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Remote Sensing (RS) & Global Information System (GIS): A Computer & Satellite based Techniques used in Natural Disaster Management

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Abstract

Disaster is a geo-climatic event. It affects the human life by destroying the whole thing with no or very little prior indication. For disasters, climate does changes and creates multiple threats. These threat does not affect the single country or continent, it effects the whole world either it is a developed country or developing country. As the changes occurs with high frequency and high intensity of weather and climate hazards, such as floods, droughts, cyclones, landslides, forest fire, heat and cold waves are expected. Globally, naturally disasters account for nearly 80 percent of all disaster affected area and people. Natural disaster and hazards cannot be prevented, but their adverse impact can be minimized by taking certain mitigation measure. Planning and preparedness are the some important measures to mitigate the negative impact of disaster. As the level of technology increases, we are able to get prior information about the location and magnitude of the disaster. With GIS and RS, it has become possible. These technologies do play an important role in disaster management and in catering to the needs of the affected area with its tools and applications.

Keywords: Remote Sensing, Global Information System, Natural Disaster, Management.

Introduction

In recent decades, the Asian & Pacific region has been hit by a series of shocks with various magnitudes. These include natural disasters, such as earthquakes, droughts or floods and others. Others are related to economic crises and energy prices. Disasters is a very serious disruption of the functioning of a community or society involving all living or non-living things like human, material, economy or environment losses impacts, which exceeds the ability of the affected community or society to cope using its own resources.

Figure 1. Ruins from 1906 San Francisco Earthquake (One of the Worst Natural Disaster in US History)
Source:https://en.wikipedia.org/wiki/Disaster

Natural Hazards is a naturally occurring even that might have a negative effect on people or the environment. It can be grouped into two broad categories like geophysical hazards and Drought. Both disaster and hazards are, generally geo-climatic events, and they strike the human life and environmental conditions badly with no or very little prior indications. These Geo-climatic event strikes all developed and developing nations in the world. It leaves a huge loss to health and wealth. Globally, natural disasters account for nearly 80 percent of all disaster affected the environment, area and people. Sufferings of the people due to natural disasters are common in the countries of South Asia as densely populated area of the world. Asian and the Pacific is the world's most disaster-prone region, registering the largest number of people affected, as well as the largest number of people killed, by disasters between 2002 and 2011.

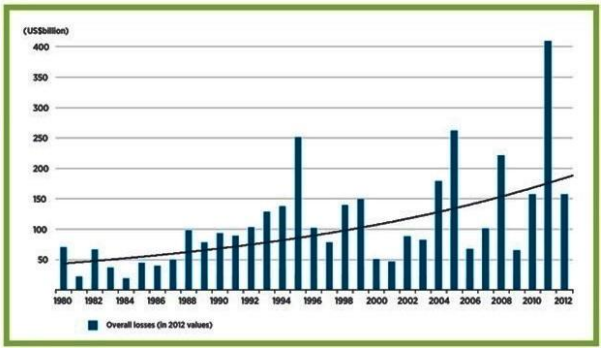

Figure 2. Global Disaster Loses (1980-2012)
Source: World Bank

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Figure 3. Total number of disasters and losses (1980-2012)
Source: Munchener Ruckversicherungs-Gesellschatt, Geo Risk Research, NarCar Service (2013)

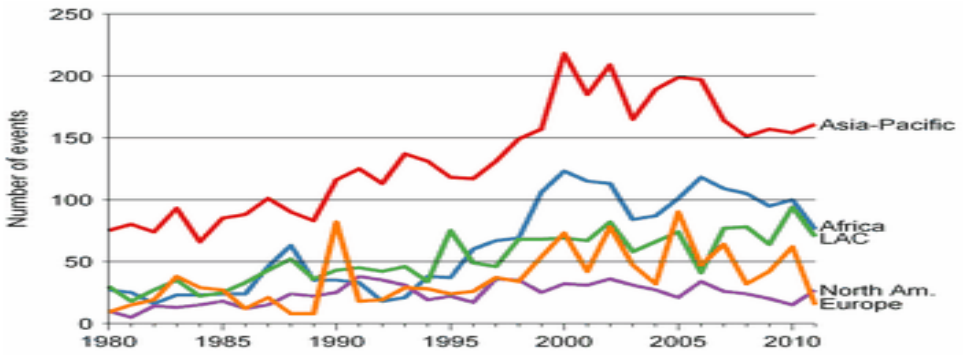

Figure 4. Number of reported natural disasters, world regions, 1980-2011
Source: World Bank

When we analyses the last three decades, the frequency of natural disaster has increased globally. But in most increase has been in the Asian and Pacific region. As per Figure 3, the highest percentage of deaths was observed in Asia pacific (Specially South-East at 47 per cent, followed by 28 per cent in South and South-West Asia). These two measurement have major differences as compared with previous to the most recent decade as 14 per cent of the region's total deaths were observed in the South-East Asia, whereas 64 percent of the death for that period were registered in South and South-West Asia in between 1992 and 2001.

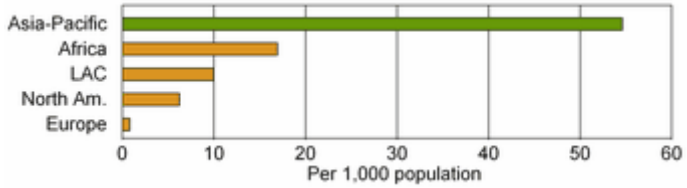

Figure 5. People affected by natural disasters, world regions, 2002-2011

According to the Emergency Events Database (EM-DAT)1 the most frequently occurring hazards in the regions are hydro-meteorological and they effect the largest number of people. A Study by the intergovernmental Panel on Climate Change concluded that, while typhoons and other climate-related disasters are not increasing in number, more of them are stronger, making the region more susceptible to greater potential losses.

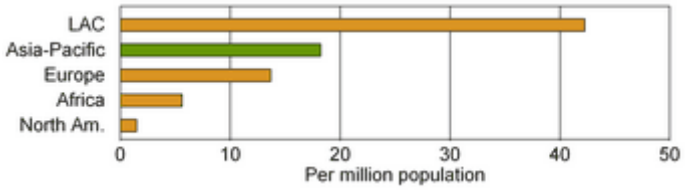

Figure 6. People affected by natural disasters, world regions, 2002-2011

While losses and damage has been rising, low-income economies have been much harder it in relative terms.

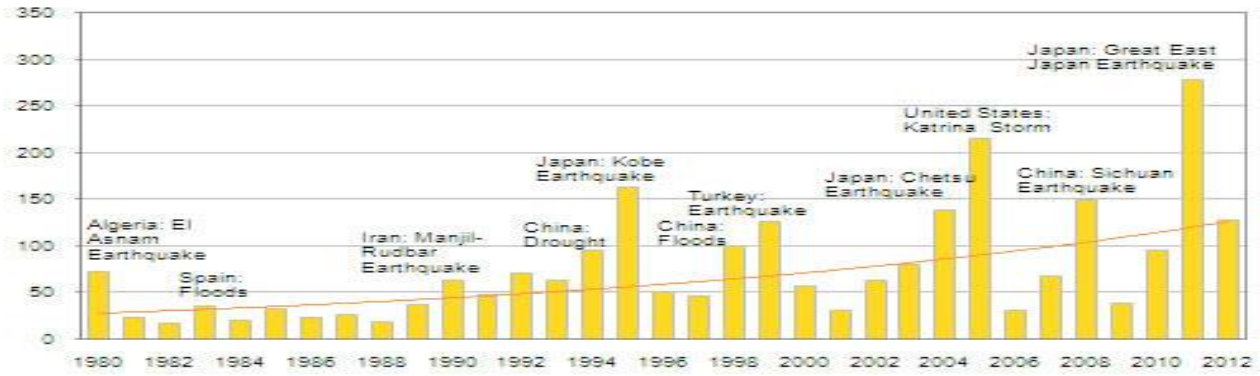

Figure 7. Rising global economic losses and damage, 1980-2012

It is true that Natural disasters cannot be prevented, but their adverse impacts can be minimized by taking certain and important mitigation measures. There are lots of measures to mitigate the negative impact of disaster on the Earth. Among these, planning and preparedness are the most important and crucial. Preparedness will save both lives and costs in the future. With latest technologies like GIS and RS and others, it has become possible to get little bit prior information about the location and magnitude of a likely disaster. Today, GIS and RS play an important role in disaster management and in catering to the needs of the affected area with its tools and applications but it will be possible with the scientist who handle and manage the software. It means a user should have enough knowledge about the procedure to handle and manage the software then will get the proper and effective information with the technology by the technologist.

Geographical Information System (GIS)

There are lots of definitions given by difference scientists. The Department of Environment UNO defines, "GIS as a system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data, which are spatially reference to the earth." According to Burrough, "GIS is a set of tools for collecting, storing, retrieving, transforming and displaying spatial data from real world for particular set of purposes." The main components of GIS are: computer system, software, Hardware and spatial data, and data management and analysis procedure.

Figure 8. GIS and their Components

Spatial data is also referred as to geographical data and is characterized by information about location, connections with other feature and detail of non-spatial characters.

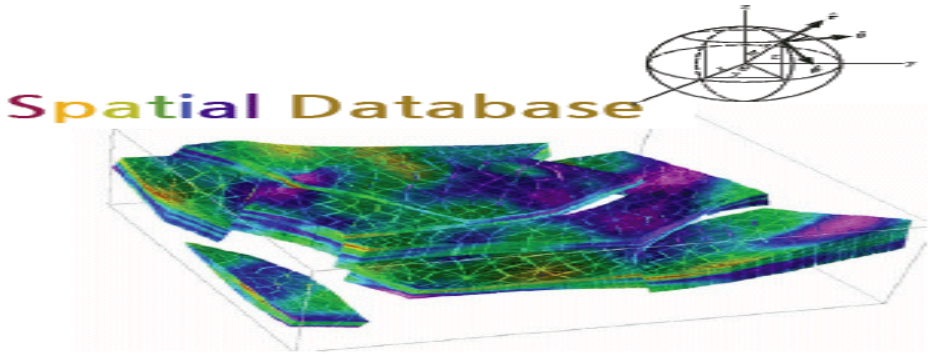

Figure 9. Representation of Spatial Data

For example- spatial data about a particular area may include:

a. Geographical reference, such as latitude and longitude

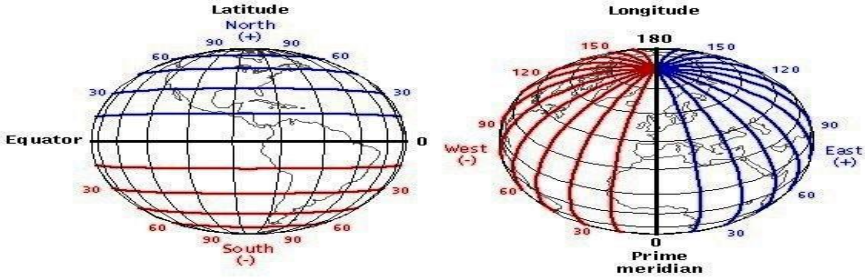

Figure 10. Representation of Geographical reference points such as latitude and longitude

b. Connection details, such as Tourist Places, Services Roads, Rail Heads, Airports, Seaports etc. which allows the outsiders to access that area as shown in the below figure.

Figure 11. Shown the Tourist Places in the Map of Delhi

Non-Spatial (or attribute) data, such details of climate conditions snow falls, rain fall, wind speed and its direction GIS use for geographical location, as a common thread to integrate and analyze information from various sources. GIS can also be put to use to access risk to life and property stemming from natural hazards such as earth quakes, cyclones, tsunami, floods, avalanches, cloud burst and fire. The potential use of GIS technology in geographical planning, it mitigates the negative impact indifferent situation of disasters. The possible uses are:

Studies and Analysis of Environmental Hazards Prone Areas

The geographical investigation of environmental hazards encompasses a wide range of studies in which GIS play an important role, including, studies of disease prone clusters, geographical surveillance, analysis of health statistics in relation to single or multiple sources of pollution, natural calamities as well as the size location and characteristics of population at risk. It has application in areas such as, quantitative risk assessment of exposure to outdoor air pollution, estimation of impact of flood hazards, health consequence of localized water pollution, infectious diseases and effects of global change, spread of vector borne disease, heat-related and cold related damages to lives both human and animals change in agricultural patterns yields, effects of ultra violet radiation from ozone depletion etc.GIS methods are also used in

planning of response of emergency service to manmade hazard especially chemical or radioactive element spillage, earthquakes or similar incidents.

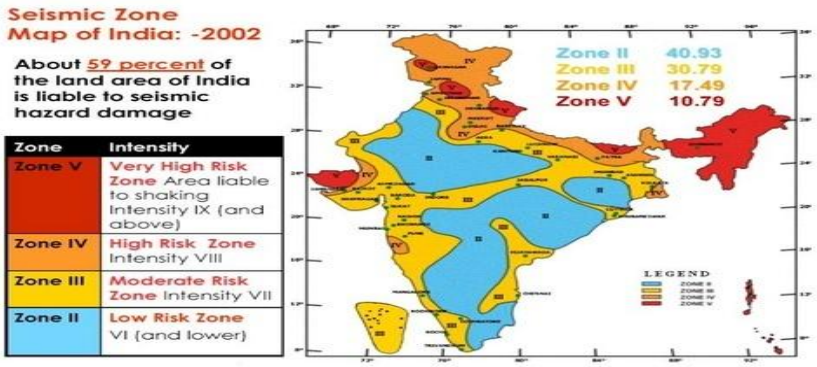

Figure 12. Shown Seismic Zone in Map of India as per 2002

Figure 13. Point out the most Polluted Points in Delhi

Figure 14. Mapped Cities in map of Delhi

Modeling of different scenario such as, pollution dispersion from an accident provides an indication of expected casualties and later health impacts. This information can then be used to test, in theory, the capacity of emergency services and health systems to deal with the emergency services and health systems to deal with the emergency. Useful lessons may be learnt and ultimate strategies be planned from such cases studies about emergency response procedures.

Mapping of Disease Prone Area

One of the most important functions of GIS is public health mapping. Maps of health statistics can be invaluable in understanding local pattern of diseases and their geographical distribution. They have the advantage of conveying instant visual information accessible to common person and even, public health professionals. Another benefit of GIS is that it allows semi-automated data processing so that analysis can be carried out at high resolution and with wide geographical coverage.GPS was used to collect the filariasis epidemiological information of selected villages, based on the GIS-based 25 km x 25 km grid sample procedures. The data pertaining to the mF and disease rate was mapped with graduated point symbol and the interpolation of contour surface was created for predicting the filariasis mF rate in the areas where data was not collected. The mF infection rate of selected sample villages was overlaid on the interpolation of contour surface of the predicted filariasis map of part of Tamil Nadu State in India. The procedures applied in the study was used for mapping the disease infection in the areas where data was not available and it was used for action plan for implementing disease surveillance, management of disease control programmes and for disease management in a vast country like India.

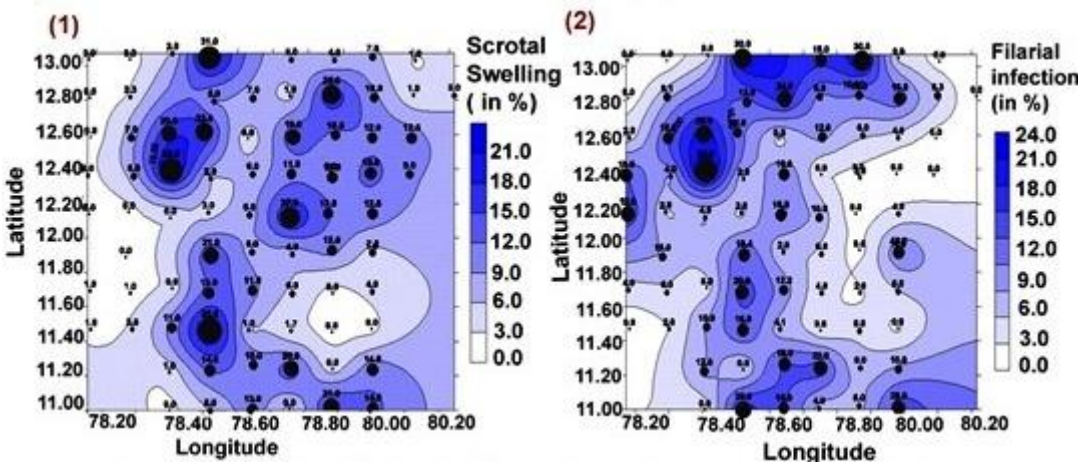

Figure 15. Spatial Interpolation of Filarial Disease **(1)**& Infection **(2)**

Spatial Analysis indicates that while filarial disease occurs as hot sports, infection is more diffused
(Source: http://geospatialworld.net/Regions/ArticleView.aspx?aid=30796#sthash.pPsaxunP.dpuf)

Search and Rescue Operations

GIS can be helped in carrying out search and rescue operations in a more effective manner by identifying areas that are disaster prone, categorizing them according to risk magnitudes, inventorying population and assets at risk and stimulating damage scenarios. In 1997, a Canadian government study determined that a better SARSAT system would be one based on medium Earth orbit (MEO) satellites. A MEO system can provide full global coverage, determine beacon location, and do this with fewer ground stations. GPS was identified as the ideal MEO constellation. And so was born the Distress Alerting Satellite System (DASS) that will become fully operational on Block III satellites. But already nine GPS satellites are hosting prototype hardware that is being used for proof-of-concept testing.

Figure 16. COSPAS-SARSAT System Overview

Records Management

Record keeping is a crucial task in disaster management claims, status of reconstruction, required repaired work, personnel and so forth can be difficult to maintain and account for GIS facilities record keeping and status changes, information can be quickly updated and reports generated. Current status can be easily viewed as an assessed through a centralized GIS, and Remote Sensing interface.

Remote Sensing (RS)

Remote Sensing is referred as, ”a technology for sampling electromagnetic radiation to acquire and interpret non-immediate geo-spatial data from which to extract information about features, objects and classes on the Earths land surface, oceans and atmosphere.”It collects data and information about the physical “world” by detecting and measuring radiation, particles and fields associated with objects located beyond the immediate vicinity of the sensor device(s).

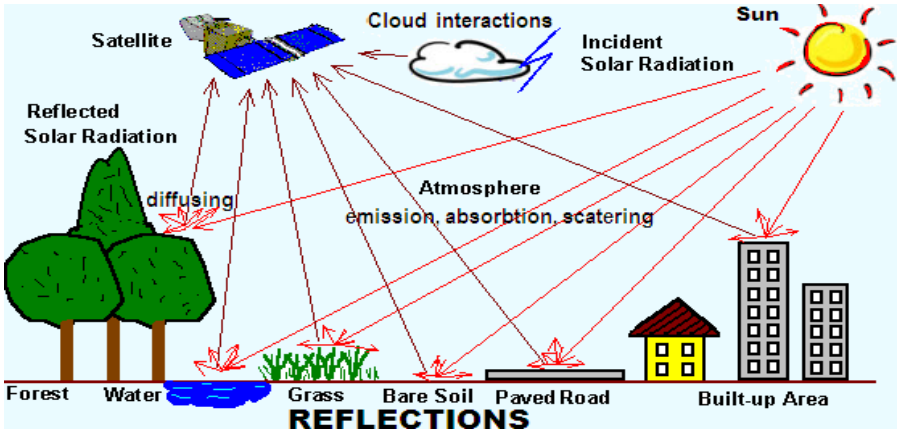

Figure 17. Work Process of RS

RS comprises of Arial Remote Sensing, which is the process of recording information such as photographs and images. The sensors may be fitted with the satellites or low flying objects or may be installed on the ground (Radars) to acquire the images from the earth. Remotely sensed imaged data may be recorded in either photographic or digital form. Data must be in digital form for computer processing. So any data, which was recorded photographically such as Ariel photography, are converted to digital form before being used in image processing systems. Most satellite image date and airborne scanner imagery are initially recorded in digital form.

RS rely upon the detection of energy emitted from or reflected by the objects. The source of the radiation being sensed may or may not be independent of the sensing device. Active remote sensing devices such as radar, direct radiation of a particular form towards an object and then detect the amount of that energy, which is radiated by the object.ERS images belong to the active RS system. On the other hand, passive RS relies on the radiation originating from some other source principally the sun aerial photography and SPOT satellite imagery are examples of data collected by passive RS systems. Images acquired from airborne sensors flying at a relatively low altitude cover rather than small areas, with a good levels of details images acquired from satellite borne sensors orbiting at hundreds of kilometers cover larger area, but usually provide a more coarse representation on the earth's surface. RS data can be useful for:

- Mapping of land-cover
- Assessment of environment
- Traffic flow management
- Air pollution modeling
- Disaster management
- Rehabilitation

Depending upon the need of the user, sources of RS information are chosen among the pool of image taken by the platform/sensors. Since the lunch of Land sat 1 in 1972, remotely sensed data have been used to map features on earth's surface. An increasing number of studies have used remotely sensed data for monitoring and surveillance or risk mapping. Nearly, all studies have used data from Landsat, French "SPOT" and NASA's "AVHRR" RS in conjunction with GIS and photogrammetric can be used to identify hazards. Scientists using GIS to analyze satellite image, aerial photos and field survey data may identify seismic faults and flood prone areas.

Application of GIS and RS in Disaster Management

Emergency disaster management requires response, incident mapping, establishing priorities, development action plans and implementing plans to protect lives, property and environment. RS and GIS allow disaster managers to quickly access and visually display critical information by location. This information facilitates the development action plans that are printed or transmitted to rescue team personnel for the coordination and implementation of emergency efforts and fast rescue work.

Real time monitoring of flood is useful for detecting the isolated villages and persons therein. This is very much helpful in initiating relief and health facilities to the victims. Simultaneously, the vulnerable population like aged, pregnant women, children, injured person and physically challenged can be better served with accuracy. Tracking of an epidemic following a disaster can be done through RS data and required health facilities can be sent to the affected area. Also, health infrastructure damaged during a disaster can be highlighted, and necessary restorative action can be plan and initiated.

Indian Meteorological Department (IMD) provides cyclone warning from the Area Cyclone Warning Centers (ACWCs) to the East Asian region. It has developed levels. It has developed necessary infrastructure to originate and disseminate the warnings at appropriate levels. It has made operational, a satellite-based communication system called Cyclone Warning Dissemination System(CWDS),for direct dissemination of Cyclone warning to cyclone prone coastal areas.IMD runs operationally a Limited Area Analysis and Forecast

System (LAFS), based on an Optimal Interpretation (OI) Analysis and Limited Area Primitive Equation(PE) Model, to provide numerical guidance.

Prior information acquired from the ACWSs could be used to respond to the health requirements of the disaster affected people. Mobilization of the health staff and other medical equipments, drinking water, food etc. can be planned before hand with the information obtained through RS. This will help in making health service responsive to the vulnerable group in the best of time.

Preparation of comprehensive landslide zone maps requires a large amount of data concerning many variables and covering large scope areas to be gathered, sorted and evaluated. The use of aerial photographs and adoption of RS techniques help in collection of such data. Hazard zone map can be helpful in planning the set up of the health facilities, like health centre and hospital, to serve the most vulnerable in the mountain ranges like Uttrakhand and other Himalayan States.

In 1998, the National Aeronautical and Space Administration (NASA),Centre for Health Applications of Aerospace Related Technologies(CHAART) evaluated current and planned satellite sensor system as a first step in enabling scientists to determine data relevant for epidemiologic, entomologic and ecologic aspects of their research, as well as development RS based models of transmission risk. The model was first implemented to characterize the spatial of key components of the Lyme disease transmission cycle in New York by using LANDSAT Thematic Map(TM) image.

In the case of West Bengal, the sediment load transported to the Bay of Bengal by the Ganga and its tributaries has nutrients that supported Plankton booms. Plankton is an important marine reservoir of Vibrio Cholera, which attaches primarily to zooplankton, which in turn is associated with phytoplankton along with this, data on sea surface temperature(SST) and sea surface height(SSH) were also analyzed after the colour infrared image were captured by different sensors. It has been observed that increase in SST and SSH has preceded cholera outbreaks in Ganga Delta region. A model driven by satellite RS will be useful in tracking the spatial and temporal development of such plumes, as they impinge on costal areas, related to outbreaks of cholera in coastal areas and enable more effective deployment of resources to counteract, if not prevent, massive epidemics of cholera.

Conclusion

Disaster preparedness, emergency relief and recovery are the three main lines of course of action that provide for an effective management of disasters. GIS addresses these issues by facilitating access to and dissemination of timely information and knowledge. It has operational utility, both, at the micro and macro level.

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