A Framework to Implement Agent Based Modeling for Resources Allocation to Reduce Disaster Risk Factor in the Urban Environment of Pakistan

by

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THESIS ACCEPTANCE CERTIFICATE

Certified that final copy of MS Thesis written by **Mr. Zain ul Abideen Usmani**, Registration No. **00000172510**, of **Military College of Signals** has been vetted by undersigned, found complete in all respects as per NUST Statutes/Regulations/MS Policy, is free of plagiarism, errors, and mistakes and is accepted as partial fulfillment for award of MS degree. It is further certified that necessary amendments as pointed out by GEC members and local evaluators of the scholar have also been incorporated in the said thesis.

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Declaration

I hereby declare that no portion of work presented in this thesis has been submitted in support of another award or qualification either at this institution or elsewhere

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Dedication

“In the name of Allah, the most Beneficent, the most Merciful"

I dedicate this thesis to my mother, sister, and teachers who supported me each step of the way.

Acknowledgements

I am extremely thankful to ALLAH Almighty for his bountiful blessings throughout this work. Indeed this would not have been possible without his substantial guidance through every step, and for putting me across people who could drive me though this work in a superlative manner. Indeed none be worthy of praise but the Almighty. In addition, my admirations be upon Prophet Hazrat Muhammad (PBUH) and his Holy Household for being source of guidance for people.

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Last, but not the least, I am highly thankful to my parents. They have always stood by my dreams and aspirations and have been a great source of inspiration for me. I would like to thank them for all their care, love and support through my times of stress and excitement.

Abstract

Disaster can be an unlikely event, a sudden accident or a random chain of contingency worldwide that may result in unexpected consequences. Many developed countries have been working over the past few decades to reduce the risk factor of disasters by using different approaches to disaster management. But these efforts are in early stage of development in the developing countries, as these countries hardly get desired results due to insufficient resources in terms of technology. There is however a growing shift in disaster management, many developing countries need a framework and approaches to reduce the risk factor for disasters. Regardless of how much resource a country has and how well it has been developed, but these efforts cannot achieve desired results in term of sudden incident. In Pakistan, very few efficient work on disaster management is done till now. Pakistan urban environment is most affected from natural and human made disasters as compared to rural environment in context of road accident and fire. Our focus centered on human-made disaster. In our work, a framework to implement Agent Based Modeling for Resource Allocation is purposed. In this framework we used two allocation algorithm; High Severity Level and First Come First Serve. These two algorithm are simulated in Netlogo by creating a hypothetical scenario in Geographical Information System space. Different experiments are designed on demands & resources dataset for allocation. The results of experiments are compared according to different parameters . In the results we analyze average wait time, overall number of demands, execution time and unallocated demands for performance measure.

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Acronyms

Agent Based Modeling	**ABM**
Resource Allocation	**RA**
Disaster Management	**DM**
Predecessor Models and Existing Research	**PMER**
High Severity Level	**HSL**
First Come First Serve	**FCFS**
Geographic Information System	**GIS**

Chapter 1

Introduction

1.1 Background

Disaster may refer to the unpredictable occurrence, sudden incident or random chain of contingency that may have uncertainty and unexpected consequence. Last few decades has observed a paradigm shift in pulling off disaster risk significance. Although mostly this shift is under emergence obligation in the developed countries, however there is a growing awareness in developing countries that they also need to have a sustaining approach and a framework to mitigate disaster. As a result of the global paradigm shift, the sudden occurrence of several disasters has increased [3]. Building rules are not enough, incompetent operational system and ignorance of how to deal with direct accidents can potentially make destruction reach to abnormal state. Modern countries around the world have worked very hard to manage the disasters, while the efforts made in developing countries are not up to the minimum required standards. Regardless of how much resources a country has and how well structured it is, it cannot do battle with sudden incident in term of disaster, but it may try to reduce their effect. The degree of human suffering is the only thing that we have to control, and it is possible only with the good deduction of risk and initial preparation for risk [4]. It is very encouraging to raise awareness at the global and regional level for dealing with these risks. However, the government should respond immediately to reduce hazardous effects. The government may have large number of resources, but cannot efficiently react to huge disasters, it is only possible if the resources allocation procedure is good and effective.

Pakistan is becoming one of the fastest country in South Asia with respect to urbanization. The urban population has risen from 16% in early 1950s to 36% in 2017. Due to huge urbanization, Pakistan has been one of the countries that has been badly affected by disasters in last two decades. As, Pakistan is the 6^{th} largest country in the world with respect to population which is main reason for huge urbanization and even small cities are growing rapidly. These cities are growing without proper planning infrastructure which is cause of urban disaster [5][6]. Cities incident in term of road accident and fire-

related disaster etc. are causing hundreds of lives and property damage at multiple level. There is no proper disaster and incident management available in urban areas of Pakistan. Due to poor disaster management small incidents result in huge infrastructure and human loss. Fire stations, ambulances and hospital emergency services are source of disaster management and should manage disaster risk efficiently.

1.1.1 Basic Terminologies (Crisis, Disaster, Emergency and Risk)

- **Crisis**

A situation for critical decisions having threats and opportunities, must be created in relatively limited interval of time is called crisis. As man-made and natural both kind of disasters come under crisis however every crisis is not undeniably a disaster. Other type of crisis may be social, political, financial, corporate crisis and so on [2].

Crisis management is the way toward developing and reacting to a random negative incident to prevent the emergence of an even greater problem or snowball into a full-fledged, extensive, and fatal disaster. As crisis management have three phases:

1) **Pre-incident phase** include finding of Potential Risk Hazards and Preparing of Emergency Plans to respond to each of them.

2) **Incident phase** involves dealing and controlling of current existing crisis state.

3) **Post-incident phase** emphasizes on long period of time recovery and preventive measures so that a similar unfortunate situation no longer succeeds in the future.

- **Disaster**

A disaster is an accident which cause of damage of ecological interruption, death toll or fall of wellbeing and health facilities on a scale that requires an additional reaction from the network of region or community concerned. A disaster can likewise be characterized as genuine disruption of movement of the society causing human, material, monetary or ecological losses, which transcends the potential of the affected society to manage this by using available resources[7].

Disaster Management Framework: The Disaster Management (DM) structure cover comprehensive planning, strategy, and program development programs to protect region, property, and the environment from the disaster's negative consequences.

- **Emergency**

Emergency is a state of affairs for communities. It is a circumstance made by future event of an occasion that requires prompt consideration, which requires exceptional thoughtfulness regarding crisis assets [1]. Most industrialized countries have operational emergency services. They are usually managed by governments and the funds are appropriated from the public exchequer, but in some cases, they are managed by private risk management companies offering their services for payments or by philanthropic. These countries have three main emergency services which utilize their resources.

Police – deal emergencies of crime-related type

Fire – deal with infernos and are usually adept in secondary rescue duties.

Medical – medical-related emergencies or support voluntary organization.

- **Risk**

Risk is something having probability and possibility of emergency to appear. It is an uncertain event or condition that if it happens, has an adverse effect on the current scheme of things. In the context of "Disaster" to understand "Risk", it is essential to comprehend the relevant concepts of hazard, vulnerability and risk. Their definitions are given below in the context of Disaster Management.

Hazard is a phenomenal danger of event or incident that has inherent characteristics of harming life or destruct environment, property or capital.

Vulnerability reflect the community vulnerability of existing conditions: physical, social and economic factors that reduce the ability to respond to such threats.

Risk in DM refer to the aggregate tendency to risk and community vulnerability having potential losses which is brought about by a specific uncertainty in a particular approaching time frame.

Disaster risk can consequently be spoken to as an element of the vulnerability, hazard & exposure

Disaster risk can be reduced in following two distinct ways:

• By mitigating the dimension of weakness of the region in danger situation and;

• By fending off exposure from high need risks (for example by moving resource, population and property to more secure regions, urgent allocation of resource to threat site etc.)

- **Disaster Risk Management**

It is the methodical improvement and execution of the approaches related to management, systems and practices to identify, examine, evaluate, process, control and monitor disaster risk. The DRM process involves analyzing the risks, measuring the potential implications, and determining how important things are in the big scheme. If this assessment is accepted in the socio-economic and political context, it will contribute to the development of strategies to reduce appropriate gaps, mitigation practices and preparation and response plans.

1.1.2 Type of Disaster

(1) Natural Disaster

A natural event can turn into a disaster that is often seen as an act of Almighty God. People, financial assets or infrastructure can be damaged Disasters often start with factors such as geological, seismic, biological and meteorological conditions.

(2) Human-Made Disaster

The causes that have prompted these disasters include human carelessness and structural collapse. As chances of survival can be improved if preemptive measures are taken, since everything relies upon the area and type of hazard. The circumstance of a disaster can be brought about by immediate or inattentional human impact. People bear the brunt of wars by losing their property and livelihood. Then again, people should just move to more secure spots, for instance on account of sudden incidents or extensive fires. Manmade disasters include: -

- Road accident
- Fires
- Aviation incident in term of crashes
- Civil-Disorder
- Domestic Terrorist & Suicide Attack
- Dam Failure

1.1.3 Disaster Management

It composed of mitigation, preparedness, response and recovery activities as part of an immediate and ongoing process during disaster and for reducing risk for future problems.

OR

DM includes activities like mitigation, preparedness, response and recovery that are due to sudden reaction and recovery to a disaster impacts of such occasions in future[8][9].

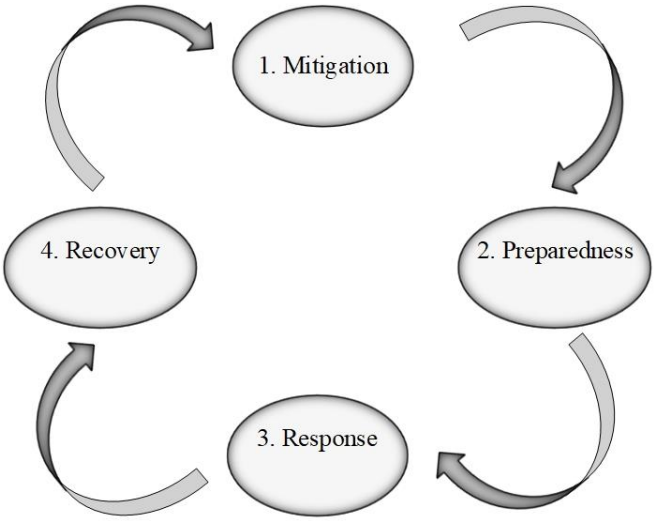

Figure 1.1: Stages of Disaster Management

1. Mitigation

As the word literally means; mitigation involves lessening, alleviating and toning down the impact of a disaster. This phase involves all the post disaster activities that are performed after a disaster has struck in order to reduce future vulnerabilities to similar hazards. In a way mitigation keeps perils from forming into disaster and aims to decrease the impacts of disaster, if they happen. Activities in recovery stage evolve into mitigation methodologies/ strategies when performed after a disaster occurs. Mitigation strategies can be structure based procedures or non-structural procedures in which the focus lies on reducing or eliminating such risks in future. It may include providing set of laws concerning evacuation, sanctions against breaching obligatory regulations and communication of probable risks to the public. Another important aspect of mitigation is Physical Risk Assessment that involves the identification and evaluation of all probable risks and hazards. Consequently, the Disaster Risk Reduction Plans can be chalked out and preemptive disaster measures can be taken. This all would account for mitigation [10][11].

2. Preparedness

It includes planning and arranging, sorting out, preparing, working out, assessment and improvement activities to provide relief in emergency situations. The whole effort is done

to ensure effective synchronization of relief operations through prior planning and the enhancement of capabilities of organizations responsible for DM. This phase gives an opportunity to emergency managers to develop plans for countering the identified risks and to make the required abilities vital to execute such plans. An important activity of preparedness is the estimation of what numbers of injuries and death tolls can happen for a certain disaster, called “casualty prediction”. Preparedness is an on-going process that should be carried out by the government disaster administration, in collaboration with the concerned private-sector agencies [12]. Emergency planners must be keen and relentless in vigilantly recognizing the hazards and vulnerability of their respective regions. They must be flexible in their approach, employing unconventional and atypical techniques where required. The aim being as efficiently and intelligently prepared as possible in case the disaster strikes.

3. Response

Response is that phase in Disaster Management that immediately goes into action as soon as the disaster strikes by mobilizing all the necessary emergency services. Response involves the main emergency services, such as firefighting, S&R operations, first medical aid and all other activities and operations necessary to provide rescue and relief to the effected masses. Response is the most crucial and critical phase of Disaster Management. It is the carrying out of the emergency plans developed during the Preparedness Phase. Only a well-rehearsed emergency plan can be well-executed. According to a study, contingent upon the injuries sustained by the people in the region and injured individual access to air and water, most of the disaster affected people die within 72 hours after impact. This further highlight how critical is the Response phase in DM. An efficient organizational response requires both discipline (procedure, structure, tenet) and agility (innovativeness, spontaneous creation, versatility) in responding to a disaster [13][14]. Developing a proficient, advanced and high functioning leadership group that can foresee efforts growing beyond first responders and take on disciplined, iterative set of response plans is also very important. The team must be capable to adapt to real-time info and changing conditions along the way.

4. Recovery

Recovery involves remaking and restoration of the disaster affected zone. It may include physical reconstruction and efforts to return quality of life to the disaster struck areas.

The recovery stage expects to reestablish the influenced zone to its previous state. After meeting the immediate needs in the Response Phase, focus is now on reconstruction of damaged infrastructure, rehabilitation of displaced population and the repair of other essential infrastructure. The effort meets its end in the event that builds back better, expecting to reduce the pre-disaster risks danger in the community and infrastructure [15]. A great deal of commitment is required in this phase as the first wave of emergency scenario is over and the nature of work requires sustainability and long-term focus. Recovery efforts can exploit a lucky opening tool for mitigation strategies that may have been unwelcome something else. With the fresh memory of the recent disaster in mind, it is more probable that otherwise unpopular schemes be accepted to mitigate the impact of such disasters in future.

1.1.4 Disaster Management Issues

According to the stages of occurrence the DM classification is per the following:

- Pre- Disaster Management
- During Disaster Management
- Post-Disaster Management

Management issues encountered at the above mention stages are discussed in the following:

1) Pre-Disaster Management Issues

Pre-Disaster management includes advance work done for emergencies and calamities. It means to decrease gravity of impact of calamity through counteractive action and mitigation, just as improved crisis response through proper planning and preparation.

2) During Disaster Management Issues

The quick reaction as rescue and relief activities take on in order to give shelter, life support and other fundamental needs of individuals impacted by an event of a disaster, come under the mode of disaster management.

3) Post-Disaster Management Issues

Post-disaster management goes for formulating methodologies for long term recovery of disaster where it takes place. Post DM arranging includes building the outline for reconstruction and rehabilitation of the disaster effected zone. Post disaster management

emphasizes on long term reconstruction and recovery of the disaster hit zone. The measures in Post DM manage issues beyond prompted rescue and relief.

1.1.5 Pakistan Urban Environment

The term “urban area” describes town, cities and its suburbs. It includes the city itself, and the areas surrounding it. Pakistan has become more urbanized in the recent past and that is why it is considered amongst South Asian countries that has fast-paced urbanization. Now it depends upon the country to manage its urban resources prudently to ensure better quality of for its residents. Pakistan’s environment is comprised of 96 urban areas, which are shown in the fig. 1.2 under each province. The target zone in the figure below is an area on which we have created a hypothetical scenario for our research purpose, as it is described in Chapter 4 in detail.

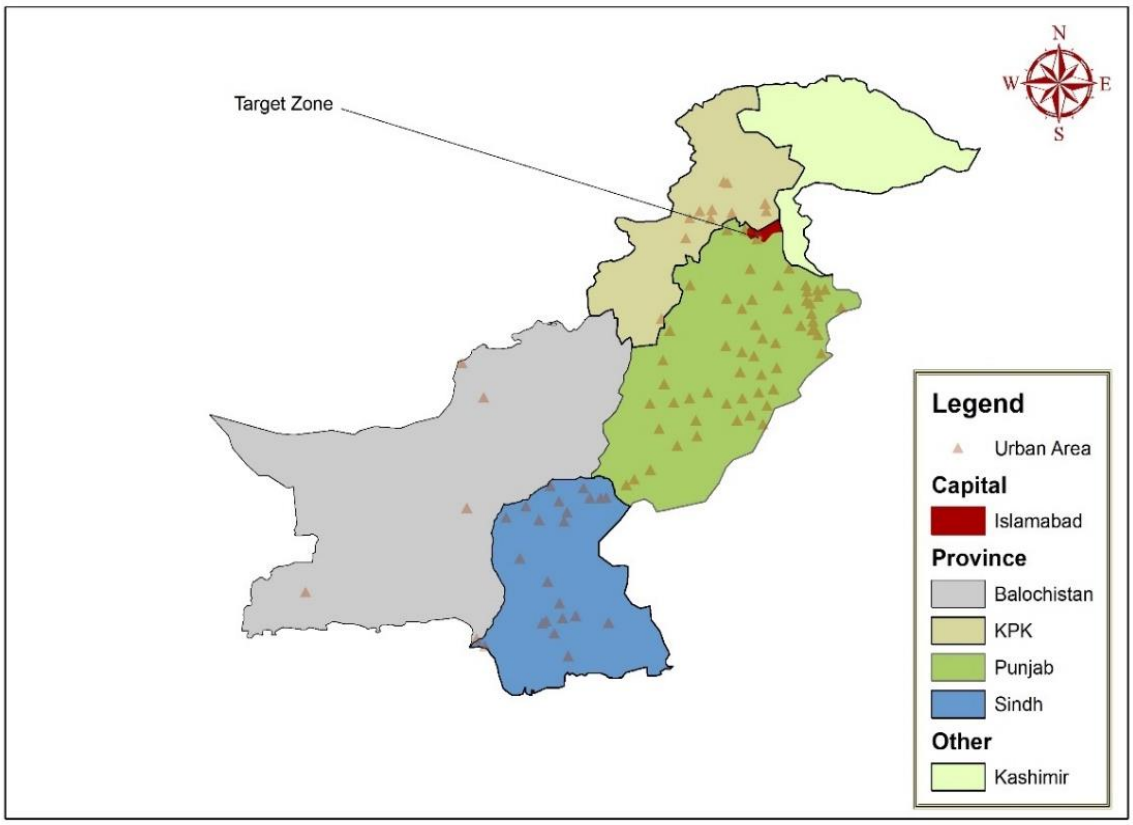

Figure 1.2: Main Urban Areas

1.2 Significance of Research

Resources Allocation (RA) is subject to ever present threat from both natural and manmade disasters but our focus is on manmade disaster. There is no other situation in which the need for correct and timely resources can be deemed of greater importance than in the rescue and relief stage of a disaster response stage. All the organizations involved in disaster management e.g. NGOs, local department of fire-fighters, military power, civil defense etc. need to respond as a very planned, organized and efficient responders. Thus, resources in both intra and inter organizational level coordination at several hierarchy stages expects a most extreme significance under such conditions. Since coordination requires data about Resource Allocation which must be shared within and between organizations upstream and downstream continuously, the need emerges for an integrated RA for DM that provides efficient, reliable and secure processing and exchange of relevant resource.

DM in Pakistan has been institutionalized but it lacks a reliable and speedy response plan, based on an effective Resource Allocation System, in accordance with the emerging technological trends. This research has been carried out to bridge the digital gap and propose an Agent Base Modeling technique for Resource Allocation in term of DM that is more in line with the computational model of technologies. The framework proposed and the ABM implemented in the course of this research are applicable as generic solution to disaster related problems in terms of RA.

The research work centers to consider the DM with respect to resource allocation and investigate the execution of resource available within the area with specific emphasis on disaster mitigation and preparedness aspect. With the growing occurrence of disasters in urban areas and their effect on the national economy and public activity, it has turned out to review the current structure of disaster management at grass root level. The aim of this work is to design an Agent Based Model for effective resource allocation featuring consistent coordination in reducing disaster risk factor.

1.3 Problem Statement

Disasters have struck Pakistan on random intervals therefore the Disaster Risk Profile of Pakistan reveals the country's vulnerability to a range of hazards. But the management of disasters has not been to the required standards either due to the lack of understanding at Government and society level or due to lack of requisite resources. RA and its planning have not been the pressing theme in the country until recently. Even now the general approach has been observed to be more reactive and response driven as opposed to being proactive and pre-emptive. The DM system in Pakistan at present does have a wide-ranging and coherent institutional arrangement but lacks an efficient, reliable and speedy response plan as there is no effective RA technique to deal with a disaster situation, in accordance with the emerging technological trends. This outcomes in a delayed response by various administration whenever an emergency situation is faced in the region resulting in huge loss of life, property and capital.

Many developing countries have carried out extensive research to develop early warning systems, disaster relief distribution systems and Geographical Information Systems to enhance their disaster response capacities in the face of such calamities. In the wake of the disaster, it has turned into Pakistan's critical need to create and actualize such RA model for improving the current DM framework in Pakistan and to accomplish activity. While, Pakistan Armed Forces have been quickly helpful in light of each disaster and their services to the affected zone have been exceptional, the reaction from civil organization has been practically insignificant. Previously mentioned realities dictate that there is an acute need to assess and devise a feasible RA model at national level to build our DM abilities at various levels of civil organization while expand upon broad shape of RA. The problem statement can thus define briefly as:

"How to reduce disaster risk factors in urban area by capitalizing on emerging technologies; Specifically formulating and developing a framework to implement Agent Based Modelling for Resource Allocation."

1.4 Objectives

- To review the DM existing model and framework and emergency system world wide.
- To develop techniques which is applicable in cities for disaster resilient to perform analysis of existing resources and urban environment.
- To suggest a RA model for providing relief and good efforts in the disaster zone
- To efficiently and effectively allocate resources within an environment proposed where disaster incident happened frequently.

1.5 Thesis Outline

- *Chapter 1:* Chapter 1 focuses on Disaster management basic knowledge, their stages and related issue and background study.

- *Chapter 2:* Chapter 2 center around basic overview of Disaster management authorities and their roles. In this chapter Predecessor Models and their comparison is described.

- *Chapter 3:* Chapter 3 introduces a methodology to implement Agent Based Modeling for Resources allocation in the Urban Environment. The two different Allocation Algorithm is also purposed in this Chapter.

- *Chapter 4:* In Chapter 4 proposed methodology is implemented in both Euclidean and GIS space. For GIS space hypothetical Scenario is created and simulation is design on the basis of scenario's data.

- *Chapter 5:* Chapter 5 present result and finding for the Allocation Algorithm.
- *Chapter 6:* In chapter 6 conclusion and future work direction is presented.

Chapter 2

Literature Review

2.1 Overview of National Disaster Management Authority (NDMA)

NDMA is set up based on constitution and self-governing federal agency to oversee and manage the whole ambit of disaster and their administration at national level. The NDMA plans and approves national disaster proposed policies at federal level and partners with various state and military authorities, and United Nations-based associations together to sort out and facilitate their efforts to lead its disaster management, search and rescue operation and long term/short term humanitarian activities in the national level and across the borders. It also hopes to make feasible functional scope and expertise to embrace its humanitarian tasks.

2.1.1 Organizational Evolution

Generally, Pakistan has been following a reactionary approach towards disaster management adapted towards relief task. The military have been widely utilized for this reason and the other main sorted out civil structure in such manner has been the Civil Defense Organization made under the Civil Defense Act. 1952. Other legislation identifying with the relief/response structure incorporates the Natural Calamities Act. 1958 under which the arrangement of the Relief Commissioners and their power have been characterized. The Civil Defense Act was considerably re-examined in 1994 to incorporate activities adapted towards relief and response including strategy planning, coordination and preparing. Additionally, ERC also known as Emergency Relief Cell was put to rights in the Cabinet Division in 1971 for mitigating the adverse effects of the act of God in the country. In the wake of the 2005 Pakistan catastrophic earthquake, the NDMO 2006 took into consideration the establishment of the NDMA with expansions in areas and locale dimension. In spite of every one of these improvements, the serious issue of how these different structures communicate and organize with one another has remained rather tricky. Different response organization have diverse revealing lines both at government and commonplace dimensions and covering jobs and duties. Notwithstanding the fact that the National Disaster Risk Management Framework

achieve to characterize roles and duties, it is only a framework and, at last, genuine reporting lines and controlling services and divisions regulate task allocating of response organizations. It is, accordingly, important that all response organizations have particular jobs and, where conceivable, osmosis happens. The interpersonal coordination among various agency's personnel is also necessary in this regard as well as all hands on deck sometimes do the trick[17].

2.1.2 National Disaster Management Organization

Federally, state agencies responsible for disaster management in Pakistan are as under [16]: -

1) National Disaster Management Authority (NDMA)
2) Provincial Disaster Management Authority (PDMA)
3) Tehsil and Town Administrations
4) Union Council Based Organizations
5) Community Based Organizations

1) National Disaster Management Authority (NDMA)

It is a national authority instituted for risk mitigation and is responsible for execution and application of plan of actions and evolving strategies pertinent to disaster management. This institution has been devolved on to provincial and district level from federal level, though the federal agency also does the work in their own capacity at federal level. The federal agency NDMA channels down the information/data to provincial level and also to the district level to assemble compendiums of various policies relevant to disaster and risk management[20].

The NDMA was established to explain and rationalize the roles and duties of all stakeholders. Everyone has been included in the framework of this institution, from national to local stakeholders, to make it an effective and useful organization. Its focus is on "to achieve sustainable social, economic and environmental development in Pakistan through reducing risks and vulnerabilities, particularly those of the poor and marginalized groups, and by effectively responding to and recovering from disaster impact" [19]. For execution and application of its policies and improving capacity building, nine areas has been prioritized given as under: -

- Localized programmes based on community input

- Early Notification System
- Institutionally setting up disaster and risk management via lawful channels
- Capacity and skill building for post-disaster activities
- Integrating disaster risk syllabus into development
- Reduction in calamities / readiness
- Danger / vulnerability evaluation process.
- Crisis management and response mechanism
- Awareness and training regarding disaster education

National Disaster Management Authority's powers are as under: -

- Lay the groundwork to recommend instructions, and enjoin a course of direction to the relevant provincial authorities and ministries, concerning activities to be carried out by them in response to disaster.
- Spreading awareness among general public about disaster management.
- Making guidelines for planning disaster management by different authorities under government
- In circumstances like a disaster, better rescue operation, cooperation and quick response.
- Act as the monitoring, coordinating and executing agency for disaster management.
- Implementation of the national policy along with coordination and supervision.
- Provide technical support to provincial peripheral authorities for making their disaster management contingency plans in regard with instructions outlined by the National Commission.
- Make a plan to be finalized by the National Commission.
- Any person having special services considered necessary should be requisitioned and be considered a member.
- Any other task asked by the National Commission must be fulfilled.

2) Provincial Disaster Management Authority (PDMA)

Provincial Disaster Management Authority (PDMA) has been conferred on the following set of duties and powers[18][20] : -

- Coordinate, synchronize, and monitor plans of actions in case of a calamity.

- Making guidelines for planning disaster management under provincial government and district authorities.
- In light of the recommendations and approval of the Provincial Commission, a robust policy should be outlined for the provincial disaster management.
- Find and appraise the risks and dangers in different parts of the province and lay out mitigation plans.
- Perform any other task asked by the National or Provincial Authority.
- Provide technical support to district authorities for effective disaster management.
- Implementation of the national policy and provincial plan along with coordination and supervision.
- Keep an eye on the compliance of the construction standards in the districts, and make sure they are compliant of the rules.
- Make sure all governmental / non-governmental organizations have a robust response mechanism in case of a disaster.
- Making sure that the communications are swift and robust post-disaster and carry out disaster management trainings.
- Lay the groundwork to recommend instructions, and enjoin a course of direction to the relevant provincial departments and authorities, concerning activities to be carried out by them in response to disaster.
- Lay out plans for provincial governments on financial aspect pertinent to disaster management.
- Spreading awareness among general public about disaster management via community based trainings and disaster education.

3) District Disaster Management Authorities (DDMA)

The provincial govt is responsible for the layout and establishment of district disaster management in respective provinces. It comprises of Mayor/Nazim, Police Officer, DCO, EDO Health and Tehsil Nazim while other representatives may be nominated by local government. Some of the goals of these are given below [21] :

- Developing a plan for disaster management and making its execution better via effective coordination.
- Advancing disaster alleviation measures on different levels.

- Check and balance on the dangers in local areas, prone to natural disasters, intermittently.
- Awareness campaigns and suggestions for local community to lessen the disasters' after-effects.
- Involve locals in disaster mitigation by providing them technical expertise and supporting roles.
- Keep an eye on the compliance of the construction standards in the districts, towns and municipals, also make sure they are compliant of the rules.
- Disseminate information and instructions via District Emergency Operations Centre.
- Work with PDMA and district relief department in cohesion.
- Any other task asked by the Provincial Authority must be fulfilled.

4) Tehsil and Town Authorities (TTA)

These are in the lowest echelon of this chain or organizations and deals with health, police, agriculture, education *et al*. The workforce of these sectors can bring a lot of refinement and rectification in their respective sectors ranging from guiding agricultural sector about crops immune to catastrophes, to awareness among general public about endemic plagues. Tehsil administration can be very productive and useful, if it works in tandem with DDMA for rescue operations as first responders.

5) Union Council Based Organizations

These are lowest tier of administration with members elected via local polls in villages and wards. Union council appropriates required money for local developments. Plans for loss incurred as a result of disaster is also in the purview of the union council administration.

6) Community Based Organizations

The need of community-based organization may be fulfilled by making new organization, if the former is not present. However, district and tehsil administrations play a crucial part in building the skills of already present organizations. Proper training about disaster management control is vital in this regard. For disaster and risk reduction, it is critical to work mutually for the greater good. Employees are imparted different skills and expertise via trainings.

2.2 Predecessor Models and Existing Research (PMER)

In the context of our research literature review the PMER is divided into following:

2.2.1 Conceptual Model and Theoretical Approach

DM learning has for quite some time been recognized as assuming a meta role in decreasing the effect brought about by disaster. The article [24] effectively composed of informative based analysis system intending to the difficulties of changing the semi-organized DM learning to the organization that can be grasped effectively. The target of the structure is to contribute the DM flexibility tries. The ABMs, the MOF metamodel and the learning move and picture of difficulties are presented. It helps individuals at the basic leadership level to create relevant choices, as they are delivered from the cooperation of the included social elements and their encounters and the individuals who are on the ground to properly respond towards the disaster. This created structure is approved utilizing a genuine contextual analysis of the flood DISPLAN (Disaster Management Plans) of the State Emergency Service (SES) the State of Victoria, Australia. While it is viewed as basic practices of DM, its acceptance is as yet testing because of its intricate structure and accessibility.

Wise et al. [26]explain simulation for urban as a creative field, using creating innovations to investigate the interdependencies, inputs, and heterogeneities which describe and drive forms that connection the elements of urban zones to their structure. The authors described developed models have more degree of variation and innovation, as it is imperative consideration to think about the transportation role which lies inside them. Transportation joins, partitions, and structures of urban zones, giving a utilitarian definition of the geometry and the monetary costs that decide urban procedures in a likely manner. Their work displays a concise preview of different researcher work and their thinking about urban framework elements as they are influenced by transportation with regards to ABM and how this identifies with the more extensive field of transportation simulation and modelling.

There are number of DISPLANs documented repositories that can be easy approachable on time being when there is necessary. In the paper [27] authors introduced a framework that is knowledge-based units which are abstract from DISPLANs. The framework main contribution is in the DM knowledge area. The DM activities units at that point allow the

mixing and coordinating knowledge between various plans. The repository is organized as a layered reflection as per Meta Object Facility (MOF) to permit the free stream access over the layers. The framework additionally shows its ability such that the information components removed from the DISPLAN can be motorized using MOF to be situated in DM timetable, specifically for basic decision, planning and layered for real world. They utilize the flood DISPLAN of the SES (State Emergency Service), an administrative DM organization in NSW (New State Wales) State of Australia for verification and validation of purposed framework.

A system way to deal with disasters, blueprints and their methodologies for integrating interdisciplinary assets all the more productively to help disaster responses. Taking a practice of DM, this paper [28] investigates the subject of why advances in system theories have failed significantly on a more extensive scale to change the DM. This distinguishes whether and how that science of system and knowledge can be conveyed to improve DM even with quick atmosphere destabilization, so manageability turns into the standard, not the infrequent example of overcoming adversity. Well managed successful DM requires systematic integration approach for review on daily basis activities of everybody who has an impact on future misfortunes. Thus, this is move in social way to deal with DM. Numerous tools are accessible to the individuals who are prepared to acknowledge that move. A portion of these tool are basic, some are progressively troublesome, yet they are for the most part giving solid help towards usage of a paradigm approach of DM.

In Pakistan Disaster Management is in its beginning time yet regardless it needs to be progressively autonomous and versatile. for building a proficient framework new expertise should be established. The author [30] utilizing the contextual investigation of Baldia town factory, Karachi. This gives a cooperative effort between different rescue unit and government organization and also a way to deal with comprehend the framework deficiencies and the significance of advancement of DM plan for a modern unit.

A lot of research has been dedicated to the improvement of Emergency medical model planning and decision making. The paper [32] analyze and talks about current demonstrating ways to deal with location issues, identified with managing emergency vehicle, especially those identified with vehicle area, movement site and dispatching vehicle decision. The main focus of this analysis to focuses on how to deal with location

strategy and operational decision making and more about interconnection between them. More significantly, this demonstrates a developing joint effort among different experts while the majority of the PMER depend on reality or sensible cases. This coordinated information effort help professional's hypothetical and methodological and enables researchers to pick up a superior knowledge of the unique circumstance, fundamental concerns, challenges and restrictions from a down to earth point of view.

In spite of the huge measure of work that has just been done on the role allocation problem, there remains various role related issues that still can't seem to be settled. In Multi-agent system for cooperative environment, roles are utilized as a conceptual design when making huge frameworks and they are known to encourage agent specialization. As in multi-robot domain they become an interference reduction tools. The kind of roles that the agent is requested to do, and the agents' abilities fundamentally influence in that way in which roles are utilized for multi-agent system in cooperative environment. Campbell et al. [25] compare role allocation computational model and their study gives a technique used to approach resource allocation problem.

Use of Big Data in DM is yet to completely experienced into a particular zone research. Through the bibliometric and system investigation, the paper [36] plans to determine the flow advancement in the field and recognize that there is appropriate degree for a far-reaching concentrate to investigate new conceivable outcomes and bearings for research later on. The time of big data and their study is opening up new conceivable outcomes for DM. Because of its capacity to envision, break down and foresee disaster, enormous information is changing the helpful tasks and emergency the executives drastically. However, the pertinent writing is assorted and divided, which requires its survey so to determine its improvement. Various productions have managed the subject of enormous information and its applications for limiting disaster. In view of an orderly writing survey, this investigation analyzes huge information in DM to show principle commitments, holes, difficulties and future research motivation. The examination shows the discoveries as far as yearly circulation, principle diaries, and most referred to papers. The discoveries additionally demonstrate a grouping of distributions, an investigation of the patterns and the effect of distributed research in the DM setting. Generally, the investigation adds to more readily comprehend the significance of huge information in DM.

DM is a diffused subject matter. It has numerous intricate highlights interconnecting the physical and the social perspectives on the world. Numerous worldwide and national bodies make learning models to permit information sharing and compelling DM exercises. Be that as it may, these are frequently tight in center and manage determined disaster types. The researcher examines thirty such models to reveal that numerous DM exercises are really regular when the occasions shift. They at that point make a bound together perspective on DM as a metamodel. They apply a metamodeling procedure to guarantee that this metamodel is finished and reliable. They approve it and present an authentic layer to bind together and share information just as consolidate and match distinctive DM exercises as per diverse disaster circumstances. DM includes community oriented basic leadership exercises regularly described by a significant level of multifaceted nature including various wellsprings of information conveyed crosswise over time, space and individuals. As such, not all situational information is quickly accessible, not one individual will be situated to settle on all choices, and not all learning is originating from a similar spot .In the paper [37] Othman et al. advocate the utilization of a center information layer to empower DM experts to perceive disaster autonomous highlights in the difficulties that they face. We present this center layer of information as a disaster autonomous metamodel to bring together learning from various disaster encounters.

In the recent decades, the effect of disaster has been destructive, influencing billion of individuals. As Improvement is a unique procedure and disaster give the chances to vitalize and additionally revitalize this procedure, particularly to create and upgrade economies and living condition. The accomplishment of the recreation stages, i.e., rescue in emergency state, help and restoration, is mainly subject to the accessibility of proficient resources and RA team. By having the knowledge-based framework to make decision in well manner and also to create effectiveness and efficient DM Structure. The Arain [42] introduces a conceptual framework of knowledge-based methodology for upgrading instant and successful economical DM. The structure is depended upon to help improving generation task techniques, coordination, and gathering building process in light of the way that the without a doubt zones on which to focus can be perceived during the starting time of the post-disaster circumstance.

2.2.2 Mathematical and Simulation Based Model

In [22] Kondaveti et al. presented an emergency manager which demonstrated a decision support system, they also developed a tool which can help in organization for emergency response effectively yet in addition to perform resources planning in crisis. The system has integration with real-time emergent response system for the management of resources in term of disaster reaction.

Natural disaster event happens everywhere throughout the world, changing the physical scene and regularly seriously disturbing individual' day by day lives. Researchers [23] consideration has centered around utilizing volunteers' resources for mapping the damaged area and annihilation brought about by disaster. The authors express a spatial prototype which demonstrated an agent-based model created using publicly utilizing supported geographic data and different freely accessible information, which can be utilized to analyze the result of disaster event. The particular case demonstrated here is the Haiti seismic tremor of January 2010. Publicly supported information is utilized to fabricate the underlying individuals influenced by the disaster. They investigate how individuals respond to the resource distribution, just as how bits of gossip identifying with resource distribution in the area of effective population. Such a model could possibly give a connection between social and cultural data about the general population influenced and the relevant resource allocation organization.

A great number of unfortunate casualties and a huge number of influenced individuals are outcomes of disaster events, consistently. Along these lines, it is basic to set up a formal responsive program that thinks about early DM activities. In urban regions, organization and municipal on local basis oversee disaster related tasks, for example, giving initial emergency resources/relief and supplies in order to reduce disaster risk. In [25] authors created a multi-objective MILP model for a two-echelon demand chain for maximal coverage to population and minimal costs coverage. Proactive estimation of damage empowers the proposed model to give valuable knowledge about a disaster fallout and consider appropriate prerequisites requirement for urban region. This create certain cluster of demands requests in various zones and blueprints a general viewpoint about effected urban zone.

In the paper authors [29] addresses a MCLP with partial coverage where distance and demand zones are rectilinear therefore when covering just piece of an interest zone is

permitted and the coverage include only that part having relative demands. More explicitly our concerned is to maximize covered demand in in rectangular demands zones with having some partial set covering in a two-dimensional plane, which is referred to PMCLP-PCR. Here they find ideal solution for facility-based problem of the issue and use them to benchmark the nature of the arrangements acquired from heuristic algorithm. Their computational trials with this heuristic demonstrate PMCLP-PCR settled optimality by algorithm.

The meng et al. determine the optimal location facilities for the terrorist attack in term of emergency response [31]. In this a game based on leader-follower between state and terrorist is created. The main phase of the game enables State to settle on a decision of service site and service task to city on attack, while the subsequent stage permits terrorist to choose one city to attack in the wake of watching the system of State. For this computational experiment in the urban areas of china are made for the verification of purposed heuristics model.

A lot of work is done on different type of facility location problem. The goals that are considered in various kinds of FLP e.g. private and public sector location problem, can differ which is depend upon the attributes of these problem. Fact is that problem related with finding private and public facilities sites are similar in that the two of them share the goal of maximizing utility capacity of decision managers but different in structuring the goals. In the paper [33] the authors developed a novel methodology for facilities problem having multi objectives with the attention on emergency location system. Their goal is one of a couple studies fusing the goals of three location problem; pMP, MCLP and pCP, while focus to locate solution for pareto optimization trade-off between them. They have built up algorithm for above given each location problem consecutively.

The transportation industrialization becoming a part of social and financial development of the country. As the vehicle foundation advancement, the vehicle improvement and advancement, just as the usage of various measures went for transportation security assurance. The Matveev et al. [35] explain reliance and proficiency of emergency responses to incident and other vehicle utilization during emergency occurrence. A technique to determine the issue of surveying the proficient arrangement, maintenance and support of vehicles is provided during emergency situation .Results of issue goals are planned for choosing an ideal choice for the arrangement and maintenance and

obtainment of new vehicles, fix of the current and created vehicles through coordinated appraisal dependent on the advancement of formalized criteria, for example, the degree of operability and accessibility of vehicles in emergency state for response to accident

Disaster are tragic occasions for a nation, not least in light of the normally extensive stretches when none happens yet in addition on the grounds that reacting to them expends immense resources. These resources are frequently specific to a specific kind of disaster and give capacities to spare life, shield individuals and their resources from damage, and diminish the effects of the effect. As disaster rarely occur, these resources are typically rare as it is infeasible for urban areas to have enormous amounts of expert tool lying inactive between disaster. The paper [38] utilizes stochastic improvement procedures to allot rare national asset crosswise over eight urban areas to best react to three concurrent disaster occurring over these areas. The first model examinations the danger of not having the option to accomplish execution targets given asset limitations while other subsequent model investigates the assets expected to meet objective execution levels. A third hybrid model (built from the first two models) investigations the ramifications of different financial spending plans. Extra affectability examination is performed by investigating different settings of area significance, number of concurrent disaster and asset prerequisites. They reflect on the utilization of such displaying strategies for these issues and talk about the influence of political parts of asset designation which such models cannot address. They additionally reflect on the requirement for advanced modelling demonstrating to perceive the capacities of the clients and the accessibility of sensible suppositions in the event that they are to influence by disaster manager.

Allocation in traffic management is a kind of RA which have dynamic and cooperative Behavior. In such a sort of RA, resources change is dynamic and unpredictable but consistent changes in certain cases. Moreover, resources consistently have more than one autonomous organization/individual that need to work to accomplish some social welfare. For instance, when a car crash happens, traffic police officers, emergency vehicle, and even firemen, who are managed by various associations, may need to cooperate in emergency situation. Kong et al. [39] propose a model which is based on back propagation neural network composed of linear programming and RA requirement prediction. As in current traffic, resources management are always pre-assign only when there is traffic accident take place, in some cases resources are allocated rapidly to reduce the risk in term of accident.

Disaster are disastrous occasions of unprecedented conditions which cause significant misfortunes all around the globe. It is in this manner significant for all countries to build up their solution to prevent and also at least to diminish these misfortunes. Cavdur et al. [40] consider facility location problem for disaster operation management, propose an approach for solution and represent with case study in turkey based on earthquake.

A disaster frequently causes property harm and individuals lives. humanitarian aid is direly required all together to save lives and provide basic resources to individuals in affected zones. Huang et al. [41] describe problem in which manner how humanitarian aid is distribute and deliver to affected zone in a proficient manner through network of transportation in order to reduce disaster effect. The outcome of disaster changes quickly and are exceptionally erratic, which demonstrates that it is difficult to make the whole schedule that which resources are help during allocation at decision making. For the situation, choices must be set aside a few minutes focuses dependent on accessible resources. At every choice point, the needs to consider the helpful resources allocation in a specific future timeframe.

2.2.3 Comparison of Models

Table 2.1: Comparison of Predecessor Models and Existing Research

Ref. #	Domain	Technique use	Proposed Solution	Result	Limitation
22	DM	DSS Algorithm	Resource allocation decision support framework.	Optimal solution for proposed supportive environment	System have no scalability property
23	GIS and Disaster	ABM utilizing with GIS	A framework to deploy to find human relief after a natural disaster	Functional map environment of aid Centre and damage area also involve verification of model	Model only adjust in current geospatial created situation and social information
24	DM	DSR Methodology	A framework for analyzing knowledge-	A knowledge-based DM having	This system makes ready to be

			based DM to structured and organized better DM decision making activities	informative and practical approach toward DM resilience task	conceivably executed in different countries but with a similar government structure
25	Urban DM	Multi objective mixed-integer linear programming model	A mathematical approach to maximize demand coverage in population zone and minimize cost	Overall estimation of damage area result and proper response requirement for urban zone disaster	The model is Scientific demonstrating to discover compelling and productive arrangement techniques and calculations, since true cases are generally enormous scale issues
26	Urban transportation system	Model based study	A theoretical approach to investigate transportation model and their element	How transportation is handled and control in different models	Discuss only reflection of models as far challenges factor is missing
27	DM	Knowledge based DM Analysis framework	Analysis framework to transform DISPLANs to knowledge-based collection units	Suitable knowledgeable DM element for PPRR	This presented work have chances to improve the DM element but prepare with average learning-based knowledge structure
28	DMS	System Approach	Implementation of system theory toward DM	How system approach improves DM	Only developed system thinking but

				related difficulties	lacks system dynamic
29	Facility location coverage	PMCLP-PCR	Using effective methodology to develop a heuristic algorithm for MSP timely based solution	Their result has nearly to optimal solution in a short span of time and proven algorithm is better than PMER of PVT algorithm.	Multi facilities site zone are covered but under rectangular distance and area
30	Urban fire-related problem	DM Analysis	A conceptual approach toward using systematic DM methodology to minimize the crisis effect	Identification of risk factor and a solution to reduce its effect	Provide an overall viewpoint about system but lack of DM critical point
31	Facility location optimization	Mixed Integer Programming	A solution for population-based heuristic algorithm is developed by creating emergency scenarios	heuristic calculation; More efficiently resources allocation on emergency attack site when they are required	Strategy, viewpoint and assumption mostly not totally practical having boundless limitation
32	Emergency medical system	Static and dynamic analysis of location and relocation problem	Utilization of stochastic programming & dynamic model Methodologies and their interaction with multiple coverage	EMS management issues, decision making technique for location and relocation	Lack of computational effort for location and relocation system
33	Facilities location problem	Branch & bound technique and	ITER-FLOC algorithm is developed based on hybrid	Compromise solution having a set of	Iterative technique for specific FLP

		iterative goal programming	approach by integrating branch & bound technique and iterative goal programming	pareto optimization	
34	Multi-agent System	Study of role allocation problem	A detailed comparative analysis of computational model for role allocation problem	pointers to important works are given so as to enable researchers to start handling these problems.	Only Discussion about method lack strategy as centralized approach
35	Transportation for rescue and emergency services	ERV optimization	Method to improve emergency vehicles services	Generalized action plan for emergency vehicle in crisis situation	Only eliminate crisis situation during vehicle services allocation
36	Big Data DM	SLR (Systematic Literature Review)	Number of publications have deal with the subject of big data and its applications for minimizing disasters.	This study examines big data in DM to present main contributions, gaps, challenges and future research agenda. The study presents the findings in terms of yearly distribution, main journals, and most cited papers.	Focus on stages of DM; mitigation, preparedness, response and recovery
37	DM	Meta-modeling process and	The researcher examines	An authentic layer to bind together and	DMM model dependent on joining

		procedure for development and validation	thirty such models to reveal that numerous DM exercises are really regular when the occasions shift	share learning just as consolidate and match distinctive DM exercises as indicated by various disaster situation.	sets of appropriate ideas dependent on their own DM requirement
38	RA for disaster	Stochastic optimization techniques, Sensitivity Analysis	Penalty-Based Model, Resource-Based Model and Hybrid Model of first two model	How to reduce risk in disaster situation and also eliminate risk taking additional resources	Covered preparedness and response stages of DM
39	Transport RA	Traffic prediction model, linear programming	Intelligent RA agent-based method	Good performance achievement in term of task allocation effectively and efficiency	Adopted a supervised - based-learning method for prediction
40	Natural Disaster Risk Reduction	stochastic-integer programming model	Deterministic model developed on 5 type after earthquake scenarios.	Utilization of average facility, average walking distance and demand stratification rate	Consideration of the available commodities during allocation phase while not in the distribution operation in the TDR facilities
41	Transportation system	1. Rolling horizon approach. 2. Convex quadratic	Multi-objective optimization model	Balancing need and equity among infected zone, real time decision for	Model is bounded to incorporate transportation constraint and

		network flow problem 3. Variational Inequality algorithm.		humanitarian aid	consideratio n of single divisible resources
42	Sustainable DM	Conceptual model	knowledge-based theoretical framework	Provide an excellent platform for researchers to view existence proven DM procedures	Every one of the experts engaged with ERM research and bounded to project of post-Disaster

Chapter 3

Proposed Methodology

3.1 Agent Based Modeling (ABM)

ABM is a moderately new way to deal with Modelling frameworks made up of self-governing agents and interaction between these agents. ABM is an approach to demonstrate the elements of complex frameworks and complex versatile frameworks. Such frameworks frequently self-compose themselves and make new request [43]. ABM additionally incorporate models of conduct (human or something else) and are utilized to watch the aggregate impacts of agents' practices and their cooperation [44]. The improvement of ABM instruments, the accessibility of small scale information, and advances in calculation have made conceivable a developing number of agent based applications over an large scale varieties of areas and disciplines [45].This development pattern is prove by the expanding quantities of articles showing up in demonstrating and applications journals, the quantity of financed programs that call for ABM that consolidate components of human and social conduct, the developing number of gatherings on or that have tracks committed to ABM. Some claimed that ABMS "is a third method for doing science" and could increase conventional deductive and inductive thinking as revolutionary techniques [46]. These are fit not exclusively to reflect cooperation between various people (and different elements). They enable one to begin off with the clear intensity of verbal argumentation and to decide the connections of various theories [47]. In specific settings, for reasons of computational productivity it might likewise be sensible to change a agent based by a total "naturally visible" recreation approach [48].

ABM can be joined well with different sorts of models. For instance, when recreating the connection with the earth, nature may be spoken to by a discrete or nonstop field. Such a methodology is sought after inside the structure of dynamic walker models [49][50]. One can couple easily ABM models with continuum models, for example, gas-active or liquid unique models. Such a methodology is, for instance, used to simulate the passage of individuals in situations where toxic gas spreads in the area [51][52]. A comparative

methodology would be connected, when climate, ecological, or atmosphere reenactments would be joined with models of human reaction to the particular outside conditions' simulation are appropriate for point by point assumption testing, for example for the investigation of the outcomes of ex-risk assumption with respect to the collaboration of agents. It is generally no issue to apply strategies from insights and econometric to simulation results and to contrast simulation results and genuine information in the wake of handling them in a manner which reflect the estimation procedure. Additionally, by demonstrating the connections on the degree of people in a standard based manner, these simulations permit one to create highlights of the framework as developing procedures without making from the earlier assumption in regard to the total naturally visible properties of system.

3.2 Formulation of Framework to Implement ABM for RA

On the basis of PMER literature review of DM Approach and practices worldwide in the previous chapter, we are purposing an ABM framework for RA Model for the present circumstance of DM in the urban environment. In this present structure for DM based RA this framework is proposed as a resource allocation tool.

3.2.1 Basis for ABM for RA

- During crisis circumstance various resources emergency organization to approach and participate in a disaster zone(demands) for the responses and recovery.
- During their regular resources allocation these emergency organization are intelligently the maker and updater of resources information and datasets.
- If the resources are shared and change over a standard resource allocation, at that point datasets are open to emergency organization.

Formulation of Framework Methodology

- The framework Introduced here is a conceptual model utilized for resources taking care of among practical demands.
- Recognize key elements of ABM for RA
- Determine the relationship and interaction between them
- Determine the flow of data between them
- Determine elementary actors/sources in each entity

3.2.2 ABM for RA Framework

The proposed Framework to Implement ABM for RA is shown below in Figure:

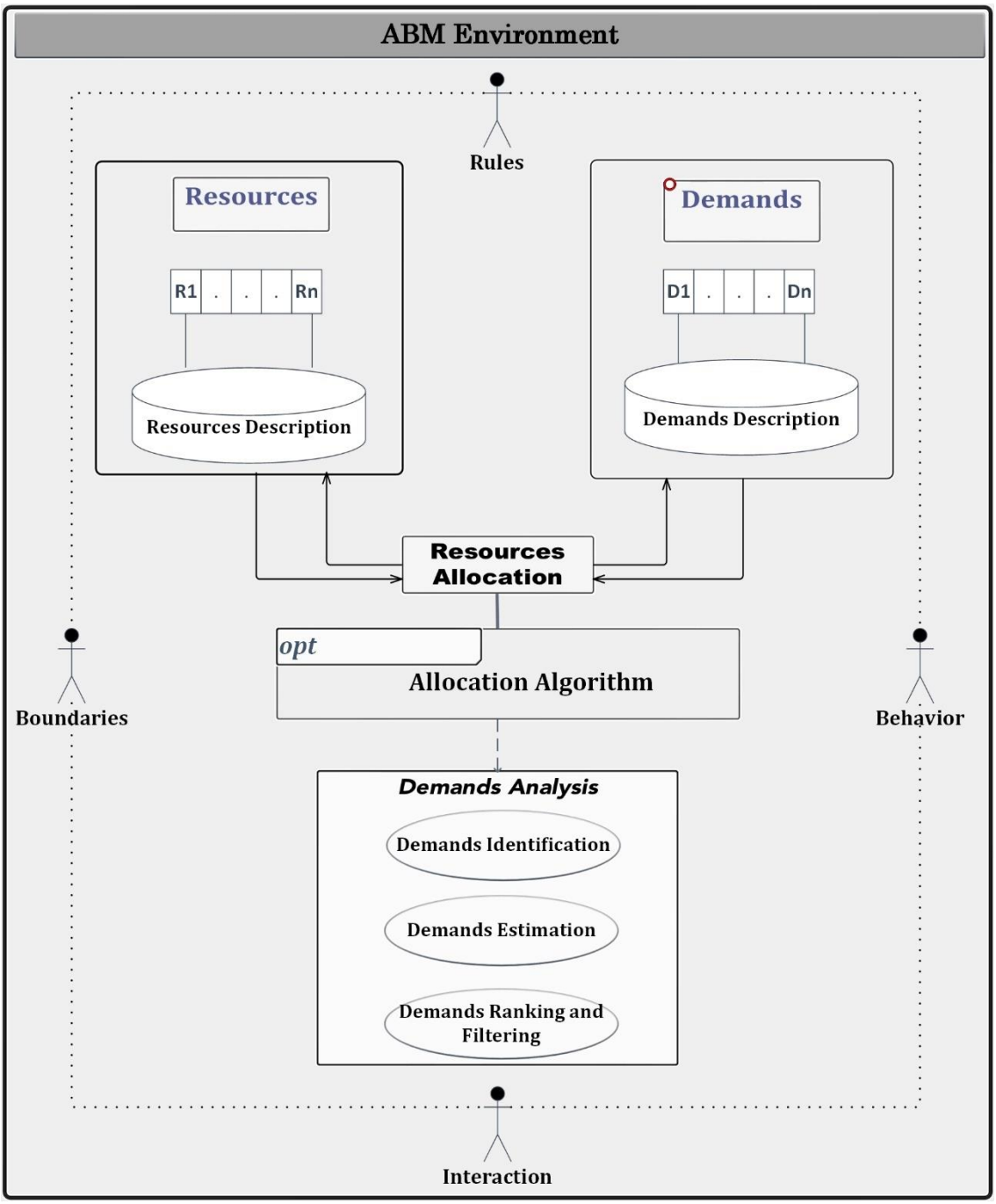

Figure 3.1: Conceptual Framework to Implement ABM for RA

3.2.2.1 Resources

Resources in that context are the organization that provide emergency services to the demand site. The emergency services which utilize their resources for the demand zone. These manage emergencies of crime-related type, solve emergencies having fire-related problem and generally claim auxiliary rescue duties, and also handle medical-related emergencies or support voluntary organizations. Here are numerous resources expected to help in the demand zone. These resources can be sorted out into various classes:

- People
- Emergency center
- Equipment and Materials
- Supplies medium
- Data

Resources are required for all periods of the program including counteractive action/prevention, relief, crisis reaction, emergency correspondences and disaster reduction. The accessibility and capacity of resources must be resolved as some are required as soon as possible. The accessibility of resources regularly relies upon logistics. Logistics is the management of resources to get them to where and when they are required.

An estimation of resources expected to achieve the targeted must be directed. Straightforward target may require constrained resources. Aggressive targets will require numerous resources with critical abilities which are accessible in short span of time. As Keeping in mind, without sufficient resources, or if resources with unavailable and lack required number of quantities, targets may not be achievable.

Other than recognizing explicit resources for the demand zone, the estimation requirements for resources should respond to different inquiries:

- What amount of a resources is required?
- When will be required?
- What ability does the resources need to have? Are there any constraints?
- What is the timing for obtaining or having the resources accessible? Are there any liabilities related with utilization of the resources?

One organization or more may give numerous aids in term of resources as following:

- Fire brigade
- Emergency medical vehicle
- Medical or emergency social services
- Rescue team
- Dangerous materials reducer
- Law implementation (local, district, state police)

3.2.2.2 Demands

Demand is basically a disaster zone, a zone authoritatively announced to be the location of a crisis made by a disaster and subsequently qualified to get specific sorts of resources. These may be a hazardous situation is an area or a district, intensely harmed by either common, innovative or social perils. Hazardous situations influence living in the network by sensational increment in cost, loss of vitality, sustenance and administrations; lastly increment the danger of ailment for natives. It may be a region that has been hit with a characteristic, innovative or sociological risk that opens the influenced zone for national or universal guide.

3.2.2.3 Resource Allocation

RA is the way toward managing and allocating resources in a way that supports an organizational key objective. It incorporates overseeing substantial resources and includes adjusting needs of resources in a balancing manner or on a priorities bases and also choosing the best strategy in order to increase the reasonable use of limited resources and get the best quantifiable benefit.

In general RA is an arrangement for utilizing accessible resources, for instance particularly in the close to term, to accomplish objectives for what to come. It is the way toward allocating rare resources among the different demand activities or special demand units. It is helping tool for us to pick the best accessible resource for your undertakings demands and oversee them all through the work, so we can stay away from under or overutilization of resources. Allocation of gainful resources among various demands zone which emerges as an issue in light of the fact that the resources of a general public are limited in number, while needs are normally boundless, and in light of the fact that any given resources can have numerous elective demands. RA is the way toward

allocating and distributing resources which are utilized by demands zone and are release by demand site after utilization. As following are the RA step:

1) Identification of resources
2) Assigning of resources
3) Determination of resources quantity
4) Resources leveling in term of duration
5) Re-allocation when necessary
6) Tracking utilization of Resources

RA within the umbrella of ABM involves deployment of a large numbers of rescue services within an urban environment in context of disaster. Resource allocation is fundamental to emergency response planning. One of the challenges faced in emergency response planning is the optimal, or near optimal, allocation of resources to specific emergencies. In context of RA problem may be stated as Resource R being allocated to demand D is stated as in following figure:

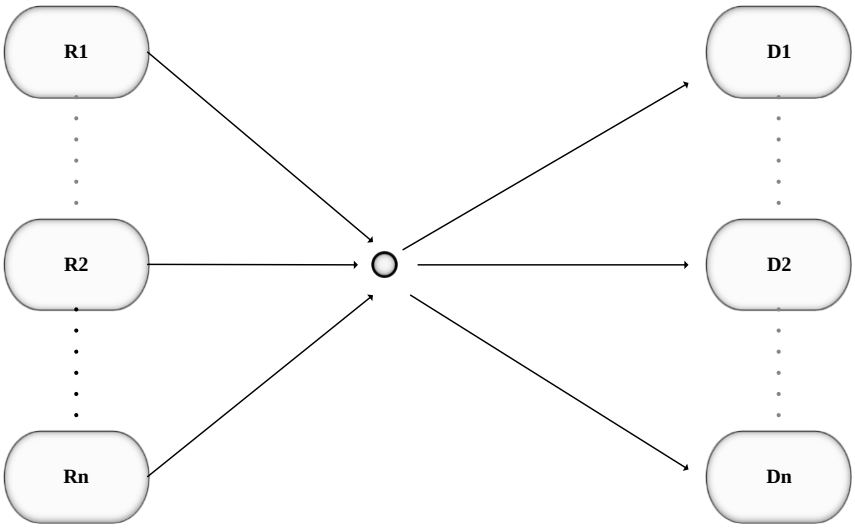

Figure 3.2: General Resource Allocation

In RA the arrival of demand at the disaster zone which is fulfilled by resources according to availability of quantity and also with respect to time can describe as tabular form are given below:

Table 3.1: i^{th} Resources with incoming j^{th} Demand at T_{Dj} Time

Resources	**Demands**
R1	D1 ……. Dj
.	Time
.	TD1 …….TDj
.	
RJ	

Here T_{D_1} ……. T_{D_j} is time for incoming Demand Respectively

Table 3.2: Number of Quantity at i^{th} Resource

Quantity	
R_1	Q_{R_1}
.	.
.	.
.	.
R_i	Q_{R_i}

Table 3.3: Number of Quantity at j^{th} Demand

Quantity	
D_1	Q_{d1}
.	.
.	.
.	.
D_j	Q_{dj}

When demand quantity is fulfilled then demand is fully allocated ,in other case it may be partial allocated or may be unallocated

D_1 Allocation (A_{D_1})

A_{D_1} = Allocation from(Qr_1,…… Q_{r_i})=Q_{D_1} at T_{D_1} Time

$A^{P}_{D_1}$= Allocation from(Qr_1,…… Q_{r_i})< Q_{D_1}< 0 at T_{D_1}Time *where A^P is Partial Allocated*

$A^{Un}_{D_1}$= Allocation from(Qr_1,…… Q_{r_i})=0 at T_{D_1} Time *where A^{Un} is Unallocated*

D_j Allocation (A_{D_j})

A_{D_j} = Allocation from(Qr_1,…… Q_{r_i})=Q_{D_j} at T_{D_j} Time

$A^{P}_{D_j}$= Allocation from(Qr_1,…… Q_{r_i})< Q_{D_j}< 0 at T_{D_j}Time *where A^P is Partial Allocated*

$A^{Un}_{D_j}$= Allocation from(Qr_1,…… Q_{r_i})=0 at T_{D_j} Time *where A^{Un} is Unallocated*

A RA cycle tracks which resource is hold by which demand and which demand is waiting for specific kind of resource. RA cycles condense the principles and settings to empower an allocation to happen. These cycles comprise of demand information and at least one allocation of demand.

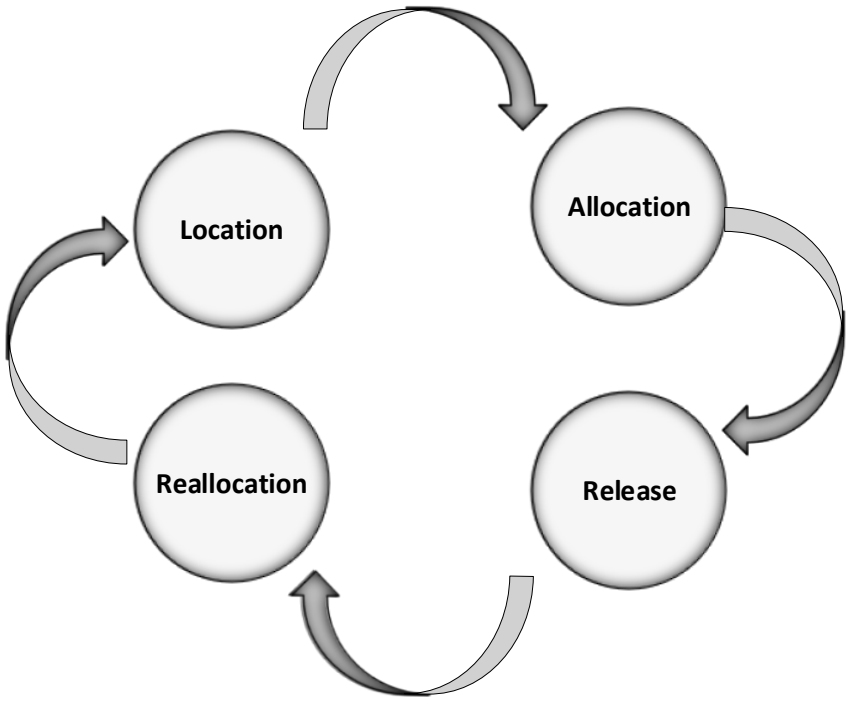

Figure 3.4: Resource Allocation Cycle

As inside RA cycle, we can characterize a few portions. In one portion we decide the standards rule by which an allocation is done. we can do the whole allocation activities of the demands in one cycle. we can characterize a few cycles that are then prepared by the framework in which they were entered. The framework guarantees that a cycle is handled in full before the next cycle is completed. These giving technique to arrangement-based RA is described. A cycle for allocating resources among a majority of demands dependent on an approach involves a majority of resources associated with each other through a organize network and also determining a strategy for allocation of resource at demands zone which are requesting for majority of the resources. It checks every resource site for recognizing requests for the resources and updating with respect to requests for the resources at the demand zone. These cycle at every demand zone for RA among the majority of demand dependent on the arrangement and data about demands for the resources.

3.2.2.4 Allocation Algorithm

Allocation algorithm define a RA plan for utilizing accessible resource, particularly in the close to accomplish objectives. It is the way toward RA among the different activities or units of demand zone. These allocation algorithms are divided into two part, firstly there is the fundamental RA decision strategy and secondly there is technique based on contingency. The fundamental RA decision is the choice of which things to support in the plan and which things are to get and leave when resources are allocated to some specific demand zone. The allocation algorithm for demand zone is a major DM activity that takes into consideration for procedure execution. In our framework that do not work with strategic DM approach for decision making to deal with RA, which is frequently founded on individual elements, but allocation Strategy allows resources to be distributed by needs set up by targets in the demand zone. Nothing could be unfriendly to DM for resources to be allocated in manners which is not consistent with needs shown by demands.

RA algorithm to specific site and zone does not imply that techniques will be effectively executed. A number of components usually disallow successful RA as an insecure resource, RA on short-run time criteria, management issue, focus on tentative methodology and an absence of satisfactory information.

In Allocation algorithm main focus center around demand analysis which rely on a procedure by which the RA make decision regarding the creation, assignment, utility of resources and estimating etc. Although how much a resource site produces resources depend on capacity of creation which base on potential demand for the zone. Demand analysis are fundamental to conceivable interlinkage furthermore in making an extension to basic RA. Demand analysis are a vital reason to create satisfactory and efficient strategies for implementing the RA in crisis /emergency situation for help and reducing their effect.

In our context of research, we have taken following two algorithm in framework for RA:

a) High Severity Level (HSL)
b) First Come First Serve (FCFS)

a. High Severity Level (HSL)

HSL is a technique for planning and utilizing of resources dependent on severity of demand . In this technique, the Demand zone utilize the Resource zone to fill in according to their severity.In the severity algorithm every demand has severity , and demand with higher severity are allocated first, while demand with equivalent severity are allocated on a the basis of First come first serve (FCFS). Resources are progressively allocated after some time in the demand zone when they required in this case. If the resources are not available, at that point the demand site within their time frame wait for the release of resources for utilization. The demand waiting request will be compared with other waiting demand in the zone, resources will be assigned accordingly on the basis of severity and if the two different demand requests for resources having the same severity in that case allocation will be done on the basis of FCFS. It depends upon possible resources availability on the resources site, else it has to wait for release of resources by other demand for reallocation within his time frame.

HSL Based RA Algorithm

1. given set of Resource R (0,……n)

Demand D (0,……m)

2. Given ith Resource and jth Demand has quantity Q_R and Q_D respectively

3. Each D_j has Severity level S_{D_j} and maximum time T_{D_j}

4. Location of ith Resource is R_{x_i} , R_{y_i}

5. Location of jth Demand is D_{x_j} , D_{y_j}

6. **while** there is a demand D_j

with quantity (Q_{D_j} >0)

with highest severity $S_{D_j} > S_{D_l}$ for(l=0,….n) ,

and (T_{D_j} > current time)

7. Checking for nearest resource R_i with

min[sqrt{(R_{x_k} - D_{x_k})^2+(R_{y_k} – D_{y_k})^2}] (for k= 1,……..n)

8. Allocate Resource to Demand and update Demand Quantity

$$\boldsymbol{Q_{Dj}^{(new)} = \begin{cases} \mathbf{0}, & (Q_{Ri} - Q_{Dj}^{(old)}) > 0 \\ Q_{Dj}^{(old)} - Q_{Ri}, & else \end{cases}}$$

9. Update Resource Quantity

$R_{D_i}^{(new)} = Q_{R_i}^{(old)} - (Q_{R_i}^{(old)} - Q_{D_j}$

end while

The flow of above HSL algorithm is given in figure 3.5:

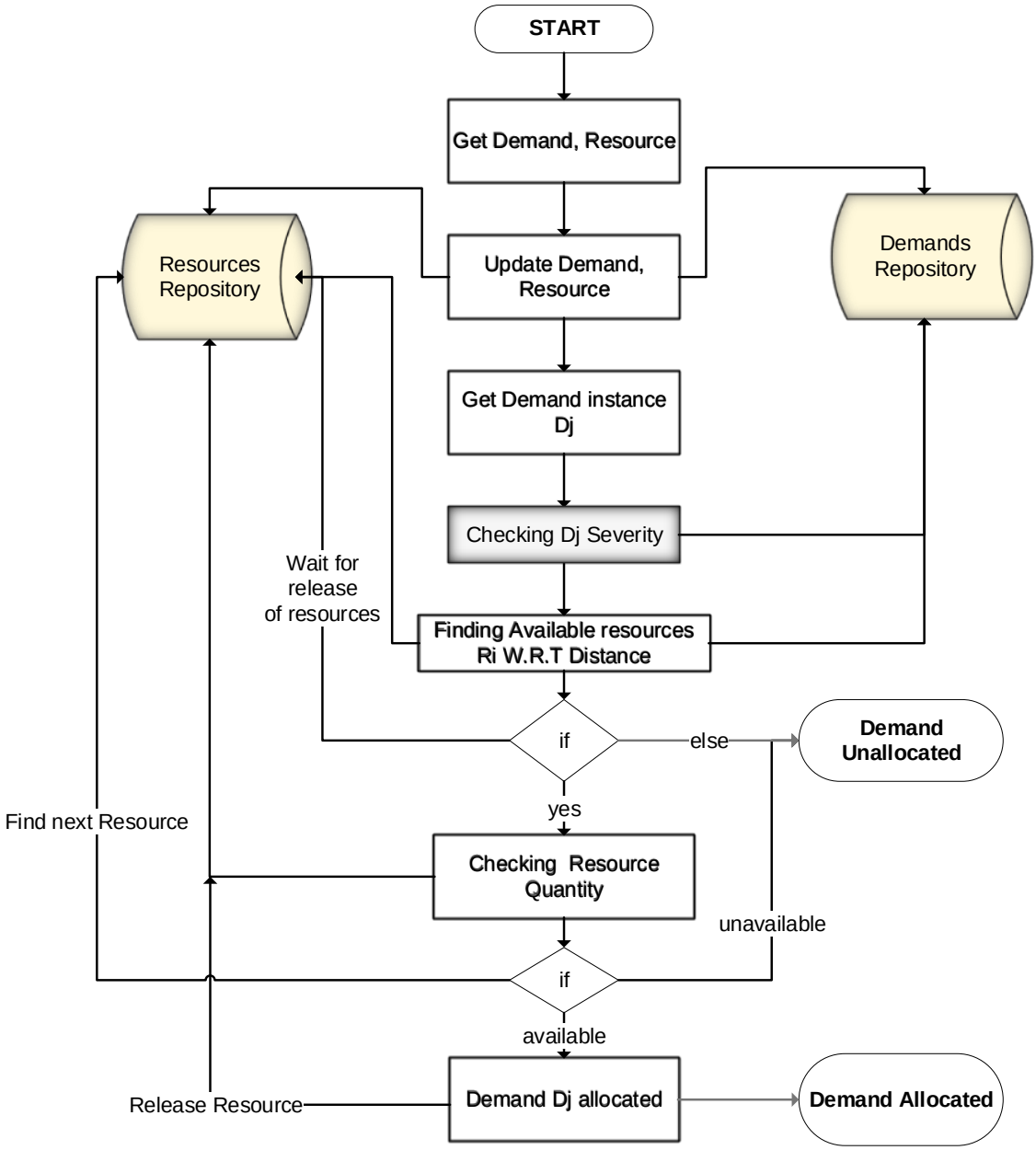

Figure 3.5: Allocation Flow on the basis of HSL

b. First Come First Serve (FCFS)

In the first come first serve (FCFS) allocation algorithm, as the name recommends, the demand which shows up first, gets allocated first.The demand site release the resources after complete utlization of resource within his time frame.

FCFS Based RA Algorithm

1. given set of Resource R (0,……n)

Demand D (0,……m)

2. Given ith Resource and jth Demand has quantity Q_R and Q_D respectively

3. Each D_j has maximum time T_{D_j}

4. Location of ith Resource is R_{x_i} , R_{y_i}

5. Location of jth Demand is D_{x_j} , D_{y_j}

6. **while** there is a demand D_j

with quantity (Q_{D_j} >0

and (T_{D_j} > current time)

7. Checking for nearest resource R_i with

min[sqrt{(R_{x_k} - D_{x_k})^2+(R_{y_k} – D_{y_k})^2}] (for k= 1,……..n)

8. Allocate Resource to Demand and update Demand Quantity

$$\boldsymbol{Q_{Dj}^{(new)}} = \begin{cases} \mathbf{0}, & (\boldsymbol{Q_{Ri}} - \boldsymbol{Q_{Dj}^{(old)}}) > \mathbf{0} \\ \boldsymbol{Q_{Dj}^{(old)}} - \boldsymbol{Q_{Ri}}, & \boldsymbol{else} \end{cases}$$

9. Update Resource Quantity

$R_{D_i}^{(new)} = Q_{R_i}^{(old)} - (Q_{R_i}^{(old)} - Q_{D_j}$

10. end **while**

The flow of FCFS algorithm is given in figure 3.6:

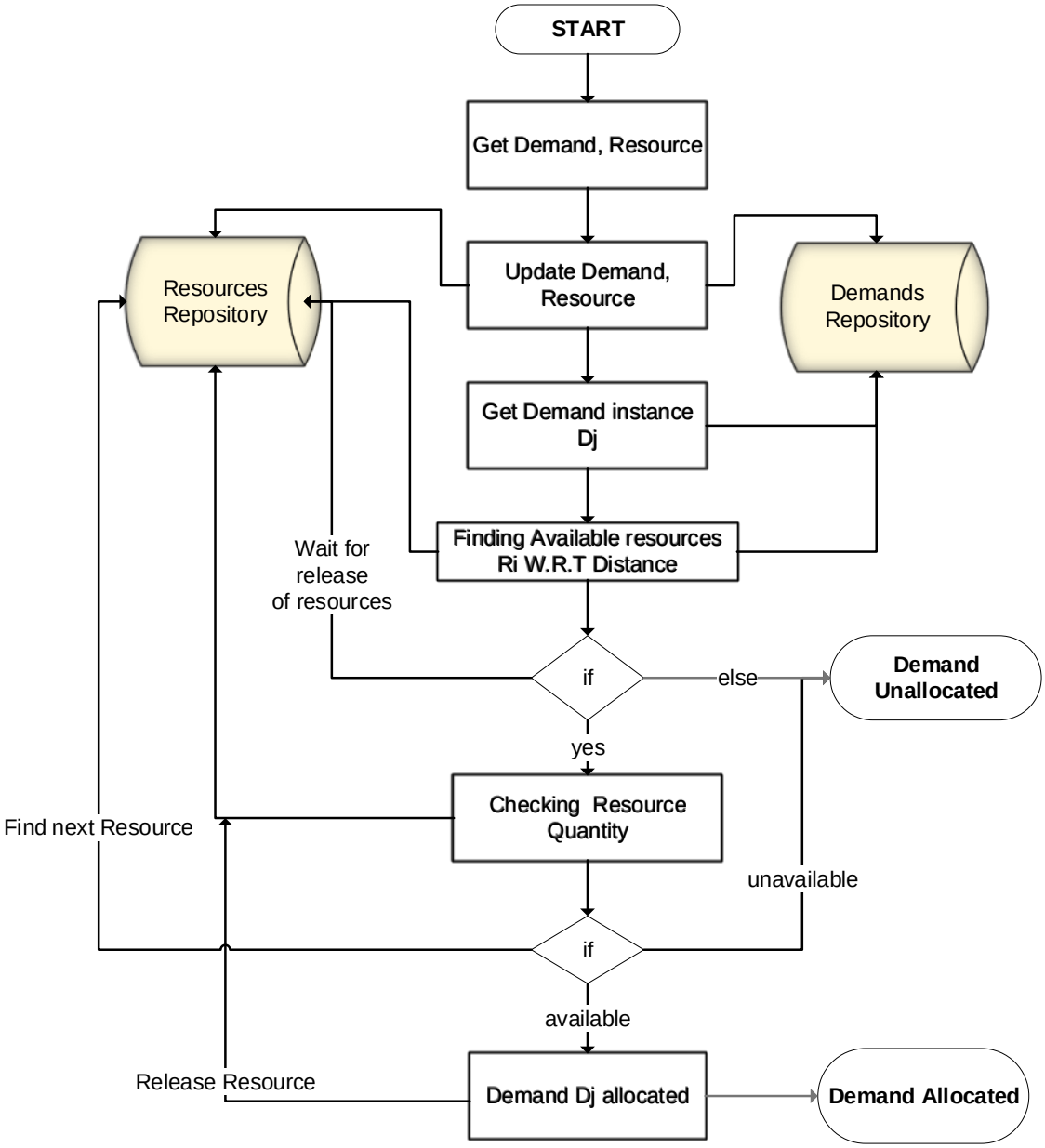

Figure 3.6: Allocation Flow on the basis of FCFS

Chapter 4

Implementation

4.1 General

ABM for RA generally can be done in universal software or programming language and it may be done utilizing extraordinarily planned programming and toolboxes that address the particular ABM requirement. RA can be possible in the small, or in the huge, utilizing enormous scale of resources, or it very well may be done at any scale. ABM for RA might be modified without any preparation in most scripting languages. It might be good from the point of view of computational efficiency. There are likewise more easy ways to use RA methods for ABM. In our case we use NetLogo environment which provide low-level libraries and modelling graphically, as it is appropriate for beginner level. NetLogo programs which are actually a model depend on a basic metaphoric representation. In NetLogo environment turtles/agents watching and connecting with one another. Turtles and patches are overall agents and more extensively, an agent is any kind of self-governing, object-oriented item fit for watching and collaborating with its condition and other agents. Agents might be ambulant, similar to turtles, or stationary, similar to patches. It might be common and intelligent. In some case it may be complex even depend upon the collective behavior of agents which is emergent behavior. The objective of ABM for RA is to think about complex behavior of the whole resources as compared to singular bit of resources.

4.2 RA in the Euclidean Space

Euclidean space is a dimensional space where the Euclidean geometry apply. Additionally, in our context a space for RA in any limited number of point where demand and resources stand. Their measurement and a point are assigned by patches for each demand and resource. The distance between two point is find out by a distance formula. One approach to think about the Euclidean space is as a lot of focuses fulfilling certain connections between demand and resources which are express in term of patches and distance. For instance, there are one essential tasks on the space is allocation of resources

to demand site on their request by allocation method. RA in that space is implemented in Netlogo and show in below figure:

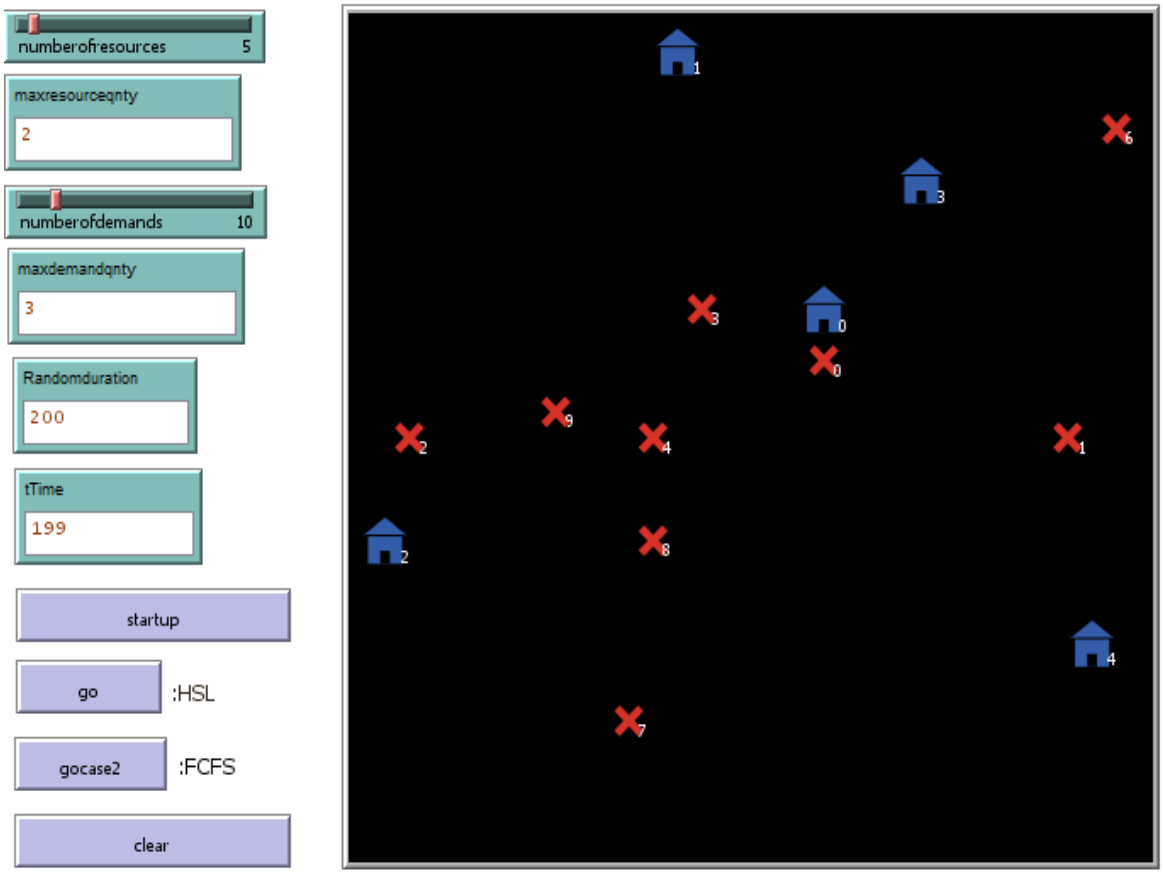

Figure 4.1: RA in the Euclidean Space NetLogo implementation

4.3 RA in GIS Space

GIS is one of most advance technology that have changed the manners in which RA is done. These technologies have effectively affected RA procedures explicit to the control, just as on the general manners by which resources are utilize by demand zone. In GIS space it allows agent in term of resources and demand into geospatial condition characterized with a GIS map. it include capacity to set and get the present agent area, to allocate the resource with the predefined characteristics starting with one area then onto the next, to execute activity upon appearance, to execute the agent in his predefined environment, to set up interaction dependent on agents design, and other valuable attribute.

4.3.1 Hypothetical Scenario

By using the proposed ABM based framework in the previous chapter, we create a scenario for disaster in the Rawalpindi city in Pakistan. As we just taken 65 union council of Rawalpindi district which are given in Table 4.3.1. A disaster is created on random building which is our demand zone, they require number of resources to reduce disaster effect in the zone. Following step are involved in creating the scenario :

1. Google earth for selecting areas boundaries
2. Creation of road network of above boundaries
3. Digitalize resource center
4. Digitalize building nodes
5. Create a kml file
6. Export to ArcGIS
7. Create a layer of kml Dataset
8. Creation of database
9. Creation of layer for our NetLogo Environment

Figure 4.2: Selected Area's Boundaries

Table 4.1: List of Selected Union Council Rawalpindi District

Province Punjab PK.			
Detail of Selected UC (Union Council) Rawalpindi District			
S. No	**Names of UC**	**Area (Sq. m)**	**Remarks**
1	SHAKRIAL(S&N)	11728932.13	Bahira Fire Rescue
2	KHANA DAK	3138402.371	NIL
3	CHAK LALA	5159498.974	NIL
4	DHOK MUNSHI KHAN	3586691.311	NIL
5	KOTHA KALAN	4989509.791	NIL
6	LAKKHAN	4741867.66	NIL
7	CHAK JALAL DIN	4668391.726	NIL
8	GIRJA	29759205.57	Fire Brigade Rescue station
9	GANGAL	2870941.392	NIL
10	RATTA AMRAL	218535.611	NIL
11	DHOK RATTA	184179.286	NIL
12	HAZARA COLONY	186898.895	NIL
13	DHOK MANGTAL	170795.41	NIL
14	DHOK HASSU(NORTH)	310042.772	NIL
15	DHOK HASSU(SOUTH)	297414.013	NIL
16	PIR WADHI	182246.086	NIL
17	FAUJI COLONY	195004.423	NIL
18	BANGISH COLONY	485217.794	NIL
19	KHYBAN SIR SYED(NORTH)	228532.946	NIL
20	DHOK NAJJU	223381.181	NIL
21	NEW KATARIAN	121670.488	NIL
22	F-BOLCK (SATTELITE TOWN)	176591.657	NIL
23	SAIDPUR SCHEME	277325.595	NIL
24	MUHALLA EIDGAH	98053.937	NIL
25	DHOK BABU IRFAN	374878.835	NIL
26	PINDORA	609527.662	NIL
27	SATTELITE TOWN	335941.527	NIL
28	ASGHAR MALL SCHEME	231789.814	NIL
29	DHOK KALA KHAN	290582.129	NIL
30	QAYYUMABAD	103247.512	NIL
31	DHOK KASHMIRIAN	242323.525	Emergency Rescue Centre
32	DHOK ALI AKBAR	100048.458	NIL
33	SADIQABAD	304045.443	NIL
34	AFANDI COLONY	206744.377	NIL
35	MUSLIM TOWN (EAST)	728726.223	NIL
36	MUSLIM TOWN (WEST)	1823282.974	NIL

37	KHURRAM COLONY	964545.989	NIL
38	CHAH SULTAN	977925.138	NIL
39	DHOK HUKAM DAD	566445.831	NIL
40	AMARPURA	885696.051	NIL
41	KARTARPURA	1886002.745	NIL
42	BANNI	1588689.891	NIL
43	MUHALLA AMAMBARA	537340.786	NIL
44	MOHANPURA	875430.978	NIL
45	DHOK DALAL	621589.125	NIL
46	GANJ MANDI	995562.848	NIL
47	WARIS KHAN	567473.122	NIL
48	PURANA QILLA	975483.928	NIL
49	SHAH CHAN CHARAGH	434243.384	NIL
50	MILLAT COLONY	2778461.823	NIL
51	DHOK KHABBA	1422941.58	NIL
52	DHOK FARMAN ALI	1290022.173	NIL
53	CHAMAN ZAR COLONY	797374.481	NIL
54	CITY-46	1154486.845	NIL
55	RAWALPINDI CANTT-1	1115814.218	NIL
56	RAWALPINDI CANTT-2	521344.007	NIL
57	RAWALPINDI CANTT-3	1157056.959	NIL
58	RAWALPINDI CANTT-4	612496.275	NIL
59	RAWALPINDI CANTT-5	788758.49	NIL
60	RAWALPINDI CANTT-6	4712928.355	NIL
61	RAWALPINDI CANTT-7	3586812.321	NIL
62	RAWALPINDI CANTT-8	3910598.321	NIL
63	RAWALPINDI CANTT-9	3119473.314	Emergency Rescue Centre
64	RAWALPINDI CANTT-10	4692064.952	NIL
65	KHYBAN SIR SYED(SOUTH)	94805.789	NIL

Figure 4.3: Road Network for Selected Boundaries

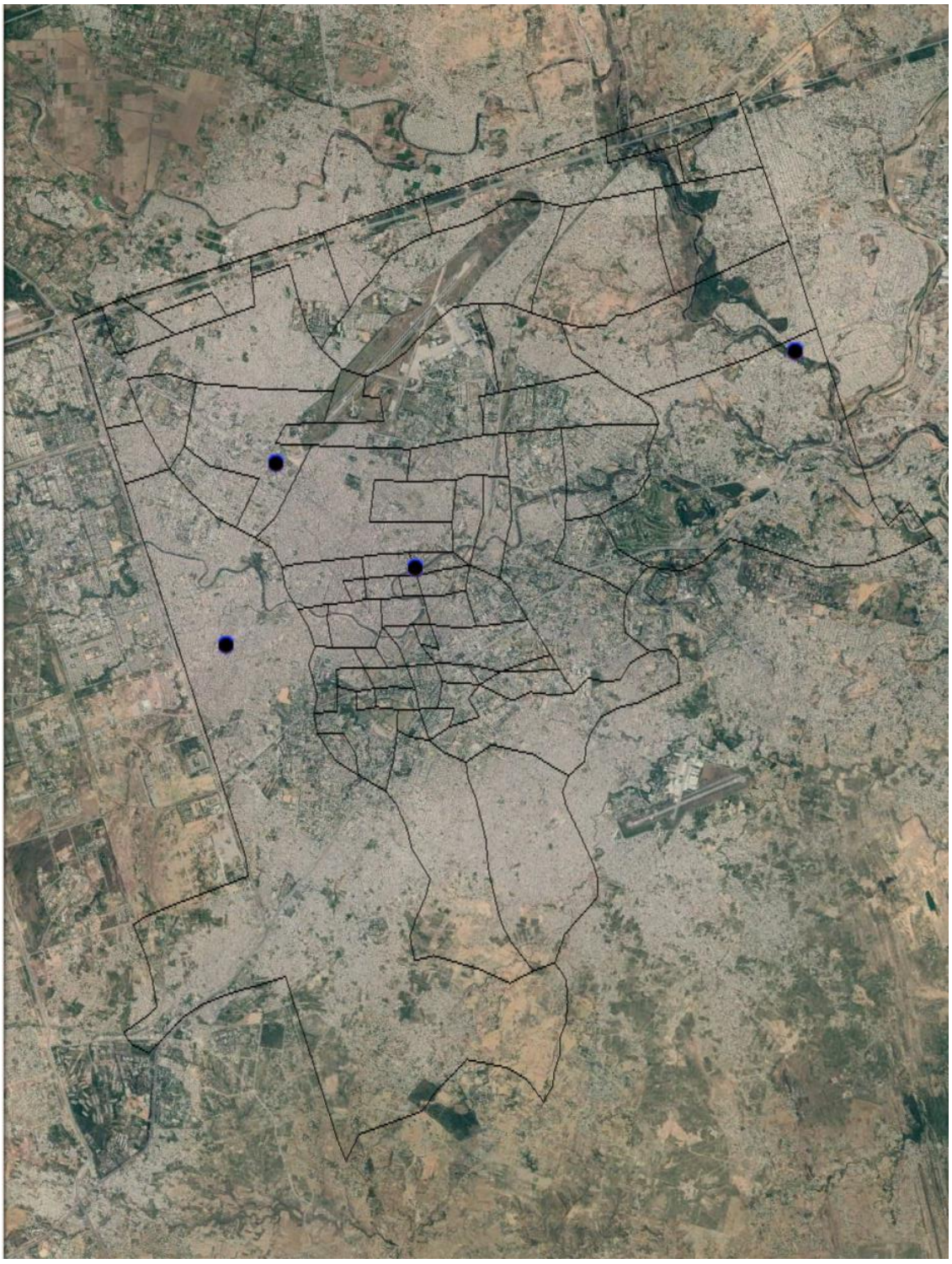

Figure 4.4: Resources Centre within the boundaries

Figure 4.5: Digitalize Building Node within the boundaries

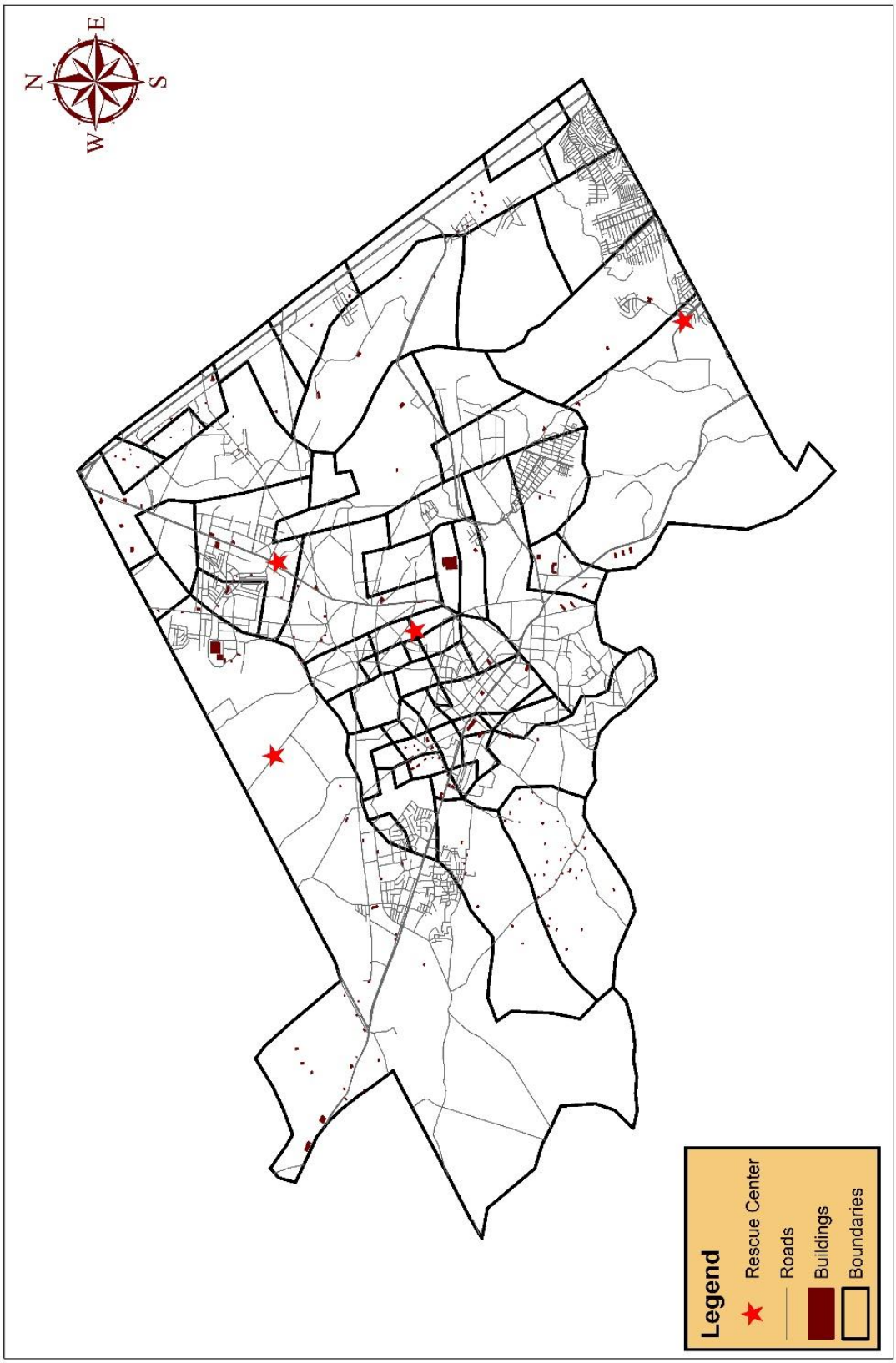

Figure 4.6: Dataset Construction in ArcGIS

Figure 4.7: RA in the GIS Space NetLogo implementation

Chapter 5

Results Analysis

5.1 Experiment Design

An experiment scenario is designed in the Rawalpindi city of Pakistan, we have taken 65 union councils of Rawalpindi district and their total area is 122982339.2 m^2.We have use netlogo Environment for simulation. In this simulation we have divided agents into two categories; Demands and Resources. As resource agents are fixed according to their actual GIS location while demand agents are created randomly on 186 building nodes according to simulation dataset. The arrival of demands at the zone which is fulfilled by resources according to availability of quantity and also with respect to time. For allocating resources among a majority of demands is dependent on an approach which involves a majority of resources associated with each other through an organized network and also determining an algorithm for allocation of resource at demand zone which are requesting for the resources. In our case, we have taken two algorithms for RA simulation; HSL and FCFS. Main focus of these algorithms is demand analysis which rely on a procedure by which the RA makes decision regarding the creation, assignment, utility of resources and estimating their quantity, etc. Both algorithms check every resource for recognizing requests for the resources and updating with respect to requests for the resources at the demand zone. Also, they have allocation cycle with their phases; location, allocation, release and reallocation. These cycles at every demand for RA among the majority of demand depend on the arrangement and data about demands for the resources. These whole scenarios are simulated 10 times for each experiment according to given dataset in the table 5.1

Table 5.1: Experiment Design

Allocation Algorithm	Experiment	Demand creation on building Node	Demand quantity	Fixed Resource Center:4 With quantity	Ticks
HSL & FCFS	Experiment 1	5	1≤random≤3	1≤random≤3	200
	Experiment 2	10	"	"	200
	Experiment 3	15	"	"	500
	Experiment 4	20	"	"	750
	Experiment 5	25	"	"	1000

5.2 Analysis and Finding

Each algorithm simulation result are analyzed in R studio with different experiment which are given in table 5.1. In order to analyze simulation we form an analysis on following data.

Data 1: Average wait time for total simulation execution time

Data 2: Effect of demand on wait time

Data 3: Effect of total execution time on unallocated demand

Data 4: Effect of number of demand on unallocated demand

We perform above analysis to establish that two algorithm; FCFS and HSL has significant different behavior. Furthermore FCFS behave slightly better than HSL, the reason is beyond this performance is non selective allocation of FCFS. In HSL the demand with high severity are allocated firstly. This behavior leaves to sight delay in allocation of low severity level demands which can be seen in the result of the following data.

5.2.1 Data 1

In this data, average wait time for demands increase as simulation execution increase which is a standard measure for RA algorithm. But in our scenario average wait time dependent on a resources and demands quantity. Their quantities rely between $1 \leq random \leq 3$ for each experiment given in the table 5.1. The average wait time is lesser if we increase the number of resource quantities which fulfill demand quantities within their time frame. Average wait time also depend on RA cycle; if it release resources as soon before the request of other demands it also effect overall average wait time. The result of both algorithm is given in figure 5.1 and figure 5.2 respectively.

Figure 5.1: FCFS- Average Wait Time with respect to Execution Time

Figure 5.2: HSL- Average Wait Time WRT Execution Time

In figure 5.3, HSL and FCFS average wait time show that they have linearity with respect to Execution time. Both show also that they have no much different

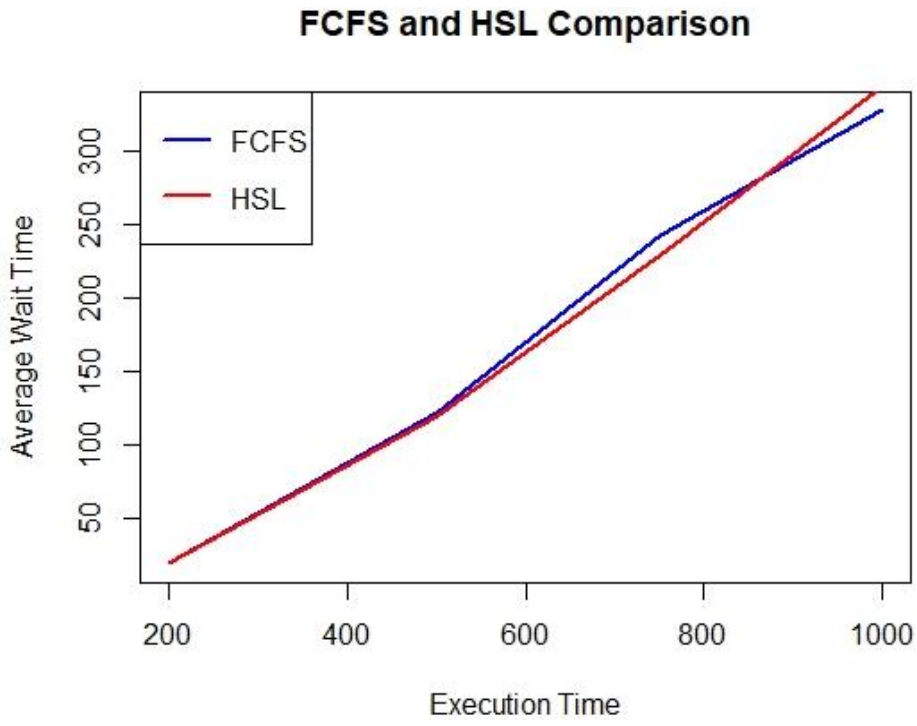

Figure 5.3: Comparison of HSL and FCFS Average Wait Time WRT Execution Time

5.2.2 Data 2

While increasing the number of demands effect the overall average wait time. Both algorithm result shown in figure 5.4 and 5.5. It describe if number of demand are lesser than or equal to number of resources then it average time almost near to zero, while its average wait time increases gradually with respect to number of demands.

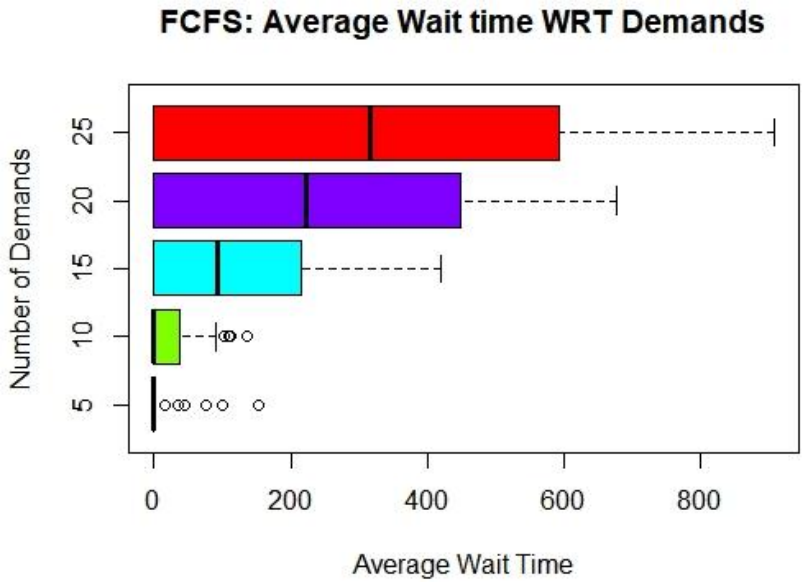

Figure 5.4: FCFS- Average Wait Time WRT Demand

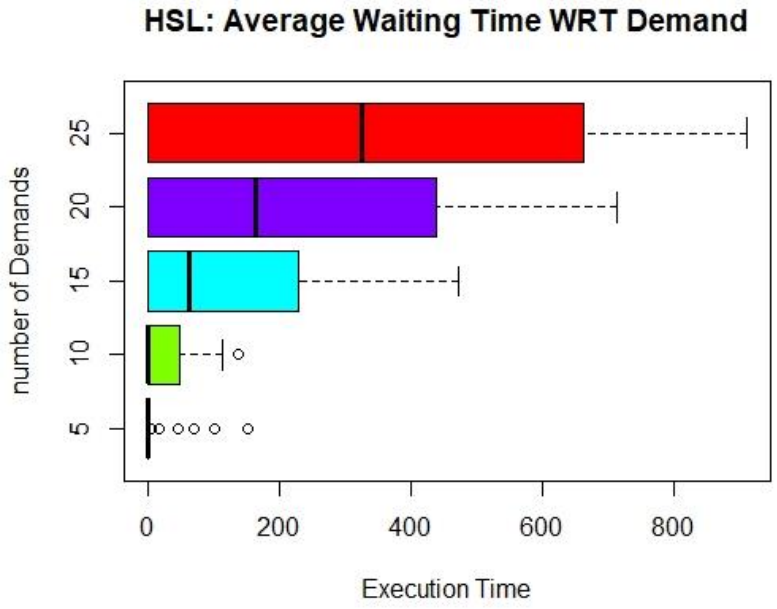

Figure 5.5: HSL- Average Wait Time WRT Demand

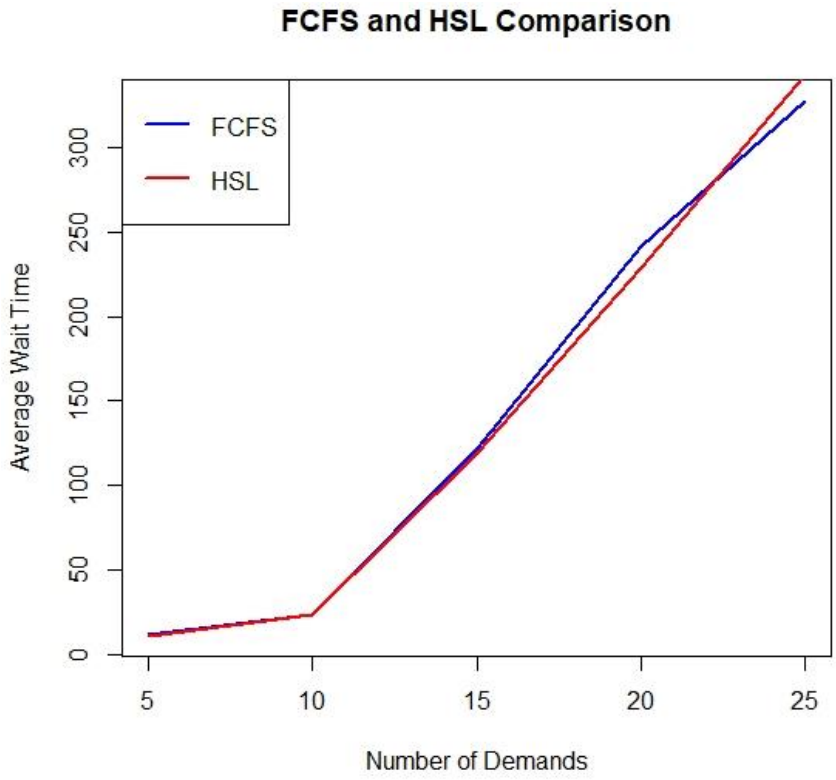

Figure 5.6: Comparison of HSL and FCFS Average Wait Time WRT Demands

5.2.3 Data 3

In this data ,we analyze that effect of unallocated demand on execution time. As gradually increment in execution time then the RA cycle take more time for completion, than the number of unallocated demand also gradually increases. The result shown in figure 5.7 and 5.8.

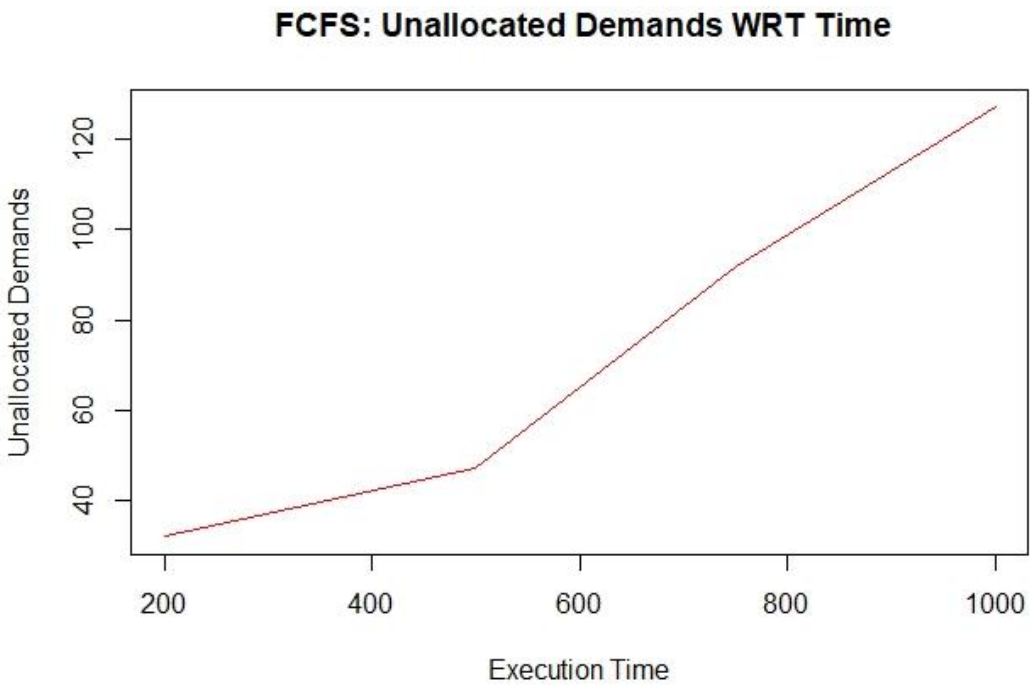

Figure 5.7: FCFS-Unallocated Demands WRT Execution Time

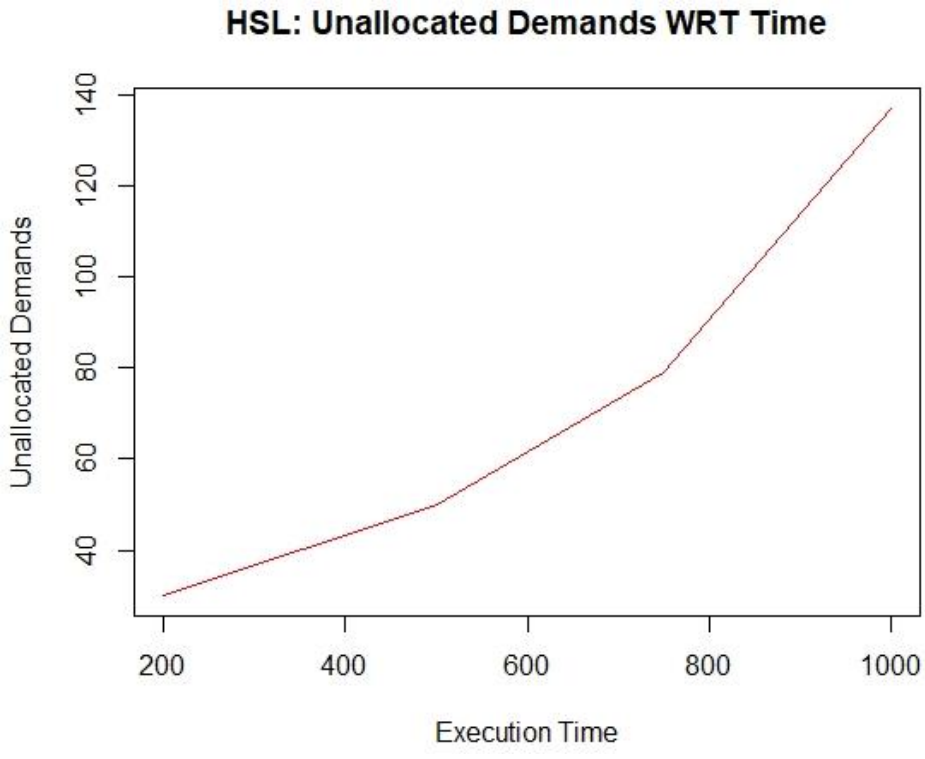

Figure 5.8: HSL-Unallocated Demands WRT Execution Time

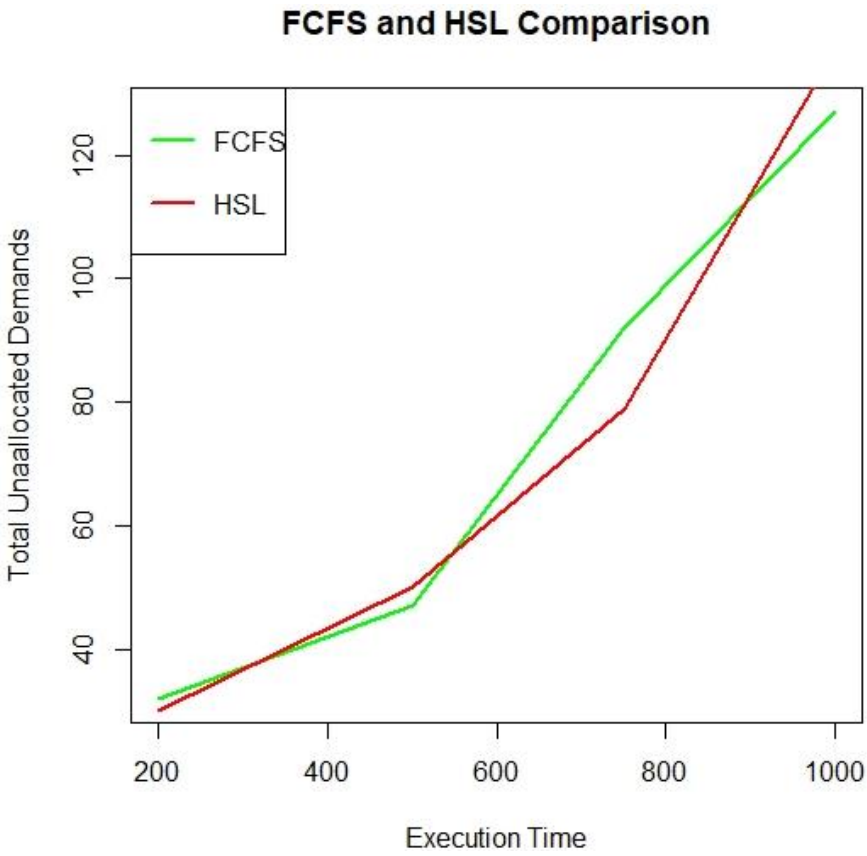

Figure 5.9: Comparison of HSL and FCFS Execution Time WRT Total Unallocated Demands

5.2.4 Data 4

For the experimental data which are shown in table 5.1,for every experiment we increase the demand node while resources remain constant with same quantity between 1≤random≤3 for both algorithm. From the figure 5.10 and 5.11 we analyze that when we have more demands as compare to the resources then more demands are undergoes unallocated.

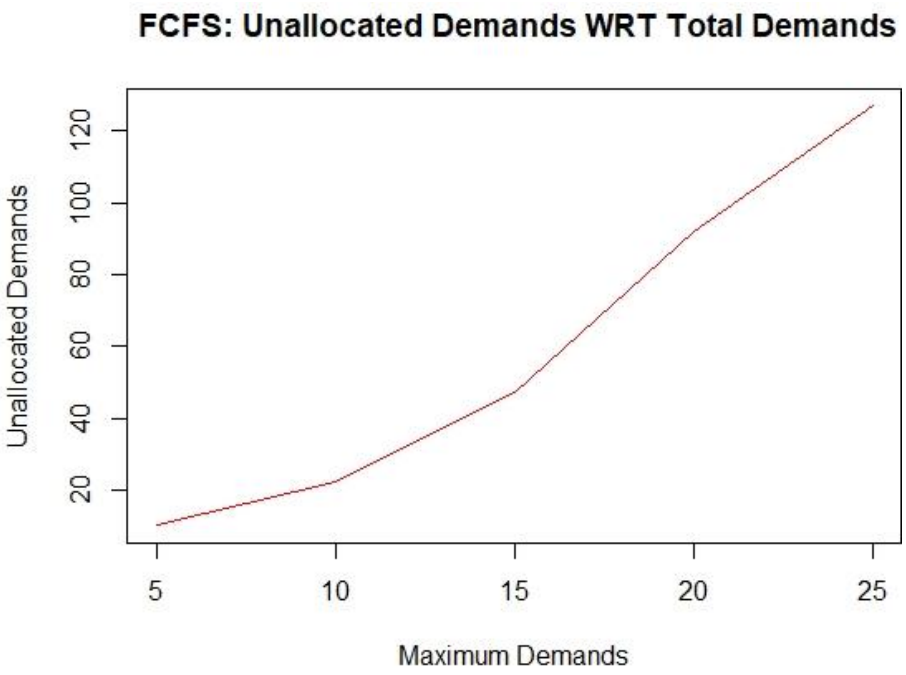

Figure 5.10: FCFS- Unallocated Demands WRT Total Demands

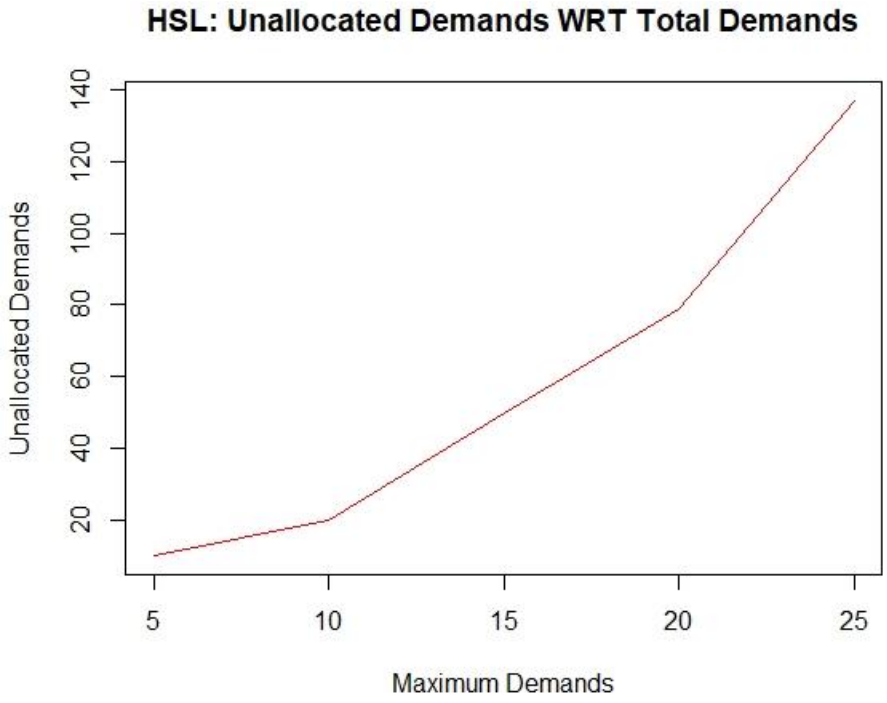

Figure 5.11: FCFS- Unallocated Demands WRT Total Demands

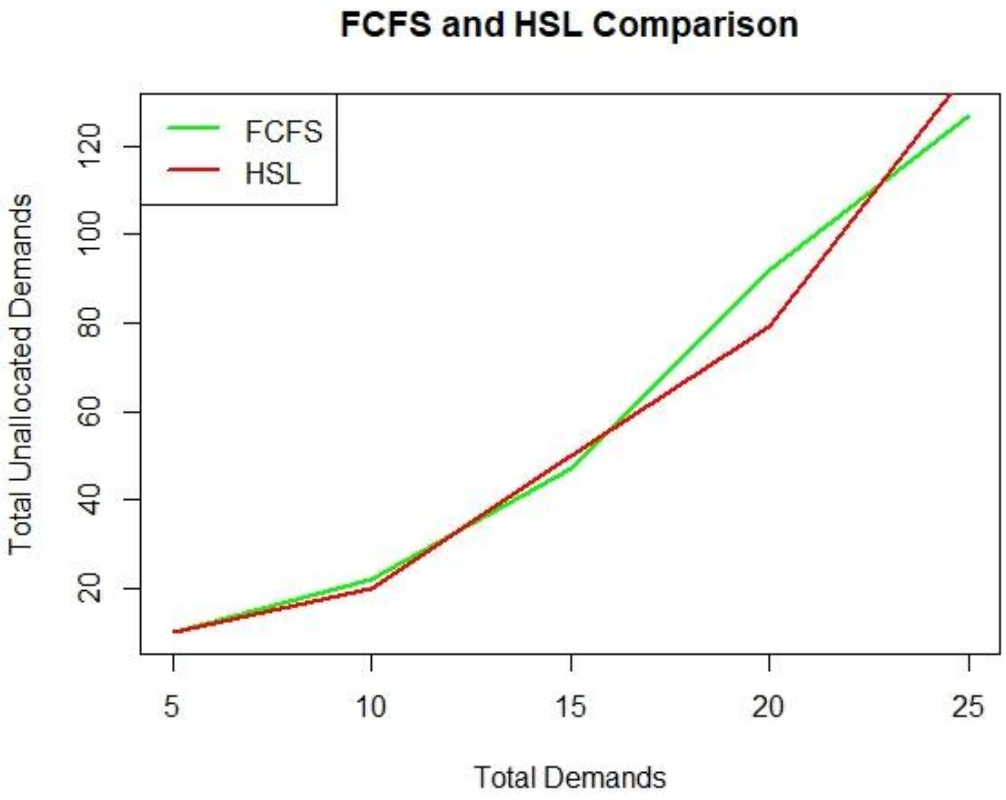

Figure 5.12: Comparison of HSL and FCFS Total Unallocated Demands WRT Total Demand

Table 5.2: ANOVA Test Summary

Factor			**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**
	Overall Average Wait Time	Execution Time	1	5530650	5530650	132.5	<2e-16
	Mean Average Wait Time		1	54393	54393	310	0.00321
	Total Unallocated Demands		1	5347	5347	38.43	0.025
	Mean Unallocated Demands		1	6241	6241	47.1	0.0206

HSL and FCFS	Average Wait Time	Number of Demand	1	5350863	5350863	126.7	<2e-16
	Mean Average Wait Time		1	54393	54393	310	0.00321
	Total Unallocated Demands		1	240.04	240.04	72.28	0.00342
	Mean Unallocated Demands		1	10214	10214	112.5	0.00179

Chapter 6

Conclusion and Future Direction

A conceptual framework to implement ABM for RA is purposed. We have developed two different algorithms; HSL and FCFS , both have slightly different performance on the basis of allocation. This allocation algorithm describes a RA strategy to use an accessible resource, particularly in the near-to-reachable demands.. The basic decision of the RA describe which things to support in the plan and which things to get and leave when resources are allocated to a specific demand zone. As by using the proposed ABM based framework, we have developed a scenario for disaster in the Rawalpindi city of Pakistan. This scenario shows a significant result on both allocation algorithms. The results of FCFS algorithm is compared with HSL algorithm. As the FCFS Algorithm provides best result for RA. Overall the result shows better allocation results in both algorithms. The number of demands affect the whole allocation procedure. The degree to which demands request and resources react to wait time is fundamental, if number of demands are higher then overall wait time increases and lot of demands are unallocated during their execution time .

To further enhance the ABM based RA technique in future by

- Working with strategic DM approach for decision making to deal with RA
- Real-time implementation to further enhanced RA strategy
- Area wise division of resources to cover demands for RA
- Real-time Map based RA Implementation
- Systems Development for contingency based RA technique

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