

# Cluster Based Large Scale Demonstration of Irrigated Wheat Production Technologies in East Wollega Zone, Oromia, Ethiopia

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**Abstract:** Ethiopian government has initiated a wheat self-sufficiency strategies through increasing wheat productivity and expansion of production to the irrigable land areas. This study investigated Cluster based large scale demonstration of irrigated bread wheat production in Wayu Tuka and Jima Arjo Districts. Irrigated bread wheat production and build local capacity for wider adoption of irrigated bread wheat production technologies practices in East wollega Zone were the main objectives of the activity. A total of 487 farmers were addressed in both districts. It was done in well-functioned eight irrigation schemes in Wayu Tuka and one irrigation schemes in Jima Arjo district. Site and farmers were selected possessively based on irrigation and production potential of the commodity, farmers' willingness and accessibility for supervision and input transportation. Improved bread wheat variety of "kingbird" for Wayu Tuka and "Dendea" for Jima Arjo District were planted at a rate of 150 kg/ha on a total land size of 124ha. Extension services such as advisory, inputs, training and field day were delivered and organized for the farmers, extension agents and others. Training was given before the implementation of the activity for a total of 80 farmers, 11 extension agents and 18 agricultural experts. Besides, training advisory services were continuously given for farmers from the land preparation up to threshing. Field day was conducted with a participants of 36 agricultural experts, 15 extension agents and 386 farmers. The maximum grain yield (66.06 qt/ha) was recorded from Goto Cluster in Wayu district. While the over all average grain yield obtained from a hectare of land is accounted 44.22 and 39.5 quintals in Wayu Tuka and Jima Arjo District respectively. Totally, 2435 peoples were benefited either directly or in directly from the implemented irrigated wheat production. Therefore, It is better to strengthen current awareness and should be continued for improving productivity of the crop in a sustainable manner.

**Keywords:** Bread Wheat, Cluster, Demonstration, Farmers, Irrigation, Self-sufficiency

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## 1. Introduction

Agricultural system in Ethiopia constitutes 46% of gross national production, employs 85% of its population [1]. It creates 75% of export commodity value. Despite its large scale, the agricultural sector is largely formed by smallholder subsistence farms burdened by dependence on erratic rain-fed systems. In all, smallholders account for 96% of total area cultivated [2].

In Ethiopia wheat is the most important cereal crops in terms of both production and use. Ethiopia is the second

largest wheat producer, after South Africa, in Sub-Saharan Africa [3]. According to several reports, wheat occupies about 700,000 ha in Ethiopia with durum wheat covering about two thirds of this area and bread wheat one third. In Ethiopia wheat grain is used for preparation of different traditional food staffs, such as "Injera", bread ("Dabo"), Local beer ("tella"), "dabokolo", "marqa" and "kinche". Besides, wheat straw is commonly used as roof thatching materials and as feed for animals.

Ethiopia, like other developing countries, faces the challenge of an increasing population and food insecurity [4].

To fill the gap, the country has been importing about 1.0 million MT of wheat grain annually since 2008 at a cost of 500 million USD [5], resulted in losing of huge foreign currency. This trend has continued and it has drawn the attention of both policymakers and researchers.

The government of Ethiopia is aware of the above-mentioned facts and different attempts are being made to make the country self-sufficient in food grains in the shortest possible time. The first and most defendable way is believed increasing the yield per unit area. The second way to grain self-sufficiency is to bring more land under cultivation. The third possible way is to intensify production under irrigation. There is high spatial variability in water resources endowment and development in the Ethiopia. Even though Ethiopia has 3.3 million ha of irrigable land in its numerous fertile river valleys, irrigated agriculture is in its infant stage. Of the above-mentioned irrigable land, only 3% is in use under irrigation [4]. Total area of irrigated agricultural land in Ethiopia is estimated about 625,819 ha in 2005/2006, out of which 483,472 is traditional irrigation, 56032 ha is modern small scale irrigation, 86,612 ha is modern medium and large scale schemes. Out of the total irrigated area, 197,250 ha is covered by the so-called modern schemes while the remaining area is traditional schemes [6]. In the Ethiopian context, the irrigation sub sector is classified as small (less than 200 ha), medium (200 to 3000 ha) and large scale (over 3000 ha) schemes [7, 8]. Hence, ninety percent of the country's water resources development occurs in four river basins [9]. Most of the large-scale irrigated farms are in the Awash Valley [10]. The land use efficiency of irrigated regions in Ethiopia is very low compared to other countries which grow more than one crop per year on the same area. To optimize the land use efficiency of the irrigable lands in Ethiopia, crops could be grown without interfering other crop production. Thus, the wheat varieties development works have been implemented fully by government money and later on with financial and technical support of Agricultural Research for Development of Strategic Crops (SARD-SC) wheat project. The variety development activities were started with adaptation trials using rain fed varieties of both bread and durum wheat for two seasons and concluded with the recommendation of 3 bread wheat and 2 durum wheat varieties. Side by side, the variety development activities have been implemented using the introduced wheat germplasms from ICARDA at different locations (Werer, Amibera, Gewane and later on Fentale and Mehoni). Both the recommended and released bread and durum wheat varieties were demonstrated on agro-pastoral fields both in Middle- and Lower-Awash areas (Afar Region) and in Fentale District (Oromia Region) followed by demonstration and pre-scaling up activities [10]. The ministry of agriculture (MoA) in collaboration with the Ethiopian institute of agricultural research (EIAR) has recently launched a new initiative to expand irrigation based wheat production. In 2019/20, the Oromia agricultural research institute and the Ethiopian institute of agricultural research have extended the experience to the high land and mid altitude areas. Therefore, this activity was proposed to popularize

irrigated wheat production technologies and practices and to build local capacity for wider adoption of irrigated wheat production technologies in East Wollega zone, Western Oromia Region.

## 2. Methodology

### 2.1. Description of the Study Area

The activity was conducted in Wayu Tuka and Jima Arjo districts of East Wollega zone, Oromia Region. It was conducted in 2020/21 off season. Gute and Arjo towns, which are the capital towns of Wayu Tuka and Jima Arjo districts were located at about 316 and 378 km distance from Finfinnee in western direction respectively. Geographically Wayu Tuka district is located between 36°40'0" and 36°50'0" E and 8°50'0" and 9°10' 0" N at an altitude range of 1300-3140 m.a.s.l. While Jima Arjo district is situated at an altitude of 1280.67 to 2563.77 m.a.s.l and lies between 8°32'39" to 8°55'10" N latitude and 36°22'17" to 36°43'53" E longitude according to Garmin 60 GPS reading.

The climate of the Wayu Tuka district is classified traditionally into three main agro-climatic zones, low land, midland, and highland. The agro climatic zone of Wayu Tuka district is categorized as Midland, high land and low. From the total land of the district, 472.5 ha is irrigable land [11]. The thirteen years (2006-2018) climatic data from Nekemte Meteorological Station was recorded and the area has a uni modal rainfall pattern that extends from April to October with average annual precipitation of 2166.43 mm. Maximum rain is received in June, July, and August, with a mean monthly temperature varying from 11.93-28.21°C. The topography of the Wayu Tuka district is a mountainous and slopping landscape. Topographically, Wayu Tuka district is characterized by very gentle slopping to strongly slopping according to the rating [12]. Nitisols are the major soils that cover the western part of Ethiopia [13]. Also, the Wayu Tuka District is among the 17 districts of the East Wollega zone and the soil is acidic in reaction. Clay loam soil coverage of the district is 17371.68 ha (60%). On the other hand, Sandy soil covers an area of 10133.49 ha (35%) and clayey soil 1447.64 ha (5%). The economic activities of the local society of the Wayu Tuka district are primarily a mixed farming system that involves animal husbandry and crop production. The farming system is a subsistence involving a mixing crop-livestock production agricultural system. Farmers of the district commonly practice the traditional way of crop production like continuous maize growing or mono-cropping using rain fed agriculture.

According to recent meteorological data of the nearby station at Jima Arjo district shows that the mean annual minimum and maximum temperatures of the districts are 11.72 and 22.09°C respectively, and the mean annual rainfall is 2417 mm. The areas has a uni modal rainfall pattern and the highest rainfall is recorded in the month of July. The district falls in between the traditional wet Kolla and wet Dega agro-climatic zones. From the total area of the district,

4.5% falls in Wet Kolla which is hot to warm moist lowland (Tropical), 80.7% is Wet Weyna Dega which is tepid to cool moist mid highlands (subtropical) and 15% falls in Wet Dega (temperate) climates [14]. The total area of the district was estimated to be 76,574 ha with a total population of 86,329. Some area of the southern part of the district is owned by Arjo Didessa Sugar Factory and is entirely being used for irrigated sugarcane production. South Western part of the

area is occupied by investors and is entirely used for rain-fed agriculture mainly for maize (*Zea mays*) production. The remaining agricultural land is occupied by local small holder farmers who practice mixed agriculture. According to the extracted digital soil data obtained from [15], the area has 4 major soil orders based on FAO/UNESCO soil classification system. They are Dystric Nitisols, Pellic Vertisols, Dystric Gleysols and Orthic Acrisols.

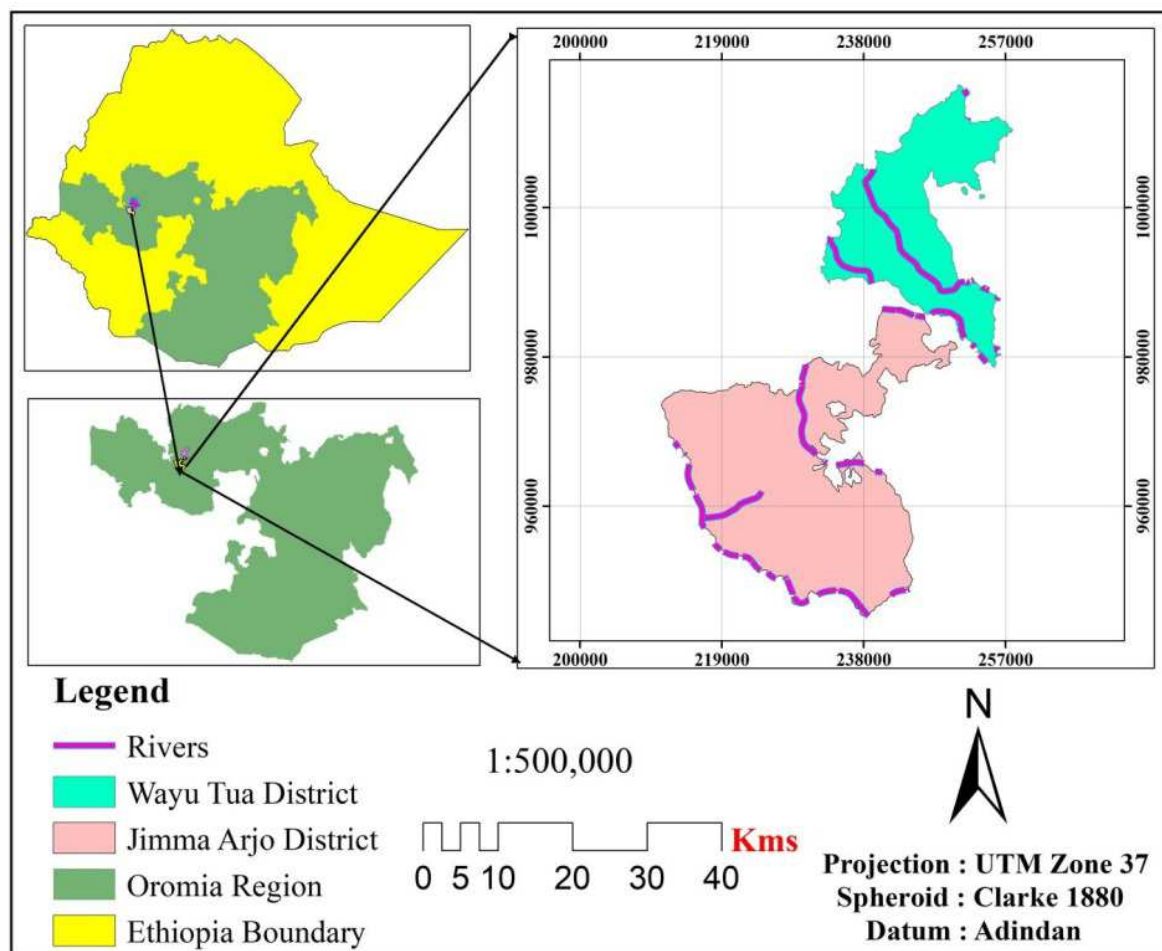


Figure 1. Map of the study areas.

## 2.2. Sites/Farmers Selection and Cluster Formation

The investigation was conducted in Wayu Tuka and Jima Arjo Districts of Eastern Wollega Zone. Site and farmers were selected possessively based on irrigation and production potential of the commodity, farmers' willingness and accessibility for supervision and input transportation. From both districts nine well-functioning irrigation schemes were selected in collaboration with experts who are members of technical team organized for irrigated wheat related activities from district office of agriculture. Eight irrigation schemes having a total land size of 114 ha Wayu Tuka district and one irrigation schemes having a total land size of 10 ha in Jima Arjo district were selected for the implementation of the activity. Each irrigation schemes were considered as cluster and serve for teaching participant and surrounding farmers.

## 2.3. Training and Advisory Services

Training was prepared and given for the farmers, extension agents and agricultural experts at the beginning of the implementation. It was aimed to improve knowledge, skills and attitudes of trainees on irrigated wheat production technology practices, production and pre and post-harvest managements. Besides, training advisory services were continuously given from the land preparation up to threshing.

## 2.4. Planting and Field Management

Improved bread wheat variety of "kingbird" for Wayu Tuka and "Dendea" for Jima Arjo district were broadcasted at a rate of 150 kg/ha. The variety was selected based on its suitability to the agro-ecology of the study area. Land

preparation and seed covering were done by using oxen. All farm operations land preparation, planting, weeding, agro-chemical spray, harvesting, threshing were carried out by the participating farmers with close supervision of researchers and district level agricultural experts. Fertilizer rate of 150 kg UREA and 100 kg NPS were used. Full doze of NPS and 1/3 of recognized UREA were applied during sowing while the remained UREA was applied 21 days after sawing. Recommended packaged production and management technologies and practices (seed rate, spacing, fertilizer management and weed management) for bread wheat production were used. Irrigation frequency used was varied 7-14 days based on soil type, micro agro- climate and crop stage. The irrigation frequency were higher at early and flowering stage.

### 2.5. Publicity and Experience Sharing

Field visits and field days were conducted at vegetative and maturity stages of the crop. Field days were organized at crop maturity stage. The technology and experiences were shared through radio (FM 91.6) and TV (OBN) for wider publicity. Furthermore, Extension materials: Leaflets and posters explaining about the production of irrigated wheat was distributed to different stakeholders.

### 2.6. Documentation

Documentation of the entire process; i.e training events,

land preparation, planting, field management, harvesting and threshing, field visits, field days, stakeholders' participation and Yield results in written form, pictures and videos were made.

### 2.7. Data Collection & Analysis

Both quantitative and qualitative data were collected. The collected data were: agronomic data (yield data), total number of farmers and other stakeholders" participated in field visits and field days, total number of farmers and other stakeholders" participated in training and farmers" perception on the attribute of the technology. The collected qualitative data were analyzed and described using descriptive statistics such as mean, frequencies and tables. Also the collected yield data was analyzed using Excel 2010. Other quantitative gender dis aggregated data were described using tables. Farmer feed backs were summarized qualitatively described.

## 3. Results

### 3.1. Cluster Formation and Its Participants

Nine clusters were organized according their land continuity. Eight cluster in Wayu Tuka and one cluster in Jima Arjo district. A total of 487 farmers (436 male and 51 female) were selected from both districts (Table 1).

**Table 1.** Cluster Formation, Area and its Participants.

District	Kebele	Cluster	Area planted (ha)	Participants		
				Male	Female	Total
Wayu Tuka	Bonaya Molo	Bolale 1	18.00	52	0	52
Wayu Tuka	Bonaya Molo	Goto	15.00	52	8	66
Wayu Tuka	Bonaya Molo	Jato	12.00	60	9	69
Wayu Tuka	Bonaya Molo	Qarsa	11.00	36	8	44
Wayu Tuka	Gara Hudha	Bolale 2	24.00	79	2	81
Wayu Tuka	Migna Kura	G/ dayito	17.00	26	5	31
Wayu Tuka	Migna Kura	B/dayito	11.00	24	3	27
Wayu Tuka	Migna Kura	T/dayito	6.00	18	4	22
Jima Arjo	Lalo	Lalo	10.00	89	12	101
	Grand total		124	436	51	487

Selected farmers from a members of organized cluster took one day training including practical sessions. The training was provided in each districts before planting. The training also included development agents and subject matter specialists. As indicated in Table 2 below a total of 18 agricultural experts, 11 extension agents and 80 farmers had participated in the training program. The training was given at the beginning of the implementation. Besides, training advisory services were continuously given from the land preparation up to threshing. At the beginning, a sort of

orientation on land preparation, irrigation canal cleaning, fertilizer application, sowing and farrow preparation were given by researchers to farmers and selected agricultural experts for production purposes. It also given to the farmers at different stages of productions by the researchers. During supervision, information on weeding practices, water application (irrigation frequency and method of application), harvesting and overall management required were delivered to producer farmers mainly by researchers, extension agents and agricultural experts.

**Table 2.** Training participants on Irrigated wheat production and management.

Training Title	Agricultural experts (SMS)			Extension agents (DAs)			Farmers		
	Male	Female	Total	male	female	Total	Male	Female	total
Irrigated wheat production	18	-	18	9	2	11	68	12	80
Over all Total	18	-	18	9	2	11	68	12	109





Figure 2. Photos taken during theoretical and practical training.

Table 3. Stakeholders involved and their roles.

Stakeholders	Roles and responsibilities
Institute (IQQO)	Cooperation, concrete suggestion, valuable criticism and endless support from the planning stage to the end
Research (NSRC)	Coordination and facilitation; Facilitates provision of inputs (Seed, fertilizer and agro-chemicals; Provision of training; Organizing field days and visits; Supervising, monitoring and Evaluation and Collecting feedback for future technology promotion
Zonal and District level Agriculture and Natural resource Office	coordinate, facilitate and assign appropriate person; Organize farmers into clusters and assist in site and farmers' selection; Monitoring of activities of farmers in each cluster; Support in providing training and field days and visits and Assist during input distributions
Farmers	Organize themselves in cluster; Allocate land as per the requirement; Prepare land for sowing and conduct required management practice (Agronomic practice) as per researchers and experts' advice; Participate in the training and field days; Share skills and experiences to neighboring farmers and operate as per the contract agreement
Plant Heath office of East Wollega Zone	Identify wheat diseases and provide the appropriate pesticide and insecticide
Oromia Seed enterprise and Gibe Didessa union	provide pure quality seed
Nekemte branch OBN and FBC	Disseminate the technology and related information for wider community.

### 3.2. Input Distributed

Except seed, all other inputs were provided by Nekemte soil research center irrigated wheat project as per the initial agreements made with participating farmers. Seed was

provided by Oromia seed enterprise. Totally, 186 qt of wheat seed, 124 qt of NPS fertilizer, 186 qt of Urea fertilizer, 62 Lit of herbicides, 12 Lit of fungicides and 40 Lit of insecticides were distributed for participating farmers (Table 4 below).

Table 4. Input distribution.

No	Zone	District	Area (Ha)	Seed		Fertilizer		Herbicide (Lit)	Fungi cide (Lit)	Insecticides (Lit)
				Variety	Seed (Qt)	NPS (Qt)	Urea (Qt)			
1	E/ Wollega	Wayu Tuka	114	Kingbird	171	114	171	62	12	40
2	East Wollega	Jima Arjo	10	Dendea	15	10	15			

### 3.3. Yield Performance of the Crop

The yield data was collected from each irrigation schemes/cluster of both Districts (Wayu Tuka and Jima Arjo). The yield data collected were analyzed and presented as table 5 below. Accordingly, higher wheat grain yield (66.06 qt/ha) was recorded from Goto Cluster which is found in Bonaya Molo Kebele, Wayu district. While, the minimum (30.15 qt/ha) was recorded from Bolale cluster found in Gara Hudha kebele, Wayu Tuka District. The increment in yield could be associated with the better management and water utilization

difference among farmers. As Jima Arjo District is high land and more preferable for wheat production, the mean productivity (39.5 qt/ha) was not as much satisfactory. Because as the irrigation is traditional; percolation and water deficiency at mid stage might be the reason. The over all mean grain yield of 43.7 qt/ha was recorded from large scale demonstration of irrigated wheat production in Wayu Tuka and Jima Arjo District. Totally, 5293.63 quintals of bread wheat was gained from the implementation of large scale demonstration of irrigated wheat production in Wayu Tuka and Jima Arjo district done during 2020/21 of season (Table 5 below).

**Table 5.** Average grain yield gained from large scale demonstration of irrigated wheat in Wayu tuka and jima Arjo district during 2020/21 off season.

District	Kebele	Cluster	Seed varieties	Average grain yield (qt/ha)
W/Tuka	B/Molo	Bolale 1	Kingbird	43.65
W/Tuka	B/Molo	Goto	Kingbird	66.06
W/Tuka	B/Molo	Jato	Kingbird	41.45
W/Tuka	B/Molo	Qarsa	Kingbird	38.83
W/Tuka	G/Hudha	Bolale 2	Kingbird	30.15
W/Tuka	M/Kura	G/ dayito	Kingbird	40.25
W/Tuka	M/Kura	B/dayito	Kingbird	45.85
W/Tuka	M/Kura	T/dayito	Kingbird	47.55
J/Arjo	Lalo	Lalo	Dendea	39.5
Over all total of grain yield obtained from the LSD				5293.63

### 3.4. Beneficiaries of the Activities

A total of 2435 peoples were benefited either directly or in directly from the irrigated wheat production. 60% participants' HH were female with addition of house wife and averagely, one farmer has five families (WAO).

**Table 6.** Beneficiaries of large scale demonstration of irrigated wheat production in Wayu tuka and jima Arjo district of each cluster for 2020/20 off season.

District	Kebele	Cluster	Beneficiaries		
			Male	Female	Total
Wayu Tuka	Bonaya Molo	Bolale 1	104	156	260
Wayu Tuka	Bonaya Molo	Goto	120	180	300
Wayu Tuka	Bonaya Molo	Jato	138	207	345
Wayu Tuka	Bonaya Molo	Qarsa	88	132	220
Wayu Tuka	Gara Hudha	Bolale 2	162	243	405
Wayu Tuka	M igna Kura	Gudatu Dayito	62	93	155
Wayu Tuka	Migna Kura	Biqiltu dayito	54	81	135
Wayu Tuka	Migna Kura	Tokuma Dyito	44	66	110
Jima Arjo	Lalo	Lalo	202	303	505
Over all total			974	1461	2435

### 3.5. Field Day

Field visits and field days were conducted at vegetative and maturity stages of the crop. Field days were organized at crop maturity stage with District, zone and regional levels agricultural experts. All participant farmers and other stake holders were participated the field day. Several presentations and discussion was conducted at each demonstration site. During the field day farmers and other stakeholders were

evaluated the technology and give different feed backs and comments. They evaluated the technology based on the stands of uniformity, tillers, spike length, resistance to any stress and overall performance of the crops. Zonal and district extension workers also partnered at the event and presented on the importance of the technology, how to test for it, and the benefits. "large scale demonstration of irrigated wheat production really shines in all our demonstration sites and make farmers to have full confident for its productivity.

**Figure 3.** Photos taken during field visits and discussing after field day.

**Table 7.** Field day participants on large scale demonstration of irrigated wheat production in Wayu Tuka District for 2020/21 off season.

Agricultural experts (SMS)			extension agents (Das)			Farmers		
Male	Female	Total	male	female	Total	Male	Female	total
36	-	36	10	5	15	347	39	386
Over all Total = 437 participants								

### 3.6. Farmers' and Other Stake Holders' Perception During Field Day

All participants of the field day appreciated the large scale demonstration of irrigated wheat production following merits; perceived better performance, better tillering, longer spike length, higher height, better resistance to disease and perceived better seed color and weight than rain fed.

### 3.7. Challenges, Measures Taken and Lessons Learned

From the start to the end of the activity, many challenges were encountered in both districts. The challenges were Social, biotic and abiotic challenges. Those challenges and their measurement were described in Table 8 below. This is presented here to serve as a learning point for future related interventions focusing on scaling up irrigated wheat.

**Table 8.** Challenges encountered and Measures taken.

Social Challenges encountered	Measures taken
Farmers resistance for accepting the idea	Convincing, creating awareness
Not early started	Advise farmers to use early matured second round crop (maize)
Over lapped with the harvesting of rain fed production	use all possible power of the house hold
Farmers' miss idea that the government could accede the irrigated land if it is well productive	Awareness creation
Competition for water irrigation	Irrigation scheduling (calendar)
Farmers and experts have no Experience	Give training and continuously advise and Supervise
Biotic Challenges encountered	Measures taken
Army Worms	
Aphids	Using chemicals
Rusts	
birds	Guarding and using traditional methods
Water percolation	Using pump
Sometimes irrigation canals make sheet erosion	Changing the canal
Weed seeds transported and distributed	Collecting and burning it

## 4. Conclusions and Recommendations

Cluster based large scale demonstration of irrigated wheat production was carried out on 124 ha irrigable farmers' fields in wayu tuka and Jima Arjo District. Generally, it can ensure sustainability of irrigated wheat production in the lowland and midland areas of country if more attention and strong extension system were given. Moreover, the participant farmers of the activity liked the the implementation for its high yield, disease tolerance, resistance to lodging, good tillering capacity, high seed/spike, good plant height, good crop stand, and seed size and color. Also they appreciated their twice production in one year from their land. Despite the challenges, synergies of actors and attention provided helped to ensure the project success. Therefore, Based on the findings gained further investigations and validation is important to enhance productivity in mid and high land area. It is better to strengthen current awareness and should be continued for improving productivity of the crop in a sustainable manner.

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