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Assessment of relation of land use characteristics with vector-borne diseases in tropical areas

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ABSTRACT

Land use and land cover changes play an important role in the occurrence of vector-borne diseases. It is highly essential to identify the prominent changes responsible for its occurrence so that suitable measures can be adopted. An attempt was made to identify the prominent land use and land cover changes responsible for the spread of chikungunya, malaria, and dengue fever in the State of Kerala, India, using hierarchical cluster analysis and multiple regression analysis. Large extent of water bodies, low land and agricultural land played a significant role on the incidence of chikungunya and malaria. High population density, built-up area and agricultural area favoured dengue fever. Vector-borne diseases were found to be the lowest in places where there is no low land and with higher forest area. Inappropriate disposal of wastes generated in the built-up area might be the reason for the spread of dengue fever. Freshwater in drains of these areas is polluted and form breeding grounds for mosquitoes. Hence much attention is to be paid to provide appropriate treatment and disposal of wastes generated in the built-up area of the State In an evolving urban policy, priority is to be given to the installation of safe treatment and disposal facility of wastes especially, sewage, sullage, and solid waste. The protection of forest land also plays an important role. Economic policy instruments such as Payment for Environment Services (PES) schemes, may constitute a useful tool to encourage an improved land use management through appropriate price signals, such as, for instance, for the preservation of forested areas especially in proximity of highly populated urban environments.

1. Introduction

At the dawn of the 21st century, vector-borne diseases still constitute a serious threat to human health, causing well over a million death and considerable morbidity worldwide (Vanwambeke and Lambin, 2007). Vector-borne diseases are linked to the environment by the ecology of the vectors, and of their hosts, including humans. Several factors, such as seasonality, proximity to breeding grounds, vector density, biting rates, and proportion of infectious mosquitoes, contribute to the spread of mosquito-borne diseases (Agarwal et al., 2012). Human activities are reflected in the land use within the landscape. According to Magori (2015), climate change will most pronouncedly affect the transmission of vector-borne diseases in the temperate and cold regions (as well as higher elevations), while in the tropics, most changes will be driven by land use and land cover change. The disturbance of habitats due to land cover change is likely the largest environmental cause of altered risk for infectious diseases (Patz et al., 2008 and Medlock and Leach, 2015). Major drivers of land use change include agricultural development, urbanization and sprawl, and deforestation. Deforestation and cultivation in natural swamps in the African highlands create conditions favourable for the survival of gambiae larvae. Vittor et al. (2006) found a strong correlation between biting rates of Anopheles darling and the extent of deforestation in the Amazon.

Agricultural land is the land primarily used for farming and production of food, fibre, and other commercial/horticultural crops. Agricultural practices, including tillage, fertilization, and residue management can affect surface runoff, soil erosion, and nutrient

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Table 1
Physiography and land use in different districts of Kerala.

Category	Population per 100 km^2	%Agri in TA	%Built in TA	% Forest in TA	% wasteland in TA	% waterbodies in TA	%High	%Medium	% Low
Thiruvananthapuram (TVPM)	162046	66.3	8.5	19.8	3.9	1.6	26.2	68.3	5.2
Kollam (KLM)	111846	56.4	2.8	33.9	2.1	4.8	43.8	41.9	14.8
Pathanamthitta (PTA)	48293	36.6	7.5	45.4	10.6	1.2	71.1	27.0	1.8
Alappuzha (ALPA)	157065	86.0	1.3	0.6	0.03	12.4	0	20.2	79.9
Kottaya (KTM)	94819	76.2	10.1	0.9	8.8	3.7	23.1	58.5	18.1
Idukki (IDK)	27100	43.9	0.3	43.9	9.8	2.1	96.3	3.6	0
Ernakulam (EKM)	112000	57.1	7.9	26.9	2.1	5.7	6.9	51.9	19.6
Thrissur (TSR)	106523	64.1	1.9	30.4	2.9	2.9	32.4	50.9	15.3
Palakkad (PLKD)	64266	57.4	1.5	30.7	7.2	2.7	65.1	34.9	0
Malappuram (MLPM)	119539	66.4	1.2	22.3	8.7	1.6	16.9	80.0	2.9
Kozhikode (KKD)	134669	67.9	3.9	19.3	6.2	2.6	26.6	57.2	15.4
Wayanad (WND)	42570	52.7	0.9	40.8	5.9	0.6	99.8	0	0
Kannur (KNR)	86720	66.2	7.5	20.9	8.8	2.7	40.9	53.6	4.9
Kasargod(KGD)	67960	71.0	4.4	5.6	16.5	2.4	51.7	37.2	9.6

cycling. This may in turn affect the quality of aquatic resources as habitat for amphibians, fish, and invertebrates, and cost of treating surface and ground water (Warrant et al., 2012). According to WHO (1996), agricultural development may have adverse health effects notably through the spread and intensification of vector-borne diseases which may invade new areas, increase transmission rate and/or season with resulting high numbers of cases, or cause more severe disease symptoms.

According to Knudsen and Slooff (1992), owing to population growth, poor levels of hygiene, and increasing urban poverty, the urban environment in many developing countries, is rapidly deteriorating. Densely packed housing in shanty towns or slums and inadequate drinking water supplies, garbage collection services, and surface water drainage systems combine to create favourable habitats for the proliferation of vectors and reservoirs of communicable diseases. As a consequence, vector-borne diseases such as malaria, lymphatic filariasis and dengue are becoming major public health problems associated with rapid urbanization in many tropical countries (Sheela et al., 2015).

A chikungunya epidemic was reported in 213 districts especially in South India during 2006 with hundreds of thousands suspected fever cases reported, 15,504 cases screened for blood samples, and 1985 cases clinically confirmed as cases of chikungunya. The occurrence of epidemics has continued across the country since 2006 (Palaniyandi, 2014). Dengue epidemics were reported in 24 states/union territories of India with 37,070 cases and 227 deaths during 2012. Epidemics steadily increased to become a very serious threat to the public. Considering the seriousness of the problem, this study was conducted in order to assess the extent of land use and land cover changes responsible for the incidence of vector-borne diseases in the state of Kerala in southern India, in the hope that it may contribute to control their occurrence at the source. The understanding of the links between land use types and the propagation of vector-borne diseases is of critical importance to identify conservation needs and substantiate the relationships between land use preservation policies and public health protection.

2. Methods

Disease data was collected from State News bulletin on Integrated Disease Surveillance Project (ISDP) and is given in Table 1 by district for 2006 (Coughanowr, 2010). Land use classification data obtained from Coughanowr (2009) is also given in Table 1. The extent of different land uses namely agricultural land, built-up area, forest area, wasteland, and water bodies as well as different physiography of the State have been discussed in detail. The relation of land use and land cover changes and physiography features with the incidence of vector-borne diseases has been assessed using statistical analysis namely hierarchical analysis and multiple regression analysis.

3. Study area

Kerala, with a total area of 38,863 km^2, is one on the smallest states of southern India. It has a vertical orientation with an average width of 50 km (Sheela et al., 2015). The State's low land region (10% of the total area), runs along the coastline with beaches, swamps and lagoons, backwaters, paddy fields and coconut plantations. The midland (42%) is primarily valleys with undulating small hills and meandering passages. The high land region (48%) with steep hills is rife with forests, plantation, reservoir and small streams. The average annual rainfall is quite high when compared to other Indian states. The different districts in Kerala are given in Fig. 1.

4. Results

4.1. District-wise distribution of population

The districts are classified on the basis of population per 100 km^2 (Fig. 2). Population density is highest Thiruvananthapuram (TVPM; 162,046/100 km^2) followed by Alappuzha (ALPA; 157,065/100 km^2); Kozhikode (KKD; 134,669/100 km^2); Malappuram (MLPM; 119,539/100 km^2); Kollam (KLM; 111,846/100 km^2) and Ernakulam (EKM; 112000/100 km^2). The lowest population density is reported for Idukki (IDK; 27,100/100 km^2) followed by Wayanad (WND; 42,570/100 km^2); Pathanamthitta (PTA; 48,293/100 km^2); Palakkad (PLKD; 64,266/100 km^2) and Kasargod (KGD; 67,960/100 km^2).

Thus the percentage population per geographic area is highest in Thiruvananthapuram followed by Alappuzha, Kozhikode, Malappuram, and Ernakulam. According to Reghunathan and Anilkumar (2014), the magnitude of the threat to the ecosystem is linked to human population size and resource use per person and thus resource use, waste production, and environmental degradation are accelerated by population growth. As human numbers further increase, the potential for irreversible changes of far-reaching magnitude also increases. This shows the threat to environment by way of waste production, and resource use especially in Thiruvananthapuram and Alappuzha. Hence more attention is to be paid for waste treatment and environmental protection in these districts.

4.2. District-wise extent of land

The land mass of Kerala can be distinguished into three natural zones namely low land, midland, and highland, and each of them runs almost parallel from north to south (http://shodhganga.