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INVENTORY MANAGEMENT FRAMEWORK FOR FLOOD RELIEFOPERATIONS

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Abstract: Over the last three decades, natural disasters on every continent have claimed the lives of more than three million people and had a detrimental effect on the lives of at least one billion people while also adversely affecting the lives of more than one billion people. This thesis offers a new and comprehensive framework for the process of development of a disaster the inventory management system is a real-time inventory management system for humanitarian emergencies.

The emergency inventory management system developed by us in this project combines offline strategies with an online stock management system. This type of system takes into account the fluctuations in demand for essential supplies during any natural disaster. This new combined inventory management system can be coupled with new Information Technology Systems such as Radio Frequency Identification Devices (RFID) for online commodity tracking and logistics.

In this project, we have also studied the application of Cost Benefit Analysis (CBA) in the cases of flood management. CBA identifies the items of benefit and cost in flood management from an economic point of view, which means enabling all of the advantages to go to the private or public sector and all of the expenses to be spent by either one.

Cost-benefit analysis helps us understand the suitable prices for calculating the benefits and expenses in monetary terms, and the prices of future costs and benefits closer to their present-day equivalents so that they may be compared with one another. This is because the costs and benefits are the result of a wide variety of consequences, hence it is necessary to follow a methodical process in order to ensure that each factor is correctly analysed and assessed.

In order to understand the practical application of Cost Benefit Analysis we have undertaken a case study of the Jammu and Kashmir, Kulgam district 2014 flood. The study is based on the secondary pooled data on the costs and benefits of the flood that were obtained from the published record of the District Disaster Management plan Kulgam 2017-18, as well as research journals, government offices, and newspapers. The data were processed for a cost-benefit analysis to get the required conclusions; the study was performed based on historical data about damage. The Analysis followed the pooled data technique, which was based on estimations of the effects that had been experienced in the past. This was especially true about the social impact. The assessment takes into account both the direct and the indirect economic repercussions. Finally, a location-allocation problem for flood relief shelters is addressed using a multi-objective mathematical model incorporating the Genetic Algorithm (GA) concept.

Keywords: Emergency Inventory Management; Radio Frequency Identification Device; Cost Benefit Analysis; Flood Relief Operations; Machine Learning.

I. INTRODUCTION

Natural disasters such as floods can cause a significant disturbance in the operation of a civilisation involving widespread human, material, financial, or ecological fatalities and consequences, which exceed the ability of the affected community or society to cope using its own resources.

Natural or man-made, these cataclysmic occurrences are intense and unexpected, and they often take place with little or no notice. As a result, they make each and every one of us painfully aware of our susceptibilities to natural and man-made catastrophes. The subsequent are the reasons why it is anticipated that the dangers presented by these concerns related to natural disasters may become even more severe in the future: The increase in the population in places that are prone to natural catastrophes, such as along the coast or in close proximity to potentially hazardous
faults, Manufacturing and transport of poisonous and dangerous products, A rapid ascent in technological sophistication and degree of industrialisation, particularly in developing nations.

It is abundantly clear that the underutilization of vitally needed resources and the ineffective supervision of those resources may place the wellbeing and well-being of stayers in serious peril. Furthermore, the key opinion is that these

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tragic catastrophes brand all of us painfully conscious of our susceptibilities to natural catastrophes and compel us to create new methods for effective and "quick-response inventory" organisation through emergency processes. This is crucial because it means that we can better prepare for the next time a disaster strikes. The mathematical modelling of disaster inventory management systems has lately gained significant interest in the literature as a result of this motivation. These models will be of use to organisers and choice creators in understanding the landscape of the scheme as well as how one may prepare for and exercise control over emergency resources. Though, there is a gap in this research when it comes to building online management for real-time management of emergency materials and supplies and including the uncertainties associated with the crisis in the model.

On the basis of this information, in order to have an effective "emergency management system", offline preparation and manufacturing rules should be combined with an online inventory management strategy. This is necessary in order to take into account the fluctuations in demand for essential supplies and the disturbances in the transport network that are expected during the period of disaster relief. The development of such an integrated control strategy for the purpose of ensuring the security and continuation of the movement of spare supplies in the wake of a catastrophe is what inspired us to do the research and writing for this dissertation.
The contributions that this thesis makes to the field:

1. The solution that has been suggested syndicates an offline preparation plan with online control techniques in a solitary outline that is resilient with regard to interruptions in the source and consumption of essential commodities inthe aftermath of a catastrophe.
2. This combined real-time inventory management system provides the capability to be coupled with developing ITS skills such as RFID for the purpose of online commodities tracking and logistics.
3. During the relief period, emergency management officials may use the early security standard that was computed as a bumper throughout the offline preparation procedure to adjust for the lack of essential supplies that was recognised in real-time by the CMPC model.
4. It is possible to do substantial research on the limited circumstances (on inventory levels, flow of supplies, and rate of change in that flow) that might arise as a result of the possibility that emergency trucks will not be able to supply shelters or that certain inventories will be lost as a result of the consequences of a catastrophe.
5. The suggested model, in contrast to earlier research found in the literature, is intended to effectively handle essential and strategic issues related to humanitarian relief operations in order to maintain the continuation of uncertain stochastic supply and consumption processes. In addition, because of the adaptability of the model for inventory management and control that has been provided, our mathematical model may be used for almost any extreme circumstance. Our model is able to take into consideration the flexibility measures of humanitarian assistance operations. Specifically, our model can take into account the capacity to adjust the production levels of key commodities as well as the flexibility of their delivery periods.
6. Our final goal in integrating the offline and online models discussed above is to develop a model-free closed-loop feedback-based inventory management system that can be efficiently functional to various kinds of extreme events, possibly as part of emergency plans and mechanisms, during the disaster relief period. In the subject of emergency inventory management, to the authors' knowledge, this has not been done before. This model-free response technique also needs real-life data as input, namely on the levels of inventory, the movement of emergency vehicles, and the supplies. It is possible to gather this tracking info in real-time by using RFID technologies.

II. METHODOLOGY

A. Introduction to RFID (Radio Frequency Identification Device)

Researchers and scientists have identified the process of tracking people and other items as a major component, particularly in the context of disaster response and search and rescue operations. Tracking procedures have made use of a variety of Auto-ID Technologies. An in-depth analysis of these technologies reveals that they often need a greater amount of resources, and their effectiveness is called into doubt while operating in unfavourable settings, such as during times of emergency. For the purpose of putting GIS to use in disaster management, for instance, every location has to be mapped out, recognised, and then entered into the appropriate database. During the growth phase as well as the upkeep stage, this necessitates an increase in both the amount of time and the staff. In compared to other methods of identification, optical character recognition systems' drawback is that they have not achieved widespread adoption due to the prohibitive cost of their readers and the complexity of the processing they need. RFID has the potential to be useful not just for tracking but also for authentication, automation, and the administration of information. This technology does not need any physical interaction and is both cost-effective and

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dependable. As a result, it is viable for usage in situations that need for identification and tracking that does not involve physical touch. An RFID system consists of a tag that has a microchip attached to one end and a reader attached to the other end; these two components are linked together via antennae. A reader is responsible for emitting electromagnetic waves, which are then picked upby the antenna of a tag.

B. Cost-Benefit Analysis

A cost-benefit analysis is a methodical procedure used by organisations to determine which choices to make and which to avoid. The cost-benefit analyst adds up the potential rewards of a scenario or activity and then removes the overall expenses of seeking that action.

The core of cost-benefit analysis rests in the following:

(i) identifying the items of benefit and cost in the flood management from an economic point of view, which means enabling all of the advantages to go to the private or public sector and all of the expenses to be spent by either one;

(ii) Using suitable prices for calculating the benefits and expenses in monetary terms; and

(iii) Bringing the prices of future costs and benefits closer to their present-day equivalents so that they may be compared with one another.Because the costs and benefits are the result of a wide variety of consequences, it is necessary to follow a methodical process in order to ensure that each factor is correctly analysed and assessed.

C. Application of Optimization Techniques in Disaster Relief Operations

The activities that are included in disaster relief operations are the establishment of emergency facilities, the search for and rescue of survivors, the provision of health and medical assistance, the distribution of relief supplies, the transfer of injuries, the scheduling of rescue forces, and the coordination of these activities across organisations. As a result, they are linked to a wide range of operational difficulties, many of which are often outside the purview of the more traditional optimisation approaches. In this project, we break the issue down into two distinct categories, which are as follows:

- General transportation planning problems, such as putting up programmes to move relief supplies from distribution centres (sources) to demand places (targets); these programmes are to be made up. However, we do not consider comprehensive route design or vehicle routing to fall within this category.
- Facility location problems, which include organising emergency facilities in the right places to meet demand points at such sites.

D. Machine Learning Model for Finding Optimal Locations

In this research project, we have designed a terminal-based application that utilizes a genetic algorithm to determine the optimal locations, denoted by ‘p’, for constructing relief shelters during floods. The algorithm considers several relevant features, such as latitude, longitude, population density, and the expected number of days until submergence, in order to identify the most suitable sites. The algorithm is programmed to account for conflicting objectives, including the maximization of a metric known as population score and the minimization of the average distance to any shelter, while also ensuring that the total cost does not exceed the allocated budget.

Constraints:

- Budget= B crores
- Population finally accumulated <= K * (current population)
- submerged_days(x) >= max(submerged_days(y) for all y)
- submerged_days(x)>0

In this approach, several constraints have been imposed to ensure that the relief shelter construction is optimal and effective. The budget allocated for the project is B crores, which serves as a limitation for the total expenditure.

Moreover, to avoid overburdening the relief shelters, the total population accommodated in the shelters should not exceed K times the current population. The algorithm selects the most suitable locations for constructing relief shelters by considering various factors, such as latitude, longitude, population density, and expected submergence time.

Additionally, the algorithm ensures that the number of days until submergence for a particular location x is greater than or equal to the maximum number of days until submergence for any other location y. Finally, the value of submerged days for any location x must be greater than zero to ensure that the location is indeed a viable option for constructing a relief shelter.

Objectives:

- O1 Maximize the population score i.e an indicator of the number of people saved
- O2 Minimise the average distance to any relief shelter.

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- O3 Maximize the cost within the budget.

The aim of this machine learning model is to determine the optimal locations for constructing relief shelters during floods using a genetic algorithm. To achieve this, several objectives have been identified.

III. FORMULATIONS

A. RFID

A variety of institutional and technical barriers prohibit governments from making better use of wireless RFID network technology and including it as an integral component of an effective disaster response programme.

1. Interferences, Reliability, and the Environment: One of the primary concerns of disaster management is the management of settings that are inherently unpredictable and unstable
2. Challenges Presented by Emerging Technologies The implementation of the technology has been impeded by the existence of standards. Because of this, it is very challenging to install systems that are compatible.
3. Costs: The business sector has been waiting for a decline in the price of RFID technology for some time. Moreover, important sources of funds are typically only available once a disaster has been declared and must also be spent in a short window of time.
4. Problems with Operations, competencies, Managerial Abilities, and Knowledge: Organisations that deal with disastermanagement often lack the resources necessary to build significant competencies.
5. Problems relating to different cultures and ethical standards In the event that RFID chips were to be used on deceased people or victims, there would be a great deal of pushback owing to various cultural, religious, societal, and ethical problems.
6. Privacy, data integrity, security, and legality concerns RFID systems used for emergency management have unique privacy and security considerations that must be addressed in order to maintain the practicability of the product.
7. Problems on the local level: Decisions about RFID should be made jointly by local governments and organizations that are required to collaborate during times of crisis.

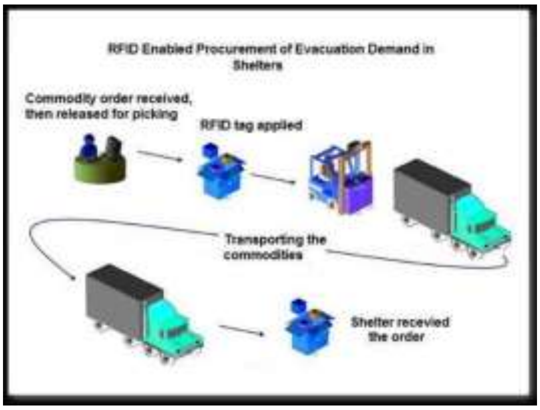

Fig 1. RFID Enabled Procurement

Essentially, RFID technology provide emergency operations three primary benefits, which are as follows:

1. Tracking: This feature of RFID may detect the location of any emergency supplies by following its movement. The concept not only involves the monitoring of real-time location (the flow of commodities), but also the tracking of movements via entrance and exit points.
2. Identifying, sensing, and authenticating individuals: This may be used in order to accurately gather information by identifying the individuals who were affected by the tragedy. First and foremost, this will assist in more properly responding to the requirements of patients in the disaster region. It is also possible to utilise it throughout the process of monitoring commodities such as medication and blood in order to provide victims with safe medical treatment.
3. Automatic data collection and transfer: This is mostly utilised for minimising the amount of time spent processing information and limiting the number of mistakes that occur during data input and collection as well as inventory management issues.

B. Implementation of RFID

According to Henderson (2007), RFID devices might be utilised effectively to monitor merchandises, such as spare provisions, that are streaming into and out of the area in near-real time. The plan was to set up an automated network with secure and moveable inquisitors to screen RFID plans connected on a map-based computer screen by means

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of live tracking tools and in-transit visibility. These 4 stages are based on a time framework.

Fig 2. Four Stages of RFIDThese emergency relief framework stages are defined as follows:

1. Stage 1 (Pre-disaster Operations): The first step is to create a connection between the various levels of government, as well as local organisations, the armed, non-combatant activities, and the commercial sector. This will assist in the construction of a support plan that is feasible and can be carried out, which will be followed by the identification and notification of available assets in the disaster zone.
2. Stage 2 (Initial Disaster Operations This needs the ID of prospective distributors and stocks that may be used, as well as the assessment of the emergency merchandise held in these inventories, and the construction of procedures that can aid workers employed in product flow organisation. Because of this, the offline preparation model that has been provided will be of great use to us at this stage, as it will give us the ability to identify the first safety supplies that are present in the inventories.
3. Stage 3 (Sustainment of Disaster Operations): This stage is essentially the online emergency management phase where the authorities oversee the flow of goods and distribute commodities across shelters. As a result, this stage calls for an accurate forecast of the workforce and the safety inventories, as well as a continuous capacity of in-transit visibility of the emergency commodities within the transportation network. An RFID implementation inside the system may give this in order to predict and report the needs of the victims who are being housed in shelters and to support future requests. In this part of the process, our online model that we have provided ought to make advantage of the RFID data.
4. Stage 4 (Closure of Disaster Operations): This stage essentially puts an end to relief assistance operations such as the management of essential supply flow and people. It is important to document both the information that was gathered and the lessons that were taken away from the experience.

C. Cost Benefit Analysis

The study is based on the secondary pooled data on the costs and benefits of the flood that were obtained from the published record of the District Disaster Management plan Kulgam 2017-18, as well as research journals, government offices, and newspapers. The data were processed for a cost-benefit analysis in order to get the conclusions that were required; the study was performed based on historical data about damage. In the instance of the management of floods in the Kulgam district, vital information was accessible, such as the number of residences that were destroyed during the flood in 2014, the amount of assistance provided, construction on the river banks, damaged roadways, and so on. The Analysis, on the other hand, followed the pooled data technique, which was based on estimations of the affects that had been experienced in the past. The assessment takes into account both the direct and the indirect economic repercussions.

S. No.	Type of Benefits	Components
1	Direct benefits: i) Tangible Costs ii) Intangible costs	Physical damage to property: Housing, Agriculture, Commercial Buildings and Livestock a) Primary: Loss of human life b) Secondary: Illness of flood victims
2	Indirect benefits:	a) Primary: Disruption of traffic and trade b) Secondary: Reduced purchasing power

Fig 3. Classification of Direct and Indirect Cost of Damage Due to Flood Approach

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Structural: Mitigation costs	Non-structural: Adaptation costs
Reshaping of land surface	Flood defense
Protection from erosion	Forecasting
Levees, dykes, floodwalls	Warning
Dams and reservoirs	Floodproofing
Flood ways and diversion works	Evacuation

Fig 4. Types of Cost

Total Damage Loss Estimation (in ₹ Lakhs)	
Housing Building	9,950
Assets	552
Land	55,785
Crops (particularly apple)	2,123.5
Remaining crops	1,089
Live stocks	1,194
Commercial buildings	1,190
Roads and bridges	902
Total	₹ 727.85 Cr

Table 1. Total damage loss estimation

Total Relief Cost due to flood	
Reconstruction of Damaged Houses	4.23 Cr
Infrastructure	700 lakhs
Floodways & diversion works	862 lakhs
Flood warning system (x 4)	1 Cr
Multipurpose disaster management	192.75 lakhs
Emergency drugs availability	11.1 lakhs
Total	23.13 Cr

Table 2. Total Relief cost due to flood

D. General Transportation Problem

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As a classic problem in OR, the basic transportation problem considers delivering a homogeneous commodity from a set of m sources to a set of n targets. Suppose the supply of source i is a_i, the demand of target j is b_j, the cost for transporting one unit of commodity from source i to target j is c_{ij}, then the problem is to determine the commodity amount x_{ij} from each source i to each target $j(1 \le i \le m, 1 \le j \le n)$, such that the total transportation cost is minimised. It can be modelled as a special case of the linear program (LP) as follows:

$$\begin{aligned} \min f = & \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij} \\ \text{s.t.} \ & \sum_{i=1}^{m} x_{ij} \ge b_j, \quad j = 1,\ldots,n \\ & \sum_{j=1}^{n} x_{ij} \le a_i, \quad i = 1,\ldots,m \\ & x_{ij} \ge 0, \quad i = 1,\ldots,m,\ j = 1,\ldots,n \end{aligned} \tag{1}$$

Fig 5. Equations of general transportation problems

Although specific methods that are more efficient than ordinary linear programmes can tackle this challenge, EAs can provide substantially superior performance on very big problem cases. Furthermore, real-world problems frequently involve heterogeneous goods and transit modes, resulting in additional (and frequently nonlinear) objectives and constraints. Furthermore, transportation in emergency logistics is frequently susceptible to uncertainty and randomness, has very limited time limitations, and prioritises timeliness and/or danger over transportation cost. Considering these additional qualities, significantly more effort should be spent into designing efficient algorithms.

E. Location Problems

The simplest form of the problem of locating any essential service, which examines supplying a single facility to cover the greatest number of demand points, has an accurate solution that is efficient. However, involving multiple facilities leads to NP-hard problems, such as the p-median problem (2) and the maximum covering problem (3):

$$\begin{aligned} \min f = & \sum_{i \in D}^{m}\sum_{j \in F}^{n} c_{ij}y_{ij} \\ \text{s.t.} \ & \sum_{j \in F} x_j = p, \\ & \sum_{j \in F} y_{ij} = 1, \quad \forall i \in D \\ & x_j \in \{0,1\}, \quad \forall j \in F \\ & y_{ij} \in \{0,1\}, \quad \forall i \in D \end{aligned} \tag{2}$$

$$\begin{aligned} \max f = & \sum_{i \in D} w_i z_i \\ \text{s.t.} \ & z_i - \sum_{j \in F} x_j \le 0, \ \forall i \in D \\ & x_j \in \{0, 1\}, \quad \forall j \in F \\ & z_i \in \{0, 1\}, \quad \forall i \in D \end{aligned} \tag{3}$$

Fig 6. Equations of Location Problem

where F indicates the possible location of the services, D represents the set of demand points, and cij represents the cost of selecting the demand from one point to other. Furthermore, in a crisis situation, facility location must frequently cope with limited facility resources, great demands, and high intense situations. To achieve the most realistic coverage the real life problems should be taken into consideration such as facility mapping of important services such as healthcare and fire department along with the important local bodies.

F. Objective Function for Cost Minimization

Humanitarian relief organisations aim to provide relief for as many disaster victims as possible, subject to limited funding. It is therefore useful to consider a model that helps the decision-maker with inventory decisions at the lowest possible

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cost. The notations of the stochastic inventory model for the SADC are addressed below:

The following objective function has been formed using the above functions:

Min $z = \sum_{i=1}^{I} \sum_{K=1}^{K} q_{ik}(c_i Q_{ik} + h\, v_{ik} + s\, u_{ik})$

subject to

$) u_{ik} + v_{ik} - Q_{ik} (= x_{ik}\; Q_{ik}, v_{ik}, u_{ik} \geq 0$

The main aim of this OF is to find the relatable amount and types of resources to minimise the cost of the inventory. The 2nd equation tells the number of essential resources required for any corresponding situation that may arise which meets the required demand, while considering the factors such as the buffer stock and shortage. Equation 3 makes sure that the value of the decision variables should always be greater than equal to zero.

G. Machine Learning Model

Objective Function/ Fitness Function:

- F= (O1 + O3)/O2

The objective function of this model is designed to optimize the selection of optimal locations for constructing relief shelters during floods. The function, denoted as F, is defined as the ratio of the sum of two objectives, O1 and O3, to the value of the third objective, O2. The first objective, O1, is focused on maximizing the population score, which indicates the number of people that can be saved by constructing relief shelters in the most suitable locations. The third objective, O3, is to maximize the cost of constructing the relief shelters within the allocated budget. By prioritizing these objectives, the algorithm selects the most suitable locations based on features such as latitude, longitude, population density, and expected submergence time. The second objective, O2, aims to minimize the average distance between the constructed relief shelters and the affected population. The optimization of the objective function F results in the identification of the most optimal 'p' locations for constructing relief shelters, ensuring that the maximum number of people can be saved while also adhering to the budgetary constraints.

Implementation Via Terminal Based App:

- The dataset folder containing information about the towns and villages in all the districts of Kerala wascollected from a government website.
- The python script gascript.py was developed to extract data from the CSV files in the dataset folder. The number of days before submerging and cost were generated randomly in this script as the data is dynamic andcan only be available in the case of an actual calamity at that place.

Figure 7. The dataset folder containing information about towns and villages in different districts of Kerala

- Latitude and longitude were added to the dataset file itself using the python script lat_lan_add_script.py asgeopy server was returning empty geocodes for certain locations.
- The final dataset that served as the input for our genetic algorithm was generated using the above-stated scriptand was saved as dataset2.csv.
- The genetic algorithm was implemented in the python script main.py.
- The best chromosome of the final population was plotted on the map and stored as index.html.
- The GA code generated a graph of average fitness over generations upon completion.
- These implementation steps enabled us to identify the most optimal 'p' locations for constructing relief shelters during floods in Kerala, based on features such as latitude, longitude, population density, and expected submergence time, while adhering to budgetary constraints.

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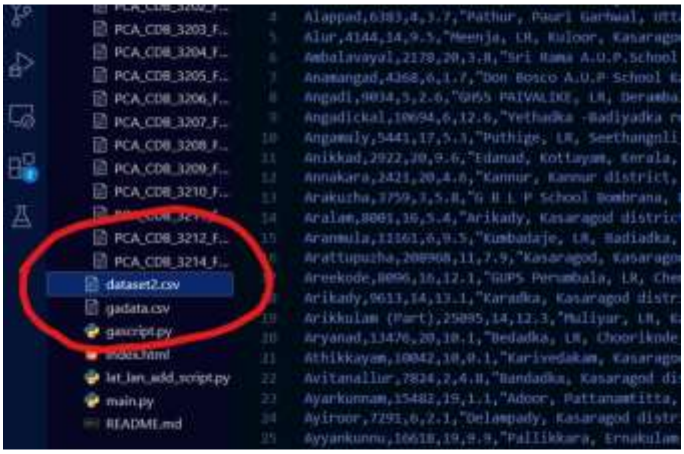

Figure 8. The final dataset folder, dataset2.csv generated after using the python script lat_lan_add_script.py and manualadditions

The implementation of the project involved several steps. Firstly, the dataset folder containing information about the towns and villages in all the districts of Kerala was collected from a government website. The python script gascript.py was developed to extract data from the CSV files in the dataset folder. The number of days before submerging and cost were generated randomly in this script as the data is dynamic and can only be available in the case of an actual calamity at that place. However, due to limitations in the geopy server, certain locations were returning empty geocodes. To overcome this challenge, latitude and longitude were added to the dataset file itself using the python script lat_lan_add_script.py. The final dataset that served as the input for our genetic algorithm was generated using this script and was saved as dataset2.csv.

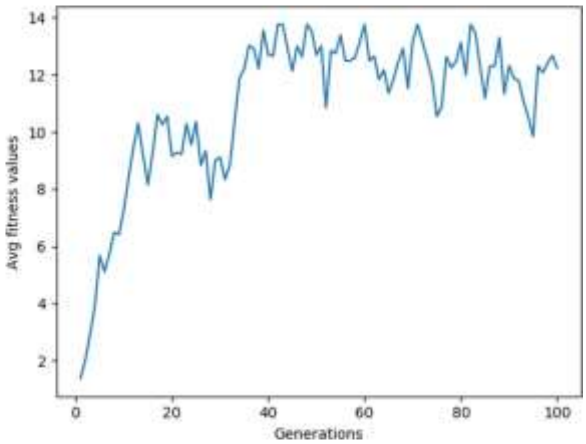

Figure 9. Graph of average fitness over generations plotted by the GA code

The genetic algorithm was implemented in the python script main.py. The best chromosome of the final population was plotted on the map and stored as index.html. In addition, the GA code generated a graph of average fitness over generations upon completion. These implementation steps enabled us to identify the most optimal 'p' locations for constructing relief shelters during floods in Kerala, based on features such as latitude, longitude, population density, and expected submergence time, while adhering to budgetary constraints.

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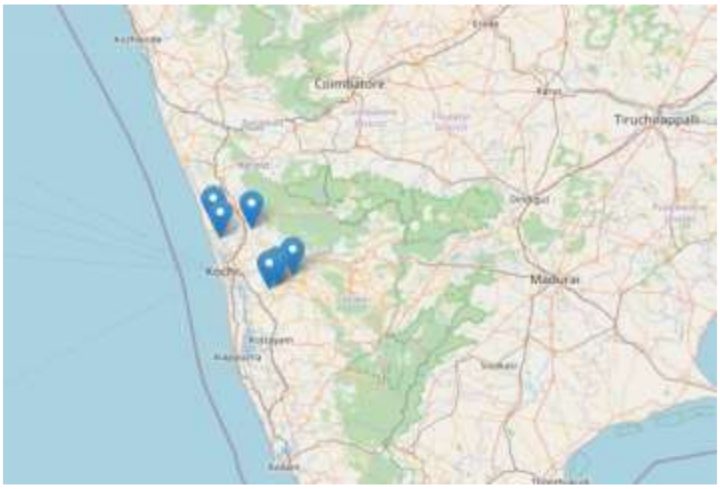

Figure 10. O out in index.js displaying the most optimal 'p' locations for constructing relief shelters in the time offloods

IV. CONCLUSION

The RFID technology is used and accepted as one of the major breakthrough of 21st century it has provided immense value and contributed a lot in supply chain, retailing, inventory management, transportation systems and even healthcare. It also has a huge academic impact as it is very crucial for research purposes as it helps us in preparing for disasters before hand and help make rescue more efficient. The integration of this software and hardware technology can boost the disaster relief operation by manifold.We can even track the essentials incase of an emergency.

The cost-benefit analysis gives us an insight about the following data:
There are 11 main parts of this calculation which influence the benefits. The benefit after rigorous calculations reveals the amount to be nearly 78686 lakh. There are 6 main parts of the calculation of costs. The final cost after considering these different parts comes out to be 2218 lakhs approximately. The final ratio of the benefits to costs in the analysis came out to be 35.5:1. These results clearly indicate the picture of the Flood Management in Kulgam which was economical and feasible.

As the severity of the tragedy grows, so does the demand for crucial supplies in shelters. if a result, if the consumption of a certain product rises, so do the corresponding initial safety stock values. The original safety supply appears to be insufficient as the catastrophe strength increases, and a massive amount of additional safety stock is required when the number of deliveries is limited owing to damaged/congested routes. This is due to the fact that if the system is extremely stochastic, the probabilistic constraints are only satisfied if the additional safety stock is large. This will result in greater costs. The task becomes infeasible if the initial safety stock is too low..As a result, the model strikes a balance between meeting probability restrictions and minimising costs. Real-world limits on inventory levels and supply flow lengthen response time because establishing constraints on the system makes the mathematical model difficult to converge. As a result, greater safety stock is required to meet the demand for critical goods. Planners and decision-makers should choose appropriate quantities of safety stock to account for the delayed response time caused by these constraints. The proposed model allows for the analysis of the following real-life issues: changes in the intensity of a catastrophe, interference in the transportation system, changes in the requirements and resources, essential items and multi-suppliers.

In this project, we have studied the application of optimization techniques in disaster relief operations. The activities that are included in disaster relief operations are the establishment of emergency facilities, the search for and rescue of survivors, the provision of health and medical assistance, the distribution of relief supplies, the transfer of injuries, the scheduling of rescue forces, and the coordination of these activities across organisations. As a result, they are linked to a wide range of operational difficulties, many of which are often outside the purview of the more traditional optimisation approaches. In this project, we broke the issue down into two distinct categories;General transportation planning problems, such as putting up programmes to move relief supplies from distribution centres (sources) to demand places (targets); these programmes are to be made up and Facility location problems, which include organising emergency facilities in the right places to meet demand points at such sites.

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According to our findings and leveraging genetic algorithm (GA), to solve location allocation problem, a terminal-based application was developed to address the task of selecting the most optimal 'p' locations for constructing flood relief shelters. The application utilizes a genetic algorithm that incorporates various features such as latitude, longitude, population, and expected number of days to submerge. In order to handle conflicting objectives, the algorithm aims to maximize a quantity referred to as the population score while simultaneously minimizing the average distance to any shelter. Additionally, the algorithm ensures that the total cost remains within the allocated budget.

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