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Vulnerability assessment of atmospheric environment driven by human impacts

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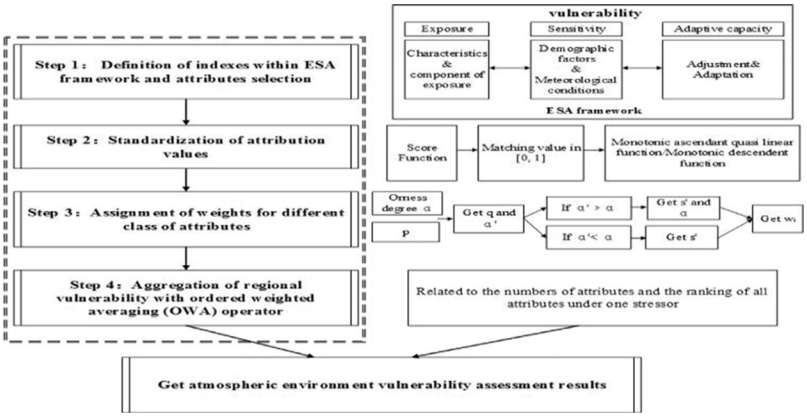
HIGHLIGHTS

- This paper develops a vulnerability assessment method of atmospheric environment associated with human impact.
- This method integrates human, atmospheric environment, and social economic elements.
- Decision makers can find out relevant vulnerability assessment results with different vulnerable attitudes.

GRAPHICAL ABSTRACT



This paper seeks to conduct a vulnerability assessment method of atmospheric environment associated with human impact which integrates spatial context of Geographic Information System tool, multi-criteria decision analysis method, ordered weighted averaging operators under the Exposure-Sensitivity-Adaptive Capacity framework, with aim of identifying and prioritizing the undesirable environmental changes as an early warning system for regional managers and decision makers.

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ABSTRACT

Atmospheric environment quality worsening is a substantial threat to public health worldwide, and in many places, air pollution due to the intensification of the human activity is increasing dramatically. However, no studies have been investigated the integration of vulnerability assessment and atmospheric environment driven by human impacts. The objective of this study was to identify and prioritize the undesirable environmental changes as an early warning system for environment managers and decision makers in term of human, atmospheric environment, and social economic elements. We conduct a vulnerability assessment method of atmospheric environment associated with human impact, this method integrates spatial context of Geographic Information System (GIS) tool, multi-criteria decision analysis (MCDA) method, ordered weighted averaging (OWA) operators under the Exposure-Sensitivity- Adaptive Capacity (ESA) framework. Decision makers can find out relevant vulnerability assessment results with different vulnerable attitudes. In the Beijing-Tianjin-Hebei (BTH) region,

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Human impacts
Multi-criteria decision analysis
Ordered weighted averaging operators

China, we further applied this developed method and proved it to be reliable and consistent with the China Environmental Status Bulletin. Results indicate that the vulnerability of atmospheric environment in the BTH region is not optimistic, and environment managers should do more about air pollution. Thus, the most appropriate strategic decision and development program of city or state can be picked out assisting by the vulnerable results.
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1. Introduction

The intensification of the human activity in urban areas has progressively altered natural processes over the past hundred years, during which human beings has played a dominant role in global and regional atmospheric environment (Etter et al., 2011). Nowadays, atmospheric environment quality worsening in cities due to urbanization and increasing population are nearly ubiquitous worldwide, and this trend is projected being accelerating for decades in the future (Lioy and Georgopoulos, 2011). Particularly in developing countries, regional haze has become a disastrous atmospheric phenomenon which threatened to human health with stimulating respiratory diseases and cerebral-cardio vascular diseases (Wang et al., 2012; Shang et al., 2013; Huang et al., 2014; Wang et al., 2015a, 2015b; Qiao et al., 2016). In this context, research on the ability of atmospheric environment to withstand effects of a hostile environment is an urgent issue to be solved. Vulnerability assessment of atmospheric environment is an effective solution to this issue.

The concept of vulnerability originates from the study of threats of natural disasters, a branch of social science (Phil et al., 1976), which is defined by International Panel of Climate Change (IPCC) as: *'The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity.'* (IPCC, 2007a). As a broad term of knowledge, vulnerability has been discussed, reformulated, and applied in various inter-disciplinary researches. It has been applied to analyze problems in social sciences (Absar and Preston, 2015; Bergstrand et al., 2015; Shaw and Elger, 2015), economics (Kerschner et al., 2013; Caschili et al., 2015), agriculture (Bär et al., 2015; Costa et al., 2016), psychology (Ansquer et al., 2014; Swartz et al., 2015), ecology (Wang et al., 2015a, 2015b; Ruiz-Mallén et al., 2015; Beroya-Eitne, 2016), environmentology (Goodwell et al., 2014; Ouedraogo et al., 2016; Shrestha et al., 2016) and many other subjects. Literatures related to vulnerability research mainly focus on Pressure and Release (PAR) framework (Blaikie et al., 1994), Risk-Hazards (R-H) framework (Burton and White, 1993), Hazards of Place (HOP) framework (Cutter, 1996), Exposure-Sensitivity-Adaptive Capacity (ESA) framework (IPCC, 2007b), and Driver-Pressure-State-Impact-Response (DPSIR) Framework (Bourdeau and Stanners, 1995). However, an integration of vulnerability assessment and atmospheric environment driven by human impacts has never been investigated.

In atmospheric environment vulnerability assessment, multiple criteria need to be taken into account. Multi Criteria Decision Analysis (MCDA) method is a sub-discipline of operations research that explicitly considers multiple criteria in decision-making environments. It has widespread applications in environment management (Pisoni et al., 2009; Vlachokostas et al., 2011; Volchko et al., 2014), vulnerability assessment (Zabeo et al., 2011; Vilas et al., 2013; Pizzol et al., 2015), solution selection (Sudhakaran et al., 2013; Nwokoagbara et al., 2015; Maimoun et al., 2016), life-cycle assessment (Toja et al., 2016; Motuzienėa et al., 2016; Onat et al., 2016), municipal solid waste

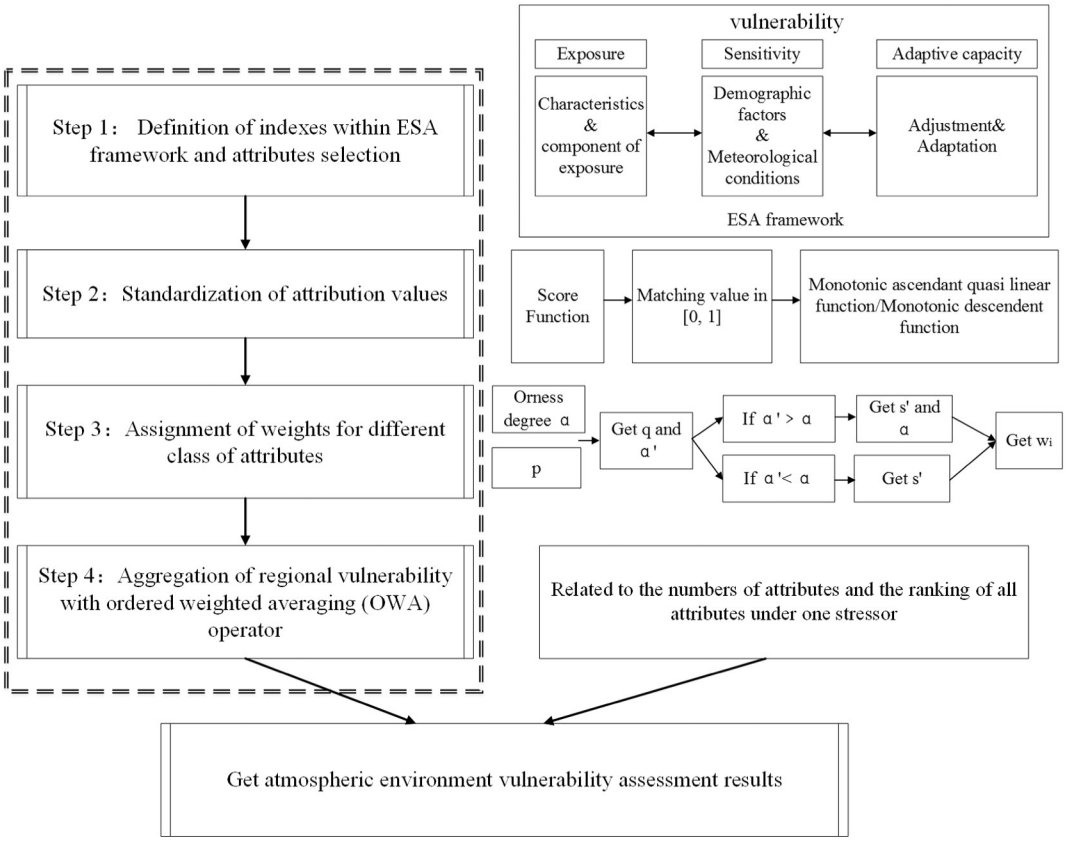

Fig. 1. Flow chart of vulnerability assessment.

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