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Artificial Intelligence in Disaster Management

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Abstract: *Human life is in danger due to human activities and natural disaster. Disaster is a one type of event which effects human life in terms of life and wealth like 6500 people died in 2017 in Asian continent due to 200 disaster and also billion dollars economic loses. But, no one can avoid disaster until we live on the lap of nature. We can only minimize the loss of life and economic losses by using scientific based proper plan with the help of computer, information communication technology (ICT) and Artificial Intelligence. All most all private and government agencies like Indian Meteorological department (IMD), National remote sensing agency (NRSA), The Central water commission (CWC) etc. using internet, Geographical information system (GIS) and Remote sensing (RS) like component of information communication technology in disaster management process. It is not enough to use ICT only in disaster management process because present and future era of engineering is Artificial Intelligence. So, It is necessary to use artificial intelligence in disaster management process to minimize loses of human life and also rescue operation time by using robotics, drone, sensors etc.*

Keywords: *ICT, GIS, RS, AI, human life, economic loses etc.*

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I. Introduction

Disaster word is the combination of two word "DES" and "star" having the meaning "bad" and "star "respectively so ,a Disaster is a seriously disruptions in community or a society material loses ,economic loses, social loses, environmental loses etc.

Management means process of continually or dealing with people or thing Disaster management can be defined as the organizing and managing the resource and response to deal humanitarian affect in emergency.

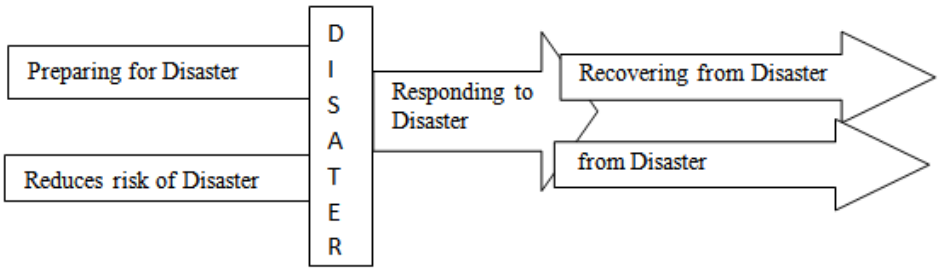

Figure 1.1 Disaster Management

Disaster risk management manages in three stages [1]:

1 **Pre-Disaster** (before a Disaster): Action taken to reduce human loss &prefer loses.
2 **Disaster occurrence:**(during a Disaster):action taken to minimize the need of victims i.e.emergency responses
3 **Post Disaster**:(after Disaster): action taken for recover and reliability taken of offered community

The main goals of disaster management are:

1 Reduces or avoid, loses from hazards
2 Assure prompt assistance to victims
3 Achieve and effective recovering

These are four phase of Disaster management [2]. But they can overlap:

1 Mitigation: Mitigation activities actually eliminate Disaster accuracy or minimize the effect of Disaster i.e. Public education vulnerability analysis etc.
2Preparedness: planning for responding i.e. emergency training warning system

3 responses: action to minimize the hazard causes by a Disaster i.e. emergencyrelief, search and rescue

4 Recovery: normalization of community i.e. temporary housing,grants, medical care etc.

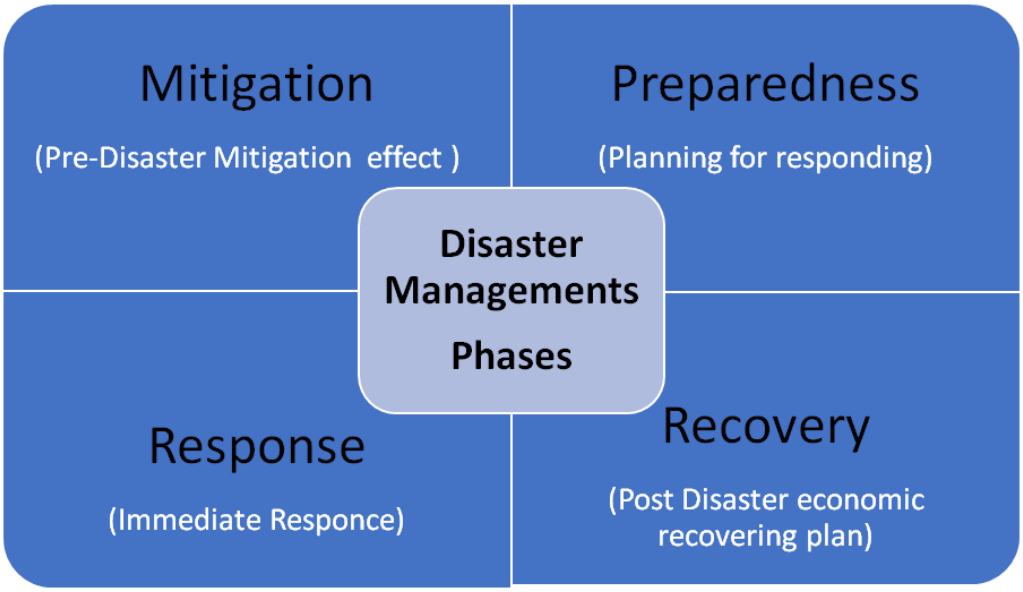

Figure 1.2: Phase of Disaster management

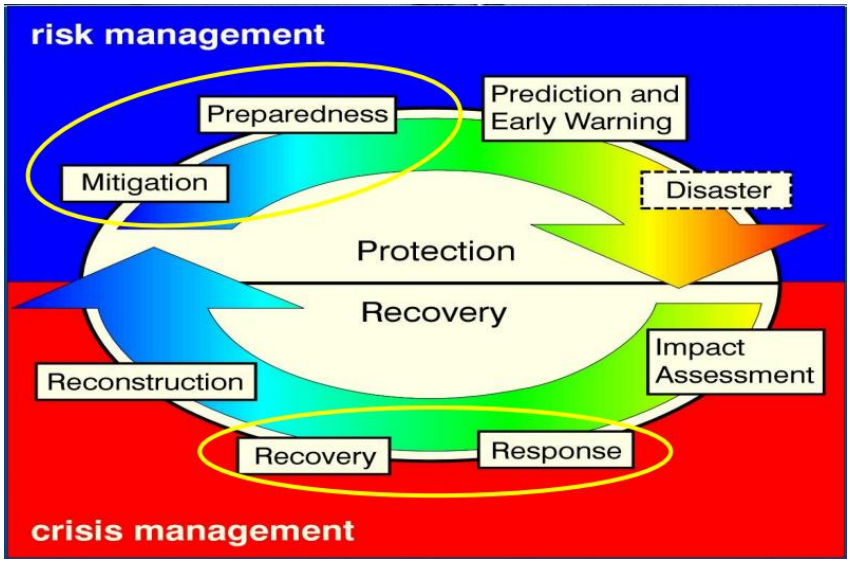

Figure 1.3: Crisis and risk Management [7]

Hazard is a dangerous condition causing loss of life or property basically there two type of hazards [3]

1 Natural hazards: land slide, floods, drought, fires etc.

2 Manmade hazards: explosion, pollution, war, dam failure etc.

3

II. Artificial Intelligence

ARTIFICIAL Inelegancy means artificial device having intelligence that means manmade device which can acquire knowledge, understand knowledge and apply the knowledge. But as per father of AI, John McCarthy AI is ”the science and engineering of making intelligence machine”.151% economic losses is due to environment related loses. AI has the opportunity for the environment also [4]:

1 climate change

2 Bio diversity and climate change

3 Clear air

4 Weather and Disaster resilience

AI Applications

1 predication and forecasting
2 early warning system
3 resilience infrastructure
4 resilience planning

AI component used by Disaster management

1 Satellite
2 Crowd sourcing
3 Sensor and IoT
4 Mobile GPS
5 Simulation
6 Combination of variants IOT's
7 Amend aerial

Need of Disaster management

As per UN report 2018, India rank fourth worst hit country among top five including US, China, Japan and PuertoRico [5].

- Global economic losses due Disaster between 1998-2017=$2.9
- 1.3 billion People lost their lives 1998-2017
- 151% economic loses increase in lost 20 years due to climate
- India lost$ 80 billion to natural Disaster over past
- 91% Disaster out of 7255 Disaster war related to climate in last 20 year
-

Table2.1: Loses due to disaster

Country	Loses($Billion)
US	9448
China	492.2
Japan	376.3
India	79.5
Puertorico	17.7

The most frequently occurring of Disaster are floods (43.4%) and storms (28.2%). 7, 47,234 people die due to earth quake in last 20 years including tsunami [6].

Typology of drought risk management [7]

1 Drought preparedness
2 Drought mitigation
3 Drought responses
4 Drought recovery

III. Drought preparedness and AI

Drought preparedness means establishment of polices, planes and activity beforedrought i.e. forecasting. Forecasting of drought using AI can be done by number of ways some of them are

- Using neural Network machine learning
- Support Vector Regression
- Using Data Mining
- And others.

There are several draught indices for draught forecasting like Palmer Index, Crop Moisture Index, standard precipitation Index etc. The most popular indices are Crop Moisture Index and standard precipitation Index while standardization is the most important characteristics of draught index. Standardization means independent of Geographical position. The characteristics of standard precipitation Index does not vary from site to site that is why it is mostly liked by researchers. Neural network working is similar to working of brain based on set of algorithms. Basically, NN is used for classification, clustering and predictive analysis. A classification problem could be seen as predictor of classes, but Predicted values are usually continuous where as classifications are discreet. Predictions are often (but not always) about the future whereas classifications are about the present. Classification is more concerned with the input than the output. Network consists of several layers of nodes. Node is just a computation place just like our brain. The simplest node is shown in following figure [8]:

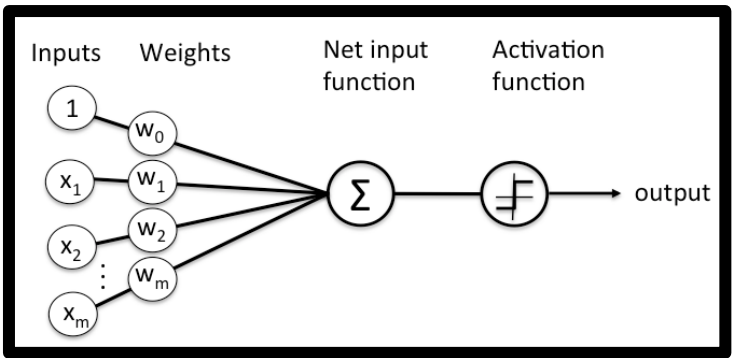

Figure: 3.1 working of NN

All neurons have the same structure. Input and outputs are mapped with the help of weights and mathematically

Output is computed as:
Input * weight = guess (i.e. output) ----------i.e. is scoring input……..(1)

Ground truth - guess = error ---------- i.e. calculation of loses……...(2)

Error * weight's contribution to error = adjustment -----i.e. updating model…….(3)

Where:

Error is difference between ground truth and network truth.
Ground truth of data is asked from experts
Adjustment is necessary to update model

Based on these three basic mathematical equations of NN, it can be defined as a corrective feedback loop, rewarding weights (that support its correct guesses), and punishing weights (that lead it to error).The following steps were used for modeling drought [9]:
a. Selection of Input and Target data for calibration and validation.
b. Model structure selection and estimation of its parameters.
c. Validation of selected model RStudio along with the ANN package (neural net) was used for designing, implementing, visualizing, validating and simulating neural networks.
MLP architecture can be used in drought prediction while there are several methods for forecasting using NN.

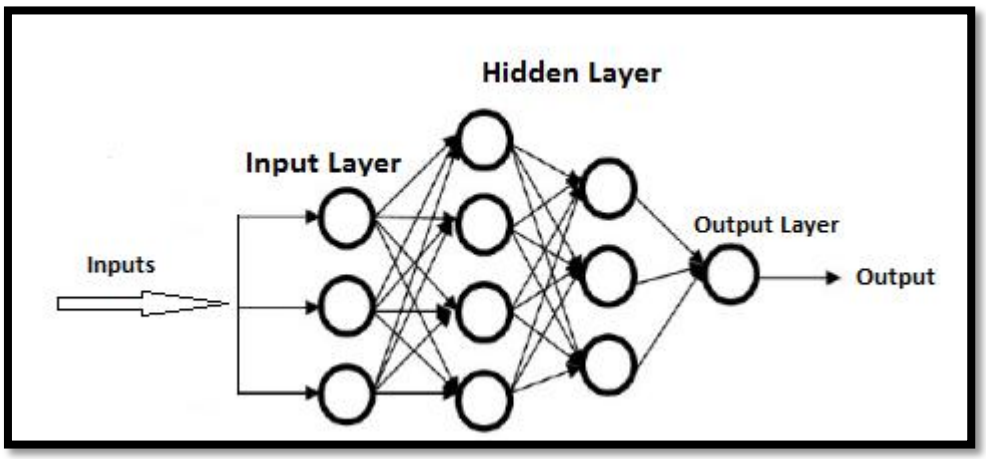

Figure: 3.2 simple feed forward network

MLP with feed forward neural network is used in many applications. The ML model is the mostly used ANN's type approach for modeling. It belongs to a general class structure of ANN called feed forward neural network. A feed forward neural network is a basic type of neural network that is capable of approximating both continuous and integrable functions. Network architecture of MLP consists of neurons that grouped in layers.

In MLPNN model, all the input nodes are in one layer and hidden layer is distributed into one or more hidden layers. Let there are "N" layers in MLP: first layer is called input, N^{th} layer is the output, and 2 to N-1 layers are hidden layers. Suppose that there L_l are neurons, where $L_{l=1,2,3,----------N.}$

Let w^L_{ij} and x_{ij} be the weight and ith be the neuron, respectively, such that$1<=L_{n-1}$, $i<<=i<=L_n$, where w_{ij} are the weights and x_{ij} is the input for model. The weight can be calculated as:

$W = \{w^1_{ij}, w^2_{ij}, w^3_{ij}, w^4_{ij}, \ldots\ldots\ldots..w^N$ LNLN-1$\}$……...(4),

where:

j=0,1,2,……,Ln-1,

i=1,2,……,L,

n=1,2,……,N

The output can be expressed as :

$$Y_j = f\left(X.W_j - b_j\right)$$

……(5)

It can be written as

$$Y = S_i\left(\sum_{y=1}^{ij} O_j .w_j + w_{ij}\right),$$

……(6)

where Y is the output and O_j is the output value of the j^{th} hidden node.

$$O_j = S_2\left(\sum_{x=1}^{n} X_i .w_{ij} + w_{oj}\right),$$

……..(7)

w_i are the connection weights between nodes of the hidden and output layer,

$w_{ij}$are the connection weights between nodes of the hidden and the input layer,

X=1.0 is a bias and $w_o$andw_{oj} are the weights for the biases,

S_1 and S_2 are activation functions.

Mean Absolute error can be calculated as

$$MAE = n^{-1}\sum_{i=1}^{n}\left|Q_{obs}(i) - Q_{pred}(i)\right|$$

……(8)

Root Mean Squared error can be calculated as

RMSE= $\sqrt{n^{-1}\sum_{i=1}^{n}\left\{Q_{obs}(i) - Q_{pred}(i)\right\}^2}$ ……(9)

R Squared can be calculated as

$$R^2 = \frac{E_o - E}{E_o},$$

……(10)

Where

$$E = =\sum_{i}^{N}\left(Q_{i\,(obs\,)} - Q_{i\,(est\,)}\right)^2$$

……(11)

The most important task is to determine the optimum number of the following layers for designing ANN architecture:

(i)The number of input layers

(ii)The number of hidden layers

(iii)The number of output layers

A neural network uses the data to modify he weighted connections between all of itsfunctions until it is able to predict the data accurately. This process is referred to as training theneural network. Neural Network Training can be done in seven following steps:

1. Prepare the data so that a file contains the predictors and the predicted variables with an example per row
2. Split the data into a test set and a training set
3. Read each row in turn into the neural network, presenting the predictors as inputs and the predicted value as the target output

4. Make a prediction and compare the value given by the neural network to the target value
5. Update the weights – see next slide
6. Present the next example in the file
7. Repeat until the error no longer reduces – ideally stop when the test error is at its lowest.

Training data has input data and output data. Each example in the training data is used as an input and the network generate an output. The MLP starts with random weights. If x predicts y then they have a non-linear relationship if the effect on y of a small change in x depends on the current value of x. if there are more than one predictor, non-linearity can occur as two or more predictors combine.

Test case [10]:

Table 3.1 Forecast result for ANN

Model Type	Meisso			
	SPI3		SPI6	
	R^2	RMSE	R^2	RMSE
ANNL1	0.727	0.16	0.835	0.091
ANNL2	0.363	0.130	0.673	0.130

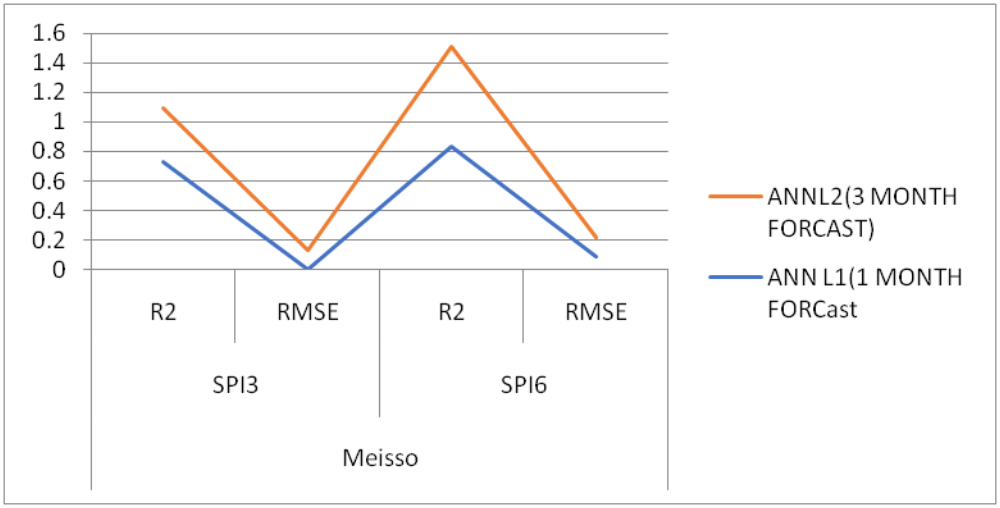

Figure: 3.3ANN prediction

Results of Test case

SPI forecasting is done for three month (SPI-3) and 6 month (SPI-6). The SPI3 and SPI6 forecast for the Messo station in 0.727 and 0.835 respectively in terms of R^2 for L1(i.e. one month forecast lead time) .While it is 0.363 and 0.673 for 3 months forecast lead time for the same.R^2value has relations with degree of correlations i.e.

0.7-0.9(means high degree of correlations),0.5-0.7(means medium degree of correlations) and0.3-0.5(means low degree of correlations).As per convention the perdition depends on RMSE values. The high value of perdition means RMSE value should be closer to zero.

Adaptive Neuro-Fuzzy Interference System (ANFIS) is a combination of two soft-computing methods of ANN and fuzzy logic (Jang 1993). Fuzzy logic has the ability to change the qualitative aspects of human knowledge and insights into the process of precise quantitative analysis. However, it does not have a defined method that can be used as a guide in the process of transformation and human thought intorule base fuzzy inference system (FIS), and it also takes quite a long time to adjust the membership functions (MFs) (Jang 1993)1

IV. Drought response

Drought response means assistance during and just after drought Disaster to save life and help affected people

Drone: Researchers have been working to discover ways to make Australian farms, both irrigated (market garden, viticulture, dairy), and non-irrigated (broad acre grain and livestock) more able to cope with a range of biological and non-biological stresses such as heat, frosts, drought and pests events using unmanned aerial vehicles (UAVs) or drones [11]

Figure: 4.1 In-field assessment of aerial imagery and data processing [11]

Robot: A robotics project in Missouri, USA is looking to tackle world hunger by using autonomous vehicles to collect data that will aid the development of drought-resistant crops [12].CropX claims the process can help farmers can use up to 25 percent less water[13]

V. Conclusion

Artificial intelligence tools for mitigation, preparedness, Response, recovery of drought offers powerful tools for drought management system. The technology machine learning can be used to solve the problem of mitigation phase. While technology of robotics and multi agent system can be used for response and recovery phase of drought management system .robotics and multi agent can also be useful for crisis management system .robotic can be used for searching and rescue to save the lives of rescue workers and challenges faced by them.

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