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Increasing the Predictive Capability of Mapping Technologies for Healthcare in Disaster Management

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Introduction

Health as defined by the WHO/EUROs Health 21 is 'the reduction in mortality, morbidity and disability due to detectable disease and disorder, and an increase in the perceived level of health' (WHO, 1999). Health Impact Assessment (HIA) is a combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population (WHO, 1999).

The use of HIA in disaster management has usually been as part of the Environmental Health Impact Assessment (EHIA) which is a part of the Environmental Impact Assessment (EIA) (Rainer, 1999). However, the use of Health Impact Assessment as a tool in disaster management has been taking on an increasing role in recent years (Russell and Saunders, 2007). The role of such assessments in providing a decision support tool for decision makers responsible for health protection and relief efforts is crucial because disaster response requires well coordinated action. This involves a spectrum of decision makers, tools and equipments, on-ground relief workers and other support personnel. Therefore the role of assessments to enhance decision making and also guide a coordinated response at the disaster site, for the immediate, short term and long term phases, is very important.

Various systems have been developed for Health Impact Assessments, HIA in public health and policy settings, and some of these have been adapted successfully for disaster management efforts (Ruijten, 2007). The aim of this paper is to develop a tool that would guide decision and policy making towards a proactive response and also to ensure a well coordinated post-disaster response, addressing both individual and community needs, by using remote sensing as a tool for disaster management. It is for strengthening the utility of satellite imagery by the end users, which in this case would be the decision makers, public health authorities, public health policy makers, doctors and other relief workers. Information is crucial to the carrying out of an effective and efficient post-disaster healthcare response. The quality of information provided by satellite imagery is very useful in determining how features and changes in the environment can affect the health of individuals and the community. This implies that in conducting Health Impact Assessments, there should be an added advantage to be enjoyed by specifically integrating satellite imagery.

Using post-disaster images as a base, criteria would be defined to be used in defining the health impact of a disaster and also in augmenting the effectiveness of the healthcare response. It would involve analyses of satellite imagery to enhance prediction of likely disease occurrence using landscape and meteorological factors in disease prediction. It would also involve:

1. Assessing the extent of destruction to healthcare infrastructure and indices,
2. Estimating affected and at-risk populations,
3. Determination of likely diseases and morbidities following the disaster,
4. Recommendations on healthcare response in terms of facilities, quantity and location of staff, volunteers, mobile units, emergency response activities, and other disease prevention efforts.

This would take the form of a rapid health impact assessment to provide basic information useful in different phases of the disaster management cycle. It would also help in understanding and defining the healthcare needs of the affected population.

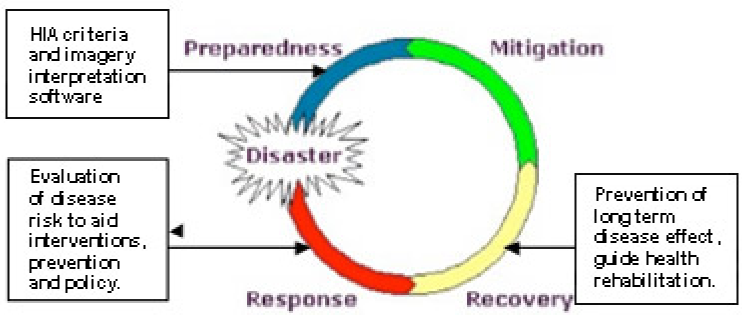

Figure 1: Impact of satellite imagery in HIA for disaster management. (Modified from Earth Observation Magazine).

In modelling the likelihood of disease occurrence using environmental data, one must consider that there are uncertain variations in the relationship of these data and their influence on disease occurrence and transmission. Thus it is expected that not only should the best evidence be relied upon but attention should be paid to the differences that could exist in disease transmission trends even in areas that are close to each other. This is because most environmental models are based on indirect estimations. Thus for example, in modelling for malaria using the changes in the Normalized Difference Vegetation Index (NDVI) or Enhanced Vegetation Index (EVI), one is actually using them as parameters to measure the temporal and spatial variations in the vegetation and their effect on disease vector populations. This is in turn influenced by the biology of the vector which is based on the genetics of the vector species and their adaptation to the environment. All these are further derived from the premise that changes in the disease vector population would inadvertently affect the transmission of a vector-borne disease. Now even though that is likely, there are other factors such as host resistance, treatment and prevention efforts, and even the existence of vector predators that could make this premise invalid in predicting the transmission of disease. Thus it is better to correlate such environmental data with vector biology factors, host indicators and apportion weights based on the statistical methods that best simulate the relationship between these factors in disease transmission.

This process would require that there be access to accurate and reliable local health data and ground data. In many cases however, in the days immediately after the occurrence of a disaster event, such data may not be easy to come by. This further underscores the need to have excellent coordination of disaster mitigation and preparedness activities on both local and international levels, with an emphasis on data that would be requisite for developing high quality mapping solutions. This would ensure the availability of such data in the crises moments following a disaster. Local capacity building efforts and stronger international cooperation between development agencies, departments and organizations that are involved in the use of geo-information solutions for disaster management and the humanitarian community at large, would further enhance the output of solutions developed for such purposes. Extra attention should also be paid by disaster-prone areas to having detailed information about their territory, indicating both geographic and social factors, and also to maintaining solid links with the disaster management community. The advantage of foresight can never be overemphasised when discussing the necessity of shifting the emphasis of disaster management practice from relief and recovery to preparedness and mitigation.

Another factor is the issue of uptake of mapping services by members of the disaster management community especially those responsible for providing medical relief. The emphases on the clinical and hygienic aspects, which bear more on the acute and long term phases of providing care, make interest in the use of predictive tools, as part of preparation for relief efforts, less attractive. The doctor wants to know the risk of disease spread; how many people are dead, injured or in need of immediate attention; how many healthcare facilities are functional, their location, staff strength and extent of damage. Thus it is necessary to demonstrate that although geo-information solutions may not have the answers to all these questions, they still have a role to play by their ability to:v

1. Provide information to aid planning and logistics in the pre-arrival stages.
2. Model the disease risk in certain areas using environmental data and background knowledge of disease trends.
3. Serve as a decision making tool in the post-disaster planning of strength and location of medical relief, due to their ability to make preliminary damage assessments and show areas where recovery efforts such as location of healthcare posts or location of refugee camps are likely to be sustainable.
4. Visually display the relationship between populations (usually from ground data) and services such as water sources, food distribution points, roads, health posts etc. This would aid the monitoring of factors influencing health and disease spread, and also facilitates the planning of

public health interventions such as vaccinations, enlightenment campaigns, mass distribution etc.

5. Demonstrate the need, where necessary, to pay attention to existing risks that may necessitate a major operational change, such as an evacuation. This is through been able to detect and predict changes in geographical and meteorological factors, interpret the consequences, and visually represent these in a manner that makes it easy for 'lay' people to utilize.

When these issues are well considered, it is evident that the use of mapping solutions by the healthcare community if encouraged, can only guarantee a greater depth of preparation. This would in turn strengthen the soundness of practice, reduce the risk of untoward events and maximize the effective use of resources and relief personnel.

No.	Activity	Telecom	Earth Observation	Geo-Navigation
1	Early Warning	√	√	
2	Decision Support	√	√	
3	Disease Risk Assessment		√	
4	Logistics	√		√
5	Search and Rescue	√		√
6	Telecom and Telemedicine Support	√		
7	Assessing the Viability of Environmental Support		√	

Table 1: Summary of Satellite Solutions used in Disaster Management

Health Needs Assessment Map Flowchart

This shows the sequence to be followed in a post-disaster situation by relying on background data from various healthcare data sources to give an understanding of the disease trends existing in the affected region. This is followed-up by reviewing the features seen from using satellite imagery in making damage assessments and then correlating those with pre-disaster healthcare infrastructure data and background disease epidemiology information. The aim is to arrive at an overview of likely disease trends and level of healthcare infrastructure in place to support surviving populations. Following this a more detailed assessment of existing social infrastructure is made to help in determining the most appropriate site to locate a health post. The strength of this evaluation would depend on the availability of ground data. An evaluation of population distribution is then made and correlated with the post-disaster assessment to determine the size, location and if possible, age and gender distribution. All these are then used in developing a map that shows the best options for citing a health post, the size of the population that needs to be served in various locations and the disease risk of these population groups.

As a decision support tool, it will aid the planning of medical relief and also contribute to guiding the allocation of resources and personnel. It will serve as a template for monitoring the progress of healthcare interventions with time and would also be a good tool in looking at the best approach to take in instituting early recovery and long term healthcare rehabilitation.

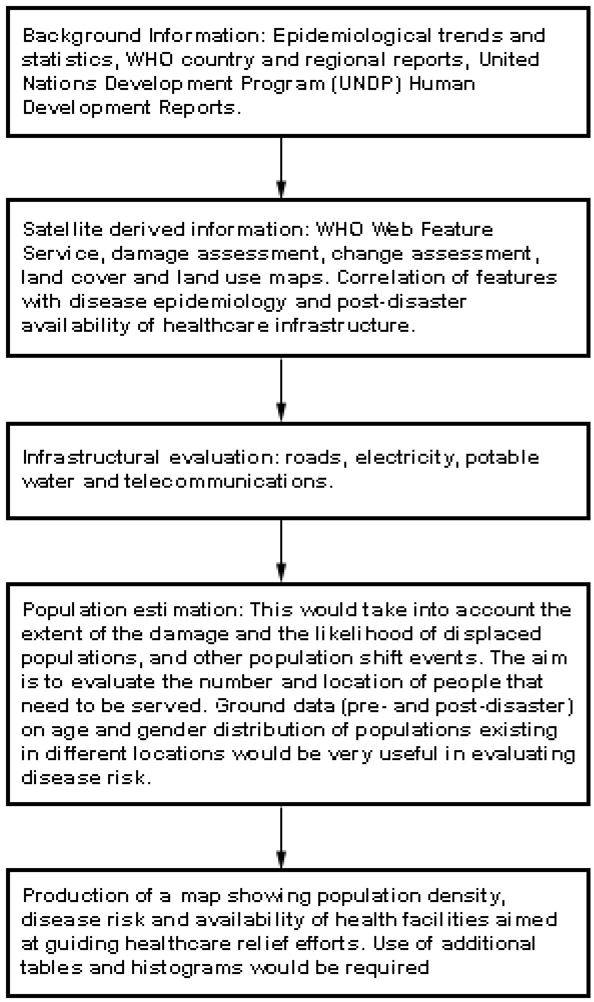

Figure 2: Health Needs Assessment Map Flowchart.

Health Impact Assessment

To aid in conducting a post-disaster rapid health impact assessment, a health risk score was developed. An initial preliminary disease assessment score to determine the risk of disease following a disaster was made. Factors considered included the relevant geographical, meteorological and environmental features that have been shown to have a direct bearing on the transmission of disease. These would then be evaluated and weighted statistically to give an estimation of the likelihood of disease occurrence in that population at that time.

For example in looking at malaria, the environmental factors that have been shown to have the strongest correlation to disease transmission are the following mentioned by Kazembe (2007):

1. Nature of the climate
2. Soil water holding capacity
3. Normalized Difference Vegetation Index/ Enhanced Vegetation Index
4. Precipitation

Other factors include humidity, temperature, altitude, temporary streams, level of urbanization etc.

For diarrhoeal diseases, they are usually influenced by the following factors described by Lama et al (2004):

1. Tropical or sub-tropical climate
2. Sea-surface temperature
3. Phytoplankton bloom
4. Sea surface height

The common diarrhoeal diseases are cholera, shigellosis (causing dysentery), typhoid and other gastroenteritides.

Another disease that could be a threat in post-disaster situations in susceptible areas is Dengue fever. Some of the satellite-observable factors for the disease are given by Rogers et al (2006)

1. Urban population
2. Land surface temperature

Closely related to that is Yellow fever a disease that shares the same vector, Aedes egypti, as Dengue fever. This mosquito specie is responsible, in both diseases, for transmission among humans. This disease however is distributed more in West Africa and South America while it is not seen in Asia for unexplained reasons. Dengue fever on the other hand is seen more in South-East Asia, South America and throughout the Pacific Islands. The geographical factors responsible for Yellow fever are thus:

1. Greenness as observed using the NDVI or
2. Humidity

Another interesting disease is the Japanese encephalitis which is transmitted by the Culex mosquito, and is carried by Ardeidae birds and pigs. Its transmission in humans usually follows an increase in Culex mosquito populations. It is common in flooded rice fields (WHO, 2008).v

For a number of these diseases, all that would be required may be just vector control and other methods of preventing vector-host transmission such as bed nets and water treatment. Not to be overlooked however is the role malnutrition could play in the spread of diseases by increasing susceptibility especially in children, the elderly and the immunosuppresed. In disasters where there has been destruction of crops and other agricultural produce, it is important to institute measures to prevent an outbreak of malnutrition which can further compound the spread of diseases such as measles and predispose to tuberculosis infection/reactivation especially in the immunosuppresed. However, with these noted, the environmental factors influencing measles transmission include the seasonal variations such as the 'dry spell', known to be responsible for increased transmission. Of course factors such as overpopulation and poor vaccination coverage also affect the spread.

It should be noted however that the relationship between these factors and disease transmission is not always linear. Also there is usually a time difference between the observation of spatial features and the manifestation of disease in a population, based on the incubation period of the disease. Thus the imagery that would be used in studying an ongoing outbreak of malaria would be that taken two weeks or more earlier, and that for studying Taeniasis-induced liver disease would be that taken about 10 years ago. This demonstrates the temporal consideration when using satellite imagery in disease modelling and prediction. The need always exist to take into account the natural history of the disease in plotting modelled patterns of disease transmission that rely on geospatial data.

An evaluation of these parameters and how they predispose to disease spread will be made and subsequently the risk would be scored and used in assessing the overall disease risk faced by the area. Subsequent to this another risk assessment is made to decide on where best to locate health centres. The higher this second risk assessment s in an area, the greater the likelihood that setting up health centres at that location would fail.

No.	Factor	Score: Criteria	Data Sources
1	Population	1: Less than a third displaced 2: Between a third and two-thirds displaced 3: Greater than two-thirds displaced	Damage/Change Assessment and Population Grid Data
2	Accessibility	1: Motorable roads and intact voice telecommunications at location 2: Roads and/or telecommunications access within	Damage/Change Assessment and Ground Data (where available)

		5km of location 3: Inaccessible by roads and/or telecommunications	
3	Potable Water	1: Access to clean and potable water source 2: Access to treatable water source 3: Limited or no access to any water source	Damage/Change Assessment, Land Cover, Ground Data
4	Electricity	1: Electricity supply intact 2: Intermittent electricity supply 3: No power source available	Ground Data, DMSP-OLS (0.5km High, 2.75km Low Resolution)
5	Population Shift	1: Area is being resettled post disaster 2: More people leaving than returning 3: Area not being resettled at all	High Resolution Imagery, Ground Data

Table 2: Rapid HIA risk score.

The risk assessment may be graded as shown below with suggested interventions.

≤ 5 = Low risk: Resuscitate existing health centres or set up a basic mobile unit to cater for the population.

6-10 = Medium risk: Evaluate needs further and decide on location, nature and extent of healthcare relief efforts.

11-15 = High risk: Conduct triage and consider possible evacuation of affected location.

The information gained from this assessment would thence influence the location, nature and extent of healthcare intervention to be made. The aim is to use satellite imagery in deriving as much of this information as possible and use that in developing a model that would be used in generating an interactive map. These maps can then be used as decision support in guiding recovery efforts.

Conclusion

In seeking to enhance the value of all stages of the disaster management cycle, it has become desirable to rely on satellite solutions to provide a backbone for most of the activities. Their role in disaster mitigation and preparedness is also a crucial factor in ensuring that hazardous events do not end up becoming disasters. This is best accomplished by training and retaining strong local capacity on ground in every country, especially in the disaster-prone areas. This way the availability of geographic core data and skilled personnel to facilitate relief and recovery efforts would help to speed up the role of satellite solutions in disaster management. The practise of healthcare as a core part of disaster management stands to benefit from the use of the additional capabilities provided by satellite imagery.

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REFERENCES

1. Kazembe L., 2007. Spatial modelling and risk factors of malaria incidence in northern Malawi. Acta Tropica Volume 102, Issue 2, May 2007, Pages 126-137.
2. Lama J.R. et al,. 2004. Environmental Temperature, Cholera, and Acute Diarrhoea in Adults in Lima, Peru. J HEALTH POPUL NUTR 2004 Dec 22(4):399-403.
3. Rainer, F., 1999. Environmental Health Impact assessment, Evaluation of a ten-step model. Epidemiology 1999; 10 (5), p. 618-625.
4. Rogers D.J. et al. 2006. Global distribution of Yellow fever and Dengue. In Global mapping of infectious diseases Global Mapping of Infectious Diseases: Methods, Examples and Emerging Applications. By Simon I. Hay, Inc NetLibrary, Alastair Graham, David J. Rogers, Published by Academic Press, 2006 pp 182-209.
5. Ruijten, M., 2007. The Dutch experience with Health Impact Assessment of disasters. The European Journal of Public Health, 17 (1), p 5-6.
6. Russell, D. & Saunders, P., 2007. The UK experience with Health Impact Assessment of disasters. The European Journal of Public Health, 17(1), p 4-5.
7. WHO Regional Office for Europe/ European Centre for Health Policy, 1999. Gothenburg Consensus paper: Health Impact assessment, Main concepts and Suggested approach. Brussels, Belgium December 1999. ECHP: Brussels.
8. WHO, 2008. Communicable Disease Risk Assessment and Intervention. Cyclone Nargis, Myanmar. [online] Available at http://www.humanitarianreform.org/humanitarianreform/Portals

/1/cluster%20approach%20page/Myanmar/Health/Myanmar CycloneNargis090508.pdf.
[Accessed on 19 Feb 2009].