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Analysis of gender vulnerability to climate-related hazards in a rural area of Ethiopia

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Abstract

Identifying the areas of the world and the communities that could be damaged by of extreme meteorological events, like droughts and floods, had been crucial for the vulnerability studies of the last decade. Within the countries of East Africa, Ethiopia is particularly sensitive to negative effects of extreme climate change-induced events.

Climate change affects differently women and men, especially in rural areas of developing countries, where women are the poorest. Aim of this work was to develop an integrated system of Early Warning and Response, whereas neither landmark data nor vulnerability drought analysis existed in the country. Specifically, a vulnerability index and incapacity to react index of the population of three Woredas in the Oromia Region of Ethiopia (Siraro, Shalla, Shashemene) were determined and analysed disaggregated by sex. Input data concerned rainfall, water availability, physical land characteristics, agricultural and livestock dimensions, as well as population and socio-economic indices.

The graphical restitution of the indices shows that the vulnerability of population is strictly dependant to the presence of governmental infrastructures, water sources and roads. In this framework, Woreda Siraro is the most vulnerable Woreda. A better situation appears in Woreda Shalla and Shashamane, where population has high skills to face vulnerability, as revealed in incapacity to react index.

In the same time the analysis shows a difference between the female and male gender. Unlike male gender that it is prevailing in low vulnerability for high resilience, the female gender is divided in two main classes (low vulnerability associated to a low resilience and low vulnerability associated with a high resilience). Finally, when the vulnerability is higher both the male and female genders have the same behavior showing higher resilience.

Key Words: Ethiopia, Climate Change, Vulnerability Analysis, Gender, Drought, Sustainability

Introduction

The Intergovernmental Panel on Climate Change in 2007 evidenced a strong correlation between the anthropic activities and a manifested climate change (IPCC 2007). The consequence is an increased probability of floods, droughts, hurricanes and storms, which are as severe as the set of the human-environment characteristics is vulnerable, namely it is sensitive to the damaging effects of extreme natural events.

The natural disasters affect both men and women everywhere, and they may be crushing both at the North and the South of the world, but it is especially in the rural poorer regions of the South (where women are the poorest) that they may have harmful socio-economic effects. These countries have both a major extent to be highly sensitive to little changes and a low ability to adapt to them (Watson et al. 1996), because of their geography, the high population growth, the heavy dependence from a subsistence agriculture, the shortage of natural (water, fuelwood) and economic resources, the weakness of social services (healthcare, schools), technologies (as improved cultivation systems) and poor accesses roads (Stern 2007). Rural women especially suffer of the negative impacts due to climate change with increased household responsibilities and agricultural work. Many authors agree that rural women in less developed countries are among the most vulnerable people (UN Women 2014; Denton 2009; FAO 2007; Lambrou and Piana 2006). In these areas the rural women's livelihood activities (which mainly depends on the natural environment) are above all vulnerable to the risks posed by damages from climate change. For example, they have to walk more searching not polluted water and fuelwood because of environmental degradation around their villages, shortening time for education or participation in market-based works. As a consequence they stay relegated to subsistence and informal activities increasing their vulnerability to extreme climate occurrences (Bynoe

2009; Goh 2012; Djoudi and Brockhaus 2011; Denton 2002; Nelson et al. 2002). Moreover the land is not equally distributed between women and men, especially the most fruitful farm plots (Agarwal 2003; Logo and Bikie 2003; Whitehead and Tsikata 2003), causing impacts on agricultural productivity and negatively affecting both women's resilience and their possibility to purchase seeds, fertilizers and livestock species more resistant to climate changes (Gladwin 1992; Fletschner and Kenney 2014).

The scientific studies concerning women and environment date back to seventies and underlined that women are more linked to nature than men (Shiva 1988, Agarwal 1992; Roth-Johnson 2013), however it is only in the last years that the debate around the 'gender and climate change' theme increased (Bunce et al. 2016; Ravera et al. 2016; Bee et al. 2013; Carr and Thompson 2014; Sultana 2014; Skinner 2011; Alston and Vize 2010; Dankelman and Willy 2010; MacGregor 2010; UN Women Watch 2009; Brody et al. 2008). It emerges that gendered schemes of climate changes in rural areas are more complex than the simple duality women versus men, but include also other classifications, as ethnicity, class, age, access rights and economic condition (Carr and Thompson, 2014). As observed by Ravera et al. (2016) it is necessary to better integrate gender and global environmental change among different scientific fields to pursue a holistic and truthful vision of the anthropic effect of the climate change. To limit the detrimental consequence of the climate change, it is therefore necessary to prompt evaluate the human-environment vulnerability to the extreme events, where the human component must be considered as a whole composed by women and men differently, in order to adopt measures to real develop their capacity of adaptation and to improve their resilience.

The vulnerability research evaluates which individual, community, region or nation is more vulnerable, in order to adopt policies to limit the effects of the climate change on the ecosystem which is fundamental for the wellbeing of women and men (Tiepolo et al. 2016). It is common knowledge that vulnerability is a 'work in process' analysis, which includes heterogeneous empiric studies (Vincent 2004) differently applied to various systems (Cutter 2003) and with the necessity to have a basic conceptual framework (Kasperson J. and Kasperson R. 2001). For these reasons in 2015 the General Assembly of United Nation created an intergovernmental working group to define common working criteria for the disasters risk reduction (AG 2015).

For the vulnerability analysis it is necessary to define a priori the layout with its four components: the system, the attribute of concern, the temporal reference and the hazard. The system is the set which may be vulnerable (e.g. community, geographic area), the attribute of concern is an infrastructural or socio-economic event treated by a dangerous event (e.g. health, education, food security), the temporal reference is the vulnerability period of time and the hazard is the potential threat to humans and their welfare. It is important to consider each of these four elements, without forgetting that the system is not a blurred set of people or undistinguished geographic area, but a set of individuals and territories populated with individuals with their peculiarities (e.g. gender, ethnic group). Talking of vulnerability, the different approaches of the vulnerability studies must be distinguished: the vulnerability to natural disasters and the vulnerability of livelihoods. In the first case the hazard is exogenous to the human being because vulnerability focuses on the human dimension conditioned by the natural disasters, while in the second case the vulnerability is the human condition caused by lack of entitlements (Alwang et al. 2001; Petzold 2016; Lin and Polsky 2016).

The vulnerability to climate change considers the hazard as the result of both endogenous and exogenous characteristics of the system and contemplates exposure to a dangerous event as part of vulnerability of the system itself (IPCC 2001). This is the methodology used in this work that it analyses the men and women vulnerability and resilience in three contiguous Woredas of the Oromia Region (Ethiopia). The choice to focus the study in a specific geographic area where the majority of the ethnic group is the same (ethnic group Oromo for more than 90% of the inhabitants) is to consider a sample more homogeneous as possible (CSA 2013). Moreover, since many years this area has been exposed droughts and humanitarian catastrophes, especially due to the ENSO phenomenon and the heating of the Indian Ocean (Hulme et al. 2001; Comenetz and Caviedes 2002; Funk et al. 2012). This research uses data collected in field both by the NGO LVIA (with a food security questionnaire) and by a project of the University of Turin in 2015. Moreover the Central Statistical Agency of the Government of Ethiopia is the source for the used census data. Also if the last national census refers to 2007, afterwards other specific censuses were carried out by the Ethiopian Government. For this reason in this study we used the most recent ones, depending by the treated information (for example, concerning the population projection for all Regions at Woreda level, it is used the 2013 statistic data which forecasted the population projection until 2017).

To evaluate the hazard and the effect of the climate change in these Ethiopian areas, an innovative methodology using the vulnerability analysis was applied, with a deeper study of the system and of the attribute of concern, considering men and women different answers to the questionnaires and with in-depth interviews.

Materials and method

Area of study

The studied area is located in the three Woredas of Siraro, Shalla and Shashamene in the Oromia Region, Ethiopia (Figure 1). In Table 1 there are the main characteristics of the examined Woredas.

Figure 1 Map of the Woredas of Siraro, Shalla and Shashame and of the lakes at the boarders (Langano salty lake in the north, Awassa lake in the south)

Ethiopia extends to 1,120,000 km^2, in the so called Horn of Africa. The phenomenon of Niño and Niña (ENSO – El Niño Southern Oscillation) in the last century provoked many irregularities in precipitation distribution in the Horn of Africa (Seleshi and Demarèe 1995; Hulme et al. 2001; Segele and Lamb 2005; Korecha and Barnston 2007) causing severe periods of drought in many regions of the country. The anomalous rain cycles in the seasonal rain periods are responsible to the agricultural losses (Viste et al. 2013; Segele and Lamb 2005) stoking the rural people vulnerability (Sadoff 2008).

Since 1996 Ethiopia is a federal country composed by nine ethnic administrative regions. Each of the nine Regions of the Ethiopia includes a certain number of districts (Woreda) and each Woreda is composed by municipalities (Kebele), the smallest administrative unit of Ethiopia.

Ethiopia is the second most populous country in Africa (more than 96 million of inhabitants in 2014; UNDP 2017) and in the last years it emerged as one of Africa's raising economies. The government has been investing in economic and social infrastructure, with the aim to raise Ethiopia to a middle-income country (CIA 2017). The agricultural sector is the driving economic engine: in 2014, agriculture accounted for 47.7% of the GDP with a total of 75.1% of labour force, with women representation of 45% (FAOSTAT 2017). This percentage dramatically drops down considering skilled agricultural, forestry, and fishery workers: 28.1% female versus 52.8% male (CSA 2013). Moreover, about the 67% of rural women are unpaid or self-employed workers, reporting high values of work expenditure in household activities (CSA 2013).

The Oromia Region is the most populated Region for around 40 million people as reported by Eriyagama et al. (2009). The most represented is the Oromo ethnicity (85% of population) and it is chiefly rural, with a large amount of cattle (CSA 2007). The Region is located in a large drainage basin with a quite good quantity of water, but the current management system cannot provide a sustainable water access to the population.

Table 1 Environmental and economic characteristics of the examined Woredas

Woreda	Area (km^2)	Environment	Male population*	Female population*	Economic activities	Crops
Shasha mane	779	Lowland (80%) Highland (20%)	230,387	232,646	Agriculture Livestock Commerce	Teff, barley, millet, sorghum, wheat, corn, beans
Siraro	607	Lowland (68%) Highland (32%)	91,659	95,369	Agriculture Livestock	Teff, wheat, corn, beans, potatoes
Shalla	749	Highland (1700-2000 m)	96,321	96,384	Agriculture Livestock	Corn

*(CSA 2013)

The high population density (from about 260 to 594 inhabitants/km^2, higher than a value lower to 70 at national level) increases the population sensitiveness to the climatic disturbs in a region where in the last years the DRMFSS (Disaster Risk Management and Food Security Sector) documented a great level of exposure to drought and floods (DRMFSS 2017). As in other Ethiopian areas, the main occupations are agriculture and livestock without economic diversification in order to reduce the population dependence from natural resources.

Data collection

The sex-disaggregated data analysis was based on the information collected with a questionnaire built by the Italian NGO LVIA for its Food Security project in the Woredas of Siraro, Shalla and Shashamane. The questionnaires were submitted to males and females of 15 Kebeles (5 for each Woreda), randomly selected.

Five sections set up the Food Security questionnaire: general information (25 questions), livelihood conditions (30 questions), food security (11 questions) and observation checklist (Belcore et al. 2017). The general information section investigates on household composition and water resources access and management. Livelihood section collects information about family economics activities, agricultural and breeding system. The food security section of the questionnaire contains questions concerning the composition of the family, the daily quantity of meals and the presence of under-nutrition conditions. The observation checklist section was inserted to collect interviewer’s personal impressions of the household. The questionnaire was created in order to be more understandable as possible: the questions of the questionnaire are short and easily understandable and translatable into the local languages.

The questionnaire distribution procedure Before conducting questionnaires, LVIA staff created the questionnaire guidelines to guarantee a homogeneous data collection. 180 questionnaires were summited to the population, particularly were interviewed 150 male household-heads and 30 female household-heads: the unbalance of the gender's sample is due to the low presence of women as household-head in this area. The disproportion of females heads in relation to male ones suggests that in Ethiopian culture women as head of the household aren't ordinary (Asfaw et al. 2013). In fact, interviewed women in most cases were widows, second wives and, rarely, they were old women. In each village interviewers found at least one female household-head to distribute the questionnaire. The LVIA field-staff assisted interviewees filling the questionnaires. All questions were translated into the local language and explained to the interviewees. Based on the data collected with the questionnaires a database was created. Some key information of the database was individuated and thereafter elaborated and used to calculate vulnerability and resilience indexes.

Analysed indices and indicators for sex-disaggregated analysis

The vulnerability, the resilience and the incapacity to react indexes were calculated and then classified for both men and women household heads. Each index was composed by one or more indicators and each of these indicators was in turn assembled by one or more other sub-indicators. The complexity in the indicators construction is due to the variety and heterogeneity of the system components, which must be correctly considered and evaluated to have a correct picture of the context. Each indicator composing the three indices (i.e. vulnerability, resilience, and incapacity to react) were normalized in a 0-1 scale. The normalization allowed a correct data treatment and homogeneous values within each index. Since standardization was applied to the indicators, the indices were not standardized in a common scale once more, to avoid too compact data series that would have been ineffective.

Vulnerability The capacity of a community to adapt when climate changes cause modifications to the livelihood environment is called vulnerability (IPCC 2001). The vulnerability index is function of three indicators: exposure, sensitivity and adaptive capacity (equation 1).

$$V = \frac{E \cdot S}{Ca} \tag{1}$$

where E is the exposure, S is the sensitivity and Ca is the adaptive capacity.

The negative consequences of the climate change-related conditions, that involve both males and females, are represented by the exposure (*E*) and sensitivity (*S*) indicators, while the adaptive capacity (*Ca*) is the parameter which may counteract the negative effect of the impact (Pezzoli and Ponte 2016).

To calculate the vulnerability index, 18 indicators were used (some of them composed by more sub-indicators, as previously explained), considering the socio-economic, environmental and climatic conditions of the system (Table 2). The 18 indicators describe the characteristics of the system related to potential climate change effects, which may affect differently females and males. Six indicators were chosen for the resilience index (Table 2).

Table 2 Macro-indicators of the vulnerability index

Index	Indicator	Macro indicator

Vulnerability	Exposure	Population density
Vulnerability	Exposure	Drought analysis
Vulnerability	Sensitivity	Cultivated land pro capita
Vulnerability	Sensitivity	Number of economically not active members(<5yeas old, >65years old)
Vulnerability	Sensitivity	Yearly income pro capita
Vulnerability	Sensitivity	Presence of a second income source
Vulnerability	Sensitivity	Average litres of water fetch per day
Vulnerability	Sensitivity	Distance from the main water source
Vulnerability	Sensitivity	Average water price
Vulnerability	Sensitivity	Water quality
Vulnerability	Sensitivity	Type of soil and soil erosion
Vulnerability	Sensitivity	Average number of meals per day
Vulnerability	Sensitivity	Number of agriculture varieties
Vulnerability	Sensitivity	Use of inputs
Vulnerability	Adaptive capacity	Number of animals per cattle
Vulnerability	Adaptive capacity	Type of water source in the village
Vulnerability	Adaptive capacity	Presence of a warehouse
Vulnerability	Adaptive capacity	Beneficiary of governmental programs

Exposure It is defined as each meaningful climatic variation influencing the examined system. Intensity, frequency, duration and physic extension of the hazard are specifically considered. There is a physical exposure, which refers to infrastructures, buildings, ecosystems and cultivations, and a social exposure, related to human and animal populations. Climatic variations affect in the same way all the population regardless of sex or age: moreover, vulnerable men and women may have a good capacity of adaptation and may be more or less sensitive, but they are always exposed. The social component (subject) and the physic component (or hazard) are necessary in the exposure calculation. For this reason, in this work two types of exposure are identified: physical (E_p) and demographic (E_d).

The physical exposure describes the nature and the level of danger of the potentially exposed area. In the area of this study the main identified hazard is the drought. As suggested by WMO (WMO 2012), to analyze physical exposure was used the Standardized Precipitation Index (SPI). Mathematically, the SPI is based on the cumulative probability of a given rainfall event occurring at a station. The historic rainfall data of the station are fitted to a gamma distribution, as the gamma distribution has been found to fit the precipitation distribution quite well. Therefore, based on the historic rainfall data, it is possible to quantify the probability of the rainfall being less than or equal to a certain amount. Therefore, if a particular rainfall event gives a low probability on the cumulative probability function, then this is indicative of a likely drought event. Alternatively, a rainfall event which gives a high probability on the cumulative probability function is an anomalously wet event (Guttman 1999). In this research the SPI was evaluated using precipitation data provided by the Ethiopian National Meteorological Services Agency (NMSA 2017). Data were aggregated and expressed in millimeters, and referred to four meteorological stations distributed in a circular area with a radius of 50 kilometers. The center of the area was located in Shashamane town that is in the middle of the three examined Woredas (Figure 2). Data collected between 1994 and 2014 were used. The choice to limit the research at four stations (Figure 2) permits a good data coverage (between 88% and 96%) that guarantees a high result confidence (WMO 2012). The SPI was calculated thanks to an open-source software created by the National Drought Mitigation Center (NDMC) of the University of Nebraska-Lincoln (NDMC 2017).

Figure 2 Analyzed area for the evaluation of the physical exposure. The circle points represent meteorological stations of NMSA, while the triangle points indicate meteorological stations of NOAA. The circle area is the area included between Shashamane town and the far meteorological station

The SPI is a positive value when precipitation data is over the average, while a negative value indicates precipitations under the averaged value. Drought is considered as the time period when the SPI is negative and it is classified on the basis of its duration. In this research a SPI of four months was used, in order to have a seasonal point of view. Then, to evaluate also the SPI for a long term period, a SPI of twelve months is used considering that it was analyzed a time series of 20 years.

The short term analysis (4 month) is focused on precipitation of the main rainy period, the Belg (February-May) and the Kiremt (June-September) seasons. The annual SPI, instead, allows to obtain a historical analysis about frequency and intensity of long-period droughts in the area.

The value of the physical exposure was achieved starting from SPI through the evaluation, according to a normalized scale of SPI, of the frequency of drought events for every recorded intensity and duration (4 month or 12 month) (WMO 2012). The evaluation considered the data from two meteorological stations: Shashamane and Bulbula. These stations were chosen for their position near the analyzed Woredas, for the good data cover and because their represent two areas at different altitudes. Comparing the results obtained from the analysis of the two stations, Bulbula area shows the most critical condition.

Considering the proximity of the stations and their significance to the analyzed area, it was decided to use the most critical values in order to have a final analysis of physical exposure factor (E_p) that had the maximum security level. Figure 3 and Table 3 show the results obtained for the Bulbula station.

Figure 3 Bulbula SPI

Table 3 Analysis of physical exposure (E_p) for Bulbula station (Belcore et al. 2017)

	SPI from -1 to -1.49	SPI from -1.49 to -1.99	SPI from ≤ -2	*Ep*
Drought intensity	Moderate	Severe	Very severe	
12 months	9.52%	4.76%	4.76%	20
Belg	9.52%	-	4.76%	14

Kiremt	4.76%	4.76%	4.76%	19

Afterwards, weights and rating values were assigned, on the basis of calculated drought severity and drought frequencies (Table 4).

Table 4. Weight, frequency and rating of E_p

Drought severity	Weight	Percentage of occurrences	Rating
Moderate	1	≤ 9.0	1
		9.1-10.0	2
		10.1-11.0	3
		≥11.1	4
Severe	2	≤ 3.5	1
		3.6-4.5	2
		4.6-5.5	3
		≥5.6	4
Very severe	3	≤ 1.5	1
		1.6-2.0	2
		2.1-2.5	3
		≥2.6	4

This operation describes, through SPI and in a quantitative way, the aptitude of a system to be affected by a drought event according to the literature about the drought hazard (Sönmez et al. 2005; Shahid and Behrawan 2008).

Physical exposure (E_p) was obtained using the formula in equation 2.

$$E_p = (MD_v \cdot MD_w) + (SD_v \cdot SD_w) + (VSD_v \cdot VSD_w) \tag{2}$$

where:

MDv: attributed rating of moderate drought frequency

MDw: weight of the moderate intensity drought

SDv: attributed rating of severe drought frequency

SDw: weight of the severe intensity drought

VSDv: attributed rating of extreme drought frequency

VSDw: weight of the extreme intensity drought.

The obtained values of the physical exposure for the three periods are reported in Table 3 and in the E_p column.

Finally, averaging the three values listed in the E_p column of the Table 3, it was obtained an E_p value equal to 17.66, on a maximum value of 24. The final normalization of the value, in a scale of 0÷1, reported a final value of 0.73.

The demographic exposure uses the population density of the studied area: whenever the population density is high, the available resources for inhabitants lower and the population is consequently more exposed to negative climate change effects. The population density was calculated using the data of the 2007 Ethiopian population census of the Central Statistical Agency of Ethiopia (CSA), updating the data to 2015 (World Bank 2016). It was not possible to use the population projection from 2014 to 2017 of the Central Statistical Agency (CSA 2013) because this projection was available for all Ethiopian Regions at Woreda level, but not at Kebele level, as it was necessary for the vulnerability evaluation at small scale. Four classes were considered, corresponding to an increased population density. The E_d indicator was normalized and at each class an E_d value between 0.3 and 1 was associated. The highest index (1) corresponds to the highest density (in this case >600 inhabitants per squared kilometre), while the lowest one (0.3) refers to a population density lower than 200 inhabitants per squared kilometre.

Sensitivity It is the population and infrastructure aptitude to be bashed by extreme events (Fellman and Lankoski 2012). The sensitivity was calculated considering the resources availability (equation 3). Twelve indicators were considered and grouped in three categories: agro-environmental indicators, water indicators and socio-economic indicators (Table 5).

$$S = \sum resources\ availability \qquad (3)$$

They were used for both male-heads and female-heads household observations, to obtain comparable data.

Table 5 Sensitivity indicators

Agro-environment	Water	Socio-economic
Soil characteristics and erosion	Water availability	Cultivable land
Quality and quantity of agricultural inputs	Water price	Income per capita
Crop diversification	Distance from the nearest water source	Members of the family economically inactive
	Water quality	Presence of secondary income sources
		Numbers daily meals

The main activity of this area is subsistence agriculture: for this reason the livelihood of the population is deeply related to the possibility to exploit agro-environment resources (soil fertility, agricultural inputs, crop variety), have good water sources available (all the cultivated crops are based on rainfalls, because the population don't practise irrigation) and rely on household economic supports (arable land, income, economically inactive members, number of daily meals). In the studied Woredas, water collection and management are considered females tasks. In male-head households as well as in the female-heads ones, young women and children are in charge of water fetching. The socio-economic indicators help to understand if the population is in a risk condition in relation to low social position and feeble economic capacity of the families.

Capacity of adaptation It is the amount of the populations' abilities that permit them to quickly react to an extreme hazard and to adapt to new situations. The capacity of adaptation can therefore contribute to mitigate the sensitivity effects permitting a positive response to the physical exposure. The capacity of adaptation is composed by indicators that consider the individual and community support elements, as governmental disaster emergency plans, community aid infrastructures, presence of warehouses and livestock. In this paper the capacity of adaptation (*Ca*) was calculated using the following indicators: warehouse presence, livestock, governmental aid, water source (equation 4).

$$Ca = \sum warehouse, livestock, governmental\ aid, water\ source \quad (4)$$

Resilience It is the ability of a potentially exposed system (community or society) to face disasters effects in a prompt and effective way, without affecting the fundamentals structures and functions of the system (UNISDR 2017). In this paper the resilience is considered as the ability of the investigated communities to change and innovate themselves thanks to the education, the services, the credit and local organizations support (equation 5 and Table 6).

$$R = \sum \begin{matrix} education\ level, intercommunity\ aid, health, cooperative, \\ micro\ credit, NGO\ support \end{matrix} \quad (5)$$

Table 6 Macro-indicators of the resilience index

Macro-indicator	Explanation
Education level	Higher educational level present in the household
Intercommunity aid	Participation to local associations (cooperative)
Health	Presence of an health centre in the village
Cooperative	Participation to agricultural cooperatives
Micro credit	Possibility to access to microcredit
NGO support	Beneficiary of NGO project

Incapacity to react to the vulnerability It represents the relationship between vulnerability and resilience. It allows the detection of the areas that can potentially show more damages and negative consequences due to climatic hazards (Belcore et al., 2017) and a combined reading of vulnerability and resilience. The incapacity to react to vulnerability identifies the areas with high vulnerability but low resilience values. The areas where the value of the incapacity to react to vulnerability is high may become critical for the population. This indicator can be therefore a useful tool to quickly find the areas that need to be closely monitored: it was introduced for the first time in Belcore et al. (2017), and it is calculated through the subtraction between vulnerability and resilience. The simply calculation results in an easy-to-read index with low variability. (equation 6).

$$In_C = V - R \quad (6)$$

Classes determination

Were collected 30 observations of female-head household and 150 of male-head household.

Considering the lower number of women and to have a comparison with the men's subset, the vulnerability, resilience and incapacity to react indicators classes were created based on the number of women interviewed, using the Sturges' formula (Simonoff 2012) as reported in equation 7:

$$N=1+10/3 \text{ Log } n \quad (7)$$

where:

n: number of female-head households observations

N: number of classes

The resulted N classes were used to calculate the class amplitude (equation 8):

$$a=((Imax-Imin))/N \quad (8)$$

where:

a = class amplitude

Imax = higher indicator value calculated for female head households

Imin = lower indicator value calculated for female-head households

N = number of classes

Statistical analysis and spatial distribution maps

Some peculiar parameters as age and education level were statistically analysed with IBM/SPSS statistic package version 23, to underline possible differences between the women and men interviewed. The Quantum GIS version 2.12.0 package was used for the spatial representation of the vulnerability indicators. The importance to map the results is to focalize where the most critical situation are situated.

Results and discussion

Before commenting the vulnerability results, it is interesting to have a picture of the sample interviewed.

While there are not significant differences in the age parameter (they are both around 40 years old) using the ANOVA test (α=0.05), a difference was revealed in the education level (Table 7: it must be underlined that the Ethiopian education system is organized in 13 years of school). Also if the mode (the value with the higher percentage of cases) of both men and women education parameter is 0 (which means illiteracy), men's numbers of school years are higher than women, not only as average, but especially in the percentile distribution. In this study 43% of the women household-head are illiterate, against the 19% of men: a value very higher than observed by Ajuang et al. (2016) in their study in Kenya, but close to the findings of Dahgbeto and Villamor (2016) in Benin.

Table 7 Statistic of the age and education level of the interviewed men and women

		Age (years)			Education (years)		
Woreda	Gender	Mean		SD	Mean		SD
Shalla	F	38.3	a	7.1	2.0	a	3.0
	M	36.1	a	7.6	4.5	b	3.5
Shashamene	F	40.5	a	10.6	3.9	a	3.0
	M	40.7	a	10.4	6.0	b	3.2
Siraro	F	37.4	a	7.1	1.9	a	2.8
	M	37.2	a	7.0	3.1	b	3.1
Total	F	38.7	a	8.2	2.6	a	3.0
	M	38.0	a	8.6	4.5	b	3.5

(Note: SD = Standard Deviation; different letters indicate significant differences between female and male groups with α = 0.05)

Some authors demonstrated that the age could be a significant parameter which produces different challenges in agricultural gender adaptation in climate change conditions (Bassett, 2002; Nelson and Stathers, 2009), but it is not the present case. On the other hand, Deressa et al., 2009 and Below et al., 2012 observed that women are more vulnerable in the context where gender and low education level are correlated.

Vulnerability: classes and maps

Vulnerability values range between 2.7 and 37 in the male answers and between 2.4 and 34 for the female ones. Also if the interval is almost the same, the distribution of the male and females vulnerability indices in their interval is different.

More than half of the observed women values were in the first class (lower than 7.40). The frequency observations then decrease, being constantly equal to 7% in classes 3, 4 and 5, but increasing to 10% in class 6 (Table 8).

Unlike females observations, the distribution of vulnerability indexes of male-head observations is more equally distributed among the central classes, with the exception of the first more numerous class (41%). The most vulnerable class has a lower number of cases (5%) compared to the female one (10%).

Table 8 Distribution of the vulnerability data of the observed men and women surveys

			Absolute frequency		Relative frequency	
Class	Lower limit	Upper limit	Female	Male	Female	Male

Class 1	2.0	7.4	16	62	53%	41%
Class 2	7.4	12.8	5	32	17%	21%
Class 3	12.8	18.2	2	20	7%	13%
Class 4	18.2	23.6	2	10	7%	7%
Class 5	23.6	29.0	2	16	7%	11%
Class 6	> 29		3	8	10%	5%

To make a more effective comparison between men and women, a figure with the percentage distribution of the vulnerability indices per gender in each class is provided (Figure 4)

Figure 4 Vulnerability index frequency distribution for male and female samples

Also if the two-thirds of both the gender vulnerability values are distributed in the first 2 classes, the male trend is about to decrease in the next classes, while the women's distribution is constant in the middle classes and it increases in the last class. In other words, women and men seem to be equally little vulnerable in absolute terms, but considering also the low number of women observations, they are much more vulnerable because of their higher presence in the worst class (the sixth).

The descriptive statistic of the sub-components of the vulnerability indicator (Table 9) highlights some interesting key-points. The exposure is the same in the male and female samples, while there are some little differences in the sensitivity component: since the interval range of the female sample (4.7) is lower compared to the male one (5.5) and the median is slightly higher (8.0 versus 7.9 for the men), then there is an higher percentage of women more sensitive than men. In contrast, the female capacity of adaptation is better (in this case all values are greater than men). Andersen et al. (2017) observed that the capacity of adaptation includes also the actions to face adverse shocks or stresses. In this study the capacity of adaptation includes the presence of warehouse, livestock, water source and governmental aid. Considering that 87% of men and women do not own a warehouse, that 50% of them have 4 animals and that the water source characteristics are the same, the difference is in the governmental aids. The 42% of the interviewed household-head women can count on this type of support, while only 28% of men have access to.

Table 9 Descriptive statistic of the components of the vulnerability indicator

	Male	Female	Male	Female	Male	Female
	Exposure		Sensitivity		Capacity of adaptation	
Average	1.2	1.2	7.9	7.8	1.2	1.3
Max	1.7	1.7	10.2	9.5	3.2	4.0
Min	1.0	1.0	4.7	4.8	0.1	0.3
Median	1.2	1.2	7.9	8.0	1.1	1.3

Considering the spatial distribution of the vulnerability indices, the two maps (Figure 5) show the worst situation in the Woreda of Siraro, both for women and men observations.

Figure 5 Vulnerability maps of women (left) and men (right) in the analysed Woredas

Resilience: classes and maps

The resilience indexes of female-head household observations ranged between 1.4 and 5.4, while 1.4-5.7 was the men's interval. The highest resilience frequency value is in the third class for the women (33%) and in the fourth for the men (24%) as shown in Table 10.

Table 10 Distribution of the resilience values of the observed men and women surveys

			Absolute frequency		Relative frequency	
Class	Lower limit	Upper limit	Female	Male	Female	Male
Class 1	1.4	2.1	6	15	20%	10%
Class 2	2.1	2.7	2	27	7%	18%
Class 3	2.7	3.4	10	33	33%	22%
Class 4	3.4	4.1	5	35	17%	24%
Class 5	4.1	4.8	4	24	13%	16%
Class 6	>4.8		3	16	10%	11%

The graph in Figure 6 shows a distribution that has a normal shape for the men, while it is more discontinuous for the women, with an higher presence of values in the less resilient classes.

Figure 6 Resilience index frequency distribution for male and female samples

In this study women look like slightly less resilient than men, differently from Andersen et al. (2017), who found a different situation in their investigation in Latin America.

It is therefore necessary to investigate the components of the resilience indicator to better understand the indicator distribution: education level, intercommunity aid, presence of an health place, participation to local cooperative systems, micro-credit access and NGO support. The health place is present for both women and men, as the NGO support. The analysis of the remaining information is summarized in Tables 7 (education) and 11 (cooperative, association and credit access). It has been already discussed that the women's number of schooling years are lower than men and, above all, the illiteracy rate is dramatically high for them (38% of female-head interviewed is illiterate, against the 19% of men-head).

Nevertheless, it seems that both women and men have equal access to the local associations: in these villages almost each family participates to self-aid community institutions (*iddir* and *iqub*) and agricultural cooperatives. *Iddir* is mainly used to afford funeral and marriage expenses, while *iqubs* is used to support little commerce of local products. A monthly fee is required to participate to these associations and in critical situations the family receives a monetary aid from the *iddir* or *iqub*. Cooperatives are instead more technical: for example they are used to rent agricultural inputs (seeds, fertilizers and chemicals) paying back with the seasonal yield. Cooperatives promote the membership cooperation helping each other for the agricultural operations (tillage, seeding, harvesting) and providing the share of the agricultural knowledge, very useful for example to easily resume the correct agricultural cycle after a disturb. Both the interviewed women and men participate quite actively to these aid groups (Table 11).

Table 11 Summary of the participation of women and men to associative institutions and to the micro-credit system

	F	M
Cooperative	58%	55%
Association	42%	46%
Credit access	16%	21%

Women show instead a slightly lower access to the credit system than men (16% versus 21%, Table 11), which may be related to the lower formal education, as observed also by some authors (FAO 2011; Fletschner and Kenney 2014). The credit is not only useful to purchase machines, fertilizers and chemicals, but also to acquire improved seeds and animals for crops and livestock more resistant to the climate changes (Demetriades and Esplen 2008). Some studies argue that a lack of formal education may limit the access to credit (Banerjee et al. 2013; Djoudi et al., 2016): for this reason, the possible gender difference in land size was investigated. The graph of Figure 7 does not look to evidence such difference: the average land size (1ha) is equal in both the samples and, if the outliers are not considered, the men land size seems almost the same than women. A little difference however exists: the statistic mode for the women is 0.5 hectares, against 1 for the men.

Figure 7 Women and men land size

Figure 8 shows the women and men resilience maps. Considering that higher is the resilience, higher is the community ability to adapt to critical situations (scarcity of water, agricultural inputs and livestock autonomy), also in this case the Woreda of Siraro presents the lowest values for both men and women, to demonstrate how the socio-environmental condition are worst in this context (Belcore et al., 2017).

Figure 8 Resilience maps of women (left) and men (right) in the analysed Woredas

Incapacity to react to the vulnerability: classes and maps

Considering the incapacity to react to the vulnerability, lower it the value, higher is the capacity of the household to react to critical conditions (Belcore et al., 2017). The class amplitude is 5.2 and both male and female-head observations show quite positive results (Table 12): half of the households, in fact, are in the first class (1 percentage point more for the men) and the lowest frequency values are in class three (9% and 7% respectively for men and women). It looks that there are not emphatic gender differences, but the worst class (the sixth), where 10% of the women reveal a severe incapacity to react to the vulnerability (6% for the men).

Table 12 Distribution of the resilience values of the observed men and women surveys

			Absolute frequency		Relative frequency	
Class	Lower limit	Upper limit	Female	Male	Female	Male
Class 1	0.0	5.2	15	76	50%	51%
Class 2	5.2	10.4	6	25	20%	17%

Class 3	10.4	15.6	2	13	7%	9%
Class 4	15.6	20.9	3	11	10%	7%
Class 5	20.9	26.1	1	16	3%	11%
Class 6	>26.1		3	9	10%	6%

The worst aspects of incapacity to react by the female-head households are in Siraro Woreda: observations of class 5 and 6 are all in this Woreda (Figure 9).

Figure 9 Incapacity to react maps of women (left) and men (right) in the analysed Woredas

Cut-off graphic

The cut-off graphic related the vulnerability index values with the ones of the resilience index for female-head and male-head observations (Figure 10). It allows a direct view of the analysed data, particularly of the incapacity to react to vulnerability index that relates vulnerability and resilience. This graph shows that both male-head and female-head majorities of observations are characterized by low values of vulnerability and quite-high values of resilience. Few female-head observations present high vulnerability and low resilience.

Figure 10 The cut-off graph with vulnerability values as abscissae and resilience values as ordinates of male (*squares*) and female observations (*rhombuses*).

Conclusions

In this work we have tried to fill a gender gap in the scientific approach of the vulnerability analysis related to the climate change. The results of this work point out that in the Ethiopian Woreda of Shalla, Shashamane and Siraro there is still a strong dependence from the subsistence of the agricultural sector and there are few forms of economic diversification that can lead to critical vulnerability situations. The vulnerability index, however, is not so critic for men and women, confirming a greater capacity of adaptation for women related to an higher access to the governmental aids. As observed also by a research conducted in 2005 (Frenken, 2005), the 50% of the household-head surveyed (men and women) own about 1 hectare of cultivated land. This value is higher than the average crop area in the Oromia Region (0.57 ha) as observed by CSA (2012). Also if Ethiopian women are on the margins of property and asset ownership, however the Ethiopian Statistic Agency highlights that there are differences between urban and rural women: 60% of rural women own land compared to 18% of urban ones (CSA, 2012). Similarly, 95.8% of rural women own her homes, against the 45.8% of the urban women (CSA, 2012). The interviewed household head women have a land of about 1 hectare on average, as their male counterpart: also the livestock number is quite similar (an average of 4 animals).

As a result, women and men do not show high vulnerability values. On the contrary women are less resilient and this fact is attributable especially to the lower education level. This aspect has been observed by many authors (Deressa et al. 2009; Skinner, 2011; Below et al. 2012; Carr and Thompson, 2014; Djoudi et al., 2016; Huyer, 2016) and it must not be underestimated: *“…* Access to information and the ability to read drastically affect people’s awareness, and thus, human behaviour. If people are aware of how their actions influence ecosystems they might consider acting differently. Thus, education must play an integral role in any mitigation strategy. When it comes to adaptation, the lack of education and access to information can play a basic role for life or death…” (Singh et al., 2010).

Some authors (Denton, 2009; Skinner, 2011; Andersen et al., 2017) address the lower women access to the education to the consequences of the climate change, because especially young women must have spent more time to collect water during droughts and must deal with increased diseases burden caused by floods.

Ethiopian government is now facing this problem with an ambitious education program: in the scholastic year 2012-2013 in the Oromya Region 87.2% of boys and 80.6% of girls attended the school (Minwyelet and Cheru, 2014).

Both women and men household-head have a good capacity to react to the vulnerability (more than 50% of them are in the higher class).

While the gender differences in the analysed indicators are not so marked, the spatial distribution of them evidenced a critic situation in one of the three examined Woredas. From a geographical point of view meaningful differences between female-head households and male-head households don't arise. A reasonable explanation can be found in the deep relation between vulnerability and the available resources of the Woredas, where both women and men are susceptible to the same environment conditions (soil, rainfall, etc). Females-head and males-head vulnerability and incapacity to react indexes shows the worst conditions in the Siraro Woreda. This information could be useful for policy-maker in adaptation specific plans, which may consider the possibility to implement specific actions aimed to reduce the population vulnerability to climate change in this area.

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