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Climate change adaptation in the Sahel

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ABSTRACT

Climate change adaptation now occupies central stage on the agenda of most environmental initiatives in Africa. Our current understanding on the state of adaptation is limited, however, both globally and in Africa in particular. This study examines the status of adaptation in the Sahel by reviewing the primary peer review literature that reports concrete climate change adaptation actions. Based on an analysis of 70 peer review papers that document 414 discrete adaptations, we create a snap shot of adaptations developed between 1975 and 2015, and also calculate the percentages of adaptation. The results show that from a country to country perspective, Kenya has the highest number of reported adaptation actions (75 or 18.1%). The percentages indicate that the adaptive capacity of the entire study area is generally low for all the countries being that the highest country-level percentage is recorded in Kenya and it is 18%. Regionally, West Africa has more adaptation actions (261 or 63%) when compared to other regions of the Sahel. Regional level percentages suggest a higher level of adaptation at the regional level being that the percentage falls within the high scale range. The most commonly used adaptation actions reported are income diversification and water harnessing respectively. When categorized, technically related adaptation actions dominate the adaptation charts. The decade 2008–2016 recorded the highest number of adaptations (65.2%). Adaptation actions are also reported to be triggered by climatic and non-climatic drivers which both record high frequencies but the climatic drivers (98%) of adaptation are slightly dominant relative to the non-climatic drivers (95%). These results should be viewed as proxies of climate change adaptation as much information may be found in grey literature and non-peer review national communications which are left out here because of their relative low standardization and acceptability due to the absence of peer review.

1. Introduction

The Sahel region of Africa is currently experiencing climate change (Giannini et al., 2003, 2005, 2008; Reynolds et al., 2007; Lu and Delworth, 2005; Mertz et al., 2009; Epule et al., 2013a). Over the past three decades temperatures in the Sahel have increased by between 0.2–2.0 °C (IPCC, 2007) while rainfall has declined from the southern to the northern limits of the Sahel. The impacts of rising temperature and rainfall variations in the Sahel are significant and include: i) increasing tree mortality or dieback, with declines in tree density and species richness across sites in the Sahel such as Mauritania, Chad, Mali, Burkina Faso, Senegal and Niger recorded in the last half of the 20th century (Gonzalez et al., 2012); ii) enhanced stress on food systems, with about 50% of the 60 million people living in the Sahel believed to be facing food insecurity linked to climate change (Clover, 2010; Verpoorten et al., 2013), with the region likely projected to potentially experience about 250 million tons of food deficits by 2020 (Nyariki and Wiggins, 1997; Battisti and Naylor, 2009; Sissoko et al., 2011); iii) enhanced occurrence of malaria and diarrheal diseases, (UNAIDS, 2002; Costello et al., 2009; Watts et al., 2015); iv) with more frequent water shortages also documented (Rohr et al., 2011). These impacts, in turn, are believed to have increased the number of environmental refugees in the Sahel (Myers, 2001, 2002; Myers and Kent, 2001; Epule et al., 2015). Climate change may also present opportunities, including increasing food production through better water management, irrigation, rainwater harvesting (Giannini et al., 2008), and potential increased crop productivity due to increased aerial fertilization by carbon dioxide (Prince et al., 1998).

Adaptation is essential to reduce the damages and take advantage of new opportunities in-light of the rapid climate change already occurring and expected future impacts (Ford et al., 2007, 2014; Verchot et al., 2007; Mertz et al., 2009; Ford and Pearce, 2010; Newton et al., 2005; Mortimore, 2010; Pearce et al., 2011; Lesnikowski et al., 2013, 2016; Berrang-Ford et al., 2014). Stakeholders on Sahel environment

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and climate change (governments, indigenous people, farmers, non-governmental organizations, donor organizations, the African Development Bank, the World Bank, and United Nations Environment Program etc.) have not been passive in the face of the climate stresses that affect this region. Their response to the climate stresses has been through several policies, programs, and adaptations. Examples of such actions at the global scale include the United Nations Reductions of Emissions from Deforestation and Forest Degradations (REDD +) which provides financial incentives to farmers in the Sahel for planting trees (Epule et al., 2014; UNREDD+, 2015), and adaptation funding programs established under the United Nations Framework Convention on Climate Change (UNFCCC) (United Nations, 2015) and at the regional level, the African Development Bank (AFDB) is now masterminding the African Climate Change Fund which has as objective to increase access of African countries to international climate finance (African Climate Change Fund, 2016). In spite of the increasing importance of climate change adaptations and related stresses, it is unclear which shocks and adaptation actions have gained prominence over time and in which parts of the Sahel? This compromises our ability to identify and characterize key gaps in the adaptation response, examine how adaptations taking place compare to the risks posed by climate change, and monitor future developments.

This paper responds to this gap in understanding, and identifies and characterizes the state of climate change adaptation in the Sahel, documenting how adaptation as a response to climate change has evolved over time and space and explores the role of climatic and non-climatic drivers in triggering adaptation actions. We use reporting on adaptation in the peer reviewed literature as a proxy of adaptation, underscoring that our work provides a general and baseline overview of adaptation in the region. The work contributes to an important gap in the literature, with most studies examining the state of adaptation focusing on developed nations (e.g. Smithers and Smit, 1997; Nicholson, 2001; Svendsen, 2008; Ford et al., 2011; Austin et al., 2015; Lesnikowski et al., 2016; Lepez-I-Gelats et al., 2016), or focused on other regions of Africa (e.g. Lwasa, 2015; Tucker et al., 2015). This study is vital at this time because so far there is no study on the Sahel that gives us a holistic baseline on the status of climate change adaptation across all Sahel countries and sub regions. Prior to this study, the information on climate change adaptation was found in several different peer review publications which entirely failed to provide a holistic picture of the state of climate change adaptation scholarship across the Sahel, a gap covered by this current study. Additionally, this study is vital because the Sahel remains a region of recurrent climate change stresses (droughts, floods and winds) (Agnew and Chappell, 1999; Mamadou et al., 2015; Karam et al., 2008) that calls for urgent adaptation actions to enhance resilience (Mannke, 2010; Sovacool et al., 2012); therefore, a holistic picture on where the peer review literature has so far focused goes a long way in improving our understanding on where the emphasis is and where attention needs to be placed.

2. The Sahel

The Sahel represents the semiarid strip of land located between the tropical rainforest in the south and the arid north of Africa and covers an area of about 3.053×10^3 km^2 and has about 60 million inhabitants (Anyamba and Tucker, 2005). The area is located between latitude 10° and 20° north and stretches some 5000 km from northern Senegal in the west, through southern Mauritania, central Mali, northern Burkina Faso, south-western Niger, northern Nigeria, central Chad, north of Cameroon, central African Republic, central Sudan and southern Sudan, northern Eritrea, extreme north of Ethiopia, to Somalia in the east and to the south east of the Sahel into Kenya (Fig. 1). The extreme south of Algeria that is also part of the northern Sahel is not included in this study because of insufficient data and the fact that it is found out of the west-east gradient used in this study. The vegetation type is dominated by open Acacia shrubs and grassland, with the region representing a transition between the desert and the more humid savannah to the south. The word Sahel is derived from an Arabic word meaning the "edge" or "fringe" or "shore" (Nicholson, 1995; Lu and Delworth, 2005, 2005). In terms of rainfall, the Sahel experiences declines with increase in latitude. At the southern border of the Sahel, about 450–500 mm of rainfall are recorded yearly while towards higher latitudes less than 200 mm of rainfall are recorded yearly (Zeng, 2003; Wang et al., 2005). Between 1930 and 1965 and 1966 and 2000, the Sahel recorded about 100 mm of rainfall per year (Maranz, 2009). The rainfall pattern in the Sahel is tied to the migration of the Inter-tropical Convergence Zone (ITCZ) (Sinclair and Fryxell, 1985; Zeng, 2003). A rainfall decline gradient of between 250 and 300 mm is recorded between the southern and northern limits of the Sahel. Precisely, at the 17° latitude north (the northern boundary of the Sahel), less than 200 mm of rainfall is recorded annually while towards the south at the 15° latitude north (southern boundary of the Sahel), more rainfall of about 450–500 mm of rainfall is recorded annually (Nicholson, 1995; Wang et al., 2005; Zeng, 2003).

The Sahel was selected for this systematic review because no detailed review on the status of climate change adaptation in the Sahel has been carried out before. In addition, the region has a growing population that is exerting pressure on environmental resources such as food and water resources which are increasingly becoming less and less accessible in the Sahel. This is seen as the Sahel ecosystem is one of the most fragile on the African continent facing recurrent droughts, declining precipitation, acute food insecurity, HIV-AIDS inter alia.

3. Methods

3.1. Systematic adaptation tracking approach

The systematic review approach had long been established in the health sciences but neglected in climate sciences. This approach is a summary and assessment of the state of knowledge on a given topic or research question structured to rigorously summarize existing knowledge. Systematic reviews are different from traditional literature reviews in a number of ways (Ford and Pearce, 2010). Firstly, the review is based on clearly formulated questions, secondly, the approach specifies systematic and explicit methods and criteria to select relevant research, furthermore, the approach includes full reporting of search terms and the criteria for inclusion and exclusion of articles. The latter contrast with literature review common in climate change research which typically does not provide details on the review procedure used (e.g. the search engines, articles included, and excluded and the search terms used). In the absence of such details, it is difficult to replicate, validate interpretation and assess completeness. Lastly, the systematic approach easily subjects the collected data to the use of qualitative and quantitative analysis of trends, meta-analysis and percentages revealed by the literature.

This current study is based on data collected from English peer review scientific literature documenting climate change adaptation actions between 1975 and 2015, drawing upon established systematic literature review approaches used in environmental change research (Berrang-Ford et al., 2015). The English peer review scholarship therefore serves as a proxy data source for regional and country level adaptation actions in the Sahel. While we note the limitations of only using English peer reviewed literature and underscore our work as developing a general outline of adaptation in the region, such literature has nevertheless been used in other adaptation tracking studies and has established quality control mechanisms (Ford et al., 2011, 2014; Eisenack and Stecker, 2012; McLeman, 2011; McLeman et al., 2014; Berrang-Ford et al., 2015; Lopez-I-Gelats et al., 2016).

We sought to capture papers that document intentional adaptation actions, where adaptation is defined based on the IPCC's AR4 definition of planned adaptation as the "result of deliberate policy decisions based on awareness that conditions have changed or are about to change and