



Palestine Polytechnic University
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Studying and evaluating the current and future MASTER PLANNING for the city of Tulkarm using geographic information systems

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جامعة بوليتكنك فلسطين
كلية الهندسة
دائرة الهندسة المدنية

دراسة وتقييم المخطط الهيكلي لمدينة طولكرم الحالي والمستقبلي باستخدام نظم المعلومات الجغرافية

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بناء على توجيهات الأستاذ المشرف وبموافقة جميع أعضاء اللجنة الممتحنة تم تقديم هذا المشروع الى دائرة الهندسة المدنية

في كلية الهندسة للوفاء الجزئي بمتطلبات الحصول على درجة البكالوريوس.

توقيع رئيس الدائرة

توقيع مشرف المشروع

.....

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Abstract

Studying and evaluating the current and future MASTER PLANNING for the city of Tulkarm using geographic information systems

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Adham Srouji

Adnan Mehdawi

Supervisor:

Dr. Ghadi Younis -Zakarneh

Master planning is usually updated with the progress of time because of the developments in the areas that are expressed and covered by this plan and the problems that occur in them. For this to happen, the problems in the current Master plan must be identified and analyzed. In our project, we decided to rely on GIS and its tools. Our project will be through the following steps, first collecting data, and this will be done by going to the Tulkarm municipality and the local government. Second, determine the work area using GIS tools. Then, take control points from the work area and link them to the coordinates using GIS. Then the problems will be identified and analyzed after comparing reality with what is in the Master plan and some techniques in GIS.

We will work on drawing up plans that will help the architect and the municipality in the Master plan that will be produced.

الملخص

دراسة وتقييم المخطط الهيكلي لمدينة طولكرم الحالي والمستقبلي باستخدام نظم المعلومات الجغرافية

فريق العمل:

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المشرف

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عادة ما يتم تحديث التخطيط العمراني مع تقدم الوقت بسبب التطورات في المناطق التي يتم التعبير عنها والتي تغطيها هذه الخطة والمشاكل التي تحدث فيها. ولكي يحدث هذا، يجب تحديد وتحليل المشاكل في المخطط العمراني الحالي.

في مشروعنا، قررنا الاعتماد على نظم المعلومات الجغرافية وأدواتها. سيكون مشروعنا من خلال الخطوات التالية، أولاً جمع البيانات، وسيتم ذلك بالذهاب إلى بلدية طولكرم والحكومة المحلية.

ثانياً، تحديد منطقة العمل باستخدام أدوات نظم المعلومات الجغرافية. ثم أخذ نقاط التحكم من منطقة العمل وربطها بالإحداثيات باستخدام نظم المعلومات الجغرافية. ثم يتم تحديد المشكلات وتحليلها بعد مقارنة الواقع بما هو موجود في المخطط الحضري وبعض التقنيات في نظم المعلومات الجغرافية.

سنعمل على وضع الخطط التي ستساعد المهندس المعماري والبلدية في المخطط العمراني الذي سيتم إنتاجه.

DEDICATION

To our true source of hope ...

to the people who keep us going through struggles and hardships ...

your encouragement and continuous support are only matched by your big hearts and pure
souls

To our families ...

To our dearest friends ...

To everyone who carries love in his heart for us ...

Thank you from the depths of our hearts.

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Our thanks are extended to the local government ministry represented by Sahar Sa'ade, Suha Bdeir, and to Abd Alkarim Awad, and finally to the Tulkarm municipality for the support.

Project Team

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Chapter One: Introduction

1-1 Introduction.

1-2 Aims & Objectives.

1-3 Problem Statement.

1-4 Literature Review.

1-5 Methodology.

1-6 Project Scope.

1-7 Study area

1-8 Project Timeline

1-9 Programs Used in The Project.

1-1 Introduction

The Master plan is crucial to meet the country's general needs, especially for Tulkarm city. Because Palestine is a growing community that tends to evolve in stages, Tulkarm city is now in the development process in all aspects after the municipal elections and the victory of a new municipal council which happened a few months ago, this development process includes the urban aspect, our community must begin right now and is increasingly making severe changes in all living areas. The phrase "Master plan" refers to long-term planning papers that offer a conceptual roadmap for potential expansion and development. It involves drawing connections between structures, social contexts, and the environments in which they are located. and seeks to ensure sustainable development while achieving development in a balanced and controlled manner to increase the cities' resilience.

The following functions can be played by master planning:[1]

- Establish a timeline for implementation and phasing and determine action priority areas.
- Serve as a foundation for revitalization and draw capital from the private sector.
- Specify what public, semi-private, private, and public amenities mean.
- Identify the land uses and how they are physically related.

Master planners can use GIS to create the towns and cities where we live, plans the future, and make modifications when the locals their residential area to others. GIS is a significant and practical instrument that has grown to be extremely valuable for many when it comes to efficient master planning.[2]

Site selection, land suitability analysis, land use and transport modelling, the identification of planning action areas, and impact assessments are just a few of the significant Master planning tasks that can benefit from the use of GIS.[2]

Master planners can do these tasks with the aid of GIS features including interpolation, buffering, map overlay, and connectivity measurement.[2]

Aerial photography has been used in regional and municipal planning. For a long time, municipal planning departments' standard equipment and the wall formed featured a mosaic map

that was typically annotated. Additionally, photogrammetrists' services have been used in some capacity.

1-2 Aims and Objectives

The main aim of this research is to produce maps and statistics that help in developing the current and future Master planning of Tulkarm City digitally, using GIS. based on these produced maps and statistics, the master management plan of the proposed district will be updated and completed. Furthermore, significant enhancements and benefits have been identified: a relevant increase in accuracy, an increase in decisions support and time, workflow optimization and zoning improvement. The specific following objectives have been created to achieve the main research aim:

1. To create new experiences for trainees in the field of urban planning with the use of GIS.
2. To re-distribute services commensurate with the population density and develop the plans to master plans for urban areas using Participative GIS.
3. To create a digital data archive to save time and effort for the citizens and staff in the target area, and to transmit this mind model for use in the other areas in the city.
4. Community participation in the decision-making process, because the participation is voluntary work which could reflect a general tendency in rational behaviours, and include the dimensions of an enlightened popular role in the world of planning, which should be armed with a deep understanding of the rights and duties of citizens and decision-makers.
5. The project aims to preserve the environment, by identifying the percentage of cultivated green areas which could be used.
6. To integrate transportation with communications, in order to improve the economic, social and cultural rights of local communities.
7. Sustainable development, which means developing land, cities and communities, as well as businesses, by providing what meets the needs of the present without compromising the ability of future generations to meet their needs and the preservation of the environment.

1-3 Problem Statement

In this study, Tulkarm city has suffered from circumstances that made the planning process difficult and complicated with a number of obstacles and challenges. The most important are:

First – Inherited Challenges and Obstacles

- Regulations and laws

This has imposed a reality that needs to be dealt with; the Ottoman land law has imposed a special reality regarding land ownership and its classifications as owned, Waqf, government-owned, abandoned, and arid. Added to that they are the applicable construction laws derived from the British mandate, as well as Israeli military rules and regulations and their implications on land reality.

- Land Settlement.

The land settlement topic gains particular importance in the planning and organizing domain. Its absence weakens the ability to control the land due to the lack of necessary information regarding land ownership, and so, the incapability in producing essential maps to produce the master plans. Lack of land settlement% of the city may be a direct factor helping in confiscating lands, building Israeli settlements and constructing bypass roads to connect those settlements together on one hand, creating disputes on ownerships and hindering the planning process on the other.

- The previous regional Master Plans.

A number of local master plans were prepared in 1979 by Israeli planners. In 1981, 183 plans, which do not meet any Palestinian needs, were endorsed and so they were rejected.

Second – Challenges in the Palestinian Authority period.

- Geographical challenges and obstacles

These challenges and obstacles are related to what the Israeli occupation has imposed and is still on Tulkarem city including the construction and expansion of the settlements, the bypass road networks, as well as the separation wall on the western borders of the city.

- Institutional and organizational challenges and obstacles

Although the Palestinian planning units and institutions have put much effort into preparing regional master plans to regulate the urban development and land uses for various localities, however, the planning and organizing process in Palestine is still suffering from many problems and facing various obstacles. These could be summarized as follows:

1. Absence or failure to adopt the planning policies on the national, regional and local levels.
2. Lack of clarity of responsibilities and overlapping of powers between the concerned parties in planning.
3. Weakness or absence of coordination and cooperation with the concerned institutions.
4. Absence or lack of appropriate regulations, laws and legislations that govern the process of preparing, implementing and monitoring the plans.
5. Shortage and weakness in the qualified technical human resources within the urban planning domain.
6. The plans do not meet the needs and they conflict, in most cases, with private interests.
7. The absence of land settlement, survey and ownership.
8. Poor or even absence of community participation in the preparation and implementation of the plans.
9. Shortage in funding to prepare and implement the plans.
10. Weakness and scarcity of necessary information, as well as lack of maps and recent aerial images.

1-4 Literature review

The Irbid Master Plan is an example of how land-use changes affect the creation of city spatial models in Jordan (1970–2017). This study examined Irbid city maps from various points in time to explain the planning stages from 1970 to 2017 in the city. It also looked into the temporal and spatial characteristics of Master growth. The study concludes with a spatial model of the city that includes structural designs and useful suggestions for Irbid Master development to provide a better understanding of the city's expansion.

expansion of the Master plan in the west of Dura city located village of Al-Burj. The researchers selected this village and the nearby villages as the search area and recreated a Master plan for them. The development of the old Master plan for the village and its subsequent modification are among the numerous issues that the new Master plan is attempting to address.

Modernization and expansion of the structural plan of the city of Tulkarm, this study is made by the aim of introducing a new approach of making master plans for the cities, this study seeks to show how planner can make urban policies which guide a community towards specific intentions and purposes, the main outputs of this study are: new master plan for the city of Tulkarem, urban system dynamic model to assess the quality of life in the city over time, and a set of acts and strategies aim to enhance the quality of life and attractiveness in the city.

In this case study, the current Master plans will be examined, and the GIS software will be used to assess and analyze earlier Master plans digitally and using maps, as well as to contribute to the development of new Master plans through maps and statistics. compared to earlier research. It was necessary to conduct a case study on what to do to lay the foundation for the new Master plan that will solve everything because the civilian lack of commitment to the previous Master plan led to an infringement on the common good and streets.

From the previous state of art, a limited number of studies were related to Palestine, and this research could be used from other local studies.

1-5 Methodology

The work of this project depends on a strategy followed by the following steps:

- **Step 1:** Identify the subject of the research in agreement with the supervisor and was (Geospatial for Urban Planning) and inquire about the study from the competent authorities such as the local government.
- **Step 2:** Dealing with case studies by analysis, characterization, and textextractingract the results to be used in our project.
- **Step 3:** Identify the work area of Tulkarem city and then pay a reconnaissance visit to the site and take a full idea of the nature of the project and the problems related to it and the important details of design and implementation to get the best and most accurate results.

- **Step 4:** Coordination with Tulkarm municipality about the area and subject of the study to help us to carry out this project, and this study was agreed to its importance, and the geoprocessing works will be done for it and then presented to the supervisor for approval and approval of the department on this case study. An official book has been issued from the department to obtain an orthophoto of the study area, in addition to the necessary information.
- **Step 5:** Obtain the aerial orthophoto of the Tulkarm region from the local government.
- **Step 6:** Going to the field and taking control points distributed throughout the town by the GNSS tool.
- **Step 7:** After the cooperation of Tulkarm Municipality, the current master plan for the city was obtained from the local government.
- **Step 8:** Start searching the library, website, and the journal's publishers for references and sources that can be used in this project.
- **Step 9:** Start writing the project with due process and the conditions to be provided in the introduction, review the supervisor, and take his advice and opinion.
- **Step 10:** Overlay the current master plans into the corrected orthophoto to ensure their legal validity.
- **Step 11:** Identifying the problems and conflicts in the study area and their size.
- **Step 12:** Assisting the urban planning engineer in preparing the future structural plan for the city, whether in planning or in statistics and maps. After preparation, the legal validity will be checked and compatibility with the objectives of the project with all necessary adjustments to them and complete any shortage in them if there is.

1-6 Project Scope

This study is composed of five chapters:

1. Chapter one Introduction: Include an introduction, problem statement, aims, and objectives.
2. Chapter two Urban planning: describes the master plans.
3. Chapter three GIS: describes the GIS analysis.
4. Chapter four Data Collection: focused on Data correction.
5. Chapter five: Analyzing & Results
6. Chapter six: Conclusions & Recommendations.

1-7 Study Area

Tulkarem or Tulkarm is a Palestinian city in the Tulkarm Governorate in the extreme northwestern of the West Bank. According to the Palestinian Central Bureau of Statistics, Tulkarem city and the adjacent refugee camp had a population of approximately (80700 inhabitants) at mid-year 2022. Its land area consists of 13,793 dunams. It is bordered to the northeast by the city of Jenin, to the south by the city of Qalqilya, to the east by the city of Nablus, and to the west by the occupied city of Um Khaled, which is today called Netanya. To the west, the Mediterranean Sea is 15 kilometres away.

Governorate	Tulkarm
Government	Tulkarm City
Altitude	162 m
Coordinates	32° 18' 41.50"N 35° 01' 37.34"E
Population	69937 (2022) [3]
Jurisdiction	13.793 dunams (13.793 Kilometre sq.)
(Refugee camps) in the city	Tulkarem Camp and Nur Shams Camp (10763 & 6961 inhabitants)
Website	www.mtulkarm.com

Table 1-1: General information about the city

This study area is located on the western side of the city and includes a small part of the city and a large part of the suburb of Irtah with total area 2112.3273 dunams. This Area suffered from many problems like the streets in the current master plan are intertwined with the lands and houses that already exist, and there has been a change in the classification of land uses, such as A, B, and C. There are also land settlements by the Israeli occupation. There are some places in this area that have not been included in the current master plan.

Study Area



Legend
Study Area

Scale 1:9000

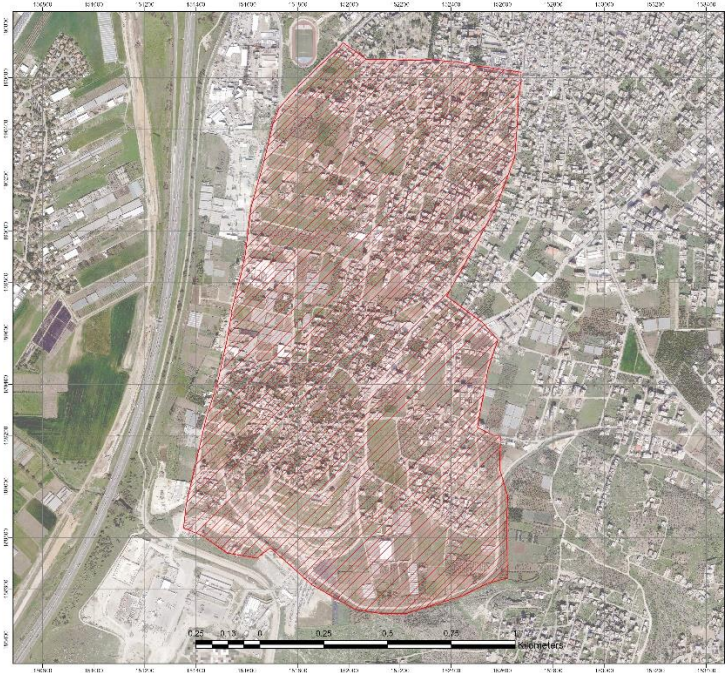


Figure 1-1: Study Area

1-8 Project Timeline

Step \ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Project Selection and information																																
Site detection and reconnaissance																																
Fieldwork																																
office work																																
Preparing and studying the plan																																
Preparing the initial project report																																
Preparing the final project report																																
reviewing and printing initial project																																
reviewing and printing final project																																

Table 1-2: Project Timeline

1-9 Programs that have been used in this study

- 1- ArcGIS Pro 3.0
- 2- AutoCAD.
- 3- Geomolog.

Chapter Two: URBAN PLANNING

2-1 Introduction

2-2 Definition

2-3 Uses

2-4 Planning types

2-5 Planning components: (Requirements)

2-6 Mccloughlin's schematic series: (Urban Planning Procedure)

2-7 Urban planning pioneers: (examples)

2-1 Introduction

The art and science of coordinating land use, building layout, and transportation systems to maximize economy, and convenience are known as urban planning.

- ❖ The condition of the urban environment and how it is managed and used by its inhabitants are fundamental to human health and well-being. Many of the problems in cities today relate to poor residential and other environments, poverty, inequity, pollution, unemployment, lack of access to jobs, goods and services, and lack of community cohesion.
- ❖ An attempt to articulate the principles that should guide us in developing a civilized physical environment for human life, with the primary goal of... anticipating and guiding change.
- ❖ The art of directing and shaping a town's physical development by constructing structures and environments to meet a variety of needs, including social, cultural, economic, and recreational ones. This ensures that both wealthy and poor people have safe, comfortable places to live, work, play, and relax.

It's also a technique for helping a community define its issues and fundamental principles, create objectives and alternative strategies for achieving those objectives, and prevent unintended effects of change.

Frameworks for coping with change are produced by this planning approach. Some of these concepts are action-oriented, such as the goal of developing into a significant distribution hub or encouraging investment in the city centre. Some are controlled, reflecting the community's desire to encourage positive development while preventing negative development.

Urban planning was not always seen in this light. For example, it has been variously regarded as an exercise in civic design, a style of corporate management, and a form of systems analysis.

Urban planning is relatively variable with time, and this is what generates the need to develop it every period of time, and the reason for this is due to the change in the need to use the land according to the opinion of designers, developers and inhabitants.

For example, the increase in population and occupation have a significant impact on the need for urban planning development for the target area.

2-2 Definition

A city's urban planning concept is a set of eternally valid principles, phenomena, and aspects of spatial, functional, and operational arrangement in urban and landscape settings. It is usually based on the territory's potential, a city's function in the population system, and projections of its future size and character. In the context of population growth, the urban planning idea is a set of established principles and norms that ensure a balanced development of the settlement structure, settlements, and landscape. One of the duties of urban planning is to determine urban planning principles.

2-3 Uses

The following summary of usage for urban planning:[4]

1. Regulating and coordinating land usage to ensure that there are no conflicts that have a detrimental impact.
2. Developing Road networks to connect quickly and easily to an economic network.
3. Developing new suburban and urban areas.
4. Reorganizing and upgrading urban communities that lack development.
5. Improving the environment, particularly the urban environment.

2-3-1 Justifications for urban planning

1. Environmental planning can be used to conserve and improve the environment in ways that make it suited for stability.
2. By using economic and urban planning, generating employment opportunities and suitable citizens.
3. Protect natural resources from careless exploitation.

4. The functional or moving part of planning is the best use of the civilian space in a way that supports human movement and makes it simple for them to access the commodities and necessities for the advancement of their lives.

2-3-2 The planning process

1. Choose the target area.
2. The probability of completing the aim given the capabilities and resources at hand.
3. The planning should be flexible.
4. A time frame should be determined.
5. To ponder continuously and comprehensively.
6. Lawmakers should back the plan in order for it to be implemented.
7. They should gain something from their financial arrangements.

2-3-2 The planning elements

1. Environment: This component serves as the foundation for planned development.
2. Technology: This one results in planning.
3. Society: Humans live in communities.
4. Human: He is both the recipient and the planner.

2-4 Plannings Types

Basic planning types:

1. Economic planning.
2. Social planning.
3. Urban planning.

4. Environmental planning.

The different types of planning vary based on the setting, industry, and intended objectives, hence there are various more types of planning:

❖ Planning by inclusivity, including:

1. Comprehensive planning: strives to promote comprehensive and sustainable development in a nation by addressing all economic, social, and political spheres.
2. Partial planning: It addresses just one area of the economy, such as the development of the industrial sector.
 - In this study, the planning followed comprehensive planning.

❖ Planning by time, and be:

1. Short-term planning: The objectives of the implementation plan are distinct, and specific, and have a time frame of no more than one to two years.
2. Planning for the medium term: His plan, which has a duration of three to five years, follows a pattern common to many Arab nations.
3. Long-term planning: The plan's timeframe, which aims to accomplish long-term development to achieve development in a variety of fields, ranges from 10 to 20 years.
 - In this study, the planning followed the long-term planning.

❖ Planning by location, including:

1. National Planning: Planning covers all regions and territories within the borders of the State.
2. Regional Planning: Focuses on the development of one or several regions of the State, to find a balance in development between different regions.
3. Local Planning: It is at the level of the administrative unit, such as a particular city or village.
 - In this study, the planning followed local planning, particularly for the city of Tulkarm.

2-5 Planning Components (Requirements)

A number of fundamental components are necessary for effective planning, the most crucial of which are:[4]

1. Specialized knowledge and experience in all planning sections
2. Technical and administrative resources.
3. With the advent of GIS and the availability of data, statistics, and maps, planning has benefited from useful knowledge regarding location, activities, and a variety of human and environmental phenomena.

2-6 Mcloughlin's schematic series: Procedure

1. The decision-making process is drawn out and involves the coordination of administrative procedures with the technological and technical resources available to the institutions carrying out the plan.
2. Clearly state and clarify goals, which takes some time.
3. Choose the best strategy with the aid of different models to make it adaptable and consistent with changes.
4. The suitable plan and evaluation phase are chosen in accordance with societal effects and cost projections.
5. The strategy will be put into action during this phase, and it may be necessary to consider other models in order to select the best ones.
6. This phase must be followed by the review and evaluation phase in order to monitor how the plan is performing.[5]

2-7 Urban Planning Pioneers: (Examples)

- ❖ Jaime Lerner – An architect and urban planner, founder of the Instituto Jaime Lerner and chairman of Jaime Lerner Arquette's Associators. A three-time mayor of Curitiba,

Brazil, during a period of revitalization that made the city renowned for urban planning, public transportation, environmental social programs, and urban projects.[6]

- ❖ Frederick Law Olmsted – (April 26, 1822 – August 28, 1903) A landscape architect, journalist, social critic, and public administrator. Olmsted is considered the “father” of American landscape architecture, and is responsible for many plans and designs of open spaces around the country, perhaps most famously exemplified by Central Park in Manhattan.[6]
- ❖ Jan Gehl – An architect and urban designer famous for refocusing design and planning on the human scale. Author of *Life Between Buildings*; *Public Spaces, Public Life*; and *Cities for People*, among other books.[6]
- ❖ In 332 BC the young 25-year-old Alexander founded the city. His chief architect, Dinocrates, was appointed to spearhead this project which was intended to see Alexandria replace Naucratis as a Hellenistic center in Egypt, and to be the link between Greece and the rich Nile Valley.[7]



Figure 2-1: Alexandria [8]

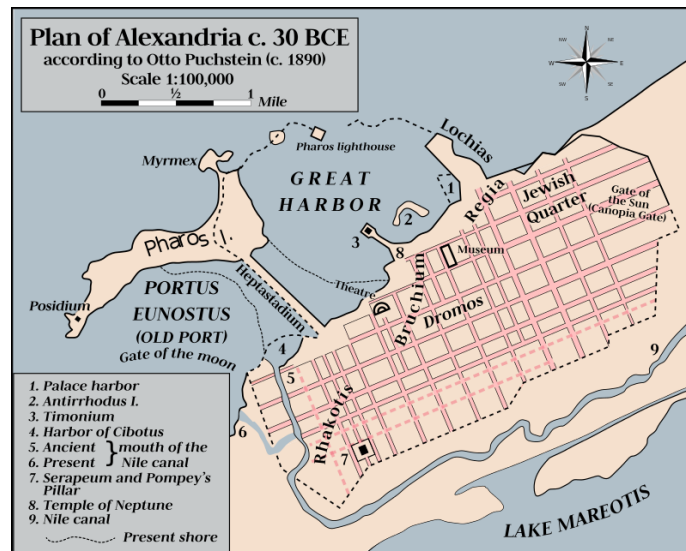


Figure 2-2: Alexandria map [7]

❖ Pierre Charles L'Enfant

- ✓ A French planner who planned Washington, the best example of planning a network of major roads above the Gedds site, planned two main sites, the Capitol – Congress and the White House, connecting them to a large garden street, and then planning a network of wide radiation streets that first appeared in America, with a network of square streets, resulting in the creation of plots of land in some sites of an abnormal shape.[6]

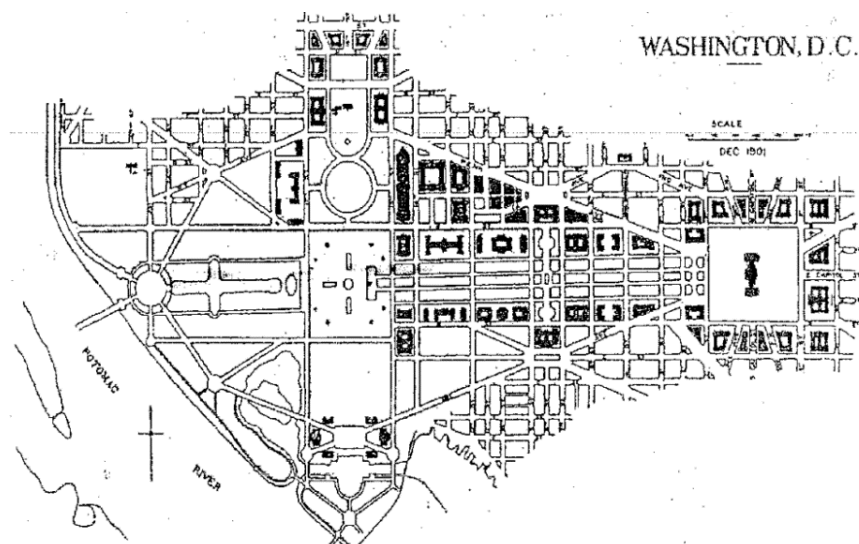


Figure 2-3: Washington D.C roads network

- ✓ The National Mall was the central point of McMillan's plan in 1901 and was the main open area where the principal could see the National Mall longitudinally.

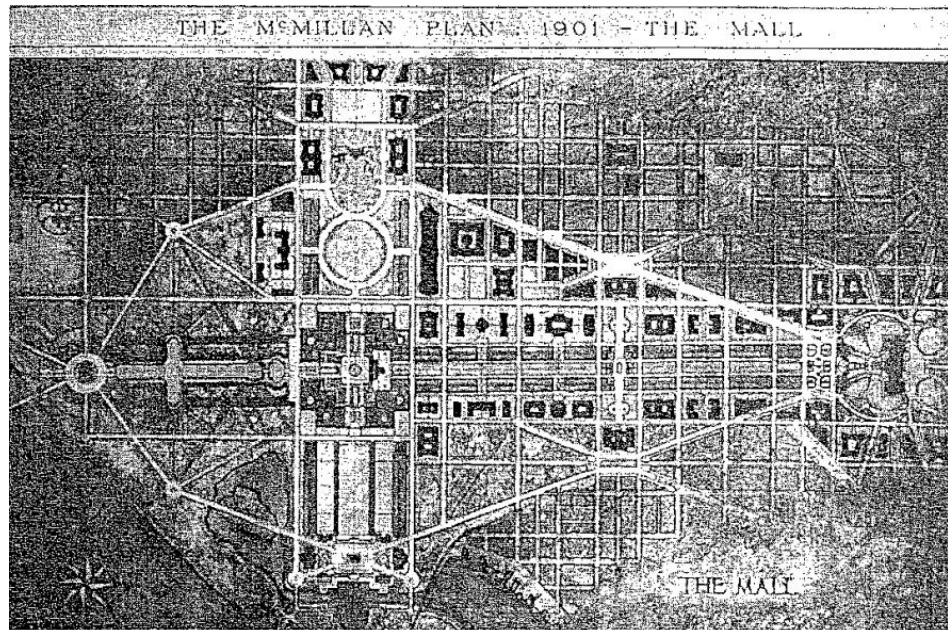


Figure 2-4: Washington D.C.

Chapter Three: Geographic information system analysis

3-1 Introduction

3-2 GIS definition

3-3 GIS elements

3-4 GIS applications

3-5 GIS analysis

3-6 Coordinate system and GIS

3-7 Coordinate system in Palestine

3-1 Introduction

Geographic Information Systems (GIS) are now essential to the work of an increasingly diverse range of organizations concerned with population characteristics, from local government and health authorities to major retailers and marketing agencies.[9]

People frequently experience a variety of issues that require support and guidance in order to address and make decisions on their resolution. The optimal location for a new urban complex, for instance, presents challenges to the urban designer. The farmer wonders about the characteristics of the soil in particular agricultural areas, the businessman wonders where to locate his new business to make the most money, the climate scientist wonders about the ozone hole's growth over the past ten years, and the military commander wonders whether it is possible to detect forces. If the adversary were to move, they would bring their weapons and equipment with them, and to answer all these questions and many of them there is a need for the existence of special databases for these elements linked to their geographical locations in nature, which is called (Spatial Data), and for this reason, technology appeared geographic information systems.

This concept refers to the connection between data and location, and it is utilized in a variety of sectors, including urban planning, where the data is displayed on maps by turning tables into maps.



Figure 3-1: GIS 1



Figure 3-2: GIS 2

3-2 GIS Definitions

A number of experts have defined the science of GIS in a variety of ways, reflecting their individual points of view, but the fundamental concepts are the same. Following the well-known GIS definitions that roughly capture the essence of this science's conceptual framework.

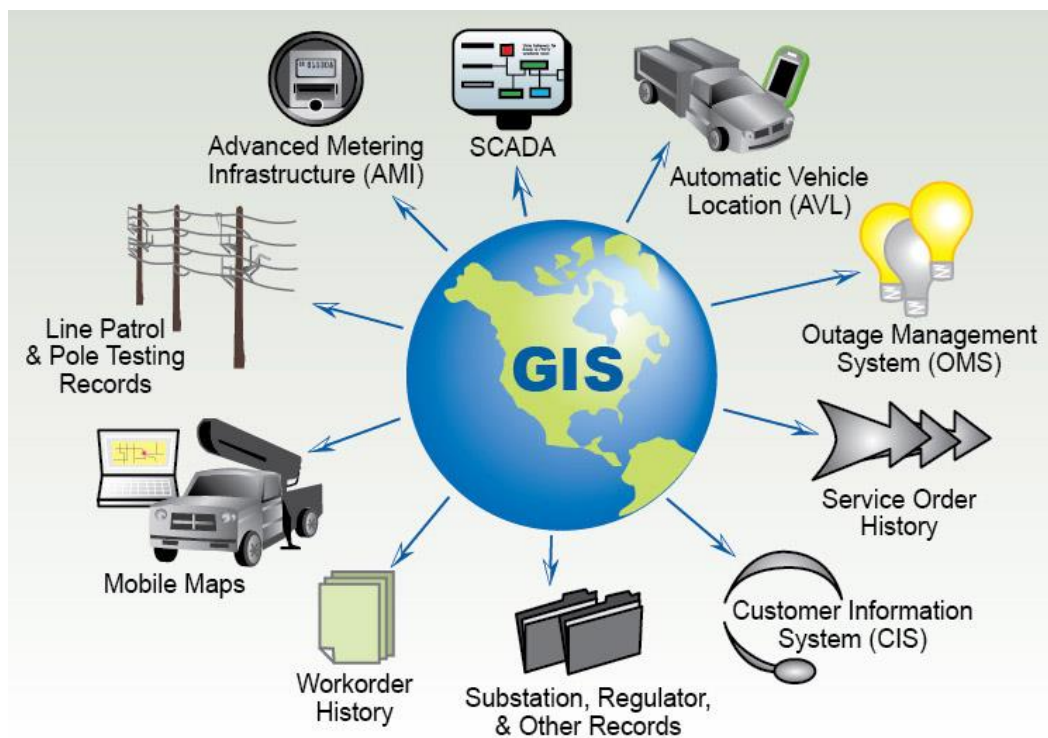


Figure 3-3: GIS Definition

First, there are 3 parts of the concept of GIS, it's definitions as follows:

1. Geographic: The system is concerned with data relating to geographic scales of measurement, which are referenced by some coordinate system to locations on the surface of the earth. Other types of information systems may contain details about location, but here spatial objects and their locations are the very building blocks of the system.[10]
2. Information: It is possible to use the system to ask questions about the geographic database, and obtain information about the geographic world. This represents the extraction of specific and meaningful information from a diverse collection of data and is only possible because of the way in which the data are organized into a 'model' of the real world.[10]
3. System: This is the environment which allows data to be managed and questions to be posed. In the most general sense, a GIS need not be automated (a non-automated example would be a traditional map library) but should be an integrated set of procedures for the input, storage, manipulation and output systems.[10]

Definitions of GIS from point of view of experts:

- ❖ It is a type of IS (Information Systems) which is a geographical type where spatial data is placed on geographical maps and collected data and converted into maps.[11]
- ❖ It is a computer system that collects, maintains, stores, analyzes, outputs, and distributes data and is used in the field of planning and other various fields.[12]
- ❖ An advanced method used to collect, process, analyze and present spatial information in thematic tables or maps for many high-quality applications that are easy to visualize, computer screen, or freehand drawing.
- ❖ A computer system is used to process, manage and analyze spatial data, i.e., geographically attributed to an area on the Earth's surface.
- ❖ A powerful system for preparing maps and linking sites with information about them.
- ❖ A computer-based method in collecting, processing, displaying, and analyzing data related to geographical location to extract important information in making appropriate decisions and used by qualified people to deal with it to solve problems dealing with data and private information in the areas of development.

- ❖ It is the science that is concerned with collecting, processing, and studying geographical information, and depends on recognizing maps, and aerial photographs, using tables, working on them, and making sure that they are completely correct and free from any errors so that they can be saved and used when needed, especially in cases that require study, or analysis by computer, map paper, or graphs.
- ❖ It is the science of collecting, entering, processing, analyzing, displaying, and outputting geographical and descriptive information for specific purposes. This definition includes the ability of systems to enter geographical information (maps, aerial photographs, satellite visuals) and descriptive information (names, tables), process it (edit it from error), store, retrieve, query, analyze it (spatial and statistical analysis), and display it on a computer screen or on paper in the form of maps, reports, and graphs.
- ❖ Definition of Dueker: "A geographic information system is a special case of information systems that contain information bases that depend on the study of the spatial distribution of phenomena, activities, and objectives that can be defined spatially as points, lines, or spaces to make the data ready for retrieval and analysis, or inquiring about data from through it".
- ❖ Definition of Parker: "A geographic information system is an information technology system that stores, analyzes and displays all spatial and non-spatial information".
- ❖ A geographic information system (GIS) is a system that creates, manages, analyzes, and maps all types of data. GIS connects data to a map, integrating location data (where things are) with all types of descriptive information (what things are like there). This provides a foundation for mapping and analysis that is used in science and almost every industry. GIS helps users understand patterns, relationships, and geographic context. The benefits include improved communication and efficiency as well as better management and decision-making.
- ❖ Geographic Information Systems, or GIS, are computer and software tools for gathering and analyzing data connected to geographic locations and their relation to human or natural activity on Earth.

3-3 GIS Elements

A GIS is a well-organized system of computer hardware, software, geographic information, and human resources created to effectively gather, store, update, alter, analyze, and present any kind

of geographically linked data. The unique visualization and spatial analytical advantages provided by maps are integrated with standard database functions, such as query and statistical analysis, via GIS technology. A functional GIS incorporates these five essential elements:

- Hardware.
- Software.
- Geographical and attribute data
- People.
- Procedures or Methodologies.

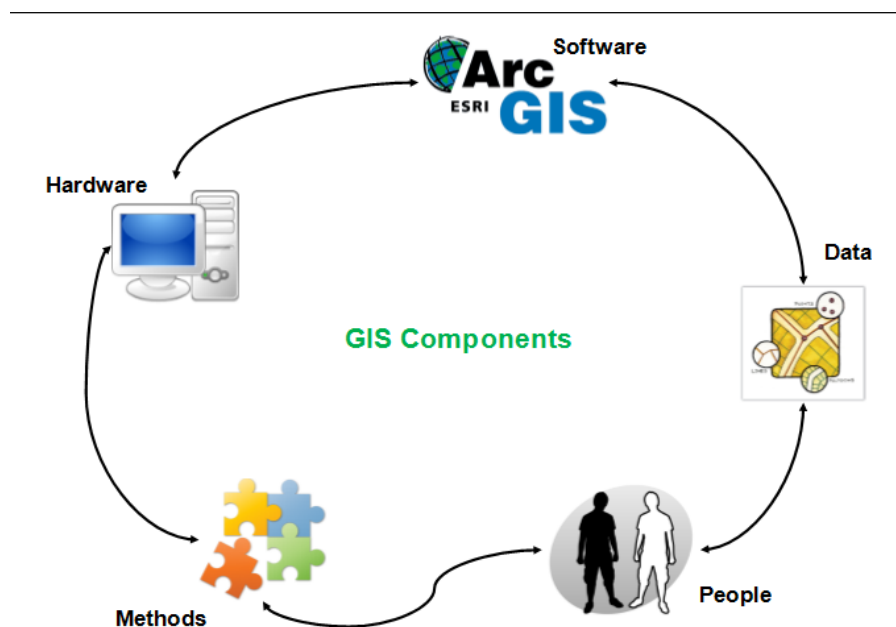


Figure 3-4: GIS elements

3-3-1 Hardware

Main Parts of the computer needed to support GIS functions along with peripherals. Today, GIS programs run on a variety of computers, including mainframes, which handle large projects, as well as personal computers, which can be used for business purposes either individually or as part of a network of other personal computers. There is also a growing use of GPS devices, which are used to determine the coordinates of specific points on the surface of the earth.[13]

3-3-2 Software

Functions & tools to store, analyze and display spatial data, the key components of GIS software are a database management system, tools for input and manipulation, functions to support query, analysis and visualization and user friend GUI (Graphical User Interfaces). GIS components are detailed in:[13]

- Tools for storing different forms of metadata or geographic data.
- Integration with database software (Relational database).
- Research, analysis, and presentation tools.
- Graphical User interface (GUI) for easy handling of the program.
- Tools for creating Topological Relationships between GIS elements.
- Tools and means that allow a large number of users to enter data and work simultaneously and with high efficiency (Multi-User Management).

3-3-3 Geographical & Attribute data

Data may be the most crucial element of a GIS. You can either collect geographic data on your own or purchase it from a commercial data supplier, along with supporting tabular data. The majority of GIS use a DBMS to build and maintain a database to aid in managing and organizing data. Earlier, this was composed of hard-copy information such as traditional cartographic maps, surveyor logs, demographic data, geographic reports, and field descriptions. The availability of more and more standard digital base maps at various scales has been made possible by improvements in geographic data collection, classification, and accuracy. Data in GIS is separated into:[13]

- ❖ **Spatial Data:** the data which are geographically referenced with the help of coordinates, that data represent nature, it can be collected from aerial photos, satellite images, and digital maps or buy it from a data source.
- ❖ **Attribute Data:** It incorporates information from tables and different statistics concerning elements of nature that nature can serve as a representation for.

3-3-4 People

It's the human resource who are actually capable of using the GIS appropriately and can make GIS work with and understanding and analyzing the output, they include the GIS manager, the data administrators, application specialist system and analysts and programmers, these are people are responsible for maintaining these databases and technically supporting the GIS work. People are associated with GIS can be categorized into three:[13]

1. The viewers.
2. The general users.
3. GIS specialists.

3-3-5 Procedures & Methodologies

The steps or the instructions used to carry out the work in GIS software, it focuses on how the data will be retrieved and input into the system stored, managed, analyzed and present into the final output.

A well-designed plan and business rules that serve as models and specific operational procedures for each institution are the foundation of a successful GIS. Examples of analytical approaches include using GIS to perform functions relating to the sciences of climate, hydrology, or urban planning, or using quality control techniques. To assure the precision of data entry, network analysis, or other analytical techniques used for various applications.[13]

3-4 GIS Applications

Different applications of geographic information systems (GIS) exist, and technology developments have greatly improved GIS data, specifically how it can be used and what can be accomplished as a result. Geographic information systems enable the gathering, storage, management, and analysis of environmental, demographic, and topographic data, making them a decision-making tool for any business or industry. Applications for urban planning will be the primary subject of this study.[14]

Geographic Information Systems is a broad area of information technology that, like any other emerging technology, has a variety of applications in a variety of industries. The Geographic Information System (GIS) is used to spread knowledge and data about the natural environment, available resources, dangers, and planned urban pathways. Models are being developed for natural resources, improved driving systems, and even national military systems by companies like ESRI, Here Maps, and Leidos Group. GIS software can be used by individuals and organizations to make geological observations and perform in-depth analyses of spatial data.[15]

Geographic information systems (GIS) and geographic science have applications in practically every field, whereas maps and cartography were previously restricted to a few applications. GIS is utilized in a variety of fields, including marketing, healthcare, and urban planning. It mixes several types of data with geography science to uncover insights and trends that aid in decision-making. The future of GIS is multi-disciplinary, as opposed to the old roles, which centered on data collection and fundamental analysis. owing to the broad application of GIS and this novel approach.

Geographical study is the pursuit of solutions to problems or inquiries regarding the universe, humankind, society, and natural phenomena. By enabling high-accuracy data capture, database management, information handling, and analysis of complex phenomena within an interactive user's interface environment, Geographical Information Systems (GIS) support the advancement of the subject. Mountains offer a varied landscape with verticality. The precise investigation of certain mountain landscape attributes is made possible by the use of GIS in geographical research. Through the use of secondary data from numerous sources, this work aims to illustrate the usefulness of GIS in geographical research in the context of mountains. The introduction of GIS and its development in Nepal, research issues, GIS application and challenges, and the new strategy for the application of GIS in the mountain context are all explained in detail.

3-4-1 GIS applications in urban planning

The technical, social, and political process of urban planning and management includes consideration for the quality of the air and water as well as the infrastructure into and out of urban

areas as it relates to the design, development, and maintenance of land use in an urban setting (e.g., transportation, communication and distribution networks). Strategic thinking, research and analysis, public input, urban design, and policy execution are all included in urban planning.

Urban planning and administration are fundamentally based on information, particularly spatial information. The majority of data utilized by planners is geographical in the sense that it utilizes topographic maps or is connected to a specific geographic area via coordinates, a street address, or an administrative region. An information system that integrates saves, edits, analyzes, shares, and displays spatial or geographic data is known as a geographic information system (GIS). Over the past few decades, these systems have become an increasingly familiar aspect of urban design and planning practice. The accessibility of modern GIS software, hardware, and databases is still an issue due to the complexity of the more potent applications, although it is improving. Planners' interest is increasing as a result of the constantly growing number of applications. The growing use of GISs in urban planning and design holds the promise of enabling higher quality quantitative and qualitative data analysis, improving the evidence base for decision-making as well as the knowledge base of the decision-making process itself—all factors on which delivering such an aspirational. Although there is still much work to be done if its promised utility is to be realized, current GIS technology advancement has created favorable conditions for the creation of solution-supporting systems at all phases in the planning and design process. The most used GISs application in urban planning are land use and roads.[2]

3-4-1-1 Land Use

When gathering information on land use and assigning each use a different colour, it is feasible to assess the quality of the use of the property, whether it is residential, industrial, commercial, or service-related. The consensus is that yellow is the colour for homes, red is for businesses, and so on. The uses of each piece of land are then shown on the maps. This helps the urban planner with the distribution of housing for a new region, the division of services, and the placement of commercial hubs, among other things.[16]

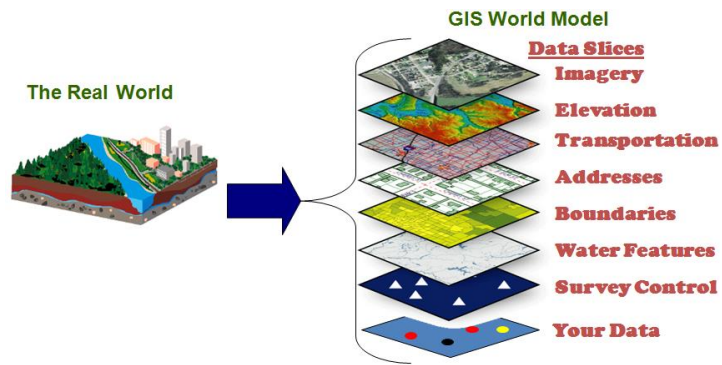


Figure 3-5: Land use 1

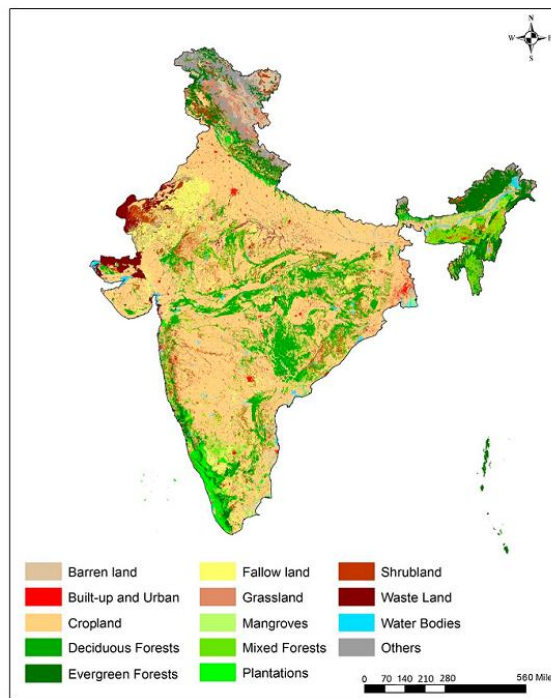


Figure 3-6: Land use 2 [17]

3-4-1-2 Roads

When planning modern roads and bridges, the urban planner uses it to establish and carry out planning operations at lower costs by taking into account the shorter distance when examining regional, national, main, and secondary roads and their distribution as well as the distribution of urbanization and buildings in places parallel to road lines to facilitate transportation, reduce transportation costs, and facilitate the process of movement for residents, workers, and others.[16]

3-4-1-3 Neighborhoods study

When creating new, enormous cities, the urban planner makes use of this field by segmenting them into neighborhoods or by researching a sizable, already-built area like Cairo.[15]

3-5 GIS analysis

There are two or more analyzing tools in GIS software, that help in interpreting statistics and features and their results, in this study the most important and used tools are overlay analyses and statistical analyses.

3-5-1 GIS Overlay analyses

Overlay operation combines spatial and attribute data from two or more layers and it creates a new layer and the corresponding attribute data, for example in figure () here layer A and layer B are overlaid to each other and the third layer includes information from both of the two layers, so it includes the spatial information which are the shapes as well as it combines the attribute tables to create a new attribute table for the overlay. One thing that has to be is required is that the two input layers is must have the same spatial reference, so it should have the same datum and coordinates system, otherwise the overlay for the output cannot be determined accurately.[18]

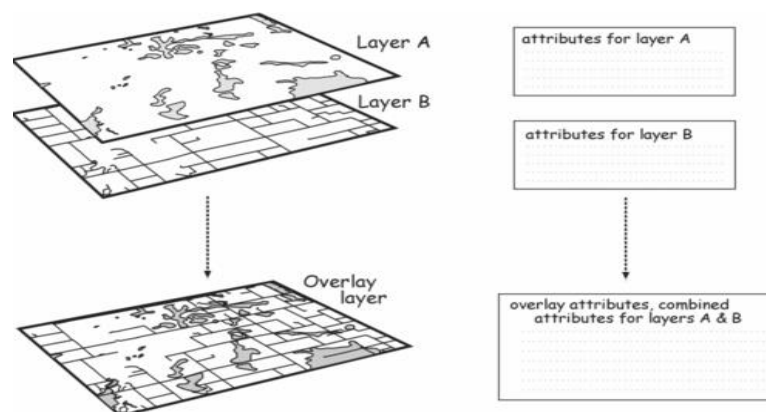


Figure 3-7: Overlay Layers [19]

Data in GIS, information is organized into individual layers, layers, each layer represents a single theme, and the overlay leverage the location information in each layer.

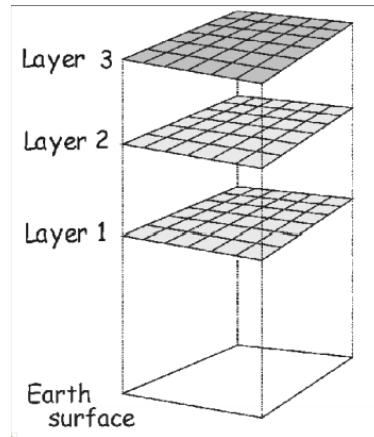


Figure 3-8: Overlay [19]

Before the advent of GIS, cartographers would produce maps on transparent plastic sheets and then layer these sheets on a light table to generate a new map of the overlaid data in order to respond to concerns like these. Overlay was essential to the creation of GIS since it produces such rich information.

The characteristics of multiple datasets can be combined into a single dataset using overlay analysis. Then, you can search for particular places or regions that satisfy the criteria you've chosen, have a particular set of attribute values, etc. This technique is typically used to identify places that are risky or perfect for a certain application. You can overlay layers of vegetation type, slope, aspect, soil moisture, and other factors to identify areas vulnerable to wildfire.

It is common practice to use overlay analysis in conjunction with other types of analysis. For instance, surface analysis or proximity analysis datasets (using tools like the Buffer tool) (the Slope or Aspect tool). The overlay results will likely also be subject to additional analysis, such as extraction to select a subset of features or generalization (to dissolve polygons, for example). In an analysis model or process, the overlay is often one phase that can start at any time.

3-5-1-1 Overlay Methods

It is common practice to use overlay analysis in conjunction with other types of analysis. For instance, surface analysis or proximity analysis datasets (using tools like the Buffer tool) (the Slope or Aspect tool). The overlay results will likely also be subject to additional analysis, such as

extraction to select a subset of features or generalization (to dissolve polygons, for example). In an analysis process or model, the overlay is often one phase that can start at any time in the process.

❖ Feature overlay

The three primary parts of feature overlay are the input layer, overlay layer, and output layer. The overlay function splits features in the input layer that cross over into features in the overlay layer. There are new places created where polygons overlap. The lines in the input layer are separated where polygons cross them. While the original input layer is unaltered, the new features are stored in the output layer. The properties of features in the overlay layer are assigned to the matching new features in the output nodes together with the original characteristics from the input layer.

Below is an example of a line-on-polygon overlay. The line is split at the polygon limits, and each of the resulting line features contains the characteristics of the original line as well as those of the polygon.

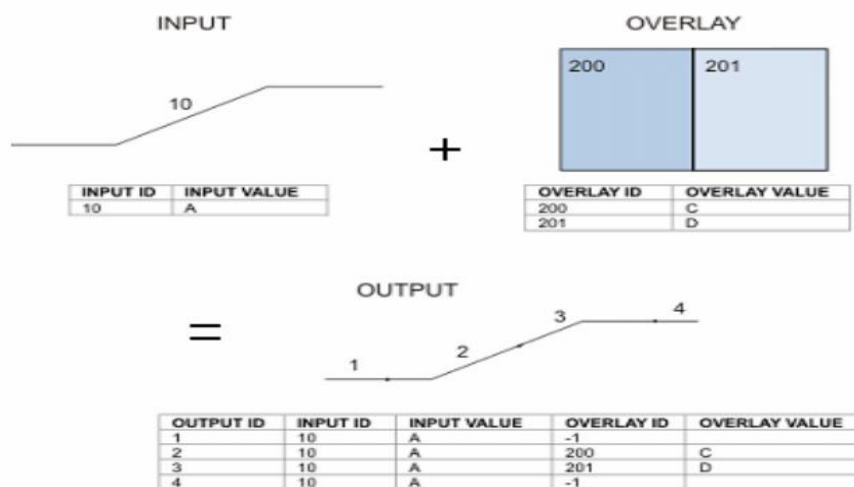


Figure 3-9: Features overlay

❖ Overlay raster

In a raster overlay, every cell of every layer relates to the same geographical area. It is therefore perfect for combining traits from different layers into a single layer. Typically, each attribute is assigned a numerical value, allowing you to mathematically combine the layers and assign a new value to each cell in the output layer.

Below is an example of a raster overlay created by addition. An output raster is created by combining two input rasters and adding the values from each cell.

INPUT 1				INPUT 2		
3	3	1	+	11	12	10
4	2	2		12	12	10
3	1	1		14	12	11

OUTPUT		
14	15	11
16	14	12
17	13	12

Figure 3-10: Raster overlay

Using this technique, attribute values are usually ranked according to their suitability or hazard, and then added together to get an overall rank for each cell. To create a weighted ranking, the relative relevance of the various levels can also be assigned (the ranks in each layer are multiplied by the weight value of that layer before being totalled with the other layers).

Below is a raster overlay created by addition for suitability modelling. Steep slopes, soils, and vegetation are the three raster layers that are evaluated on a scale of 1 to 7 for development suitability. Once the layers are inserted, each cell is graded on a scale from 3 to 21. (bottom).

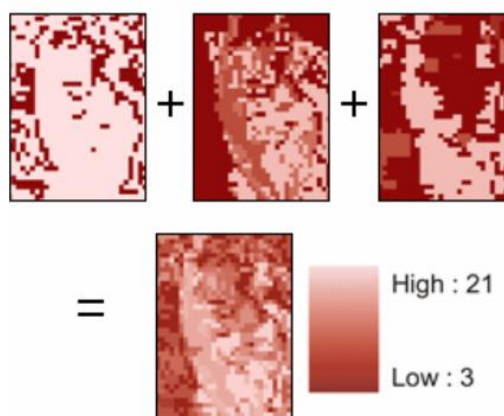


Figure 3-11: Example of raster overlay

As an alternative, you can give each cell in the output layer a value by using special combinations of values from various input layers.

3-5-1-2 Overlay Tools

❖ Vector overlay tools

The feature overlay tools are located in the Analysis toolbox of the Overlay tools. Although the tools have similar conceptual underpinnings, they differ in terms of the feature types that can be overlaid, whether many layers can be overlaid simultaneously, and whether input and overlay characteristics are retained in the output layer.

So, the vector overlay tools are:

1. Identity.

Computes a geometric intersection of the input features and identity features. The input features or portions thereof that overlap identity features will get the attributes of those identity features.

Input Features must be simple features: point, multipoint, line, or polygon. They cannot be complex features such as annotation features, dimension features, or network features.

The Output Type can be that of the Input Features with the lowest dimension geometry or lower. For example, if all the inputs are polygons, the output could be polygon, line, or point. If one of the inputs is of type line and none are points, the output can be line or point. If any of the inputs are point, the Output Type can only be point

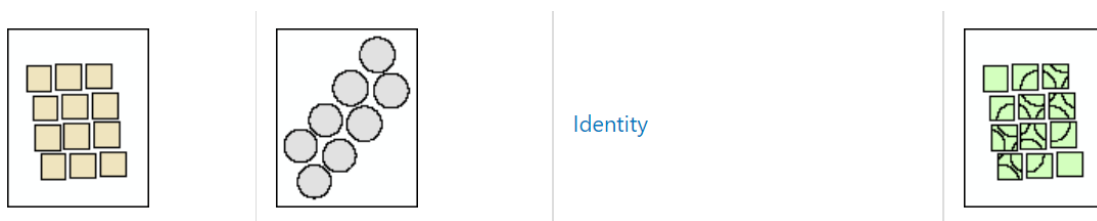


Figure 3-12: Identity

2. Intersect.

calculating the geometric intersection of the features in the input. All layers and/or feature classes will have features or portions of features that overlap written to the output feature class.

The input and the output features like the identity tool.



Figure 3-13: Intersect

3. Symmetrical Difference.

Features or portions of features in the input and update features that do not overlap will be written to the output feature class.

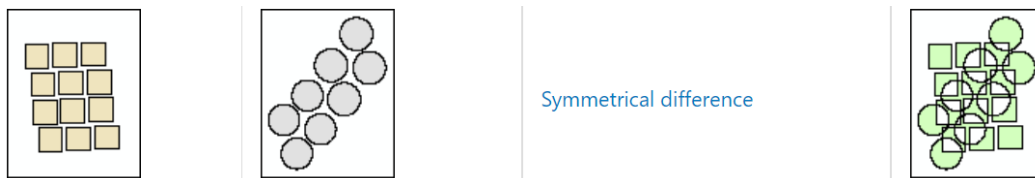


Figure 3-14: Symmetrical Difference

4. Union.

computes the input features' geometric union. The generated feature class will contain all features and their associated attributes.



Figure 3-15: Union

5. Update.

The intersection of the Input Features and Update Features is calculated geometrically. The update features in the output feature class modify the characteristics and geometry of the input features.

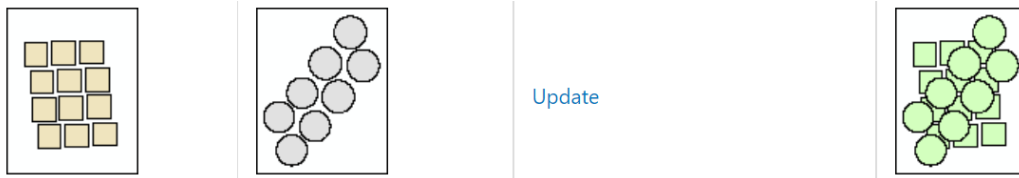


Figure 3-16: Update

❖ Raster overlay tools

The Spatial Analyst toolbox has a number of toolsets that include Raster overlay tools. An ArcGIS addon that requires a separate license is called Spatial Analyst. You will have access to the Spatial Analyst toolbox in Arc Toolbox if your site has a Spatial Analyst license and the Spatial Analyst extension has been installed.

1. Weighted Sum.

Overlays many rasters, dividing each by its assigned weight and adding them all up.

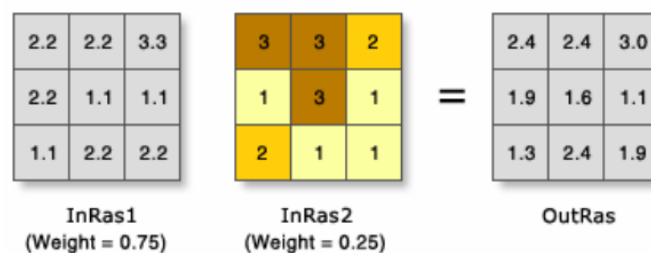


Figure 3-17: Weighted Sum

In the illustration, the cell values are multiplied by their weight factor, and the results are added together to create the output raster. For example, consider the upper-left cell. The values for the two inputs become $(2.2 * 0.75) = 1.65$ and $(3 * 0.25) = 0.75$. The sum of 1.65 and 0.75 is 2.4.

2. Weighted Overlay.

Uses a common measurement scale to overlay many rasters, giving each one a weight based on its significance.

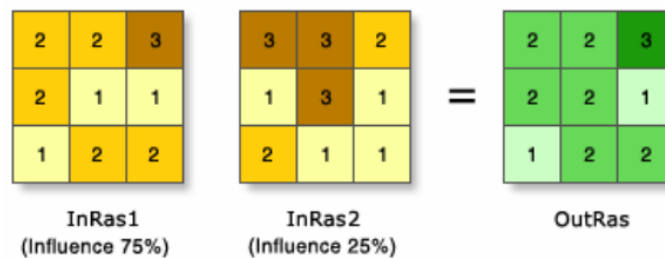


Figure 3-18: Weighted Overlay

The two input rasters in the illustration have been categorized to a standard measurement range of 1 to 3. A percentage influence is assigned to each raster. The output raster is produced by multiplying the cell values by the percentage effect of each, then adding the resulting values. Think about the upper-left cell, for instance. The results are $(2 * 0.75) = 1.5$ and $(3 * 0.25) = 0.75$ for the two inputs. 1.5 plus 0.75 equals 2.25. The final number is rounded to 2 because the output raster from Weighted Overlay is an integer.

3. Combine

combines several rasters to assign a distinct output value to each distinct combination of input values.

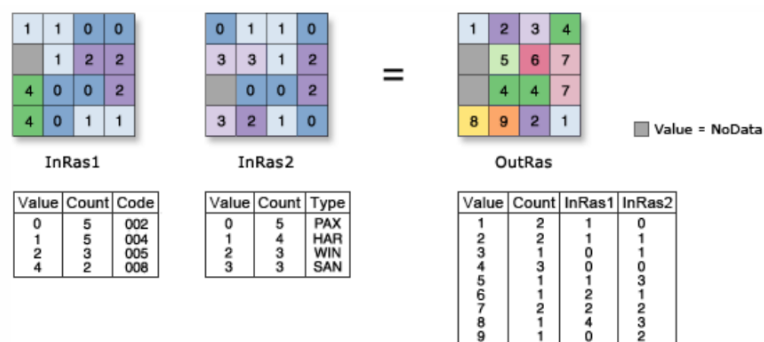


Figure 3-19: Combine

4. Zonal Statistics

Calculates statistics on values of a raster within the zones of another dataset.

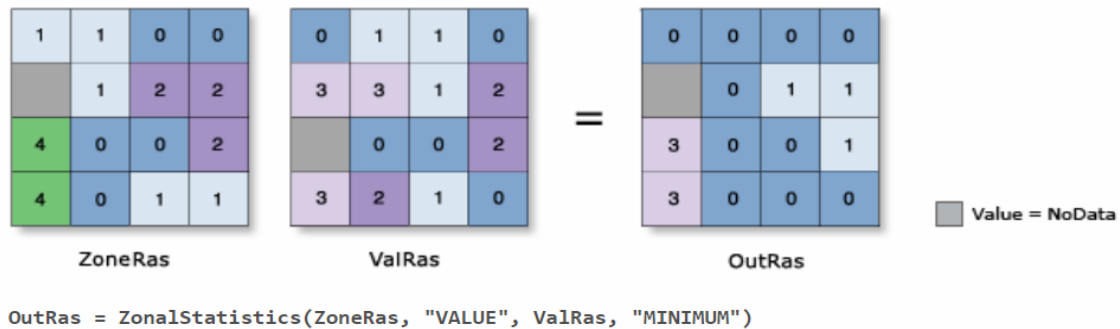


Figure 3-20: Zonal Statistics

3-5-2 GIS Statistical analyses

The qualities of features as well as their positions are included in GIS data. Using this data, maps that may be visually studied are produced. By using statistical analysis, you can glean information from your GIS data that might not be readily apparent just by glancing at a map, such as the distribution of attribute values, the existence of spatial trends in the data, or if the features form spatial patterns. Statistical analysis displays the characteristics of a group of features as a whole, unlike query operations like identify or selection, which provide information about individual features.[20]

For interactive apps like ArcMap that let you pick and visualize data in ad hoc and fluid environments, several of the statistical analysis techniques outlined in this document work best. Some of the techniques covered in this article can be found in the menus and toolbars of ArcMap and don't have a geoprocessing tool equivalent. Other techniques, like the tools for spatial statistics, are exclusively used as geoprocessing tools.

The distribution of values for a specific attribute may be examined, or outliers may be identified, using statistical analysis (extreme high or low values). When establishing classes and ranges on a map, reclassifying data, or searching for data mistakes, having this information on hand is helpful.

The distribution of seniors by census tract in this region has been computed statistically in the example below (% of those 65 and over in each tract), and the mean, standard deviation, and a histogram outlining the distribution of values have all been calculated. A few tracts contain a very high percentage of seniors, but most tracts have a lower-than-average proportion of seniors.

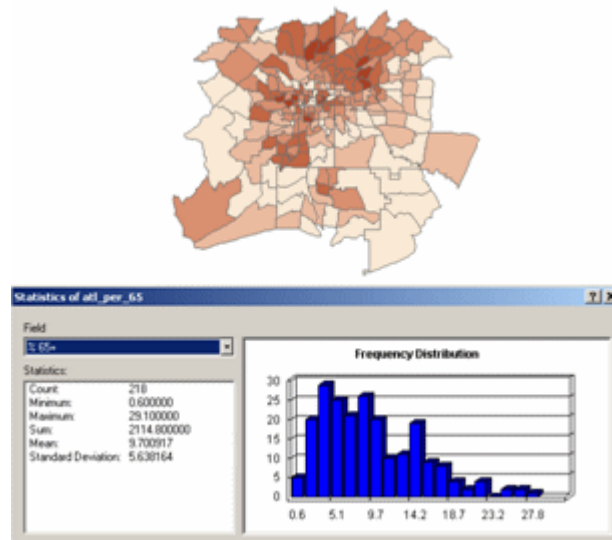


Figure 3-21: Statistical Analyses

The statistical analysis of data is also used to summarize data. This is frequently done for categories, such as figuring out how much land is used in each land-use category overall. Additionally, you can produce geographic summaries, such as figuring out the typical height of each watershed. A greater knowledge of the circumstances in a research region can be attained by using summary data.

In the example below, summary statistics for each land-use class have been computed, showing the number of parcels in that class, the smallest and biggest parcel sizes, the average parcel size, and the class's overall area.



Landuse	Cnt_Land	Min_AREA	Max_AREA	Ave_AREA	Sum_AREA
	6	1315.1	6499.3	3007.7	18046.1
AGRI	1	37243.5	37243.5	37243.5	37243.5
COMM	210	37.1	29780.0	1679.9	352776.9
FC	1	9861.1	9861.1	9861.1	9861.1
HDR	270	46.5	11343.4	522.3	141030.8
LDR	668	0.2	11195.1	758.1	506386.9
LI	30	300.1	18031.1	2728.6	81857.6
LMDR	361	5.0	1740.1	598.5	216069.7
MDR	329	0.4	17182.8	519.7	170972.8
OFF	92	74.8	12843.7	1388.6	127755.7
OSVAC	4	3983.4	8392.0	6242.9	24971.5

Figure 3-22: Statistical analyses example

The center of a group of features, the directional trend, or whether features form clusters are only a few examples of spatial patterns that can be found and verified using statistical analysis. While patterns may be visible on a map, it can be challenging to draw inferences from it since the classification and symbolism of the data can either conceal or exaggerate trends. A measure that you can use to verify the existence and strength of the pattern is provided by statistical functions after analysis of the underlying data.

As examples, the mean center of a collection of burglaries and the standard deviation ellipse for a set of moose sightings are shown below (showing the directional trend).

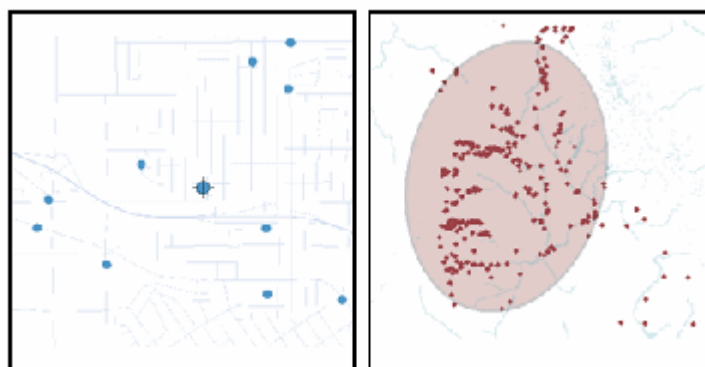


Figure 3-23: Example

An example of an analysis that demonstrates statistically significant groups of census tracts with lots of senior citizens (orange) or few senior citizens (blue).

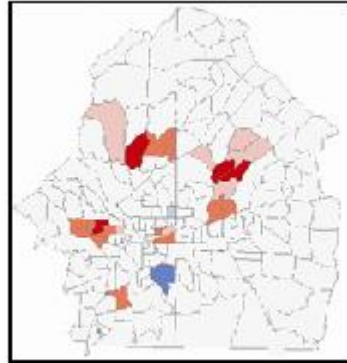


Figure 3-24: Example

4-3-5-2Types of statistical analysis

ArcGIS for Desktop's statistical analysis tools are either spatial or nonspatial (tabular) (containing location).

Analysis of attribute values related to feature values is done using non-spatial statistics. The values are directly accessible from the feature attribute table of a layer. The mean and standard deviation are just two examples of non-spatial statistics.

In this example, the total, the mean, and the standard deviation of the number of unoccupied parcels for a series of census tracts were determined using the Summary Statistics tool.

FID	AREA	FIPS	TRACT	VACANT
0	2.62693	13089021100	0211	252
1	3.94704	13089021702	021702	301
2	4.02565	13121010000	0100	265
3	1.92502	13089021403	021403	271
4	3.2758	13067031103	031103	349
5	3.40703	13089021809	021809	117
6	6.31864	13121009800	0098	140
7	3.0219	13121009900	0099	283
8	4.32517	13067031107	031107	249
9	3.64932	13067031204	031204	333
10	1.48157	13089021404	021404	466
11	4.16051	13121009700	0097	68
Count:			218	
Minimum:			0.000000	
Maximum:			1365.000000	
Sum:			58036.000000	
Mean:			266.220183	
Standard Deviation:			220.748678	

Figure 3-25: non-spatial statistics

Another method of examining non-spatial data is through charts and graphs, like a histogram or Q-Q plots. Only the values are examined in each case. Locations of the features and any spatial relationships between the features that the values are connected with are not taken into account.

A Normal Q-Q Plot is used to assess the similarity of the distribution of a set of values to that of a standard normal distribution (the typical bell curve, when shown on a histogram). The line on the Normal Q-Q plot shows expected values for a normal distribution—the closer the values to the line, the closer the distribution is to normal. In this example, the concentration of the elements Phosphorous for a set of soil samples is close to normally distributed.

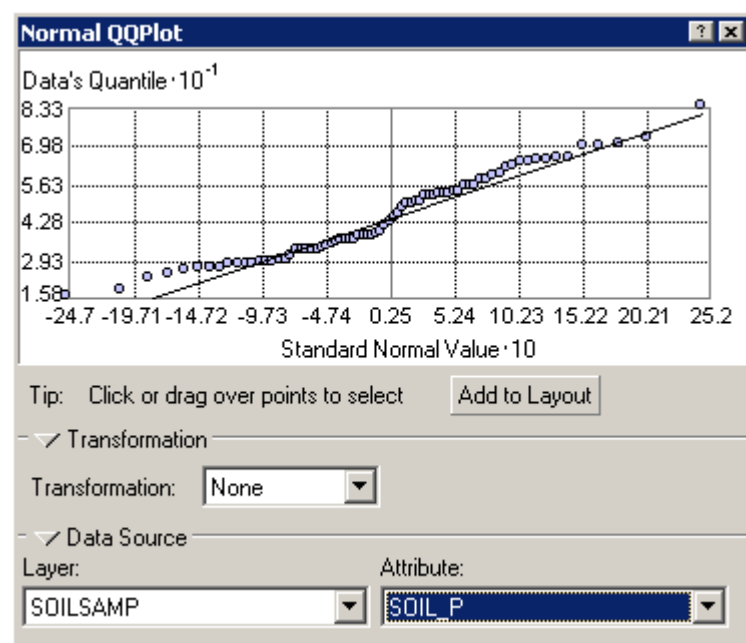


Figure 3-26: The Normal QQ Plot

The Normal QQ Plot tool is one of the data explorations tools available with the Geostatistical Analyst extension.

Spatial statistics, on the other hand, focus on the spatial relationships between features—how compact or dispersed the features are, whether they're oriented in a particular direction and whether they form clusters. The spatial relationship is usually defined as the distance (how far apart features are) but can also be other forms of interaction between features.

In the example below, the output of the Standard Distance tool (displayed graphically as a circle) is calculated using the distance of each wildlife sighting from the calculated center of the sightings.

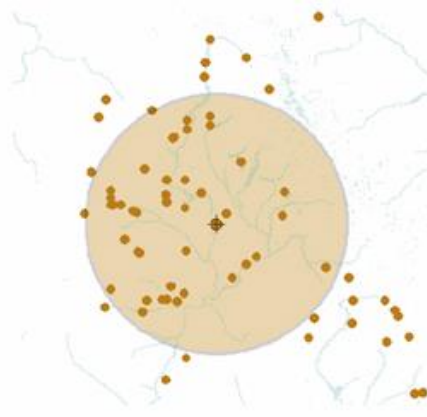


Figure 3-27: Standard Distance tool

Some spatial statistics consider both the spatial relationships of features and the values of an attribute associated with the features. These are known as weighted statistics—the spatial relationship is influenced by the values. Weighted spatial statistics are used to find out if features having similar values occur together—if, for example, schools with similarly high- or low-test scores form clusters.

In the example below, the center of parks is weighted by the number of visitors at each park (represented by the size of the green circles).

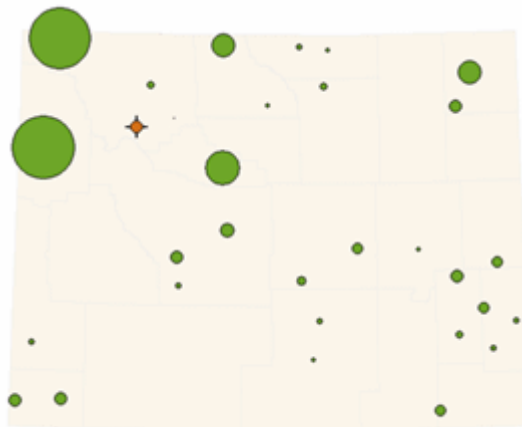


Figure 3-28: Example

Statistical functions can also be classified by whether they're descriptive or inferential. Descriptive statistics summarize some characteristic of the values or features you're analyzing—the mean value, the frequency distribution of values, or the directional trend of a group of features. Descriptive statistics are often useful for comparing two sets of features for the same area.

The example below compares the distribution of senior citizens (top) to that of children under 5 (bottom) for the same set of census tracts.

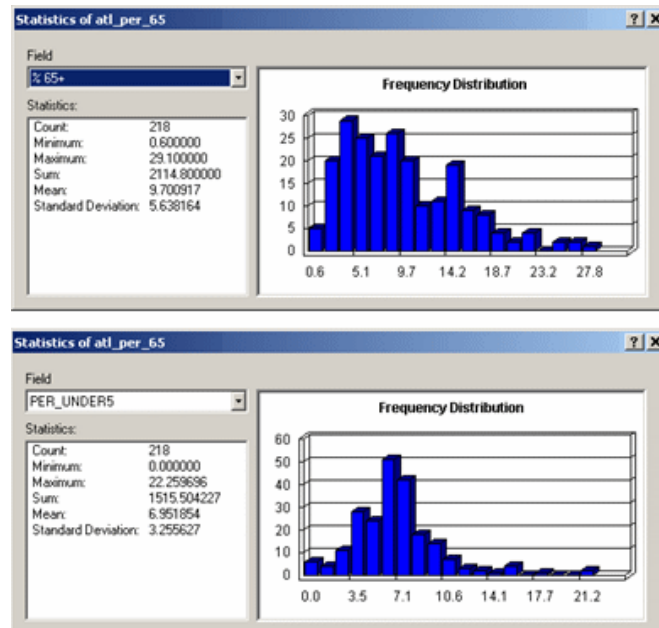


Figure 3-29: Example

In the example below, the standard distance circles for the American Indian and African American population show that the distribution of the African American population in this area is much more compact.

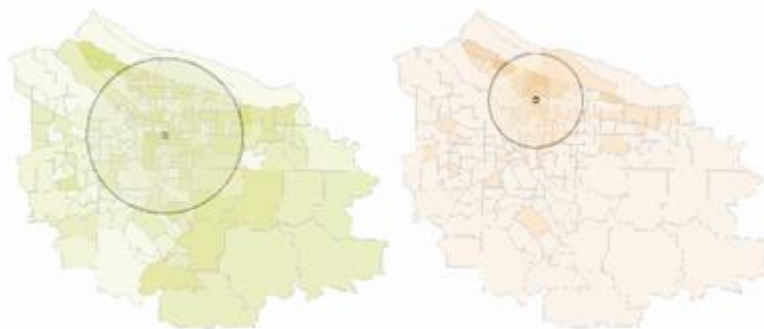


Figure 3-30: Example

Inferential statistics use probability theory to either predict the likely occurrence of values (using a set of known values), or to assess the likelihood that any pattern or trend you see in the data is not due to chance. The function provides a measure of the pattern or relationship. You then perform a statistical test on this measure to determine whether it is significant at some level of confidence. If the statistical analysis indicates that burglaries occur in clusters, you'd then run

a test to find out the chance that the clusters occurred by chance. You might find, for example, that there's a 90 percent likelihood that the clusters didn't occur by chance, indicating the burglaries may be linked in some way. Essentially to determine the probability, the test compares the measure you get for the existing features to the measure you'd expect to get for the same number of features spread over the same area, but distributed randomly.

In the example below, the map on the left shows clusters of census tracts having a high number of senior citizens (orange) or a low number (blue), at a 90 percent level of probability; the right map shows clusters at a 99 percent level of probability.

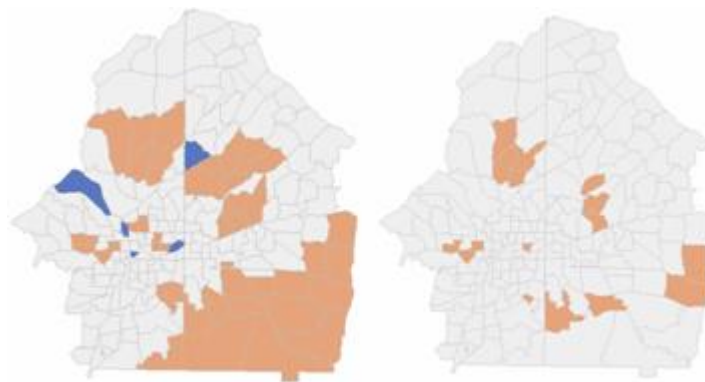


Figure 3-31: Example

3-5-2-2 Statistical analysis functions

The statistical functions in ArcGIS for Desktop are located in ArcMap, ArcCatalog, and geoprocessing, as well as within two extensions: Spatial Analyst and Geostatistical Analyst

❖ Table statistics

A core set of descriptive statistics that summarize the values for a single field is available from several locations in ArcGIS for Desktop—the table window in ArcMap, the table preview tab in ArcCatalog, and the Statistics toolset (within the Analysis toolbox).

Function	Location	Statistics	Output
Statistics menu option	ArcMap table window or ArcCatalog table preview tab	Count, Minimum, Maximum, Sum, Mean, Standard Deviation, Frequency histogram	Results are displayed in a window.
Summary Statistics tool	Analysis Toolbox/Statistics Toolset	Minimum, Maximum, Sum, Mean, Standard Deviation, Range, First, Last	Results are written to a new table.

Table 3-1: Function location in Software

To summarize a field by one or more other fields (for example, to count the number of parcels in each land-use class, sum the area in each land-use class, or find the average parcel size in each class), use the Summarize option on the ArcMap table window or the Frequency tool in the Statistics toolset in the Analysis toolbox.

Function	Location	Statistics	Output
Summarize menu option	ArcMap table window (right-click field name)	Minimum, Maximum, Average (mean), Sum, Standard Deviation, Variance	Results are written to a new table.
Frequency tool	Analysis Toolbox/Statistics Toolset	Count, Sum	Results are written to a new table.

Table 2-2: Summarize option location in software

❖ Spatial statistics

The Spatial Statistics toolbox contains a number of statistical routines for analyzing the distribution of a set of features, analyzing patterns, and identifying clusters.

Functional Area	Toolset	Tools
Geographic distribution measurements	Measuring Geographic Distributions	Mean Center, Central Feature, Standard Distance, Directional Distribution (Standard Deviational Ellipse), Linear Directional Mean
Geographic pattern analysis	Analyzing patterns	Average Nearest Neighbor, Spatial Autocorrelation (Moran's I), High/Low Clustering (Getis-Ord General G)
Geographic cluster analysis	Mapping Clusters	Cluster and Outlier Analysis (Anselin Local Moran's I), Hot Spot Analysis (Getis-Ord Gi*)
Regression analysis	Modeling spatial relationships	Ordinary Least Squares, Exploratory Regression, Geographically Weighted Regression

Table 3-3: Spatial Statistics

❖ Raster statistics

The Spatial Analyst includes several statistical functions that can be used to analyze rasters, primarily to summarize attribute values and assign the summary statistics to cells in a new raster layer. These are located in several different toolsets with the Spatial Analyst toolbox.

Tool	Location	Input	Output	What it does
Cell Statistics	Local Toolset	Multiple rasters	Raster	Calculates the specified statistic for each cell based on multiple inputs
Focal Statistics	Neighborhood Toolset	Raster	Raster	Summarizes the values for a raster within a defined neighborhood around each cell and assigns the value to that cell in the output raster
Point Statistics	Neighborhood Toolset	Point features	Raster	Summarizes values for point feature attributes within a defined neighborhood and assigns values to cells in the output raster
Line Statistics	Neighborhood Toolset	Line features	Raster	Summarizes values for line feature attributes within a defined neighborhood and assigns values to cells in the output raster
Zonal Statistics	Zonal Toolset	Raster or polygon features	Raster or summary table	Summarizes values of a raster surface by categories or classes (zones) of the input raster or polygon dataset

Table 3-4: Raster Statistics

3-6 Coordinate system and GIS

GIS, mapping, and surveying all depend on coordinates. They serve as their core. Geometry is made up of points, lines, and polygons. Polygons are defined by lines, points are defined by lines, and coordinates are defined by points. In the end, the coordinates are what connect the physical world to its digital representation in the computer.

There are currently in use more than 3,000 Cartesian coordinate systems and more than 1,000 horizontal geodetic datums that have been approved for use by governments all over the world.

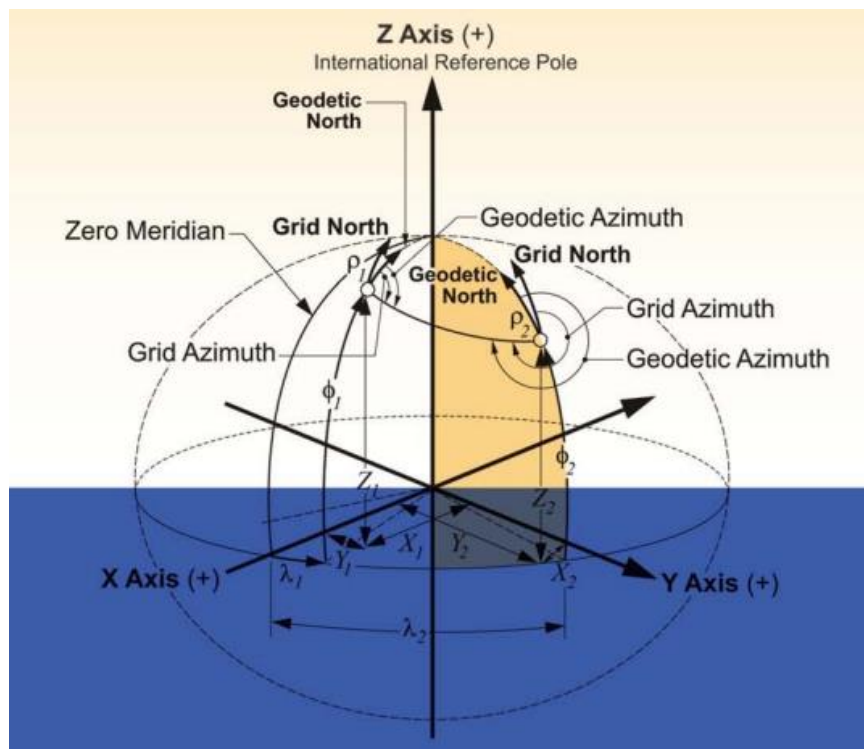


Figure 3-32: Coordinates System [16]

A spatial reference system is present in all GIS data by default. It might be made up of a straightforward arbitrary reference system, such as a 10 m by 10 m sample grid in a wooded area or the lines delineating a soccer field, or it could be made up of a geographic reference system, in which case the spatial features are mapped to an earth-based reference system. This topic focuses on earth reference systems, which can be based on either the Geographic Coordinate System (GCS) or the Project Coordinate System (PCS). [16]

Coordinates are slippery devils. Even though the statistics are exact, it is very difficult for the coordinates of a stake pushed into the earth to be as certain.

4-3-5 Geographic Coordinate Systems

An identification system for locations on the wavy surface of the planet is called a geographic coordinate system. In relation to two planes—the equator-defined plane and the prime meridian-defined plane—locations on the surface of the planet are measured in angular units away from its center (which crosses Greenwich England). Consequently, a position is determined by two values: a longitudinal value and a latitudinal value.

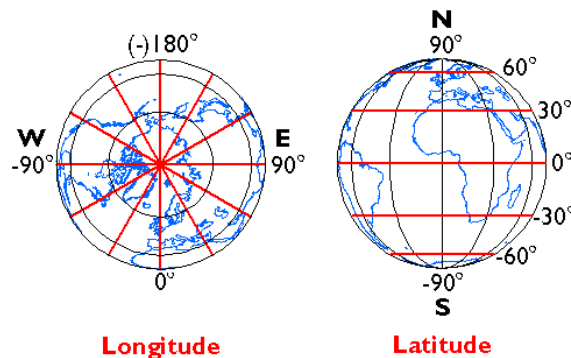


Figure 3-33: Geographic Coordinates System [21]

A latitude is a unit used to describe the angle between a location on the earth's surface and the equatorial plane. The angle between the prime meridian plane and the north-south plane that intersects the area of interest is known as the longitude. Colby College, for instance, is situated roughly at 45.56° North and 69.66° West. The North-South and East-West directions are represented as signs in a GIS system. South and West are given a negative (-) sign, while North and East are given a positive (+) sign. Therefore, the coordinates of Colby College are $+45.56^\circ$ and -69.66° .

3-6-2 Sphere and Ellipsoid

It is much easier to perform mathematical calculations and makes for good small-scale maps to assume that the world is a perfect sphere (maps that show a large area of the earth). If precise measurements are required, an ellipsoid model of the planet might be preferred when working at bigger sizes. The equatorial radius and the semi-minor axis are the two radii that make up an ellipsoid (the polar radius).

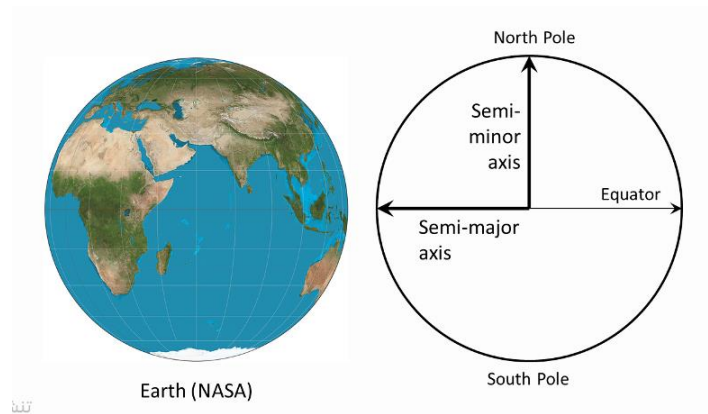


Figure 3-34: Sphere & Ellipsoid [22]

Because of its revolution, which produces a centripetal force at the equator, the planet has a slightly ellipsoidal form. Due to this, the equatorial axis is around 21 km longer than the polar axis.

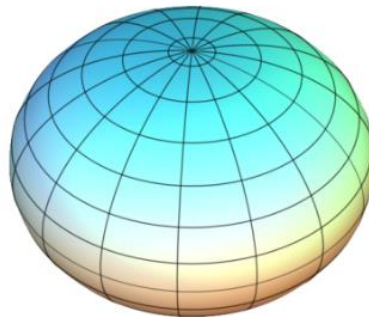


Figure 3-35: Slightly Ellipsoidal [22]

3-6-3 Geoid

The geoid, the actual shape of the earth, must be represented mathematically in a GIS context. But the earth's surface is not completely flat. Its surface is wavy due to variations in gravitational attraction. Despite not being visible to the unaided eye, these undulations can have an impact on locational measures. Remember that we are not talking about mountains or ocean bottoms, but only about the gravitational potential of the earth, which is best understood by picturing the entire

surface of the earth submerged in water and calculating the distance between the center of the earth and the surface of the water over the entire surface of the earth.

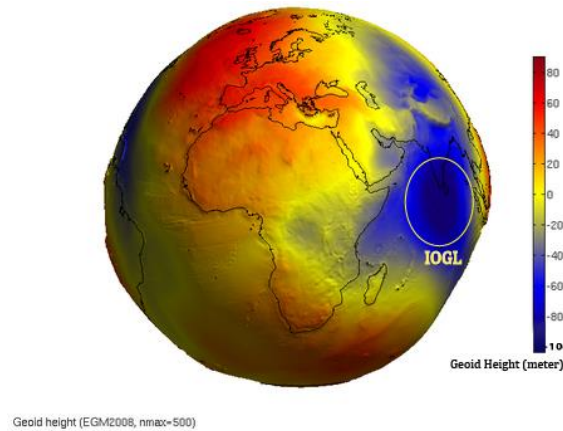


Figure 3-36: Geoid

The dynamic gravitational field is linked to the flow of the hot, fluid core of the earth. As a result, even though over a lengthy time, its geoid is constantly changing. The measurement and depiction of the shape of the earth are topics covered in the field of geodesy, a part of applied mathematics.

To compare the difference between geoid and ellipsoid. The deviation between the Geoid and a reference ellipsoid is called geoid separation (N) (see figure below).

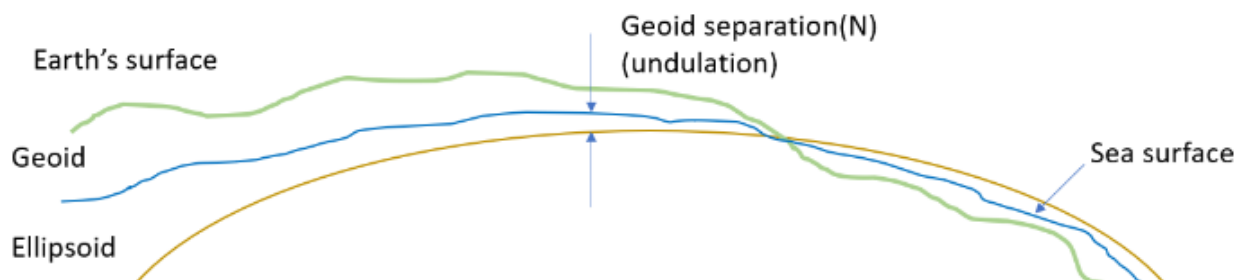


Figure 3-37: Relationships between Geoid & Ellipsoid

3-6-4 Datum

So how can we balance the undulating character of the geoid with our requirement to work with a (basic) mathematical representation of the earth's shape? The earth's surface features should be

mapped onto this ellipsoid/sphere, with the geoid aligned with the depiction of the earth as an ellipsoid (or sphere). The alignment can be geocentric, with the ellipsoid aligned with the earth's center, or local, with the ellipsoid surface closely approximating the geoid at a particular region on the earth's surface (such as Kansas). The alignment of the ellipsoid with the geoid establishes a datum.



Figure 3-38: Datum [23]

3-6-5 Map Projection

After deciding where to draw, your data will need to know how to draw. Your GCS and the surface of the globe are both spherical, yet your computer screen and the map are both flat. That is a serious problem. If the circular earth is drawn on a flat surface, it will distort. Think about trying to lay an orange peel flat on a table after it has been peeled. If you first tear the peel-apart, you can get close. In this case, map projections are useful. The most crucial features of your map should be the least deformed and should appear the best on the flat surface of the map, so they instruct you on how to distort the earth—how to tear and stretch that orange peel.

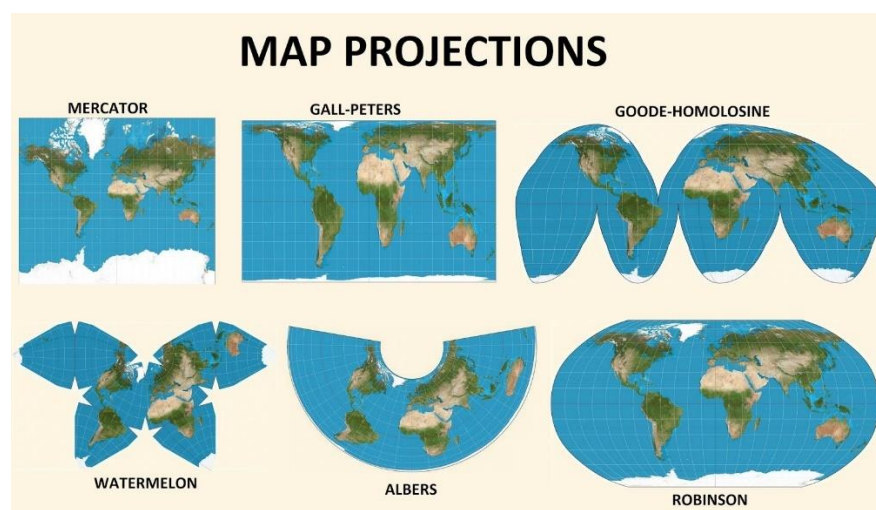


Figure 3-39: Map Projection

You may already be aware of the several map projections that exist, each of which presents the world in a unique way. Others are useful for keeping angles or lengths, while some are useful for retaining map areas.

A GCS that has been flattened using a map projection is known as a projected coordinate system (PCS).

Your data must have a GCS before it can determine its location on the planet. You can choose to project your data but not your map. Maps are flat; thus, you'll need to be a PCS to be able to draw.

3-7 Coordinate system in Palestine

Cadastral surveys or mapping were frequently constructed for engineering applications employing regional networks of horizontal triangulation sites and leveling benchmarks. For the purposes of conducting surveys, these places functioned as quality control and reference points. In Palestine, the geodetic triangulation network was created early on.

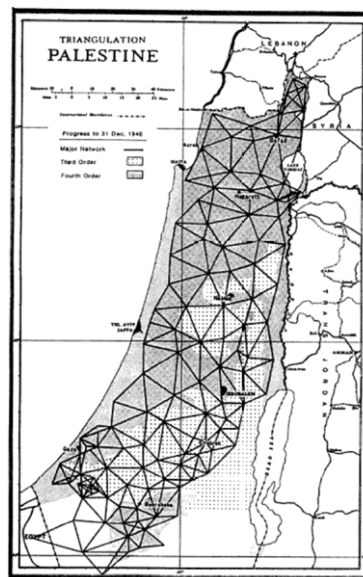


Figure 3-40: Geodetic Triangulation in Palestine

From the 1920s to 1947, angular triangulations and traverses were used. The network contained about 15,000 points, ranging from second-order major points to fourth-order points. Occasionally, local surveyors added extra points during cadastral surveys.

On the other hand, the network of levelling benchmarks was created in the 1920s and 1930s utilizing exact differential levelling, beginning from a gauge point in Gaza City's Mediterranean Sea. Between the main benchmarks, a process of densification was carried out between the middle of the 1970s and the middle of the 1980s. Both horizontal and vertical networks have been destroyed since the early 1990s as a result of urban growth or because people deliberately destroyed them out of political curiosity.

In 1999, a static observation was utilized to observe a particular collection of sites as a GNSS network. The network was transformed to WGS84 coordinates based on the ITRF96 coordinate system. The original Pal1923Grid coordinates were used to calculate the transformation parameters, yielding one solution for Palestine and two extra solutions for the West Bank and Gaza Strip, respectively (Mason 1999).

Finally, due to Palestine's location at the juncture of the Arabian and Sinai tectonic plates, as well as the Dead Sea Rift and Jordan Valley, the geodetic network has been subject to effective earth kinematics for more than a century (GFZ-Potsdam 2019). The resulting relative displacements between the locations were up to 30 cm. For a few specific points, it is necessary to take into account additional local movements brought on by stone businesses and urban constructions.

A reference ellipsoid TMs selected to calculate three-dimensional coordinates because geodetic network computations are based on three-dimensional geocentric coordinates or comparable geographic coordinates. The three-dimensional coordinates are then translated into horizontal easting and northing coordinates using the correct map projection. The horizontal coordinates can be used by surveyors and engineers to carry out cadastral, engineering, and mapping surveys. For all engineering and cadastral surveys in Palestine, the coordinate system (Pal1923Grid) based on the Cassini-Soldner (Cassini) map projection was employed (Epsg 2020).

During World War II, a modified system for military mapping was used, which used the Pal1923Belt Transverse Mercator TM map projection, which was based on the same datum as Pal1923Grid (Epsg 2020). Even though both projections are cylindrical, they have different properties and applications, resulting in different coordinates and distortions (Snyder 1).

For cadastral surveys in 2018, the Palestinian Surveying Department requested that land surveyors add a specific set of parameters to their GNSS data collectors. They claimed that even

if Transverse Mercator Projection and different parameters were used, the resulting coordinates would still be compatible with Pal1923Grid coordinates. This system, known as New Pal TM, was derived from the IGD05/12 system and based on ITRF2000 at epoch 2004.75. (Georepository 2019).

Parameter	Pal1923Grid	Pal1923Belt	New Pal-TM ¹
Ellipsoid	Clarck 1880	Clarck 1880	GRS 80
Semi-major axis	6378300.789m	6378300.789m	6378137.00m
Inverse flattening	293.4663155389802	293.4663155389802	298.257222100882
Projection type	Transverse Cylinder	Transverse Cylinder	Transverse Cylinder
Projection Name	Cassini-Soldner	Transverse Mercator	Transverse Mercator
Latitude of origin	31.73409694444445°	31.73409694444445°	31.73439361°
Central meridian	35.21208055555556°	35.21208055555556°	35.20451694°
False easing	170251.555 m	170251.555 m	169529.584 m
False northing	126867.909 m	126867.909 m	126907.39 m
Scale	1	1	1.0000067
Datum	Palestine_1923	Palestine_1923	ITRF00/2004.75
EPSG code	28191	28192	--
Usage	Cadastral/Engineering	Cartography/Mapping	Cadastral/Engineering

Table 3-5: Coordinates Systems in Palestine

The establishment of connections between various datum and coordinate systems was necessary due to the widespread use of contemporary geospatial technologies and applications. When conducting surveys and gathering data using GNSS technology, the WGS84 or international terrestrial reference frames and systems (ITRF) is used (ITRF 2019). Additionally, satellite photos are based on a number of international systems. The GIS program manages data from several sources.

Chapter Four: Data collection

4-1 Data collection in survey

4-2 GNSS

4-3 Photogrammetry

4-1 Data collection in survey

The creation of survey drawings—which could be maps, plans, sections, cross-sections, or elevation drawings is frequently a part of surveying operations. Typically, two-dimensional drawings of three-dimensional objects are needed for the survey of land and the natural or man-made features on or near the Earth's surface. These illustrations are often created on a horizontal or vertical plane. There are different methods for gathering information during surveys.

4-1-1 Land Surveying

Surveying, often known as land surveying, is the art, profession, and science of precisely finding the terrestrial or three-dimensional position of points, as well as the distances and angles between them. Licensed surveyors and people in various building professions frequently practice it. These points, which are often situated on the surface of the Earth, are frequently used to draw land maps and delineate boundaries for ownership, location (building corners, surface location of subterranean objects), and other governmental or civil law criteria (property sales). To accomplish their tasks, surveyors make use of concepts from geometry and trigonometry, as well as from physics, engineering, and law.[24]

The American Congress on Surveying and Mapping (ACSM) defines surveying as "the science and art of making all necessary measurements to determine the relative position of points or physical and cultural details above, on, or beneath the surface of the Earth, and to depict them in a usable form, or to establish the position of points or details".

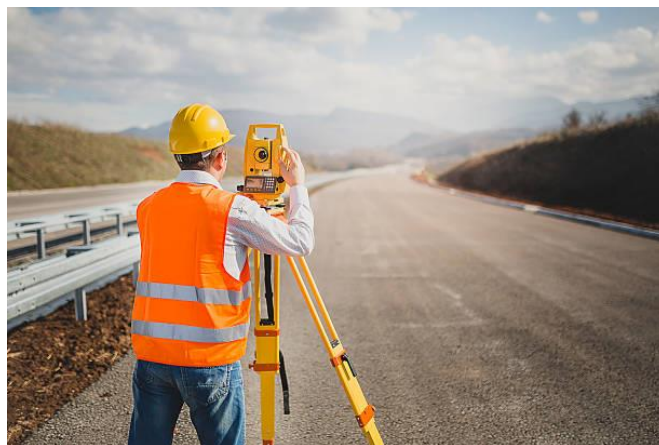


Figure 4-1: Land Surveying

In addition, as was already mentioned, "land surveying" (also per ACSM) is a thorough study or inspection that includes obtaining information through field measurements, questionnaires, legal instrument research, and data analysis in support of designing, planning, and establishing property boundaries. In addition to certifying surveys of subdivision plats or maps, registered land surveys, judicial surveys, and space demarcation, it comprises re-establishing cadastral surveys and land borders based on historical records and evidence (as required by statute or local ordinance). Among the services offered by land surveying are data collecting and mapping, surveys for building layout, accurate measurements of length, angle, elevation, area, and volume, horizontal and vertical control surveys, and analysis and use of land survey data.

Surveyors employ a variety of instruments to carry out their task successfully and precisely, including total stations, robotic total stations, GPS receivers, prisms, 3D scanners, radio communicators, handheld tablets, digital levels, and surveying software. Control surveys that are horizontal and vertical, as well as the interpretation and use of data from land surveys.

Surveying has played a significant role in the advancement of the human environment ever since recorded history began (about 6,000 years ago). It is necessary for the preparation and implementation of almost any kind of building project. Some of its most well-known contemporary uses are transportation, building and construction, communications, mapping, and the establishment of property lines.

4-1-2 Global Position System

Anywhere on or near the Earth where four or more GPS satellites are visible, the Global Positioning System (GPS) gives location and timing information in all weather circumstances. The system's vital capabilities are relied upon by military, governmental, and commercial users worldwide.[25]

4-1-3 Photogrammetry

Photogrammetry is the science, technology, and art of recording, measuring, analyzing, and representing the Earth and its environment, as well as other physical objects and processes, using

noncontact imaging and other sensor systems. Photogrammetry incorporates techniques from a variety of fields, including optics and projective geometry.

The locations of object points in 3-D space are defined by 3-D coordinates. The image coordinates specify where the images of the object points appear on film or an electronic imaging device. A camera's location in space and view direction is predetermined by its exterior orientation. The geometric parameters of the imaging process are defined by the inner orientation. This primarily refers to the lens' focal length, but it can also refer to lens distortions. Additional observations are also very important: The connection to the basic measuring units is created with scale bars, which are a known distance between two points in space, or a known fixed point, the photogrammetric method can use any of the four main variables as an input or output.

4-1-4 Remote Sensing

The science (and, to some extent, the art) of acquiring data about the Earth's surface without physically touching it is known as remote sensing. This is done through detecting and capturing energy that is reflected or emitted, as well as processing, interpreting, and using the resulting data.

4-2 GNSS

Global navigation satellite system (GNSS) is a general term describing any satellite constellation that provides positioning, navigation, and timing (PNT) services on a global or regional basis.

The term GPS is now so familiar to the general public that it has become synonymous with any satellite navigation system—but we need to be careful. The term GPS is the name of the system created by the American military and stands for Global Positioning System. There are other systems too. The Russian military system for example is called GLONASS (Global Orbiting Navigation Satellite System), while China has developed a system called BeiDou-2. And all of them are considered under the GNSS.

When talking about satellite navigation systems, a term you will often encounter is GNSS, which stands for Global Navigation Satellite System. This is the generic name used to describe any global system of satellites that transmit signals for navigation purposes on Earth. The distinction of using terms like GPS or GLONASS is important if you're using satellite systems for

measurement purposes because each system works in a slightly different way (although the result appears to be the same).

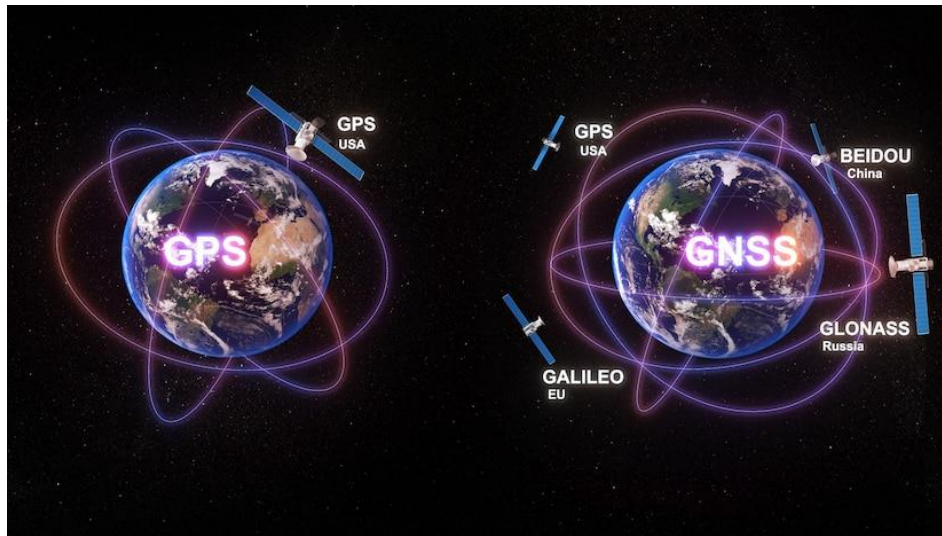


Figure 4-2: GNSS

GPS has a lot of features including

1. The Global Positioning System (GPS) is a U.S.-owned utility.
2. provides users with positioning, navigation, and timing (PNT) services.
3. This system consists of three segments: the space segment, the control segment, and the user segment.
4. The U.S. Air Force develops, maintains, and operates the space and control segments.

4-2-1 Measurement methods (RTK & Static)

Before moving on to RTK and static, it's important to grasp the overall concept of positioning methods. The entire GNSS system is based on timing the time it takes for a signal to travel from a satellite to a receiver.

Knowing the precise orbits of the space vehicles (the ephemeris) and travel times from at least four satellites allows you to form an area and then determine your precise location by finding the point where all the spheres cross. To get a better understanding of positioning.

You might wonder how accurate your position is once you've determined it. Most GNSS or GPS receivers, such as the one in your smartphone or on most robotic platforms, determine your position with a precision of 2-4 meters. It's enough to use Google Maps to locate a store you're looking for. However, for purposes such as land surveying, the estimate is far too rough. So, what causes such an error and how can it be avoided?

4-2-2 RTK

Real-Time Kinematic (RTK) is a technique that minimizes errors to provide accurate results and improved positional data down to centimeter resolution.

The signal from satellites travels through the ionosphere and atmosphere for 20,200 kilometers before reaching the receiver. The ionospheric effect slows down the signal and can also cause it to be disrupted while traveling. Furthermore, numerous factors such as clouds or obstacles can affect travel time and increase position error.

RTK comes to the rescue to solve these problems. Two GNSS receivers are required for RTK: one is stationary and referred to as a "base station," while the other is mobile and referred to as a "rover." The static base station is placed at known coordinates while both receivers observe the same satellites at the same time (a benchmark or a point measured beforehand). The base transmits corrections to the moving rover based on known coordinates and received satellite signals. The rover can achieve sub-centimeter accuracy this way.

In this method, one receiver remains open over a known point (the Base Station) while another receiver moves between different positions (the Rover Station). Using a radio link, the position of the Rover Station can be calculated within a few seconds, ensuring a similar level of accuracy to baseline measurements as long as they are within 10km of the Base Station.

4-2-3 Static survey

Static GPS surveying is a relative positioning method that uses two (or more) stationary receivers to track the same satellites at the same time. A base receiver is placed over a point with precisely known coordinates, such as a survey monument. The other receiver, the remote receiver, is positioned over an unknown location. This surveying method is based on taking simultaneous

measurements at both the base and remote receivers for a set period of time, which are then processed to yield the unknown point's coordinates. This type of survey is primarily used to establish control in situations where there is none and to achieve very high accuracies.

This method involves simultaneously recording GPS observations over both a known and unknown survey point for at least 20 minutes to determine the coordinates for survey points. The data is then processed to produce coordinates that are accurate to within 5mm.

4-3 Photogrammetry

The American Society for Photogrammetry and Remote Sensing defines photogrammetry as the art, science, and technology of recording, measuring, and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena to obtain reliable information about physical objects and the environment. The science began with the analysis of images, as its name suggests, although the usage of film cameras has drastically decreased in favor of digital sensors. Other records, such as digital imaging, radiated acoustic energy patterns, laser range data, and magnetic phenomena, are now analyzed by photogrammetry. Photographic and digital photogrammetry are both treated in this article because they share many of the same ideas, although additional sources of data are also discussed. The terms photograph and photo as used in this book can be considered synonymous with a digital image unless specifically noted.[26]

4-3-1 Photographic Types

Terrestrial and aerial photography are the two basic types of photography utilized in photogrammetry. Terrestrial photographs are taken with ground-based cameras, the position and orientation of which might be measured directly at the time of exposure. For taking terrestrial images, a wide range of cameras are employed, ranging from affordable commercially accessible cameras to precise, custom-designed cameras. While film cameras are still employed in terrestrial photogrammetry, digital cameras have become the primary image acquisition sensors.

Aerial photography is usually divided into two categories: vertical and oblique. The camera axis is directed as close vertically as possible when taking vertical images. When an exposure is

made with the camera axis vertical, the photographic plane is parallel to the datum plane, and the resulting photograph is called fully vertical. Due to unavoidable airplane tilts, the camera axis is rarely retained completely vertical in practice.

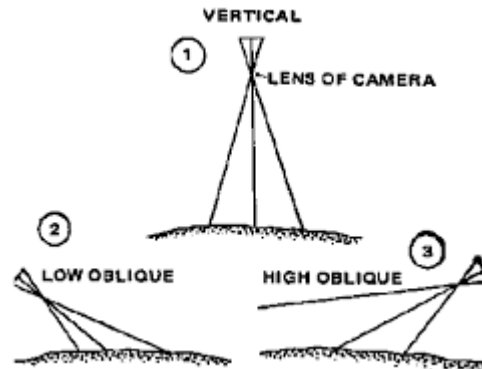


Figure 4-3: Photographic Types

4-3-2 Uses of Photogrammetry

Topographic mapping was one of the first uses of photogrammetry, and it is still the most prevalent photogrammetric activity today. Many special-purpose topographic maps are photogrammetrically prepared by private engineering and surveying firms. These maps are used to plan and design highways, railroads, rapid transit systems, bridges, pipelines, aqueducts, transmission lines, hydroelectric dams, flood control structures, river and harbor improvements, and urban regeneration projects, among other things. A large number of topographic maps are produced for use as spatial data in geographic information systems. Orthophotos and digital elevation models (DEMs), two newer photogrammetric products, are increasingly frequently utilized to replace old topographic maps. An orthophoto is an aerial photograph that has been scaled uniformly across the image. As a result, orthophotos are similar to planimetric maps, however, unlike planimetric maps, which depict features using lines and symbols, orthophotos display actual photographs of features. As a result, they are more easily interpreted than planimetric maps, and many users prefer them. A DEM is an array of points in a given area whose X, Y, and Z coordinates have been computed. As a result, they provide a numerical representation of the topography in the area, from which contour cross-sections, and profiles, among other things, can be calculated. Because orthophotos and DEMs are both digital, one of their most prevalent applications is in conjunction with geographic information systems.[27]

4-3-3 Orthophoto

An orthophoto is an aerial photograph that has been geometrically corrected or 'ortho-rectified' such that the scale of the photograph is uniform and utilized in the same manner as a map. An ortho-photograph can be used to measure the true distances of features within the photograph. Planimetric corrections have been applied to remove lens distortions and optics, camera angle, and differences in elevation (topographic relief) through a process of measuring ground control points to 'tie' the photo to the ground, in a drawing-pin like manner. An orthophoto is an accurate representation of the earth's surface. Orthophotos have the benefits of high demand il, timely coverage combined with the benefits of a map including uniform scale and true geometry.

A photo that depicts items in their accurate orthographic positions is called an orthophoto. Therefore, orthophotos are geometrically identical to traditional line and symbol planimetric maps, which likewise depict items in their actual orthographic positions. An orthophoto consists of photographs of features, whereas maps use lines and symbols plotted to scale to depict features. This is the main distinction between an orthophoto and a map.

Orthophotos can be used as maps to directly measure distances, angles, locations, and areas without having to compensate for picture displacements because they are planimetrically accurate. Of course, perspective images can't be used for this. In conjunction with geographic information systems, orthophotos are frequently used to create layers of data for databases as well as to act as planimetric frames of reference for analysis.

Orthophotos are produced from perspective photos (usually aerial photos) through a process called dif essential rectification, which eliminates image displacements due to photographic tilt and terrain relief



Figure 4-4: Orthophoto

4-3-4 Photogrammetry Processing

In this project, aerial photographs and their functions are used in the process of digitizing the required survey plans and inferring them and taking the required data that represents the current situation of the area. Where the aerial photograph is used after ensuring the validity of its data in terms of image clarity and date of imaging, as well as according to the validity and the accuracy of its coordinates.[28]

The aerial photograph of Tulkarm city used in this project was taken from the Palestinian Ministry of Local Government, and the validity of the image was confirmed in terms of the date of photography and clarity, as the image was photographed in 2021, and any missing data were left for field survey work. In terms of the correctness of the coordinates, the image is in its correct location, but the accuracy of the coordinates is not acceptable and needs to be modified to put the image in its exact correct location.

4-3-5 Control points observation

For analytical photogrammetry, a certain number of control points in object space are typically necessary. In most cases, a field survey technique like GPS is used to identify the object space coordinates of these control points, which could be either image-identifiable features or exposure stations of the actual images. The object space coordinates must be established using a three-dimensional cartesian system with straight, parallel axes. Often, this calls for three-dimensional coordinates.[28]

The first practical step in the process of correcting the coordinates of the aerial image is the process of monitoring the control points in the city of Tulkarm, taking into consideration the selection of the locations of the points so that they are visible and clearly identifiable on the aerial image.

See figure 4-5.



Figure 4-5: Control points observation

4-3-6 Georeferencing

Georeferencing means that the internal coordinate system of a map or aerial photo image can be related to a geographic coordinate system. The relevant coordinate transforms are typically stored within the image file (Geo PDF and Geo TIFF are examples), though there are many possible mechanisms for implementing georeferencing. The most visible effect of georeferencing is that display software can show ground coordinates (such as latitude/longitude or UTM coordinates) and also measure ground distances and areas. Geographical locations can be defined in multiple spatial dimensions: 0-dimensional (points), 1-dimensional (lines), 2-dimensional (areas) and, rarely.[28]

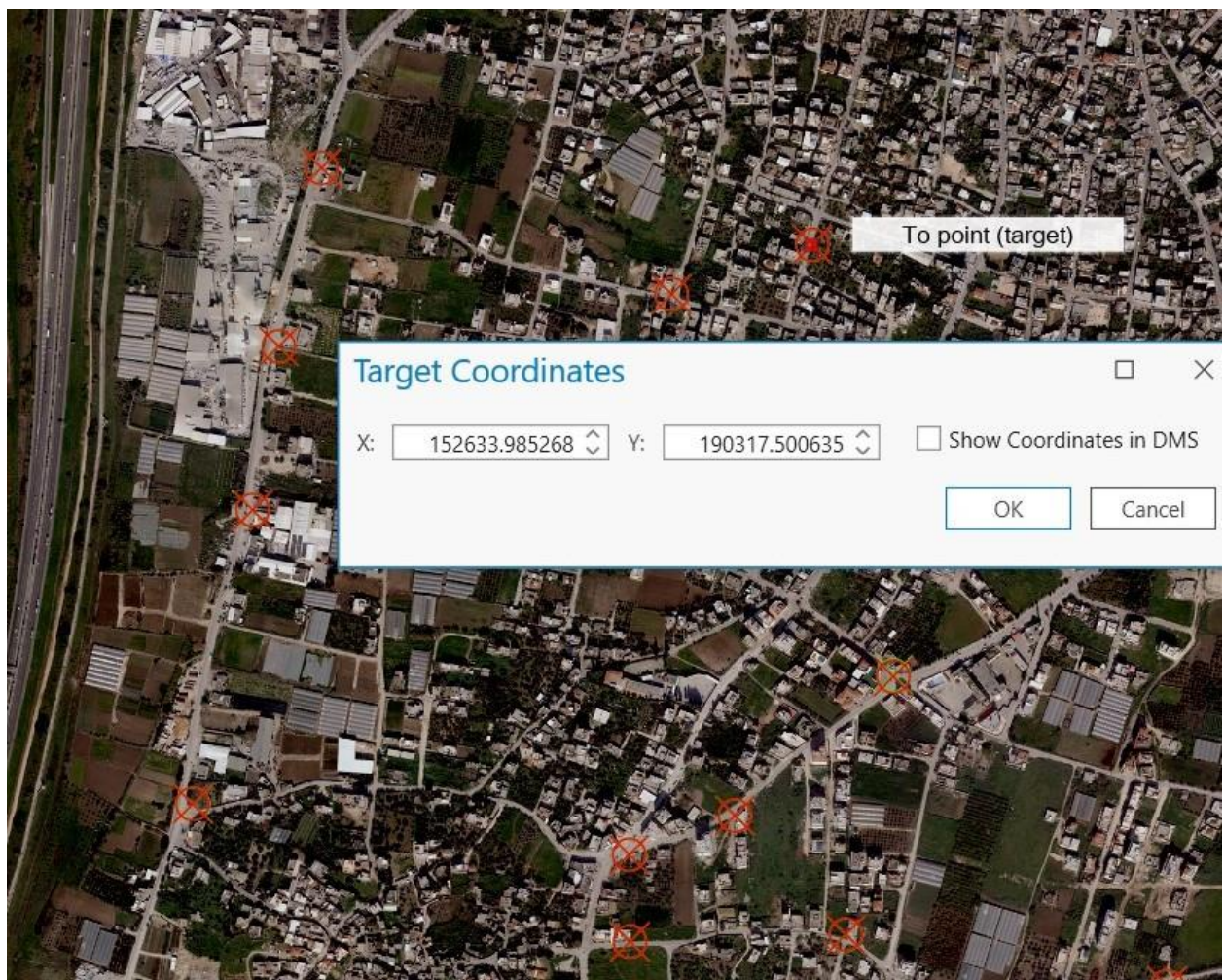


Figure 4-6: Georeferencing

Chapter Five: Analyzing & Results

5-1 Introduction

5-2 Data Collection

5-3 Analyzing

5-4 Project obstacles

5-5 Model Builder

5-6 Processing

5-7 Results

5-1 Introduction

In general, the city of Tulkarm suffers from many planning problems that limit and reduce the vitality and effectiveness of this city. One of these problems is the mixing of land uses in some areas of the city without the existence of any law that defines and controls this use, there is actually existing roads overlapping with the boundaries of the residential building and lands. In addition, roads under construction overlap with it as well, and there are areas that have no urban plan, in addition to many other problems that this city suffers from daily and which will be discussed in this study.

5-2 Data Collection

5-2-1 Identify the work area of Tulkarm city

Identify the work area of Tulkarm city and then pay a reconnaissance visit to the site and take a full idea of the nature of the project and the problems related to it and the important details of design and implementation to get the best and most accurate results.

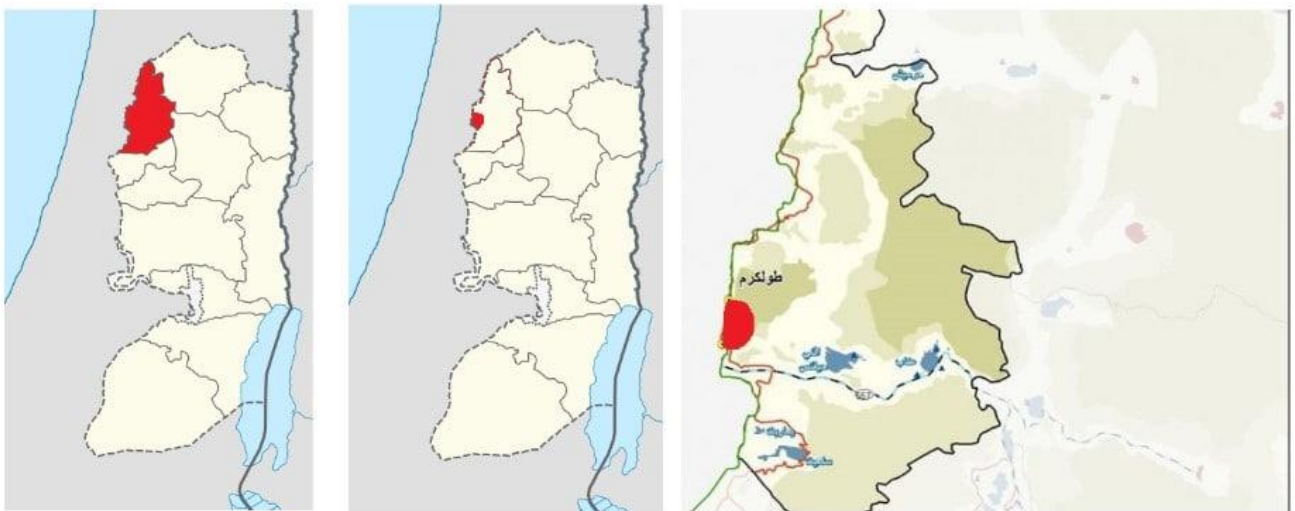


Figure 5-1: Study Area

5-2-2 Obtain the orthophoto of the Tulkarm region from the local government

The orthophoto of the study area was obtained from the local government for the year 2022, after which it was processed and clipped through GIS tools.



Figure 5-2: Orthophoto of Tulkarm

5-2-3 Control points distribution in the ortho photo

The locations of the control points were carefully and deliberately chosen to achieve the highest percentage of accuracy in georeferencing & RMSE, and they are distributed in a way that covers most of the aerial image of the study area. It was observed by GNSS tools.



Figure 5-3: Control points

5-2-4 The current Master Plan



Figure 5-4: The current Master Plan

5-2-5 Parcels

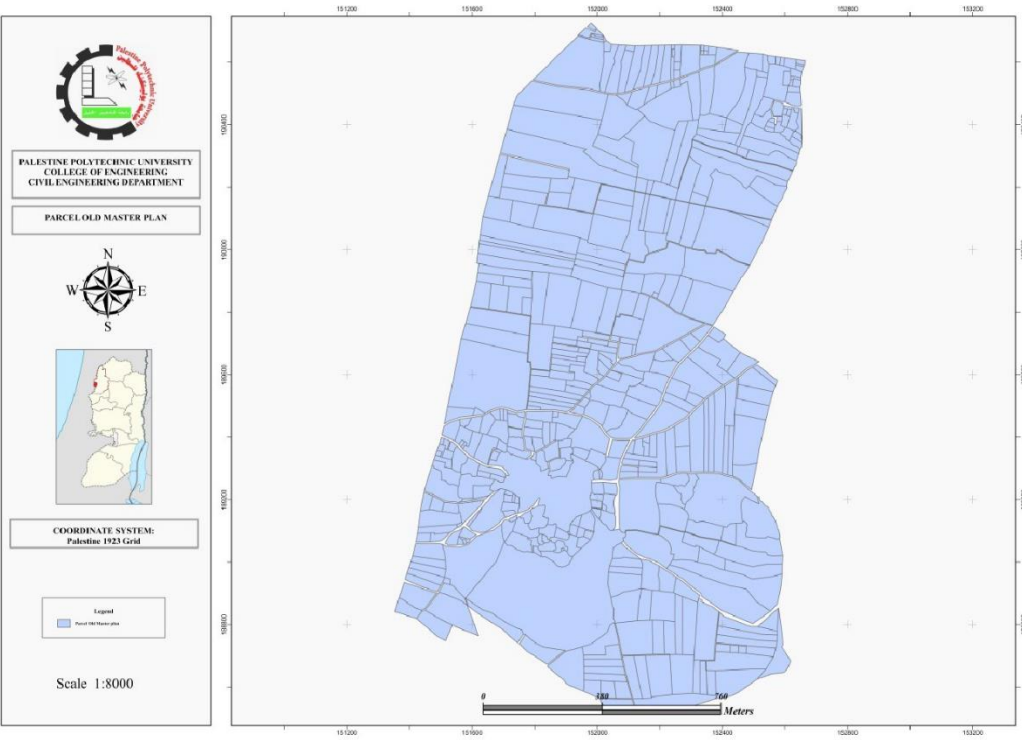


Figure 5-5: Parcels

5-2-6 Contour Line 5 meter

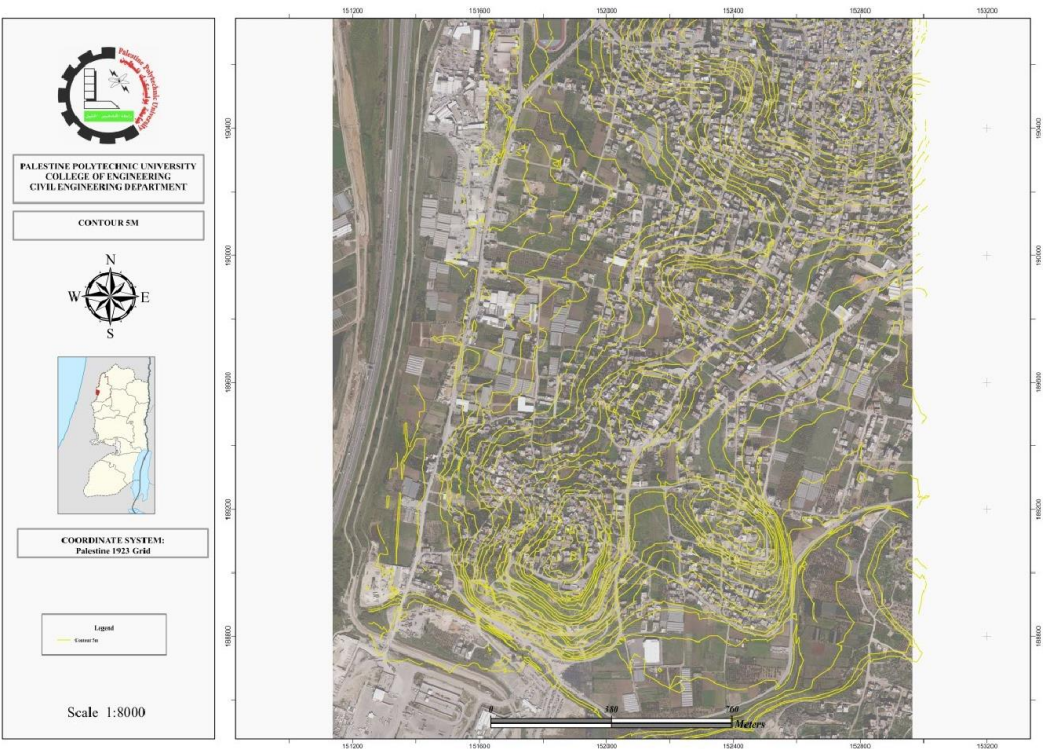


Figure 5-6: Contour Lines

5-2-7 Landuse



Figure 5-7: Landuse

5-3 Analyzing

In this study, a lot of geographic information systems and other analysis tools were used, and they will be explained below

5-3-1 RMSE

The root mean square error (RMSE), a statistical measure, is frequently used as the basis for modern map accuracy standards. Finding the mismatch between the coordinates calculated from map points and the same points observed with a higher-order check survey is necessary to evaluate the correctness of a map. In order to get coordinate values at the same locations throughout the field survey, it is obvious that these points must be clearly delineated on the map and on the surface of the earth.[29]

Since the check survey must be more accurate than the map, these differences are frequently regarded as residuals because the check survey's results are thought to be accurate and so represent the true values. This idea of considering values obtained from a higher-order survey to be true values has been used before. For instance, since the surveys used to determine these values are thought to be more accurate than what a typical field survey would reveal, the distances stated on the coordinate datasheet for a station or the lengths listed on an EDM calibration baseline report are frequently considered the genuine values.

The square root of the average of the squared residuals for the tested values is known as RMSE. In order to assess the correctness of a map, it is necessary to compare the coordinates and elevation of points derived from a map with their values as established by a check survey. In mathematics, RMSE is represented as

$$\text{RMSE} = \sqrt{\sum_{i=1}^n \frac{[f(x_i) - x_i]^2}{n}}$$

Figure 5-8: RMSE

In this study RMSE results is:

	1	2	3	4	5	6	7	8	9
Point	x(m)	y(m)	z(m)	E(m)	N(m)	H(m)	$\Delta E(m)$	$\Delta N(m)$	$\Delta H(m)$
1	151916.658	190243.632	55.115	151916.611	190243.660	55.761	0.047	-0.028	-0.646
2	152233.465	190544.423	77.434	152233.491	190544.418	76.702	-0.026	0.005	0.732
3	152281.771	190551.550	78.591	152281.687	190551.465	78.293	0.084	0.085	0.298
4	152263.535	190544.094	77.882	152263.661	190544.165	77.655	-0.126	-0.071	0.227
5	152266.028	190600.586	83.689	152266.022	190600.645	83.682	0.006	-0.059	0.007
6	152249.756	190668.500	87.780	152249.892	190668.412	87.501	-0.136	0.088	0.279
7	152390.515	190667.834	92.677	152390.580	190667.763	92.312	-0.065	0.071	0.365
8	152381.395	190633.759	90.513	152381.375	190633.670	90.271	0.020	0.089	0.242
9	152330.552	190577.737	82.845	152330.547	190577.659	82.165	0.005	0.078	0.680
10	152497.642	189220.148	62.568	152497.674	189220.182	63.210	-0.032	-0.034	-0.642
11	152444.033	189858.472	80.098	152444.060	189858.524	81.103	-0.027	-0.052	-1.005
12	151875.625	188981.197	92.842	151875.573	188981.204	92.374	0.052	-0.007	0.468
13	151915.336	189919.034	58.000	151915.426	189919.093	57.898	-0.090	-0.059	0.102
14	151765.979	189490.345	62.000	151765.884	189490.339	61.789	0.095	0.006	0.211
15	152561.843	190075.190	75.984	152561.938	190075.263	76.044	-0.095	-0.073	-0.060
						Sum	0.080	0.056	3.525
						S	0.073	0.063	0.494
						RMSE	0.073	0.061	0.485
						RMSE Sq	0.005	0.004	0.235
						RMSEr	0.095		

Table 5-1: RMSE

5-3-2 Pyramid

By only getting the data at a specific resolution needed for the display, pyramids can speed up the presentation of raster data. When drawing the complete dataset, pyramids immediately display a lower-resolution duplicate of the data. Performance is maintained because you're drawing progressively smaller areas as you zoom in because levels with finer resolutions are generated. Based on the user's display scale, the database server automatically selects the best pyramid level. The full dataset must be read from disk and resampled to a smaller size in the absence of pyramids. When the ArcGIS display is refreshed, this is known as display resampling.

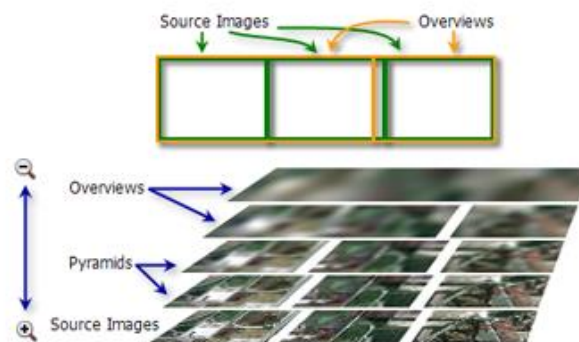


Figure 5-9: Pyramid Layers [30]

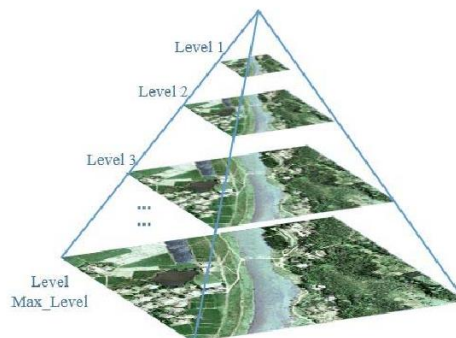


Figure 3-10: Pyramid [30]

In addition, the GIS analyzing tools mentioned in [Chapter 3](#) were used, and the most important tool is **Model Builder** that will be explained in detail next in this chapter.

5-3-3 TIN

Triangular irregular networks (TIN), a digital method of representing surface morphology, have been used by the GIS community for many years. The creation of TINs, a type of vector-based digital geographic data, involves triangulating a collection of vertices (points). A network of triangles is created by connecting the vertices with a variety of edges. These triangles can be formed using a variety of interpolation techniques, including distance ordering or Delaunay triangulation. The Delaunay triangulation technique is supported by ArcGIS.[31]

The resulting triangulation assures that no vertex is inside the interior of any of the network's triangles' circumcircles, according to the Delaunay triangle criterion. The smallest internal angle of every triangle is maximized if the Delaunay criterion is met everywhere on the TIN. As a result, long, thin triangles are kept as far away from as practicable.

The position of linear features that are relevant to a surface, like ridgelines or stream courses, can be determined using the edges of TINs, which form continuous, nonoverlapping triangular facets.

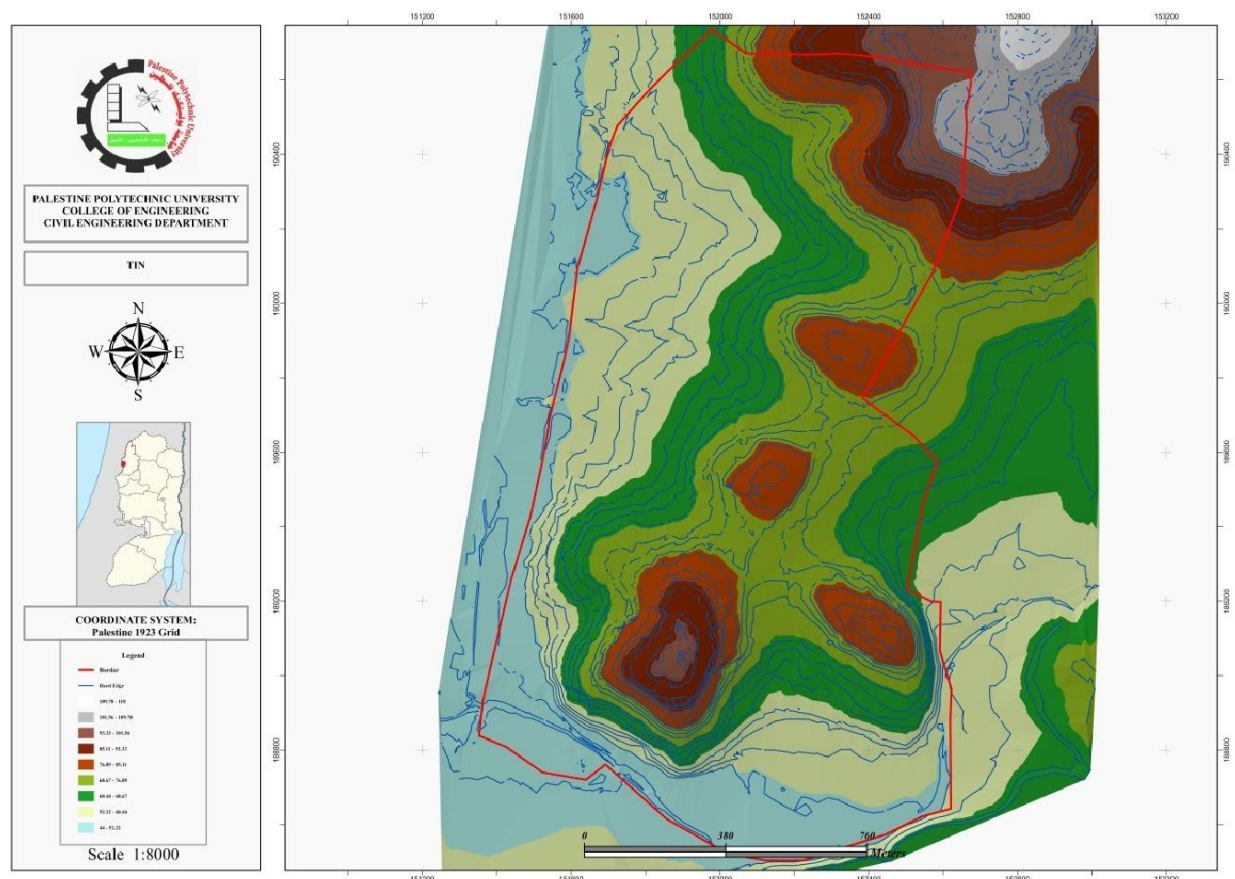


Figure 5-11: TIN

5-4 Project obstacles

These obstacles done while studying the current master plan.

5-4-1 Displacement in orthophoto after geofencing



Figure 5-12: Obstacles 1



Figure 5-13: Obstacles 2

5-4-2 Parcels are not emptied from roads

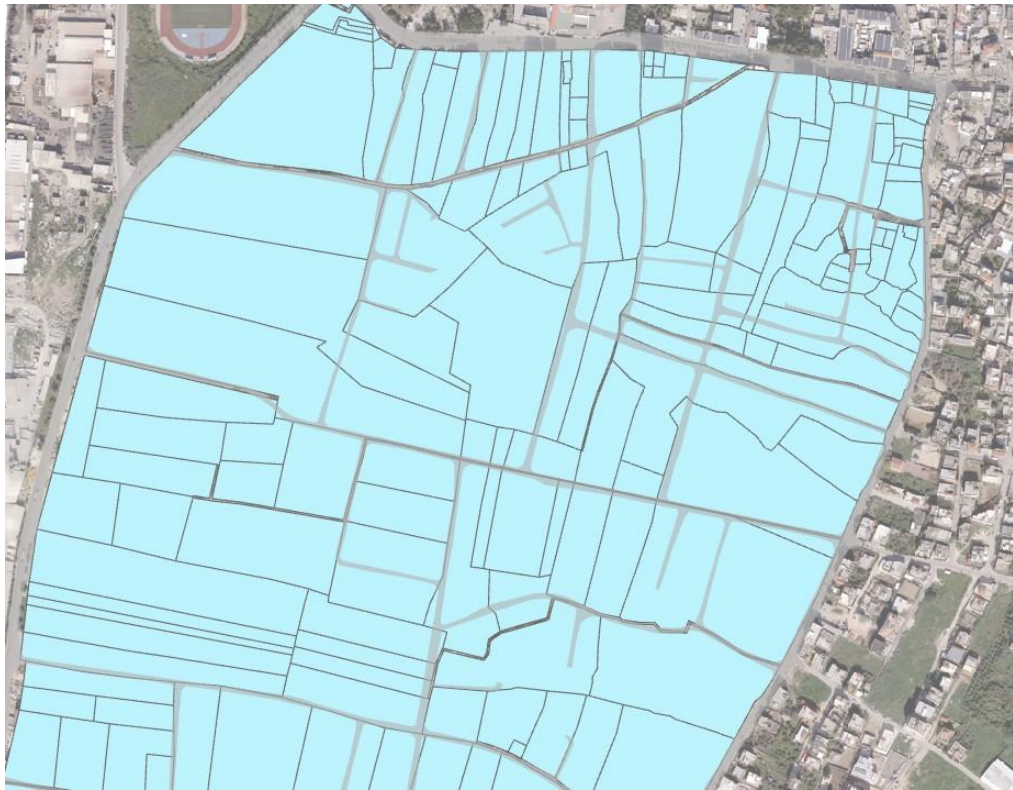


Figure 5-14: Obstacles 3



Figure 5-15: Obstacles 4

5-4-3 A large number of intersected places and the large time to search for them



Figure 5-15: Obstacles 5



Figure 5-16: Obstacles 6

5-5 Model Builder

ModelBuilder is an application you use to create, edit, and manage models. Models are workflows that string together sequences of geoprocessing tools, providing the output of one tool to another tool as input. ModelBuilder can also be thought of as a visual programming language for building workflows.[32]

5-5-1 Model Builder rules

- ✓ Add data and tools, then integrate them to create a model.
- ✓ Each feature class, raster, file, and table in a workspace should be processed iteratively.
- ✓ Try to imagine your workflow cycle as a simple diagram.
- ✓ Run a model in its entirety, up to a chosen step, or step by step.
- ✓ Transform your model into a geoprocessing tool that can be shared or applied to other models and Python scripts.[32]

5-5-2 Model Builder Creation

To create a geoprocessing model in ModelBuilder, add tools and data to a model and connect them to determine the order in which they should be used.

5-5-2-1 Add ModelBuilder

On the Analysis tab, in the Geoprocessing group, click ModelBuilder

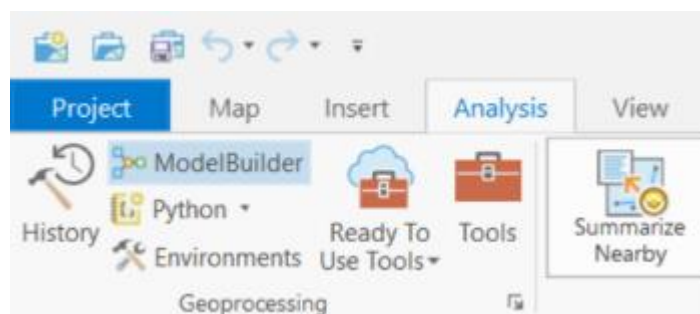


Figure 5-17: ModelBuilder

5-5-2-2 Add Data

Models operate on data, using one geoprocessing tool's result as the input to another. Drag layers from the map's contents and datasets from the project into the model to add data. The layers and datasets are added to the model and displayed as input data variables.

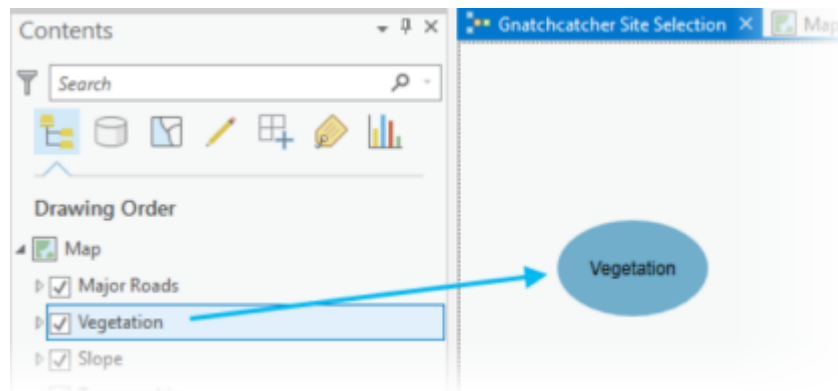


Figure 5-18: Add Data

5-5-2-3 Add geoprocessing tools

The model's essential building piece is a geoprocessing tool. For completing a wide range of GIS activities, ArcGIS Pro provides a large variety of geoprocessing tools. It is simple to add those tools to a model once you are aware of the best tools for the job at hand.

Start looking for a tool to apply a geoprocessing to your model. The Add Tools to Model dialog box will show a list of search results. To include a tool in the model, double-click on it. As an alternative, you can drag a geoprocessing tool from the Geoprocessing pane or Catalog pane into the model.

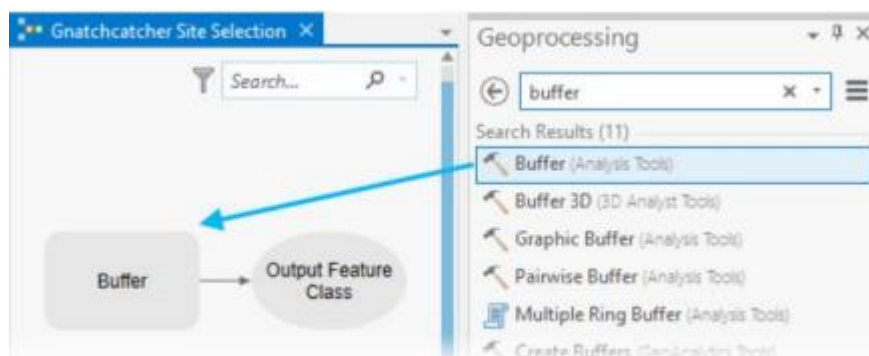


Figure 5-19: Add geoprocessing tools

5-5-2-4 Connect data and tools

Data and tools can be connected to processes using geoprocessing models. The model's data variables that shall be processed by which geoprocessing tools must be specified.

By making a connection between the data variables that were introduced to the model and the tool, you can attach them directly to that tool's parameter. One tool's output can serve as the input for another tool.[32]

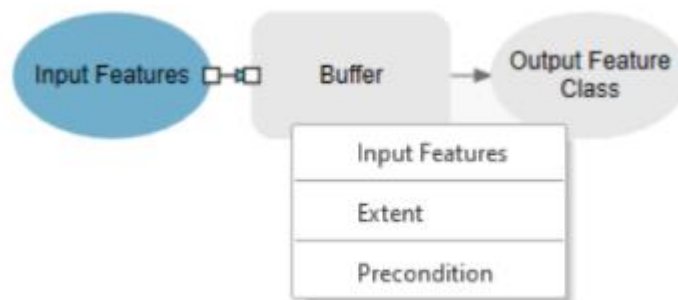


Figure 5-20: Connect data and tools

5-5-3 Model Elements

The fundamental components of models are known as model elements. Model components can be divided into four categories: geoprocessing tools, variables, connectors, and groups.

- ❖ Geoprocessing tools perform various operations on geographic or tabular data. When tools are added to a model, they become model elements. You can open the tool dialog box of any geoprocessing tool in your model to set the input and output parameters.
- ❖ Variables are elements in a model that holds a value or a reference to data. There are two types of variables: data and value variables.
- ❖ Connectors connect data and values to tools. The connector arrows show the direction of processing. There are four types of connectors: data, environment, precondition, and feedback.
- ❖ Groups are visual elements that group related tools together. These groups can collapse or expand to hide or show tools, providing more visual space to work with.

The illustration and table below show the different model elements in ModelBuilder.







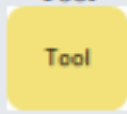
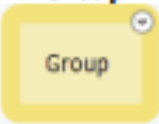
Element	Description
Data variable 	<p>Data variables are model elements that store paths and other properties of data on disk. Common data variables include feature class, feature layer, raster dataset, and workspace.</p>
Derived or output data variable 	<p>It is new data created by a tool in the model, when a geoprocessing tool is added to a model, variables for the tool's output parameters are automatically created and connected to the tool.</p> <div>  <p>This tool creates a dataset that is written to disk when the model is run.</p>  <p>This tool alters the input data when the model is run. By default, the in/out derived data variable will have the same name as the input data but with a unique number appended at the end.</p> </div>
Value variable 	<p>Value variables are values such as strings, numbers, Boolean (true/false values), spatial references, linear units, or extents. Value variables contain anything but references to layers or data stored on disk.</p>
Derived value variable 	<p>Values that are the result of a tool. Derived values can be inputs to other tools. The Calculate Value tool, for example, outputs the result of a logical or mathematical calculation.</p>
Tool 	<p>ModelBuilder utilities are tools that help construct models and only work within ModelBuilder, not in scripting.</p>
Group 	<p>Groups are visual categories that include other elements in the model. These groups can be expanded and collapsed.</p>

Table 5-2: ModelBuilder Elements

5-5-4 Model Builder Processes

A model process consists of a tool and all variables connected to it. Connector lines indicate the sequence of processing. Many processes can be chained together to create a larger process.

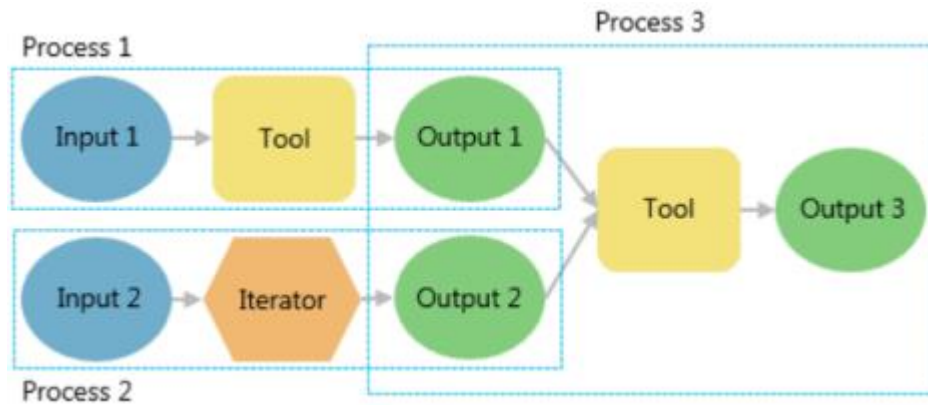


Figure 5-21: Model Builder Processes

5-6 Processing

In this study the processing stage is divided into three categories: Ortho photo, The current Master Plan, the future master plan (recommended).

5-6-1 Ortho photo

The ortho photo 2022 is obtained from the local government, processed by "Pyramid" mentioned in [5-3-2 Sec.](#) and georeferenced by 15 control points distributed in specific order shown in [5-2-3 Sec.](#) its accuracy calculated using RMSE mentioned in [5-3-1 Sec.](#) its results were:

		$\Delta E(m)$	$\Delta N(m)$	$\Delta H(m)$
	Sum	0.080	0.056	3.525
	S	0.073	0.063	0.494
	RMSE	0.073	0.061	0.485
	RMSE Sq	0.005	0.004	0.235
Resultant	RMSEr	0.095		

Table 5-3: RMSE Results

5-6-2 The current Master Plan

This Master Plan is produced in 2005, so an ortho photo in the same year is needed to achieve the highest accuracy in this study.

5-6-2-1 Ortho photo 2005



Figure 5-22: Ortho photo 2005

5-6-2-2 Overlay the current Master Plan & Ortho Photo

After obtained the current Master Plan & Ortho Photo 2005 for the city of Tulkarm from the local government and identifying the coordinates system for the plan and photo as "Palestine 1923 Grid", The current Master Plan overlayed with ortho photo. This step done to check any lake or shortage exist in the current Master Plan.

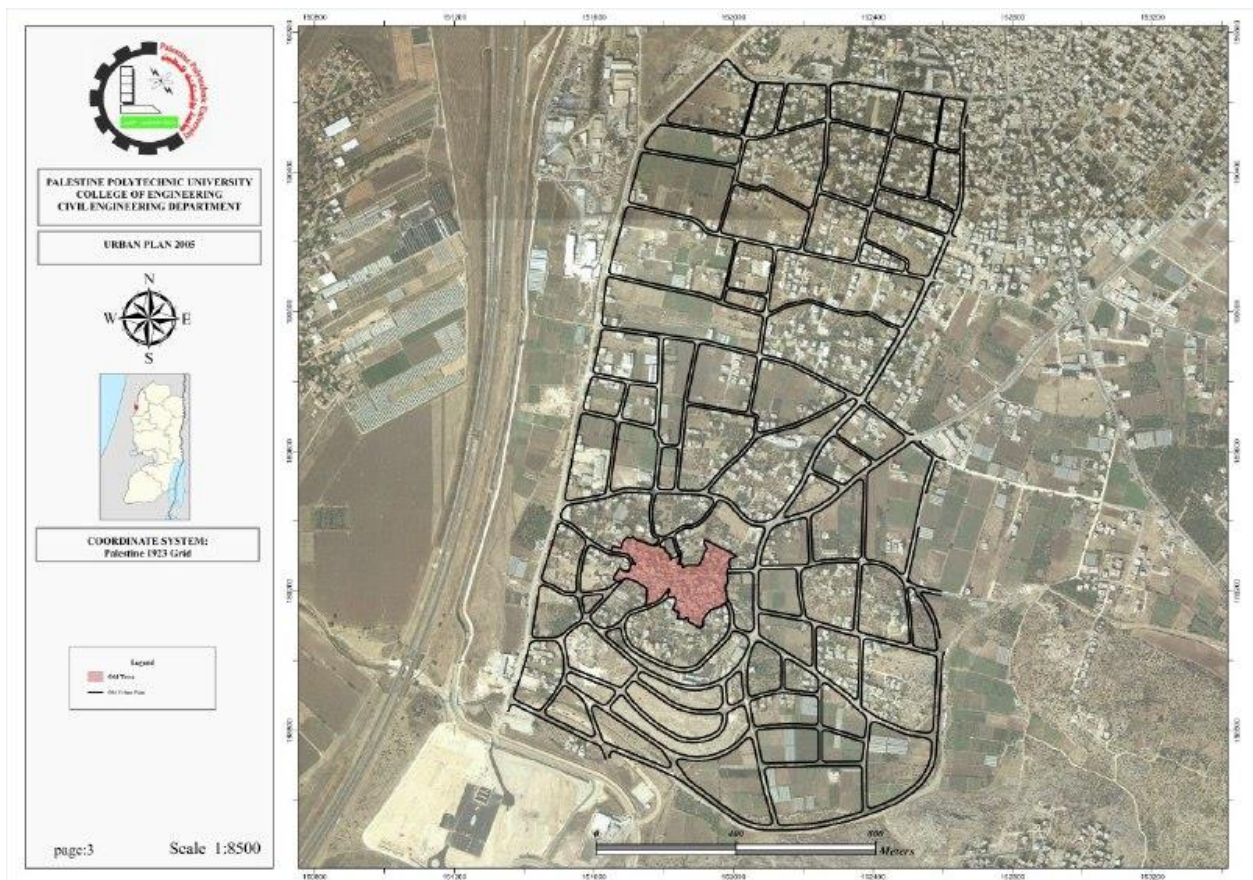


Figure 5-23: Overlay

5-6-2-3 Digitizing

The next step is digitizing the built up areas and roads that does not appear in the current Master Plan to start over evaluating and analyzing the plan using the GIS analyzing tools mentioned in [Chapter 3](#) and in [5-5 Sec.](#) to produce statics and maps.

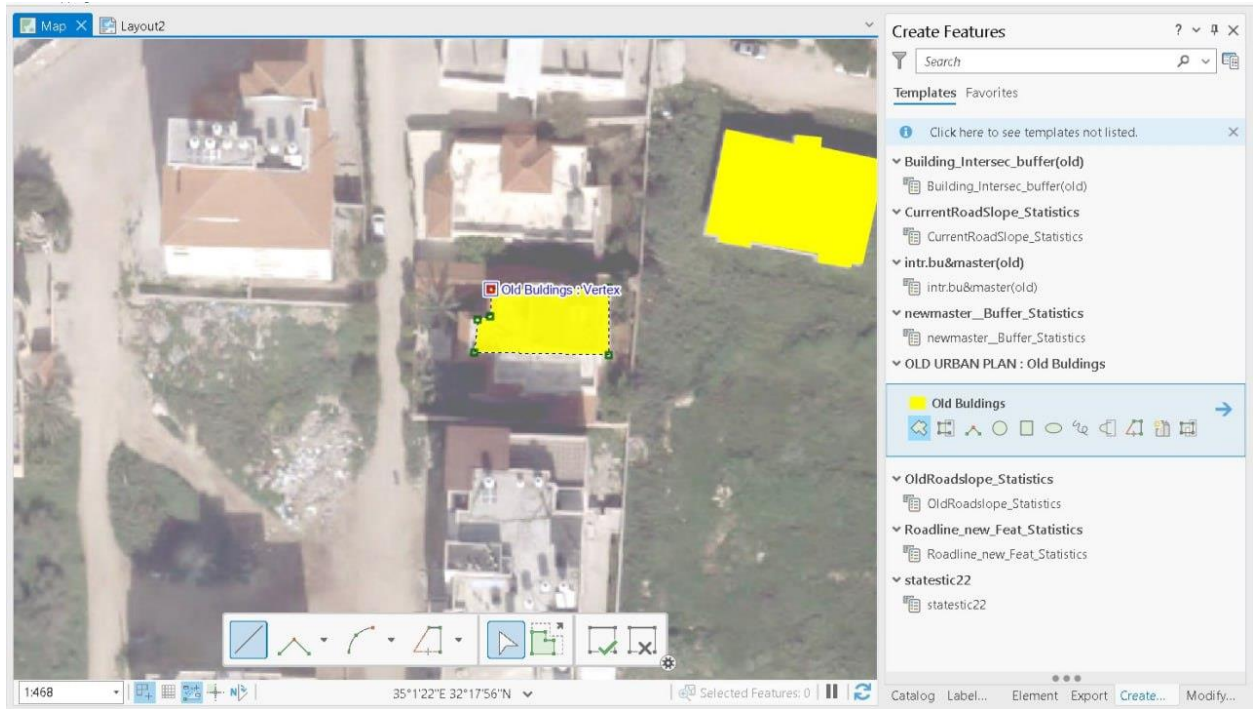


Figure 5-24: Digitizing

5-6-2-4 Create Model Builders to the current Master Plan

Model Builder is useful to calculate the statistics and produce raster maps that needed in this study, three models are needed and applied to both of the current and the future Master Plan: **Budlings & Roads intersect**, **"Building & Buffered Roads intersect"**, **Road's centerline slope**, **Master plan intersected area with Parcels**.

5-6-2-4-1 Building & Roads Model

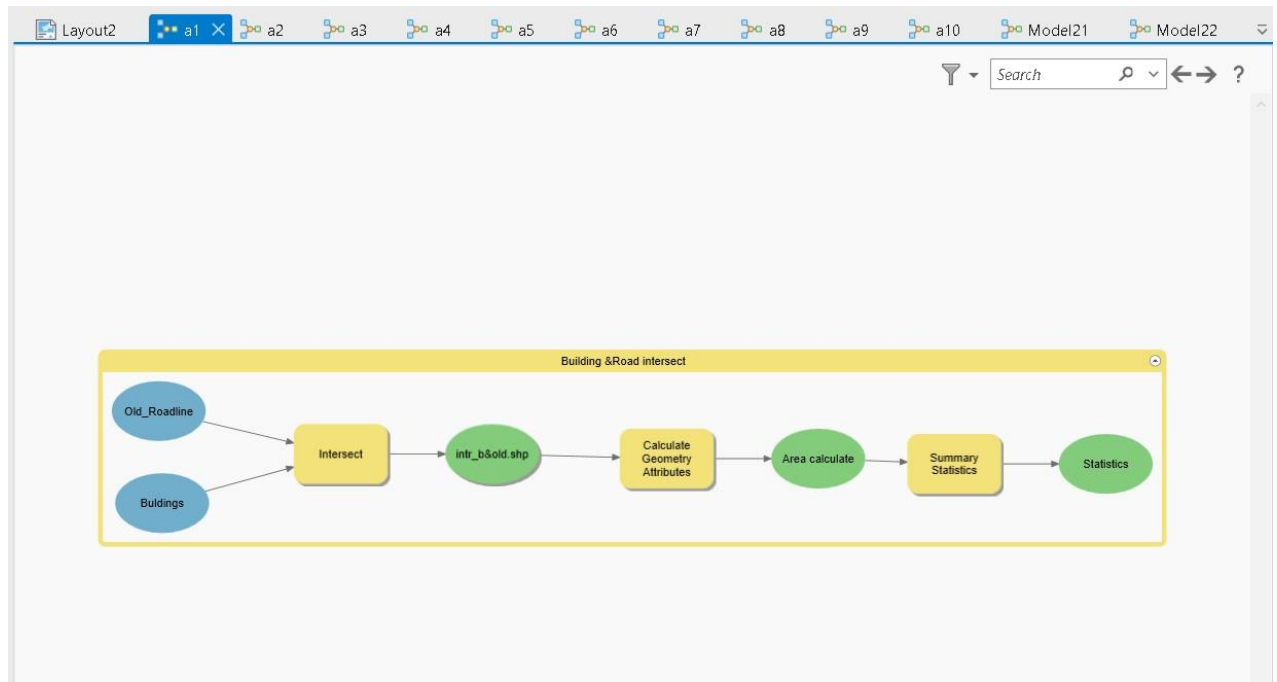


Figure 5-25: Building & Roads Model

❖ Objectives of this model:

- ✓ Find the intersected area between the current building and the current master plan roads.
- ✓ Calculate the area of the intersection in square meters.
- ✓ Calculate the statistic of intersected area.

❖ The previous model runs the following tools in sequence:

- ✓ Intersect — Overlay the output of the Erase tool with other map layers, including the current building and the old master plan roads. This identifies the areas that meet all criteria.
- ✓ Calculate geometry attributes — Adds information to a feature's attribute fields representing the spatial or geometric characteristics and location of each feature, such as length or area and x-, y-, z-coordinates, and m-values.
- ✓ Summary statistics — Calculates summary statistics for fields in a table.

5-6-2-4-2 Building & Buffered Roads intersect

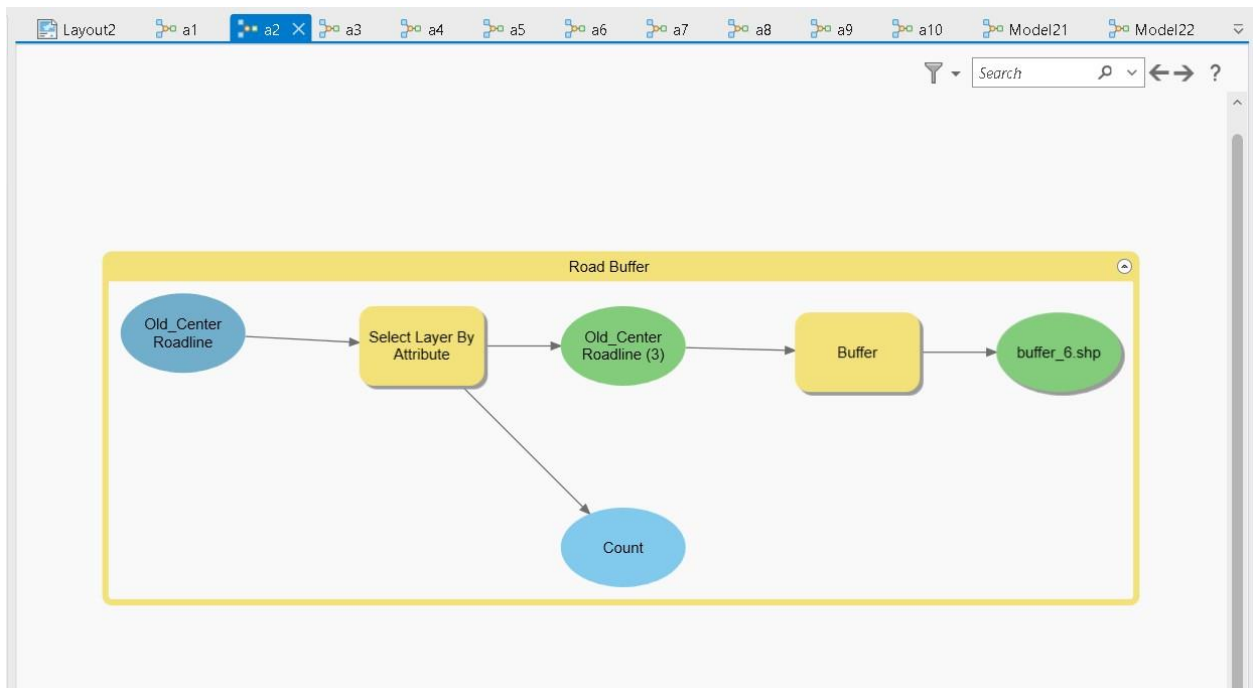


Figure 5-26: Building & Buffered Roads intersect 1

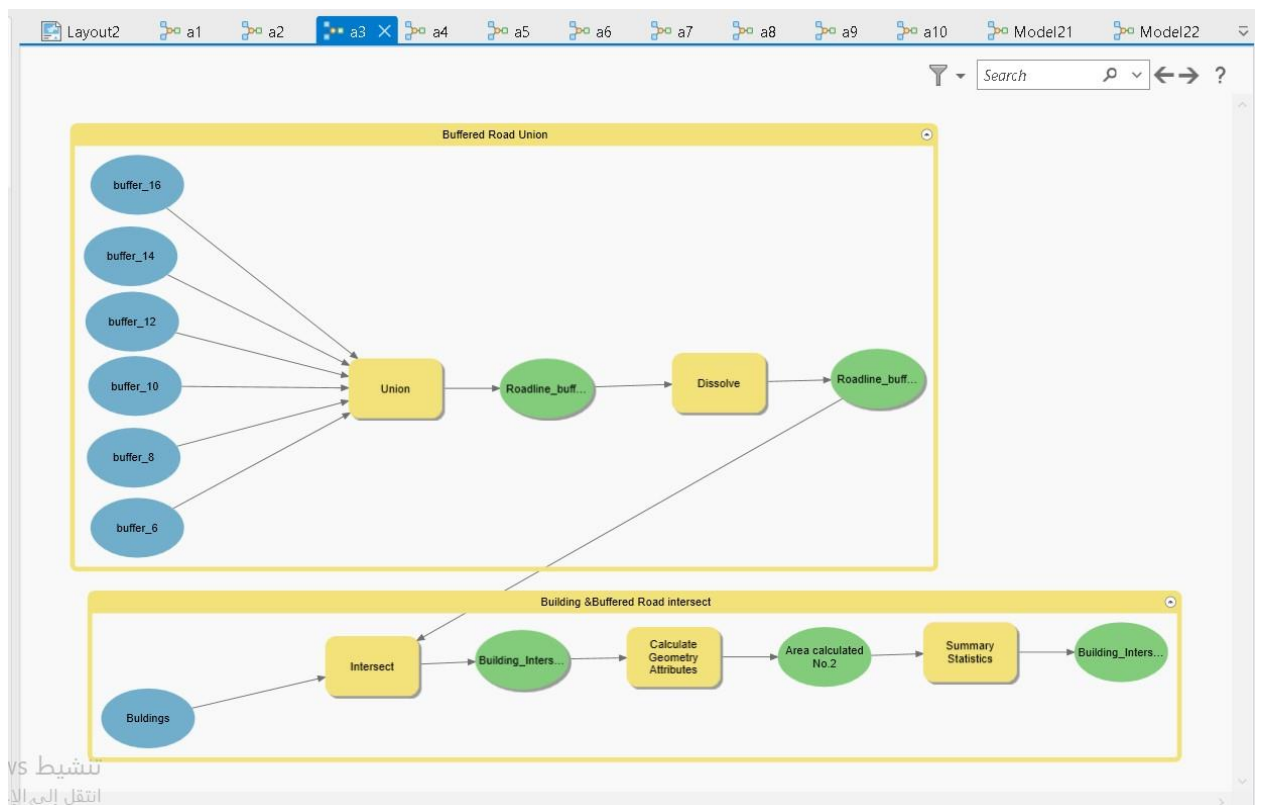


Figure 5-27: Building & Buffered Roads intersect 2

❖ Objectives of this model:

- ✓ Buffer all the old master plan center line types with the standard road width according to AASHTO specifications.
- ✓ Union and dissolve the buffered roads to remove the overlap and finally get one road polygon shape file in order to be used in the intersect area calculation with the buildings.
- ✓ Find the intersected area between the current building and the buffered roads.
- ✓ Calculate the area of the intersection in square meters.
- ✓ Calculate the statistic of intersected area.

❖ The previous model runs the following tools in sequence:

- ✓ Select Layer by Attribute — Adds, updates, or removes a selection based on an attribute query.
- ✓ Buffer — Creates buffer polygons around input features to a specified distance.
- ✓ Union — Computes a geometric union of the input features. All features and their attributes will be written to the output feature class.
- ✓ Dissolve — Aggregates features based on specified attributes.
- ✓ Intersect.
- ✓ Calculate geometry attributes.
- ✓ Summary statistics.

5-6-2-4-3 Road's centerline slope

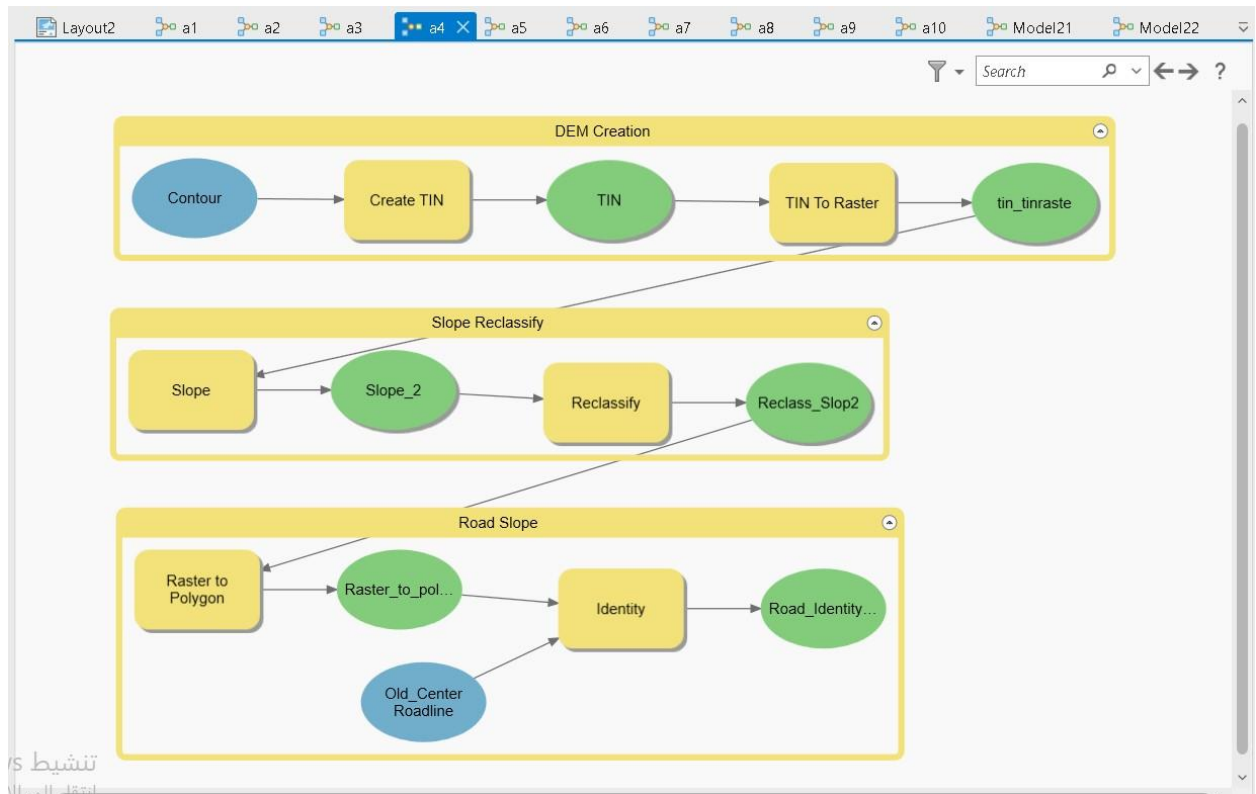


Figure 5-28: Road's centerline slope Model

❖ Objectives of this model:

- ✓ Use a contour layer to create a TIN surface then use it to generate a DEM raster.
- ✓ Using the DEM raster to create a slope raster that will be reclassified into intervals every 5%.
- ✓ Convert reclassified slope raster into shapefile "polygon" then and use it with the identify tool so that the road centerline takes the slope value from the slope shapefile.

❖ The previous model runs the following tools in sequence:

- ✓ Create TIN — Creates a triangulated irregular network (TIN) dataset.
- ✓ TIN To Raster — interpolates a raster using z-values from the input TIN.
- ✓ Slope — Identifies the slope (gradient or steepness) from each cell of a raster.
- ✓ Reclassify — Reclassifies (or changes) the values in a raster.
- ✓ Raster to Polygon — Converts a raster dataset to polygon features.
- ✓ Identity — Computes a geometric intersection of the input features and identity features.
- ✓ The input features or portions thereof that overlap identity features will get the attributes of those identity features.

5-6-2-4-4 Master plan intersected area with Parcels

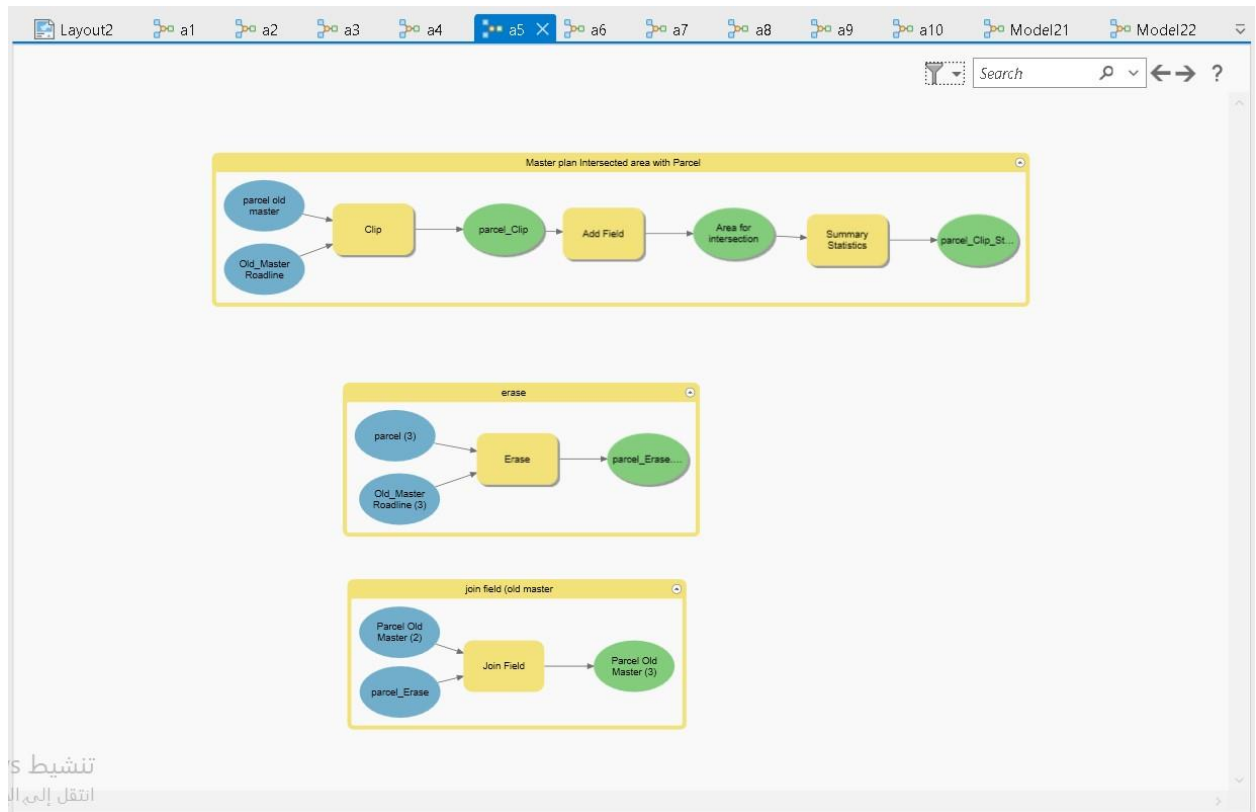


Figure 5-29: Master plan intersected area with Parcels Model

❖ Objectives of this model:

- ✓ Find the intersection between Master plan roads and Current Roads {Master-Current Roads intersection}.
- ✓ Clip the Parcel layer to the project area which is the Master plan area.
- ✓ Select & remove roads from the Parcel layer and save the output as {Parcel without roads}.
- ✓ Select & remove {Master-Current Roads intersection} from the Master Plan and save the output as {Master without roads}.
- ✓ Find the intersection between {Master without roads} & {Parcel without roads} and save the output as {Master-Parcel intersect} then calculate its area.
- ✓ Add field and calculate its area for {Master-Parcel intersect} and for {Parcel without roads}.
- ✓ Join tables between {Master-Parcel intersect} and {Parcel without roads} and present the output classification on the {Parcel without roads}.

- ❖ The previous model runs the following tools in sequence:
 - ✓ Intersect.
 - ✓ Select Layer by Attribute.
 - ✓ Calculate Geometry Attributes.
 - ✓ Summary Statistics.
 - ✓ Erase.
 - ✓ Clip — Extracts input features that overlay the clip features.
 - ✓ Add Field — Adds a new field to a table or the table of a feature class or feature layer, as well as to rasters with attribute tables.
 - ✓ Join Field — permanently joins the contents of a table to another table based on a common attribute field. The input table is updated to contain the fields from the join table. fields from the join table will be added to the input table.

5-6-3 The Future Master Plan

This Master Plan is recommended from Municipality of Tulkarm urban planners in 2022, the ortho photo is shown in [5-2-2 Sec](#) obtained from the local government. and georeferencing is mentioned in [5-6-1 Sec](#).

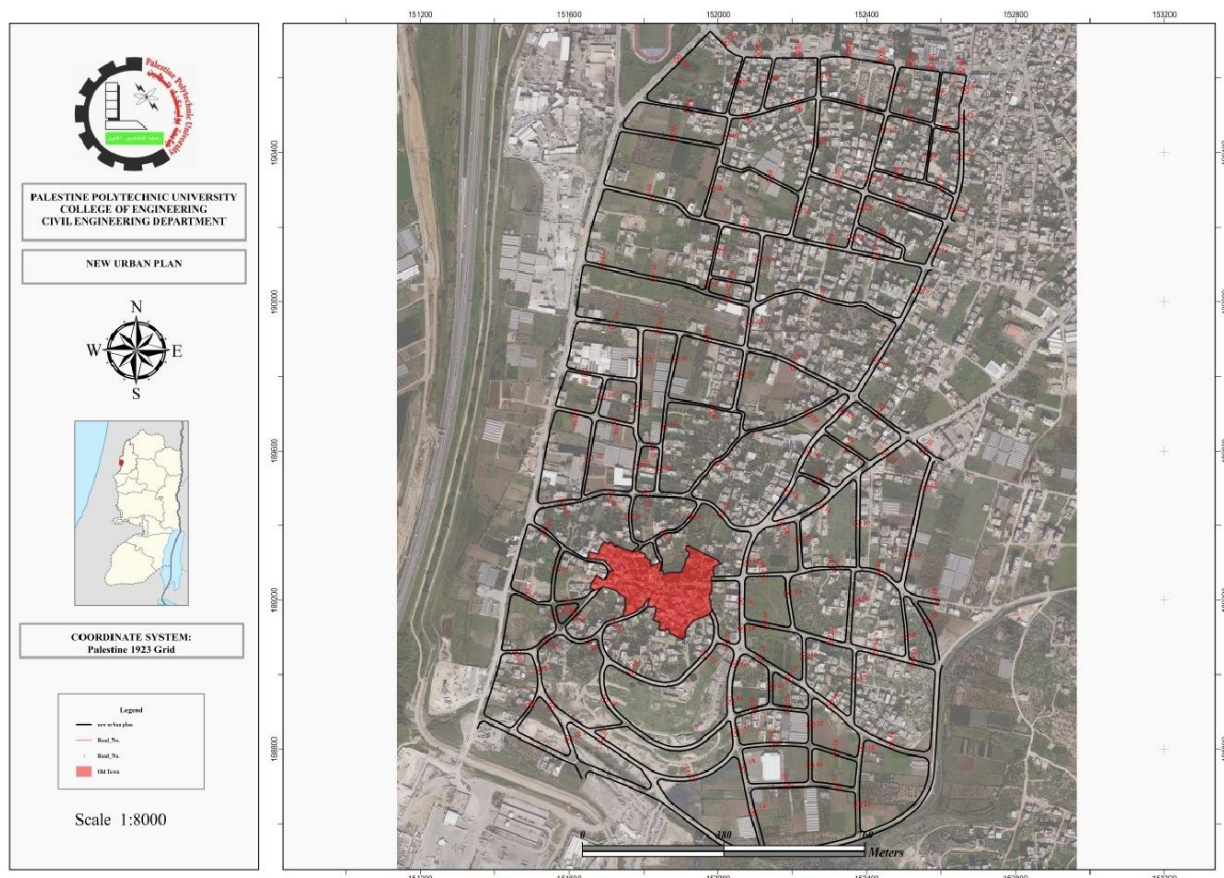


Figure 5-30: The Future Master Plan



Figure 5-31: Future Master Plan Parcels

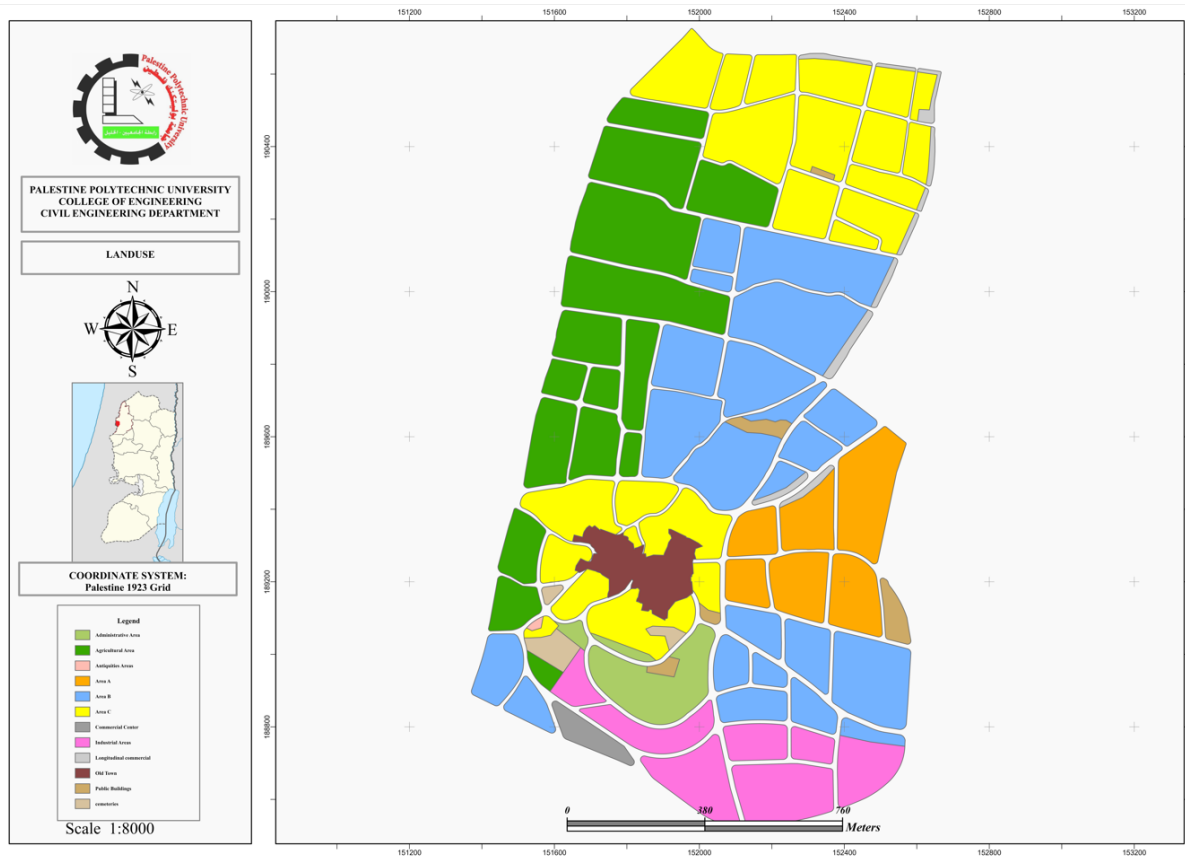


Figure 5-32: Landuse

The same steps were applied on the current Master Plan is applied to the future Master Plan to analyze and study it which is: Overlay, Digitizing, Create Model Builders. Then compare the current Master Plan results with the future Master Plan in [Results Sec.](#)

The same Model Builders with the same objectives and the using tools (in sequence) is created to the future Master Plan.

5-6-3-1 Building & Roads Model

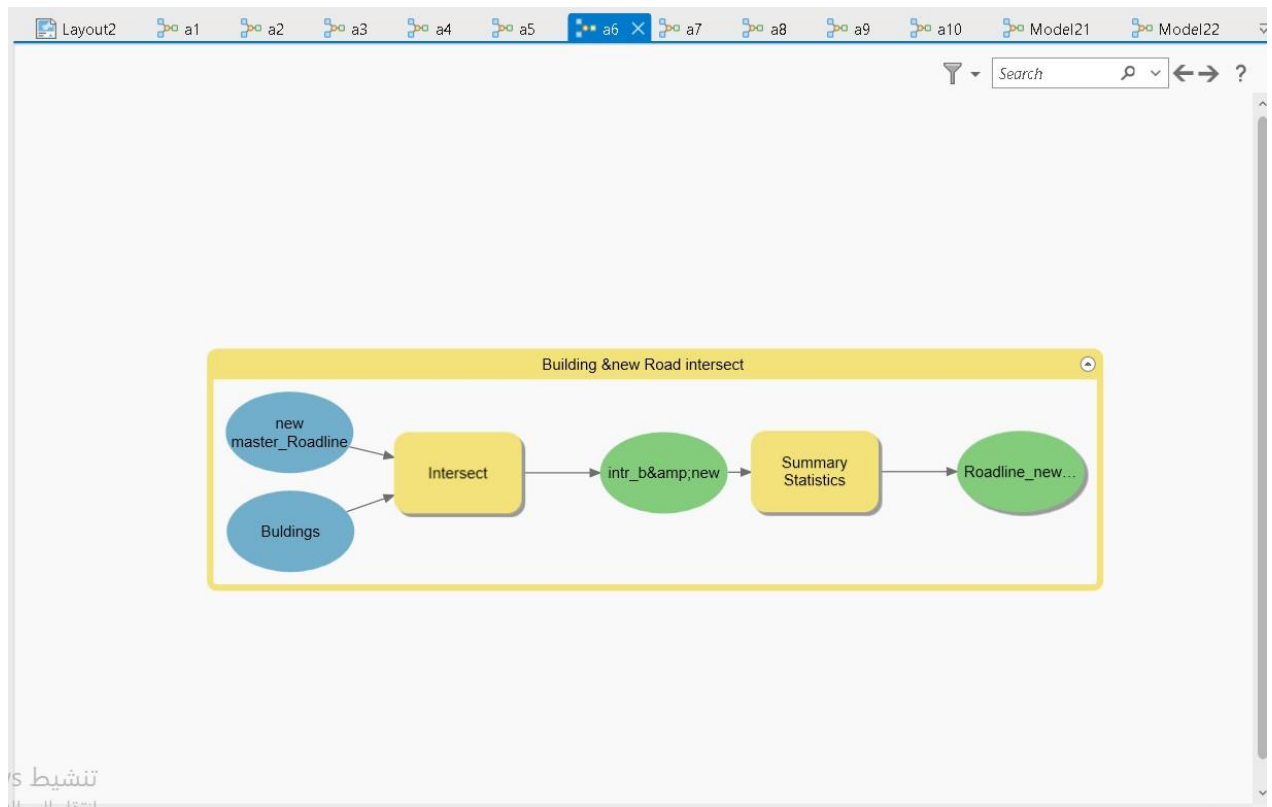


Figure 5-33: 1st Model

5-6-3-2-Building & Buffered Roads intersect

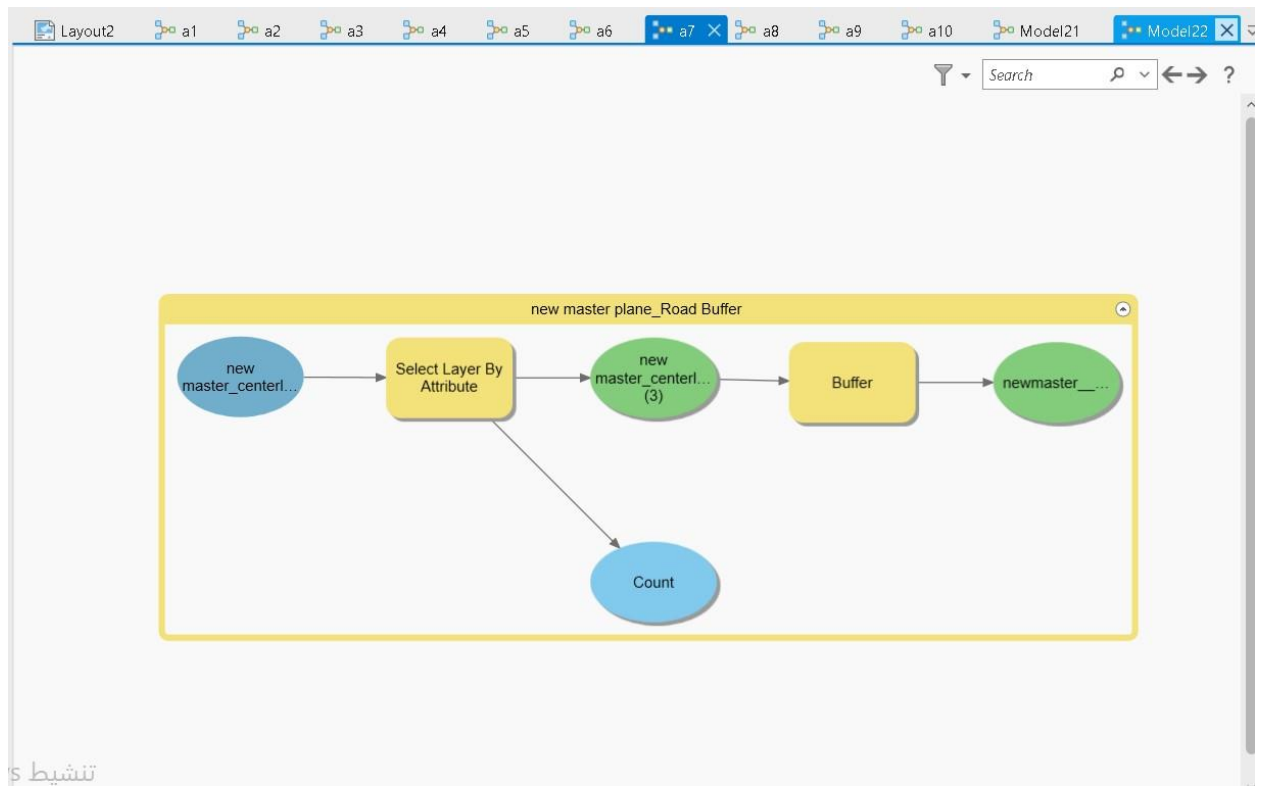


Figure 5-34: 2nd Model 1

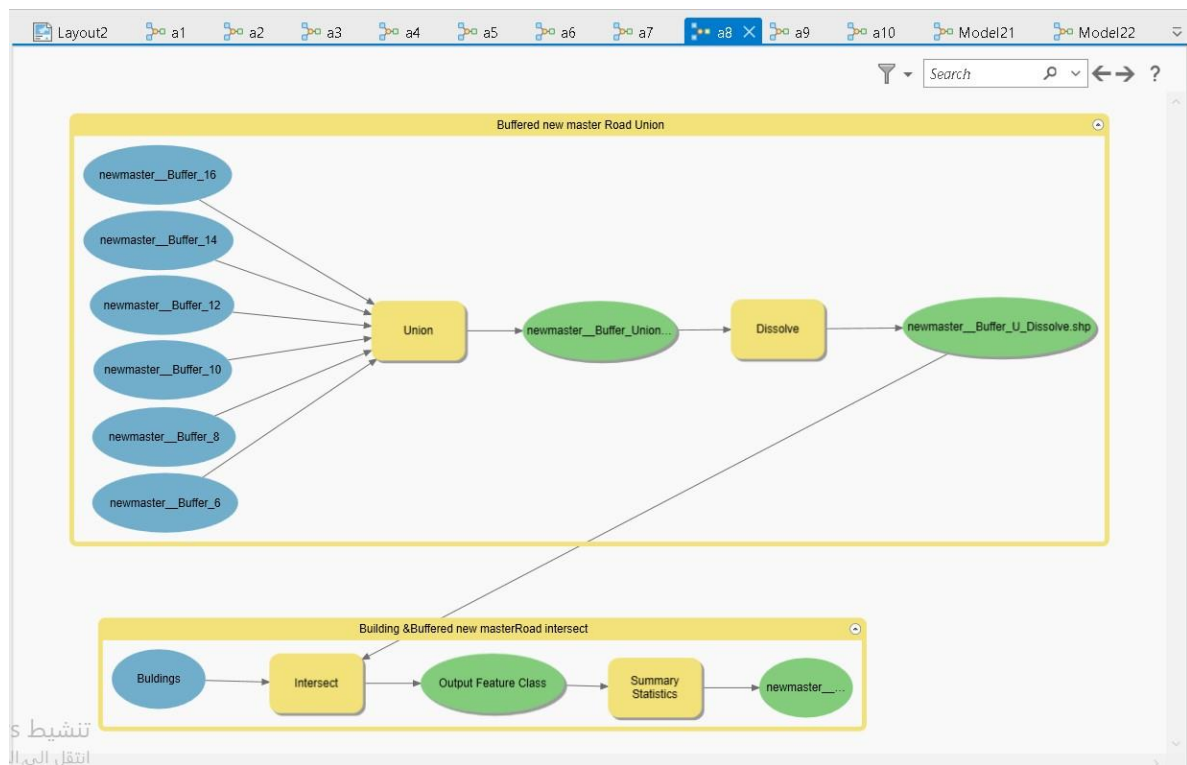


Figure 5-35: 2nd Model 2

5-6-3-3 Road's centerline slope

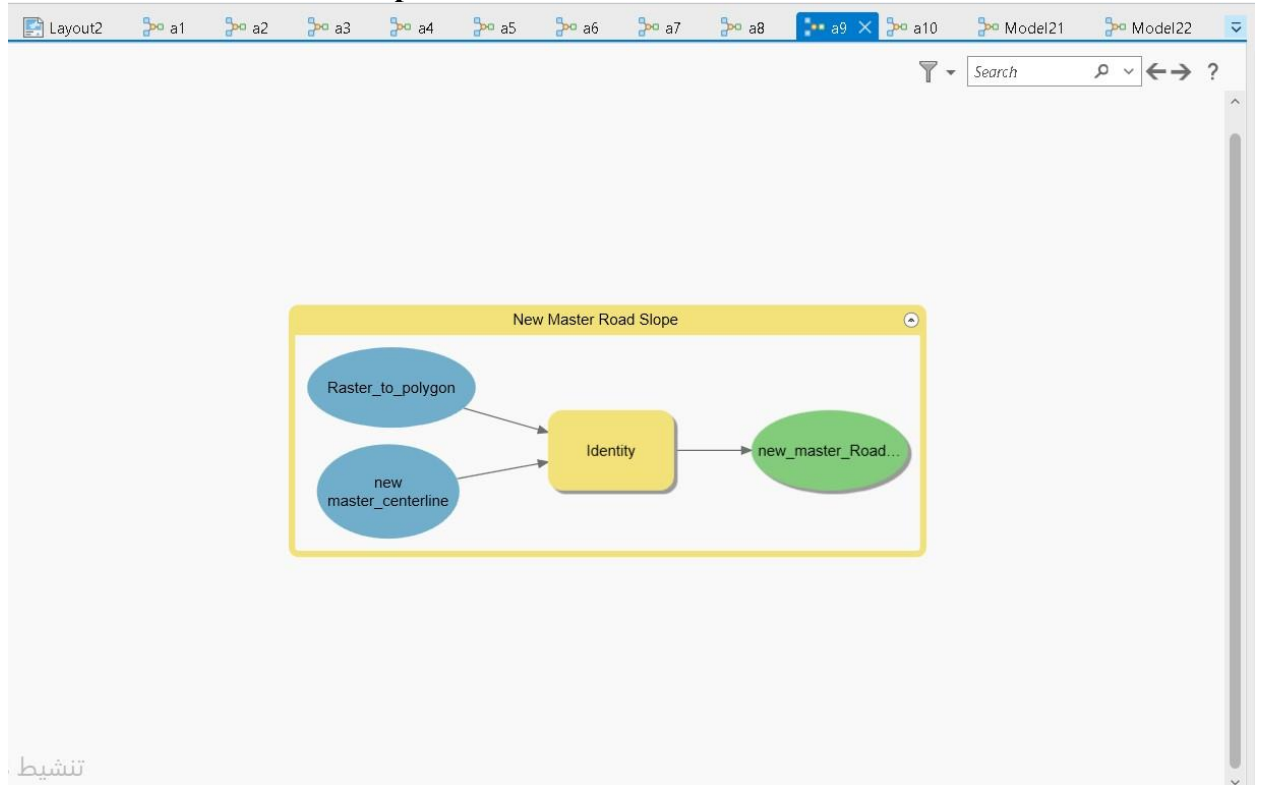


Figure 5-36: 3rd Model

5-6-3-4 Master plan intersected area with Parcels

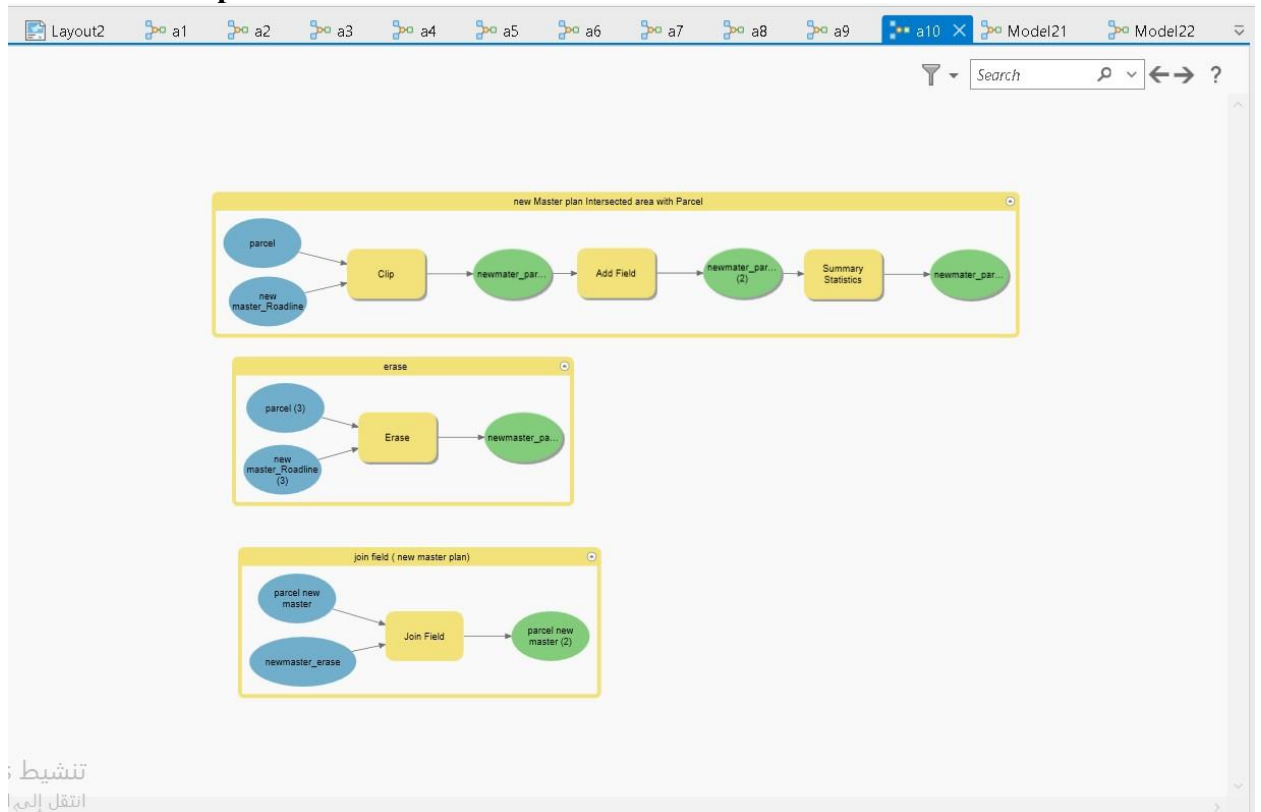


Figure 5-37: 4th Model4

5-7 Results

All Maps Mentioned and Produced in this study are shown in o appendix A, Statistics results came as:

5-7-1 Model Builders Statistical Results to The Current Master Plan

5-7-1-1 Building & Roads Model

Intersect Building & Road						
count	sum (m2)	mean (m2)	min. (m2)	max. (m2)	median (m2)	std. (m2)
149	2353.105	15.7926	0.000362	127.9079	8.55	20.197

Table 5-4: 1st Model Results 1

5-7-1-2-Building & Buffered Roads intersect

intersect old building & old urban buffer road					
count	sum (m2)	mean (m2)	min. (m2)	max. (m2)	median (m2)
140	2305.989	16.471	0.00051	114.4111	8.9704

Table 5-5: 2nd Model Results 1

5-7-1-3 Road's centerline slope

Road's centerline slope							
FREQUENCY	COUNT_gridcode	Sum_gridcode	Mean_gridcode	MEDIAN_gridcode	STD_gridcode	MIN_gridcode	MAX_gridcode
398	398	982	2.949749	3	1.5526	1	8

Table 5-6: 3rd Model Results 1

5-7-1-4 Master plan intersected area with Parcels

Master plan intersected area with Parcels					
count	sum (m2)	mean (m2)	min. (m2)	max. (m2)	median (m2)
350	220333.13	629.523229	0.065175	32147.4	1833.349

Table 5-7: 4th Model Results 1

5-7-2 Model Builders Statistical Results to The Future Master Plan

5-7-2-1 Building & Roads Model

intersect building & road						
count	sum (m2)	mean (m2)	min. (m2)	max. (m2)	median (m2)	std. (m2)
89	739.955	8.314	0.000055	86.253	2.4895	14.129

Table 5-8: 1st Model Results 2

5-7-2-2-Building & Buffered Roads intersect

intersect current building & current urban buffer road					
count	sum (m2)	mean (m2)	min. (m2)	max. (m2)	median (m2)
141	1632.397	11.577	0.00001	127.3615	5.1505

Table 5-9: 2nd Model Results 2

5-7-2-3 Road's centerline slope

Road's centerline slope							
FREQUENCY	COUNT_gridcode	Sum_gridcode	Mean_gridcode	MEDIAN_gridcode	STD_gridcode	MIN_gridcode	MAX_gridcode
354	354	982	2.774	3	1.507225	1	8

Table 5-10: 3rd Model Results 2

5-7-2-4 Master plan intersected area with Parcels

Master plan intersected area with Parcels					
count	sum (m2)	mean (m2)	min. (m2)	max. (m2)	median (m2)
347	201364.35	580.3007	0.60118	21699.757	240.3352

Table 5-11: 4th Model Results 2

By Finding and calculating the intersection area between the parcel and the master plan road come up with the statistics, there are 350 areas of intersection with a total area of 220333.13 square meters, an average of 630 square meters, and most intersections area ranges between 1-32000 square meter and the largest area equals 32147.4 square meters in the current Master Plan. If there is any indication, that will indicate the failure of the master plan particularly in front of this number of intersections. While in the recommended Master Plan there are 347 areas of intersection with a total area of 201364.35 square meters, an average of 580 square meters and most intersections area ranges between 1-21700 square meter and the largest area equals 21699.757 square meters. If there is any indication, that will indicate the need for big edits to the current and the future master plan, particularly in front of this number of intersections.

Chapter Six: Conclusions & Recommendations.

1-1 Conclusions

1-2 Recommendations

Any work that is completed, whether it be engineering-related or not, has an impact on the desired outcomes and the purposes for which it was completed, either positively or negatively. In order to accomplish the intended goal of this study, recommendations are made to the municipality and the relevant institutions in this chapter, as well as a discussion of the results obtained through the process of master plan analysis.

6-1 Conclusion

The area of deduction from the buildings was calculated in the previous models, and in order to see if there was a way to improve the situation and reduce the deduction, we turned to the ASSHTO specifications. However, as was previously mentioned, the result was that the deduction areas increased, indicating that any attempt to change or modify the width of the roads to match The ASSHTO specifications. After several conversion and export operations, the processing went into more detail, and the road slope was calculated using a contour map every 5 meters. It was determined that most of the roads in the study area have a very suitable slope of less than 20%, which means that it is safe to drive on those roads. However, a small percentage of the roads must have their locations changed because the slope is high. In the end, the proposed master plan roads were subtracted from the parcels in a calculated manner and provided with the proper classification.

The statistics and maps produced in this study show that the future Master Plan is better than the current Master Plan, but the two Plans need big editing and there is a big similarity between them in shape or the included details and in the shortage.

All previous geospatial analyses were performed on the ArcGIS Pro3.0 software using the ModelBuilder tool, and anyone in the world can export this ModelBuilder to perform the same analyses and build, add to them in order to enter into the specifics of the specifics in the analysis of the Master Plans.

6-2 Recommendations

1. Changing the proposed roads' positions in the current or a newer master plan so that they are identical to the geospatial data currently available and do not cross any properties such as buildings or lands, or there are just a few junctions for the benefit of the general public.
2. Based on what has been made clear, any attempt to refer to AASHTO standards is a failure, and it is required to refer to the local government models used in the construction of the roads and their extensions.
3. Changing the placements of the proposed master roads in the city's study area while also considering that there are roads in the area with slopes that are higher than 25%.

4. Highlighting the significance of working to create a master plan for the city that integrates the region's urban development process and addresses many of the issues that the study area faces
5. The creation of a master plan for the city that is characterized by its sustainability and capacity to accommodate future developments by carrying out actual and practical procedures on the ground, adhering to proper and up-to-date scientific methods in its implementation, and relying on accurate information gathered from the ground.
6. Increasing the general public's understanding of the value of following regulatory regulations and their role in the growth and development of the city.
7. By providing the legal force to uphold and defend these laws and the executive force to carry them out on the ground, try to develop ways and means to put the master plan into action.
8. Developing the master plan for the study area in accordance with the findings of our analytical analysis of the city and with the aid of contemporary planning theories. Land uses will be primarily determined during this, and their relationships will be examined.
9. Providing public housing to support long-term urban development.
10. Creating regulations for roads while also expanding the road network.
11. As the community has a green space that may be expanded and used as a public garden and a recreational area, work on enhancing the recreational side of the village.
12. After a new master plan has been created, its execution must be monitored, and anyone who tries to violate it will face severe penalties.

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