



# Wheat Rust Early Warning and Advisory System in Ethiopia:

Impact Assessment in Two Major Wheat-Growing Regional States

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## 3. Results and discussion

### 3.1. Descriptive findings

The number of sampled respondents by region and district and the demographic composition of the sampled households are presented in Table 2.

**Table 2: Background information of the sampled wheat farmers in Ethiopia.**

District	No. of sampled HH	% Male headed HH	Years of schooling		Household composition				
			Head	Spouse	Total	>14 years old male	>14 years old female	In agriculture (No.)	% In non-farm activities
Basoliben	76 (7.5)	97.4	0.83	0.68	5.42	1.94	1.78	2.8	14.5
Motta	76 (7.5)	93.4	2.05	1.82	5.33	2.0	1.78	2.86	25.0
Wonberima	52 (5.1)	100	4.25	2.06	6.52	2.48	2.0	3.46	17.3
Burie	52 (5.1)	98.1	2.27	0.73	6.35	2.31	1.98	3.27	15.4
Lay gaint	74 (7.4)	98.7	3.79	3.41	6.31	2.32	1.85	2.35	24.0
Misrak estie	75 (7.4)	97.3	1.23	0.56	6.48	2.19	1.97	2.4	26.7
Mekiet	51 (5.0)	98.0	2.0	1.75	5.78	1.86	1.57	2.14	21.6
Wadiia	10 (0.98)	100	2.3	1.4	5.7	1.7	2.2	1.9	20.0
Debay Telatgin	51 (5.0)	98.0	2.1	0.82	5.4	1.96	1.82	2.47	13.7
Amhara region average/total	518 (51)	97.9	2.3	1.47	5.9	2.1	1.9	2.6	19.8
Arsi robe	50 (4.9)	98.0	4.84	2.14	7.66	2.36	2.1	3.26	6.0
Hitosa	50 (4.9)	78.0	5.84	3.86	5.9	2.38	1.82	2.96	20.0
Gedeb Assosa	75 (7.4)	92.0	4.47	2.23	8.1	2.28	2.0	3.0	13.3
Dodola	75 (7.4)	89.3	4.49	2.6	7.23	2.17	1.76	2.89	12.0
Sinana	50 (4.9)	94.0	2.44	1.06	7.12	2.04	1.8	2.52	0
Agarfa	75 (7.4)	97.3	4.32	2.57	6.96	2.28	1.93	2.89	12.0
Ginir	75 (7.4)	97.3	3.0	1.73	7.28	2.28	1.72	2.83	0
Gololcha	50 (4.9)	100	2.68	1.5	7.18	2.44	1.92	2.94	0
Oromia regional average/Total	500 (49)	93.5	3.9	2.2	7.1	2.3	1.9	2.9	8.6
Group total /average	1,017	95.5	3.12	1.86	6.56	2.19	1.86	2.8	14.3

Source: Authors, based on CIMMYT household survey, November-December 2020.

A total of 517 (51%) households were interviewed from the Amhara region and 500 (49%) from the Oromia region. The largest number of households interviewed was from the Basoliben district (n=76) of Amhara, and the Gedeb Assosa, Dodola, Agarfa, and Ginir districts (n=75) of Oromia (Table 2). On average, a sampled household was most likely to be headed by a male with an average of 3.1 years of schooling and was composed of more than six members, of which at least nearly three family members were engaged in agriculture (Table 2). The average number of years of schooling of the heads and spouses in the Oromia region was higher than in the Amhara region (Table 2). In our econometric estimation procedure, we included years of schooling of both head and spouse in estimating their opinions on rust and the early warning system, to examine the impacts of these on the decision-making process.

Information on social capital and access to basic infrastructure is presented in Table 3. It shows that in the Amhara region, more than 53% of the sampled households were members of a savings and credit association, 52% were members of a farmers' input supplier group and at least 5% of the sampled households were members of a community-based NGO. In contrast, less than 8% of the sampled households from the Oromia region were members of a farmers' input supplier group, and less than 5% of them were members of a saving and credit association. Table 3 shows that more than 65% of the sampled respondents in the Amhara region and 72% in the Oromia region accessed the major infrastructural facilities in one hour or less. These included the walking distance, one-way, from home to the village market, main market, seed dealers, fertilizer dealers, herbicides and pesticides dealers, agricultural extension office, health center, and the source of drinking water (Table 3). We used these variables as independent variables in our econometric estimation process to examine their influence on the decision-making process.

**Table 3: Information on social capital and social network of the sampled wheat farmers in Ethiopia.**

District	Social capital and network: % Household member of the following organizations:				Infrastructure: % Households with access to the following facilities:		
	Savings and credit association	Farm input supplier group	Crop and seed-producing group	Any NGO	Access to electricity	Access to piped water	Access to major facilities in less than 1 hour*
Basoliben	63.2	60.5	6.6	0.0	5.3	28.9	56.6
Motta	51.3	64.5	18.4	1.3	35.5	26.3	80.3
Wonberima	55.8	67.3	25.0	1.9	5.8	44.2	78.8
Burie	61.5	59.6	13.5	3.8	5.8	36.5	57.7
Lay gaint	48.0	29.3	14.7	2.7	69.3	53.3	68.0
Misrak estie	41.3	46.7	20.0	1.3	6.7	18.7	53.3
Mekiet	49.0	45.1	5.9	2.0	31.4	54.9	66.7
Wadila	30.0	40.0	0.1	30.0	0	10.0	80.0

Debay telatgin	80.4	54.9	27.5	2.0	27.5	35.3	47.1
Amhara region average/Total	53.4	52.0	14.6	5.0	20.8	34.2	65.4
Arsi robe	0.0	12.0	0	2.0	10.0	8.0	82.0
Hitosa	26.0	10.0	2.0	6.0	88.0	84.0	96.0
Gedeb Assosa	0	2.7	0	0	6.7	18.7	70.7
Dodola	5.3	0	0	0	29.3	17.3	85.3
Sinana	0	2.0	0	0	92.0	84.0	50.0
Agarfa	4.0	14.7	0	0	68.0	61.3	86.7
Ginir	0	12.0	0	0	81.3	38.7	41.3
Gololcha	2.0	10.0	0	0	64.0	36.0	64.0
Oromia region average/Total	4.7	7.9	0.3	1.0	54.9	43.5	72.0
Group average	30.0	30.6	8.3	1.6	38.3	38.6	68.5

Source: Authors, based on CIMMYT household survey, November–December 2020.

\*Major facilities include the one-way walking distance from residence to the village market, nearest main market, seed dealer, fertilizer dealer, herbicides and pesticides dealer, agricultural extension office, health center, source of drinking water.

On average, nearly 59% of the sampled households in the survey districts produced wheat for home consumption, and the yearly total expenditure on food per person was nearly US\$ 98 (Table 4). The yearly average total cereal consumption per capita was 196.5 kg and the yearly total expenditure per capita was US\$ 117, of which nearly 60% was spent on food (Table 4). Considering this fact, we included district dummies in our econometric estimation procedure to capture the influence of the district-specific unobserved factors in the decision-making processes of the sampled households.

**Table 4: Food expenditure, wheat production, and consumption information.**

	% HH wheat produced for self-consumption	Total food exp. (c/US\$/y)	Total cereal consumed (c/kg/y)	Price of wheat flour (US\$/kg)	% wheat self-sufficient	All exp. (y/c/US\$)	% Expenditure on food
Basoliben	44.7	91.8	201.8	0.79	90.8	134.6	66.8
Motta	59.2	108.1	239.8	0.82	88.2	149.5	65.6
Wonberima	7.7	112.6	212.1	0.79	96.2	143.8	63.9
Burie	26.9	93.5	153.8	0.82	94.2	123.4	64.7
Lay gaint	97.3	142.6	173.3	0.80	33.3	119.9	70.4
Misrak estie	97.3	115.2	177.0	0.79	50.7	97.1	66.9

Mekiet	100.0	101.7	177.0	0.87	33.3	111.2	69.4
Wadila	100.0	86.2	134.0	0.83	40.0	83.8	71.0
Debay telatgin	68.6	77.7	222.7	0.85	68.6	138.5	68.1
Amhara region average/Total	66.9	103.3	187.9	0.8	66.1	122.4	67.4
Arsi robe	66.0	65.5	181.7	0.95	92.0	73.2	39.9
Hitosa	40.0	88.1	223.1	0.79	94.0	116.2	45.2
Gedeb Assosa	34.7	69.2	195.1	0.79	90.7	79.9	50.5
Dodola	45.3	71.7	195.2	0.8	92.0	83.9	51.5
Sinana	80.0	139.0	220.0	0.8	100.0	140.8	58.8
Agarfa	30.7	73.2	209.4	0.8	93.3	99.8	51.3
Ginir	61.3	125.5	198.6	0.8	96.0	157.6	59.3
Gololcha	74.0	86.3	166.1	0.8	100.0	121.0	59.2
Oromia region average/Total	54.0	89.8	198.7	0.8	94.8	109.1	52.0
Group average	58.7	97.9	196.5	0.81	81.1	117.4	59.8

Source: Authors, based on CIMMYT household survey, November-December 2020.

#Average exchange rate between Birr and USD is set at 1 USD= 37.5

Source: <https://www.exchangerates.org.uk/USD-ETB-exchange-rate-history.html>

The information on land cultivation by season is presented in Table 5. On average, in 2020 a household in the sampled districts of Ethiopia cultivated 0.29 ha of land in the *belg* season and 1.76 ha in the *meher* season. *Belg* season crops were detected in Oromia, and the average wheat land size in Oromia (1.51-1.53 ha) was much larger than in the Amhara region (0.58 ha).

**Table 5: Land allocation to all crops and wheat in 2019 and 2020 *Belg* and *Meher* seasons in Ethiopia.**

District	Land cultivated 2019 (ha)		Land cultivated 2020 (ha)		Wheat land 2019 (ha)		Wheat land 2020 (ha)	
	<i>Belg</i>	<i>Meher</i>	<i>Belg</i>	<i>Meher</i>	<i>Belg</i>	<i>Meher</i>	<i>Belg</i>	<i>Meher</i>
Basoliben	0.01	1.70	0.00	1.74	0.01	0.88	0.00	0.85
Motta	0.02	1.66	0.02	1.67	0.00	0.31	0.00	0.28
Wonberima	0.00	2.78	0.00	2.80	0.00	1.09	0.00	0.97
Burie	0.05	1.69	0.04	1.77	0.00	0.36	0.00	0.43
Lay gaint	0.01	1.07	0.01	0.99	0.02	0.59	0.02	0.63
Misrak estie	0.08	1.12	0.09	1.14	0.003	0.59	0.01	0.60
Mekiet	0.0	0.80	0.0	0.82	0.02	0.51	0.0	0.55
Wadila	0.0	0.58	0.0	0.6	0.0	0.39	0.0	0.36
Debay telatgin	0.03	1.47	0.04	1.49	0.0	0.51	0.0	0.58

Amhara region average/Total	0.02	1.43	0.02	1.45	0.01	0.58	0.00	0.58
Arsi robe	0.40	1.98	0.41	1.98	0.06	1.29	0.06	1.21
Hitosa	0.0	2.31	0.	2.48	0.0	1.78	0.0	1.9
Gedeb Assosa	0.02	1.95	0.01	2.05	0.0	1.54	0.0	0.1.69
Dodola	0.0	1.85	0	1.85	0.0	1.31	0.0	0.1.35
Sinana	1.1	1.64	1.0	1.7	0.49	1.15	0.45	1.2
Agarfa	0.61	2.49	0.63	2.57	0.36	2.1	0.23	2.1
Ginir	1.34	1.48	1.36	1.5	0.75	1.1	0.75	1.1
Gololcha	1.27	2.27	1.23	2.18	0.33	1.78	0.35	1.68
Oromia region average/Total	0.59	2.00	0.58	2.04	0.25	1.51	0.23	1.53
Group average	0.29	1.73	0.29	1.76	0.13	1.04	0.12	1.06

Source: Authors, based on CIMMYT household survey, November-December 2020.

According to our survey, nearly 74% of sampled households in the Amhara region and 38% in the Oromia region reported cultivating an improved wheat variety (Table 6). However, based on previous DNA fingerprinting studies (Hodson et al., 2020), the reliability of the reports by the farmers on improved and local varieties is questionable, as many farmers could not tell the actual variety name or type. The actual cultivation of improved varieties is almost certainly much higher in both regions. Nearly 50% of households in the Amhara region and about 57% in the Oromia region reported that they had collected wheat seeds from government sources. The reported wheat seed price in the sampled regions was US\$ 0.59/kg (Table 6).

**Table 6: Seed source, seed variety, and seed used (Meher 2019 and 2020 average).**

Districts	% Cultivated improved wheat	% Used seed from govt. source	% Used own seeds	Seed price USD/kg
Basoliben	91.1	28.9	61.5	0.55
Motta	93.8	48.0	44.6	0.65
Wonberima	95.5	32.7	46.5	0.60
Burie	97.3	14.8	67.8	0.47
Lay gaint	57.9	21.1	43.4	0.68
Misrak estie	41.7	12.2	57.5	0.56
Mekiet	52.9	28.5	36.6	0.76
Wadila	50.0	4.5	40.9	0.85
Debay telatgin	84.5	31.5	50.0	0.63
Amhara region average/Total	73.86	24.69	49.87	0.64
Arsi robe	60.6	6.7	46.7	0.55

Hitosa	60.8	8.2	45.6	0.55
Gedeb Assosa	49.3	6.1	55.9	0.59
Dodola	54.0	2.5	46.4	0.61
Sinana	8.2	4.1	65.6	0.52
Agarfa	47.4	8.5	51.8	0.57
Ginir	12.7	1.8	72.7	0.51
Gololcha	9.7	0.7	69.4	0.54
Oromia region average/Total	37.8	4.8	56.8	0.56
Group average	59.4	16.5	53.2	0.59

Source: Authors, based on CIMMYT household survey, November-December 2020.

The information on wheat production costs is presented in Table 7. It shows that the average wheat production cost per ha was US\$ 304 for the Oromia region and US\$ 291 for the Amhara region. Seed cost is the largest wheat production cost in the sampled regions. The cost of the seed was 27% of the total wheat cultivation cost in Oromia and 35% in Amhara (Table 7). The reported wheat yield was higher in the Oromia region (2.6 t/ha) than in the Amhara region (1.4 t/ha) and the wheat farmers in Oromia were more market-oriented than those in Amhara (Table 7). In the Amhara region, 27% of the total wheat produced was sold in the market, and nearly 46% of the sampled farm households said that they sold wheat. In contrast, in the Oromia region, nearly 56% of the total wheat produced was sold in the market and 92% of the sampled farm households said that they sold wheat. The results show that wheat farming in the Oromia region is more market-oriented, whereas wheat farmed in the Amhara region is more likely to be for home consumption.

**Table 7: Information on wheat production cost (USD/ha) and yield (Meher 2019 and 2020 average).**

District	Land preparation, weeding and labor cost	Seed cost	Fertilizer cost	Pesticides and herbicides	Harvesting cost	Yield (kg/ha)	Total Production (kg)	% Wheat Production Sold	%h HH Selling wheat
Basoliben	17.4	98.3	118.3	4.8	16.9	1291.7	1131.3	47.1	77.6
Motta	44.0	143.8	164.3	8.3	30.6	2252.8	652.8	35.1	69.5
Wonberima	81.7	79.2	91.6	6.4	56.0	1731.1	1800.2	68.8	89.1
Burie	73.1	120.9	135.7	10.2	31.3	2550.9	1018.9	48.1	85.2
Lay gaint	125.0	70.4	43.4	13.6	17.5	1000.8	558.7	6.3	16.1
Misrak estie	66.9	74.5	59.7	12.7	12.9	813.4	447.3	4.4	12.2
Mekiet	53.9	100.7	60.2	1.2	5.0	734.4	374.0	2.7	5.2
Wadila	101.8	151.1	91.9	0.0	24.0	1275.8	412.3	6.1	9.1
Debay telatgin	27.5	77.2	76.2	8.4	9.7	1048.4	547.4	25.7	46.4
Amhara region average	65.7	101.8	93.5	7.3	22.7	1411.0	771.4	27.1	45.6

Arsi robe	34.1	61.9	67.5	31.5	38.9	1913.6	2490.3	45.8	79.4
Hitosa	52.5	81.9	63.3	28.3	52.6	2227.5	3982.9	66.6	93.6
Gedeb Assosa	71.7	81.6	60.2	45.4	40.9	2576.0	4263.9	59.3	90.6
Dodola	55.8	74.5	60.9	41.2	38.1	2298.9	3170.3	64.1	94.1
Sinana	21.1	90.3	74.6	67.6	84.6	2861.1	3277.0	42.6	96.7
Agarfa	24.3	71.6	55.7	56.2	64.0	2494.6	5101.2	66.2	94.7
Ginir	28.7	101.8	95.0	78.2	94.9	3555.9	3788.5	53.7	90.9
Gololcha	17.2	95.0	74.1	63.6	89.9	2813.4	4614.9	46.7	99.3
Oromia region average	38.2	82.3	68.9	51.5	63.0	2592.6	3836.1	55.6	92.4
Group average	51.7	87.9	80.2	27.6	39.5	1914.9	2241.0	42.2	68.9

Source: Authors, based on CIMMYT household survey, November-December 2020.

The major biotic and abiotic stresses on wheat in the sampled regions of Ethiopia are reported in Table 8. In the Amhara region, more than 79% of sampled households reported yellow rust and more than 81% reported rodents as major biotic stresses on wheat. In contrast, in the Oromia region, more than 99% of sampled households reported yellow rust, and 97% of the farmers said that stem rust was the main biotic stress on wheat production (Table 8). This indicates that while yellow rust is a major stress on wheat production in the Amhara region, both stem rust and yellow rust are major wheat yield-reducing factors in the Oromia region.

**Table 8: Household reported major biotic and abiotic stresses on wheat production (percentages).**

District	Stem rust	Yellow rust	Insects/pests	Frost	Hailstorm	Flood	Water logging	Rodents	Long dry spell
Basoliben	0.0	90.5	40.1	58.6	50.0	43.1	21.1	56.6	9.5
Motta	13.6	82.5	24.9	63.8	81.9	53.1	14.1	73.4	5.1
Wonberima	3.5	23.3	20.3	9.9	85.1	37.6	10.4	61.4	6.4
Burie	0.0	43.6	26.2	60.4	57.7	75.2	14.1	73.8	4.0
Lay gaint	7.9	98.8	13.6	69.0	43.4	29.8	33.1	95.9	36.4
Misrak estie	17.3	92.9	9.1	89.0	73.6	46.5	28.3	91.3	18.5
Mekiet	8.1	89.5	16.3	94.2	83.7	23.8	26.7	92.4	12.2
Wadila	0.0	100.0	0.0	100.0	54.5	40.9	36.4	100.0	0.0
Debay telatgin	16.1	92.9	3.0	83.3	69.0	82.7	30.4	86.9	10.1
Amhara region average	7.4	79.3	17.1	69.8	66.5	48.1	23.8	81.3	11.4
Arsi robe	100.0	100.0	61.2	1.8	4.2	6.7	75.2	4.2	30.9
Hitosa	82.5	98.8	53.2	2.9	2.9	5.8	12.9	0.0	0.0



Gedeb Assosa	95.3	100.0	43.2	0.0	0.0	0.9	1.4	0.0	0.0
Dodola	100.0	98.3	41.8	0.0	0.0	1.7	7.1	0.0	0.0
Sinana	100.0	100.0	47.5	0.0	0.0	11.5	39.3	0.0	31.1
Agarfa	100.0	100.0	55.1	0.0	0.0	0.0	5.7	0.0	0.0
Ginir	100.0	100.0	60.0	0.0	0.0	0.0	11.5	0.0	35.8
Gololcha	100.0	98.5	35.1	0.0	0.0	0.0	3.0	0.0	85.1
Oromia region average	97.2	99.5	49.6	0.6	0.9	3.3	19.5	0.5	22.9
Group average	49.3	88.6	33.7	35.8	36.0	26.5	20.3	42.4	15.6

Source: Authors, based on CIMMYT household survey, November-December 2020.

In Table 9, the sampled households were asked to inform us about yellow rust and stem rust exclusively. The table shows that 71% of the sampled households in the Amhara region and nearly 99% in the Oromia region reported that yellow rust and/or stem rust were major problems for wheat production. In addition, the table indicates that the rust infestations may have increased over the years. For example, in 2015 only 44% of sampled households reported the presence of wheat rust (yellow rust and/or stem rust), whereas in 2020 more than 78% of sampled households reported the incidence of rust (Table 9). This indicates that according to farmer recall, incidences of wheat rust have been increasing over the five years. This is supported by rust survey data over the same period that show increasing incidence, especially for yellow rust (Meyer et al., 2021)

**Table 9: Households' perception on rust (both yellow and stem rust) (%).**

District	% Household reported either stem and/or yellow rust is a major problem	% Rust observed in 2015	% Rust observed in 2016	% Rust observed in 2017	% Rust observed in 2018	% Rust observed in 2019	% Rust observed in 2020
Basoliben	82.6	21.7	19.1	19.4	21.7	54.3	79.9
Motta	44.6	15.8	17.5	20.9	21.5	21.5	27.7
Wonberima	9.9	0.0	2.0	6.4	5.9	3.5	6.4
Burie	24.2	12.8	10.1	8.1	16.1	14.8	14.8
Lay gaint	97.1	38.0	47.1	55.0	77.7	88.4	77.3
Misrak estie	97.2	50.0	66.5	72.8	86.2	92.9	90.6
Mekiet	97.1	50.6	62.2	70.9	90.7	82.0	93.0
Wadila	100.0	40.9	50.0	59.1	50.0	90.9	100.0
Debay telatgin	89.3	33.9	40.5	44.0	54.2	62.5	89.3

Amhara region average	71.3	29.3	35.0	39.6	47.1	56.8	64.3
Arsi robe	97.0	74.5	78.2	83.0	91.5	91.5	88.5
Hitosa	97.7	72.5	71.3	74.9	91.8	95.3	95.3
Gedeb Assosa	98.1	67.6	71.8	80.8	92.5	93.0	92.0
Dodola	99.2	75.7	83.7	97.5	99.2	99.2	98.3
Sinana	100.0	34.4	57.4	91.8	100.0	91.8	96.7
Agarfa	100.0	73.3	80.6	93.9	99.2	100.0	96.8
Ginir	98.8	34.5	53.9	84.2	91.5	97.6	98.8
Gololcha	98.5	37.3	55.2	97.0	95.5	98.5	98.5
Oromia region average	98.7	58.7	69.0	87.9	95.2	95.9	95.6
Group average	84.0	44.1	51.3	61.4	69.7	74.7	78.4

Source: Authors, based on CIMMYT household survey, November-December 2020.

Table 10 presents the sampled farmers' opinions on yellow/stem rust-related loss in wheat production. It shows that in the Amhara region, yellow rust is the main biotic stress, whereas in the Oromia region both yellow rust and stem rust are major stresses. In Amhara 57% of the farmers reported some yield loss due to rust, whereas in Oromia nearly 100% of the farmers reported rust-related yield loss (Table 10). The table shows that 37% of the sampled farmers in Amhara and 6.1% of the sampled farmers in Oromia reported a loss of nearly 50% of the estimated wheat yield due to rust. Interestingly, more than 72% of sampled farmers in Amhara said that their awareness of wheat rust has increased, and 66% said that they were better able to control wheat rust (Table 10). In contrast, more than 98% of sampled farmers in the Oromia region said that their awareness of wheat rust has increased, and 100% reported being better able to control wheat rust (Table 10).

**Table 10: Yellow and stem rust and their perceived impacts on yield; farmers' awareness and control ability.**

District	% Affected by rust		Yield reduced	Yield reduced by yellow and stem rust					% with improved rust awareness	% With higher ability to control rust
	Yellow	Stem	% Yes	<25%	25%	33%	<50%	50%		
Basoliben	68.1	0.3	60.5	8.2	3.3	13.5	38.8	36.2	69.4	25.0
Motta	42.4	5.1	28.8	10.7	11.9	16.4	47.5	13.6	55.4	29.4
Wonberima	5.9	1.5	6.4	70.3	2.0	0.0	27.7	0.0	47.5	29.7
Burie	22.8	0.7	22.1	50.3	10.7	10.7	21.5	6.7	58.4	28.9
Lay gaint	92.6	9.5	81.8	10.3	5.8	7.9	35.1	40.9	93.8	84.3
Misrak estie	90.6	12.6	89.8	0.0	0.0	1.6	37.8	60.6	88.6	70.5

Mekiet	82.6	7.0	83.7	1.7	0.0	7.6	34.9	55.8	84.9	44.8
Wadila	90.9	0.0	86.4	9.1	9.1	0.0	31.8	50.0	81.8	72.2
Debay telatqin	76.8	8.3	53.6	0.0	1.8	0.0	29.2	69.0	72.6	66.4
Amhara region average	63.6	5.0	57.0	17.8	5.0	6.4	33.8	37.0	72.5	50.1
Arsi robe	99.4	99.4	100.0	31.5	14.5	21.2	31.5	1.2	96.4	100.0
Hitosa	100.0	85.4	100.0	38.0	8.2	30.4	9.4	14.0	96.5	100.0
Gedeb Assosa	100.0	99.1	100.0	41.8	11.3	19.7	21.6	5.6	99.1	100.0
Dodola	99.6	99.6	99.6	32.2	8.8	18.8	26.4	13.8	100.0	100.0
Sinana	100.0	100.0	100.0	0.0	32.8	36.1	29.5	1.6	98.4	100.0
Agarfa	100.0	99.6	100.0	44.5	14.2	19.0	13.8	8.5	99.2	100.0
Ginir	99.4	99.4	99.4	0.0	40.0	40.6	18.2	1.2	98.8	100.0
Gololcha	100.0	99.3	97.8	35.8	17.9	17.2	26.1	3.0	97.0	100.0
Oromia region average	99.8	97.7	99.6	28.0	18.5	25.4	22.1	6.1	98.2	100
Group average	80.3	48.3	76.6	23.3	10.1	15.2	28.6	22.9	84.6	83.3

Source: Authors, based on CIMMYT household survey, November-December 2020.

The details on perceived yield loss due to yellow rust and stem rust compared to rust-free years by district and region are presented in Table 11. It shows that yellow rust is the main problem in the Amhara region, where over 35% of sampled households reported a perceived yield loss of more than 50% due to yellow rust. In the same region, less than 10% of sampled households reported a perceived yield loss of more than 50% due to stem rust. In contrast, both stem rust and yellow rust are major yield-impacting factors in the Oromia region, but only 10% of the farmers reported a perceived wheat yield loss of more than 50% due to stem and/or yellow rust. This indicates that the severity of the impact of rust on wheat yield is more pronounced in the Amhara region than in the Oromia region and/or that farmers in the Oromia region practice better control of rusts.

**Table 11: Perceived loss in yield due to yellow and stem rust compared to no-rust year.**

District	Yield loss from yellow rust					Yield loss from stem (black) rust				
	<25	25%	33%	50%	>50%	<25	25%	33%	50%	>50%
Basoliben	5.6	3.3	11.8	40.1	39.1	69.4	9.2	2.3	13.8	5.3
Motta	12.4	11.9	16.4	47.5	11.9	64.4	4.0	4.0	24.3	3.4
Wonberima	70.3	2.0	0.0	27.7	0.0	83.2	0.0	0.0	16.8	0.0
Burie	49.0	14.8	6.7	20.8	8.7	83.2	0.0	0.0	12.8	4.0
Lay gaint	10.7	5.4	8.3	43.4	32.2	59.1	2.5	1.7	24.0	12.8

Misrak estie	0.0	0.0	0.0	45.3	54.7	68.9	8.3	2.0	5.9	15.0
Mekiet	1.2	1.2	6.4	33.7	57.6	77.9	3.5	1.2	0.0	17.4
Wadila	0.0	9.1	0.0	31.8	59.1	81.8	0.0	0.0	0.0	18.2
Debay telatgin	7.1	1.8	1.2	35.7	54.2	55.4	6.0	3.6	22.6	12.5
<b>Amhara region average</b>	<b>17.4</b>	<b>5.5</b>	<b>5.6</b>	<b>36.2</b>	<b>35.3</b>	<b>71.5</b>	<b>3.7</b>	<b>1.6</b>	<b>13.4</b>	<b>9.8</b>
Arsi robe	17.0	24.8	38.2	20.0	0.0	12.1	29.1	26.7	27.3	4.8
Hitosa	27.5	24.0	25.7	7.6	15.2	39.8	22.2	21.1	14.6	2.3
Gedeb Assosa	47.6	0	34.4	39.5	45.1	21.2	45.5	38.4	32.8	48.8
Dodola	32.2	6.7	19.2	28.0	13.8	34.7	10.9	6.3	33.5	14.6
Sinana	0.0	31.1	32.8	34.4	1.6	1.6	27.9	39.3	29.5	1.6
Agarfa	42.9	13.4	22.3	15.4	6.1	43.7	18.6	13.0	17.8	6.9
Ginir	0.0	41.2	43.0	15.8	0.0	1.2	50.9	32.1	15.8	0.0
Gololcha	34.3	17.9	20.1	26.1	1.5	29.9	23.9	18.7	26.1	1.5
<b>Oromia region average</b>	<b>25.2</b>	<b>19.9</b>	<b>29.5</b>	<b>23.4</b>	<b>10.4</b>	<b>23.0</b>	<b>28.6</b>	<b>24.5</b>	<b>24.7</b>	<b>10.1</b>
<b>Group average</b>	<b>21.3</b>	<b>11.7</b>	<b>15.7</b>	<b>30.3</b>	<b>21.0</b>	<b>49.7</b>	<b>13.5</b>	<b>9.9</b>	<b>19.8</b>	<b>7.2</b>

Source: Authors, based on CIMMYT household survey, November-December 2020.

The early warning messages (EWM) were distributed through partner networks for widespread distribution but were not targeted at any specific farmers included in the surveys as these were selected randomly. About 65% of the households in the Amhara region and nearly 80% of those in the Oromia region reported that they had received EWM in the 2020 *meher* season (Table 12). The table shows that since 2015, the number of EWM recipients in both Amhara and Oromia regions has progressively increased. In Amhara the percentage of farmers receiving the messages rose from 31% in 2015 to 65% in 2020. The corresponding rise in Oromia was from 52% in 2015 to 80% in 2020. Fifty percent (50%) of the households in both regions said that they had received the EWM through the agricultural extension agents (Table 12).

**Table 12: Percentage of farmers that received EWM and sources of the messages in the *meher* season.**

District	% Received message in the following years						% Received through extension agents	% Received through farmers' cooperative
	2015	2016	2017	2018	2019	2020		
Basoliben	29.6	32.6	34.2	38.8	44.4	43.8	35.5	10.2
Motta	55.9	66.7	67.8	66.1	69.5	67.8	55.4	14.7
Wonberima	36.1	42.1	49.5	54.5	58.4	64.9	51.0	10.4
Burie	20.1	22.1	24.8	43.6	51.0	47.7	38.3	13.4
Lay gaint	26.9	37.2	45.9	62.0	75.2	77.3	47.5	28.5

Misrak estie	26.0	40.6	47.2	64.6	72.0	72.0	48.0	28.3
Mekiet	30.2	43.6	52.3	64.0	70.3	73.8	58.7	16.9
Wadila	22.7	45.5	45.5	54.5	81.8	81.8	72.7	9.1
Debay telatgin	35.7	47.6	47.6	53.0	53.0	56.0	38.1	14.9
Amhara region average	31.5	42.0	46.1	55.7	64.0	65.0	49.5	16.3
Arsi robe	67.3	67.3	76.4	90.9	93.3	89.1	75.8	20.6
Hitosa	67.8	67.8	70.2	93.0	93.0	90.6	72.5	11.1
Gedeb Assosa	57.7	59.6	68.1	81.2	76.5	76.5	43.2	28.6
Dodola	61.1	61.9	77.0	83.7	82.8	82.8	53.1	29.7
Sinana	36.1	41.0	68.9	68.9	68.9	68.9	34.4	34.4
Agarfa	66.0	68.4	80.6	85.8	85.8	85.8	46.2	38.9
Ginir	24.8	27.3	61.2	70.9	70.9	70.9	35.8	35.2
Gololcha	32.8	38.8	73.1	73.1	73.1	73.1	40.3	32.8
Oromia region average	51.7	54.0	71.9	80.9	80.5	79.7	50.2	28.9
Group average	57.2	65.1	78.8	91.6	96.0	96.4	48.3	22.9

Source: Authors, based on CIMMYT household survey, November-December 2020.

The behavioral changes in the form of the farmers' actions that were potentially prompted by the EWM are presented in Tables 13 and 14. In the 2020 *meher* season, around 31% of the sampled households (319) reportedly did not receive the EWM, compared with 67% (698) that reportedly received them. The proportion of households that applied fungicide was much higher in Oromia than in Amhara. On average, the households that received the EWM about a possible outbreak of rust were more likely to purchase or collect a spray machine and apply fungicides in both Amhara and Oromia regions than the households that reportedly did not receive the EWM (Table 13). In both regions, fungicide use was seen to have increased over time. Interestingly, in Oromia, nearly 100% of the sampled households that had received the EWM purchased or collected a spray machine and applied fungicides to control rust. In contrast, in 2015 only 38% of the sampled households in Oromia that did not receive the EWM applied fungicides. However, in 2020, around 100% of the sampled households in the Oromia region purchased or collected a spray machine and applied fungicides irrespective of whether or not they had received the EWM. There are two plausible explanations for this behavior on the part of the farmers: firstly, a spillover effect in which non-recipient farmers just imitated farmers that had received a message. Secondly, as indicated in Table 10, the sampled households said that they were more aware of rust and that their ability to control rust had increased over the years. Table 13 probably reflects the increased awareness and capability of the sampled households.

**Table 13: Action of the sampled households based on whether or not they have received EWM in the sampled years.**

District	% Purchased /collected spray machine/ fungicides/pesticides and sprayed											
	Received EWM= Yes						Received EWM= No					
	2015	2016	2017	2018	2019	2020	2015	2016	2017	2018	2019	2020
Basoliben	0.0	0.0	8.5	18.2	7.3	6.6	0.0	0.0	0.0	0.0	0.0	0.0
Motta	10.7	16.1	0.0	5.3	7.9	8.2	1.3	0.0	1.4	0.0	0.0	0.0
Wonberima	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Burie	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4
Lay gaint	27.2	44.7	53.4	68.6	87.9	89.8	18.0	12.5	14.7	40.7	10.7	78.2
Misrak estie	26.8	30.8	36.2	53.9	78.8	87.4	3.1	14.1	17.4	17.1	66.7	50.0
Mekiet	6.9	12.1	10.7	21.2	29.8	11.9	0.0	4.6	20.0	31.3	9.7	0.0
Wadila	0.0	0.0	0.0	27.3	45.0	18.2	0.0	0.0	0.0	0.0	0.0	0.0
Debay telatqjn	0.0	32.4	52.7	50.5	86.7	88.0	4.5	12.0	0.0	9.1	17.5	88.9
Amhara region average	8.0	15.1	17.9	27.2	38.2	34.5	3.0	4.8	5.9	10.9	11.6	24.4
Arsi robe	98.4	98.4	98.5	98.7	100.0	100.0	26.2	50.0	78.6	85.7	71.4	89.5
Hitosa	98.4	100.0	100.0	100.0	100.0	100.0	25.5	46.9	95.3	100.0	100.0	100.0
Gedeb Assosa	100.0	100.0	100.0	100.0	100.0	100.0	36.2	80.0	90.2	100.0	100.0	100.0
Dodola	100.0	100.0	100.0	100.0	100.0	100.0	39.7	74.4	100.0	100.0	100.0	100.0
Sinana	100.0	97.1	100.0	98.4	100.0	100.0	50.0	92.3	100.0	0.0	100.0	100.0
Agarfa	100.0	100.0	98.3	100.0	100.0	100.0	47.0	89.6	66.7	100.0	0.0	100.0
Ginir	100.0	97.8	100.0	98.7	100.0	100.0	44.4	76.3	100.0	100.0	100.0	100.0
Gololcha	100.0	100.0	100.0	100.0	100.0	100.0	38.1	86.7	100.0	100.0	100.0	100.0
Oromia region average	99.6	99.2	99.6	99.5	100.0	100.0	38.4	74.5	91.4	85.7	83.9	98.7
Group average	69.6	72.7	76.2	78.7	82.2	78.4	14.8	23.6	16.1	11.1	10.0	20.0

Source: Authors, based on CIMMYT household survey, November-December 2020.

Table 14 presents the behavioral change related to fungicide expenditure by the sampled farmers based on whether or not they had received the EWM. It shows that in general, the sampled wheat farmers in the Oromia region spent more on fungicides than those in the Amhara region due to higher usage. However, in Oromia, the sampled farmers that received the EWM about possible outbreaks of wheat rust spent considerably more on fungicides than their counterparts. This most likely indicates that this group of farmers made multiple fungicide applications, although the possibility that they had purchased more expensive products with improved efficacy cannot be ruled out. The fungicide expenditure of the sampled households in Oromia that did not access the EWM was much lower than that of the farmers that received the early warning messages, but increased over time from US\$ 22/ha in 2015 to US\$ 83/ha in 2020 (Table 14) presumably due to an increasing use of fungicides.

**Table 14: Fungicide expenditure in USD/ha by whether or not sampled farmers received EWM.**

District	Cost of fungicides/insecticides application (USD/ha)											
	Received EWM= Yes						Received EWM= No					
	2015	2016	2017	2018	2019	2020	2015	2016	2017	2018	2019	2020
Basoliben	0.0	0.0	0.88	2.89	2.73	3.46	0.00	0.00	0.00	0.00	0.00	0.94
Motta	1.0	2.0	0.29	0.10	0.00	1.57	0.15	0.00	0.00	0.00	1.30	0.00
Wonberima	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Burie	0.0	0.0	0.00	0.00	0.00	1.49	0.00	0.00	0.00	0.00	0.00	0.00
Lay gaint	15.6	21.1	30.60	40.91	49.34	58.93	7.75	8.32	8.86	23.94	34.61	35.90
Misrak estie	12.3	16.1	22.84	30.11	43.93	51.37	5.14	5.05	4.50	15.50	34.14	47.70
Mekiet	0.5	2.0	4.73	8.48	13.32	6.65	0.91	1.32	1.56	0.97	4.39	1.68
Wadila	0.0	0.0	0.00	3.66	14.43	9.46	0.00	0.00	0.00	0.00	0.00	0.00
Debay telatgin	0.0	3.9	8.71	15.05	21.14	43.91	2.00	7.68	6.65	11.46	29.65	56.68
Amhara region average	3.3	5.0	7.56	11.24	16.10	19.65	1.77	2.49	2.40	5.76	11.56	15.88
Arsi robe	88.7	83.0	91.6	82.4	96.4	93.6	37.2	42.6	51.0	54.9	80.1	71.3
Hitosa	103.8	98.9	102.0	91.5	103.9	110.5	18.9	37.3	50.2	62.0	66.9	87.6
Gedeb Assosa	156.2	150.6	138.4	123.4	133.4	156.4	18.4	32.4	38.4	49.3	83.5	142.1
Dodola	310.6	307.9	270.7	261.2	132.7	152.4	47.2	57.8	40.5	34.4	51.9	86.2
Sinana	139.8	131.9	90.5	100.1	123.6	136.1	13.3	25.8	31.0	34.5	59.7	71.7
Agarfa	244.1	237.3	201.2	204.4	215.8	223.9	13.6	22.4	23.1	23.7	37.4	73.7
Ginir	65.9	66.6	45.5	52.0	80.0	94.7	13.4	21.2	28.4	26.8	66.4	78.2
Gololcha	346.3	302.4	178.9	191.1	252.1	274.4	10.2	20.6	27.3	31.6	40.6	52.5
Oromia region average	181.9	172.3	139.8	138.3	142.2	155.3	21.5	32.5	36.2	39.7	60.8	82.9
Group average	92.6	88.7	73.7	74.8	79.2	87.5	11.6	17.5	19.3	22.7	36.2	49.4

Source: Authors, based on CIMMYT household survey, November-December 2020.

In Table 15, we have presented selected factors by region and the status of receiving the EWM in 2019. The average years of schooling of the households in the Amhara region are 2.4 years and 4.6 years for the Oromia region, respectively (Table 1). On average 62% of the households in the Amhara region and more than 81% of the households in the Oromia region received the EWM in 2019. It shows that, among the households that received the EWM in 2019, the average years of schooling of the household heads of the Amhara region were 2.51 years and it was 5.24 years for the Oromia region (Table 15). In contrast, the average years of schooling of the household heads that did not receive the EWM in 2019, was 2.1 years for the Amhara region and 2.06 years for the Oromia region (Table 15). Our simple t-test reveals that for both Amhara and Oromia regions, the difference of the average years of schooling of the household heads is statistically significant between the households who received and who did not the EWM in 2019. It indicates that the access to the early warning message in both Amhara and Oromia regions is skewed to relatively educated farm households. Interestingly, although the average years of schooling of the household

heads that received EWM in 2019 were statistically significantly higher in the Oromia region (5.24 years) than Amhara region (2.51), the difference is statistically insignificant for the households that did not receive EWM in 2019 (Table 15).

**Table 15: Selected variables by regions and contrasting early warning message group in 2019.**

Region		Received message		Difference	t-test
		Yes	No		
		Head's schooling			
		c	d	d-c	
Amhara	a	2.51	2.10	0.41	2.43*** (0.01)
Oromia	b	5.24	2.06	3.18	271*** (0.00)
Difference	b-a	-2.73	0.03		
	T-test	-17.8*** (0.00)	0.17 (0.43)		
		Wheat Area  (ha)			
		C	d	d-c	
Amhara	a	0.69	0.71	0.02	0.75 (0.45)
Oromia	b	2.09	1.62	-0.48	-6.05*** (0.00)
Difference	b-a	-1.40	-0.91		
	T-test	-35.7*** (0.00)	-17.9*** (0.00)		
		Expenditure (US\$/ha)			
		C	d	d-c	
Amhara	a	20.2	11.06	9.16	6.08*** (0.00)
Oromia	b	143.1	59.8	83.3	6.01*** (0.00)
Difference	b-a	-122.9	-48.8		
	T-test	-17.3*** (0.00)	-21.9*** (0.00)		
		Yield (kg)			
		C	d	d-c	
Amhara	a	1333.1	1530.5	-197.5	-2.59*** (0.00)
Oromia	b	2468.9	3204.3	-735.3	-4.17*** (0.00)
Difference	b-a	-1135.9	-1673.7		
	T-test	-11.7*** (0.00)	-14.08*** (0.00)		

Source: Authors, based on survey November-December, 2020.

Note: One-sided t-test. Hypothesis  $a \neq b$ . p-values are in parentheses. (\*\*)[\*\*\*] indicate statistically significantly different at the 10%(5)[1%] level



Similarly, the total wheat area (ha) in 2019 was analyzed by region and by status of whether or not sampled households received the EWM. Table 15 shows that the average wheat area for households that received the EWM in 2019 was 0.69 ha in the Amhara region and 2.09 ha in the Oromia region. In contrast, the average wheat area for households that did not receive the EWM in 2019 was 0.71 ha in the Amhara region and 1.62 ha in the Oromia region. On average, the difference in wheat area for the Amhara region based on whether or not the household received the EWM in 2019 is statistically insignificant. In contrast, the wheat area of the households that did not receive the EWM in 2019 in Oromia is statistically significantly smaller by 0.48 ha ( $p < 0.00$ ) than the wheat area of the households that received the EWM. We conclude that it is more likely in the Oromia region that relatively less-educated households that operated relatively smaller plots were not accessing the EWAS (Table 15).

We also examined the fungicide expenditure behavior (US\$/ha) of the sampled households in 2019 by region and by whether or not they received the EWM. Table 15 shows that in 2019 the households that received the EWM spent nearly 20 US\$/ha on fungicides in the Amhara region and 143 US\$/ha in the Oromia region. In contrast, the households in the sample group that did not receive the EWM spent 11 US\$/ha on average on fungicides in Amhara and 73.5 US\$/ha in Oromia. Table 15 also shows that in Amhara in 2019, households that received the EWM spent on average nearly 9 USD/ha more on fungicides than households that did not receive the EWM. The difference is statistically highly significant ( $p < 0.00$ ). Similarly, in the Oromia region in 2019, households that received the EWM spent on average nearly US\$ 83/ha more on fungicides than households that did not receive the messages and the difference is highly statistically significant. It indicates that in the Oromia region, irrespective of access to EWM, households generally spent more on fungicides to control wheat rust than households in the Amhara region (Table 15), and households that received the EWM spent more on fungicides to control wheat rust than those that did not. However, the gap between the groups in the Oromia region has become narrower over time. For example, in 2015, households that received the EWM spent around 100 US\$/ha on fungicides to control wheat rust, whereas in the same year households that did not receive the EWM spent only 38 US\$/ha on fungicides. However, in 2019 a household in Oromia that received the EWM spent on average 100 US\$/ha on fungicides to control wheat rusts, and other households spent 84 US\$/ha (Table 14). Table 15, shows that in both regions, farmers that had access to the EWM spent more on fungicides than farmers who did not have access to the messages.

We also examined wheat yield/ha in 2019 by region and by whether or not the sampled households accessed the EWM. Table 15 shows that in 2019 the average wheat yield in Oromia was significantly higher than in Amhara, irrespective of whether or not the household accessed the EWM. Surprisingly, in 2019 the average wheat yield of households that accessed the EWM was lower in both Amhara and Oromia regions than the wheat yield of the households that did not access the EWM. (Table 15). The average wheat yield in 2019 for households in the Amhara region that received the EWM was 1,333 kg/ha, compared with 1,530 kg/ha for households that did not access the EWM. The yield difference (197 kg/ha) between these two groups in the Amhara region is highly statistically significant ( $p < 0.00$ ). The per ha wheat yield (kg) in 2019 in the Oromia region for households that did not receive the EWM was higher by 735 kg than the yield of the households that did receive the EWM, and the difference is highly statistically significant (Table 15). The exact reasons behind the reported yield differences between the two groups of households are currently unknown and need further investigation. Other, unrecorded management factors (e.g., use of fertilizers, weed control, etc.) and biophysical/climatic conditions other than rust control may have

had an influence. In Oromia, a very high proportion of farmers (irrespective of receiving the EWM or not) reported the use of fungicides, and that may have contributed to the observed results.

The estimated economic benefits, based on farmers' perceived gains associated with the EWAS are calculated following Eqs. (1) and (2) and presented in Table 16. The vast majority of farmers who received the early warning messages regarded the EAWS positively, with 73% of farmers surveyed in Amhara and 100% of farmers surveyed in Oromia considering it beneficial. In the Amhara region, the perceived per ha average yield gain associated with the EWM was estimated at 505 kg/ha with a monetary value of US\$ 290/ha (Table 16). In Oromia, the equivalent perceived yield gain associated with the EWM was 860 kg/ha with a monetary value of US\$ 364/ha. Both yellow rust and stem rust are major stresses on wheat production in the Oromia region. In addition, the average wheat yield in Oromia is statistically significantly higher than in the Amhara region. The average higher yield in the Oromia region resulted in a higher estimated perceived gain from the EWAS than the gain perceived by the farmers in the Amhara region. However, it must be noted that the actual reported yield data did not match these farmer perceptions. The reasons behind these differences need further investigation.

**Table 16: Estimated economic benefits of EWAS based on farmers perceived yield gains.**

District	%Expressed EWM was beneficial	Benefit from EWM *					Equivalent yield gain (kg)**	Equivalent monetary gain (USD)**
		<25% yield equi	25% yield equi	33% yield equi	50% yield equi	>50% yield equi		
Basoliben	59.7	0.0	0.0	0.0	28.8	30.9	406.8	224.6
Motta	81.5	0.0	0.0	4.0	31.5	46.0	937.2	545.9
Wonberima	79.0	11.3	0.0	0.0	17.7	50.0	622.9	305.8
Burie	70.9	0.0	0.0	0.0	22.8	48.1	839.6	399.0
Lay gaint	97.0	6.6	12.1	4.0	0.0	0.0	397.5	269.3
Misrak estie	92.4	0.0	4.0	6.1	42.9	39.4	348.4	205.5
Mekiet	32.6	0.0	3.0	1.5	15.2	12.9	115.8	86.0
Wadila	72.2	0.0	11.1	27.8	11.1	22.2	354.8	230.8
Debay telatgin	71.3	0.0	5.3	11.7	35.1	19.1	526.6	341.6
Amhara region average	73.0	2.0	3.9	6.1	22.8	29.8	505.5	289.8
Arsi robe	100.0	28.3	20.8	27.7	14.5	8.8	689.4	318.6
Hitosa	97.5	36.5	11.3	23.3	11.3	15.1	731.3	372.5
Gedeb Assosa	100.0	34.7	14.5	23.1	24.9	2.9	821.5	443.7
Dodola	100.0	20.0	11.0	6.0	33.5	29.5	821.9	431.9
Sinana	100.0	2.4	42.9	7.1	45.2	2.4	923.9	479.2
Agarfa	100.0	17.9	10.8	15.6	19.3	36.3	931.0	497.2
Ginir	100.0	8.5	42.7	21.4	27.4	0.0	1109.1	566.8

Gololcha	100.0	49.0	2.0	13.3	28.6	7.1	851.9	435.5
Oromia region average	99.7	24.7	19.5	17.2	25.6	12.8	860.0	443.2
Group average	88.1	14.2	10.9	11.0	26.9	25.1	675.7	363.8

Source: Authors, based on CIMMYT household survey, November-December 2020.

\*Only the sub-sample that received EWM during 2015-2020

\*\*Actual yield in 2019 *meher* season considered

To examine the business viability of the early warning service, we asked the sampled respondents about their willingness to pay for the service. More than 95% of the sampled respondents from the Amhara region and nearly 100% from the Oromia region said that they would like to receive early warning messages about yellow rust (Table 17). However, in the case of the stem rust early warning service, although more than 96% of sampled respondents from Oromia expressed interest in receiving early warning messages about stem rust, only 38% of sampled respondents from Amhara expressed interest in the stem rust early warning service. This finding again confirms that while both yellow rust and stem rust are major stresses on wheat yield in Oromia, stem rust is a relatively minor issue in Amhara compared to yellow rust. Furthermore, 66% of respondents from Amhara and 72% of those from Oromia expressed willingness to receive early warning messages about weather conditions (Table 17).

**Table 17: Willingness to pay for the EWAS and the preferred source of the message.**

District	% Expressing interest in receiving EWM on			% Revealed to pay	Min.	Max	% Opted the following way to receive EWM					
	Yellow rust	Stem rust	Weather				SMS	IVRS	Ext. agen	Farmers co.	Radio	TV
Basoliben	100.0	50.0	75.0	71.1	8.2	13.0	23.7	7.9	92.1	2.6	7.9	0.0
Motta	94.7	52.6	64.5	61.8	2.0	4.7	14.5	15.8	94.7	7.9	2.6	9.2
Wonberima	90.4	65.4	53.8	73.1	4.5	10.1	38.5	9.6	88.5	19.2	21.2	5.8
Burie	90.4	28.8	55.8	69.2	4.8	10.1	30.8	3.8	86.5	13.5	11.5	0.0
Lay gaint	94.6	18.9	60.8	82.4	6.4	12.9	23.0	10.8	79.7	18.9	10.8	16.2
Misrak estie	93.3	34.7	54.7	68.0	5.6	10.9	9.3	13.3	86.7	24.0	5.3	2.7
Mekiet	92.2	33.3	54.9	84.3	5.6	13.6	15.7	9.8	100.0	31.4	0.0	2.0
Wadila	100.0	10.0	60.0	80.0	13.8	27.0	0.0	0.0	100.0	20.0	0.0	0.0
Debay telatqin	96.1	54.9	66.7	62.7	2.9	7.1	11.8	9.8	94.1	7.8	5.9	5.9
Amhara region average	94.6	38.7	60.7	72.5	6.0	12.2	18.6	9.0	91.4	16.1	7.2	4.6
Arsi robe	100.0	98.0	68.0	0.0	0.0	0.0	2.0	2.0	100.0	26.0	0.0	0.0
Hitosa	100.0	78.0	76.0	0.0	0.0	0.0	8.0	10.0	96.0	36.0	4.0	22.0
Gedeb Assosa	96.0	88.0	65.3	4.0	2.0	2.8	6.7	1.3	96.0	32.0	2.7	0.0
Dodola	100.0	100.0	73.3	0.0	0.0	0.0	2.7	0.0	100.0	36.0	0.0	0.0
Sinana	100.0	100.0	84.0	0.0	0.0	0.0	0.0	0.0	100.0	80.0	0.0	4.0
Agarfa	100.0	98.7	69.3	1.3	0.0	0.0	1.3	0.0	100.0	36.0	0.0	2.7
Ginir	100.0	97.3	81.3	0.0	0.0	0.0	5.3	0.0	100.0	73.3	0.0	13.3
Gololcha	100.0	100.0	80.0	0.0	0.0	0.0	4.0	2.0	100.0	40.0	4.0	0.0
Oromia region average	99.1	90.5	73.8	7.6	0.5	1.1	4.6	2.8	98.5	40.8	1.8	5.3
Group average	96.9	64.6	67.3	40.1	3.3	6.7	11.6	5.9	95.0	28.5	4.5	5.0

73% of the respondents in the Amhara region expressed willingness to pay for the early warning services and offered to pay US\$ 6–12 per season for it. (Table 17). In contrast, only 8% of the respondents in the Oromia region expressed willingness to pay for the early warning services and offered to pay US\$ 0.5–1.1 as the service charge per season. The dichotomy between regions is surprising given that wheat cultivation in Oromia is more market-oriented than in Amhara. In addition, there are indications that the early warning services have generated more benefits for wheat farmers in Oromia. It was expected that the farmers from Oromia would be more inclined to purchase the early warning services than those from Amhara. One possible explanation might be that effective rust control is now routinely practiced by farmers in Oromia, whereas in Amhara farmers need more assistance.

Most of the respondents in both the Amhara and Oromia regions expressed interest in receiving the early warning messages through extension agents (91–98%), and through farmers cooperatives (16–41%). The short message service (SMS) or early warning through radio and TV were less preferred media, according to the farmers who wanted to receive the EWAS messages.