Ocean & Coastal Management 146 (2017) 109–120

Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

# A systematic review of tropical cyclone disaster management research using remote sensing and spatial analysis

Muhammad Al-Amin Hoque [a, b, *], Stuart Phinn [a], Chris Roelfsema [a]

[a] Remote Sensing Research Centre, School of Earth and Environmental Sciences, The University of Queensland, Brisbane, QLD, 4072, Australia
[b] Department of Geography and Environment, Jagannath University, Dhaka, 1100, Bangladesh

ARTICLE INFO

*Article history:*
Received 19 March 2017
Received in revised form
24 June 2017
Accepted 2 July 2017

*Keywords:*
Tropical cyclone
Disaster management
Remote sensing
Spatial analysis
Risk
Climate change

ABSTRACT

Tropical cyclones are among the most dangerous and devastating natural disasters affecting life, property and environment. The use of remote sensing and spatial analysis has significantly increased to manage the on-ground impacts of these disasters with rapid advances in a wide range of data availability and processing techniques. This paper reviews recent studies of on-ground cyclone disaster management using remote sensing and spatial analysis in the context of response, recovery, prevention/reduction and preparedness to find out the key knowledge gaps for future research. The study used a systematic quantitative literature review technique to assess the past 21 years of research. Following the systematic search and developed selection criteria, the relevant original published articles on cyclone disaster management using remote sensing and spatial analysis were selected. The selected literature was then categorised and analysed based on the particular research focus. Our findings showed that most of the studies were concentrated in Asia (55%) and North and Central America (40%). The extensive use of remote sensing and spatial analysis started after 2004 and largely focused on the preparedness (34%) and prevention/reduction (32%) phases. Nearly all studies used the optical imagery, and the use of SAR imagery was limited. The object-based classification approach was rarely used under post-classification comparison techniques for overall tropical cyclone impact assessment and recovery. Very limited studies examined tropical cyclone risk assessment incorporating mitigation capacity and spatial multi-criteria using the analytical hierarchy process (AHP). A simple modelling approach is required for producing detailed cyclone risk models. Most of the studies were conducted at the regional scale without validation of results. Cyclone risk mapping and modelling should consider future climate changes scenarios at the local scale. Future research is needed to cover reported knowledge gaps for improving cyclone disaster management.



**Contents**



* Corresponding author. Remote Sensing Research Centre, School of Earth and Environmental Sciences, The University of Queensland, Brisbane, QLD, 4072, Australia.
*E-mail addresses:* m.hoque2@uq.edu.au (M.A.-A. Hoque), s.phinn@uq.edu.au (S. Phinn), c.roelfsema@uq.edu.au (C. Roelfsema).

http://dx.doi.org/10.1016/j.ocecoaman.2017.07.001
0964-5691/

## 1. Introduction

Tropical cyclones, hurricanes or typhoons, are major natural disturbances affecting life, property and the environment in many coastal areas across the world (Poulos, 2010; Gallina et al., 2016). These hydro-meteorological natural disasters generally form over tropical oceans, and are referred to as cyclones, typhoons and hurricanes based on their particular locations (Puotinen, 2007; Bobby, 2012). The destructive characteristics, for example, sustained high winds, storm surges and intensive rainfall, are typically associated with land falling tropical cyclones (Saxena et al., 2013; Hoque et al., 2017b). Occurrences of tropical cyclones are very common in coastal environments worldwide (Peduzzi et al., 2012). During 1970–2010, 637 major tropical cyclones were recorded globally (Weinkle et al., 2012). It is predicted that the frequency and intensity of tropical cyclones will likely increase in the coming decades under most climate change scenarios (Mendelsohn et al., 2012; Yin et al., 2013; Krishnamohan et al., 2014; Deo and Ganer, 2014). The overall impact of tropical cyclone disasters is very high at the global level compared to any other natural disasters (Li and Li, 2013). These disasters have been responsible for the loss of around 1.9 million lives along with large scale property and environmental damage over the last two centuries globally (Shultz et al., 2005; Hoque et al., 2017a). Tropical cyclones cause around US $5 billion worth of damage per year in the Gulf and east coast of United States (Burroughs, 2007). Mendelsohn et al. (2012) estimated that US $26 billion worth of damage occurs annually due to tropical cyclones worldwide.

The impacts of tropical cyclones can be reduced by using appropriate management approaches. An effective cyclone disaster management plan is structured into four phases – response, recovery, prevention/reduction and preparedness (Fig. 1) (Khan, 2008; Joyce et al., 2009b; Islam and Chik, 2011). Response and recovery are considered in the post-disaster phase, while the pre-disaster phase is covered by prevention/reduction and preparedness. The response phase incorporates evacuation, relief, search and rescue, and the management of natural resources both during and immediately after the cyclone disaster to minimise the impact (Moe and Pathranarakul, 2006; Coppola, 2006). The overall impact assessment of cyclone disasters is an important process to deliver supportive information in the response phase. The restoration and reconstruction of cyclone disaster affected areas, in particular, monitoring the progress of debris removal and vegetation regrowth, and the reconstruction of settlements and structures, are included in the recovery phase (Joyce et al., 2009b; Rathfon et al., 2012). The prevention/reduction and preparedness phases include appropriate measures and planning that reduce the likelihood and impact of tropical cyclone disasters (Islam and Chik, 2011; Van Westen, 2013). Cyclone risk management is an essential process to generate required information for these two phases in the context of cyclone vulnerability, hazard and mitigation assessment and modelling (Taubenböck et al., 2008; Li and Li, 2013; Fang et al., 2016). The preparedness phase also includes the processes of cyclone tracking and forecasting to produce the required information for warning systems. However, this review is solely focussed on the on-ground impacts and use of remote sensing and spatial analysis to address this.

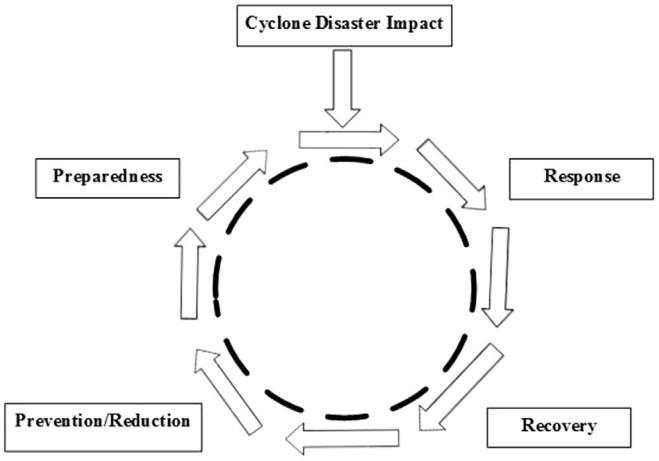


**Fig. 1.** The tropical cyclone disaster management cycle (adapted from Khan, 2008).

Remote sensing and spatial analysis techniques can provide a valuable source of information in every phase of cyclone disaster management (Hussain et al., 2005; Joyce et al., 2009b; Wang et al., 2010). Repeated high spatial resolution (<5 m pixels) satellite imagery before and after the cyclone event is the most common use of remote sensing for cyclone disaster management (Joyce et al., 2009a; Martino et al., 2009; Klemas, 2009). Advances in remote sensing processing techniques provide methods to use these satellite images for assessing tropical cyclone disaster impacts and monitoring the progress of recovery (Yamazaki and Matsuoka, 2007; Joyce et al., 2009b; Hoque et al., 2016). Accordingly, the information about spatial location, type and intensity, percentage of area and structures affected is derived from impact assessment, while debris removal, vegetation regrowth, and reconstruction information is obtained from recovery assessment (Hoque et al., 2016). Satellite remote sensing and spatial analysis can also be used to assist risk management measures through estimation of cyclone hazard, vulnerability, and mitigation capacity assessment and modelling under likely future climate conditions (Li and Li, 2013; Van Westen, 2013; Appelquist and Balstrøm, 2015; Fang et al., 2016). Additionally, using satellite remote sensing and spatial analysis tools, tropical cyclones can be tracked and forecasted (Roy and Kovordányi, 2012; Elsberry, 2014), however, this is