IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.-6, Issue-6, June 2018 E-ISSN: 2347-2693

The Role of Information Technology in the Predictive, Risk and Loss Estimate Models for various Natural Disasters

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Available online at: www.ijcseonline.org

Accepted: 09/Jun/2018, Published: 30/Jun/2018

Abstract— The paper depicts the various natural disasters occurring in different parts of the globe. With the help of information technology along with other branches of science it has become possible to study the basic environmental conditions before and after the events; even it becomes possible to predict the manifestations and indications before a disastrous occurrence. After the brief study of the different predictive models, it is easier to view the scenario of a country like India, where the major cities frequently faces the problem of urban flood which occurs due to continuous downpour. Along with the rain water the debris, sand particles and plastic solid waste (PSW) flowing from the nearby hilly or high level areas cause blockage to the major sewer drainage basins; resulting in different types of epidemic diseases. Urban flood can be avoided by keeping the flow of drainage basin clean, running and free of blockages. The study further helps to improvise a mathematical calculation of urban flood where the Lyapunov's stability criterion is discussed and a relation between the parameters of the artificial flood is implemented using the theory.

Keywords— Mike, OpenQuake, Artificial Flood, Sediment, Lyapunov stability .

I. INTRODUCTION

There has been many researches and studies done till present date and still going on in many zones over the globe for the natural disaster management and disaster risk management through modelling of the hazards, which acts an predictive model of the natural disasters. Many preventive measures has been discussed through decades of researches and experiments still it is difficult to bring out a permanent solution to get rid of these natural disasters. Predictive models cannot only prevent many mortality ratio and property damage but it can also take adequate steps in dealing with the natural calamities in proper time. In this paper it is tried to discuss the existing predictive models. Also the reason behind the urban flood and the parameters responsible due to heavy rainfall in some low lying cities in India has been studied.

The paper has been organized as follows, Section I contains the introduction for the need of a predictive model, Section II contain the literature survey on the existing models, Section III describes the related work done in the previous paper, Section IV gives the methodology where it is explained how the work can be extended with the concept of Lyapunov's definitions to construct a dynamical system and Section V concludes research work with future directions.

II. LITERATURE SURVEY ON VARIOUS MODELS

Before talking about the modelling techniques of different natural hazards due to climate change, it is important to discuss the various disastrous events that the globe has been facing from time to time. Among the various calamities the major ones which are chosen for this study are flood due to excessive rain, urbanization in hilly areas resulting in soil erosion, volcanic eruptions and earthquake. Various modelling techniques and models are designed to cope up with the different types of natural disasters.

A. MIKE FLOOD Model

Starting with flood inundation modelling using MIKE FLOOD [11], developed at the Danish Hydraulic Institute, Denmark which has been used to simulate the flood inundation and the maximum simulated extent was then compared with the image obtained from the IRS-1D WiFS of the inundated area. Using the MIKE 11 software the river flow for the delta region of Mahanadi river basin has been simulated and performed quite satisfactorily [11]. Mahanadi river basin falls in the delta region in eastern India and it is a highly populated region in the state of Orissa. Orissa is considered as a major paddy growing state in the country.

Floods are frequently occurring in this part during the monsoon period which starts from June till October, it not only causes severe damage to crops but also to lives. There are two types of flood management measures, i.e., structural and non-structural that may be adopted. The structural measures can be considered as embankments, levees or spurs which have not been proved very effective during the long run. Thus the practice of non-structural measures came into existence which includes flood risk zoning and flood forecasting [7, 11]. It is necessary to simulate the flood inundation in the flood plains caused by different magnitudes of floods for the development of flood hazard and risk zone maps. In the past few years, various researchers have used the hydrodynamic modeling approach to simulate flood inundation in the floodplains [11]. For floodplain delineation, inundation and flow simulation different numerical models have been developed that are used as tools to delineate the floodplain zones bordering the rivers and calculate the associated risk. The numerical models can be categorized as:

1) One dimensional (1D) models
2) Two dimensional(2D) models, and
3) One dimensional river flow models coupled with two-dimensional floodplain flow (1D-2D) models.

MIKE FLOOD is a coupled 1D-2D hydrodynamic model where the flood inundation is done using an average value of Manning's n equal to 0.05 for the floodplains. The model calibrates and validates the results and proves that the model performs satisfactorily in simulating the river flow for the delta region of Mahanadi river basin.

B. Global Earthquake Model

Global Earthquake Model (GEM) has an open-source software named OpenQuake which is a web-based risk assessment platform. Earthquake risk is modelled, viewed, explored and managed by OpenQuake, it has got five main calculators, and each one has got its own contribution in the area of seismic risk assessment and mitigation. One of the calculators of the OpenQuake engine is the SDA (Scenario damage assessment) which estimates the damage distribution due to a single, scenario earthquake; it also gives the estimation of collective assets. It is used for emergency management planning or to assess which assets are more seismic vulnerable [14].

The OpenQuake project was initiated by GEM [14] for calculating and communicating earthquake risk worldwide. OpenQuake engine has got a scientific library that rely on a data model; the objects used in hazard and risk calculations are represented by the data model; which was developed in parallel to the engine. To transfer different types of information within the software and outside it a transparent and standard markup language is used, named as the Natural hazards Risk Markup Language (NRML), it is XML-based and influenced from the GEM1 experience and existing standards, such as the Geography Markup Language (GML).
NRML can be found hosted on a repository at GitHub, and Open-Quake Engine User Manual has all the information regarding how to create and edit the existing files found within. At the beginning the scope of NRML is for seismic risk, it was not planned to cover the language for other natural hazards such as hurricanes, floods or tsunamis. Later it is being used to represent input data such as logic trees, hazard maps, loss curves and loss maps, vulnerability models, hazard source zone models, finite ruptures, exposure models, hazard curves, ground-motion fields, and damage distributions [14].
Seismic source model is a model that provides information about location, geometry, and activity of seismic sources. The model is defined as a sequence of seismic sources, each seismic source in NRML, can be defined as one of four possible typologies:

1) Area of uniform seismicity.
2) Point of concentrated seismicity.
3) Simple fault: 3D surface describing seismicity on a regular fault plane.
4) Complex fault: 3D surface describing seismicity occurring on a complex fault plane (Figure 1).

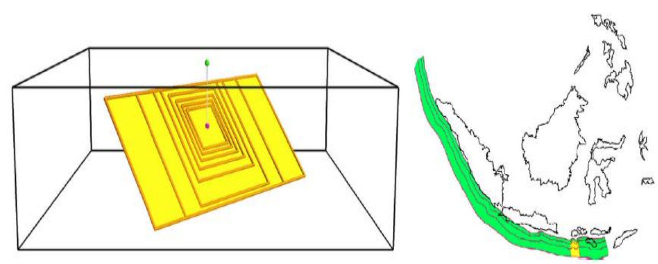

Figure 1. Point sources (left) and modeling of complex geometry fault sources (right) in the OpenQuake engine. Source [14]

C. Erosion Potential Model

Erosion Potential Model (EPM) was developed by Gavrilovic and carried out in South Serbia closely to the Macedonian border was based on field researches. EPM was used for Erosion Map for the watershed or erosive regions in Croatia, Slovenia and Czech Republic. There were two EPM approaches: expert-based method that was used basically for the development of the Erosion Map of Serbia, 1975 and Erosion map of R Macedonia 1993. And the second approach is the empirical based model. Both the models hold different characteristics. The coefficient of erosion Z is calculated based on erosion map of the watershed and the formula given Gavrilovic [5] is a numerical expression of the intensity of soil erosion in the watershed. Erosion map is also necessary in land use plans and can be used as the basis for calculation of gross erosion production and transport of sediment for the watershed. The model helped significantly for the non gauged watersheds, which have not been hydrologically researched, i.e. without measured data on water discharge and sediment transport. These data are necessary design for all kinds of erosion control and torrent management works, also for the designs of all types of construction dealing with water. Based on erosion map, localities in the watershed, different sizes of watersheds can be planned for erosion control works, land use plans [5].

D. Deltares hydro software

Deltares is an independent institute in the field of water and subsurface for applied research. Deltares hydro software has been considered as a name for decades which is used throughout the world by water modelers, consultants, managers, and researchers. Five numbers of packages are integrated and renovated technologically as part of the Next Generation Hydro Software (NGHS) project. One of the main goals of the NGHS project is to integrate the functionality packages within a single software framework named Delta Shell. The packages have been used by many international water modeling communities, these are Delft3D, Simona, SOBEK, DUFLOW and SOBEK-RE. For the simulation of river morphology, salt intrusion and surface water quality, flood forecasting, optimization of drainage systems, control of irrigation systems, and in many other applications these packages are used. The NGHS project mainly focuses for improvement, harmonization and integration of existing hydro software that has been developed throughout the years. A new computational core, which is user-friendly, open modelling environment Delta Shell, innovated as an important technological development known as the D-Flow Flexible Mesh. The project focuses on the possibility of setting up integrated models of the whole aquatic chain from the source to the sea, resulting in complex model configurations [4].

The new hydro software has got benefits for its users, an integrated model of the water system, from source to sea is provided by a powerful computational core; the core results in a more precise and effective representation of the flow using unstructured grids; large and complex models can also be scaled. The main innovations and strength of the new hydro software lie within the new computational core D-Flow Flexible Mesh and the integrated modeling environment Delta Shell [4].

Further, the most important features of the new modeling environment assumes that a map of the area is continuously present, so all the measures affecting the catchment are visible at a glance; it is possible to couple and run several models; the same tools are used for different models; numerical models are decoupled from the high-level data structures like hydrographic schematizations, grids, or measurements; a wide user group like developers, modelers, advisors and managers should be able to use the new software.

Delta Shell is an Open Integrated Modelling System which tries to simplify by providing a set of components that are used to save, define and visualize different scientific data structures and coupled model configurations. Delta Shell also operates in command-line and graphical user interface mode. High-end open-source libraries are required for the development and it is also available as open source software. The architecture of Delta Shell creates an environment for the development of new plug-ins, like managing geospatial and time dependent data, integrate models or provide specific visualization of components, import/export model configurations. Delta Shell also provides an intuitive and clean application programming interface (API) fully accessible from the Python-based scripting environment. SOBEK 3, a new version of graphical user interface which is used for simulation of flow of water and transport of pollutants in rivers, catchments and channels is one of the application developed using software framework by Delta Shell. Integration of 0D model can be shown by lumped hydrological models and real-time control rules, 1D model can be shown for river flow and water quality models and 2D/3D model components can be shown for estuary, river and coastal areas. The project's preliminary results were demonstrated with its current status along with a preview of possible future developments. In SOBEK, 1D and 2D approaches are combined and allows simulation of water flow in river reaches as well as river-bank overflow and flow at flood plains [4].

E. Event driven flood management model.

Flood is considered as a natural phenomenon which is difficult to prevent but it can be managed by proper planning and implementation. For taking decisions distributed information and resources need to be considered. Organizing, transferring, and analyzing the information at the time of flood is an overhead, which is why to minimize it, service-oriented architecture (SOA) is implemented for flood management. It has the advantage of utilizing the information as a service, which can be reused without extra efforts [13]. SOA has a model-driven implementation functionality facilitating development of new functions. By using this functionality, an event-driven SOA is proposed and implemented for managing the flood disaster. The software modules developed on event-driven SOA to collect the details about the various environmental factors like rainfall, cloud cover, and river level which effects flood situation. It also has the advantage of tracking the status simultaneously. When the parameter values crosses the thresholds, automatic flood event alerts get generated and auto procedures get activated for satellite data planning, satellite data processing, situation analysis, flood extraction and decision-making by utilizing the distributed information as a service [2, 13].

Flood management applications need a framework based on principles of SOA. A study devises a mechanism with SOA design [13] where the probability of flood event occurrence can be monitored by different environmental parameters. These parameters are studied by many nodal agencies working in different areas. For flood management different comprehensive techniques needs integration using remote sensing technologies for satellite data planning, mapping, processing, acquisition and decision-making. The architecture is proposed based on SOA basic principles, to enable all these processes in an efficient manner along with application of event-driven methods to address flood management. It also addresses available ways to convert non-spatial data into spatial form and interoperability issues, unavailability of spatial data, for integrating spatial data for flood event identification and management. The SOA can provide service reusability, but during an actual emergency it becomes critical to provide the right data, at the right time to respond and take appropriate action. Components of event-driven SOA for flood management are discussed in the following sections:

1) Data Collection

The information generated by nodal agencies may not be in standard data representation format which can be interoperable and ready to use or be generally closed. Thus the concept of data collection layer came, where the layer is responsible for data collection and interoperability of the collected data. After gathering information, it should be converted into machine-independent interoperable format which are further used for organization into spatial databases.

2) Data Filtering

Before injecting the data into databases the layer does a filtration. The main issue in automatic real-time data collection is the unavailability of information or non-updating at another side. It may happen that there may be a time lag between data collection and hosting at data provider end.

3) Data Publishing

Once the data have been filtered, it is ready for publishing and for organizing into database. Different tables are maintained to organize the river levels, rainfall and news data-sets along with the metadata of the cloud images. The point water levels, data of rainfall, and news have been organized into open-source relational database (PostgreSQL) for querying and retrieval.

4) Situation Monitoring

The most important module after information collection is the monitoring and event generation module. The historical flood events have been organized into databases with different thresholds for different area and basins. A library of rules and values has been created for rainfall and water level.

5) Flood Mapping

The damage can be accessed using the pre and post satellite imagery after the flood event is activated and satellite data are planned by event-driven methods on SOA. All the possible satellite coverage over the area can be found out by automatic procedures developed and the user can select the suitable coverage for planning the satellite acquisition. Flood inundation area, worst flood affected area, its extent, and the depth can be calculated by semi-automatic procedures. Semi-automated procedures for image correction, flood depth estimation and flood area extraction have been developed with open-source softwares. Quantum GIS has been customized for semi-automated flood delineation using NEST (Next ESA SAR Toolbox) and optical data. Once the flood area and depth have been calculated they are interlinked with the socio economic data giving the statistics of people, house, or village affected for planning relief and rescue operations.

6) Presentation and Decision-Making

To analyze the data and results, a thin client web-based application is needed. A 2D spatial viewer with GIS tools has been developed for data visualization. The viewer is capable of integrating the different OGC compatible web service, ground data, emergency/critical facility databases, crowd sourced data, model simulation, and flood products. For depth visualization, a 3D viewer has been customized using open-source software Cesium. The decision-makers can overlay the pre- and post-images along with the emergency facility and can draw plan of action for relief and rescue. Advanced GIS tools like shortest path, facility finding in vicinity (proximity analysis), and resource distribution can be implemented using this. After drawing the plan of action, the decision-makers can take a print online and send soft copy and hard copy to the teams on ground in near real time [13].

F. Volcanic ash fall hazard and risk

Volcanic eruptions have been looked as one of the steady and slow destructive event in the world. It can produce a number of hazards that vary widely in their spatial distribution. The impacts volcanic eruption can have for the society is most frequent, and often widespread. Volcanic hazard tephra occurs more than 90% of all eruptions. Ash falls usually do not endanger human life directly, but it threatens public health in the long run. For the first time when volcanic hazard has been included in the UNISDR Global Assessment Report and it has been reviewed by the Global Volcano Model network (GVM) and the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI). These organizations highlight the importance of ash as a far-reaching volcanic hazard that can disrupt human activities at very small intensities. Volcanic hazard and risk research is a rapidly evolving field and ongoing researches has been going on towards better quantitative analysis and communication of the uncertainties associated with current approaches. The examples illustrated and broad overviews that were discussed depict only some of the many strands of volcanic hazard and risk research being undertaken by the volcanology community. For example KazanRisk loss model which uses numerical dispersal modelling of ash fall in Greater Tokyo to estimate potential losses associated with building damage, clean-up and reductions in agricultural productivity have been discussed. CAPRA risk modelling platform were used to provide preliminary estimates of potential building damage around active volcanoes in the Asia-Pacific Region using simplified volcanic hazard outputs from a statistical emulator [10].

G. *Earthquake Risk Model*

Earthquake Risk Model (EQRM) is Geoscience Australia's event-based tool for modelling the ground motion and loss associated with individual earthquake scenarios and probabilistic seismic hazard analysis (PSHA) and probabilistic seismic risk analysis (PSRA). It has been used for many of Australia's largest cities and it has become an important tool for the emergency management community which uses it for scenario response planning. The tool has been refined for use to provide automatic loss estimates within minutes of an earthquake occurring, in Australian earthquake monitoring programs. The software's open-source beta-release version is freely available on SourceForge [12]. It can be used for hazard or risk analysis in any region of the world with the supply of appropriate formatted input files. For the use of advanced users source code is also supplied so that they can modify individual components to suit their needs. The need for open source tools for modelling earthquake risk is rapidly recognized in the broader earthquake engineering community. The Global Earthquake Model initiative led by the Global Science Forum of the Organization for Economic Cooperation and Development has worked in the field. In the sense of earthquake risk studies the nature of a risk assessment depends on its purpose, it can be categorized into scenario and probabilistic analysis. Modelling earthquake scenarios involves the estimation of loss for events of interest and an analysis of expected ground motion. Through geological studies events can be identified in advance and scenario simulations undertaken to assist with mitigation planning, emergency response exercises and providing advice to the community. Alternatively, software can be linked with seismic networks to provide real time estimates of losses for events as they are observed. The idea behind was implemented by PAGER, project JRA3 of NERIES and Philippine Institute of Volcanology and Seismology's implementation REDAS. PSHA and PSRA provide a framework for uncertainty in the size, location and likelihood of earthquakes can be modelled for future events. Earthquake hazard is measured in terms of the level of ground shaking that has a certain chance of being exceeded in a given time. And earthquake risk can be defined as the likelihood that social or economic consequence suffer, it can be quantified by the level of financial loss that has a certain chance of being exceeded in a given time period. Generally, PSRA focuses on the direct financial loss after an earthquake, however indirect losses and economic flow on effects can also be considered. EQRM is a multi-purpose software package for earthquake hazard and risk analysis that can be used to model ground motion or financial loss to a building inventory for an event of interest in *scenario mode*. It can be used in *probabilistic mode* to generate a catalogue of synthetic events which are representative of all events in a region with a few small changes to the input parameters. The model then utilises the catalogue for a building inventory of interest to undertake PSHA and/or PSRA. EQRM has a beta-release version which is freely available with an open-source license from Source Forge. The EQRM model is used to generate and investigate the potential impacts of an event on the Morwell Monocline having magnitude Mw 6.9. A study on EQRM model focuses on impacts to residential structures. A map of the peak ground acceleration (PGA) on soil, a ground motion model designed for eastern North America calculates ground motion due to the absence of an appropriate Australian specific ground motion model for rock motions can also be shown. Local soil conditions were then incorporated using national scale site-response models developed collaboratively with Risk Management Solutions [12].

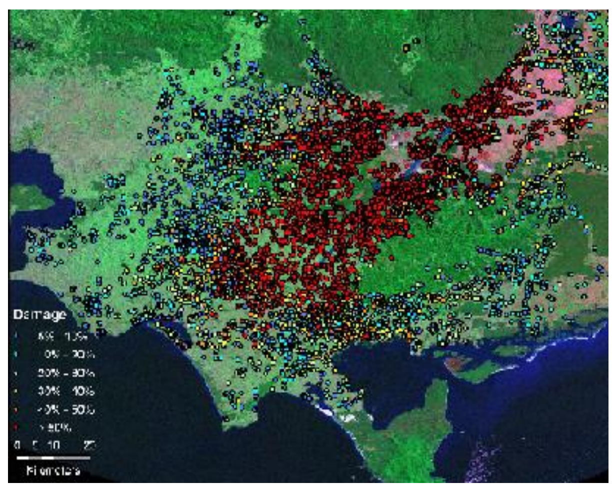

Figure 2. Damage to residential structures from a Mw 6.9 earthquake on the Morwell Moncline. Source [12]

The spatial variation of modelled residential losses for this scenario is illustrated in Figure 2. Losses are illustrated as a percentage of the total building value. The figure provides invaluable information sustained as well as identifying areas which should be the priority on the level of damage for any search and rescue operation. For example, the majority of severely damaged structures which are more than 50% of the damage are located near the actual earthquake. EQRM can produce broad estimates of casualties associated with this event along with providing a spatial distribution of damage [12].

III. RELATED WORK

Urban flood due to heavy rainfall in some parts of India is a common problem. There are many factors responsible for urban flood; few of the unavoidable factors are the amount of rainfall, duration of rainfall, amount of sedimentation deposited at the drainage basin and the self cleansing velocity. It has been discussed previously in a study paper which has been accepted in the upcoming conference of International Conference on Intelligent Manufacturing and Automation, 2018 organised by Departments of Mechanical and Production Engineering jointly with Indian Society of Manufacturing Engineers [6]. A computational model has been evaluated by a mathematical equation of artificial flood considering all the discussed factors. The work can be divided into the following steps:

A. Access the rainfall data

First of all, annual rainfall data set is collected from the Regional Meteorological Center, LGBI, Airport, Guwahati.

B. Clustering of data

The rainfall data is clustered into three categories i.e. low rainfall, medium rainfall and heavy rainfall using the data mining tool Weka [6].

C. Computational Model

A mathematical computational model is evaluated for artificial flood (AF) which is given by the equation:

$$AF = Rainfall\ in\ m + \frac{Rate\ of\ Deposition\ of\ sediment\ in\ m/s}{Self\ cleansing\ velocity\ in\ m/s} \quad (1)$$

Where Self cleansing velocity is the rate at which the rain water is soaked at the ground naturally. It is given by [6]

$$V_s = \frac{8K}{f}(S_s - 1)gd_s \quad (2)$$

where V_s= Velocity of Flow or Self-cleansing velocity

K = characteristics of solid usually which is taken as 0.04 to 0.06

f = Dancy’s coefficient of friction which is usually taken as 0.03

S_s= Specific gravity of solid which is usually taken as 2.65

d_s = Effective grain size.

The value of self-cleansing velocity (2) for the calculation varies between 0.7 *m/s* to 1.2 *m/s* in general estimation. And it is considered that there is a possibility of artificial flood in the area when the rain water rises to a level to a level of $0.5\ m$

Therefore, two examples are taken

Example I: Considering Rate of deposition of sediment = $0.65\ m/s$

Amount of rainfall in m = $0.0073\ m$

Self-Cleansing Velocity = $0.7\ m/s$

AF = $0.935m$ (Big possibility of Artificial flood)

Example II: Now when self -cleansing velocity is increased manually or mechanically by some suitable method. Considering Rate of deposition of sediment = $0.65\ m/s$

Amount of rainfall in m =$0.0073\ m$

Self-Cleansing Velocity = $1.2\ m/s$

AF = $0.548\ m$

Naturally when the self-cleansing velocity is increased the level of sediment in the drain basin should go down, here if we consider rate of deposition of sediment = $0.15\ m/s$

Amount of rainfall in m = $0.0073\ m$

Self-Cleansing Velocity = $1.2\ m/s$

AF = $0.132\ m$

We can see that when the self cleansing velocity is increased to 1.2 m/s the value of AF decreases, which clearly shows that the level of artificial flood depends on the rate of self cleansing velocity. We then tried to figure out the relationship of AF and self cleansing velocity with the help of an automaton which is modeled using timed transition automaton with the clock values.

D. Verification using Uppaal

The model is then converted into a timed transition automaton which simulated using Uppaal [6].

IV. METHODOLOGY

The paper depicts about the various models designed for calculating the risk handling and predictive methods with the help of different software tools. For the computation of different predictive measures that can be implemented before an urban flood occurs, we have already presented a mathematical calculation of artificial flood in Equation (1), where the amount of rainfall doesn’t affect the value of AF in large, it mostly depends on the amount of sediment brought along with the rainfall water from the higher level areas. The sediment contains sand, concrete debris, dust particles, sewer wastage, plastic bags etc. which results in the blockage of the mainstream drain. Thus the artificial flood mostly depends on the value of rate of sediment depositing at the bed of the drainage basin and the rate of cleansing velocity. We can consider the scenario as a system where the stability of the system can be created.

A. Overview of Lyapunov stability criterion

A nonlinear system, in general, can be defined as follows:

$x'(t) = f(t, t_0, x, x_0)$

$x(t_0) = x_0$

where f is a non-linear function of the time, the system state, and the initial conditions. If the initial conditions are known, we can simplify this as [3]:

$x'(t) = f(t, x)$ (3)

Lyapunov's direct method is employed to prove these stability properties for a nonlinear system and prove stability and convergence. The possible function definiteness is introduced which forms the building block of Lyapunov's direct method [8].

The equilibrium point x^*=0 of (3) is stable in the sense of Lyapunov at t= $t_0$if for any ϵ >0 there exists a $\partial(t_0, \epsilon)$ >0 such that

$\| x(t_0)\| < \partial \Rightarrow \| x(t_0)\| < \epsilon$, where $t \geq t_0$ (4)

Stability in the sense of Lyapunov is a very mild requirement on equilibrium points. In particular, it does not require that trajectories starting close to the origin tend to the origin asymptotically. Also, stability is defined at a time instant t_0. Uniform stability is a concept which guarantees that the equilibrium point is not losing stability. It is stated that for a uniformly stable equilibrium point x^*, ∂ in the definition (3) not be a function of t_0, so that (4) may hold for all t_0 [8]. Stability of a dynamic system can be understood from the Figure 3 where two regions are considered S(ϵ) and S(∂), x_0, x_e are the starting point and the origin of the trajectory respectively.

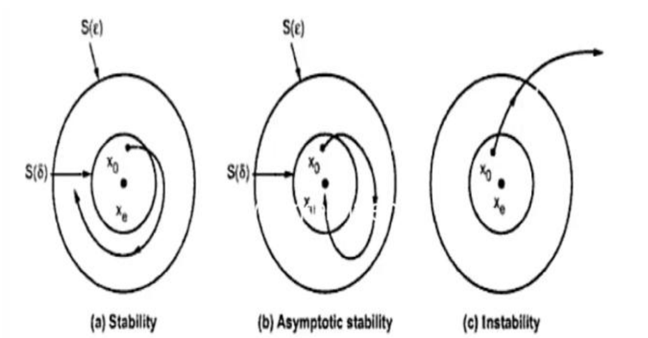

Figure 3. Shows three trajectories for stability of a dynamical system. Source [15]

Lyapunov's stability criterion holds some of the scenarios:

1) Positive Definiteness

A scalar function $f(x)$ is said to be positive definite in a particular definite region which includes the origin of state space if $f(x) > 0$ [1, 15] for all non-zero states x in that region and $f(0) = 0$. For e.g. $f(x) = x_1^2 + 2\,x_2^2$ (5)

2) Negative Definiteness

A scalar function $f(x)$is said to be negative definite if $f(x)$is positive definite. For e.g.$f(x) = -x_1^2 - (3x_1 + 2\,x_2)^2$[1,15]

Here we can apply the concept of the water flowing in the drainage as a system where we can consider the rate of sediment and the self cleansing velocity can be assigned some numerical value to see if a Lyapunov function can be generated to study the stability of non linear dynamical systems. The method is applied to systems of the form (3)

Here at time t, .rise of water due to sediment can be extracted from the following example.

$$AF = Rainfall\ in\ m + \{\frac{Rate of Deposition\ of\ sediment\ in\ m/s}{V_s\ in\ m/s}\}$$

Where $V_s = \frac{8K}{f}(S_s - 1)gd_s$ [6]

Considering Rate of deposition of sediment = $0.65\ m/s$

Amount of rainfall in m= $0.0073\ m$

Self-Cleansing Velocity = $0.7\ m/s$

Rise of water/AF = $0.935m$

Similarly, when Self-Cleansing Velocity = $1.2\ m/s$

AF = $0.548\ m$

Let us consider (5) $f(x) = x_1^2 + 2\,x_2^2$

$x_1 = 0.935$

$x_2 = 0.548$

Therefore, $f(x) = 1.174$

It shows a positive definite system. It is possible to evaluate for negative definiteness, positive semidefinite, negative semidefinite and for indefiniteness of a system.

V. CONCLUSION AND FUTURE WORK

We can further describe the scenario in depth as how the cleansing mechanism can be carried out during a heavy rainfall; considering it as a non linear system to achieve a certain equilibrium point. In this survey we have tried to study the different existing predictive and risk estimation models. Thereafter a mathematical computation for AF which has been carried out in our previous work, using two parameters i.e. rate of deposition of sediment and the self cleansing velocity; are shown with the help of two examples. We have then viewed the concept of Lyapunov's stability criterion and the definiteness of a system in terms of few of the relevant parameters which are responsible for the occurrence of AF which might help us to design a stable system in the future and further research over the matter to bring out a solution of artificial flood.

ACKNOWLEDGMENT

The authors would like to thank the Regional Meteorological Centre, Guwahati for availing the rainfall data sets and the entire members of Department of Information Technology, Gauhati University, Jalukbari, Assam for giving the working environment and constant support during the survey.

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