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Solid waste collection/transport optimization and vegetation land cover estimation using Geographic Information System (GIS): A case study of a proposed smart-city

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ABSTRACT

Population growth at an interminable rate is depleting resources uncontrollably. Researchers are concentrating on sustainable development mainly in urban areas where the growth rate is higher than any other regions. In addition to the development of new technologies for reducing the rate of natural resources usage, technologies are being developed to recover the resources from waste. In this perspective, solid waste management with proper collection and transportation techniques facilitates the waste managers to segregate and extract the required resources for recovery. GIS and remote sensing approaches come to the aid of managing this solid waste through its generation stage to the dumping stage. Using a proposed smart city, Vellore in India as a case study, this paper discusses possible collection methods for solid waste management in India, and presents methods for optimal collection and transportation of waste using GIS techniques through network analysis. The optimal waste collection and transportation routes derived from our analysis result in 59.12% reduction in travel distance along the routine collection road network followed. In addition, this study proposes possible transfer station locations based on various design factors like open land availability, ease of access from all the composting units/dustbin locations, transfer means by tractor trailers, and sanitation and environmental requirements. This study also reveals the vegetation cover changes at a depletion rate of 2100 square meters area in and around dumping sites.

1. Introduction

The eleventh five-year plan of Government of India promoted urbanization with the aim of advancing the economic development in India. This urbanization has put pressure on public utilities including transportation, housing, water, sanitation and health (Franco, Mandla, & Rao, 2017a; Franco, Mandla, & Rao, 2017b). The Indian population of around 31% is living in urban areas. It is also estimated that by the year 2030 this would rise to an incessant rate of 40.8% (Sainu et al., 2017). These drastic changes are leading to the new development of physical, institutional, socio and economic infrastructure for improvement in the quality of life and attracting people. With the increasing population rate, the natural resources consumption is very fast and their stocks are getting exhausted (World Trade Report, 2010). This is increasing the production rate of waste materials globally. There is an estimation of doubling in solid waste quantity by 2025 from the current generation rates (Hoornweg & Bhada-Tata, 2012). Studies are being improvised by environmentalists and scientists to figure out adverse changes in the environment brought about by urban waste (Raghavan, Mandla, & Franco, 2015). Hence, the proper waste management system is observed in every part of the globe from a sustainable point of view for using waste as resources through material recovery.

Urban areas in India generate more than 1, 00,000 MT of waste per day. A large metropolis such as Mumbai generates about 7000 MT of waste per day, Chennai about 5000 MT, Bangalore about 5000 MT and other large cities such as Pune and Ahmedabad in the range of 1600–3500 MT per day (NIUA, 2015). According to Central Public Health and Environment Engineering Organisation (CPHEEO), solid waste management (SWM) in Urban Local Bodies (ULBs) are very critical due to dense development and congestion. Local governments are unable to cope with all these challenging tasks like unavailability of land for landfill and pollution of groundwater and surface water caused

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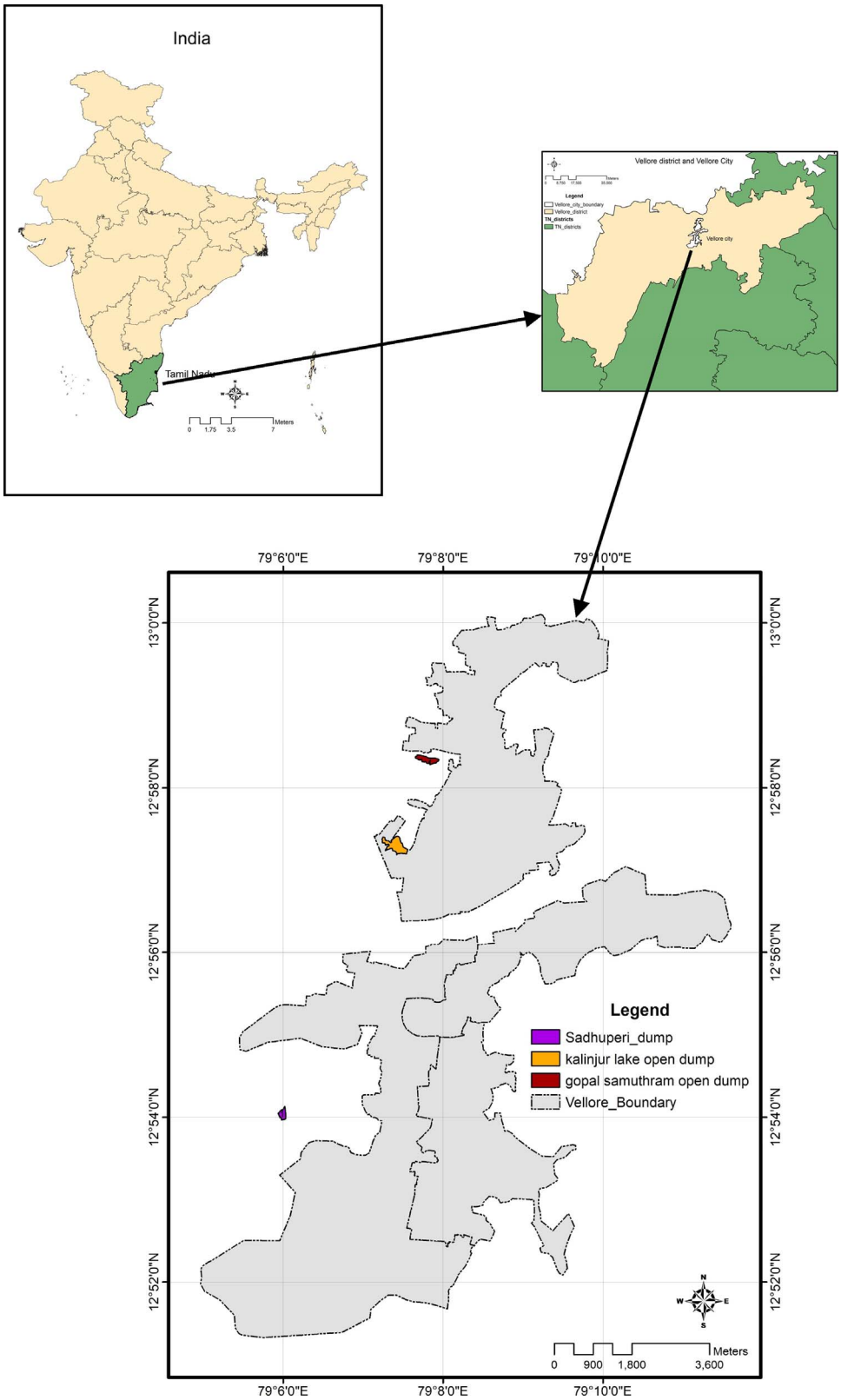

Fig. 1. Location map of study area, Vellore.

by accumulated waste (CPHEEO, 2005; CPHEEO, 2016a, 2016b).

Indian government proposals of smart cities have driven many technologies and ideas for various infrastructural developments in physical, institutional, socio and economic features. These include proper solid waste management and cleanliness in the urban bodies. Key findings/challenges in Indian solid waste management systems (SWMS) include improper collection of waste, waste accumulation along streets and roads, lack of proper processing and disposal systems, lesser involvement of stakeholders, environmentalists and technology providers (Ghatak, 2016; Rajput, Prasad, & Chopra, 2009; NIUA, 2015). As SWM is one of the major concerns in smart city developments in India, this study forwards in reviewing the solutions for issues related to