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Perception of Farmers and Agricultural Professionals on Changes in Productivity and Water Resources in Ethiopia

D. Mojo[a], Y. Todo[b], and P. Matous[c]

***Abstract*—**In this paper, perceptions of actors on changes in crop productivity, quantity and quality of water, and determinants of their perception are analyzed using descriptive statistics and ordered logit model. Data collected from 297 Ethiopian farmers and 103 agricultural professionals from December 2009 to January 2010 are employed. Results show that the majority of the farmers and professionals recognized decline in water resources, reasoning climate changes and soil erosion as some of the causes. However, there is a variation in views on changes in productivity. The household asset, education level, age and geographical positions are found to affect farmers' perception on changes in crop productivity. But, the study underlines that there is no evidence that farmers' economic status, age, or education level affects recognition of degradation of water resources. Thus, more focus shall be given on providing them different coping mechanisms and alternative resource conserving technologies than educating about the problems.

***Keywords*—**Agricultural Sustainability, Ethiopia, Perception, Productivity, Water Resources

I. Introduction

TECHNOLOGICAL improvement and progress has brought tremendous increments in agricultural productivity throughout the world, but significant gaps between regions remain. Sub-Saharan Africa (SSA) is the least productive region in the world [1]. It is the only region where per capita food production has been on decline for the last two decades. As cited by [2], the rate of growth in food production in SSA has been 2% per year while population growth has been 3% that made SSA food unsecured. Besides, it was indicated that 65% of African agricultural land, 31% of permanent pastureland, and 19% of forest and woodland is degraded [3]. The land degradation has also direct effect on the water resources of the region. This has put the agricultural sustainability of the region under serious challenges.

Among those Sub-Saharan African countries, Ethiopia is one of the most heavily dependent countries on agriculture. The sector supports about its half of GDP, 60 percent of exports and more than 80 percent of total employment [4]. Similar to other countries in the region, natural resource degradation is the main environmental problem constraining productivity in Ethiopia [5]. Low rates of agricultural technology adoption and weather fluctuation are other challenging factors repeatedly addressed by many authors. For instance, the proportion of farmers using inorganic fertilizers was reported to be less than 37%, and application rates remained at around 16 kg/ha of nutrient [6]. There are many studies on consumers' (farmers') perceptions of the benefit and characteristics of agricultural technologies both in Ethiopia and elsewhere in the world [7] -[10]. Most of them were addressing that if the farmers understand the benefit of the technology, they would adopt it. However, the low rate of adoption of fertilizers in Ethiopia is not the question of understanding the benefit or not, rather it is the question of affordability. Thus, crop productivity remained low in the country.

Even though Ethiopia has potential in freshwater resources like rivers and lakes, water is also another important constraining factor of production. Agriculture is the most exploiter of freshwater in the world, which could be from different sources. The main water source for Ethiopian agriculture is directly from the rain. Rain-fed crop production is the basis of all subsistence farming in most parts of the country and accounts for more than 95% of the land area cultivated annually [11]. The changes in water resources, therefore, complicate the lives on terrestrial and in water ecosystems. In turn, it is affected directly or indirectly by human activities, like soil erosion and deforestation, which enhances climate changes and weather fluctuations. Thus, the change in water resources and crop productivity are highly inter-linked.

Regardless of the weather fluctuations, there are different controversies that the crop productivity per unit of land in Ethiopia is not increasing as food shortage and poverty is apparent in the country every year. In fact, the national average of cereal crops production data estimation shows slight increases over years, which could be due to little expansion of cultivated lands, and inaccuracy of the estimation.

This study exploit how farmers and agricultural professionals think of the changes in crop productivity and water resources, and the causes of the changes and what the influencing factors behind their thought are. Studying farmers' and professionals' perception on the problems could be more important to devise mechanism on how to promote environment friendly agricultural technologies. It can be an implicit that those who are more aware of the problems are

[a]D. Mojo is with the Graduate Program in Sustainability Science, the University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8563, Japan, on study leave from the Ethiopian Institute of Agricultural Research (EIAR), Kulumsa Research Center (KARC), Asella, Ethiopia (e-mail: kk086864@mail.ecc.u-tokyo.ac.jp, dagnemojo@yahoo.com.au, phone: +81-09-9820-6070).

[b] Y. Todo is with the Department of International Studies, the University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8563 Japan (e-mail: yastodo@k.u-tokyo.ac.jp; phone: +81-4-7136-4863).

[c] P. Matous is with the Department of Civil Engineering, the University of Tokyo, Japan (e-mail: petr@civil.t.u-tokyo.ac.jp).

more likely to promote and adopt resource conserving agricultural technologies. However, there are limited studies on the perception of people on the agricultural sustainability problems. Many factors can potentially affect the perception of the people. Therefore, the objectives of this study are:

- To analyze and compare the perception of both farmers and agricultural professionals on yearly changes in crop productivity, quantity and quality of water resources. And, to describe the current severity of environmental degradation as perceived by the professionals.
- To quantitatively estimate the effects of socioeconomic, personal network and geographical characteristics of farmers on their perception behavior of agricultural sustainability problems.

A study by [12] on the perception of farmers on the soil erosion of their parcel in Ethiopia showed that the higher the physical erosion potential of the parcel (slope) is, the more they recognize soil erosion. However, the size of cultivable land per capita negatively affects their perception. This study also indicated that there is no significant effect of age and the education level of farmers on their perception. Another study by [13] on the perception of farmers on environmental degradation in China showed the education level of farmers and availability of extension service was significantly positively correlated with their perception. Thus, there are mixed findings on the effect of the education for the recognition of resource degradation.

The findings of this paper are, about 60% of farmers recognized an increase in crop productivity over years. In contrast, only 36% of agricultural professionals recognized the increase, while 60% of the professionals recognized either fluctuation or a decrease in productivity.

However, with respect to water quality and quantity, they have very similar perception. About 80% of farmers and 78% of agricultural professionals realized a decline in water quantity over the last five years. Besides, about 60% of farmers and 70% of the professionals realized a decline in water quality.

The ordered logit regression results reveal that the higher the household asset, age, and education level the less likely to perceive a decrease in crop productivity. But, the distances to a major agricultural research center in the region and agricultural cooperatives do not have significant effect. Households in highland agro-ecology are more likely to observe a decline in water quantity and quality. There is no strong evidence of the effect of social networks, age, household asset and the education level on the perception of the farmers on the changes in quantity or quality of water. These findings indicate the severity of the problem in the sense that households with any characteristic can observe the similar trends.

The contribution of this study is twofold. First, it helps to characterize and identify the farmers' (under different agro-ecology) and agricultural professionals' perception, and determinants of their perception. Second, it shows the agricultural sustainability situation of the area at glance. This will in turn help policy makers and researchers to further focus on how different stakeholders consider the agricultural sustainability issues that may affect the adoption of resource conserving technologies. In short, the study puts foundations for further work on the resource conservation activities either through promotion and diffusion of sustainable agricultural technologies to ensure agricultural sustainability in the country, or through direct conservation policy measures.

The rest of this paper is organized as follows. In Section II, details of the methodology, including description of the research area, sampling methods, survey instruments, variable specification and data analysis methods, are described. Then, summary statistics of socio-economic, geographical position and agro-ecological characteristics of the farm households, and sample characteristics of professionals are presented in the same section. Section III presents the perception of both farmers and agricultural professionals on the resource changes with their corresponding reason(s) for the changes, the correlation and regression results showing determinants of the perception of the farmers. Finally, some conclusions and remarks are made in Section IV.

II. Methodology and Data Description

A. Research Area Description

The household level survey was conducted in three rural villages, or kebeles in the local language, of Tiyo Woreda (a "woreda" is an administrative unit, similar to a county in United States), Arsi Zone of Oromiya Regional State in the southeastern part of Ethiopia from December 2009 to January 2010. According to [14], the total population of the woreda is about 188,858 of which 92,062 are male and 96,796 are female. There are about 17,000 land owned households on its total land area of 638.44 square kilometers (km). Tiyo Woreda is one of the highly populated woredas with population of 295.8 per square km, and at the same time facing various crop productivity constraints over years. The woreda is sub-divided in to 18 administrative kebeles of which 7 or 37% of the land area are under highland agro-ecological zones, 9 or 52% under mid-highland, and 2 or 11% under lowland [15]. Dosha, Kater Genet and Dugda Ukolo (Okolo) are the three randomly selected kebeles from the highland, mid-highland and lowland agro-ecologies, respectively. Table I. shows basic characteristics of the three kebeles.

The agricultural professionals responded are also from the Oromiya Regional State, including two more zones (Jimma and East Showa) in addition to Arsi Zone. Particularly, respondents from Kulumsa Agricultural Research Center (KARC), Faculty of Agriculture at Adama University (AU) Asella campus, and Tiyo Agricultural Office are within the household survey area. However, Melkasa Agricultural Research Center (MARC) and Jima Agricultural Research Center (JARC) are located in East Showa Zone and Jima Zone, not in Arsi Zone. In Ethiopia, each kebele has three Development Agents (DAs) who are in charge of agricultural activities in the kebele, including diffusion of new technologies. The agricultural professionals surveyed include some of these DAs in Tiyo Woreda.

TABLE I
METEOROLOGICAL DATA OF SELECTED KEBELES

	Dosha	Kater Genet	Dugda Ukolo
Rain fall (mm)	1279	1064	951
Annual Temp (^{0}C)	14.0	16.2	17.8
Evapotranspiration (mm)	1225	1308	1370
Relative humidity (Hpa)	10.1	11.8	12.7
Elevation (m)	2500-2560	2150-2200	1800-1850

Source: LocClim, Local Monthly Climate Estimator of FAO (Averages per annum). Data on elevation are taken from the record of Tiyo Woreda Office.

B. Sample Selection

The data used in this study were collected from a total sample of 297 farm households in the three kebeles, and from the total of 103 agricultural professionals. In order to have representative for the main agro-ecologies of the woreda, the three kebeles were randomly selected, one from each of the three sets of kebeles that were grouped under highland, mid-highland and lowland agro-ecological zones. 100 agricultural households were then randomly selected from the list of households in each kebele. Out of the 300 selected households in total, 292 were successfully interviewed. In addition, total of 5 households were replaced from the reserves, and thus the total number of interviewed households is 297.

As to the agricultural professionals, there was no systematic sample selection method. The questionnaires were distributed to the professionals who were available at their work place, volunteer to respond and had minimum of diploma in the field of agriculture.

C. Survey Instruments

The household data were collected using a formal questionnaire verbally administered at the household level. At the beginning (in September 2009) of the project, a draft questionnaire was used to conduct preliminary survey on some selected farmers. In addition, some governmental and non-governmental officials were contacted, and discussions were held on the research questions. Then, using the results and feedbacks from the farmers and agricultural expertise, the questionnaire was modified and further improved. It was again used for the training and discussion with the enumerators at the beginning of the survey period to familiarize and make any necessary modification. Four days were spent on training the enumerators. They had been made to practice on each other, and under farmers' condition before the final survey started. Eight enumerators were hired to execute the survey. The target person to be interviewed was the household head or an influential person in each household. Each enumerator was carrying a Global Positioning System (GPS) receiver to record the path they traveled, altitude, and geographical coordinates (North-East) at the household's homestead, and an instant camera to take the pictures of the respondent and his/her family to keep the records.

Data collected in the formal household questionnaire were on characteristics of household members, farmland, and farm and non-farm activities and institutional factors hypothesized to influence perception of the farmers on resource degradation. More specifically, the collected data include: demographic characteristics of the farm households, such as family size, age, educational status, religion, language they can speak; farm and non-farm income; the location and size of their parcels; major agricultural inputs and outputs; their perception on agricultural production; household assets; and geographic information, such as accessibility of the household to the basic infrastructures.

Likewise, the questionnaires distributed to the agricultural professionals had different parts that focus on some basic information such as the age, sex, educational status and field of study, institution he/she belongs to, position and responsibility of the respondent in the institution, and their views on environmental degradation and resource changes.

D. Data Analysis Methods

Descriptive statistics such as frequency distribution, percentage and mean were used to analyze the demographic characteristics, perception of both farmers and professionals. To see the association of the factors, Person's correlation and Spearman's R tests were conducted.

Moreover, the ordered logit regression model was used to estimate the effect of different factors on the perception of the farmers. The three dependent variables in question are perception on changes in crop productivity (yields per unit area), and quantity and quality of water over the last five years. Each of these dependent variables has three categories (the outcome for perception on productivity was originally six, but rearranged to three). In all the cases, the variable takes 1 if the household or the professional perceives a decline, 2 if s/he perceives a stable trend, and 3 if s/he perceives an increase. For the detail description of the independent variables, see Appendix 1.

For the interpretation of the results, the marginal effect approach was used. Since marginal effect depends on the value of all the independent variables, the level is set at their mean. The marginal effect can show us both the direction and the extent of effect of the independent variable on the outcome probabilities. In fact, the marginal effect set at the mean deals with only one category of the ordinal variable at a time [16]. It is like focusing on what affects the likelihood of perceiving a decline in productivity. Thus, only the first category (" a decline") of the ordinal variables is considered in this paper.

E. Summary Statistics

1) Demographic and Socioeconomic Characteristics of the Households

Table II shows the number of households by ethnicity, religion, and kebele, whereas Table III shows summary statistics of household characteristics. On average, Oromo and Amhara are the dominant ethnic groups in the area constituting of 53.5 and 40.4% of the interviewed households, respectively. About 50 percent of the household heads are recorded to speak Amharic as their first language, while 47 % speak Afan Oromo. The religion of the majority (85%) is Orthodox Christianity followed by Islam (about 13%). The average number of household member is about 6 in all the three kebeles. In the highland kebele (Dosha), the male to female ratio (0.46), and average education level

(3.37) are found to be the lowest. However, Dosha's average age of household head and non-farm income are the highest of the three. The highest non-farm income is maybe due to its proximity to the main city (Asella) of the zone. Having highest average age of the household head proves the saying in Ethiopia that the lifespan of people in the highland area is longer. Dugda Ukolo is one of the remotest kebeles in the woreda. Thus, the low farm and non-farm income could be due to less accessibility to information and other technologies.

TABLE II
ETHNICITY AND RELIGION OF HOUSEHOLD HEADS IN THE STUDY AREA

	Count				
	Dosha	Kater Genet	Dugda Ukolo	Total	Total (%)
Ethnicity					
Oromo	77	41	41	159	53.54
Amhara	19	58	43	120	40.40
Gurage	3	0	15	18	6.06
Total	99	99	99	297	100.00
Religion					
Orthodox	93	78	81	252	85.42
Muslim	0	21	17	38	12.88
Protestant	5	0	0	5	1.69
Total	98	99	98	295	100.00

TABLE III
MEANS OF SOME DEMOGRAPHIC AND SOCIOECONOMIC CHARACTERS OF HOUSEHOLDS IN THE THREE KEBELES

Variables	Dosha	Kater Genet	Dugda Ukolo	Average
Family size	6.01	6.13	6.24	6.13
Male ratio	0.46	0.55	0.58	0.53
Female headed	0.21	0.12	0.07	0.14
Age of head	47.64	44.45	44.41	45.50
Education of head	3.93	4.42	5.23	4.53
Ave. Education	3.78	4.66	4.64	4.36
Max. Education	8.49	8.97	9.01	8.83
Literacy rate	0.70	0.71	0.73	0.71
Total non-farm income	1437	1340	1146	1308
Total farm income	15095	22032	15760	17556
Household asset	7638	7463	6254	7116
Land owned	1.95	1.28	1.47	1.57
Owned + rented in	1.77	1.82	1.57	1.72

Land ownership and input use: The average land size owned by an household is about 1.57 ha, and 1.72 ha including the land rented-in (Table III). It is larger than the average area per holder of Oromia State and the whole country, about 2.4 and 1.1 ha, respectively. However, the result is closer to the average of Arsi Zone, 1.62 [14]. Farmers in the study area are also found to use chemical inputs (both fertilizers and pesticide) and organic fertilizers for the crop production. On average, each household spends about 262 Ethiopian Birr (ETB), or about 16 US dollars, per year for the purchase of herbicides. Besides, they use 235 kg of DAP and 22 kg of urea every year.

Access to resources (people or materials/ infrastructures): As it can be seen from Table IV, in all the three kebeles the accessibility of the farmers to some important people have similar trend. On average, most of the farmers (74.91%) know, and are accessible to a Development Agent (DA) in their kebele. However, it seems that some farmers do not consider DA as a resource person who can give them information and may affect their perception. Only 58.36 % of the households know somebody who can give them information about new agricultural technologies. Besides, more than 50% of the households do not know the pilot farmers either in their kebele or elsewhere. The pilot farmers are assumed to be those who are active in using new technologies. They are considered as innovative farmers and can also recognize the environmental problems in their area easily. Close contact of the other farmers with those pilot farmers is crucial for updating their information.

TABLE IV
PERCENTAGE OF HOUSEHOLDS WHO ARE ACCESSIBLE TO DIFFERENT POTENTIAL PEOPLE AND INFORMATION SOURCES

Do you know somebody:	Percent of total positive count in each kebele			Average
	Dosha	Kater Ganet	Dugda Ukolo	
Who is a Development Agent (DA)?	73.47	84.54	66.67	74.91
Who can provide you info about new techno?	58.16	68.37	48.45	58.36
Who has been selected as pilot farmer?	51.55	61.62	28.57	47.28

In Table V, the proximity of farmers to some basic infrastructures and services is shown. On average, an household in the study area is expected to travel on foot for about 74 minutes to access the nearest market, 37 to a public phone, 35 to an agricultural cooperative, 24 to an elementary school, and 107 to a paved road.

TABLE V
AVERAGE WALKING DISTANCE (IN MINUTES) TO SOME BASIC INFRASTRUCTURE (MEAN AND SD)

Infrastructure	Dosha	Kater Genet	Dugda Ukolo	Average
Market	74.49 (3.47)*	18.08 (1.16)	130.10 (6.17)	74.22 (3.65)
Public phone	49.96 (3.80)	19.17 (1.21)	41.86 (4.54)	36.80 (2.14)
Agri. Cooperatives	50.52 (3.10)	19.25 (1.16)	34.82 (2.45)	34.81 (1.56)
Elementary School	22.79 (1.87)	18.90 (1.16)	28.80 (1.81)	23.51 (0.98)
Secondary School	69.58 (3.29)	26.98 (1.55)	146.38 (5.22)	79.95 (3.58)
Health Post	42.96 (3.26)	21.57 (1.36)	33.53 (2.49)	32.54 (1.51)
Paved road	46.84 (3.35)	138.83 (19.71)	159.79 (4.06)	107.10 (4.84)
Unpaved	20.12 (2.52)	10.95 (0.98)	71.43 (4.02)	34.23 (2.24)
Post office	59.66 (3.82)	96.30 (19.89)	147.67 (6.18)	102.15 (4.89)

*Numbers in the parentheses are standard deviations.

2) Sample characteristics of Agricultural professionals

The sample of agricultural professionals constitutes 19, 46, 35 and 3 respondents who are diploma, first degree, MSc and PhD holders, respectively. Institution wise, 26 respondents are from Adama University, 18 from agricultural offices (woreda) and 59 from agricultural research centers. Their average service year is about 7.5 years, while their average age being 32 (Table VI).

TABLE VI
SAMPLE CHARACTERISTICS OF AGRICULTURAL PROFESSIONALS

	Freq.	Percent	Cumulative
Institution			
University (AU)	26	25.24	25.24
Agricultural office	18	17.48	42.72
Research centers	59	57.28	100.00
Sex of Respondent			
Male	98	95.15	95.15
Female	5	4.85	100.00
Education Level			
Diploma	19	18.45	18.45
BSc/BA	46	44.66	63.11
MSc	35	33.98	97.09
PhD	3	2.91	100.00

Others	Mean	Std. Dev.	Min	Max
Age (years)	31.81	7.68	21	50
Service year	7.48	7.50	.08	30

III. RESULTS AND DISCUSSIONS

A. Perception of Farmers and Professionals on Changes in Resources

This sub-section describes and compares the perceptions of farmers in different agro-ecology (kebeles), and agricultural professionals on the changes in crop productivity, quantity and quality of water.

1) Perception on Changes in Crop Productivity

Regardless of differences in the agro-ecology, the majority (about 60%) of the farmers believe that crop productive (yield per unit of land) has been increasing (either much or a little) over the last five years (Table VII). However, about 20.61 % perceive a small decline, and 11.82% a large decline in productivity. In the same way, a considerable number of agricultural professionals (35.92%) thought the change in productivity as increasing a little, though a higher proportion (43.69%) perceived that it is fluctuating, or does not change over years. Increases in uses of high yielding varieties, improved farming practices, and increases in fertilizers use are major reasons for the increase in productivity for those farmers who perceived the increase. On the other hand, weather fluctuation is the major reason for those who recognized the decline in productivity followed by lack of improved technologies, soil fertility losses, and decrease in use of chemical fertilizers (Fig. 1).

TABLE VII
PERCEPTION OF FARMERS AND PROFESSIONALS ON CHANGE IN CROP PRODUCTIVITY OVER THE LAST FIVE YEARS (PERCENT OF TOTAL COUNT)

Perception on productivity	Dosha	Kater Genet	Dugda Ukolo	Av. of Kebeles	Agri. Professional
Declining much	10.10	11.22	14.14	11.82	0.97
Declining a little	20.20	23.47	18.18	20.61	17.48
No change /fluctuating	3.03	7.14	11.11	7.09	43.69
Increasing a little	48.48	35.71	46.46	43.58	35.92
Increasing much	18.18	21.43	9.09	16.22	
Others	0.00	1.02	1.01	0.68	1.94
Total	100.0	100.0	100.0	100.0	100.0

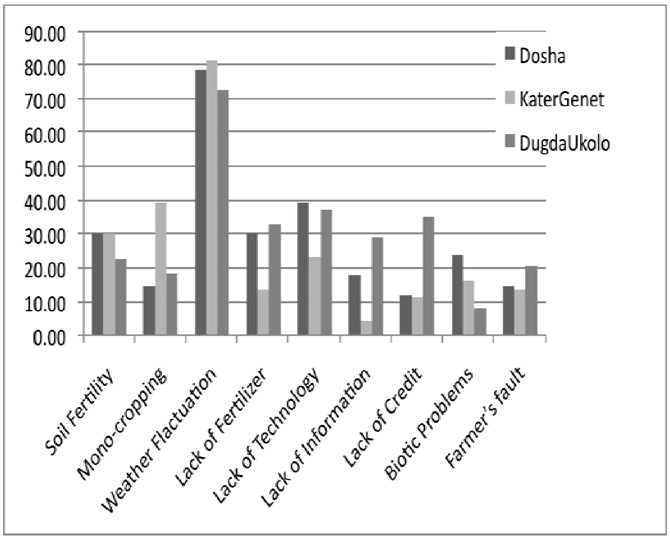

Fig. 1 Reasons for those who perceived non-increase in productivity (Percent of respondent).

2) Perception on Changes in Quantity and Quality of Water

In terms of both quality and quantity of water resources such as lakes, rivers, rainwater, etc, large numbers of the professionals and farmers have a similar view (Table VIII). It seems the decline in the water resource is very severe in the study area. About 79.5% and 78.4 % of the farmers and professionals perceive the decline in water quantity, in the same order. Besides, 57.9% of farmers and 69.0% of professionals are also thought declining in quality of water. Obviously, the change in quantity is more visible than quality and thus higher percentage. The study by [17] supports that there was a decline in rainfall in both midland and low land areas in the western part of Arsi Zone, while rainfall increased in highland areas. Rainfall is the main source of water, but the quality and quantity of the water bodies such as rivers and lakes can be affected by soil erosion and agricultural activities.

In addition to the common questions to both farmers and professionals, agricultural professionals were asked their rationale of their perception of the decline in water resources, and to rate severity of environmental degradation as a whole. As a result, climate change has been indicated as the main cause for the decline. They also rated environmental degradation as a “sever” in their area (Fig. 2 & 3).

TABLE VIII
PERCENTAGE OF FARMERS AND PROFESSIONALS WHO RATED THE STATUS OF CHANGES IN QUANTITY AND QUALITY OF WATER RESOURCES OVER THE LAST FIVE YEARS

Perception on	Dosha	Kater Genet	Dugda Ukolo	Ave. kebeles	Agri. Professional
Quantity of water					
Declining	86.87	66.67	84.85	79.46	78.43
The Same	8.08	27.27	10.10	15.15	3.92
Increasing	5.05	6.06	5.05	5.39	4.90
Don't know	0.00	0.00	0.00	0.00	12.75
Quality of water					
Declining	72.73	43.43	57.58	57.91	69.00
The Same	18.18	48.48	27.27	31.31	7.00
Increasing	9.09	8.08	15.15	10.77	6.00
Don't know	0.00	0.00	0.00	0.00	18.00

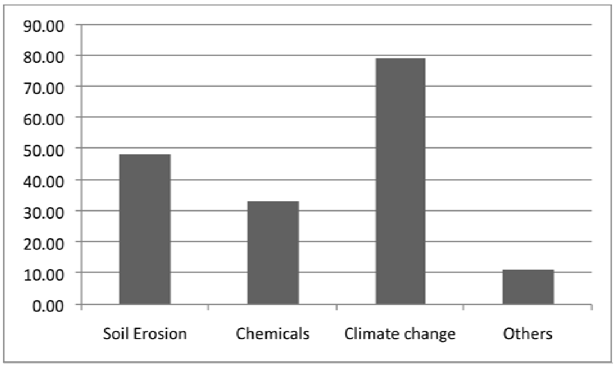

Fig. **2** Professionals' perception on the cause of changes in water resources (percent of respondent).

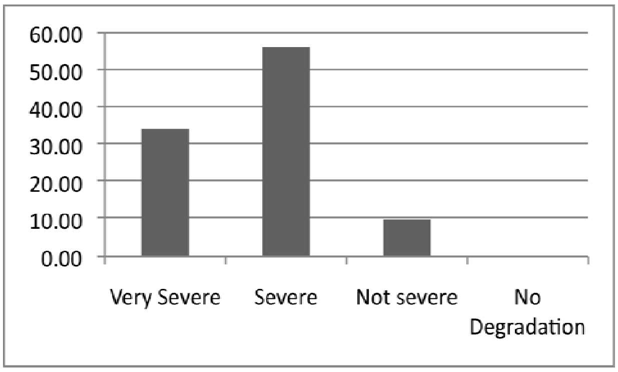

Fig. 3 Professionals' perception on over all severity of environmental degradation (percent of respondent)

B. Factors Associated with Perception of Farmers and Professionals

This sub-section shows the association between different independent and dependent variables using correlation and regression analysis. The correlation results show us only the strength of association of the variables. The ordered logit regression model is used to estimates how much the socioeconomic, geographical and personal network characteristics of the household affects their perception on the changes in the crop productivity, quantity and quality of water in their area. Most of the data from agricultural professional are not included in this sub-section.

1) Correlation Results

Table IX shows the association of different factors with the perception of farmers on changes in their resources. Perception on changes in crop productivity is positively and strongly related to their total (farm and non-farm) income and total value of household assets. Moreover, there is slight correlation with distance to paved road and the education level. While, perception on quality and quantity of water has strong and negative correlation with land area the household has. In addition, their perception on the change in water quality is strong and negatively correlated with the elevation (altitude) in which they live. That is, those in the higher altitude perceive decline in water quality than those in lower altitude.

In the case of the agricultural professionals (results not shown), almost all the factors related to the characteristics of the professionals are not significantly associated with their perception on the crop productivity. Moreover, there is no evidence for the correlation of other variables such as the institute they belong to and their work place with their perception. However, it is seen that the older and more educated professionals are less likely to recognize the decline in water quality. As expected, perception on the severity of environmental degradation is negatively correlated with perception on change in quantity and quality of water. That is, if they perceived a decline in the quality and/or quantity of water, they are more likely to observe higher severity of environmental degradations or vice versa.

TABLE IX
CORRELATION COEFFICIENTS OF SOME SOCIO-ECONOMIC VARIABLES WITH PERCEPTION OF FARMERS ON THE CHANGES IN PRODUCTIVITY, QUANTITY AND QUALITY OF WATER

Variables	Productivity	Water quantity	Water quality
Person's correlation			
Age of head	-0.02	-0.04	-0.06
Education of head	0.10*	-0.05	-0.05
Household asset	0.18***	-0.05	-0.10*
Total income	0.20***	-0.05	-0.02
Land size	0.02	-0.17***	-0.23***
Altitude (elevation)	0.06	-0.03	-0.16***
Dist. to paved road	0.13**	0.05	0.07
Dist. to Unpaved road	0.02	-0.13**	-0.13**
Dist. to market	0.02	-0.16***	-0.10*
Dist. to Agri. Cooperative	0.08	-0.11*	0.20***
Dist. to research center	0.05	-0.02	-0.04
Spearman's R			
Access to DA	0.04	0.07	0.09
Access to Pilot farmer	0.08	0.13**	0.001

Notes: * Significant at 0.1, ** at 0.05, *** at 0.01

2) The Regression Results

As it can be seen from the Table X, in each of the three separate models on the perception on change in productivity, water quantity, and water quality, the null hypothesis that the effect of all the independent variables is insignificant is rejected at the 1% significance level. The value of household assets, the education level of the head, the distance to the nearest paved road and the elevation of their farmland seem to be the most important determinants of farmers' perception on the changes in crop productivity. The corresponding marginal effect shows that, when the years of schooling of the head increased by one year around the mean, the probability of perceiving a decline in productivity (category 1, see section II) decreases by 0.026, holding other variables constant at their mean. In general, more educated and richer farmers perceive increases in productivity. This could be related to their knowledge to manage their farm, affordability to buy and use high yielding varieties and chemical inputs and thus do not observe decline in productivity. For instance, it can be seen in the same table that the probability to observe decline in productivity declines by 0.16 if a farmer adopts new crop variety. Besides, many studies on the effect of education on productivity, reports educative farmers are more productive, early adopters, etc [18] – [20].

More over, the geographical position of the household such as elevation gives important insight on differences in agro-ecology. The marginal effect shows that for a unit increase in elevation centered around the mean, the probability to observe a decline in productivity reduces by 0.083, keeping other variables at their mean. Farmers in the higher areas are found to observe less declines in productivity. This could be directly related to the rainfall distribution and amount. In the study area, the higher altitude areas have more rainfall and less affected by weather fluctuations compared to the low land areas.

Similarly, when the distance from the nearest paved road increases by one unit, the probability to perceive a decline in productivity also decreases by 0.027. It is actually expected to be an increase, because if the farmers are close to roads and other facilities they have access to agricultural inputs and thus could have observed increase in productivity. Since the geographical positions of the three kebeles are somewhat at different distance from the paved road (which is in Asella), it could be more experiencing other unrelated factors.

Focusing on the same table, Table X, there is no evidence that age of the farmer, the education level, social network density, and household asset shapes their perception on changes in water resources. It means that regardless of the age, income status, density of their social network and education level, most of the farmer tends to recognize the declines in the resources (refer back to Table VIII). Moreover, those farmers who are either in highland or lowland areas have the higher tendency to observe the decline in water resources both in quality and quantity.

Distance to research center, and land size significantly shape their perception on decline in water quality. For instance, for a unit increases in the land size around the mean, the probability to observe decline in water quality increases by 0.105, keeping other variables constant. Farmers with larger farmland recognize the decline in water quality more than the others.

Farmers who know more agricultural professionals (contact with professionals) recognized the non-decline in water quantity. This could be due to the difference in the way they get water. Specially, those who have irrigation facility (like in the Kater Genet kebele), tend to be visited by DAs and others, and thus have more contacts with professionals. At the same time, since they get irrigation water recently they could observe increase in water resource in their area.

TABLE X
ORDINAL LOGISTIC RESULTS ON THE PERCEPTION OF FARMERS ON THE CHANGE IN PRODUCTIVITY, WATER QUANTITY AND QUALITY OVER THE PAST FIVE YEARS

Variables	Sample Mean	Perception on Productivity		Perception on Water Quantity		Perception on Water Quality	
		Coef.	Marginal effect	Coef.	Marginal effect	Coef.	Marginal effect
Adopt new variety [a]	0.717	0.777***	-0.155	-0.167	0.022	-0.497*	0.119
Family size	6.115	-0.134**	0.027	-0.067	0.009	-0.068	0.016
Age	45.208	0.018*	-0.004	0.012	-0.002	0.009	-0.002
Education level	4.287	0.130***	-0.026	-0.049	0.006	-0.029	0.007
Household asset	6888.820	8.8e-5***	-1.8e-5	3.6e-6	-4.74e-07	3.7e-5	-8.87e-6
Land size	1.552	-0.013	0.003	-0.522**	0.068	-0.438***	0.105
Network density	10.724	0.019	-0.004	0.021	-0.003	0.024	-0.006
Contact with professionals	1.262	-0.242	0.048	0.489**	-0.064	-0.014	0.003
Dist. to research	29.586	0.015	-0.003	-0.205	0.027	-0.348***	0.084
Dist. to paved road	7.273	0.135***	-0.027	-0.050	0.007	-0.020	0.005
Dist. agri. cooperatives	1.814	0.023	-0.005	0.045	-0.006	-0.139	0.033
Dist. health post	1.694	-0.050	0.010	0.028	-0.004	0.222	-0.053
Elevation	1.731	0.416**	-0.083	0.077	-0.010	0.239	-0.057
Dosha[a]	0.344	1.601	-0.320	-7.326*	0.961	-11.611***	2.786
Dugda Ukolo[a]	0.351	0.263	-0.053	-3.875*	0.508	-5.787***	1.389
_/cut1		3.39		-8.51		-16.18	
_/cut2		3.82		-6.89		-14.09	
Log likelihood		-217.69		-152.66		-228.86	
DF		15.00		15.00		15.00	
Chi2		49.29		30.64		57.39	
Prob > Chi2		0.000		0.0098		0.0000	

* Significant at 10%; ** significant at 5%; *** significant at 1%
[a] Dummy variables, (the discrete change of dummy variable from 0 to 1 is considered)

IV. Conclusions and Remarks

This study shows that there is a common understanding by both agricultural professionals and farmers on the declining in quality and quantity of water resources, though, no common clear observation on the changes in crop productivity. Besides, the professionals ranked the environmental degradation as "sever". With he high population growth rate (around 3%), a little or no increase in productivity and a decline in resources (specially water resources), reconsidering agricultural sustainable situation of the area is vital, and it is facing serious challenges. Moreover, the main reason for those farmers and professionals who realized decreases in productivity is weather fluctuation. Soil fertility loses seem to be less important compared to weather fluctuation in the area.

The regression results indicate educated and richer farmers have less tendency to observed the decline in productivity. The weather is similar and common for the sample farmers in the study area. But, it could be due to the fact that educated and richer farmers use improved technologies and managed their farms better than the others. Hence, soil fertility issues and technology adoption could be a big concern as well.

The other important finding of this study is whether the farmers are literate or illiterate, rich or poor, young or old they could recognize the environmental and resource degradation such as decreases in water resources. Besides, having contacts and knowing agricultural professionals, and their personal networks have no influence on perception on changes in water resource. The probabilities of observing decline in water quantity and quality are higher in highland are (Dosha) compared to the lowland area (Ukolo).

The study remarks that the environmental education given to farmers should be on how to cop and mitigate the problems rather than teaching about the problems as they have best knowledge of it. Moreover, the alternative technologies that could be locally available, mitigate the environmental problems, and improve productivity shall be promoted. The promotion of new crop varieties, fertilizers, and other chemicals made the farmers to think that these are the best yield augmenting technologies that can bring them high yields. Rather, the inclining cost of fertilizers and other imported chemicals from foreign countries put the resource poor farmers under critical problems.

As a finally remark the severity of resource degradation shall be physically assessed more in details, and that can help to impose policy supports to focus on the resource conserving technologies, and conservation measures.

Appendix 1

Definition of Independent Variables

Access to DA: A dummy variable, whether a farmer knows a DA (development Agent or not), (1 = Yes, 0 = Otherwise), used in correlation analysis.

Access to pilot farmer: Dummy variable, whether the farmer knows a pilot farmer or not (1 = Yes, 0= Otherwise), used only in correlation analysis.

Adopt new variety: Is a dummy variables representing either the farmers used a new crop variety or not (1 = Yes, 0 = Otherwise)

Age: The age of household head (in years) as of the interview date.

Contact with professionals: Sum of "Yes" for whether the household knows a DA, somebody from research center, and/or pilot farmers (where Yes = 1). For example, if a farmer knows all the three, the value will be 3.

Dist. agri. Cooperatives: Walking distance to the nearest agricultural cooperatives. (All the distance are estimated from farmer's home, and it is in walking minutes)

Dist. health post: Walking distance to the nearest health post

Dist. to Market: Is estimated walking distance to the nearest market.

Dist. to paved road: Estimated walking distance to paved road.

Dist. to research: Estimated walking Distance to research center.

Dist. to unpaved road: Estimated walking distance to the nearest unpaved road.

Dosha : Is a dummy variable for the highland kebele, (1 = Dosha, 0= Otherwise).

Dugda Ukolo: Is a dummy variable for the lowland kebele(1 = Dugda Ukolo, 0 = Otherwise)

Education level: years of schooling of the household head

Elevation: Altitude above sea level (in maters) taken at the homestead of every household using GPS

Family size: Total number of the household members who lived at least for two months over the last 12 months (from the date of interview).

Household asset: Total estimated amount of values (in Ethiopian Birr) of some selected farm and household assets, including oxen, *mofer, kenber*, axes, Television, Radio, moter bicycle, bicycle, etc. (land is not included).

Land size: Total land area the household own (in hectors).

Social Network density: estimated indirectly by asking the household head whether 14 random pairs of persons the farmer knows, know each other or not. And the total "Yes"s are considered, to judge whether the network is dense or not. (If they know each other = Yes = 1, Otherwise = 0).

Total income: the sum of farm and non-farm incomes of the household calculate per annum (in Ethiopian Birr)

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