, perhaps due to the influence of the local political officials. Alternatively, photos of respondents were used for supportive evidence.

The nine villages used for this study with their respective number of respondents are Chalalaka Bobe (11), Sarawa Debissa (12), Qella Imbortu (10), Fincha'a Godeti (three), Jamjam Lega Batu (three), Kataa Handodee (two), Simbo Goro (seven), Goru Kurkufa (one), and Ejersa Lafo (one). Only four of the sampled respondents are female.

Field evaluator's first day visit to discuss with village leaders in Chalalaka Bobe

RESULTS

EXPERIENCE WITH INNOVATOR

All 50 end users indicated that no new crops were introduced due to the innovation. Difficulties were experienced by respondents in using the innovation in the study area, and all respondents agreed that reduced use of water was due to the innovation.

Eighty-eight percent (44) of the end users mentioned no improvement of access to credit due to the innovation in the study area. Hence, most (88 percent) finance their agricultural activities using their own savings. Only 10 percent (five) changed their irrigation system due to the innovation. In contrast, 98 percent (49) noted that the innovation assisted them with when to plant (Table 5).

TABLE 5. CHALLENGES AND BENEFITS OF USING THE AYBAR BBM

	FREQUENCY	PERCENT	VALID PERCENT	CUMMULATIVE PERCENT
Access to credit				
Not Improved	44	88.0	88.0	88.0
Improved	6	12.0	12.0	100.0
Total	**50**	**100.0**	**100.0**	
Financing agriculture				
Own Savings	44	88.0	88.0	88.0
Credit and saving	6	12.0	12.0	100.0
Total	**50**	**100.0**	**100.0**	
New crops introduced				
No	50	100.0	100.0	100.0
What crop to plant				
No	50	100.0	100.0	100.0
Difficulties of Aybar BBM				
No	50	100.0	100.0	100.0
Reduced water use				
Yes	50	100.0	100.0	100.0
Change in irrigation				
No	45	90.0	90.0	90.0
Yes	5	10.0	10.0	100.0
Total	**50**	**100.0**	**100.0**	
When to plant				
No	1	2.0	2.0	2.0
Yes	49	98.0	98.0	100
Total	**50**	**100.0**	**100.0**	

BENEFITS OF INNOVATION

Agricultural Activities Benefits

With a four month growing season for major cereals (wheat and Teff), end users of the innovation harvest twice a year in the study area. The innovation is used only for wheat growing. After the major crop harvest, farmers grow the second crop (mainly chickpea) using the residual moisture.

Farming and Wheat field ploughed by Aybar BBM in West Shewa, Ethiopia

Water Benefits

All the respondents indicated that wheat yield increased by using less water. This is attributed to the reduced water logging benefit of the innovation. Except one respondent, 98 percent (49) indicated improved water access due to the innovation in the study area (Table 6).

TABLE 6. ACCESS TO WATER DUE TO AYBAR BBM: FREQUENCY DISTRIBUTION

ACCESS TO WATER	FREQUENCY	PERCENT	VALID PERCENT	CUMMULATIVE PERCENT
Improved	49	98.0	98.0	98.0
Fundamentally improved	1	2.0	2.0	100.0
Total	**50**	**100.0**	**100.0**	

Despite reduced water logging and increased access to water due to the innovation, the practice of water storage is not used by respondents in the study areas. Introducing small-scale water storage practices can possibly increase water use efficiency and improve people's livelihood if practiced properly through consultation with professionals.

Crop Benefits

Wheat and Teff are the two cereals grown in West Shewa Zone of Oromia National Regional State, Ethiopia. However, during the survey respondents indicated that the innovation is solely used for growing wheat. Row-planting of Teff, following adoption of Aybar BBM, is considered a secondary benefit. Yield level differences due to the innovation for both wheat and Teff are estimated.

The average yield level of wheat in the study area before the innovation was 0.26 MT/acre (Figure 2). After the innovation, the average yield level of wheat increased to 0.57 MT/acre (Figure 3). Due to the innovation, the average yield level of wheat increased by 115 percent in the study area.

FIGURE 2. AVERAGE YIELD LEVEL OF WHEAT (QUINTAL/HA) BEFORE THE INNOVATION

Mean = 13.26
Std. Dev. = 4.897
N = 50

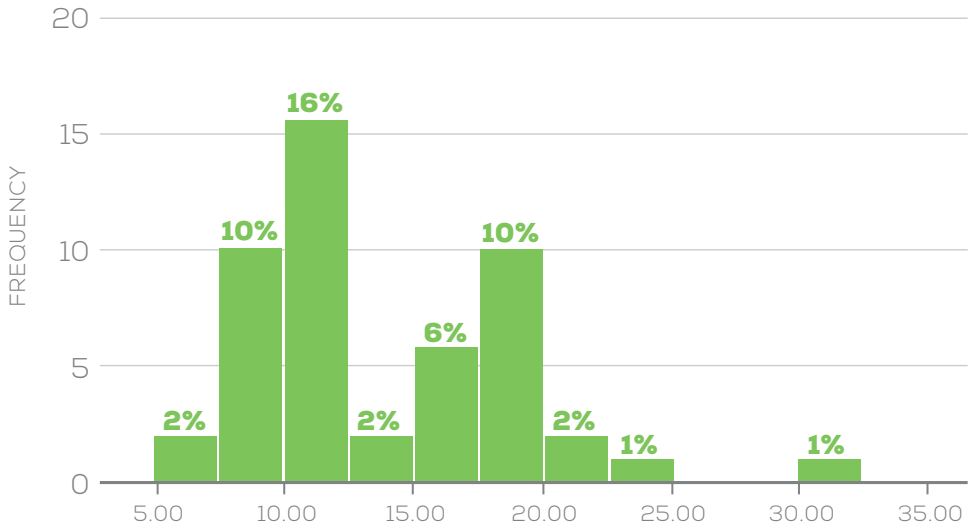
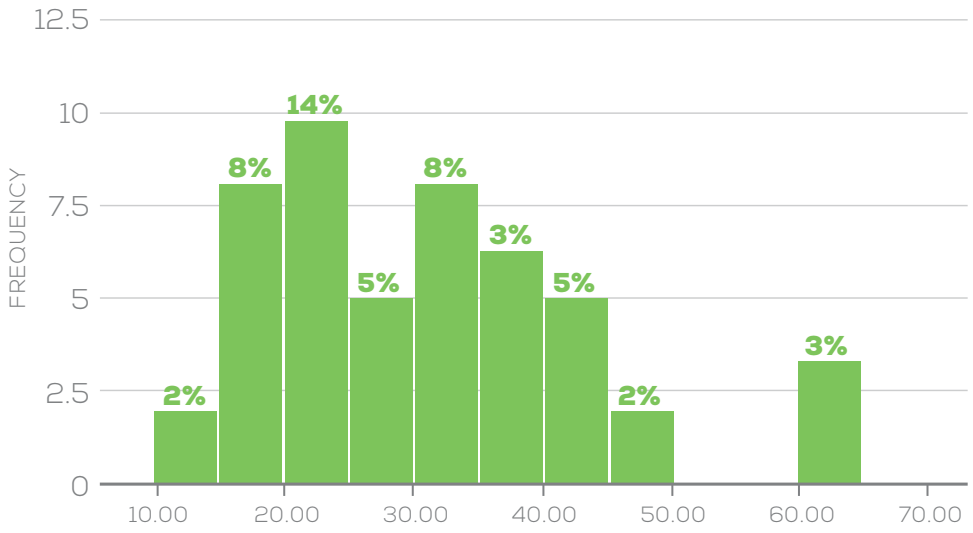


FIGURE 3. AVERAGE YIELD LEVEL OF WHEAT (QUINTAL/HA) AFTER THE INNOVATION

Mean = 28.58
Std. Dev. = 12.049
N = 50



The average yield level of Teff before the innovation was 9.39 quintal/ha [0.18 MT/acre] (Figure 4). After the introduction of row-planting, the average yield level of Teff was 16.55 quintal/ha [0.33 MT/acre] (Figure 5). The row-planting innovation increased the average yield level of Teff by 76 percent in the study area.

FIGURE 4. AVERAGE YIELD LEVEL OF TEFF (QUINTAL/HA) BEFORE ROW-PLANTING INNOVATION

Mean = 9.39
Std. Dev. = 2.714
N = 40

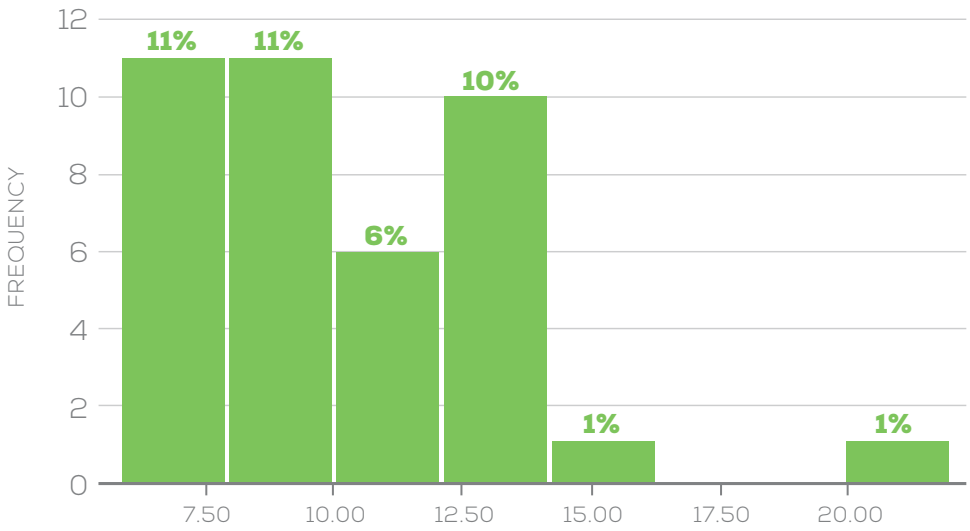
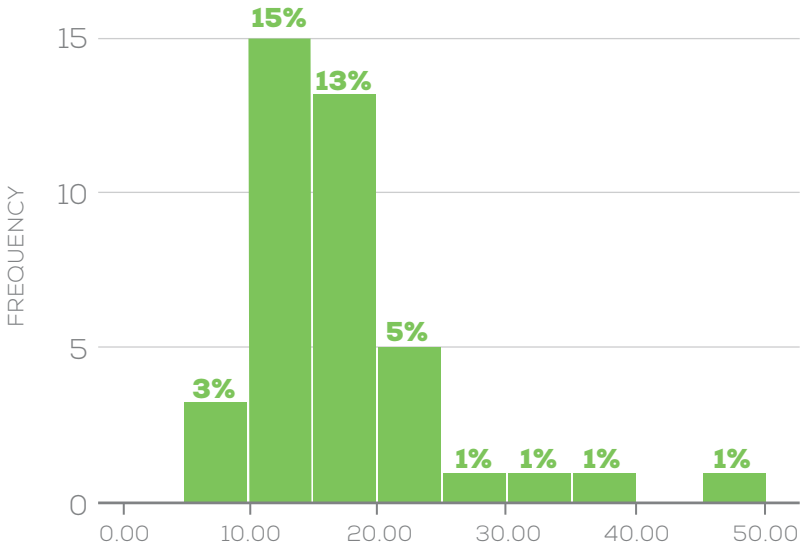


FIGURE 5. AVERAGE YIELD LEVEL OF TEFF (QUINTAL/HA) AFTER ROW-PLANTING INNOVATION

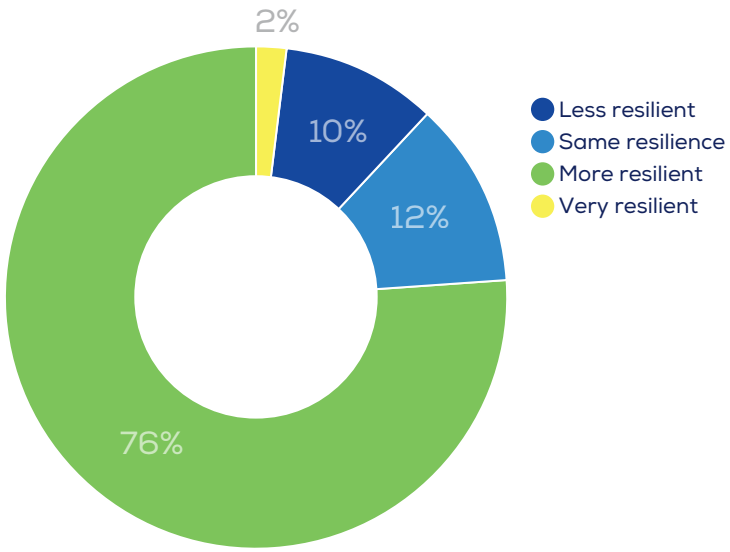
Mean = 16.55
Std. Dev. = 7.669
N = 40



The other benefit of using this innovation is crop survival. End users were asked to express their perception toward crop survival due to the innovation. Accordingly, 76 percent (38) indicated crop survival due to more resilience, followed by the same resilience with 12 percent (six), and less resilience among 10 percent (five) (Figure 6). Some indicated expanding weed invasion, particularly on wheat farms, as the main cause for reduced crop resilience in the study area.

Despite the desire for crop diversification, end users of the innovation do not practice diversifying the crops they grow. There is a potential demand for the innovation to be used for crops other than wheat. The limit to only using this innovation for wheat growing was not clarified by respondents or the innovator. Hence, there is a need to identify the applicability of this innovation for other crops, which, with possible modifications, can realize crop diversification in the study area.

FIGURE 6. PERCEPTION OF CROPS SURVIVAL DUE TO AYBAR BBM IN THE STUDY AREA N=50



Income Benefits

The average annual farm income of end users before the innovation was 10,313 ETB (approximately USD 362), and it increased to 24,155 ETB (approximately USD 847) after the innovation. This implies that the average annual farm income increased by 134 percent due to the innovation. The minimum and maximum farm incomes also increased by 200 percent and 42 percent, respectively (Table 7).

TABLE 7. FARM INCOME OF RESPONDENTS BEFORE AND AFTER THE INNOVATION

		BEFORE THE INNOVATION (IN ETB)	AFTER THE INNOVATION (IN ETB)	RATE OF CHANGE (IN %)
N	Valid	46	47	
	Missing	4	3	
Mean (in ETB)		10,313	24,155	134 (increased
Std. Dev		11,348	20,260	78 (increased)
Minimum		1,000	3,000	200 (increased)
Maximum		70,000	100,000	42 (increased)

Poverty Reduction Benefits

To estimate poverty reduction benefits of using the innovation, a non-parametric Friedman mean rank was estimated on how end users spent their increased income.

Friedman's test result indicates that end users rated the innovation's poverty reduction benefits differently, and the difference is statistically significant at a one percent significance level. The highest mean rank (2.81) is obtained for spending new income on children for school which is followed by investment in farming, improving a house, and spending on weeding (Table 8).

TABLE 8. AYBAR BBM POVERTY REDUCTION BENEFITS: MEAN RANK TEST

INCREASED INCOME BENEFITS	MEAN RANK
Spent on children for school	2.81
Spent for weeding	2.21
Spent as investment in farming	2.68
Spent on improving a house	2.30
TEST STATISTICS	
N	47
Chi-Square	11.978
df	3
Asymp. Sig.	0.007***

[a]. Friedman Test, *** significant at 1% significance level

Gender Differences

Before the innovation, female farmers generated an average household income of 1,766 ETB (approximately USD 62) while male farmers generated 10,909 ETB (approximately USD 383). The difference is significant at a 10 percent significance level (Table 9).

TABLE 9. GENDER AND HOUSEHOLD INCOME DIFFERENCE BEFORE INNOVATION (IN ETB)

GROUP	OBS	MEAN	STD. ERR	STD.DEV	[95% CONF INTERVAL]	
Female	3	1766.667	317.9797	550.7571	398.5103	3134.82
Male	43	10909.3	1754.607	11505.73	7368. 361	14450. 24
Combined	46	10313.04	1673.183	11348.08	6943.079	13683.01
diff		-9142.636	6713.055		-22671.91	4386.638
diff = mean (Female) - mean (Male)					t =	1.3619
H_0 : diff = 0				degrees of freedom	=	48
H_a : diff < 0	H_a : diff !=0		H_a : diff > 0			
Pr (T < t) = 0.0901*	Pr (|T| > |t| = 0.1802				Pr (T > t) =	0.9099

*-significant at 10% significance level

After the innovation, female farmers generated an average household income of 4,433 ETB (approximately USD 155) while male farmers generated 25,500 ETB (approximately USD 895). The difference is significant at a five percent significance level (Table 10).

TABLE 10. GENDER AND HOUSEHOLD INCOME DIFFERENCE AFTER INNOVATION (IN ETB)

GROUP	OBS	MEAN	STD. ERR	STD.DEV	[95% CONF INTERVAL]	
Female	3	4433.33	470.2245	814.4528	2410.12	6456.546
Male	44	25500.00	3052.926	20250.82	19343.19	31656.81
Combined	47	24155.32	2955.253	20260.2	18206.7	30103.94
diff		-21066.67	11812.69		-44858.65	2725.319
diff = mean (Female) - mean (Male)					t =	1.7834
H_0 : diff = 0				degrees of freedom	=	45
H_a : diff < 0	H_a : diff !=0		H_a : diff > 0			
Pr (T < t) = 0.0406**	Pr (|T| > |t| = 0.0813				Pr (T > t) =	0.9594

**- Significant at 5% significance level

Regional Differences

An earlier case study report by the innovator in 2012 indicated that Aybar BBM was first introduced at selected sites in Oromia National Regional State in Ethiopia. In 2013, the Ministry of Agriculture (MoA) conducted a survey to assess the performance of this innovation and confirmed increased crop yield due to the innovation. With some exceptions in Amhara National Regional State, the innovation is mainly distributed in central highland areas of Oromia National Regional State in Ethiopia.

There is no updated and clarified distribution of the innovation in various regions of Ethiopia. This requires commitment of the innovator and other stakeholders to realize the intended objectives of expanding and disseminating this innovation in Ethiopia and other East African countries.

Comparison between latest Innovator M&E and latest SWFF M&E

Lack of lists of innovation end users and how Aybar BBM is sold and distributed is a challenge when comparing the result of this impact analysis with that of the innovator. In particular, the higher number of female innovation users over male users contradicts information obtained from the East Shewa Zone Bureau of Agriculture and Rural Development.

DISCUSSION

From left to right, Gemechu (agriculture DA) and the field evaluator (Mohammed) traveling by cart to Chalalaka Bobe village

The main challenge encountered during the survey for this impact evaluation study is the lack of the list of innovation end users with the innovator and the indirect supply of the innovation. The innovator does not directly supply the Aybar BBM to end users, rather it is only supplied through regional and zonal Bureaus of Agriculture and Rural Development. Due to the upcoming national election in Ethiopia, farmers were engaged in different trainings. As a result, one-half of the individual interviews were conducted in training centers.

Lack of transparency on how the innovation is distributed to end users and why they are unable to afford a durable and relatively cheap Aybar BBM was not clarified. There is a need to identify the stakeholders involved in disseminating the innovation to address the increasing demands of end users. All the sampled respondents' areas are interested in using this innovation in the next five to 10 years but indicated an inadequate supply of Aybar BBM. Whether the limited supply of the innovation is due to innovator's capacity or the indirect mechanism used for dissemination needs to be investigated.

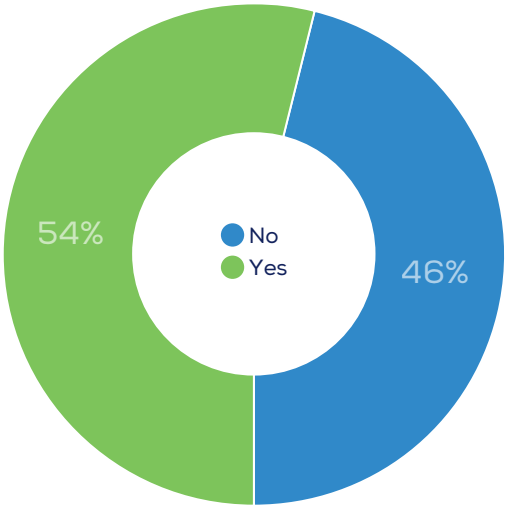
Cart transportation to rural villages off the main roads, West Shew Zone.

Usage/Availability

One of the major challenges faced by end users in adopting the innovation is its availability. This is due to the mechanism in which the innovation is distributed to end users. It is rare to find the supply of the innovation to end users directly from the innovator. Instead, the innovator supplies the Regional Bureau of Agriculture and Rural Development. The Zonal agricultural offices receive the Aybar BBM from regional bureaus and distribute to their respective woredas. As a result, there are possible differences in the availability of the innovation in each woredas.

The availability challenge was identified during the survey, with 54 percent (27) of respondents indicating they shared or borrowed the innovation from neighbors or relatives rather than purchasing it. Only 46 percent (23) indicated they purchased the Aybar BBM (Figure 7). Those who borrowed or shared the innovation also are considered end users in this study.

FIGURE 7. SHARING/BORROWING AYBAR BBM WITH NEIGHBORS/RELATIVES BY RESPONDENTS N=50



Adequate supply of the innovation with a lower price is one of the questions/suggestions raised by end users during the survey. Without a feasible supply channel of the innovation to final users through forum and discussion with stakeholders, including the innovator and officials from the Ministry of Agriculture and Natural Resources, it is not possible to solve availability problems in the study area. As a result, the number of innovation end users can increase both in the study area and in other parts of Ethiopia.

Crop Yield/Survival

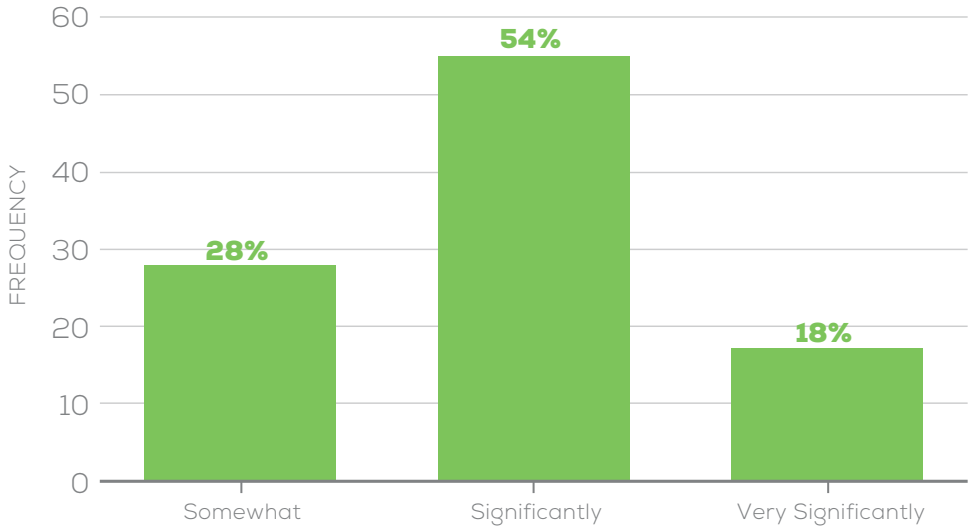
Among respondents, 90 percent (45) agreed that the innovation reduced water logging in their farm and increased crop yield in the study area. The innovation also helped respondents to adjust their sowing time. As a result, survival of the crop increased. High rates of weed invasion, particularly in wheat farms, coupled with inadequate supply and high cost of herbicide are among challenges respondents face. Moreover, escalating costs of fertilizer and labor also are concerns in the study area.

Wheat and Teff are the two cereals mainly grown in the study area. Due to the innovation, the average yield level of wheat increased by 115 percent compared to a 76 percent increase in average Teff yield. Compared to the average yield increment of wheat, the yield increment of Teff is lower. This is mainly because the innovation is solely used for wheat growing. During the survey, respondents indicated their need for Aybar BBM that can be used to grow Teff and other crops. Hence, based on farmers' needs assessment, there is a need to further extend how to use the innovation to grow Teff and other crops.

Changes in Income

Respondents were asked to rank the change in their family income due to the Aybar BBM innovation. For 54 percent of the respondents (27), family income significantly increased due to the innovation. Another 28 percent (14) perceived their family income somewhat increased, and 18 percent (nine) indicated their family income increased very significantly (Figure 8).

FIGURE 8. PERCEPTION OF CHANGE IN FAMILY INCOME DUE TO AYBAR BBM



One factor that can influence income level obtained by respondents is the amount and price of inputs used. Except for fertilizer and labor, the amount and costs of other inputs was not obtained from respondents. The change in amount and cost of fertilizer and labor was estimated.

Before Aybar BBM, the average amount of fertilizer used by end users was 137.2 kg/ha. After the innovation, the average amount of fertilizer was 252 kg/ha. This shows an 84 percent increase in the average amount of fertilizer used. The average expenditure on fertilizer increased from 1,189.7 ETB (approximately USD 42) before the innovation to 3,787.8 ETB (approximately USD 133) after the innovation (Table 11). The average expenditure on fertilizer increased by 218 percent. Whether the increased amount of fertilizer is due to the innovation or consultation by other stakeholders needs further investigation.

The daily average labor requirement (no/ha) increased from seven to eight before and after innovation, respectively. The average labor expenditure also increased from 386 ETB (approximately USD 16) to 667 ETB (approximately USD 23), respectively (Table 11). The average expenditure on labor increased by 73 percent. Whether the increased amount of labor use and cost is due to the innovation needs further investigation and is not in the scope of this study.

TABLE 11. FERTILIZER, LABOR USE AND COST: BEFORE AND AFTER INNOVATION

FERTILIZER USE (KG/HA)	N	MINIMUM	MAXIMUM	MEAN	STD. DEVIATION
Before innovation	50	25.00	300.00	137.2	59.26557
After innovation	50	100.00	400.00	252.0	70.99152
Valid N (listwise)	50				
FERTILIZER COST (IN ETB)					
Before innovation	50	200.00	4200.00	1,189.7	810.06828
After innovation	50	1363.00	5729.50	3,787.8	1055.18155
Valid N (listwise)	50				
FERTILIZER USE (KG/HA)	N	MINIMUM	MAXIMUM	MEAN	STD. DEVIATION
Before innovation	12	2.00	20.00	7.4167	5.72805
After innovation	11	2.00	36.00	8.7273	9.79889
Valid N (listwise)	11				
FERTILIZER COST (IN ETB)					
Before innovation	11	120.00	1080.00	386.36	296.25235
After innovation	12	200.00	1440.00	667.5	361.18806
Valid N (listwise)	11				

Gender Differences

For female respondents, the mean household income due to the innovation increased from 1,766 ETB (approximately USD 62) to 4,433 ETB (approximately USD 155). This implies that the mean household income for female respondents increased by 150 percent

For male respondents, the mean household income due to the innovation increased from 10,909 ETB (approximately USD 383) to 25,500 ETB (approximately USD 895). This implies that the mean household income for male respondents increased by 134 percent.

Even if the average household income of male respondents is significantly higher than female respondents, the percentage change in income is higher for females (150 percent) than for males (134 percent). With other things remaining the same, the innovation can contribute more to the income of female headed households if it is scaled-up in the study area.

Affordability

The average unit price of an Aybar BBM is 345 ETB (approximately USD 12). However, 50 percent (25) of the respondents indicated their willingness to pay 50 percent less, and 26 percent (13) are willing to pay the same price (Table 12). The remaining 24 percent (12) did not comment on the price they are willing to pay for the innovation.

TABLE 12. UNIT PRICE OF AYBAR BBM THAT END USERS ARE WILLING TO PAY

	PRICE WILLING TO PAY	FREQUENCY	PERCENT
	Same as what I pay now	13	26
	50% Less	25	50
Missing		12	24
Total		**50**	**100**

Compared to the durability of the innovation and the average farm income level of end users, the Aybar BBM can be considered affordable. With the exception of two missing responses, 85 percent (41) of the respondents rated themselves as middle-income, and the remaining 15 percent (seven) chose low-income (Table 13).

TABLE 13. RESPONDENTS' PERCEPTION OF THEIR ANNUAL INCOME LEVEL

	INCOME LEVEL	FREQUENCY	PERCENT	VALID PERCENT	CUMULATIVE PERCENT
	MIddle	41	82	85	85
	Low	7	14	15	100
	Total	48	96	100	
Missing		2	4		
Total		**50**	**100**		

The increasing price of inputs like fertilizer and labor can be possible reasons for end users willingness to pay one-half the price for Aybar BBM. Realizing the supply of the innovation at one-half price depends on the cost-benefit analysis of the innovator, among other issues.

Other Benefits

The sample respondents suggested modifications are needed on Aybar BBM to further maximize their benefits. Suggestions constituted weight (an Aybar BBM weighs approximately 3.5 kilograms), price, Aybar BBM suitable for other crops (in the study area they solely use the innovation for growing wheat), adequate supply, and better extension services.

Even if it is not related to the innovation, end users also suggested an effective mechanism to control weeds. Of 50 respondents, only 20 suggested the aforementioned modifications on the innovation. Adequate supply at lower price was suggested by 25 percent, followed by weed control with adequate extension service (20 percent), lower price and use for other crops (20 percent), and the same price and use for other crops (15 percent) (Table 14). Realization of the suggested modifications depends on transparent discussion with the innovator and responsible stakeholders.

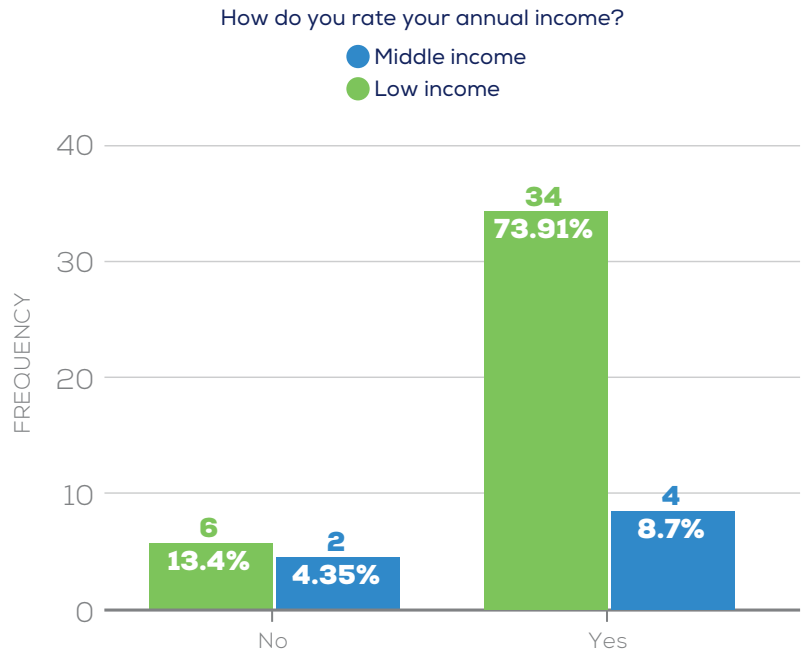
TABLE 14. SUGGESTED MODIFICATIONS ON AYBAR BBM BY END USERS

	SUGGESTED MODIFICATIONS ON AYBAR BBM	FREQUENCY	PERCENT	VALID PERCENT
	Less weight and lower price	1	2	5
	Lower price and for other crops	4	8	20
	Same price and for other crops	3	6	15
	Lower price, less weight and for other crops	1	2	5
	Weed control and better extension service	4	8	20
	Adequate supply at lower price	5	10	25
	Adequate supply and for other crops	2	4	10
	Total	**20**	**40**	**100**
Missing		30	60	
Total		**50**	**100**	

Impact on Poverty

Even if detailed data is not collected to measure impact on poverty, this study attempts to measure using proxy measures. The proportion of low-income end users of the innovation that spend their new income on children for school is 8.7 percent (four) and is higher than those in the same category who do not spend. This can be a promising result to further promote access for the innovation by low-income end users (Figure 9).

FIGURE 9. SPENDING OF NEW INCOME ON CHILDREN FOR SCHOOL



Compared to low-income end users, most of the middle-income end users of the innovation (69 percent) spent their new income as an investment in farming. The possible reason is that low-income level end users mostly spend their new income on household consumption rather than on investment (Table 15).

TABLE 15. INCOME SPENT AS INVESTMENT ON FARMING: LOW AND MIDDLE INCOME END USERS

	LEVEL OF ANNUAL INCOME		
SPENT ON FARMING INVESTMENT	MIDDLE INCOME (%)	LOW INCOME (%)	TOTAL
No	17.4	6.5	23.9
Yes	69.6	6.5	76.1
Total	**87.0**	**13.0**	**100.0**

Benefits of Innovation on Community

Four major benefits of the innovation were identified during the survey. These are yield, income, reduced labor, and reduced water logging benefits. Yield benefit of the innovation is agreed on by 92 percent (46) of respondents and reduced water logging by 90 percent (45). According to the respondents, reducing labor is the least benefit of Aybar BBM and is perceived only by 26 percent (13) of the end users. The benefit perception difference is statistically significant at a one percent significance level (Table 16).

TABLE 16. AYBAR BBM BENEFITS: FRIEDMAN MEAN RANK TEST

BENEFITS	MEAN RANK
The innovation has yield benefit	2.87
The innovation has income benefit	2.75
The innovation has (lowered) labor benefit	1.55
The innovation has (reduced) water logging benefit	2.83
TEST STATISTICS[a]	
N	50
Chi-Square	63.503
df	3
Asymp. Sig.	0.000***

****- significant at 1% significance level

Comparison of latest innovator M&E statistics with latest SWFF M&E statistics

As there are no available lists of innovation end users, it is difficult to confirm the numbers indicated. Lack of transparency on how the innovation is sold and distributed to customers is another challenge to accepting the innovator's negative profit margin, given the increasing demand for the innovation. In contrast to information from West Shewa Zone Bureau of Agriculture and Rural Development, the number of females using the innovation (5,741) is higher than male users (5,627).

During the survey, some respondents indicated they have been using Aybar BBM for the last four years. During the impact analysis survey, customers' satisfaction with the innovation was identified and all respondents indicated their intention to use it in future with some suggested modifications. This can be an input for the innovator in future planning.

CONCLUSION

Aybar Broad Bed and Furrow Maker was a SWFF-supported agricultural innovation project targeting to solve the pressing challenge of waterlogging in Vertisols of Ethiopia. This report presents performance analysis results conducted in July and August, 2019, in West Shewa Zone of Oromia National Regional State in Ethiopia. The innovation was active in the study area for four years.

All 50 end users indicated that no new crops were introduced due to the innovation, and the innovation does not help them decide what crops to plant. No difficulties were experienced by respondents in using the innovation in the study area. All respondents agreed on reduced use of water due to the innovation.

The four major benefits of the innovation are yield, income, reduced labor, and reduced water logging. Yield benefit of the innovation is agreed upon by 92 percent (46) of respondents and reduced water logging by 90 percent (45). The least perceived benefit of Aybar BBM is reduced labor, with only 26 percent (13) of the end users indicating this benefit.

Among the respondents, 90 percent (45) agree that the innovation reduced water logging on their farm and increased crop yield in the study area. Accordingly, the average wheat yield increased by 115 percent (from 0.26 MT/acre to 0.57 MT/acre) and Teff increased by 76 percent (from 0.18 MT/acre to 0.33 MT/acre). The average annual farm income of end users before the innovation was 10,313 ETB (approximately USD 362) and increased to 24,155 ETB (approximately USD 847) after the innovation. Even if the average household income of male respondents is significantly higher than female respondents, the percentage change in income is higher for females (150 percent) than it is for males (134 percent).

The average unit price of an Aybar BBM is 345 ETB (approximately USD 12). However, 50 percent (25) of the respondents indicated their willingness to pay 50 percent less and 26 percent (13) are willing to pay the same price. Reduced unit price and applicability for crops other than wheat are among suggested modifications on the innovation by end users in the study area.

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ANNEX I

FARMER INFORMATION

NAME _____

AGE _____

DATE _____ TIME _____

GROUP INTERVIEW? ❑ Yes ❑ No

GROUP INTERVIEW NOTES

_____

_____

_____

HOW MANY FAMILY MEMBERS LIVE WITH YOU? _____

GENDER ❑ Male ❑ Female

WHAT IS YOUR PRIMARY OCCUPATION?

- ❑ Farming
- ❑ Wage Labor
- ❑ Seasonal Migrant Labor
- ❑ Small Enterprise
- ❑ Other: _____

DO YOU HAVE ANOTHER OCCUPATION?

- ❑ Farming
- ❑ Wage Labor
- ❑ Seasonal Migrant Labor
- ❑ Small Enterprise
- ❑ Other: _____

SIZE OF FARM (ACRES) _____

NAME OF VILLAGE _____

HOW MUCH LAND DO YOU OWN? _____

HOW LARGE IS YOUR FARM/PLOT?

- ❑ Large
- ❑ Medium
- ❑ Small
- ❑ Very Small

HOW MUCH IS LAND RENT? _____

OTHER LAND NOTES

_____

_____

_____

HOW LONG HAVE YOU BEEN USING AYBAR? _____

DID YOU PARTICIPATE IN AGRICULTURAL ACTIVITIES THIS YEAR? ❑ Yes ❑ No

HOW MANY MONTHS IS THE PRIMARY GROWING SEASON? _____

HOW MANY TIMES DO YOU HARVEST PER YEAR? _____

FARM INFORMATION

WHAT CROPS DO YOU GROW AS A RESULT OF THE INNOVATION? LIST FROM MOST IMPORTANT TO LEAST IMPORTANT:

1. _____
2. _____
3. _____

DID THE MOST IMPORTANT CROP BENEFIT FROM AYBAR? ❑ Yes ❑ No

DID THE SECOND MOST IMPORTANT CROP BENEFIT FROM AYBAR? ❑ Yes ❑ No

DID THE THIRD MOST IMPORTANT CROP BENEFIT FROM AYBAR? ❑ Yes ❑ No

WHAT IS THE WATER SOURCE FOR YOUR IRRIGATION OF CROPS?

- ❑ Own pond
- ❑ River
- ❑ Groundwater
- ❑ Innovation Source
- ❑ Other: _____

WHAT IS YOUR METHOD OF IRRIGATION?

- ❏ Drip feed
- ❏ Flooding
- ❏ Hand watering
- ❏ Rainfed
- ❏ Other: _____

HOW MUCH HAS YOUR WATER USAGE CHANGED SINCE USING AYBAR, IF AT ALL?

_____

USING AYBAR HAS YOUR ACCESS TO WATER:

- ❏ Had no change
- ❏ Improved
- ❏ Fundamentally improved (Improved a lot)
- ❏ Other: _____

PREVIOUSLY GROWN CROPS: DID YOUR FARM PRODUCE DIFFERENT CROPS IN THE PAST THAT ARE NO LONGER GROWN HERE? IF SO, WHICH ONES? _____

_____

MASS OF PRODUCE: WHAT YIELDS DID YOU HAVE FOR EACH CROP YOU MENTIONED?

_____

_____

MASS OF PRODUCE 2: WHAT YIELDS DID YOU HAVE FOR YOUR CROPS BEFORE USING AYBAR?

_____

USING AYBAR HAVE YOU, FOR EACH CROP:

- ❏ Used more water
- ❏ Had no change in water use
- ❏ Used less water
- ❏ Other: _____

USING AYBAR HAVE YOUR CROP YIELDS (ASK FOR EACH CROP):

- ❏ Declined
- ❏ Remained the same
- ❏ Increased
- ❏ Substantially increased

IS THERE A DIFFERENCE IN THE SURVIVAL RATES OF YOUR CROPS DUE TO AYBAR? ❑ Yes ❑ No

HOW MUCH OF YOUR PRODUCE DID YOU CONSUME IN YOUR HOUSEHOLD? (PERCENTAGE – NOTE IF DIFFERENT FOR EACH CROP) _____

_____

HOW MUCH OF EACH OF THE FOLLOWING INPUTS DID YOU USE BEFORE AYBAR?

FERTILIZER _____ (KG)
PESTICIDE _____ (KG)
HERBICIDE _____ (L)
CHARCOAL _____ (KG)
WATER _____ (TOTAL)
LABOR _____ (DAYS)
OTHER _____

HOW MUCH DID YOU SPEND ON EACH OF THE FOLLOWING INPUTS BEFORE AYBAR?

FERTILIZER _____ (KG)
PESTICIDE _____ (KG)
HERBICIDE _____ (L)
CHARCOAL _____ (KG)
WATER _____ (TOTAL)
LABOR _____ (DAYS)
OTHER _____

HOW MUCH OF EACH OF THE FOLLOWING INPUTS DO YOU USE AFTER AYBAR?

FERTILIZER _____ (KG)
PESTICIDE _____ (KG)
HERBICIDE _____ (L)
CHARCOAL _____ (KG)
WATER _____ (TOTAL)
LABOR _____ (DAYS)
OTHER _____

HOW MUCH DID YOU SPEND ON THE FOLLOWING INPUTS AFTER AYBAR?

FERTILIZER _____ (KG)
PESTICIDE _____ (KG)
HERBICIDE _____ (L)
CHARCOAL _____ (KG)
WATER _____ (TOTAL)
LABOR _____ (DAYS)
OTHER _____

HOW MUCH DID YOU SPEND ON EQUIPMENT BEFORE AND AFTER AYBAR? _____

_____

HOW MUCH DID YOU SPEND ON TRANSPORT AND STORAGE BEFORE AND AFTER AYBAR? _____

DO YOU HAVE PROBLEMS FINDING A MARKET TO SELL YOUR CROPS IN? ❑ Yes ❑ No
PLEASE EXPLAIN. _____

_____

DO YOU HAVE PROBLEMS GETTING YOUR CROPS TO THE MARKET? ❑ Yes ❑ No
PLEASE EXPLAIN. _____

_____

OTHER FARM NOTES (OPTIONAL).

_____

_____

_____

INCOME AND EXPENDITURES

WHAT IS YOUR ANNUAL HOUSEHOLD INCOME? _____

HOW MUCH INCOME DID YOU MAKE BEFORE AYBAR? _____
AFTER AYBAR? _____

HAS AYBAR IMPROVED YOUR FAMILY INCOME? _____

WHAT PERCENTAGE OF YOUR INCOME DO YOU GET FROM NON-FARM SOURCES? _____

HOW MUCH PRODUCE DID YOU SELL FOR EACH OF YOUR CROPS IN THE LAST SEASON AND THE LAST YEAR? _____

_____

WHAT IS THE PRICE PER KILO YOU RECEIVED FOR EACH OF YOUR CROPS FOR THE LAST SEASON?

_____

_____

USING AYBAR HAS YOUR ACCESS TO CREDIT:

- ❑ Not improved
- ❑ Improved
- ❑ Improved and have been able to repay over a short period

HOW DO YOU CURRENTLY FINANCE AGRICULTURAL ACTIVITIES?

- ❑ Own savings
- ❑ Credit and savings scheme
- ❑ Other credit

HOW MUCH DO YOU PAY FOR AYBAR? _____

HOW MUCH ARE YOU WILLING TO PAY FOR AYBAR?

- ❑ Nothing
- ❑ AYBAR is free
- ❑ The same as what I pay now
- ❑ 50% less
- ❑ 50% more
- ❑ Other: _____

HOW HAVE YOU SPENT YOUR NEW INCOME?

- ❑ N/A (if no new income)
- ❑ Send children to school or keep children in school
- ❑ Social functions (like weddings)
- ❑ Investment in farming
- ❑ Improving house
- ❑ Other: _____

OTHER INCOME NOTES (OPTIONAL)

_____

_____

_____

PERCEPTIONS OF AYBAR

WILL YOU USE AYBAR IN THE FUTURE (5 TO 10 YEARS)? ❑ Yes ❑ No

WHY? _____

_____

HOW, IF AT ALL, HAVE YOU CHANGED YOUR FARMING PRACTICES DUE TO AYBAR?

- ❑ No change
- ❑ Introduced new crops
- ❑ Changed irrigation system
- ❑ Reduced water usage
- ❑ It helps me decide when to plant
- ❑ It helps me decide which crops to plant

HAVE YOU FACED ANY DIFFICULTIES OR PROBLEMS USING AYBAR? ❑ Yes ❑ No

HOW CAN AYBAR BE IMPROVED? _____

_____

HOW DID YOU HEAR ABOUT AYBAR?

- ❑ Wealthy farmer
- ❑ Neighbor
- ❑ Innovation personnel
- ❑ Extension worker
- ❑ Other: _____

WHAT FACTORS INFLUENCED YOU TO TRY AYBAR?

- ❑ Demonstration from neighbor's farm
- ❑ Innovation is free from extension services
- ❑ No alternative water source
- ❑ Other: _____

DO YOU SHARE YOUR KNOWLEDGE SKILLS FROM AYBAR WITH OTHERS? ❑ Yes ❑ No

IF SO, HOW? _____

_____

_____

WHAT DO YOU FEEL ARE THE BENEFITS OF AYBAR? _____

_____

_____

HAVE YOU HEARD ABOUT CLIMATIC VARIATION? HAVE CHANGES IN RAINFALL OR TEMPERATURE AFFECTED YOUR FARMING PRACTICES OR CROP YIELDS COMPARED TO YOUR HISTORICAL RAINY/DRY SEASON PERIODS? ❑ Yes ❑ No

PLEASE SPECIFY HOW. _____

_____

_____

HOW HAS AYBAR HELPED YOU? PLEASE RANK THE TOP 3 AND EXPLAIN POSITIVES/NEGATIVES.

☐ Makes water reusable _____

☐ Helps women farmers as well as men _____

☐ They made a special effort to include women farmers _____

☐ Helps in producing more of our most important crop _____

☐ Increases my yield through timely forecasts _____

☐ Helps by lowering cost of inputs _____

☐ Improves health and strength of livestock _____

☐ Helps reduce labor _____

☐ Reduces crop wastage _____

☐ Helps me decide when to plant _____

☐ Helps me decide which crops to plant _____

☐ Other: _____

WOULD YOU RECOMMEND AYBAR?

❑ No
❑ Yes
❑ Yes, would strongly recommend

ARE THERE NEGATIVE IMPACTS FROM AYBAR IN THE COMMUNITY? ❑ Yes ❑ No

PLEASE EXPLAIN IF YES. _____

_____

_____

IF THERE HAVE BEEN ANY NEGATIVE IMPACTS, HAVE EFFORTS BEEN MADE TO RESOLVE THEM?
❑ Yes ❑ No

EXPLAIN. _____

_____

_____

OTHER

INCOME/POVERTY NOTES

_____

_____

GENDER OBSERVATIONS

_____

_____

QUESTIONS/REQUESTS

_____

_____

OTHER NOTES

_____

_____

_____

SECURING
WATER
FOR FOOD:
A GRAND CHALLENGE
FOR DEVELOPMENT

Securing Water for Food has sourced and invested in a portfolio of innovative solutions that aim to help farmers use water more efficiently and effectively, improve water storage for lean times, and remove salt from water to make more food. Our cohort of innovators are helping people in 35 low-resource countries with tools they need to produce more food with less water.

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