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Future Prospects

India is one of the few countries in the world which has earth observing satellites. Integration of satellite and geo-referenced epidemiological data, and availability of sophisticated statistical Geographical Information System and well developed algorithms to translate satellite images into land use factors related to insect vector species provide great research opportunities in the field of vector-borne diseases. India has been regularly experiencing vector-borne disease epidemics causing prolonged morbidity and mortality. Vector-borne diseases are responsible for a huge number of deaths through out India. There is an urgent need to address these diseases with best possible strategies to control them to a stage that they do not cause public health concern any longer.

Satellites have the ability to detect anomalies from the normal climate patterns that are conducive to the breeding of insect vector species. Furthermore, remotely sensed variables in environmental data such as air temperature, humidity and rainfall that are related to insect vector biology can now be obtained in real-time. The IC/D LISS III with 23.5 m resolution and PAN data with 5.8 m resolution satellite operational in India has 25 days temporal resolution. Global Positioning System (GPS) can be used to get longitude and latitude of houses, health centres, hospitals, vector breeding places, etc. in an area. GIS with its facility to incorporate data from different resources (environmental data from satellite images, ground data from entomological and parasitological surveys and GPS data on village/area) and its mapping capabilities, it can form an invaluable tool in vector-borne diseases prevalence, surveillance, prevention and control programmes and strategies.

Forecasting of vector-borne disease epidemics is a necessity to prevent and control epidemics effectively. This is an emerging field. RS and GIS technologies together with GPS can help in developing effective vector-borne disease forecasting models and decision support systems. For people living in remote rural areas accessing health services is a major concern and this is an issue to be addressed urgently by the public health system. GIS and GPS can be used to map disease prevalence, health infrastructure and individual patients, and to monitor surveillance activities and people accessing the health facilities in that area. Once the decision support/making tools are in place monitoring can be done in a desktop environment, and the decisions can be made immediately by the concerned authorities.

Studies reported in this document have demonstrated the efficacy and utility of RS and GIS technologies in malaria, filariasis and kala-azar. There is however, a need to extend these studies to other areas for testing their wider applicability. Stratification strategies achieved for macro level have to be fine tuned for micro level stratification as per the needs of the control programmes. Land use and environmental factors that were found specific to *Anopheles culicifacies* and also to kala-azar vector, *P. argentipes* have to be examined in much wider geographical areas before accepting them as a rule of thumb. Ranges of ecological parameters, namely forest-cover, soil type, altitude, temperature and rainfall that have been found suitable to develop distribution maps of the major malaria vectors in India have to be analyzed in greater depth to map the distribution of sibling species of these major vectors. Majority of the malaria vectors in India are species complexes, i.e. each morphologically recognized taxon has biologically distinct morphologically identical/similar species which are commonly referred to as sibling species or cryptic species or isomorphic species. Sibling species have distinct distribution pattern and also differ in several biological characters that are relevant to malaria epidemiology and malaria endemicity. Their response to control methods/tools may also vary. Keeping in view that the control strategies have to be species specific, these studies need to be done on a priority.

Now that the World Health Organization under Integrated Vector Management (IVM) recommends to plan multiple communicable diseases prevention , i.e. developing strategies that can target more than one disease in an area, these analyses have to be extended to map vectors of other diseases also. Furthermore, it is now accepted that global warming is causing climate change. Vector distribution and the development of pathogens in the vectors are climate related. It is considered that climate change will influence the vectors especially at the periphery of their distribution. Using the information from GIS analysis on the distribution of vectors, models could be developed to predict the effect of climate change. The geo-environmental risk model (GERM) developed to produce 'Lymphatic Filariasis Transmission Risk Map' in Tamil Nadu can be extended to other areas immediately to delineate non-transmission areas from not so accuarately identifiable transmission areas. As the filariasis transmission at the 'macro' level depends on the geo-environmental variables, and the occurrence of filariasis at the 'micro' level depends on 'human' factors under the favourable environmental conditions, attempts should made to develop models incorporating factors other than geo-environmental. It may be mentioned that the Task Force Committee has already initiated more studies to extend the applicability of the out come of these studies.

Following are few studies identified for initiating keeping in view the need of extending the studies that have been carried out and of the vector control programmes in India. Some of the studies identified are applicable to vector-borne diseases in general while others are specific to a disease:

(i) Development of disease transmission and epidemic forecasting models;

(ii) Development of models to predict changes in vector distribution due to climate change;

(iii) Decision support/information management systems for use at local level for vector and disease control;

(iv) Identification of risk factors responsible for differential disease endemicity;

(v) Surveillance system(s) to monitor—(a) health infrastructure facilities and their accessing by patients, (b) disease and vector(s) prevalence, (c) environmental changes, and (d) land use features;

(vi) Development of algorithms between land use features, environmental factors and disease/vector species prevalence. Once such well-tested algorithms are in place, ground surveys can be replaced with remote sensing image analysis;

(vii) Paradigm-wise malaria risk maps; i.e. for urban, forest, coastal, water/mining development project and migratory population movement are needed as the control strategies differ for each paradigm;

(viii) Identification of land use and environmental characterstics for each sibling species of malaria vector species complexes recognized so far (except for *An. stephensi* among major malaria vectors and *An. varuna* among secondary vectors, all other vector species in India are species complexes);

(ix) Micro-stratification of areas based on disease endemicity/vector prevalence for planning situation specific malaria control strategies;

(x) Surveillance of spatial and temporal determinants for *Ae. aegypti*/*Ae. albopictus* prevalence/abundance and dengue infection;

(xi) Surveillance to monitor spatial and temporal determinants for JE vectors and disease; and

(xii) Integrated maps of multiple vectors (vectors of different diseases) prevalent in an area for developing strategies based on integrated vector management (IVM) guidelines.