LOCAL MIGRATIONS AND CLIMATE CHANGE: THE INCAPACITY TO ADAPT INDEX. A CASE STUDY IN THE WEST ARSI WOREDA (ETHIOPIA)

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Abstract
Droughts and floods caused by climate changes impoverish rural regions and as a consequence people leave rural areas, reinforcing existing migration trends in a downward cycle.Local people movements are the first effect of the climate changes, that modify the main environmental resources. In this framework, vulnerability and resilience analysis are sound tools to identify the most critical situations. In this work, the data obtained by a survey conducted by an NGO in three Ethiopian Woredas were the input for the incapacity to adapt calculation. The index mapping highlighted a critical situation especially in one of the three analyzed Woredas.
Siccità e alluvioni causate dai cambiamenti climatici impoveriscono le regioni rurali e, come conseguenza le popolazioni abbandonano le zone rurali, rinforzando le rotte di migrazione già esistenti. Gli spostamenti delle popolazioni locali sono il primo effetto dei cambiamenti climatici che si ripercuotono sulle principali risorse naturali. In questo quadro, vulnerabilità e resilienza sono strumenti potenti per indentificare le situazioni critiche. in questo lavoro i dati ottenuti da questionari somministrati da una ONG in tre Woreda Etiopi sono stati l'input per il calcolo dell'indice di incapacità di reagire alla vulnerabilità. La restituzione grafica dell'indice evidenzia una situazione di criticità in una delle tre Woreda esaminate.

Keywords
Climate change, Ethiopia, vulnerability, migration

Introduction

The innovative "incapacity to react index" was developed in early 2017 by the researchers of the University of Turin and of the polytechnic of Turin. It analyses the climate change's effects on populations and represents the relationship between vulnerability and resilience. Specifically, it detects of the areas that can potentially show more damages and negative consequences due to climatic hazards (Belcore et al. 2017). The incapacity to react to vulnerability allows the identification of the areas of high vulnerability to climate change but low resilience. The areas where the value of the incapacity to react to vulnerability is high may become critical for the study population. This indicator can be therefore a useful tools to quickly find the areas that need to be

closely monitored: it was introduced for the first time in Belcore et al., 2017, and is calculated simply subtracting the resilience index to the vulnerability.

Belcore et Al. evaluated the vulnerability and resilience indexes applying a multifactorial weighting calculation method, and described the indexes through the selection of socio-environmental and institutional indicators and sub-indicators related to climate.

The first incapacity to react index was applied in three Ethiopian Regions.

The effects of the climate changes on the most exposed and vulnerable populations

In 2007 the document of the Intergovernmental Panel on Climate Change (IPCC 2007) confirmed with absolute certainty that the climate change is a man-made phenomenon manifested by the increasing of the average global temperatures. The effects of climate change have become increasingly evident worldwide. One of the main consequences of climate change is the variation in rainfall patterns and the increasing probability of extreme meteorological events like floods or droughts.

The relationship between water, agriculture and climate is a significant one, due to climate change. The climate change enhance the alteration of global temperatures and influences the runoff, the temperature and the chemistry of water. These effects can cause a reduction of the water quality and can damage the infrastructure used for water transport and deliver (UNESCO-IHP 2011). Higher temperatures increase the processes of decomposition and the mineralisation of the organic matter in the soil, reducing organic carbon content, and affecting the soil moisture content.

In this framework, the increasing of extreme climatic phenomenon - such as floods and drought- and the alteration of the hydrologic cycle, as well as the one of the main soil nutrients, strongly raise the natural disaster risk for growing communities, sensitive ecosystems, farmers, and manufacturers (Setegn S., Donoso M. 2015). Various areas of the world are therefore at natural disaster risk.

Many countries of the world face crises related to the effects of climate change. Scenario analysis procedures and risk assessment can identify the vulnerability of communities, predict climatic risk, and propose and test adaptation strategies. Climate, economic, political, demographic, social, and environmental factors must be considered in assessing vulnerability and coping capacities. Vulnerability analysis can have a lead role in adaptation policies designed to reduce climate change impacts and extreme events on ecosystem services that are the foundations of the human wellbeing (MEA 2009).

The natural disasters affect people everywhere; the rural poorer regions of the South of the world may have the most harmful socio-economic effects. That is because the countries in this part of the

world are characterized by a major extent to be highly sensitive to little climatic changes and a low ability to adapt to them (Watson et al. 1996). The vulnerability of these countries is the result of their geography, the high population growth, the heavy dependence from a subsistence agriculture, the shortage of natural (especially water and fuelwood) and economic resources, the weakness of social and educational services, technologies (as improved cultivation systems) and poor accesses roads (Stern 2007).

The incapacity to adapt index obtained by the vulnerability and resilience indices as a forecast method to foresee local migrations

The First Assessment Report of the Intergovernmental Panel on Climate Change issued that the greatest single impact of climate change might be on human migration and displacement (IPCC 1990).

Migration is one possible form of adaptation responses that individuals – both males and females- and households make when sensitive systems are exposed to stressed or changing environmental conditions (McLeman, Hunter 2010) (McLeman 2006) (Tacoli 2009). Certain types of socioeconomic systems are inherently more sensitive to climate-related environmental changes and are therefore more likely to adaptive migration. These include systems characterized by agricultural and natural resource-dependence where exposure to climate-related risks is high and human livelihood possibilities are limited. In cases of natural disasters and for those with fewer means to move, displacement can be an expression of failed adaption and constitute a survival mechanism.

Understanding which individuals are more likely to be damaged by the effects of climate change allows to individuate the areas that need specific actions to prevent climate change-induced displacements and migrations.

In this framework, the innovative "incapacity to react to vulnerability" index is a tool that can potentially individuate which individuals can be more damaged by climatic hazards and more likely to displacement the populations in function of the vulnerability and resilience.

Material and methods

At the beginning, the steps for the vulnerability and resilience (with an anthropic meaning) indices calculation were followed. In this case physical and demographic exposure, sensitivity (that included soil type, cultivated land, water availability and quality for the local population, number of

meals per day), adaptive capacity (with aspects regarding also the livestock, the water and the governmental aids) and resilience (with education, sanitation and economic arguments) were calculated. All the sub-indices were scaled in a 0-1 range. The incapacity to react was therefore calculated as simple difference between the vulnerability and the resilience indicators for each surveyed village in the three analyzed Woredas.

Vulnerability, resilience and incapacity to react to vulnerability

Natural disaster risk is not just a function of climatic events, but also of the system characteristics.

The vulnerability of the system includes the characteristics of the human-environment system that made it sensitive to damaging effects of extreme events. It is function of three variables: exposure, sensitivity and adaptive capacity and its calculation is well explained in Belcore et al., 2017.

The vulnerability index V was calculated as the result of exposure (E), sensitivity (S) and capacity of adaptation (Ca) (Equation 1).

$$V = (E * S) / Ca \qquad \text{(Equation 1)}$$

Particularly, the social exposure calculation was based on the population density of the studied Kebele. The physical exposure was evaluated through the application of a statistical tool, the Standardized Precipitation Index (SPI) suggested by WMO (2012). The SPI is function of precipitation and temperature in the three Woreda of the study and it was calculated as described by Belcore et al. (2017).

The sensitivity index was composed by 12 indicators categorized in three classes based on the nature of the indicators: agro-environment indicators, water indicators and Socio-economic indicators.

The value of the capacity of adaptation was defined by 4 indicators.

To detect human-environment system that can potentially show more damages and negative consequences due to climatic hazards, it is necessary consider also the resilience of the system itself beside the vulnerability. Resilience is the ability of a potentially exposed human-environment system to resist and promptly recover from disasters effects, even though the conservation of its essential base structures and functions (UNISDR 2009).

The resilience was function of 6 indicators.

The areas with high vulnerability and low resilience may be identified by the the incapacity to react index IR, that was therefore calculated, as a difference between the vulnerability V and the resilience R indices (Equation 2).

$$IR = V - R \qquad \text{(Equation 2)}$$

To evaluate the incapacity to react index were selected 28 indicators (Belcore et al. 2017).

For each calculate indicator had been created eight classes of different amplitude and had been generated also thematic maps, to deeply analyze the incapacity to react index in each study area.

The investigated area: the West ArsiWoreda in Ethiopia

Ethiopia, located in the Horn of Africa, is one of the country in which populations may be strongly affected by natural disaster. For its social, economic and climatic conditions, the incapacity to react index had been applied and tested in three district (Woredas) of the south of Ethiopia, in Oromia region.

In the last decades Ethiopia has been interested by severe droughts and humanitarian catastrophes, especially caused by the ENSO (El Niño Southern Oscillation) phenomenon and the heating of the Indian Ocean (Hulme et al. 2001, Comenetz and Caviedes 2002, Funk et al. 2012).

Ethiopia is the second most populous country in Africa after Niger (more than 96 million of inhabitants in 2014; (UNDP 2015), and in the last years it has emerged as one of Africa's rising economies. To rise the country to a middle-income nation, the Ethiopian government has been investing in economic and social infrastructure (CIA 2016). The agricultural sector is the economic engine of Ethiopia: in 2014, 47.7% of the GDP is accounted by agriculture, with a total of 75.1% of labour force (FAOSTAT 2015).

The Oromia Region is the most populated Region (around 40 million people, IWMI 2009). The most represented ethnicity is the Oromo (it cover the 85% of population) and it is chiefly rural, with a large amount of livestock (CSA 2007). The Region is located in a large drainage basin with a quite good quantity of water, but the current management system is not able to provide a sustainable water access to the population (LVIA 2015).

The incapacity to react to vulnerability index was applied in a study that interested three Woredas of the Oromia Region: Siraro, Shalla and Shashamane, located in the West Arsi zone, along the Rift Valley.

The study based the evaluation of the index on data collected in 2015 by the NGO LVIA (with a questionnaire carried out to gathering information on the food security condition of the area) and by a project of the University of Turin. To evaluate the hazard and the effect of 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. The methodologies used to collect data

were self-assessment questionnaires administrated by LVIA officers to the heads of the household and validated by the researchers of the University of Turin, focus groups performed in rural communities, and individual interviews to relevant stakeholders (i.e. water ministries officers, head of villages and members of water committees).

Results

Concerning the vulnerability, highest is the class, highest is poor and weak the study area. In this case study, it seems that the human-environment system is not too much vulnerable, as visible in Figure 1.

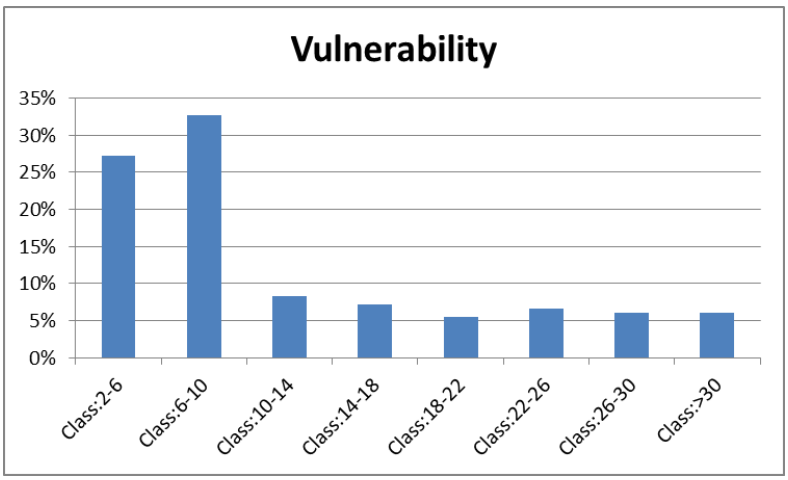

Figure 1. Distribution of vulnerability classes in the study area

On the contrary, the resilience has a different distribution among the classes (Figure 2), underlying a not always good values (higher is the resilience, higher is the human-environment system ability to adapt to critical situations, as scarcity of water, inputs and food).

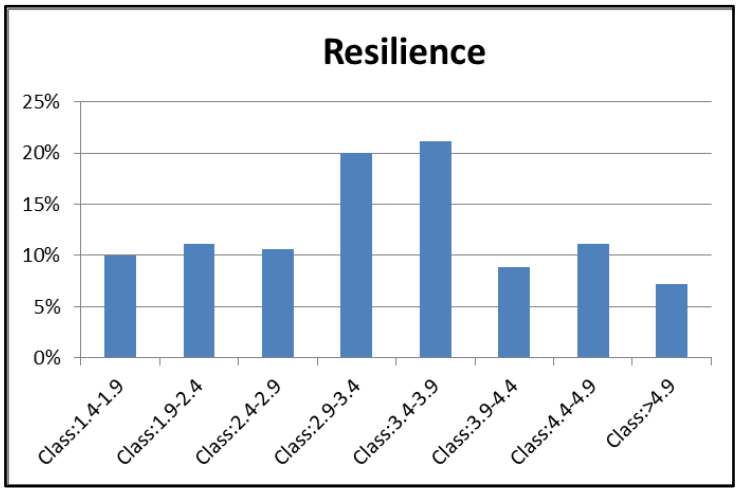

Figure 2. Distribution of resilience classes in the study area

It is therefore interesting to analyze the incapacity to react index distribution (Figure 3), that highlights a 45% of good capacities in the three Woredas.

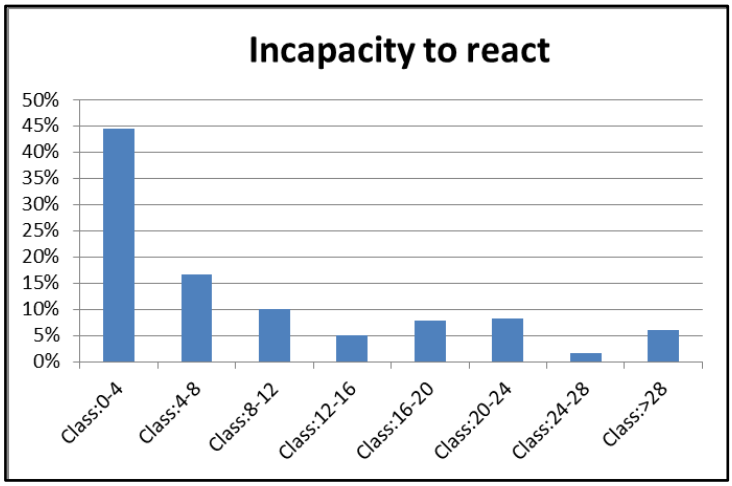

Figure 3. Distribution of incapacity to react classes in the study area

On the contrary, analyzing where are located the most critical areas in the three study Woredas, it come out that the most critical conditions are in the Woreda of Siraro (Figure 4).

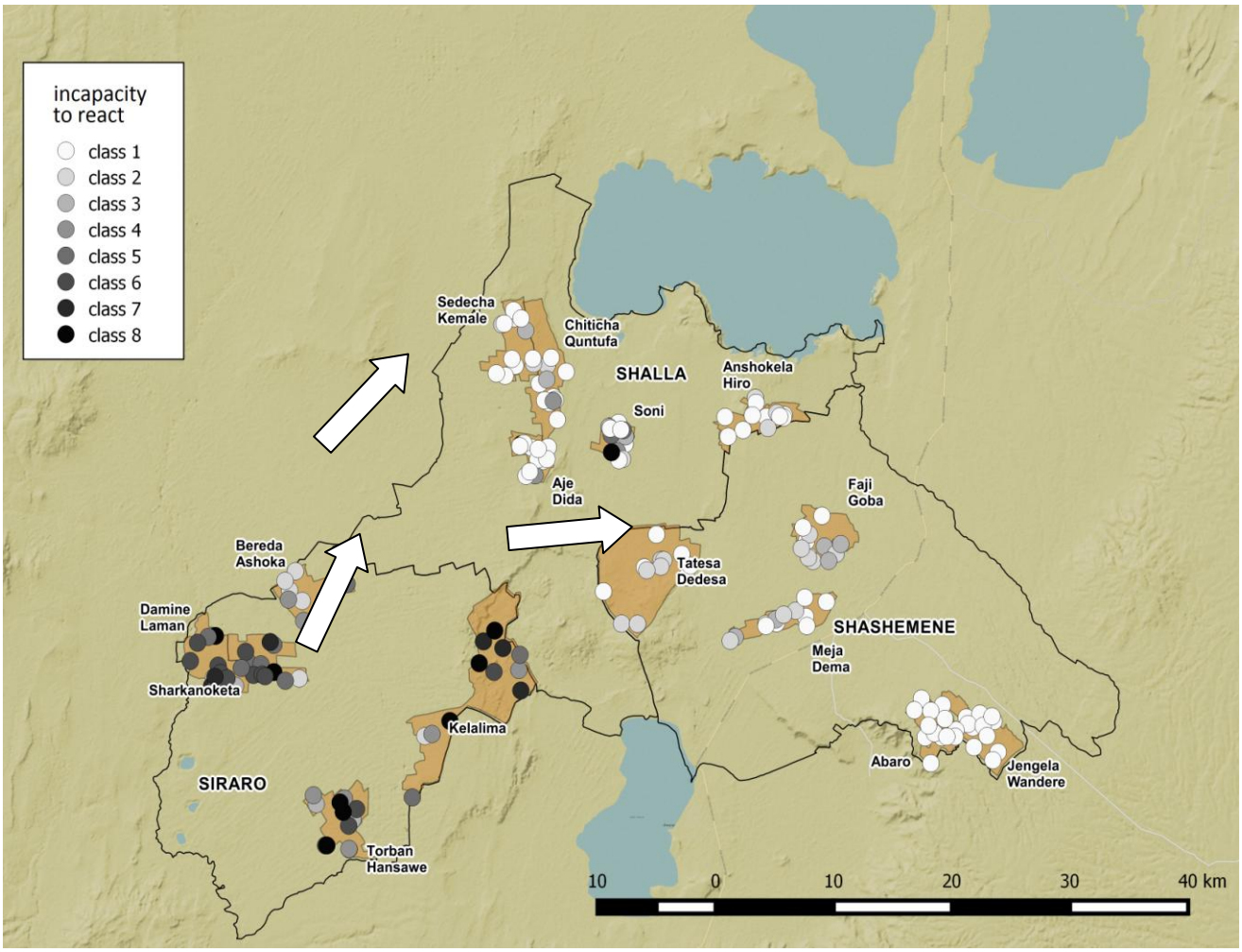

Figure 4. Incapacity to react index map. The image describes the geographical distribution of the observation in the Kebeles of Siraro, Shalla and Shashamane. (Belcore et al. 2017)

The SiraroWoreda shows the highest values of incapacity to react, the low resilience and elevated value of vulnerability, create the conditions for possible displacement towards the closest Woredas (Shalla and Shashamane) and also in other territories (the arrows represent the foreseen displacement fluxes).

The index mapping highlights a critical situation especially in the Woreda of Siraro, where there is an evident lack of water and it is also highly exposed to the drought risk. The rainfall reduction, together with increased temperatures, negatively affect the crop production and the breeding, both at the basis of the subsistence agricultural production system. In these areas there is not the practice of the field irrigation or of the water collect for breeding purposes and the agricultural production is based only on the rainfall availability.

Conclusions

The IPCC identified as main caused for migration and displacement the loss of housing (because of river or sea flooding or mudslides); the loss of living resources (like water, energy and food supply or employment affected by climate change); the loss of social and cultural resources(like loss of cultural properties, neighborhood or community networks, particularly in the case of a devastating flood). For governments it is fundamental being able to identify a priori which area is potentially more damaged by extreme events and at climate change-induced migration in order to prevent potential human catastrophes though the creation of specific adaptation plans and policies.

The incapacity to react index is a powerful forecasting tool for displacement and local migration, which allow the immediate identification of the high risk areas. Being composed by indicators that can be tailored to suit the study area facilitates its application in different region of the world, in rural and urban areas.

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Acronyms

Ca	Capacity of adaptation
CSA	Central Statistical Agency of Ethiopia
Cucs	Coordinamento Università per la Cooperazione allo Sviluppo
E	Exposure
ENSO	El Niño Southern Oscillation
Ic	Incapacity to react to vulnerability
IPCC	International Panel on Climate Change
LVIA	Laic Volunteers Italian Association
NGO	Non-governative organization
R	Resilience
S	Sensitivity
V	Vulnerabilityindex
WMO	World Meteorological Organization