

*National College of Business  
Administration and Economics  
Lahore*



**PREDICTION OF HUMAN LIFE STANDARD  
(PHLS) USING FUZZY INFERENCE SYSTEM**

**BY**

***SHAZAB BASHIR***

**MASTER OF PHILOSOPHY  
IN  
COMPUTER SCIENCE**

**AUGUST, 2021**

# **NATIONAL COLLEGE OF BUSINESS ADMINISTRATION AND ECONOMICS**

## **PREDICTION OF HUMAN LIFE STANDARD (PHLS) USING FUZZY INFERENCE SYSTEM**

**BY**

**SHAZAB BASHIR**

**A dissertation submitted to  
School of Computer Sciences**

**In Partial Fulfillment of the  
Requirements for the Degree of**

**MASTER OF PHILOSOPHY  
IN  
COMPUTER SCIENCE**

**August, 2021**



*In the name of ALLAH,  
The Most Beneficial,  
The Most Merciful,*

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**Dissertation Committee:**

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**Chairman**

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**Member**

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**Member**

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**Director Research**  
National College of Business  
Administration and Economics

# **DECLARATION**

It is to declare that this research work has not been submitted for obtaining similar degree from any other university/college.

**SHAZAB BASHIR**  
**August, 2021**

## DEDICATION

*This dissertation and all of  
My Academic achievements are  
dedicated to My Glee*

## ACKNOWLEDGEMENT

Praise and thanks to Allah for sustaining and helping me throughout this Endeavour. Many individuals performed a vital role in the completion of this research work. I would like to present my humble gratitude to my august supervisor *Dr. Gulzar Ahmad* for his efforts. I especially thank *Dr. Sagheer Abbas* who has provided me with guidance, inspiration, and devoting a vast number of hours to review my work. I gratefully acknowledge his support and encouragement during the preparation of this thesis, and his contribution to a challenging and comfortable working environment.

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**Thank you all**

## **RESEARCH COMPLETION CERTIFICATE**

Certified that the research work contained in this thesis entitled “**Prediction of Human Life Standard (PHLS) using Fuzzy Inference System**” has been carried out and completed by **Shazab Bashir** under my supervision during his **M.Phil. Computer Science** Programme.

*(Dr. Gulzar Ahmad)*  
**Co-Supervisor**

*(Dr. Sagheer Abbas)*  
**Supervisor**

## SUMMARY

Academics and professional researchers have been interested in the future of cities in recent years. They argue that the advancement of artificial intelligence (AI) will have an impact on both design and infrastructure, giving rise to the smart city idea. The spectacular developments of Artificial Intelligence (AI) which are daily announced, are transforming individuals into complex species. AI has established the norms in all walks of human life-embracing healthcare, education, automotive, defense, security, home appliances, retail, and logistics. the smart city is also a futuristic leader in the fight against the adversities caused by the increasing population and rapid development. Smart city social and economic progress has been taken from modern-day cities. Smart cities construct cities more resourceful, maintainable, and viable. In plenty of other aspects, a smart city can monitor and integrate all essential infrastructure features including roads, tunnels, airports, waterways, trains, communications, and maintenance, while also considering safety issues. It can contribute to the optimization of resources. This research assessed various aspects and dimensions of the city of the future. To acquire enhanced insight into the idea of smart cities, a framework has been developed to overcome the lacuna in the conception of smart cities and their implementation. Deterministic methodologies generally do not generate accurate results, whereas heuristic methodologies like Fuzzy Inference Systems (FIS), produce better results. This study promotes a FIS that is ready to evaluate "PEOPLE" as the prime prediction of human life standard (PHLS). We also explore smart cities and propose an expert city model based on FIS. This research is important to our model of the latest improvements in life.

## **ABBREVIATIONS**

<b>AI</b>	Artificial Intelligence
<b>AIS</b>	Artificial Immune Systems
<b>ANN</b>	Artificial Neural Networks
<b>AR</b>	Augmented Reality
<b>CC</b>	Cooperate Co-evolutionary
<b>CI</b>	Computation Intelligence
<b>DE</b>	Differential Evolutionary
<b>DL</b>	Deep Learning
<b>EC</b>	Evolutionary Computing
<b>ECA</b>	Evolutionary Computing Algorithms
<b>ENERNET</b>	Energy of Things
<b>FIS</b>	Fuzzy Inference Systems
<b>GA</b>	Genetic Algorithms
<b>GOe</b>	Global Observatory
<b>HCS</b>	Human-Centric Solutions
<b>IBM</b>	International Business Machine
<b>ICT</b>	Information and Communications Technology
<b>IEEE</b>	Institute of Electrical and Electronics Engineers
<b>IoT</b>	Internet of Things
<b>IRS</b>	Integrating Release Systems
<b>ITS</b>	Intelligent Transportation Systems
<b>MFs</b>	Functions of Membership
<b>ML</b>	Machine Learning

<b>PHLS</b>	Prediction of Human Life Standard
<b>SC</b>	Smart City
<b>SCI</b>	Safe Cities Index
<b>SI</b>	Swarm Intelligence
<b>U-City</b>	Ubiquitous City
<b>VR</b>	Virtual Reality
<b>WHO</b>	World Health Organization

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# CHAPTER 1

## INTRODUCTION

Academics and professional researchers have been interested in the future of cities in recent years. They argue that the advancement of artificial intelligence (AI) will have an impact on both design and infrastructure, giving rise to the smart city idea. By assessing various smart city definitions that are based on each city's geological, ecological, financial, and societal pressures, and also conveying aspects that begin to make urban areas a three-dimensional idea as well as highlighting the proposed smart urban Model, this study has given a complete comprehension of the smart urban movement. It includes big representations of the parts of each paradigm, as well as an overview of the characteristics of smart cities, including Smart Economics, Smart Atmosphere, Smart Governance, Smart Mobility, Effective Care, and Smart People Development. People typically relocate to cities in quest of better living conditions in terms of employment, relationships, and enjoyment of modern life. A substantial number of Smart city difficulties have evolved in metropolitan areas as a result of urban growth, climate change, and resource depletion, all of which must be addressed. Metropolitan Areas, but on the other hand, enable people to invent, innovate, test, and experience new things to improve their quality of life, thanks to information and communication technology.

Economic development, social development, and environmental protection are all linked to the urbanization process. As a result, the proportion of people living in cities is becoming increasingly essential. Since 2007, this last has used the speed character to surpass the rural one [1]. As a result, cities all over the world are scrambling to come up with the best answers to new challenges that change through time and space. The recent change to a heavily developed population has prompted civilizations to provide solutions to a variety of major issues, including sustainability, education, power, the atmosphere, security, and urban facilities. As a central purpose of human life, metropolitan areas have transformed into complex social ecosystems in which it is critical to ensure sustainability and high quality of life.

Diverse administrations around the globe also displayed a large number of potential city models wherein innovation, accessibility, sustainable development, convenience, security, and desirability structure the essential goals and accomplish on just one side, and metropolitan areas will become familiar with the idea of "Smart Cities" but at the other side, in terms of improving the livability procedures and populaces.

In this aspect, and for much of the twentieth century, the city's smartness was science fiction in the media. Therefore, because of innovations in telematics and device intelligence, the Smart City is the city's smartness was sci-fi in the media throughout much of the twentieth century in this regard. As a result of advancements in telematics and device intellect, the Smart City is “quickly has become actuality” [2]. Information and communications technology (ICTs) are exceptionally important for enhancing system automation and allowing people to view, study, evaluate, and design the metropolis. As a result, smart cities are establishing themselves in the integration of advanced networks and the ICT-based link, strengthening its urban interaction, and utilizing the green economy.

## **1.1 SMART CITIES [SC]**

To put it another way, the city can be thought of as a collection of systems. As a result, the metropolis may be described as a "Networked society." All we do to get to a Smart City is add insight to infrastructure. The Smart Cities that generate several accomplishments from many supplying new products for metropolis marketplaces to realize such an intellect, without neglecting advancements creating past elicited from traffic patterns to Wi-Fi innovations to concisely and install time and, as just a consequence, individual options to develop intellectual prowess in a range of locations.

## **1.2 SIGNIFICANCE OF SMART CITY**

As a result of the metropolitan phenomenon, a significant number of hazards, concerns, and issues have arisen. These last allow concerned administrations to find optimal solutions, which will only be found in "Smartness," as per researchers. Additionally, smartness could be eco-friendly, comfortable, safe, greener, or linked. Indeed, Smart Citizenship can be defined as the goal of utilizing ICT to achieve each of those objectives.

The Internet of Things (IoT) is used to set up, organize, and sustain a smart city. Urban development areas have become the arising marvel with quick metropolitan development and upgrade in the field of data innovation. Difficulties urban communities face today Growing populace, Traffic Space – homes and public space Resource the executives (water also, energy use) Global warming (fossil fuel byproducts) restricted city spending plans, Aging framework, medical care, sports ground, what's more, parks, and water emergency [3]. The worked-on thought is that assembling data from a city with its insightful taking care of to accomplish brilliant dynamic and control is the

thing that comprises a smart city. Particularly is a foundation issue and enormous urban communities stuffed.

The Smart city is a result of the advancement of present-day high innovation. Its improvement principally relies upon the constant advancement of science and innovation. Presently we live in a data society, and a wide range of day-to-day environments are creating to a significant level. The smart city is presently an assortment of higher ideas. It is the recent fad of metropolitan turn of events, by the current social pattern, and helpful for the undeniable level advancement of our general public. Smart city not just incorporates the greater part of the qualities of a computerized city, yet in addition utilizes present-day data and correspondence innovation to coordinate and break down different key variables during the time spent the metropolitan turn of events, and, as indicated by these key components, it receives relating astute answers for individuals' work, metropolitan administrations, and various fractions of the metropolis. The goal behind a smart city is to use current innovation and data to integrate all parts and make the city more reasonable and rational in its inactivity. What's more, this thought is likewise helpful for the turn of events and progress of an agreeable society, to accomplish the objective of the amicable advancement of the city and the improvement of individuals' expectations for everyday comforts.

According to IBM, a "smart city" is defined as the use of data as well as communication innovation to detect, analyze, and synchronize important data of main components in functioning public spaces. Simultaneously time, the smart city may respond intelligently to a variety of needs, such as daily activities, environmental security, public health and city authorities, as well as engineering and commercial activities. [4]

Computational Intelligence (CI) alludes to the learning capacity of a framework (either from the information or exploratory perceptions) to do a particular errand. It comprises nature-roused computational strategies to resolve complex true issues where customary techniques become pointless like some genuine issues can't be addressed in 0s and 1s to measures by PCs. CI for the most part utilizes five integral methods which incorporate Fuzzy logic, Evolutionary Computing (EC), Swarm Intelligence (SI), Artificial Neural Networks (ANN), and Artificial Immune systems (AIS). Out of these, Evolutionary Computing Algorithms (ECA) like Genetic Algorithms (GA), Differential Evolutionary (DE), and so on are better decisions in multicarrier frameworks. Multi-objective Cooperate Co-evolutionary (CC), Swarm optimization, and fuzzy methodologies are likewise encouraging possibility for it.

### 1.3 PROBLEM STATEMENT

The spectacular developments of Artificial Intelligence (AI) which are daily announced, are transforming individuals into complex species. AI has established the norms in all walks of human life-embracing healthcare, education, automotive, defense, security, home appliances, retail, and logistics. The smart city is also a futuristic leader in the fight against the adversities caused by the increasing population and rapid development. Smart city social and economic progress has been taken from modern-day cities. Smart cities construct cities more resourceful, maintainable, and viable. In plenty of other aspects, a smart city can monitor and integrate all essential infrastructure features including roads, tunnels, airports, waterways, trains, communications, and maintenance, while also considering safety issues. It can contribute to the optimization of resources. This research assessed various aspects and dimensions of the city of the future. To acquire enhanced insight into the idea of smart cities, a framework has been developed to overcome the lacuna in the conception of smart cities and their implementation. Deterministic methodologies generally do not generate accurate results, whereas heuristic methodologies like Fuzzy Inference Systems (FIS), produce better results. This study promotes a FIS that is ready to evaluate "PEOPLE" as the prime Prediction of Human Life Standard (PHLS). We also explore smart cities and propose an expert city model based on FIS. This research is important to our model of the latest improvements in life.

### 1.4 RESEARCH OBJECTIVE

This research advertises a FIS ready to consider "PEOPLE" as the entire Prediction of Human Life Standard (PHLS). We are also looking at the smart city and are proposing a FIS-based expert city model of the latest developments in life.

*The Research is Intended to Address the Problem of*

- How to propose a FIS-based Smart city model that improves the quality of people's living standards?

### 1.5 RESEARCH QUESTIONS

**RQ1:** How to establish a mechanism for Assessment of the performance of a person's living standard?

**RQ2:** How fuzzy logic can help in the Assessment of the performance of a person's standard?

**RQ3:** How to formulate the categories of various factors that impact the performance of a person's living standard?

## **1.6 HYPOTHESIS**

The above mention discussion helped in formulating the following hypotheses for this research;

*H<sub>1</sub>: Fuzzy Inference System is a homogenized knowledge unit while containing uncertain constituents.*

*H<sub>2</sub>: Fuzzy Inference System helps measure the performance of PHLS.*

## **1.7 THESIS STRUCTURE**

In this dissertation, the first chapter provides the background on "smart city", problem statement, and hypotheses. The second chapter provides the relevant literature of selected papers by keeping in view the problem statement. The third chapter provides the proposed methodology and proposed model while the fourth chapter provides the simulation results for Prediction of Human Life Standard (PHLS) using MATLAB. the fifth chapter gives the conclusion of the dissertation. Sixth chapter highlights the limitation of this research while the Seventh chapter gives the future work related to this research.

## **1.8 CONCLUSION**

In this chapter, we have provided the background of numerous segments related to our research. Various definitions of smart city have been discussed, similarly, the concept of Smart City and different types of these artifacts have been highlighted. Further discussion covers smart city constituents along with performance criteria to understand the existing practices for Smart city development and maintenance. Last section of this chapter provides the research objectives, research questions, and formal problem statement along with hypotheses.

## CHAPTER 2

### LITERATURE REVIEW

Guaranteeing manageable turn of events and personal satisfaction in complex social biological systems of urban areas and metropolitan regions are significant concerns. Urban communities are becoming increasingly aware of the concept of a "smart city" and are successfully developing systems to become "resourceful" and oversee city assets all the more productively while tending to improvement and consideration challenges.

To comprehend the idea of a smart city, we start with understanding the applied family members of the model. Albeit restricted in scope, they set the hypothetical system for the comprehensive thought of the smart city presently perceived by the metropolitan arranging circle. The city is extremely smart when we consider not just the technologies, but also the segments of society. Furthermore, the dense deployment of ICT allows the metropolis to always have innovative, diversified, and educated people as well as a government in ensuring the relationship between the two key features to power continual progress and improve living standards. Some of the people dimensions include Innovative City, Education City, Living Beings City, and Technology Metropolis. Personal and organizational networks are vital aspects of urbanization. (5)

Another antecedent to the smart city is the computerized city, an innovatively characterized city that utilizations an inescapable broadband foundation to help e-Governance and "a worldwide climate for public exchanges". The thought of the smart city is set up from the mix of the information society and advanced city. It is characterized as a "multi-facet regional arrangement of advancement" comprised of computerized networks, singular scholarly capital, and the social capital of the city, which together comprise aggregate insight. Monetary seriousness and development accomplished through the information-based economy mark a city as smart, permitting it to produce a "spatial upper hand" through modern locale, districts, and learning groups that produce modern R&D and are upheld by computerized networks and artificial intelligence. [6]

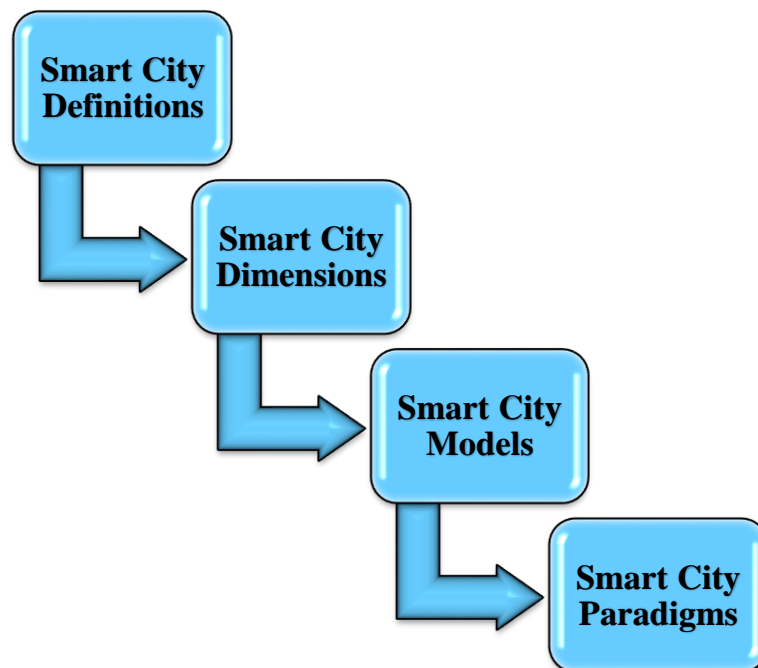
As the name implies, computerized city refers to employing far-flung remotely sensed (RS), GPS-navigation, GIS, and other spatial analysis advances to construct a computerized city's geospatial data structure and a metropolitan geographical information stage for social aid. Also, by developing a foundation, we may augment that course of events and incorporate all types of geographic

information, as well as organize, digitalize, and gain insight into the metropolitan economics, cultural, and natural environments, as well as many aspects of every action. [7]

A smart city is built on the foundation of a far-reaching digital metropolis, with visual and quantifiable metropolitan administration and activities. The idea is that detectors have been attached to various products to shape the IoT technologies and that the IoT devices are mixed using computer systems and distributed systems. Digitalization is the consequence of a computerized metropolis combined with the IoT systems when all factors are considered.

## 2.1 SMART CITY CONCEPTS

Further clarity, several studies have shown that these words are the ingredients that constitute Smart City a three-dimensional notion. Significant initiatives have been conceived to determine the features of the subject (Figure 1).



**Figure 1: Smart City Concept**

## 2.2 SMART CITY DEFINITION

Several writers have attempted to define a "smart city" using combining concepts, indicating the absence of a consistent or widely identified definition.

There are many appropriate phrases for a "smart city" in articles published relating to the topic, such as "digital city" (20), "wired city" (21), "information city" (22), "ubiquitous city" (23), "sensing city" (23) (24). While analyzing the research, this was determined which the great majority of authors seeking to describe the notion of a "smart city" concentrated on the technological element of the term.

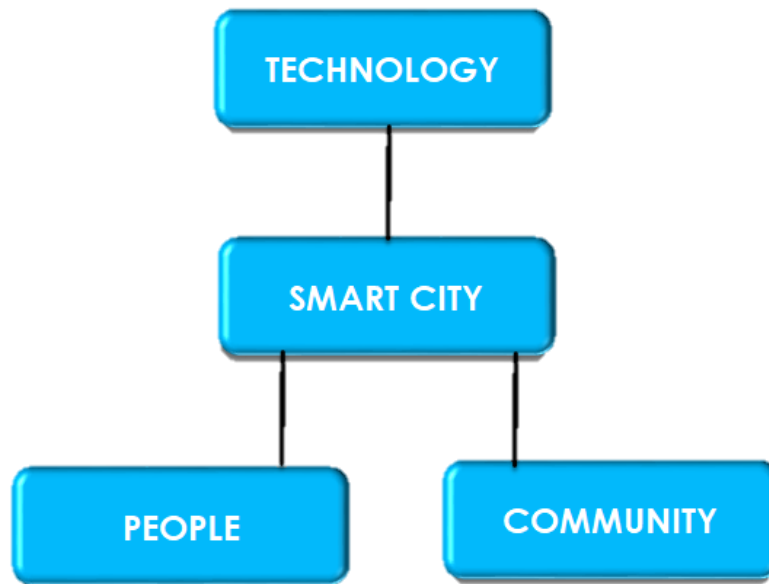
Peng, Nunes, and Zheng (2017), for instance, described a "smart city" as one that employs a variety of sophisticated technologies including wireless sensors, smart grids, intelligent cars, smartphones, cellular networks, and digital storage technology. (25)

- When investing in physical and human capital, as well as modernized communication and transportation facilities, generate sustained economic development and just a decent quality of life while also wisely managing resources via public administration, a metropolis may be described as “smart.”
- “A metropolis that is well-performing in the economics, persons, government, transportation, atmosphere, and lifestyle, and is founded on the clever combination of endowment and actions of self-determined, autonomous, and informed citizens.”
- “Smart Growth encompasses a wide range of concepts. It isn't just about getting around. It's a way of thinking about how to build a more integrated society. We've discussed the importance of the standard of living. And what has become more important to one's living standards than one's bodily well-being?”

### **2.3 SMART CITY DIMENSIONS**

“The city may be described as “smart” when resources in physical and human capital, as well as modernized communication and transportation infrastructures, are used to drive long-term economic growth and a high standard of living, while also ensuring sensible resource management through sustainable development.”

The term smart has several aspects in the context of metropolitan infrastructure (Figure 2): In a nutshell, there have been three essential components in a smart city. Technologies, humans, and communities.



**Figure 2: Pillar of Smart Metropolis Archives**

Thus, technologies could boost innovation via humans, and the whole process could be regulated by organizational characteristics or improved governance, which is the way to identifying or researching the city. As a result, there is no widely recognized definition of what constitutes a smart city. To various people, it implies different things. Utilizing technologies, as well as better processes and procedures on occasion. The distinction between such a smart city and ordinary cities is this. Whereas a smart city fundamentally entails a new method, a new strategy, and new technologies to make a certain service or advantage both for the populace highly practical, extra significant.

The phrase "Smart Cities" has also been defined and described in a variety of ways, comprising four technology city brands: "Digital City, Intelligent City, Ubiquitous City, and Information City."

The level of information systems that integrate telecoms, computers, and creative infrastructures to aggregate government, corporate, and public needs is proportionate to the size of the digital city. Intelligent City can only be defined as a city that strives for out-performance through 3-dimensional innovative technology employing ICT infrastructure. The networks run the Ubiquitous City (U-City), which has high-tech mobile and fixed infrastructure. Information City is a city that collects data from sensors and delivers it to residents via internet services.

Information & Communications Technology (ICT) is utilized to improve the quality, effectiveness, and interaction of public utilities, as well as to reduce costs and consumption of resources and to promote citizen-government

interaction. The widespread use of ICT provides a chance for both the people and the city should be innovative, diversified, and intelligent. Via assuring that there is a link between the two-dimension to fuel long-term expansion and encourage the standard of living Creative City, for example, is one of the people aspects.

Learning City, Humane City, and Knowledge City are three different types of cities. Both human and the establishment of a city's public infrastructure are critical. Social and human infrastructure are critical elements in the growth of cities.

The learning city's purpose is to promote metropolitan settings' competitiveness in the global knowledge-based economy by establishing a digital economy citizenry. The humane city has several chances to function human capabilities and establish a new lifestyle based on a highly educational, smarter, and personally specialized labor force, all of which are dependent on the developmental rankings of smart cities. The function of the knowledge metropolis is to foster academic encouragement. Knowledge City is comparable with the following developing concepts: Intelligence, Educational, or Smart, and advancement is the distinguishing factor.

Smart Society, the third dimension, is a's perspective at incorporating the greatest amount of participants in IT, spanning from either a smaller to a large demographic, to improve the lives of people.

Furthermore, all of these cities do have their unique viewpoints, but the bulk of academics have concentrated on a few key elements to creating a city that combines three aspects: **Humans, Technologies, and Governments**. These researchers' efforts have been acknowledged in important publications that identify the true features of a Smart City.

## 2.4 CHARACTERISTICS OF A SMART CITY

There are only some very aspects in the smart city characteristic. Mixed land utilization is one of them. Now, mixed land development improves compaction and social connections, and there are several benefits to it. As a result, smart cities improve or incentivize mixed land usage. Accommodation and inclusivity because it can welcome individuals from all walks of life. Since this is a walkable city, there'll be a combination of non-motorized transportation, walking pathways, and cycling tracks. As just a consequence, when these elements are combined, they will provide a substitute for motorized vehicles and

motorized modes of transportation. There's an open area, and how it may act as a city's lungs, and how it's linked to pedestrian paths and non-motorized transit. Similarly, a range of transportation choices must be available. As an instance, MRTS, LRTS, rapid transit transportation system, metropolitan rail, bus, cycling, rickshaw, and walking might all be options. There will be a wide range of transportation choices available.

Then there's a government that's sympathetic to the people. When a government communicates with citizens effectively, it is a competent government. People also access benefits within the agreed-upon timeline. As a result of their interactions with the government and local governments, the citizen-friendly governance has become more successful in promoting good governance and responsiveness. Most people have their unique sense of self-identity's cultures, ancestry, and regional setting. Therefore, whenever we create our smart city, we must remember what our context, cultural, or localized strengths or prospective factor is intrinsic to the city or in the inhabitants of our city.

So when people term smart solution, we're referring to a solution in terms of traffic and transport wherein people shouldn't have to purchase a ticket every, every time. People simply acquire a one-time card and then use that to access any services or kind of service. A smart citizen's card, for instance, is a smart solution. We comprehend different elements that might impact the quality of lifestyle in a smart city based on past studies and literature. When moving towards a smart, sustained Information & Communication Technology - centered metropolis, citizens and state officials should examine those elements.

Inside this research, we use artificial intelligence to estimate the standards of living of a smart city. Machine Learning, especially incorporates certain advanced Computational Intelligence methods, is given by AI technology and therefore can provide categorization and suggestions for humans. Artificial Neural network (ANN), Swarm Optimization, Fuzzy Computing, and Evolutionary Computing techniques such as Island DE, Genetic Algorithm (GA), Island GA, and DE all illustrations of these methodologies. These are powerful artificial intelligence techniques for evaluating standards of living in smart cities.

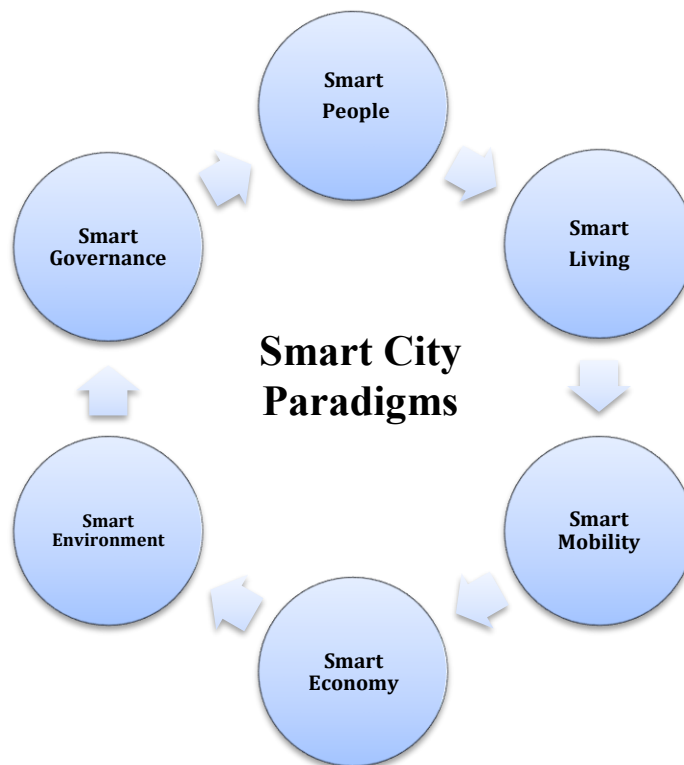
## 2.5 SMART CITY MODEL INITIATIVE

In this investigation, we have proposed basic factors that are pivotal for understanding and creating smart urban communities. These elements have been utilized to plan a system that gives a more comprehensive perspective on the smart city drive. A FIS ready to screen the general **P**rediction of **H**uman **L**ife **S**tandard (PHLS) emphasized on PEOPLE. The components are:

- People (Health, Safety, Education, Quality of Living Environment, and Access to Other Services).
- Planet (Resources, Waters & Landscape, Environment & Disposal, Power and Prevention, EcoSystem Climate Resilience)
- Prosperity (Economic Performance, Innovation, Local Job Creation Environment, Equity, Green Economy, Competitiveness of Attraction).
- Governance (Community Involvement, Organization, Multi-Level Governance)
- Propagation (Social Compatibility, Technical Compatibility, Ease of Use for Professions, Affordability of Housing, Market Demand, Reliability, Scalability)

## 2.6 SMART CITY PARADIGMS

Because a metropolis is a set of techniques, various studies have found specific features that guarantee actual city sophistication, and Sustainable City has become a much more specific term as a result. To demonstrate the relationship between analysis levels, the EU research [10] relied on a hierarchical framework. As seen in Figure 3, each attribute is defined by some parameters.



**Figure 3: Smart City Characteristics**

### **2.6.1 Smart People**

Smart people, who are the most important component of smart urban systems, must possess several fundamental characteristics.

- Professionals and smart people excel in their endeavors.
- Smart people are those who have a high development index.
- In a smart city, academic institutions are woven into every aspect of life.
- It targets citizens with exceptional human resources, such as highly talented professionals.

### **2.6.2 Smart Living**

Through technology, citizens build sophisticated ways of life. Because everything is in connected devices, many chores become faster, safe, and much less expensive. Humans' lives have been more professional, sustainable, and productive in recent years as a result of inventive solutions in development.

### **2.6.3 Smart Mobility**

The growth of metropolitan centers throughout the globe has culminated in a shift in people's lifestyles and mobility habits: people are traveling using a variety of forms of transportation for a variety of reasons.

### **2.6.4 Smart Economy**

According to scholars, the Smart Economy has the following characteristics:

- Innovative technologies that increase productivity while cutting costs.
- ICT devices are widely employed in business and are increasingly digital.
- Be competitive; be available, utilize knowledge, and innovate to reach a good quality of better revenues, productive resources, and efficient expenses.
- Greens; a focus on long-term ideals, renewable energy development, and the restoration of clean environments.
- Human prosperity is boosted by being socially responsible.

### **2.6.5 Smart Environment**

To improve durability, the municipality must take action on environmental facilities such as streams, sewerage, and green places. It also needs to emphasize the usage of alternative energy sources.

## 2.6.6 Smart Government

As just a result of the expansion of ICTs, cities are seeking to develop their governments, and any government activities that create technologies are termed Smart Governance. “A combination of innovations, humans, regulations, tactics, assets, cultural norms, and information that interact to support metropolises administration operations,” according to the definition. By introducing new legislation, innovations, and corporate strategies, improves information technology and communications infrastructure.

Conversely, despite the various benefits of a "smart city" that communities might benefit from, there are several obstacles that make the notion challenging to execute. Several stand out among all the challenges that occur while adopting the “smart city” notion. (26)

- The application of smart innovations in metropolises of complicated societal issues could exasperate racial inequality through the improved technology;
- The absence of a proposed solution using the surrounding residents to co-administer the metropolis;
- The lack of implemented solutions to use the local community to co-administer the city
- Numerous efforts related to the development of the "smart city" notion, primarily such as the technological standpoint, could adversely affect its damage of the established name and distinctive charisma of certain conglomerations, particularly individuals highly prized for everyone's conventional personality;
- a large number of interdisciplinary research projects are focused on cities;
- the inadequacy of a holistic vision of cities that encompasses all aspects of their operation;
- The concept of a smart infrastructure system necessitates massive investments, that are provided implicitly by people, for example, in the form of greater taxes.
- Governing communities is a major task that necessitates, most of all, intellect, accountability, and rationality, qualities which can be substituted by modern technology, especially when cities are built

from the ground up. The development of the finest living and working circumstances is what modern development is all about, not glassy skyscrapers and cosmos architecture.

- So-called digital illiterates can inflict a lot of social and personal harm by using services disastrously or unintentionally.

## **2.7 CONCLUSION**

The literature research performed in this work aids in the comprehension of the idea. In a broad sense, a smart city concept can be defined as a metropolis that handles human capital development thru communication and information technologies even while ensuring that resources are used effectively as well as possessing the standardized governance model and infrastructural facilities that can encourage the economy to improve the standard of living of its residents. Therefore, it is critical to identify the indications or dimensions that may be utilized as a reference or standard for each case's smart city paradigm. Hence, six dimensions have been established as a result of this research, that have taken into account the use of technological advances in giving solutions, adjusting the environmental issue in development, and having the capacity to fulfill customers' desires. The discovered dimensions will be able to complement the present framework and contribute to the direction of future research, particularly in poor countries, to lead the development of smart cities by concentrating on the elements that may turn them into smarter cities.

## **CHAPTER 3**

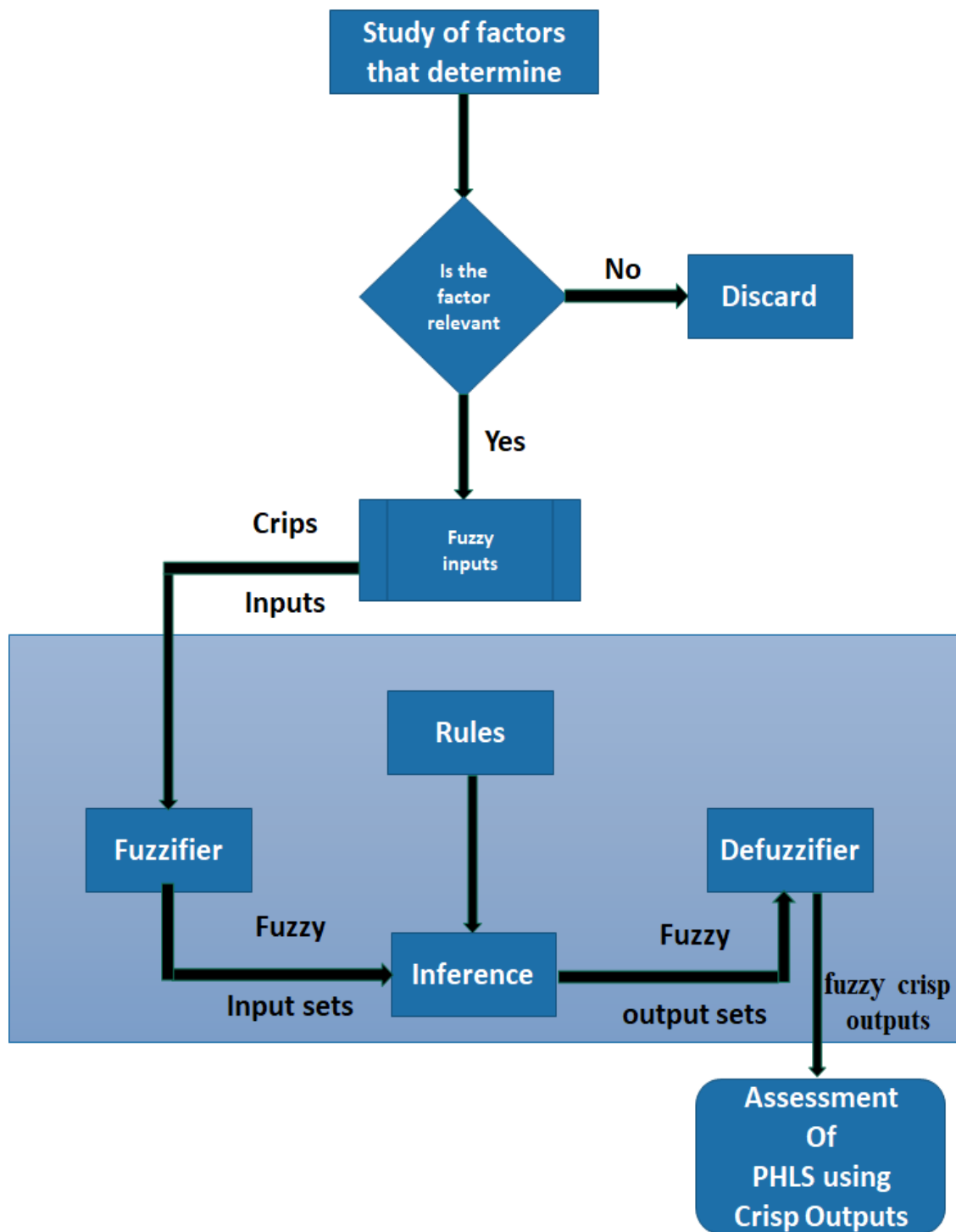
### **PREDICTION OF HUMAN LIFE STANDARD (PHLS)**

#### **3.1 PROPOSED METHODOLOGY**

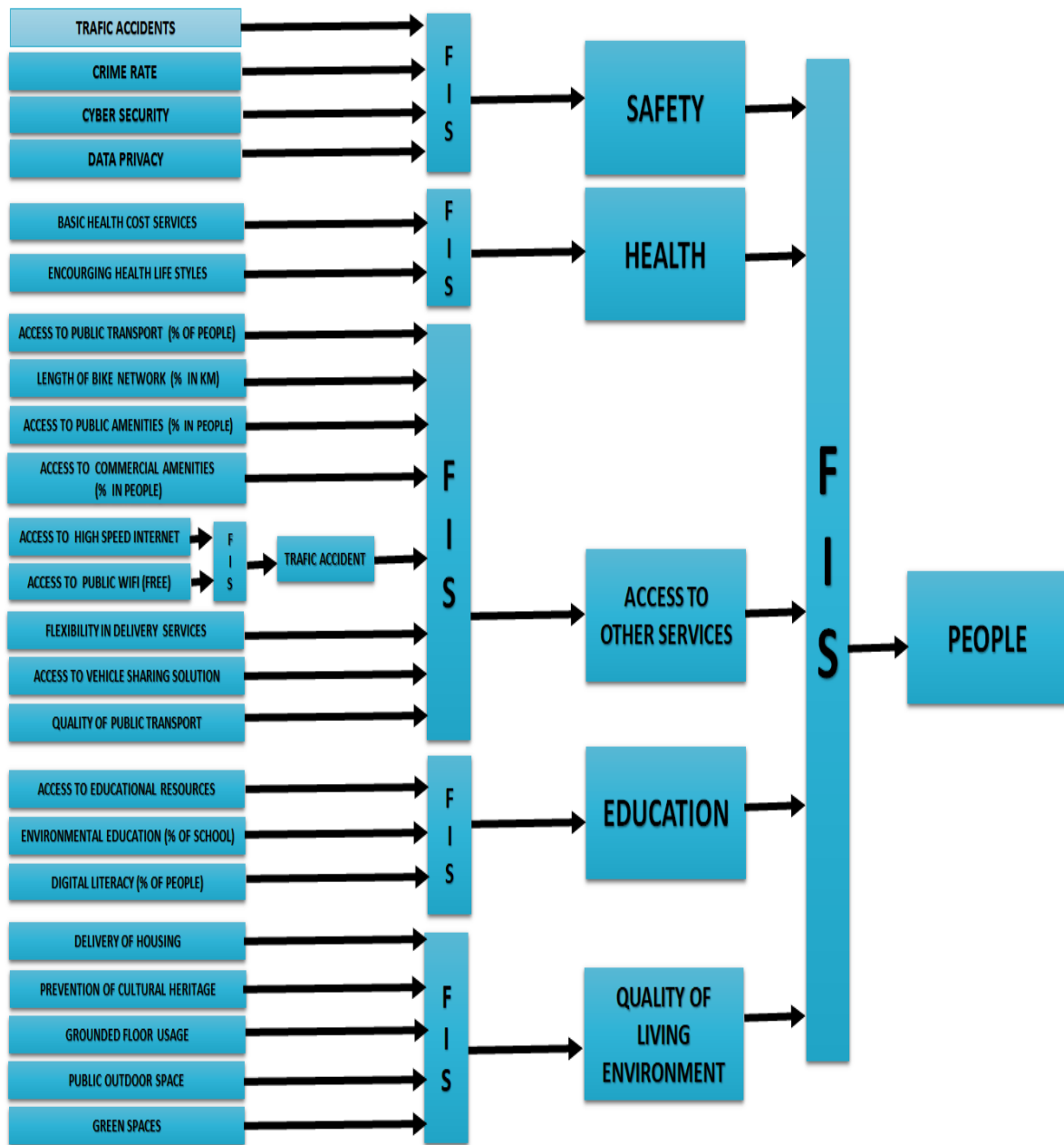
For Valuation of the quality of living standards in smart cities, our proposed method is based on Mamdani's Fuzzy Engine. Our proposed system is Appraisal of Living Standards in Smart Cities Using Mamdani's Expert Fuzzy system FIS-PHLS. This is a powerful model that takes a large number of factors that affect the lives of inhabitants of smart cities. These factors are indexed b/w some ranges that are taken by experts. The model takes these factors as crisp inputs, the inputs that come directly from sensors or meters, or devices. The Inference Engine takes some rules that are applied to these inputs and makes conclusions.

A proposed Fuzzy Inference System (FIS) based Prediction of Human Life Standard (PHLS) "FIS-PHLS" Model's research methodology is depicted in Figure -2. Originally, only appropriate input elements are taken and inappropriate input components are deleted following the research of the problem. The fuzzy inference Engine has been used to transfer fuzzification sets to fuzzy yield sets by obtaining desired fuzzy crisp inputs and transforming them into fuzzy input sets. The fuzzy output set has been transformed into fuzzy crisp output using a fuzzified.

This research presents an investigation report on Fuzzy Inference System (FIS) featuring the application for computer sciences /engineering projects. In light of the undertaking center, the FIS model is without a doubt accommodating to recognize a task execution assessment. The thinking cycles of a design of Fuzzy principles, the information base of the framework is great. By applying this, with thinking it is commonsense to have a quantitative evaluation of the advancement of ventures also, challenges by representation. Moreover, it is conceivable to recognize the positives and negatives of the arranging and execution measures for deciding where improvement is required. Fuzzy ideas are decided in this research obviously and this FIS will be accommodating for appropriate arrangements.



**Figure 4: Proposed FIS-PHLS Based Expert System Methodology**



**Figure 5: Essentials of Smart Cities infrastructure for development of Smart Cities**

### 3.2 FOUNDATION OF SMART CITY INITIATIVE

In this investigation, we have proposed six basic dimensions each of which is characterized by a set of aspects as is highlighted in figure 3, which are often referenced in the literature and determined to be pivotal for understanding and creating smart urban communities. These elements have been utilized to plan a system that gives a more comprehensive perspective on the smart city

drive. A FIS ready to screen the general Prediction of **Human Life Standard (PHLS)** emphasized on PEOPLE. The components are:

- People (Health, Safety, Education, Quality of Living Environment, and Access to Other Services).
- Planet (Resources, Waters & Landscape, Environment & Disposal, Power and Prevention, Ecosystems Climate Resilience)
- Prosperity (Economic Performance, Innovation, Local Job Creation Environment, Equity, Green Economy, Competitiveness of Attraction).
- Governance (Community Involvement, Organization, Multi-Level Governance)
- Propagation (Social Compatibility, Technical Compatibility, Ease of Use for Professions, Affordability of Housing, Market Demand, Reliability, Scalability)

### **3.2.1 People**

All smart city activities and goals are ultimately aimed at improving people's quality of life and ensuring everyone's (financial) prosperity. People of a city or community represent an essential role in developing and implementing effective methods and responses. Technological developments are essential attributes, but without people's intelligence, meaningful participation will be impossible, and smart city initiatives will fail. However, the human aspect involves more than just individuals harnessing data to create a human-centric smart metropolis. It's about folks being empowered to participate in the building of smart cities or smart communities as "smart citizens." One of the fundamental Smart City cornerstones for ensuring the direction towards a better human lifestyle is to focus on the quality of life [11]. If a city or local area needs to get more astute, it should take the requirements and issues of its clients – most of its residents – into account. Human-Centric Solutions [HCS] that smart cities are implementing as part of their strategic approach.

- Perceiving the requirement for resident-driven methodologies in savvy urban areas
- Moving the concentration from innovation to using aggregate knowledge as the most important achievement factor

The intensive existence of Computing gives a chance for the city to have innovative, diversified and trained respectively government and its people by providing a relationship between these two main components to enable complete evaluation and increase living style. Some of the people dynamics are Innovative City, Education City, Humane City, and Information City. Human and social infrastructures are vital to urban growth. Smart People benefit from social capital, thus they integrate schooling, cultural heritage, and industry to create an effective city [12].

### **3.2.2 Health**

Smart healthcare arose from IBM's (Armonk, NY, USA) vision of "Smart Planet" presented in 2009. Essentially said, Smart Planet is a smart architecture that detects information with sensors, communicates it via the internet of things (IoT), and evaluates it with computing systems and cloud services. [13]

The smart health concept encompasses e-health and m-health systems, digital records maintenance, home automation service providers, and smart and connected medical equipment. As informational technology advances, the concept of smart healthcare has gained acceptance. Smart healthcare makes use of a new era of global innovations, such as IoT technology, data analytics, cloud services, 5G, and AI, to radically transform the current healthcare system, providing a reliable, easy, and personal. [14]

According to the WHO, "e-Health is the application of Information and communications technologies for quality of life." People are being treated, research is being conducted, the health workforce is being trained, diseases are being identified, and public health is being monitored."

According to the Global Observatory of e-Health, m-Health is defined as "modern healthcare practices aided by digital technology, such as mobile phones, telemetry equipment, electronic devices (Tablet PCs), as well as other wireless technologies" (GOe). Patients are assisted, and healthcare is improved, thanks to mobile phones and other devices.

Patients can use wearable devices to keep track of their loved ones throughout all time, seek medical treatment via smart devices, and then use smart homes to provide computer systems, while doctors can use a variety of advanced clinical decision support systems to aid and improve diagnosis. All of these cutting-edge services will be available for a very low basic health cost, while simultaneously improving people's healthy lifestyles.

### 3.2.3 Safety

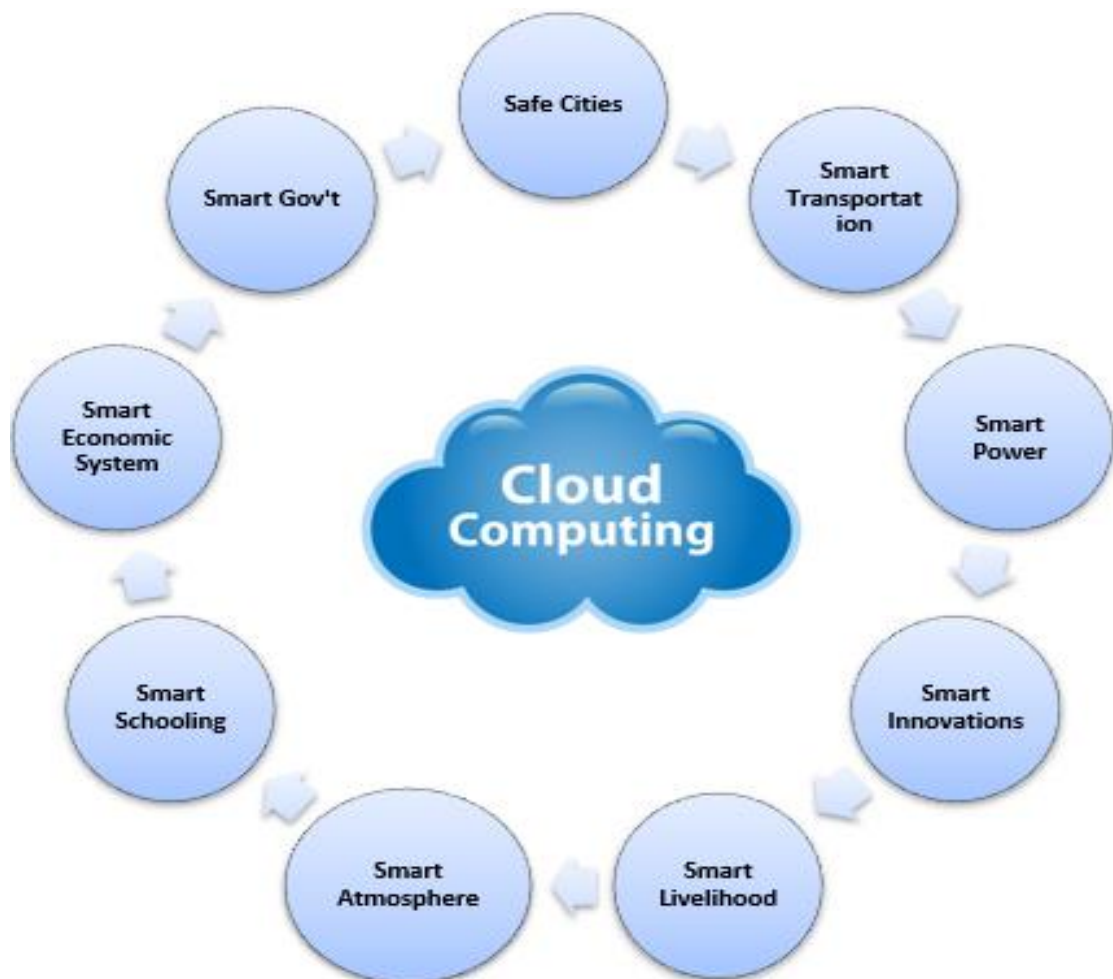
Every city's quality of life depends on its level of safety. As a result, we may state that a Smart City must be a Safe City. Safe Metropolitan is a city that improves its effectiveness of safety processes by ICT integration and the natural environment, to reduce criminality and violence potential risks, to provide a safe environment for its residents with easy healthcare coverage, or to achieve the capability and innovative event with endangering as well as emerged crises. The rapid advancement of ICTs that enhance Safe City characteristics and infrastructure makes it impossible to make a comprehensive list of all conceivable solutions, such as crime rates, traffic accidents, cyber security, and data privacy. Smart traffic systems and networks do have the capacity to transform numerous new informational sources and options to crisis management. Drone surveillance is one example, while cars may lower the number of incidents via rigorously adhering to road laws. We can gather information on the flow of traffic, road obstructions, and traffic conditions, among other things, thanks to their ability to interface with the surroundings. [15]

A safe city system should incorporate the following features:

- Health
- Intelligent transportation systems, and pathways.
- Smart surveillance, searching, detecting, and analysis systems,
- Efficient transport networks and routes
- Smart disaster management systems can help with decision-making, alerting, tracking, and forecasting emergency scenarios and environmental aspects.
- Secure internet providers including information privacy, data mining hubs,
- Centrally controlled police forces and the Integrating Release Systems (IRS).

Safe City, as depicted in Figure 4. [16]

- Safe Cities
- Smart Transportation
- Smart Power
- Smart Innovations
- Smart Livelihood
- Smart Atmosphere
- Smart People
- Smart Schooling
- Smart Economic System
- Smart Govt.



**Figure 1: Safe Cities Systems**

### **3.2.3.1 Safe Cities**

Whenever advances in human resources, as well as advanced mass transportation facilities, generate sustained economic development as well as a good standard of living while also wisely managing the national environment via public administration, the metropolis could be described as “smart.”

### **3.2.3.2 Smart Transportation**

Intelligent Transport Systems (ITS) is a sophisticated system that strives to provide novel applications based on various forms of urban transportation administration, allowing users will become fully efficient and aware better, well synchronized, and 'smarter' usage of transportation networks.

### **3.2.3.3 Smart Power**

To achieve intelligent power generation, it is possible to build a national grid able to effectively distributing power for process transactions fully utilizing communication skills. The future of energy was discussed in an IEEE webcast by proposing the notion of “ENERNET” (“Energy of Things”) as both a wedding of Power Grid and the Internet of Things. ENERNET's development opens up new avenues for obtaining a cost-effective, dependable, safe, and long-term source of electrical strength and power.

### **3.2.3.4 Smart Innovations**

The building of smart infrastructure and the linkage of Information and communication technologies and human beings are at the heart of smart cities. To design more Smart Urban models, various Technologies disciplines such as Artificial Intelligence, Internet of Things, data analytics, & nanostructures have been integrated. Smart City, gratitude to ICT, allows individuals to design, innovate, research, and explore creativity to improve the standard of living.

### **3.2.3.5 Smart Livelihood**

Several of the six factors of such a smart city is the smart livelihood. Smart people, smart mobility, smart economy, smart environment, and smart governance are the other five. The six components are indeed linked with both

the smart city systems across all smart life activities. City differs in size depending on whether they will be megacities, metropolises, or large or very small continent populations. This is due to its distinct cultural and biological systems.

### **3.2.3.6 Smart Atmosphere**

The city must act on environmental facilities such as waterways, sewage, and green areas to enhance durability. It must also be centered on the use of renewable energy sources.

### **3.2.3.7 Smart People**

Many critical traits are required of Smart People, the essential key component of a Smart Urban System.

- Professional, smart persons succeed at what they're doing.
- Persons with a high Development Index are smart.
- Academic institutions are incorporated through all elements of urban life in a smart city.
- It appeals to citizens with outstanding human resources, such as skilled professionals.

### **3.2.3.8 Smart Schooling**

In the creation of smart cities, smart education is a critical component. A smart city has advantages in quality education, professional certification, academic institutions, and public universities, e-learning networks, personal development, and innovative educational development. "Human beings first must establish schooling at the core of a smart city's people's development," says the author.

### 3.2.3.9 Smart Economic System

As per the academics, the Smart Economy has the following features:

- Creative ideas are those which boost productivity while reducing prices.
- ICT tools are extensively used during business and are digitized.
- To achieve a good quality of better revenues, productive resources, and efficient costs, be competing; being accessible, apply knowledge, and innovative.
- Green; an emphasis on long-term principles, the development of renewable energy sources, and the restoration of clean places.
- Individual prosperity is enhanced through being socially accountable.

### 3.2.3.10 Smart Gov't

Cities are attempting to develop their government as a result of the growth of ICTs, and any government operations that are developing technology are referred to as Smart Governance. It is defined as “a set of technologies, persons, laws, strategies, assets, cultural standards, and intelligence that interplay to enable metropolitan governance activities” [20]. It enhances information technology and communications infrastructure by implementing new regulations, innovations, and business strategies.

### 3.2.4 Education

Smart Education is a word that has lately appeared in the literature. It is a whole new technology, a new phrase for old ones and the relationship between this paradigm and other notions like “**Smart Learning**”, “**Smart Campus**”, “**Smart University**”, “**Smart Classroom**”, “**Smart Pedagogy**” “**Smart Schooling**”, or “**Smart Tutoring**” And intelligent components “Artificial Intelligence [AI]”, “Augmented Reality [AR]”, “Machine Learning [ML]”, “Internet of Things [IoT]”, “Big Data”, “Virtual Reality [VR]”, “Deep Learning [DL]”, or others have performed a fundamental character in the advancement of Smart Education.[17]

Smart Education is concerned with the modernization of the world that allows us to study increasingly conveniently, productively, dynamically, and pleasantly. Smart education, a paradigm that characterizes education in the information realm, has gotten a lot of publicity recently. As a result, we are pushing forward with the building of smart cities using the notion of smart education. Learning settings have moved beyond schools to a broader space, and even to the entire city, in the context of lifelong learning, life-wide learning, and learning society. In a smart city, common learning contexts include schools, home, city, employment, and culture.

A smart city, when it comes to education, is referred to as the epicenter of producing smarter persons and competent workers. Smart cities attract creative individuals and professionals, allowing them to form a circular economy that makes them wiser and smart. As a reason, smart cities may draw into their human achievement in a variety of ways. Furthermore, increased use of technology in education is a smart city attempts to enhance access to educational resources. An innovative system of education can also enhance educational quality and digital literacy while lowering educational expenditures.

### **3.2.5 Quality of Living Environment**

Smart Environment means Smart systems for controlling environmental protection, drainage, waste, photovoltaic, electricity, weather forecasting, and water system are some of the smart solutions for the environment. Its goal is to increase energy efficiency and environmental safety in cities.

Smart environments are built on the foundation of smart cities elements, which require cities to have appropriate resources such as housing (Delivery of Housing), roadways, piping, bridges, underpasses, buildings (residential, commercial, and recreational), Public Outdoor Space, Cultural Heritage Preservation, and electrical systems lines. In the smart environment, the natural habitat and the ecological consequences of human advancement and growth are also addressed. [18] smart e atmosphere is characterized by pleasing natural systems (atmospheric pressure, green areas, and so on); Smart living is described by many aspects of standard of living like cultural values, safety, protection, homes, tourist activities, and so on; the smart environment is characterized by pleasing natural systems (atmospheric pressure, green areas, and so on); Citizens' needs should be met through public open space. It should preferably pay for at least thirty percent of the city's area and take into account the number of people. Not only does public open space serve environmental, sociological,

cultural, and economic purposes, but it also serves aesthetically intended purposes.

### **3.2.6 Access to Other Services**

Smart cities have grown in popularity as the development and deployment of ICT in city infrastructure has expanded. A smart city's huge goal is to improve the service quality provided to people and, as a result, their standard of living. [19]

#### **3.2.6.1 Effective Metropolitan Systems**

Which provide efficient transport environments, such as convenience, smaller queues, better information, shorter commute times, flexibility in delivery services, lower CO<sub>2</sub> emissions, enhanced municipal service operations (quick and effective response to citizen [user] demands), and decreased processing time in the event of city delivery failures or theft.

#### **3.2.6.2 Demonstrated Positive Services**

These provide real-time information about a person's usage, enable residences to use green energy, maintain the energy consumption of buildings through a power grid (e.g., expecting usage), and automate all construction processes, resulting in lower electricity and water bills (heating and cooling, security, and lighting).

#### **3.2.6.3 Cyberspace Services**

These enable reliable and elevated services to consumers, delivering fast and efficient responses to the inquiries of people (e.g., through electronic operations), delivering much range of facilities to citizens, access to high-speed internet, free Wi-Fi access to people, including cloud technology and remote data management. One of the most important determining characteristics that could be used to distinguish safe cities in the world is cyber security. The Safe Cities Index (SCI) is widely utilized, and it is based on an index that includes over 40 qualitative analysis variables that are divided into four categories: cyber safety, health care, infrastructural security, and personal security.

### **3.2.6.4 Sector of Transportation**

Most of the global population now live in urban areas. In larger cities, transportation produces a plethora of problems, including traffic congestion, pollution, and energy use. **Intelligent Transportation Systems (ITS)** are also the answer to these issues. ITS provide a range of services in a smart city, including decreasing mobility by enabling product contains, optimization tour management and planning, the sensor determines drivers, enhancing motorist & traveler security, decreasing CO<sub>2</sub>, provide traffic information on cellphones, and monitor vehicles, among other things. As a result, vehicle communication is an important smart city technology. User-centric advanced technologies and network monitoring will assist in analyzing traffic circumstances, planning, and detecting dangerous traffic scenarios.

### **3.3 FUZZY CONCEPT**

The fuzzy idea is one whose applicability bounds might change significantly depending on the situation or circumstance, rather than being defined and get it over with. This indicates that the idea is ambiguous in certain sense, having a firm, definite definition, without being completely confused or worthless. It does have a specific definition that can only be clarified through greater development and specificity, which comprises a more exact characterization of the situation in which the notion is applied.

### **3.4 FUZZY LOGIC**

The humans' dynamical strategy is likely to be Fuzzy Logic. It deals with data that is unclear or imprecise. This is a major deception of current situation concerns, and it is based on layers of truths rather than the usual legitimate or 1/0 logic of Boolean algebra.

Examine the outline that follows. It demonstrates that in Fuzzy systems, attributes are represented by an integer scale from zero to 1. Here, 1.0 denotes immaculate truth, whereas 0.0 denotes utter deception. Reality esteem is a quantity that represents the worth of a Fuzzy frame. As a result, we might say that Fuzzy reason is argumentation that is used to show crispiness rather than rationale that is Fuzzy. There could have been a variety of alternative systems like this that can help us understand the concept of fuzzy logic. Lofti A. Zadeh introduced fuzzy logic in his research article "Fuzzy Sets" in 1965. He is known as the father of Fuzzy Logic.

### **3.5 ETYMOLOGY OF FUZZY AND ITS APPLICATION**

Seiji Yasunobu and Soji Miyamoto of Hitachi sparked interest in fuzzy systems in 1985 when they presented copies of Fuzzy based frameworks for the Sendai rail line. Takeshi Yamakawa demonstrated an "altered pendulum" using a set of basic devoted Fuzzy reasoning chips in a trial wherein the vehicle continues to protect the shafts placed onto its tip via a pivoting when rail route lines first opened in 1987. Yamakawa put on a display by suspending a beer bottle full of liquid and, astonishingly, a live rat from the pendulum's pinnacle, while the frame maintained dependability for both circumstances. Similarly, Fuzzy frameworks for mechanical and customer applications were developed by Japanese designers. In 1988, Japan established the Laboratories of Internationally Fuzzy Design (LIFE) as a cooperative plan for 48 institutions to conduct fuzzy development.

### **3.6 FUZZY INFERENCE SYSTEM [FIS]**

The Fuzzy Inference System is a critical component of a Fuzzy logic framework that does dynamic work. It draws basic choice recommendations using the "Assuming... THEN" leads, as well as connections "OR" and "AND." Fuzzy Inference Systems are perhaps the most noticeable uses of The Fuzzy rationale and fuzzy sets hypothesis. A Fuzzy Inference System (FIS) is a framework that utilizes the Fuzzy set hypothesis to plan contributions to yields to imagine the result by expectation and the sorts of FIS are Mamdani and the Sugeno model. Rule age is the principal factor and the conditions are examined and given for rule base. FIS offers a high execution and a decent speculation capacity to get ideal arrangements. The standard base lucidity is a significant viewpoint and is the primary benefit of Fuzzy deduction frameworks.[9]

### **3.7 FIS INPUTS AND OUTPUTS**

- The principal fuzzy inference system can accept either fuzzy or crisp arguments, but the outcome is almost always fuzzy sets.
- Having a clear result is sometimes essential, particularly whenever a fuzzy inference system is being used as a regulator.
- As an outcome, we'll require a defuzzification approach to have a crisp value to represent a fuzzy set.

### **3.8 FUZZY INFERENCE SYSTEMS IN USE (FUZZY MODELS)**

- Fuzzy Mamdani Models
- Fuzzy Sugeno Models

The outcomes of their fuzzy rules, as well as their distinct agglomeration and defuzzification techniques, are the key differences between these fuzzy inference systems.

### **3.9 THE FUZZY MODEL OF EBRAHIM MAMDANI**

- The most widely used fuzzy inference system is this one.

Professor Mamdani invented one of the very first fuzzy control systems for a Steam motor and kettle mix. He employed fuzzy rules devised by skilled human operators.

### **3.10 THE PROCEDURE FOR CALCULATING THE YIELD**

The steps below should be followed to calculate the output from such a FIS:

- Step 1:** Indicate a group of fuzzy systems.
- Step 2:** Fuzzifying the inputs with the components of information involvement
- Step 3:** By utilizing fuzzy systems, unite the fuzzified parameters to determine a standardized resilience.
- Step 4:** Calculate the standard's affectability by adding norm strengths to the yield inclusion work.
- Step 5:** Combine the results to obtain the yielding conveyance.
- Step 6:** Presenting defuzzification of the outcome dispersion

### **3.11 WHEN I SHOULD USE THE MAMDANI OR SUGENO FIS**

- The Mamdani approach is well-known for gathering expert insights.
- It enables us to show the expertise in a more natural, human-like manner.
- Fuzzy inference of the Mamdani kind is computationally intensive.
- The Sugeno approach, on, either way, is sufficiently efficient.
- It works well with development and adaptability procedures, giving it
- notably appealing in a variety of situations, especially for dynamic nonlinear systems.

### **3.12 FUZZY INFERENCE SYSTEM [FIS] FEATURES**

- Its yield from FIS is dependably a Fuzzy sets independent of the information that can be Fuzzy nor fresh.
- When using this as a regulator, it's critical to have a Fuzzy yield.
- With FIS, a defuzzification component will be present to convert Fuzzy factors into new factors.

### **3.13 FIS OPERATIONAL MODULES**

The five utilitarian squares that follow will help you comprehend the evolution of FIS.

- This features Fuzzy Conditional statement principles in the Rule Base.
- This characterizes all participation aspects of the Fuzzy system used in Fuzzy principles as a data set.
- It is a dynamic component that performs the procedure according to the rules.

- This transforms fresh quantities into fuzzy numbers using the Fuzzification Interaction Component.
- This turns Fuzzy quantities into fresher quantities using the Defuzzification Interaction Component. A Fuzzy resistance system is depicted in the squares figure beneath.

### **3.14 DEFUZZIFICATION**

Defuzzification is the extraction of a worth addressing a fluffy set.

- Defuzzification techniques:
- Centroid of territory
- Bisector of territory
- Mean of max
- Littlest of max
- Biggest of max

It is obligatory to have a fresh yield on certain occasions where we utilize an impedance framework as a regulator.

### **3.15 FIS FUNCTIONING**

The FIS's operation is composed of the following advancements.

- A fuzzified unit maintains its use of multiple fuzzified algorithms and transforms new contributions to Fuzzy information.
- The transformation of new contributions to Fuzzy information creates a data source - a collection of rule bases and data sets.
- Fuzzy information can finally be converted into a new yield by the fuzzified component.

### 3.16 STRATEGIES FOR FIS

Let's discuss the different FIS approaches right now. The two major FIS strategies are listed below, each with its own set of Fuzzy rules —

### 3.17 FUZZY INFERENCE SYSTEM OF MAMDANI

- Fuzzy Model of Takagi-Sugeno
- Fuzzy Inference System of Mamdani

Ebhasim Mamdani proposed this concept in 1975. It was supposed to incorporate a bunch of Fuzzy ideas gleaned through people hacking away at the framework to operate a steam motor and kettle mix.

### 3.18 FUZZY INFERENCE PROCESS

The Fuzzified induction measure in the Takagi-Sugeno Fuzzy Model (TS Method) goes as follows:

**Stage-1:** Fuzzifying the sources of information in this, the framework's benefits are provided Fuzzy.

**Stage-2:** Making use of the Fuzzy administrator The Fuzzified administrators should be used in this progression to obtain the yield.

### 3.19 MAKING FUZZY GUIDELINES

Fuzzy guidelines are given as an assortment of sets of rules to settle on a choice concerning the characterization of info or deciding a yield. Fuzzy standards are given as in the accompanying.

- Fuzzy Rules if (input1 is membership function (MF)1) or are
- (Input2 is members functions (MF) 2) and/or (input3 is members functions(MF)3) then (output membership function(MF)).
- Statement: if the temperature is low and humidity is the low climate is chill then the room is cold.

### **3.20 FUZZY INFERENCE SYSTEMS [FIS] ADVANTAGES MAMDANI**

- Instinctive
- Well-fit to human information sources
- More interpretable and rule-based
- Has inescapable acknowledgment
- Fuzzy platforms help address numerous decision-making challenges in recent times, frequently generating optimal judgments based on the inputs with knowledge-based criteria. The evolution of "Aristotelian Reasoning" may be seen in fuzzification, which is created regarding human judgments.

### **3.21 DEDUCTION**

A fuzzy surmising framework makes it simpler to automate any errand. This is the reason the fuzzy induction framework has discovered fruitful applications in different fields like mechanical technology, design acknowledgment, arrangement expectation, and so on.

### **3.22 CONCLUSION**

In this chapter, we have proposed the FIS-PHLS model and elaborated on different modules from a connectivity and processing perspective. As per our research objectives, this model is designed to provide an autonomous self-evolving mechanism as explained in the learning module and memories. This research presents an investigation report on Fuzzy Inference System (FIS) featuring the application for computer sciences /engineering projects. In light of the undertaking center, the FIS model is without a doubt accommodating to recognize a task execution assessment. The thinking cycles of a design of Fuzzy principles, the information base of the framework is great. By applying this, with thinking it is commonsense to have a quantitative evaluation of the advancement of ventures also, challenges by representation. Moreover, it is conceivable to recognize the positives and negatives of the arranging and execution measures for deciding where improvement is required. Fuzzy ideas are decided in this research obviously and this FIS will be accommodating for appropriate arrangements.

## CHAPTER 4

### SIMULATION FOR PREDICTION OF HUMAN LIFE STANDARD (PHLS)

#### 4.1 PROPOSED APPROACH

For Valuation of the quality of living standards in smart cities, our proposed method is based on Mamdani's Fuzzy Engine. Our proposed system is Appraisal of Living Standards in Smart Cities Using Mamdani's Expert Fuzzy system FIS-PHLS. This is a powerful model that takes a large number of factors that affect the lives of inhabitants of smart cities. These factors are indexed b/w some ranges that are taken by experts. The model takes these factors as crisp inputs, the inputs that come directly from sensors or meters, or devices. The Inference Engine takes some rules that are applied to these inputs and makes conclusions.

In this investigation, we have proposed six basic dimensions each of which is characterized by a set of aspects as is highlighted in figure 3, which are often referenced in the literature and determined to be pivotal for understanding and creating smart urban communities. These elements have been utilized to plan a system that gives a more comprehensive perspective on the smart city drive. A FIS ready to screen the general Prediction of Human Life Standard (PHLS) emphasized on PEOPLE. The components are:

- People (Health, Safety, Education, Quality of Living Environment, and Access to Other Services).
- Planet (Resources, Waters & Landscape, Environment & Disposal, Power and Prevention, Ecosystems Climate Resilience)
- Prosperity (Economic Performance, Innovation, Local Job Creation Environment, Equity, Green Economy, Competitiveness of Attraction).
- Governance (Community Involvement, Organization, Multi-Level Governance)
- Propagation (Social Compatibility, Technical Compatibility, Ease of Use for Professions, Affordability of Housing, Market Demand, Reliability, Scalability)

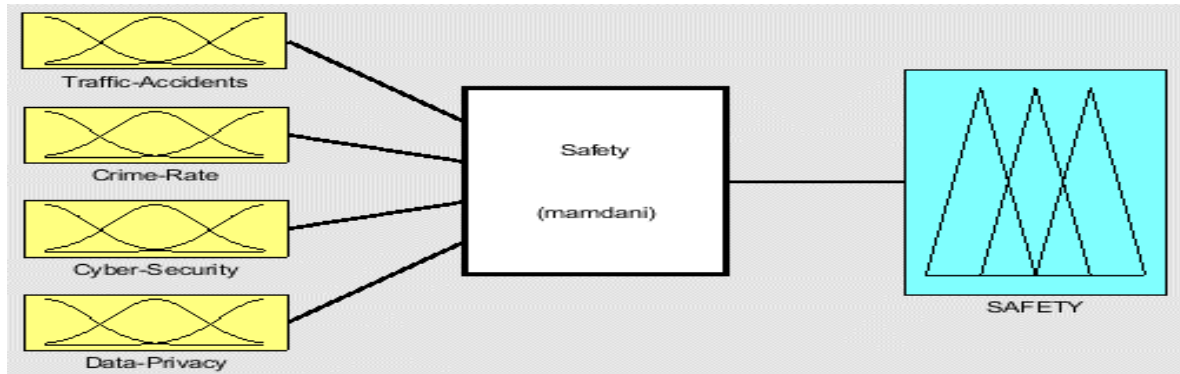
People, Health, Safety, Education, Quality of Living Environment, and Access to Other Services are the elements to consider. These factors are influenced by several sub-factors. Also as an outcome, FIS analyzes and evaluates significant factors based on individual aspects, and FIS examines the ultimate Health and Living standards overview of the key factors. Figures 4 and 5 depict the FIS-PHLS model in its entirety. The model is made up of several layers. There has been FIS for each layer that receives inputs and creates outputs. The very first FIS is being used to determine whether or not a situation is safe. People's safety in smart cities is measured by many elements, including traffic accidents per million inhabitants, crime levels, cyber warfare, and data protection. The FIS examines all inputs using the standards foundation that is supplied to it and then outputs the degree of safety. The next FIS is based on the inputs of Primary Healthcare Costs Service and Promoting a Healthy Lifestyle. On just this premise, the quality of one's health is appraised. For the assessment of high-speed internet availability, which is the core of a smart city, its third FIS considers high-speed internet connectivity and the provision of public Wi-Fi. Its fourth FIS assesses the additional services that citizens of a smart, sustainable, and contemporary city should have access to. The related Fuzzy system analyzes the standard of education and the level of living conditions.

## **4.2 VARIABLES FOR INPUT AND OUTPUT**

The inputs in the Fuzzy inference system are numerical being used to evaluate the standard of living in such a smart city. In the first layers, the proposed FIS-PHLS includes several sub-FIS for measuring the safeness, healthcare, accessibility to other services, education, and quality of living conditions in smart cities. The outcomes of such sub fuzzy logic-based systems are then fed into FIS-PHLS, which is used to assess the overall level of living in any smart city. All of these FIS are explained in more detail.

## **4.3 FIS FOR SAFETY**

The FIS evaluates a smart city's level of safety. There are 4 input quantities and one target output in all. The inputs and outputs of the Safety FIS are shown in Figure 7. Such input and output quantities, as well as their range, are detailed in Table 1:



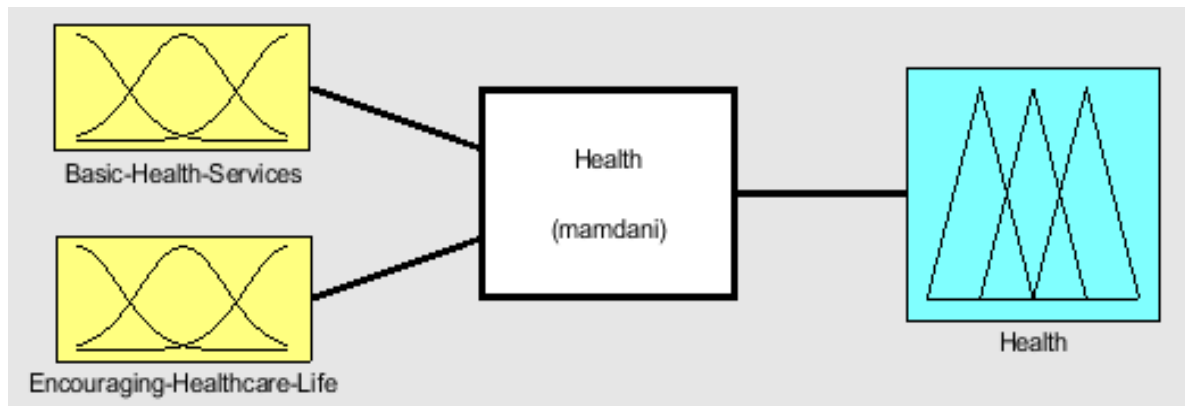
**Figure 7: The FIS- Evaluates a Smart City's Level of Safety.**

**Table 1  
Safety-FIS Expert System I/O variables**

Input Parameter	Range	Semantic Meanings
<b>Traffic Accidents (TA) per 1000000</b>	<b>0 - 12</b>	<b>Low</b>
	<b>10 to 20</b>	<b>Medium</b>
	<b>15 - 25</b>	<b>High</b>
<b>Crime Rate (CR)</b>	<b>0 - 45</b>	<b>Dangerous</b>
	<b>35 - 85</b>	<b>Risky</b>
	<b>80 - 100</b>	<b>Safer</b>
<b>Cyber security (CS) (% of risk)</b>	<b>0 - 30</b>	<b>Low</b>
	<b>25 - 85</b>	<b>Medium</b>
	<b>80 - 100</b>	<b>High</b>
<b>Data privacy (DP) (% of risk)</b>	<b>0 - 18</b>	<b>Safer</b>
	<b>15 - 30</b>	<b>Risky</b>
	<b>25 - 50</b>	<b>Dangerous</b>
<b>Output</b>	<b>Range</b>	<b>Semantic meanings</b>
<b>Safety</b>	<b>0 - 5</b>	<b>Poor</b>
	<b>4 -- 8</b>	<b>Good</b>
	<b>7 -- 10</b>	<b>Excellent</b>

#### **4.4 FIS FOR HEALTH**

The FIS evaluates the state of health services in such a smart city. There are two input values and one output value in all. The Health FIS is depicted in Figure 8 along with its inputs or outputs. Table 2 elucidates these input and output values in terms of their range, as follows:



**Figure 8: Health-FIS Expert System I/O Variables**

FIS for health may be expressed mathematically as follows:

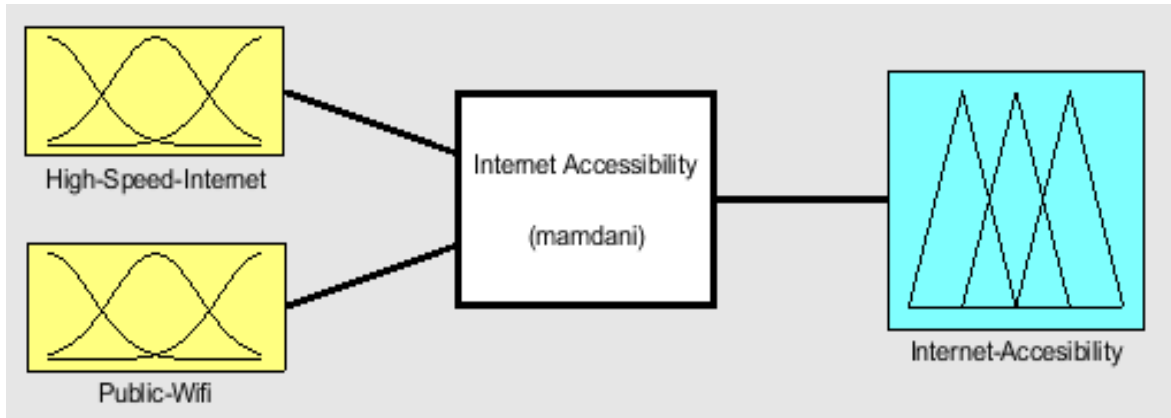
- $\mu_{\text{health}}(h) = t[\mu_{\text{basic-health-services}}(hs), \mu_{\text{health-lifestyle}}(hl)]$

**Table 2**  
**Health-FIS Expert System I/O Variables**

<b>Input Parameter</b>	<b>Range</b>	<b>Semantic Meaning</b>
<b>Basic Health Cost and Services (HS)</b>	<b>0 - 30</b>	<b>Worst</b>
	<b>25 - 70</b>	<b>Good</b>
	<b>60 - 93</b>	<b>Better</b>
	<b>90 -100</b>	<b>Best</b>
<b>Encouraging Health Care Life Styles (HL) (% Relative Change)</b>	<b>0 - 30</b>	<b>Worst</b>
	<b>25 - 70</b>	<b>Good</b>
	<b>60 - 93</b>	<b>Better</b>
	<b>90 -100</b>	<b>Best</b>
<b>Output</b>	<b>Range</b>	<b>Semantic Meanings</b>
<b>Health</b>	<b>0 - 5</b>	<b>Poor</b>
	<b>4 -- 8</b>	<b>Good</b>
	<b>7 -- 10</b>	<b>Excellent</b>

#### 4.5 FIS FOR INTERNET ACCESS

The FIS evaluates the availability and quality of internet access in such a smart city. There are 2 input quantities and one target output in all. The Internet accessibility FIS is depicted in Figure 9 along with its inputs or outputs. All input and output quantities, as well as respective range, are detailed in Table 3.



**Figure 9: Internet Access-FIS Expert System I/O Variables**

FIS for Internet Accessibility may be expressed Mathematically as follows:

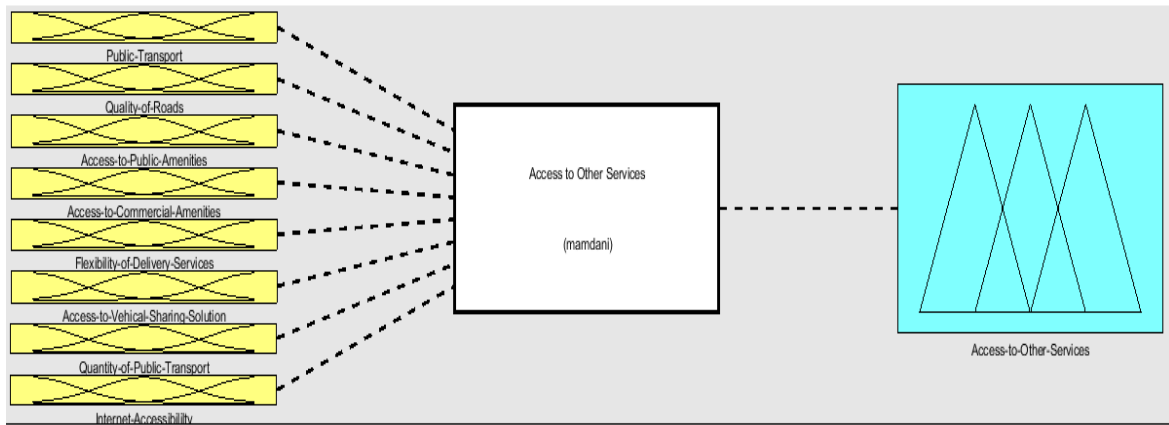
- $\mu_{\text{internet-accessibility}}(i) = t[\mu_{\text{high-speed-internet}}(Hi), \mu_{\text{publicWi-Fi}}(pw)]$

**Table 3**  
**Internet Access-FIS Expert System I/O Variables**

<b>Input Parameter</b>	<b>Range</b>	<b>Semantic Meaning</b>
<b>Access to high speed Internet (Hi) (in Mbps)</b>	<b>0 - 25</b>	<b>Poor</b>
	<b>20 -- 50</b>	<b>Moderate</b>
	<b>45 - 65</b>	<b>Good</b>
	<b>60 -- 80</b>	<b>V-good</b>
	<b>75 -- 100</b>	<b>Excellent</b>
<b>Access to public Wi-Fi (PW)</b>	<b>0 - 5</b>	<b>Poor</b>
	<b>4 -- 8</b>	<b>Good</b>
	<b>7 -- 10</b>	<b>Excellent</b>
<b>Output</b>	<b>Range</b>	<b>Semantic Meanings</b>
<b>Internet Accessibility</b>	<b>0 - 5</b>	<b>Poor</b>
	<b>4 -- 8</b>	<b>Good</b>
	<b>7 -- 10</b>	<b>Excellent</b>

#### 4.6 FIS FOR ACCESS TO OTHER SERVICES (FIS-AOS)

In a smart city, the FIS evaluates the accessibility of all other resources. There are many eight input entries but one target output in all. The FIS- AOS is depicted in Figure 10 with its outputs & inputs. Table 4 elucidates these input and output values of respective limits, as shown below:



**Figure 10: Access to Other Services-FIS Expert System I/O Variables**

FIS-AOS may be Expressed Mathematically as follows:

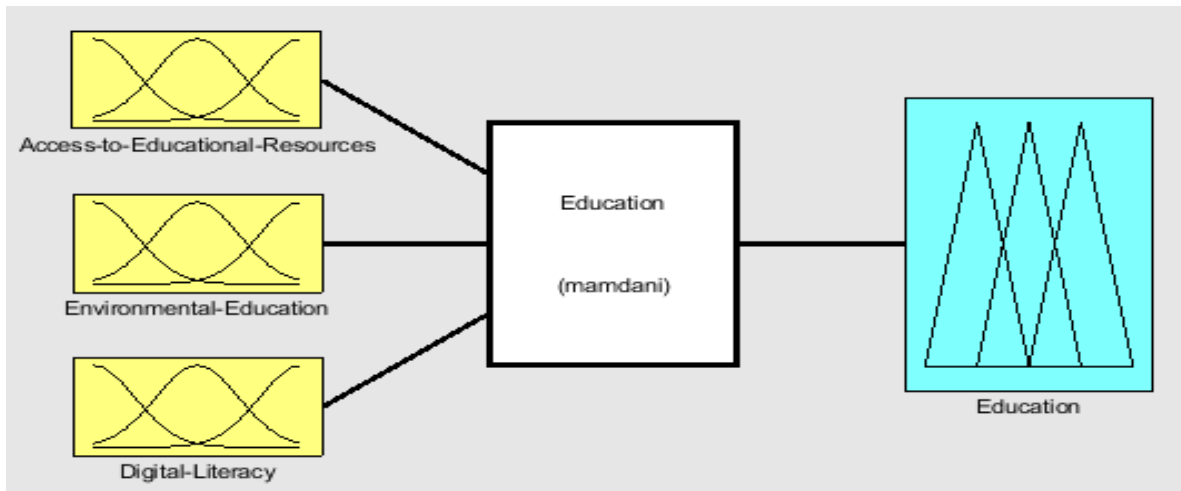
- $\mu_{\text{other-services}}(\text{os}) = t[\mu_{\text{public-transport}}(\text{pt}), \mu_{\text{length-of-routes}}(\text{lr}), \mu_{\text{public-amenities}}(\text{pa}), \mu_{\text{commercial=amenities}}(\text{ca}), \mu_{\text{internet-accessibility}}(\text{ia}), \mu_{\text{delivery-services}}(\text{ds}), \mu_{\text{vehical-sharing}}(\text{vs}), \mu_{\text{public-transport}}(\text{ptr})]$

**Table 4**  
**Access to Other Services-FIS Expert System I/O Variables**

<b>Input</b>	<b>Range</b>	<b>Semantic Meanings</b>
<b>Access to Public Transport</b>	<b>0 - 6</b>	<b>No</b>
	<b>5 -- 10</b>	<b>Yes</b>
<b>Quality of Roads</b>	<b>0 - 6</b>	<b>Poor</b>
	<b>5 -- 10</b>	<b>Good</b>
<b>Access to Public Amenities</b>	<b>0 - 6</b>	<b>Low</b>
	<b>5 -- 10</b>	<b>High</b>
<b>Access to Commercial Amenities</b>	<b>0 - 6</b>	<b>Low</b>
	<b>5 -- 10</b>	<b>High</b>
<b>Flexibility of Delivery Services</b>	<b>0 - 6</b>	<b>Poor</b>
	<b>5 -- 10</b>	<b>Good</b>
<b>Access to Vehicle Sharing Solution</b>	<b>0 - 6</b>	<b>Poor</b>
	<b>5 -- 10</b>	<b>Good</b>
<b>Quantity of Public Transport</b>	<b>0 - 6</b>	<b>Poor</b>
	<b>5 -- 10</b>	<b>Good</b>
<b>Internet Accessibility</b>	<b>0 - 6</b>	<b>Low</b>
	<b>5 -- 10</b>	<b>High</b>
<b>Output</b>	<b>Range</b>	<b>Semantic meanings</b>
<b>Access to other services</b>	<b>0 - 5</b>	<b>Poor</b>
	<b>4 -- 8</b>	<b>Good</b>
	<b>7 -- 10</b>	<b>Excellent</b>

## 4.7 FIS FOR EDUCATION

The FIS evaluates the quality and accessibility of education in smart cities. There are three input entries and one target output in all. The Educational FIS is visualized in Fig 11 along with its outputs and inputs. These input and output quantities, as well as respective variations, are detailed in Table 5:



**Figure 11: Education to Other Services-FIS Expert System I/O Variables**

FIS for Education may be Expressed Mathematically as follows:

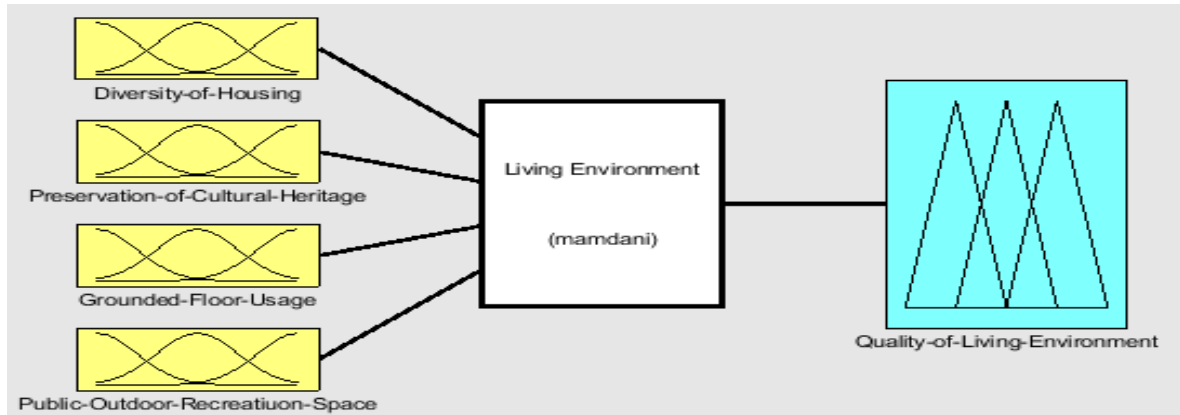
- $\mu_{\text{education}}(e) = t[\mu_{\text{educational-resources}}(er), \mu_{\text{environmental-education}}(ee), \mu_{\text{digital-literacy}}(dl)]$

**Table 5**  
**Education -FIS Expert System I/O Variables**

Input	Range	Semantic Meanings
Access to Educational Resources	0 - 5	Poor
	4 -- 8	Good
	7 -- 10	Excellent
Environmental Education	0 - 5	Poor
	4 -- 8	Good
	7 -- 10	Excellent
Digital Literacy	0 - 5	Poor
	4 -- 8	Good
	7 -- 10	Excellent
Output	Range	Semantic meanings
Education	0 - 5	Poor
	4 -- 8	Good
	7 -- 10	Excellent

#### 4.8 FIS FOR QUALITY OF LIVING ENVIRONMENT (FIS-QLE)

The FIS evaluates the quality of a smart city's living arrangement. There are 4 input entries and one target output in all. The QLE-FIS is visualized in Fig 12 along with its outputs and inputs. These input and output values, as well as respective limits, are detailed in Table 6:



**Figure 12: Living Environment-FIS Expert System I/O Variables**

FIS for Living Environment may be Expressed Mathematically as follows:

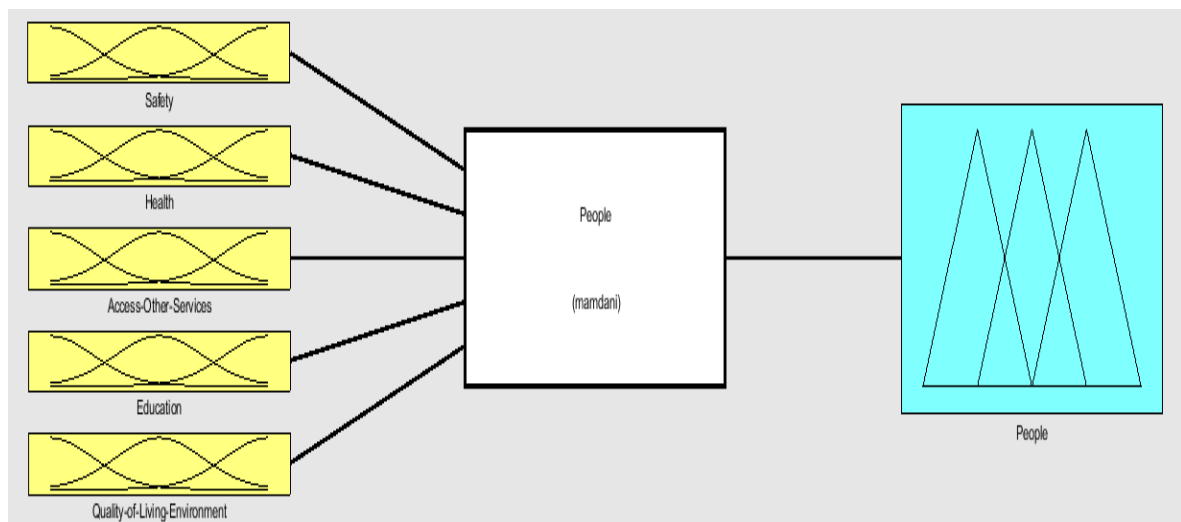
- $\mu_{\text{living-environment}}(le) = t[\mu_{\text{diversity-of-housing}}(dh), \mu_{\text{preserving-heritage}}(ph), \mu_{\text{grounded-floor}}(gf), \mu_{\text{public-outdoor}}(po), \mu_{\text{green-space}}(gs)]$

**Table 6**  
**Living Environment-FIS Expert System I/O Variables**

<b>Input</b>	<b>Range</b>	<b>Semantic Meanings</b>
<b>Diversity of housing</b>	<b>0 - 6</b>	<b>Bad</b>
	<b>5 -- 10</b>	<b>Good</b>
<b>Preservation of Cultural Housing</b>	<b>0 - 6</b>	<b>No</b>
	<b>5 -- 10</b>	<b>Yes</b>
<b>Grounded Floor Usage</b>	<b>0 - 6</b>	<b>No</b>
	<b>5 -- 10</b>	<b>Yes</b>
<b>Public Outdoor Recreation Space</b>	<b>0 - 5</b>	<b>Poor</b>
	<b>4 -- 8</b>	<b>Good</b>
	<b>7 -- 10</b>	<b>Excellent</b>
<b>Output</b>	<b>Range</b>	<b>Semantic meanings</b>
<b>Quality of the Living Environment</b>	<b>0 - 5</b>	<b>Poor</b>
	<b>4 -- 8</b>	<b>Good</b>
	<b>7 -- 10</b>	<b>Excellent</b>

## 4.9 FIS-PEOPLE OR PHLS OF LAYER -2

There is a second level, the PHLS evaluates people's living standards in smart cities. As an argument, it accepts the outcomes of all preceding FISs. The degree of the home environment is produced by a total of five input values and one target output. The PHLS is depicted in Figure 13 along with its outputs and inputs. These input and output quantities, as well as associated variations, are detailed in Table 7:



**Figure 13: People's Living Standard-FIS Expert System I/O Variables**

FIS for Living Standard of people may be Expressed Mathematically as follows:

- $\mu_{\text{people}}(p) = t[\mu_{\text{safety}}(s), \mu_{\text{health}}(h), \mu_{\text{other-services}}(os), \mu_{\text{education}}(e), \mu_{\text{living-environment}}(le)]$

**Table 7**  
**People's Living Standard-FIS Expert System I/O Variables**

<b>Inputs</b>	<b>Range</b>	<b>Semantic Meanings</b>
<b>Safety</b>	<b>0 - 6</b>	<b>No</b>
	<b>5 -- 10</b>	<b>Yes</b>
<b>Health</b>	<b>0 - 6</b>	<b>No</b>
	<b>5 -- 10</b>	<b>Yes</b>
<b>Access to other Services</b>	<b>0 - 6</b>	<b>No</b>
	<b>5 -- 10</b>	<b>Yes</b>
<b>Education</b>	<b>0 - 5</b>	<b>Poor</b>
	<b>4 -- 8</b>	<b>Good</b>
	<b>7 -- 10</b>	<b>Excellent</b>
<b>Quality of Living Environment</b>	<b>0 - 5</b>	<b>Poor</b>
	<b>4 -- 8</b>	<b>Good</b>
	<b>7 -- 10</b>	<b>Excellent</b>
<b>Output</b>		
<b>Output</b>	<b>Range</b>	<b>Semantic meanings</b>
<b>People</b>	<b>0 - 5</b>	<b>Poor</b>
	<b>4 -- 8</b>	<b>Good</b>
	<b>7 -- 10</b>	<b>Excellent</b>

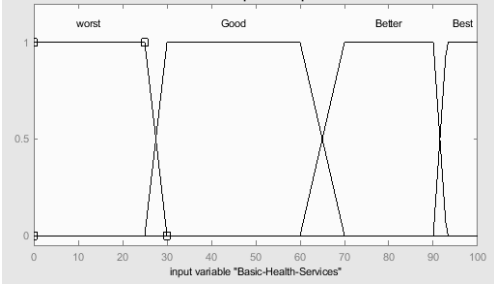
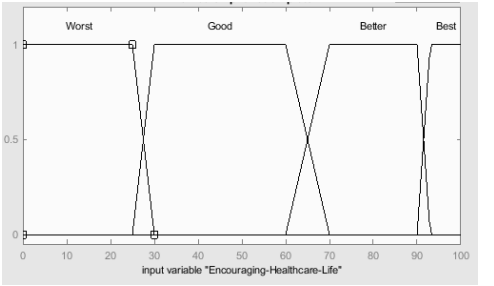
#### **4.10 FUNCTIONS OF MEMBERSHIP (*MFs*)**

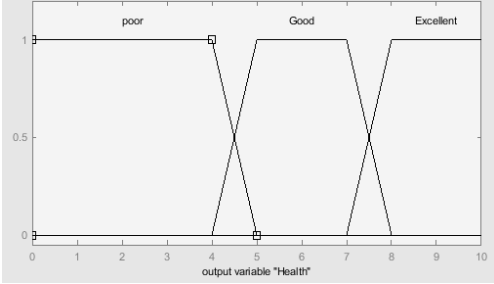
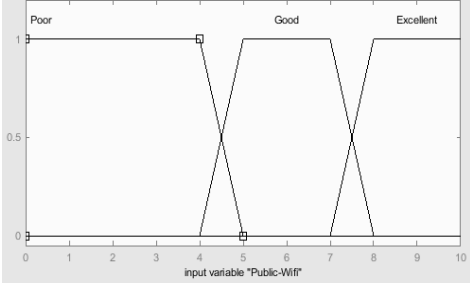
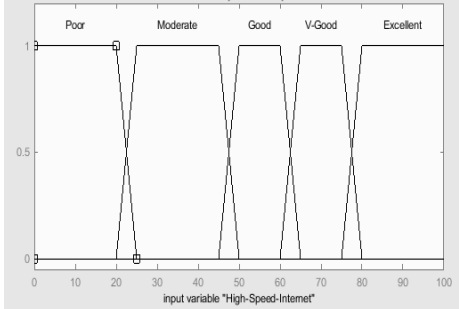
This system displays graphically curve quantities ranging from 0 to 1, as well as simple arithmetic capabilities that suggest summary statistics for both inputs and outputs. The MATLAB package has membership features as well. Table 8 shows a visual and mathematical notation example of the FIS-PHLS membership functions of input and output factors in both levels. Following the expertise discussions, the membership functions are presented.

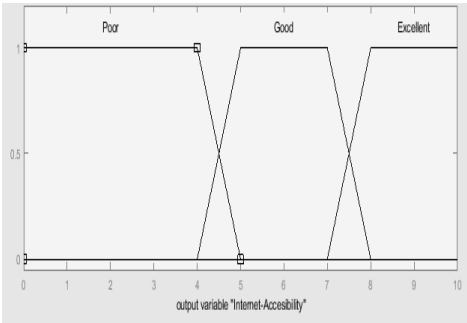
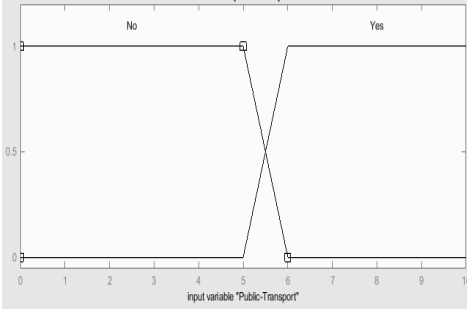
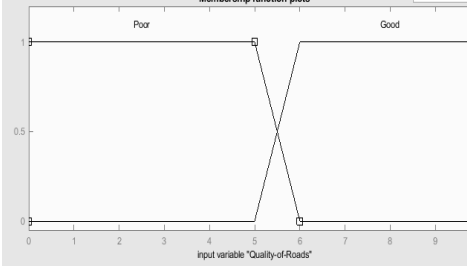
**TABLE 8**  
**The proposed FIS-PHLS Expert System uses Membership Functions for input and output Variables**

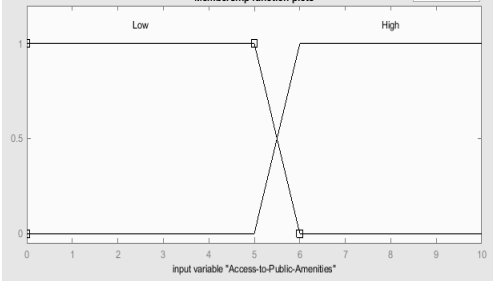
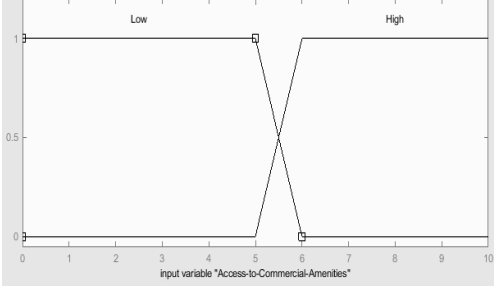
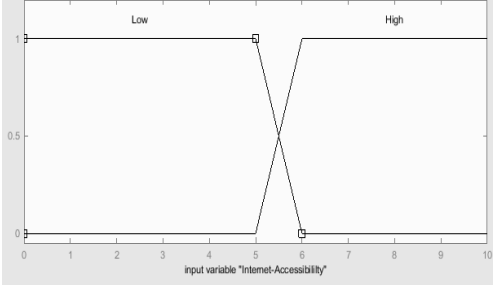
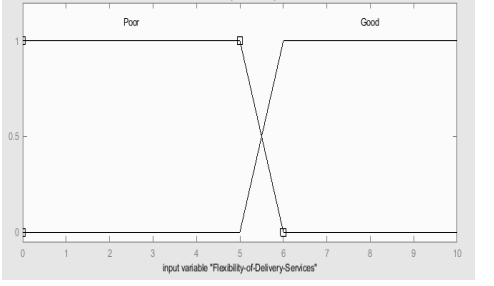
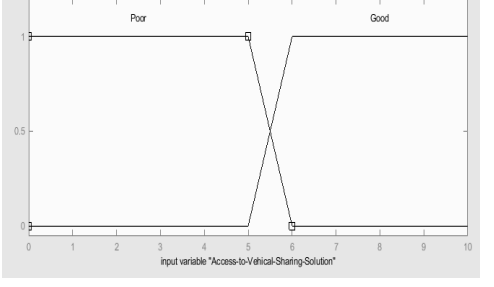
Safety FIS		
Input	Membership Functions (MFs)	Graphical Representation of MFs
$\mu_{\text{traffic-ACCIDENTS}}(ta)$	$\mu_{\text{TRAFFIC-ACCIDENTS,Low}}(ta) = \begin{cases} 1, & \text{if } ta \in [0,10] \\ \frac{12-ta}{2}, & \text{if } ta \in [10,12] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{TRAFFIC-ACCIDENTS,Medium}}(ta) = \begin{cases} \frac{ta-10}{3}, & \text{if } ta \in [10,12] \\ 1, & \text{if } ta \in [12,15] \\ \frac{20-ta}{3}, & \text{if } ta \in [15,20] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{TRAFFIC-ACCIDENTS,High}}(ta) = \begin{cases} \frac{a-15}{5}, & \text{if } ta \in [15,20] \\ 1, & \text{if } ta \in [20,25] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{crime-RATE}}(cr)$	$\mu_{\text{CRIME-RATE,Dangerous}}(cr) = \begin{cases} 1, & \text{if } cr \in [0,35] \\ \frac{45-ta}{10}, & \text{if } cr \in [35,45] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{CRIME-RATE,Risky}}(cr) = \begin{cases} 1, & \text{if } cr \in [45,80] \\ \frac{cr-35}{10}, & \text{if } cr \in [35,45] \\ \frac{85-cr}{5}, & \text{if } cr \in [80,85] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{CRIME-RATE,Safer}}(cr) = \begin{cases} 1, & \text{if } cr \in [85,100] \\ \frac{cr-80}{5}, & \text{if } cr \in [80,85] \\ 0, & \text{otherwise} \end{cases}$	

Input	Membership Functions (MFs)	Graphical Representation of MFs
$\mu_{\text{Cyber-SECURITY}}(\text{cs})$	$\mu_{\text{CYBER-SECURITY,Low}}(\text{cs}) = \begin{cases} 1, & \text{if } \text{cs} \in [0,25] \\ \frac{\text{cs} - 25}{10}, & \text{if } \text{cs} \in [25,35] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{CYBER-SECURITY,Medium}}(\text{cs}) = \begin{cases} 1, & \text{if } \text{cs} \in [30,80] \\ \frac{\text{cs} - 25}{5}, & \text{if } \text{cs} \in [25,30] \\ \frac{85 - \text{cs}}{5}, & \text{if } \text{cs} \in [80,85] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{CYBER-SECURITY,High}}(\text{cs}) = \begin{cases} 1, & \text{if } \text{cs} \in [85,100] \\ \frac{\text{cs} - 80}{5}, & \text{if } \text{cs} \in [80,85] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{data-PRIVACY}}(\text{dp})$	$\mu_{\text{DATA-PRIVACY,Safer}}(\text{dp}) = \begin{cases} 1, & \text{if } \text{dp} \in [0,15] \\ \frac{18 - \text{dp}}{3}, & \text{if } \text{dp} \in [15,18] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{DATA-PRIVACY,Risky}}(\text{dp}) = \begin{cases} 1, & \text{if } \text{dp} \in [18,25] \\ \frac{\text{dp} - 15}{3}, & \text{if } \text{dp} \in [15,18] \\ \frac{30 - \text{dp}}{5}, & \text{if } \text{dp} \in [25,30] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{DATA-PRIVACY,Dangerous}}(\text{dp}) = \begin{cases} 1, & \text{if } \text{dp} \in [30,50] \\ \frac{\text{dp} - 25}{5}, & \text{if } \text{dp} \in [25,30] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{safety}}(s)$	$\mu_{\text{SAFETY,Poor}}(s) = \begin{cases} 1, & \text{if } s \in [0,4] \\ \frac{5 - s}{1}, & \text{if } s \in [4,5] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{SAFETY,Good}}(s) = \begin{cases} 1, & \text{if } s \in [5,7] \\ \frac{s - 4}{1}, & \text{if } s \in [4,5] \\ \frac{8 - s}{1}, & \text{if } s \in [7,8] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{SAFETY,Excellent}}(s) = \begin{cases} 1, & \text{if } s \in [8,10] \\ \frac{s - 7}{1}, & \text{if } s \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	

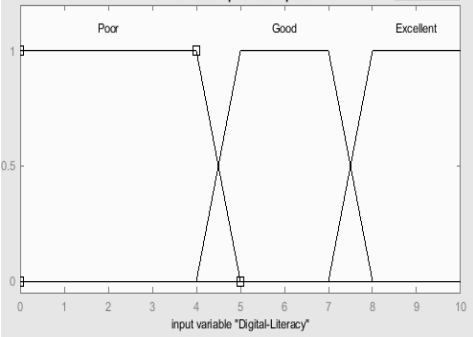
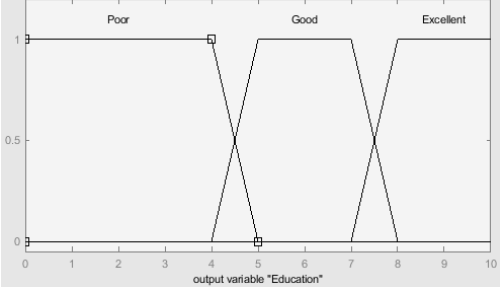
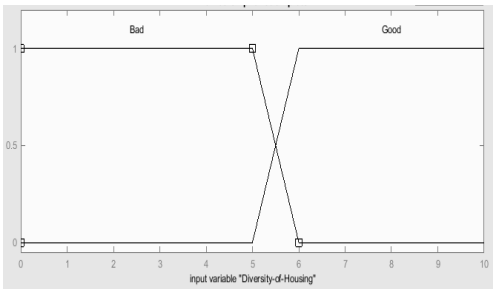
Input	Membership Functions (MFs)	Graphical Representation of MFs
<b>Health FIS</b>		
$\mu_{\text{basic-HEALTH-SERVICES}}(hs)$	$\mu_{\text{BASIC-HEALTH-SERVICES,Worst}}(hs) = \begin{cases} 1, & \text{if } hs \in [0,25] \\ \frac{30 - hs}{5}, & \text{if } hs \in [25,30] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{BASIC-HEALTH-SERVICES,Good}}(hs) = \begin{cases} 1, & \text{if } hs \in [30,60] \\ \frac{hs - 25}{5}, & \text{if } hs \in [30,25] \\ \frac{70 - hs}{10}, & \text{if } hs \in [60,70] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{BASIC-HEALTH-SERVICES,Better}}(hs) = \begin{cases} 1, & \text{if } hs \in [70,90] \\ \frac{93 - hs}{3}, & \text{if } hs \in [90,93] \\ \frac{hs - 60}{10}, & \text{if } hs \in [60,70] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{BASIC-HEALTH-SERVICES,Best}}(hs) = \begin{cases} 1, & \text{if } hs \in [93,100] \\ \frac{hs - 90}{3}, & \text{if } hs \in [90,93] \\ 0, & \text{otherwise} \end{cases}$	 <p>The graph shows four membership functions for the input variable "Basic-Health-Services" on a scale from 0 to 100. The functions are: "worst" (1 from 0-25, then linear to 0 at 30), "Good" (1 from 30-60, then linear to 0 at 70), "Better" (1 from 70-90, then linear to 0 at 93), and "Best" (1 from 93-100, then linear to 0 at 90). The y-axis represents the membership degree from 0 to 1.</p>
$\mu_{\text{healthcare-LIFE}}(hl)$	$\mu_{\text{HEALTHCARE-LIFE,Worst}}(hl) = \begin{cases} 1, & \text{if } hl \in [0,25] \\ \frac{30 - hl}{5}, & \text{if } hl \in [25,30] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{HEALTHCARE-LIFE,Good}}(hl) = \begin{cases} 1, & \text{if } hl \in [30,60] \\ \frac{hl - 25}{5}, & \text{if } hl \in [30,25] \\ \frac{70 - hl}{10}, & \text{if } hl \in [60,70] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{HEALTHCARE-LIFE,Better}}(hl) = \begin{cases} 1, & \text{if } hl \in [70,90] \\ \frac{93 - hl}{3}, & \text{if } hl \in [90,93] \\ \frac{hl - 60}{10}, & \text{if } hl \in [60,70] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{HEALTHCARE-LIFE,Best}}(hl) = \begin{cases} 1, & \text{if } hl \in [93,100] \\ \frac{hl - 90}{3}, & \text{if } hl \in [90,93] \\ 0, & \text{otherwise} \end{cases}$	 <p>The graph shows four membership functions for the input variable "Encouraging-Healthcare-Life" on a scale from 0 to 100. The functions are: "Worst" (1 from 0-25, then linear to 0 at 30), "Good" (1 from 30-60, then linear to 0 at 70), "Better" (1 from 70-90, then linear to 0 at 93), and "Best" (1 from 93-100, then linear to 0 at 90). The y-axis represents the membership degree from 0 to 1.</p>

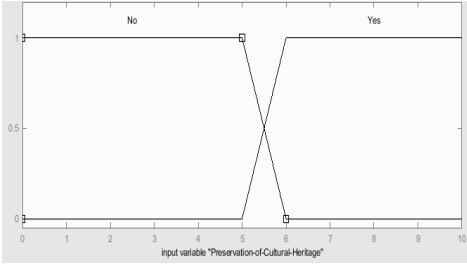
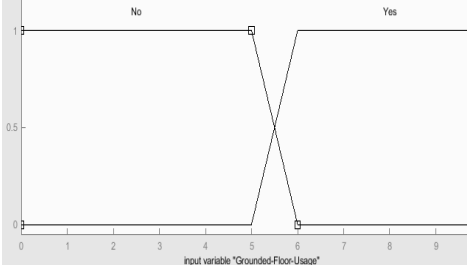
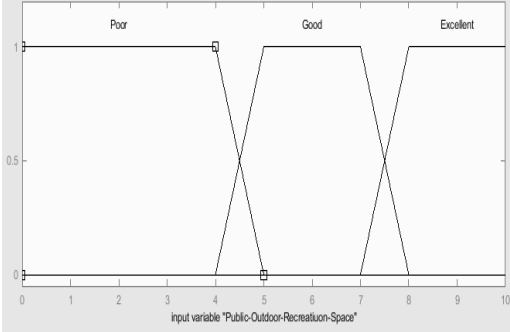
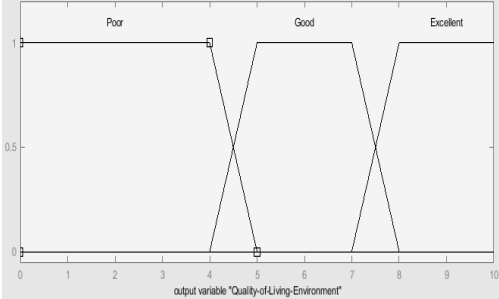
Input	Membership Functions (MFs)	Graphical Representation of MFs
$\mu_{\text{health}}(h)$	$\mu_{\text{HEALTH,Poor}}(h) = \begin{cases} 1, & \text{if } h \in [0,4] \\ \frac{5-h}{1}, & \text{if } h \in [4,5] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{HEALTH,Good}}(h) = \begin{cases} 1, & \text{if } h \in [5,7] \\ \frac{h-4}{1}, & \text{if } h \in [4,5] \\ \frac{8-h}{1}, & \text{if } h \in [7,8] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{HEALTH,Excellent}}(h) = \begin{cases} 1, & \text{if } h \in [8,10] \\ \frac{h-7}{1}, & \text{if } h \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	 <p>The graph shows three trapezoidal membership functions for the output variable 'Health' on a scale from 0 to 10. The 'Poor' function is 1 from 0 to 4 and then decreases to 0 at 5. The 'Good' function increases from 0 at 4 to 1 at 5, stays at 1 until 7, and then decreases to 0 at 8. The 'Excellent' function increases from 0 at 7 to 1 at 8 and stays at 1 until 10.</p>
<b>Internet Accessibility FIS</b>		
$\mu_{\text{public-WIFI}}(w)$	$\mu_{\text{PUBLIC-WIFI,Poor}}(w) = \begin{cases} 1, & \text{if } w \in [0,4] \\ \frac{5-w}{1}, & \text{if } w \in [4,5] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{PUBLIC-WIFI,Good}}(w) = \begin{cases} 1, & \text{if } w \in [5,7] \\ \frac{w-4}{1}, & \text{if } w \in [4,5] \\ \frac{8-w}{1}, & \text{if } w \in [7,8] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{PUBLIC-WIFI,Excellent}}(w) = \begin{cases} 1, & \text{if } w \in [8,10] \\ \frac{w-7}{1}, & \text{if } w \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	 <p>The graph shows three trapezoidal membership functions for the input variable 'Public-Wifi' on a scale from 0 to 10. The 'Poor' function is 1 from 0 to 4 and then decreases to 0 at 5. The 'Good' function increases from 0 at 4 to 1 at 5, stays at 1 until 7, and then decreases to 0 at 8. The 'Excellent' function increases from 0 at 7 to 1 at 8 and stays at 1 until 10.</p>
$\mu_{\text{high-SPEED-INTERNET}}(si)$	$\mu_{\text{HIGH-SPEED-INTERNET,Poor}}(si) = \begin{cases} 1, & \text{if } si \in [0,20] \\ \frac{25-si}{5}, & \text{if } si \in [20,25] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{HIGH-SPEED-INTERNET,Moderate}}(si) = \begin{cases} 1, & \text{if } si \in [25,45] \\ \frac{50-si}{5}, & \text{if } si \in [45,50] \\ \frac{si-20}{5}, & \text{if } si \in [20,25] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{HIGH-SPEED-INTERNET,Good}}(si) = \begin{cases} 1, & \text{if } si \in [50,60] \\ \frac{65-si}{5}, & \text{if } si \in [60,65] \\ \frac{si-40}{5}, & \text{if } si \in [45,50] \\ 0, & \text{otherwise} \end{cases}$	 <p>The graph shows five trapezoidal membership functions for the input variable 'High-Speed-Internet' on a scale from 0 to 100. The 'Poor' function is 1 from 0 to 20 and then decreases to 0 at 25. The 'Moderate' function increases from 0 at 20 to 1 at 25, stays at 1 until 45, and then decreases to 0 at 50. The 'Good' function increases from 0 at 45 to 1 at 50, stays at 1 until 60, and then decreases to 0 at 65. The 'V-Good' function increases from 0 at 60 to 1 at 65 and stays at 1 until 80. The 'Excellent' function increases from 0 at 80 to 1 at 85 and stays at 1 until 100.</p>

Input	Membership Functions (MFs)	Graphical Representation of MFs
	$\mu_{\text{HIGH-SPEED-INTERNET,V-Good}}(si) = \begin{cases} 1, & \text{if } si \in [65,75] \\ \frac{80 - si}{5}, & \text{if } si \in [75,80] \\ \frac{si - 60}{5}, & \text{if } si \in [60,65] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{HIGH-SPEED-INTERNET,Excellent}}(si) = \begin{cases} 1, & \text{if } si \in [80,100] \\ \frac{si - 75}{5}, & \text{if } si \in [75,80] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{internet-ACCESSIBILITY}}(i)$	$\mu_{\text{INTERNET-ACCESSIBILITY,Poor}}(i) = \begin{cases} 1, & \text{if } i \in [0,4] \\ \frac{5 - i}{1}, & \text{if } i \in [4,5] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{INTERNET-ACCESSIBILITY,Good}}(i) = \begin{cases} 1, & \text{if } i \in [5,7] \\ \frac{i - 4}{1}, & \text{if } i \in [4,5] \\ \frac{8 - i}{1}, & \text{if } i \in [7,8] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{INTERNET-ACCESSIBILITY,Excellent}}(i) = \begin{cases} 1, & \text{if } i \in [8,10] \\ \frac{i - 7}{1}, & \text{if } i \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	
<b>Access to Other Services FIS</b>		
$\mu_{\text{public-TRANSPORT}}(pt)$	$\mu_{\text{PUBLIC-TRANSPORT,No}}(pt) = \begin{cases} 1, & \text{if } pt \in [0,5] \\ \frac{6 - pt}{1}, & \text{if } pt \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{PUBLIC-TRANSPORT,Yes}}(pt) = \begin{cases} 1, & \text{if } pt \in [6,10] \\ \frac{pt - 5}{1}, & \text{if } pt \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	
Input	Membership Functions (MFs)	Graphical Representation of MFs
$\mu_{\text{quality-OF-ROUTES}}(q)$	$\mu_{\text{QUALITY-OF-ROUTES,Poor}}(q) = \begin{cases} 1, & \text{if } q \in [0,5] \\ \frac{6 - q}{1}, & \text{if } q \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{QUALITY-OF-ROUTES,Good}}(q) = \begin{cases} 1, & \text{if } q \in [6,10] \\ \frac{q - 5}{1}, & \text{if } q \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	

Input	Membership Functions (MFs)	Graphical Representation of MFs
$\mu_{\text{public-AMENITIES}}(pa)$	$\mu_{\text{PUBLIC-AMENITIES,Low}}(pa) = \begin{cases} 1, & \text{if } pa \in [0,5] \\ \frac{6-pa}{1}, & \text{if } pa \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{PUBLIC-AMENITIES,High}}(pa) = \begin{cases} 1, & \text{if } pa \in [6,10] \\ \frac{pa-5}{1}, & \text{if } pa \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{commercial-AMENITIES}}(ca)$	$\mu_{\text{COMMERCIAL-AMENITIES,Low}}(ca) = \begin{cases} 1, & \text{if } ca \in [0,5] \\ \frac{6-ca}{1}, & \text{if } ca \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{COMMERCIAL-AMENITIES,High}}(ca) = \begin{cases} 1, & \text{if } ca \in [6,10] \\ \frac{ca-5}{1}, & \text{if } ca \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{internet-ACCESSIBILITY}}(i)$	$\mu_{\text{INTERNET-ACCESSIBILITY,Low}}(i) = \begin{cases} 1, & \text{if } i \in [0,5] \\ \frac{6-i}{1}, & \text{if } i \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{INTERNET-ACCESSIBILITY,High}}(i) = \begin{cases} 1, & \text{if } i \in [6,10] \\ \frac{i-5}{1}, & \text{if } i \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{delivery-SERVICES}}(d)$	$\mu_{\text{DELIVERY-SERVICES,Poor}}(d) = \begin{cases} 1, & \text{if } d \in [0,5] \\ \frac{6-d}{1}, & \text{if } d \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{DELIVERY-SERVICES,Good}}(d) = \begin{cases} 1, & \text{if } d \in [6,10] \\ \frac{d-5}{1}, & \text{if } d \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{vehical-SHARING}}(v)$	$\mu_{\text{VEHICLE-SHARING,Poor}}(v) = \begin{cases} 1, & \text{if } v \in [0,5] \\ \frac{6-v}{1}, & \text{if } v \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{VEHICLE-SHARING,Good}}(v) = \begin{cases} 1, & \text{if } v \in [6,10] \\ \frac{v-5}{1}, & \text{if } v \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	

Input	Membership Functions (MFs)	Graphical Representation of MFs
$\mu_{\text{QUANTITY-OF-PUBLIC-TRANSPORT}}(\text{qpt})$	$\mu_{\text{QUANTITY-OF-PUBLIC-TRANSPORT,Poor}}(\text{qpt}) = \begin{cases} 1, & \text{if } \text{qpt} \in [0,5] \\ \frac{6 - \text{qpt}}{1}, & \text{if } \text{qpt} \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{QUANTITY-OF-PUBLIC-TRANSPORT,Good}}(\text{qpt}) = \begin{cases} 1, & \text{if } \text{qpt} \in [6,10] \\ \frac{\text{qpt} - 5}{1}, & \text{if } \text{qpt} \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{other-SERVICES}}(\text{os})$	$\mu_{\text{OTHER-SERVICES,Poor}}(\text{os}) = \begin{cases} 1, & \text{if } \text{os} \in [0,5] \\ \frac{6 - \text{os}}{1}, & \text{if } \text{os} \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{OTHER-SERVICES,Good}}(\text{os}) = \begin{cases} 1, & \text{if } \text{os} \in [6,10] \\ \frac{\text{os} - 5}{1}, & \text{if } \text{os} \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	
<b>Education FIS</b>		
$\mu_{\text{educational-RESOURCES}}(\text{er})$	$\mu_{\text{EDUCATIONAL-RESOURCES,Poor}}(\text{er}) = \begin{cases} 1, & \text{if } \text{er} \in [0,4] \\ \frac{5 - \text{er}}{1}, & \text{if } \text{er} \in [4,5] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{EDUCATIONAL-RESOURCES,Good}}(\text{er}) = \begin{cases} 1, & \text{if } \text{er} \in [5,7] \\ \frac{\text{er} - 4}{1}, & \text{if } \text{er} \in [4,5] \\ \frac{8 - \text{er}}{1}, & \text{if } \text{er} \in [7,8] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{EDUCATIONAL-RESOURCES,Excellent}}(\text{er}) = \begin{cases} 1, & \text{if } \text{er} \in [8,10] \\ \frac{\text{er} - 7}{1}, & \text{if } \text{er} \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{environmental-EDUCATION}}(\text{ee})$	$\mu_{\text{ENVIRONMENTAL-EDUCATION,Poor}}(\text{ee}) = \begin{cases} 1, & \text{if } \text{ee} \in [0,4] \\ \frac{5 - \text{ee}}{1}, & \text{if } \text{ee} \in [4,5] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{ENVIRONMENTAL-EDUCATION,Good}}(\text{ee}) = \begin{cases} 1, & \text{if } \text{ee} \in [5,7] \\ \frac{\text{ee} - 4}{1}, & \text{if } \text{ee} \in [4,5] \\ \frac{8 - \text{ee}}{1}, & \text{if } \text{ee} \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	

Input	Membership Functions (MFs)	Graphical Representation of MFs
	$(ee) = \begin{cases} 1, & \text{if } ee \in [8,10] \\ \frac{ee - 7}{1}, & \text{if } ee \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{digital-LITERVvACY}}(dl)$	$\mu_{\text{DIGITAL-LITERACY,Poor}}(dl) = \begin{cases} 1, & \text{if } dl \in [0,4] \\ \frac{5 - dl}{1}, & \text{if } dl \in [4,5] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{DIGITAL-LITERACY,Good}}(dl) = \begin{cases} 1, & \text{if } dl \in [5,7] \\ \frac{dl - 4}{1}, & \text{if } dl \in [4,5] \\ \frac{8 - dl}{1}, & \text{if } dl \in [7,8] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{DIGITAL-LITERACY,Excellent}}(dl) = \begin{cases} 1, & \text{if } dl \in [8,10] \\ \frac{dl - 7}{1}, & \text{if } dl \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{Education}}(e)$	$\mu_{\text{EDUCATION,Poor}}(e) = \begin{cases} 1, & \text{if } e \in [0,4] \\ \frac{5 - e}{1}, & \text{if } e \in [4,5] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{EDUCATION,Good}}(e) = \begin{cases} 1, & \text{if } e \in [5,7] \\ \frac{e - 4}{1}, & \text{if } e \in [4,5] \\ \frac{8 - e}{1}, & \text{if } e \in [7,8] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{EDUCATION,Excellent}}(e) = \begin{cases} 1, & \text{if } e \in [8,10] \\ \frac{e - 7}{1}, & \text{if } e \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	
<b>Quality of Living Environment</b>		
$\mu_{\text{diversity-OF-HOUSING-}}(dh)$	$\mu_{\text{DIVERSITY-OF-HOUSING,Bad}}(dh) = \begin{cases} 1, & \text{if } dh \in [0,5] \\ \frac{6 - dh}{1}, & \text{if } dh \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{DIVERSITY-OF-HOUSING,Good}}(dh) = \begin{cases} 1, & \text{if } dh \in [6,10] \\ \frac{dh - 5}{1}, & \text{if } dh \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	

Input	Membership Functions (MFs)	Graphical Representation of MFs
$\mu_{\text{preserving-HERITAGE}}(\text{ph})$	$\mu_{\text{PRESERVING-HERITAGE,No}}(\text{ph}) = \begin{cases} 1, & \text{if } \text{ph} \in [0,5] \\ \frac{6-\text{ph}}{1}, & \text{if } \text{ph} \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{PRESERVING-HERITAGE,Yes}}(\text{ph}) = \begin{cases} 1, & \text{if } \text{ph} \in [6,10] \\ \frac{\text{ph}-5}{1}, & \text{if } \text{ph} \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{grounded-FLOOR}}(\text{gf})$	$\mu_{\text{GROUNDED-FLOOR,No}}(\text{gf}) = \begin{cases} 1, & \text{if } \text{gf} \in [0,5] \\ \frac{6-\text{gf}}{1}, & \text{if } \text{gf} \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{GROUNDED-FLOOR,Yes}}(\text{gf}) = \begin{cases} 1, & \text{if } \text{gf} \in [6,10] \\ \frac{\text{gf}-5}{1}, & \text{if } \text{gf} \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{public-OUTDOOR}}(\text{po})$	$\mu_{\text{PUBLIC-OUTDOOR,Poor}}(\text{po}) = \begin{cases} 1, & \text{if } \text{po} \in [0,4] \\ \frac{5-\text{po}}{1}, & \text{if } \text{po} \in [4,5] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{PUBLIC-OUTDOOR,Good}}(\text{po}) = \begin{cases} 1, & \text{if } \text{po} \in [5,7] \\ \frac{\text{po}-4}{1}, & \text{if } \text{po} \in [4,5] \\ \frac{8-\text{po}}{1}, & \text{if } \text{po} \in [7,8] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{PUBLIC-OUTDOOR,Excellent}}(\text{po}) = \begin{cases} 1, & \text{if } \text{po} \in [8,10] \\ \frac{\text{po}-7}{1}, & \text{if } \text{po} \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{living-ENVIRONME NT}}(\text{le})$	$\mu_{\text{LIVING-ENVIRONMENT,Poor}}(\text{le}) = \begin{cases} 1, & \text{if } \text{le} \in [0,4] \\ \frac{5-\text{le}}{1}, & \text{if } \text{le} \in [4,5] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{LIVING-ENVIRONMENT,Good}}(\text{le}) = \begin{cases} 1, & \text{if } \text{le} \in [5,7] \\ \frac{\text{le}-4}{1}, & \text{if } \text{le} \in [4,5] \\ \frac{8-\text{le}}{1}, & \text{if } \text{le} \in [7,8] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{LIVING-ENVIRONMENT,Excellent}}(\text{le}) = \begin{cases} 1, & \text{if } \text{le} \in [8,10] \\ \frac{\text{le}-7}{1}, & \text{if } \text{le} \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	

Input	Membership Functions (MFs)	Graphical Representation of MFs
<b>People FIS</b>		
$\mu_{\text{safety}}(s)$	$\mu_{\text{SAFETY,No}}(s) = \begin{cases} 1, & \text{if } s \in [0,5] \\ \frac{6-s}{1}, & \text{if } s \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{SAFETY,Yes}}(s) = \begin{cases} 1, & \text{if } s \in [6,10] \\ \frac{s-5}{1}, & \text{if } s \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{health}}(h)$	$\mu_{\text{HEALTH,No}}(h) = \begin{cases} 1, & \text{if } h \in [0,5] \\ \frac{6-h}{1}, & \text{if } h \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{HEALTH,Yes}}(h) = \begin{cases} 1, & \text{if } h \in [6,10] \\ \frac{h-5}{1}, & \text{if } h \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{other-SERVICES}}(os)$	$\mu_{\text{OTHER-SERVICES,No}}(os) = \begin{cases} 1, & \text{if } os \in [0,5] \\ \frac{6-os}{1}, & \text{if } os \in [5,6] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{OTHER-SERVICES,Yes}}(os) = \begin{cases} 1, & \text{if } os \in [6,10] \\ \frac{os-5}{1}, & \text{if } os \in [5,6] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{education}}(e)$	$\mu_{\text{EDUCATION,Poor}}(e) = \begin{cases} 1, & \text{if } e \in [0,4] \\ \frac{5-e}{1}, & \text{if } e \in [4,5] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{EDUCATION,Good}}(e) = \begin{cases} 1, & \text{if } e \in [5,7] \\ \frac{e-4}{1}, & \text{if } e \in [4,5] \\ \frac{8-e}{1}, & \text{if } e \in [7,8] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{EDUCATION,Excellent}}(e) = \begin{cases} 1, & \text{if } e \in [8,10] \\ \frac{e-7}{1}, & \text{if } e \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	

Input	Membership Functions (MFs)	Graphical Representation of MFs
$\mu_{\text{living-ENVIRONMENT}}(le)$	$\mu_{\text{LIVING-ENVIRONMENT,Poor}}(le) = \begin{cases} 1, & \text{if } le \in [0,4] \\ \frac{5-le}{1}, & \text{if } le \in [4,5] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{LIVING-ENVIRONMENT,Good}}(le) = \begin{cases} 1, & \text{if } le \in [5,7] \\ \frac{le-4}{1}, & \text{if } le \in [4,5] \\ \frac{8-le}{1}, & \text{if } le \in [7,8] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{LIVING-ENVIRONMENT,Excellent}}(le) = \begin{cases} 1, & \text{if } le \in [8,10] \\ \frac{le-7}{1}, & \text{if } le \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	
$\mu_{\text{people}}(p)$	$\mu_{\text{PEOPLE,Poor}}(p) = \begin{cases} 1, & \text{if } p \in [0,4] \\ \frac{5-p}{1}, & \text{if } p \in [4,5] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{PEOPLE,Good}}(p) = \begin{cases} 1, & \text{if } p \in [5,7] \\ \frac{p-4}{1}, & \text{if } p \in [4,5] \\ \frac{8-p}{1}, & \text{if } p \in [7,8] \\ 0, & \text{otherwise} \end{cases}$ $\mu_{\text{PEOPLE,Excellent}}(p) = \begin{cases} 1, & \text{if } p \in [8,10] \\ \frac{p-7}{1}, & \text{if } p \in [7,8] \\ 0, & \text{otherwise} \end{cases}$	

#### 4.11 LOOK-UP TABLE

Fuzzy expert systems (FES) are a form of an expert systems that evolved from fuzzification. The FES is made up of a fuzzy inference system, fuzzy rules, knowledge databases, and defuzzification elements, and it uses fuzzy logic to examine data in the inference process, similar to Boolean algebra. The system is also used to represent issues requiring decision-making but for which no effective method exists. Conversely, a heuristic approach to solving problems might be used, which is linked with experts in the form of If-Then rules. A fuzzy expert system that explains uncertainty arising from fuzziness, uncertainty, or subjectivity can be completely satisfied with the challenge.

The Fuzzy inference systems of the Prospective Expert System FIS-PHLS have a look-up table that covers input-output criteria. Safety FIS has 81 rules, Health FIS has 16, Internet Accessibility FIS has 15, Access to Other Services FIS has 256 regulations, Education FIS has 27 rules, Quality of Living

Environment FIS has 24 rules, and FIS-PHLS has 72 rules. Table 9 to table 14, are only a handful of them.

#### 4.12 LOOK-UP TABLE 9: SAFETY FIS

**Table 9**  
**Look-Up Safety**

<b>Traffic Accidents per 1000000</b>	<b>Crime Rate</b>	<b>Cyber security (% of risk)</b>	<b>Data Privacy (% of risk)</b>	<b>Safety</b>
Low	Dangerous	Low	Safer	Good
Low	Dangerous	Low	Risky	Good
Low	Dangerous	Low	Danger	Poor
Low	Dangerous	Medium	Safer	Good
Low	Dangerous	Medium	Risky	Good
Low	Risky	High	Safer	Poor
Low	Risky	High	Risky	Poor
Low	Risky	High	Danger	Poor
Low	Safer	Low	Safer	Excellent
Low	Safer	Low	Risky	Excellent
Low	Safer	Low	Danger	Excellent
Low	Safer	Medium	Safer	Excellent
Low	Safer	Medium	Risky	Excellent
Low	Safer	Medium	Danger	Good
Low	Safer	High	Safer	Good
Low	Safer	High	Risky	Good
Low	Safer	High	Danger	Poor

#### 4.13 LOOK-UP TABLE 10: HEALTH FIS

**Table 10**  
**Look-Up Health**

<b>Encouraging Health Care Lifestyles (% Relative Change)</b>	<b>Basic Health Cost and Services</b>	<b>Health</b>
Good	Best	Excellent
Better	Best	Excellent
Best	Better	Excellent
Best	Best	Excellent
Worst	Better	Good
Worst	Best	Good
Good	Good	Good
Good	Better	Good
Better	Good	Good
Better	Better	Good
Best	Good	Good
Worst	Worst	Poor
Worst	Good	Poor
Good	Worst	Poor
Better	Worst	Poor
Best	Worst	Poor

#### 4.14 LOOK-UP TABLE 11: INTERNET ACCESSIBILITY

**Table 11**  
**Look-Up Internet Accessibility**

<b>Access to public Wi-Fi</b>	<b>Access to high-speed Internet (in Mbps)</b>	<b>Internet Accessibility</b>
Poor	Poor	Poor
Moderate	Poor	Poor
Good	Poor	Poor
V-good	Poor	Poor
Excellent	Poor	Poor
Poor	Good	Poor
Moderate	Good	Good
Good	Good	Good
V-good	Good	Excellent
Excellent	Good	Excellent
Poor	Excellent	Good
Moderate	Excellent	Excellent
Good	Excellent	Excellent
V-good	Excellent	Excellent
Excellent	Excellent	Excellent

#### 4.15 LOOK-UP TABLE 12: OTHER SERVICES

**Table 12**  
**Look-Up Other Services**

Access to Public Transport	Quality of Roads	Access to Public Amenities	Access to Commercial Amenities	Flexibility of Delivery Services	Access to Vehicle Sharing Solution	Quantity of Public Transport	Internet Accessibility	Access to Other Services
No	Poor	Low	Low	Poor	Poor	Poor	Low	Poor
No	Poor	Low	Low	Poor	Poor	Poor	High	Poor
No	Poor	Low	Low	Poor	Poor	Good	Low	Poor
No	Poor	Low	Low	Poor	Poor	Good	High	Poor
No	Poor	Low	Low	Poor	Good	Poor	Low	Poor
No	Poor	Low	Low	Poor	Good	Poor	High	Poor
No	Poor	Low	Low	Poor	Good	Good	Low	Poor
No	Poor	Low	Low	Poor	Good	Good	High	Poor
No	Poor	Low	Low	Good	Poor	Poor	Low	Poor
No	Poor	Low	Low	Good	Poor	Poor	High	Poor
No	Poor	Low	Low	Good	Poor	Good	Low	Poor
No	Poor	Low	Low	Good	Poor	Good	High	Poor
No	Poor	Low	Low	Good	Good	Poor	Low	Poor
No	Poor	Low	Low	Good	Good	Poor	High	Poor
No	Poor	Low	Low	Good	Good	Good	Low	Poor
No	Poor	Low	Low	Good	Good	Good	High	Poor
No	Good	Good	Good	Poor	Poor	Poor	High	Poor
No	Good	Good	Good	Poor	Poor	Good	Low	Poor
No	Good	Good	Good	Poor	Poor	Good	High	Good
No	Good	Good	Good	Poor	Good	Poor	Low	Good
No	Good	Good	Good	Poor	Good	Poor	High	Good
No	Good	Good	Good	Poor	Good	Good	Low	Good
No	Good	Good	Good	Poor	Good	Good	High	Good
No	Good	Good	Good	Good	Poor	Poor	Low	Poor
No	Good	Good	Good	Good	Poor	Poor	High	Good
No	Good	Good	Good	Good	Poor	Good	Low	Good
No	Good	Good	Good	Good	Poor	Good	High	Good
No	Good	Good	Good	Good	Good	Poor	Low	Good
No	Good	Good	Good	Good	Good	Poor	High	Good
No	Good	Good	Good	Good	Good	Good	Low	Good
No	Good	Good	Good	Good	Good	Good	High	Good

#### 4.16 LOOK-UP TABLE 13: EDUCATION

**Table 13**  
**Look-Up Education**

<b>Access to Educational Resources</b>	<b>Environmental Education</b>	<b>Digital Literacy</b>	<b>Education</b>
Poor	Poor	Poor	Poor
Poor	Poor	Good	Poor
Poor	Poor	Excellent	Poor
Poor	Good	Poor	Poor
Poor	Good	Good	Good
Poor	Good	Excellent	Good
Poor	Excellent	Poor	Poor
Poor	Excellent	Good	Good
Poor	Excellent	Excellent	Excellent
Good	Poor	Poor	Poor
Good	Poor	Good	Good
Good	Poor	Excellent	Good
Good	Good	Poor	Good
Good	Good	Good	Good
Good	Good	Excellent	Excellent
Good	Excellent	Poor	Good
Good	Excellent	Good	Excellent
Good	Excellent	Excellent	Excellent
Excellent	Poor	Poor	Poor
Excellent	Poor	Good	Poor
Excellent	Poor	Excellent	Good
Excellent	Good	Poor	Good
Excellent	Good	Good	Good
Excellent	Good	Excellent	Excellent
Excellent	Excellent	Poor	Good
Excellent	Excellent	Good	Excellent
Excellent	Excellent	Excellent	Excellent

#### 4.17 LOOK-UP TABLE 14: QUALITY OF LIVING ENVIRONMENT

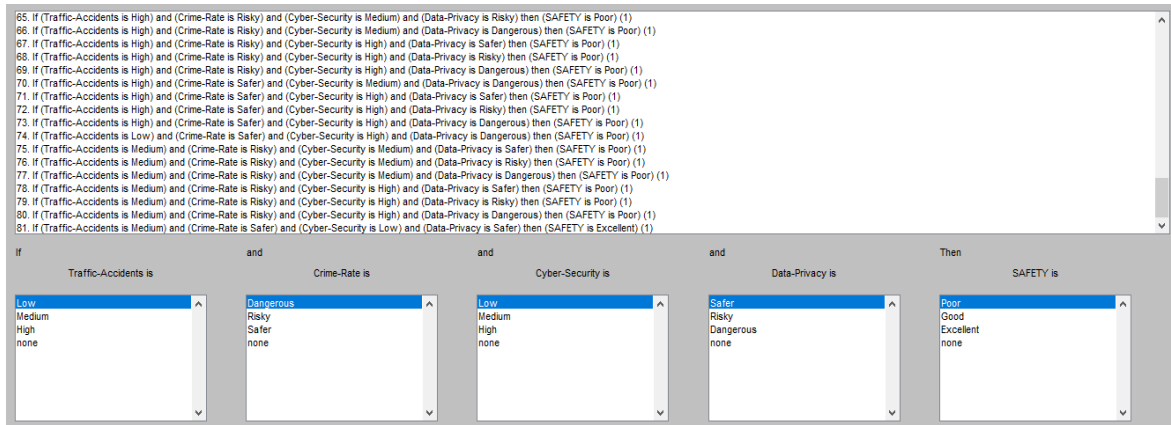
**Table 14**  
**Look-Up Quality of Living Environment**

Quality of Living Environment	Education	Access to other Services	Health	Safety	People
Poor	Poor	No	Yes	Yes	Poor
Poor	Poor	Yes	No	No	Poor
Poor	Poor	Yes	No	Yes	Poor
Poor	Poor	Yes	Yes	No	Poor
Poor	Poor	Yes	Yes	Yes	Good
Poor	Good	No	No	No	Poor
Poor	Good	No	No	Yes	Good
Poor	Good	No	Yes	No	Poor
Poor	Good	No	Yes	Yes	Good
Poor	Good	Yes	No	No	Poor
Poor	Good	Yes	No	Yes	Good
Poor	Good	Yes	Yes	No	Good
Poor	Good	Yes	Yes	Yes	Good
Poor	Excellent	No	No	No	Good
Poor	Excellent	No	No	Yes	Good
Poor	Excellent	No	Yes	No	Good
Poor	Excellent	No	Yes	Yes	Excellent
Excellent	Excellent	No	No	No	Poor
Excellent	Excellent	No	No	Yes	Good
Excellent	Excellent	No	Yes	No	Good
Excellent	Excellent	No	Yes	Yes	Excellent
Excellent	Excellent	Yes	No	No	Good
Excellent	Excellent	Yes	No	Yes	Excellent
Excellent	Excellent	Yes	Yes	No	Excellent
Excellent	Excellent	Yes	Yes	Yes	Excellent

#### 4.18 A RULE-BASED APPROACH

In every FIS, I/O rules are critical. The rules govern how an expert system is presented. Table 7 shows how I/O is done in this project using a look-up table. Figures 7 and 8 depict layer-I and layer-II, I/O rules based on the FIS-PHLS Expert System.

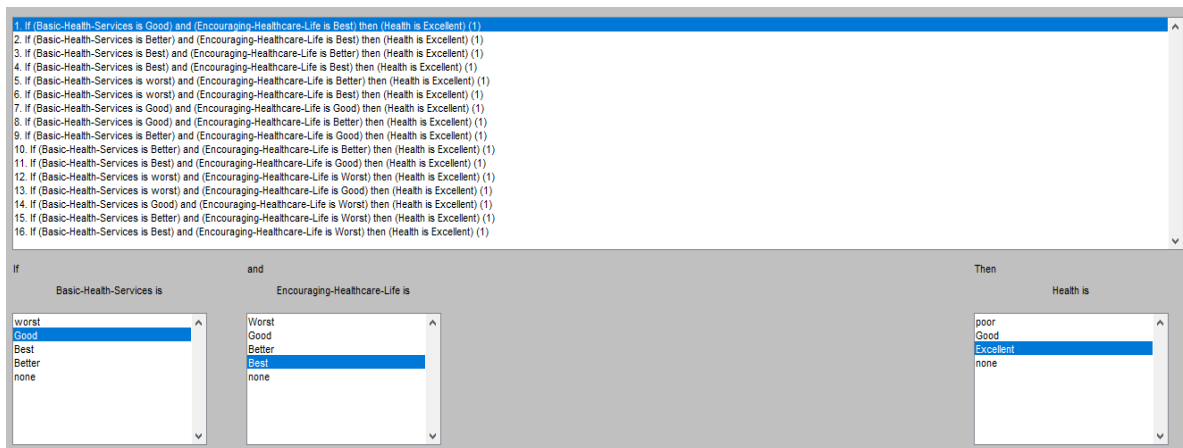
### 4.18.1 Safety FIS



**Figure 14: Look-Up of Human Safety**

Lookup diagram for ranking fig.14 shows the relation of the system on input variables performance traffic accidents, crime rate, cyber security, data privacy, and safety. If the traffic accidents are high and crime rates are safer cyber security is high and data privacy is safer than safety is poor. Whereas, if the traffic accidents are medium and crime rates are safer, cyber security is low and data privacy is safer then safety is Excellent.

### 4.18.2 Health FIS



**Figure 15: Look-Up of Human Health**

Lookup diagram for ranking fig.15 shows the relation of the system on input variables performance basic health services, and encouraging health care life. If the basic health services are better and encouraging health care life is best then health is excellent. Whereas, if the basic health services are worst and encouraging health care life is worst then health is excellent.

### 4.18.3 For Internet Accessibility

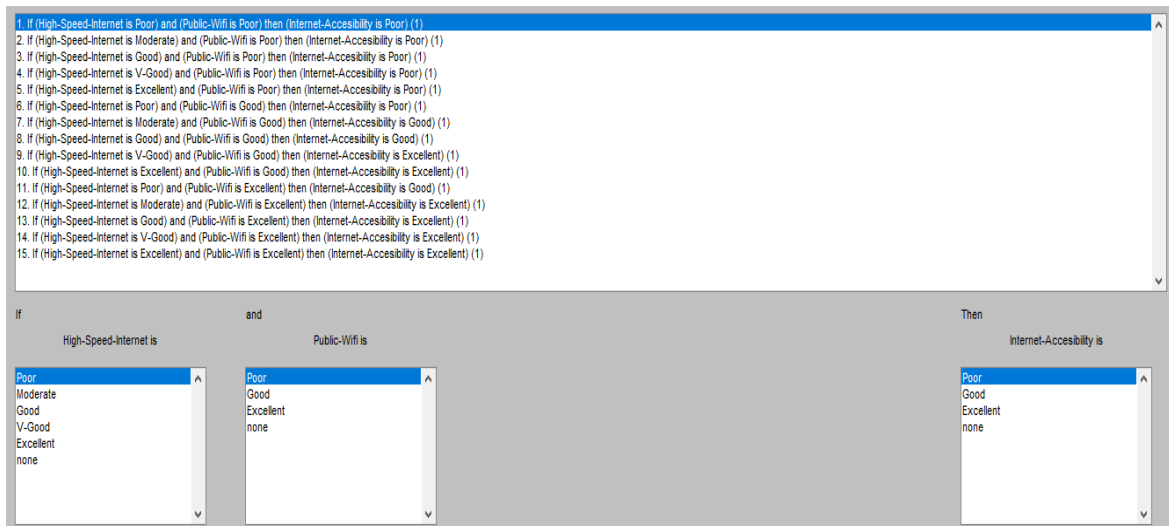


Figure 16: Look-Up of Human Internet Accessibility

Lookup diagram for ranking fig.16 shows the relation of the system on input variables’ performance high-speed-internet services, Public Wi-Fi, and internet accessibility. If high-speed-internet services are excellent and Public Wi-Fi is poor then internet accessibility is poor. Whereas, if high-speed-internet services are excellent and Public Wi-Fi is excellent then internet accessibility is excellent.

### 4.18.4 For Other Services

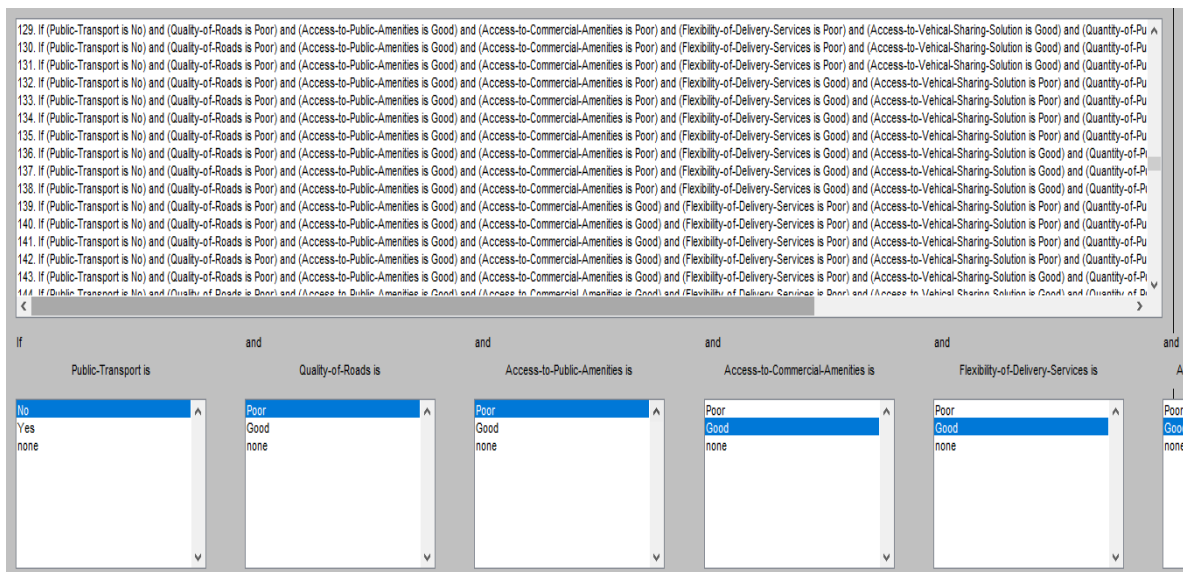
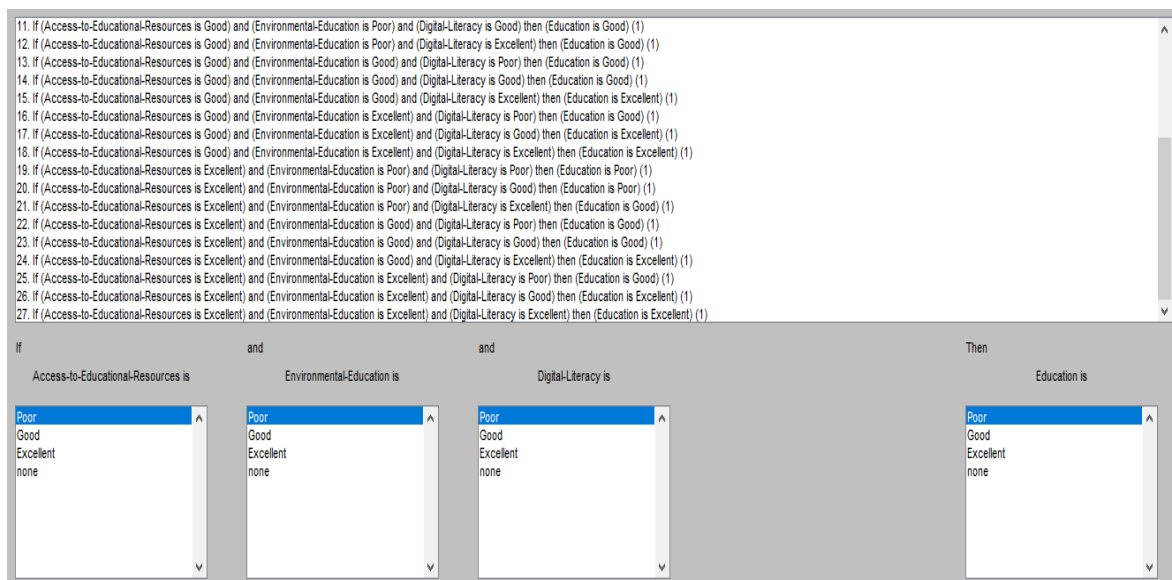


Figure 17: Look-Up of Human Access to Other Services

Lookup diagram for ranking fig.17 shows the relation of the system on input variables' performance Access to public transport, Quality of roads, access to public amenities, Access to commercial amenities, Flexibility of delivery services, Access to vehicle sharing solution, Quantity of public transport, Internet Accessibility and Access to other services. If Access to public transport is No, Quality of roads is good, Access to public amenities is good, Access to commercial amenities is good, Flexibility of delivery services is poor, Access to vehicle sharing solution is poor, Quantity of public transport is good, Internet Accessibility is low then Access to other services is poor.

Whereas, If Access to public transport is No, Quality of roads is good, Access to public amenities is good, Access to commercial amenities is good, Flexibility of delivery services is good, Access to vehicle sharing solution is good, Quantity of public transport is good, Internet Accessibility is high then Access to other services is good.

#### 4.18.5 For Education



**Figure 18: Look-Up of Human Education**

Lookup diagram for ranking fig.18 shows the relation of the system on input variables' performance Access to educational resources, Environmental education, Digital Literacy, and Education. If Access to educational resources is good, and Environmental education is poor, and Digital Literacy is good then Education is good. Whereas, if Access to educational resources is excellent, and Environmental education is good, and Digital Literacy is excellent then Education is excellent.



Lookup diagram for ranking fig.20 shows the relation of the system on input variables' performance Quality of Living Environment, Education, Access to other services, Health, safety, and People. If the Quality of Living Environment is poor, and Education is poor, Access to other services is yes, Health is yes, and safety is yes then People are good. Whereas, if the Quality of Living Environment is excellent, and Education is excellent, Access to other services is no, Health is yes, and safety is yes then People are excellent.

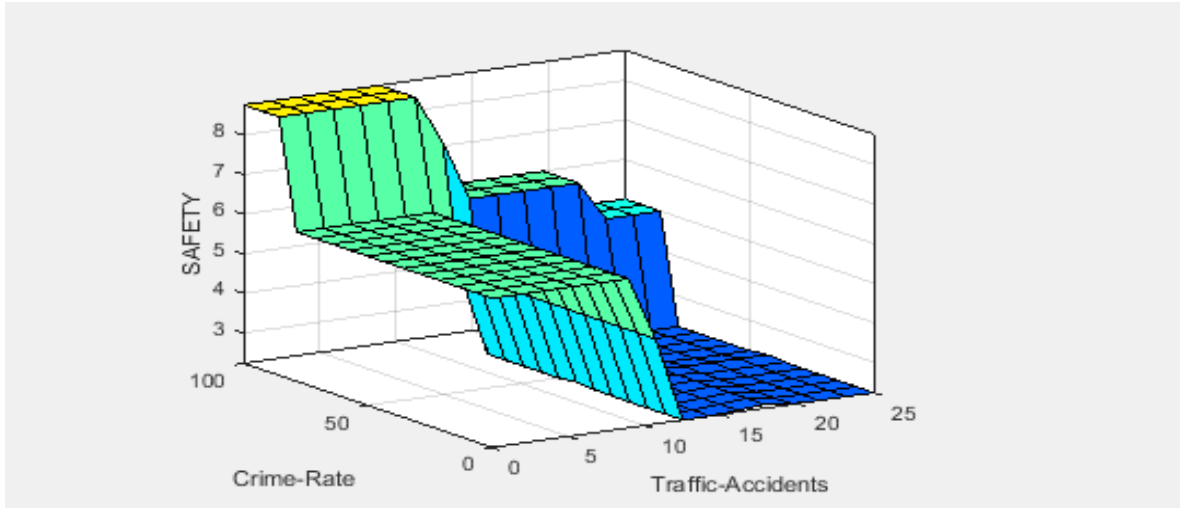
#### **4.19 DEFUZZIFICATION**

One of the most important parts of an expert system is fuzzified. Defuzzifiers come in a variety of shapes and sizes. A coordinate defuzzifier is utilized in this study. The defuzzifier visual depiction of layer I of the FIS-PHLS expert system is shown in Figure 6.

#### **4.20 RESULTS**

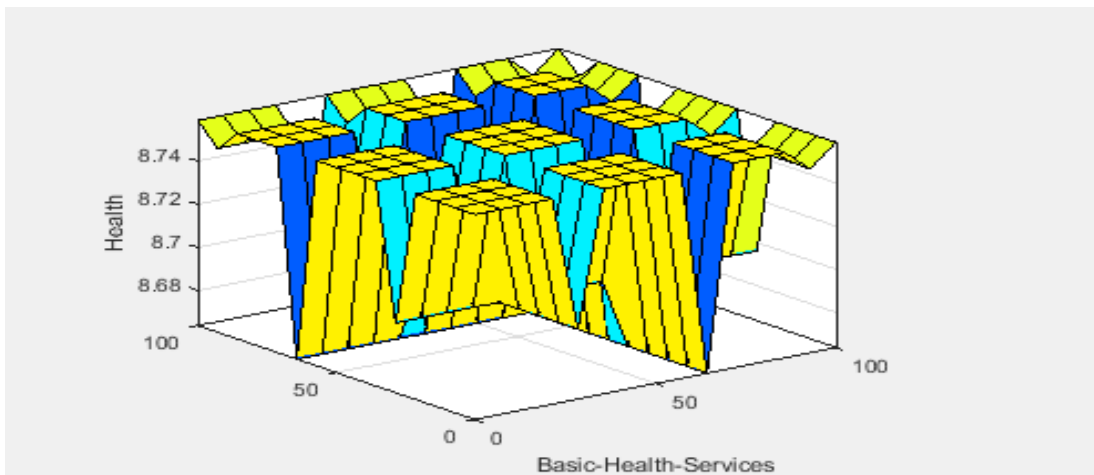
The MATLAB R2017a tool is used to generate simulated results. Modeling, simulations, algorithm development, prototypes, as well as many other disciplines employ MATLAB. MATLAB is a powerful application that may be used for coding, statistical analysis, visualizations, and computations.

For this research, the input-output fuzzy membership functions are thoroughly examined. The generated 3D graphs depict its variability with fire possibility as a function of variations input variables like safety, rate of crime, traffic accidents, as well as basic health services, internet accessibility, public-Wi-Fi, high-speed internet, and road quality, public transportation, and access to educational resources, and housing diversity and people's health and safety are shown in Figure 21 to Figure 27, respectively.



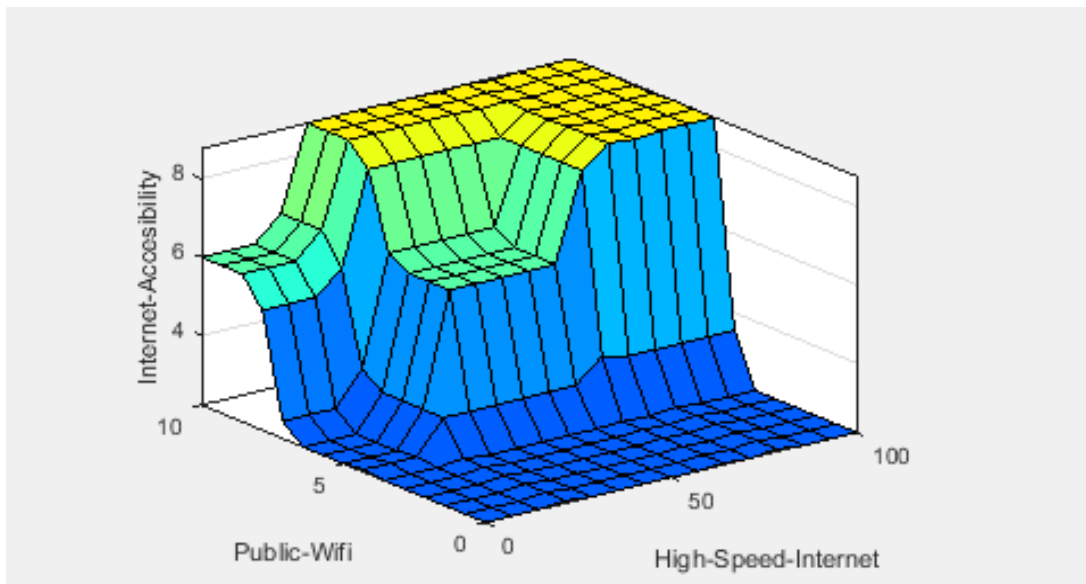
**Figure 21: Surface view of PHLS based on Crime Rate & Traffic Accident**

This fig 21 displayed the presentation of outcome safety against the inputs are crime rate and traffic accidents. For control applications, usual FIS inputs are the crime rate and traffic accidents accordingly in the control surface plot. The FIS output is the control action deduced from the fuzzy system, safety represented in the surface plot. The crime rate and traffic accidents are along the x-axis, whereas, the Safety is taken along the y-axis. The dark blue line represents the traffic accidents ranging from 0 to 25, the crime rate characterizes with white color varies from 0 to 100, and finally, the output Safety also signifies with white color and scales from 1 to 10. The graph depicts that if traffic accidents are low, the crime rate is dangerous, having low cyber security with safer data privacy results a good safety. Whereas, traffic accidents are low, the crime rate is safer, having high cyber security with danger data privacy results in an excellent safety.



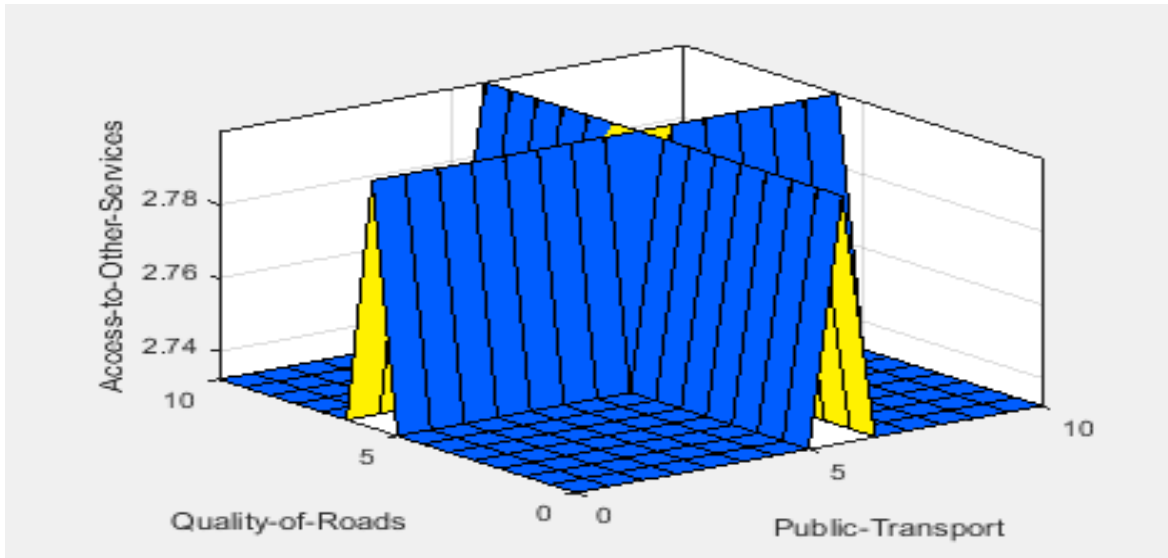
**Figure 22: Surface view of PHLS based on basic Health Services & Health**

This fig 22 displayed the presentation of outcome health against the input basic health services. For control applications, the usual FIS input is basic health services accordingly in the control surface plot. The FIS output is the health deduced from the fuzzy system, represented in the surface plot. The basic health services are along the x-axis whereas, health is denoted along the y-axis. The dark blue line represents the basic health services ranging from 0 to 100, the output health characterizes with white color varies from 0 to 10. The graph depicts that if basic health services are better, encouraging health care life is worst, will result in a good Health. Whereas, basic health services are better, encouraging health care life is best, will results from excellent Health.



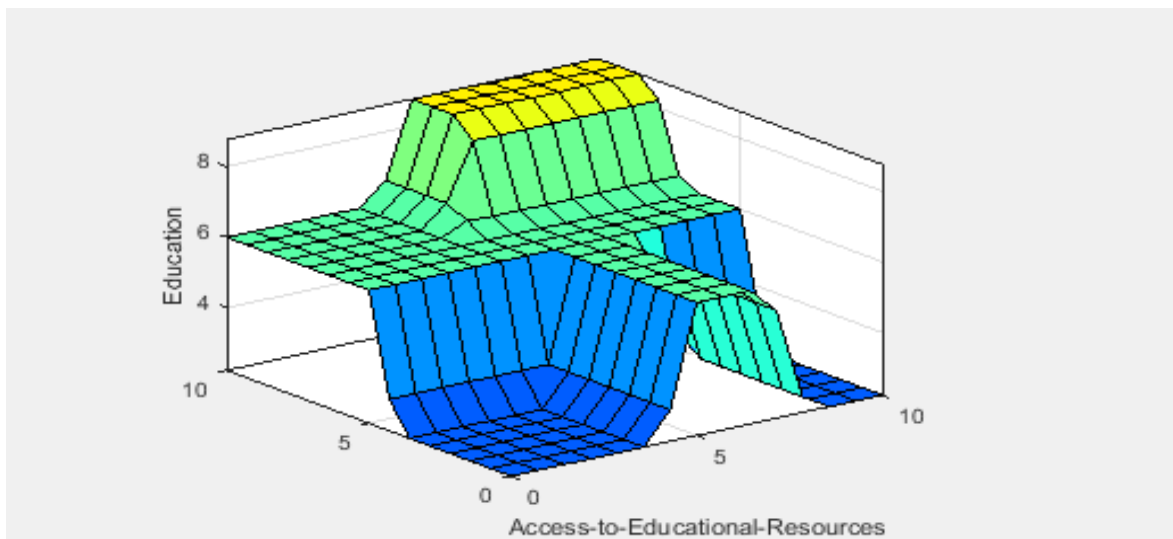
**Figure 23: Surface view of PHLS based on High-Speed Internet & Public Wi-Fi**

This fig 23 displayed the presentation of outcome internet accessibility against the inputs are public-Wi-Fi, and high-speed internet. For control applications, usual FIS inputs are public Wi-Fi, and high-speed internet accordingly in the control surface plot. The FIS output internet accessibility is the control action deduced from the fuzzy system, represented in the surface plot. The Public Wi-Fi and High-speed internet are along the x-axis, whereas, internet accessibility is taken along the y-axis. The dark blue line represents the public-Wi-Fi, ranging from 0 to 10, and high-speed internet characterizes with blue color varies from 0 to 100, and finally, the output internet accessibility also signifies with white color and scales from 0 to 10. The graph depicts that if access to public Wi-Fi is very good, and access to high-speed internet is good, then results in excellent internet accessibility. Whereas, if access to public Wi-Fi is moderate, and access to high-speed internet is excellent, then results in excellent internet accessibility.



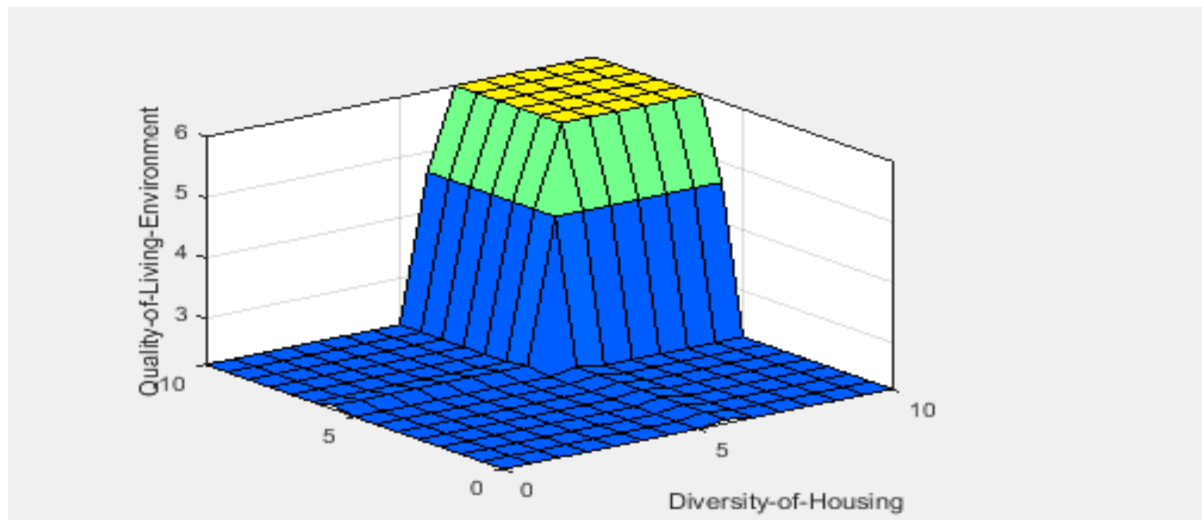
**Figure 24: Surface view of PHLS based on Road Quality, and Public Transportation**

This fig 24 displayed the presentation of outcome Access to Other Services against the inputs are road quality and public transportation. For control applications, usual FIS inputs are road quality, and public transportation accordingly in the control surface plot. The FIS output Access to Other Services is the control action deduced from the fuzzy system, represented in the surface plot. Since the road quality and public transportation are represented along the x-axis both are ranging from 0 to 10 whereas the output Access to Other Services is denoted along the y-axis signifies from 0 to 3. The dark blue line represents good road quality, and also good public transportation will result in good Access to Other Services.



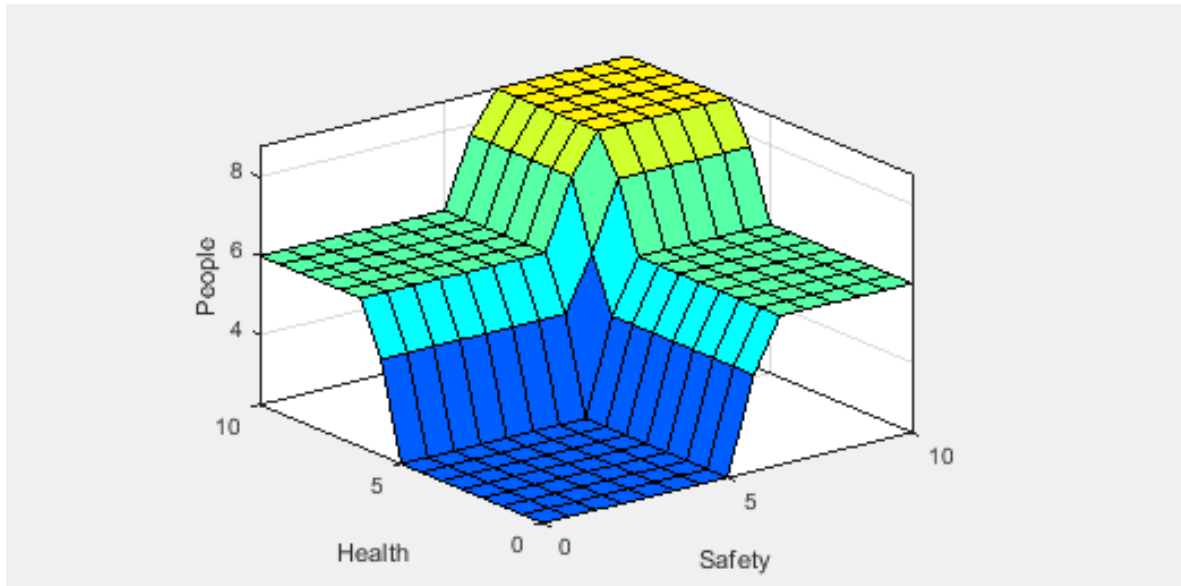
**Figure 25: Surface view of PHLS based on Education & ATER**

This fig 25 displayed the presentation of outcome education against the input Access to Educational Resources. For control applications, the usual FIS input Access to Educational Resources accordingly in the control surface plot. The FIS output Education is the control action deduced from the fuzzy system, represented in the surface plot. Since the Access to Educational Resources, are represented along the x-axis both are ranging from 0 to 10 whereas the output Access to Education is denoted along the y-axis signifies from 0 to 10. The dark blue line represents good Access to Educational Resources, and the green lines result in excellent Education.



**Figure 26: Surface view of PHLS based on Diversity of Housing & QOLE**

This fig 26 displayed the presentation of outcome Quality of Living Environment against the input housing diversity. For control applications, the usual FIS input housing diversity accordingly in the control surface plot. The FIS output Quality of Living Environment is the control action deduced from the fuzzy system, represented in the surface plot. Since the housing diversity, is represented along the x-axis and ranging from 0 to 10 whereas the output Quality of Living Environment is denoted along the y-axis signifies from 0 to 6. The dark blue line represents the good housing diversity, and green lines result in excellent Quality of Living Environment.



**Figure 27: Surface view of PHLS based on Health & Safety**

This fig 27 displayed the presentation of outcome People against the input health and safety. For control applications, usual FIS inputs are health and safety accordingly in the control surface plot. The FIS output People is the control action deduced from the fuzzy system, represented in the surface plot. Since both health and safety are represented along the x-axis and both ranging from 0 to 10 whereas the output people is denoted along the y-axis signifies from 0 to 10. The dark blue line represents good health & safety, and the green lines result in excellent Quality of Living standards for People.

#### **4.21 CONCLUSION**

This chapter provides the details on the validation process of PHLS which splits into the simulation. The simulation is spread over four different cases to analyze the proposed model PHLS. Therefore, the main target is to provide such an environment to the members in which they can perform to the optimum level. The performing phenomenon and rankings are the center of validated instances (which again is a representation of performance). The scenario was tested using fuzzy logic; the findings are substantial and demonstrate a favorable predisposition in favor of the problem statement and hypothesis.

## **CHAPTER 5**

### **CONCLUSION**

Academics and professional researchers have been interested in the future of cities in recent years. They argue that the advancement of artificial intelligence (AI) will have an impact on both design and infrastructure, giving rise to the smart city idea. The spectacular developments of Artificial Intelligence (AI) which are daily announced, are transforming individuals into complex species. AI has established the norms in all walks of human life-embracing healthcare, education, automotive, defense, security, home appliances, retail, and logistics. The smart city is also a futuristic leader in the fight against the adversities caused by the increasing population and rapid development. Smart city social and economic progress has been taken from modern-day cities. Smart cities construct cities more resourceful, maintainable, and viable. In plenty of other aspects, a smart city can monitor and integrate all essential infrastructure features including roads, tunnels, airports, waterways, trains, communications, and maintenance, while also considering safety issues. It can contribute to the optimization of resources. The literature research performed in this work aids in the comprehension of the idea. In a broad sense, a smart city concept can be defined as a metropolis that handles human capital development thru communication and information technologies even while ensuring that resources are used effectively as well as possessing the standardized governance model and infrastructural facilities that can encourage the economy to improve the standard of living of its residents. Therefore, it is critical to identify the indications or dimensions that may be utilized as a reference or standard for each case's smart city paradigm.

This research assessed various aspects and dimensions of the city of the future. To acquire enhanced insight into the idea of smart cities, a framework has been developed to overcome the lacuna in the conception of smart cities and their implementation. Deterministic methodologies generally do not generate accurate results, whereas heuristic methodologies like Fuzzy Inference Systems (FIS), produce better results. This study promotes a FIS that is ready to evaluate "PEOPLE" as the prime Prediction of Human Life Standard (PHLS). We also explore smart cities and propose an expert city model based on FIS. The simulation is spread over four different cases to analyze the proposed model PHLS. Therefore, the main target is to provide such an environment to the members in which they can perform to the optimum level. The performing phenomenon and rankings are the center of validated instances (which again is a representation of performance). The scenario was tested using fuzzy logic; the findings are substantial and demonstrate a favorable predisposition in favor of the problem statement and hypothesis. This research is important to our model of the latest improvements in life.

## **CHAPTER 6**

### **LIMITATION**

One of its study's flaws was that the rules were predefined, and the decision-making procedure has relied on a fuzzy inference system. If such guidelines are incorrect, the outcomes may be unacceptably awful. One of the most difficult aspects of building fuzzy systems is deciding on a membership function and fundamental rules. But on the other side, implementing a fuzzy approach on ordinary hardware necessitates numerous and time-consuming experimentation, and the effectiveness of fuzzy systems in pattern recognition is lower than that of a neural net in artificial intelligence, which is discussed less in Data Science.

Furthermore, the use of a fuzzy inference system may provide a barrier to the testing of systems' dependability and security. Membership functions (MFs) must be fine-tuned. Large or complicated issues may not be effectively served by fuzzy systems. It deals with ambiguity and imprecision, and not with uncertainties.

## **CHAPTER 7**

### **FUTURE WORK**

Since we have proposed the FIS-PHLS model and elaborated on different modules from a connectivity and processing perspective. As per our research objectives, this model is designed to provide an autonomous self-evolving mechanism as explained in the learning module and memories. This research presents an investigation report on Fuzzy Inference System (FIS) featuring the application for computer sciences /engineering projects. In light of the undertaking center, the FIS model is without a doubt accommodating to recognize a task execution assessment. The thinking cycles of a design of Fuzzy principles, the information base of the framework is great. By applying this, with thinking it is commonsense to have a quantitative evaluation of the advancement of ventures also, challenges by representation. Moreover, it is conceivable to recognize the positives and negatives of the arranging and execution measures for deciding where improvement is required. Fuzzy ideas are decided in this research obviously and this FIS will be accommodating for appropriate arrangements.

Other approaches, like computational intelligence (CI), including such neural nets and neuro-fuzzy networks, could be used to increase the effectiveness of the suggested system in future research.

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