



Uncovering links between livelihoods, land-use practices, vulnerability and forests after hurricane Jova in Jalisco, Mexico

Elena Lazos-Chavero^{a,*}, Tuyeni H. Mwampamba^b, Eduardo García-Frapolli^b

^a Instituto de Investigaciones Sociales, Universidad Nacional Autónoma de México, Circuito Mario de la Cueva, Ciudad Universitaria, Coyoacán, 04510 Ciudad de México, Mexico

^b Instituto de Investigaciones en Ecosistemas y Sustentabilidad, Universidad Nacional Autónoma de México - Campus Morelia, Antigua Carretera a Pátzcuaro, Col. Exhacienda de San José Huerta, C.P. 58190, Morelia, Michoacán, Mexico

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ABSTRACT

The gravity of hurricane effects on forests, livelihoods, and infrastructure is the product of social-political dynamics, land-use practices and decisions, and biophysical and meteorological factors that interact to make some societies more vulnerable than others to experiencing a hurricane event as a disaster. In this article, we discuss how three syndromes of vulnerability (elimination of natural vegetation cover, deficient land and ecological planning, and economic specialization) interact to determine the ecological and social vulnerability of nine rural communities located in the south coast of Jalisco, Mexico, after the passage of hurricane Jova in October 2011. Based on interviews with 80 families from these communities and visual interpretations of satellite imagery before and after the hurricane, we show how position in the landscape, economic specialization, land use practices, and non-fulfillment of the legal framework for protecting forests in risky areas combine to determine vulnerability of families and vegetation to the effects of hurricane. As disasters are the result of a complex combination of natural menaces and accumulated human actions that increase vulnerability, decreasing impacts of future hurricanes in the area will depend on a landscape planning, willingness to cooperate towards common objectives, change in land use practices, and a more proactive political interrelationship of local, state and federal government.

1. Introduction

A fundamental consequence of global warming and the associated climate change effects is the increase in the frequency and intensity of hydrometeorological disasters, such as hurricanes, a phenomenon that is already being felt in many parts of the world (Boose et al., 2004; Lugo, 2008; Keenlyside et al., 2008; Sánchez-Sesma et al., 2009; Ruiz and Fandiño, 2010; Soares et al., 2014b; Segundo-Métay and Bocco, 2015). A recent series of hurricanes (Kenna in 2002, Lane in 2006, Jova in 2011, Patricia in 2015) in the NE and NW Pacific suggest that higher frequency hurricanes are already part of current experiences, much of which is catching civil society and institutions off-guard (Sánchez-Sesma et al., 2009; Palafox and Gutiérrez, 2013; Maldonado et al., 2016). The geographic position of Mexico in this region, compounded by a history of deforestation and ongoing land-cover change make Mexico's coasts highly susceptible to the effects of hurricanes (IPCC, 2007; Sánchez-Sesma et al., 2009; Ponette-González et al., 2010; Anderson-Teixeira et al., 2014).

Twenty-five hurricanes, on average, arrive annually to coastal areas

around Mexico (CENAPRED, 2000; Sánchez-Sesma et al., 2009; Ponette-González et al., 2010; Navarro-Martínez et al., 2012). Along the coast of Jalisco, hurricanes are among the meteorological events forecasted to contribute to major future problems to forest cover, water resources, agricultural land, livelihoods and infrastructure (Sánchez-Sesma et al., 2009; González del Castillo, 2016).

The impact of hurricanes on forests (including trees outside of forests) is a function of multiple interacting factors, ranging from topographical and meteorological, to biological and social (McSweeney, 2005; Eisenbies et al., 2007; Stanturf et al., 2007; Batke and Kelly, 2014; Cameron and Shah, 2015; Wagner et al., 2016). Specifically, hurricane socioenvironmental impacts depend on wind speed and the rainfall produced, topographic and soil conditions, forests dynamics and structure that are the outcome of forest management practices (Erickson and Ayala, 2004; Beard et al., 2005; Lugo, 2008; Ponette-González et al., 2010; Shiels et al., 2010). Extreme climatic events, such as hurricanes, can abruptly alter societies and ecological processes in forests, shaping their function and dynamics (Tanner et al., 1991; Everham and Brokaw 1996; Bonilla-Moheno, 2010; Rittenhouse et al.,

* Corresponding author.

E-mail address: lazos@unam.mx (E. Lazos-Chavero).

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2010), and affecting species composition (Ruiz and Fandiño, 2010; Salazar-Vallejo, 2012; Navarro-Martínez et al., 2012).

Understanding how forests respond, under different use and management practices, is critical for forest conservation and for addressing socioecological vulnerability (Weishampel et al., 2007; McGroddy et al., 2013; Wagner et al., 2016). Immediate, short-and long-term effects of hurricanes on forests brought about by changes in microclimate, forest canopy, seed rain, tree recruitment and survival are widely documented in the literature (Wang and Scatena, 2003; Van Bloem et al., 2005; Lugo, 2008; Ponette-González et al., 2010; Shiels et al., 2010; Navarro-Martínez et al., 2012; Fischer et al., 2013; Tanner et al., 2014; Leigh, 2014; Jayakaran et al., 2014) and can be summarized into six principal effects: changes on the ecological space available to organisms, increase of the landscape heterogeneity and of the variability in ecosystem processes, redirection of succession, shaping forest structure, influencing species composition, and induction of evolutionary change through natural selection (Lugo, 2008). Indeed, where hurricanes are frequent, they become part of the natural dynamics of forests (Navarro-Martínez et al., 2012). However, from a human perspective, hurricanes are often perceived as causative agents of ‘disasters’.

Disasters are the result of a complex combination of natural menaces and accumulated human actions that increase vulnerability (Hewitt, 1983; Wilches-Chaux, 1993; Blaikie et al., 1996; Navarrete et al., 2007; Soares et al., 2014). Strictly speaking, disasters are socially constructed processes that are best understood as “not just a single physical event, but as a whole process in which the event is just one part” (Hoffman and Oliver-Smith, 2002; Swee and Hrdličková, 2017: 2). The gravity of hurricane effects on lives, infrastructure and forest ecosystems is the product of social-political, biophysical and meteorological factors that interact to make some areas and societies more vulnerable than others to experiencing hurricanes as a disaster. Incorporation of social processes to understand disasters caused by natural geophysical and meteorological events is relatively recent. Since the publication of *Interpretations of Calamity* by Hewitt (1983), which outlines how natural menaces and political, economic, and socio-cultural processes are interlinked, inclusion of societal processes in interpreting the effects of ‘natural’ phenomena and characterizing vulnerability is now commonplace.

Vulnerability is a concept that is increasingly incorporated in studies and discussions of disaster. It has become a central concept for understanding the differentiated impacts of events on diverse groups of inhabitants living at risk (Wisner et al., 1994; Oliver-Smith, 1999; McSweeney, 2005; Gallopín, 2006; Stanturf et al., 2007; Tierney and Oliver-Smith, 2012; Wagner et al., 2016). Vulnerability is the sum of characteristics that describe the ability of people to anticipate, survive, resist and recover from the impact of a natural menace (Oliver-Smith, 2004). It is a continuous, long-term, and iterative process whereby responses to events can exacerbate, decrease, or eliminate future vulnerability. Comprehensive perceptions of the causes as well as the impacts of hurricanes facilitates understanding individual, community and institutional responses and permits an evaluation of the implications of such responses to future vulnerability.

Numerous factors contribute to determining the vulnerability of an area to hydrometeorological disasters. Vulnerability models delineate the insecure connections that characterize temporal and spatial configurations of livelihoods with global economic, and political processes (Gallopín, 2006; Eriksen and Lind, 2009; Fuchs, 2010). Such models incorporate the role of differential access to resources across social configurations (families, communities, regions) where gender, ethnicity, capacities, and generational disparities play a key role on the entitlements to a secure livelihood (Sen, 1983; Scoones, 2009; Adams et al., 2016). Generally, the most vulnerable groups are those that have the most difficulty (in the long-run) in recovering their ways of subsistence after a disaster (Oliver-Smith, 1996).

In the case of Mexico, Tudela (2004) proposes a syndrome approach based on the “syndromes of global change” (Schellnhuber et al., 1997;

Anderson-Teixeira et al., 2014) to analyze vulnerability specific to hydrometeorological disasters. The syndrome approach helps capture the dynamics of interactions and their cumulative effects within the framework of socioenvironmental vulnerabilities and in the context of multi-causal and cumulative stressors. Tudela (2004) proposes ten symptoms of vulnerability that predispose societies to hydrometeorological disasters: (1) population growth; (2) rapid and unplanned urbanization process; (3) relative increase in poverty; (4) economic expansion; (5) deficient land and ecological planning; (6) non-fulfillment of legal frameworks; (7) water management; (8) elimination of natural vegetation cover; (9) reduction of insurance and “buffering” financial instruments; and (10) loss of historical memory of disasters. Broadly, the vulnerability of a socioecological landscape to the effects of hurricanes and other hydrometeorological events is a multi-causal and multi-layered process, resulting from exogenous factors such as 1–4; direct factors related to poor planning or inadequate implementation of existing plans such as 5–7; land use practices (often-times stimulated by incentive mechanisms in the agriculture and forestry sectors) that affect ecosystems’ ability to buffer the effects of extreme events (8); faulty financial systems (9) and post-disaster social processes that help maintain or dampen experiences of disasters in living memory (10). Untangling and tackling the multiple chains of causality existing between these symptoms and experiences of disasters is key to developing effective responses and to minimize the effects of meteorological phenomena, particularly on the most vulnerable sectors of society (Lavell, 1996; Bankoff et al., 2004; McSweeney, 2005; Navarrete et al., 2007; Swee and Hrdličková, 2017) and the most fragile features of the landscape.

Even though all these symptoms affect vulnerability, we establish as an hypothesis that in our region, the south coast of Jalisco, three key factors are explaining more the historic process of vulnerability: elimination of natural vegetation cover, deficient land and ecological planning, and economic expansion and specialization. In the studied region, nowadays, the other symptoms play a less important role than in other areas. Population growth is steady, even less than the national population growth rate (INEGI, 2010); there has been no rapid and unplanned urbanization process (INEGI, 2010); the relative increase in poverty has been compensated by migration and remittances (INEGI, 2010; Lazos-Chavero and Gerritsen, 2017), and there has been no drastic reduction of insurance and “buffering” financial instruments, as these have been practically non-existent in the region (Lazos-Chavero, 2017). Water management and the loss of historical memory of disasters will be part of future research goals.

In this article, we describe how three of Tudela’s syndromes (economic expansion, elimination of natural vegetation cover, and inadequate land and ecological planning) interact to affect forests outside of reserves and the social and ecological vulnerability of nine rural settlements in South Coast of Jalisco, Mexico, after the passage of Hurricane Jova (a Category 2 hurricane) on 12th of October 2011. We describe and analyze the experience and perceptions of the hurricane, as reported by 80 households in the study area. Applying the syndrome approach, we link livelihoods, location in the landscape, land use practices and regional land-use planning to understand why trees and forests are affected and the preconditions for vulnerability are settled. By analyzing post-hurricane responses of households and satellite images of forest cover, we provide important insights into the possible effects of future events, which are expected to be more frequent and probably more intense.

2. Methods

2.1. Study area

The study was conducted between August 2014 and November 2015 in the State of Jalisco located in western Mexico within three watersheds (Cuiztuala, San Nicolas, and Purificación) and one micro-

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