Environmental and Climate Justice Program – Palestine
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Dust Pollution Assessment and Mitigation by Green Belts in Bani Naim – An Applied Environmental Research

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Disclaimer

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[1] The Environmental and Climate Justice Program (ECJP) is a program managed by We Effect and implemented by the Palestinian Agricultural Institutions Coalition (PAIC). PAIC is a coalition of six Palestinian environment, climate, and agricultural non-governmental organizations- Palestinian Agriculture Relief Committee (PARC), Union of Agricultural Work Committees (UAWC), Palestinian Hydrology Group (PHG), Land Research Centre (LRC), MA'AN Development Centre, and the Applied Research Institute – Jerusalem (ARIJ).

1.1 Abstract

Air pollution mitigation is critical to avert deleterious environmental impacts on ecosystems and human health. This study investigates the feasibility and efficacy of localized green belt implementation as a cost-effective strategy for particulate matter (PM) reduction in the context of industrial stone production, exemplified by Bani Naim, Palestine. While stone manufacturing provides vital economic contributions, it generates significant air pollutants, mainly PM, posing environmental and health risks. Traditional mitigation measures often present substantial financial and operational burdens. This research employs a multi-faceted approach, integrating in-situ PM measurements, spatial analysis, and phytoremediation suitability assessments to evaluate the potential of targeted green belt establishment. The findings recommend strategically deploying three green belts upwind and downwind of significant stone quarries and processing facilities to intercept and mitigate dust dispersal effectively. Furthermore, this study proposes the development of context-specific outdoor PM standards and guidelines. It advocates for integrating mandatory green belt requirements into municipal master planning, particularly for regions with similar industrial profiles, to enhance environmental sustainability.

Keywords: Air pollution, Bani Naim quarries, PM, GIS.

1.2 Study Area

Bani Naim is a Palestinian town in the Hebron Governorate, 7 km east of Hebron City. It borders Masafer Bani Naim to the east, Hebron City to the west, Sa'eer and Al-Shuyukh to the north, and Yatta to the south. Bani Naim is 770 meters above sea level, with an annual rainfall average of approximately 369 mm. The average temperature is 16°C, and the relative humidity averages around 61%. The town is known for being the burial place of the prophet "Lot" PBUH, which is mentioned in the Quran and the Bible.

The Arabic name "Bani Na'im" means "children of bliss". This seems appropriate, given the town's calm situation and rich history. For centuries, the area has seen human settlements and has the amenities to sustain it. Bani Na'im has been the site of various historical events, including the region's Islamic conquest.

Today, the population of Bani Naim is slightly more than 29,862, according to the Palestinian Central Bureau of Statistics (2024). The town, a business center of surrounding villages, is also known for agriculture, especially olives. There are several schools, mosques, and community centers in this town. Like several Palestinian towns and villages, Bani Naim faces problems despite being historically and culturally important. Movement restrictions, land confiscation, and expansion of settlements around the town have affected the town's development and the people's daily lives. The researcher conducted a study in the area shown in Figure 1.1 below, which contains city-populated areas, active quarries, and agricultural land. The total area covered by this study reaches around 44 square Kilometers. Bani Naim faces several environmental problems associated with the consequences of stone production on flora, fauna, and human beings. Figure 1 shows the study area boundary.

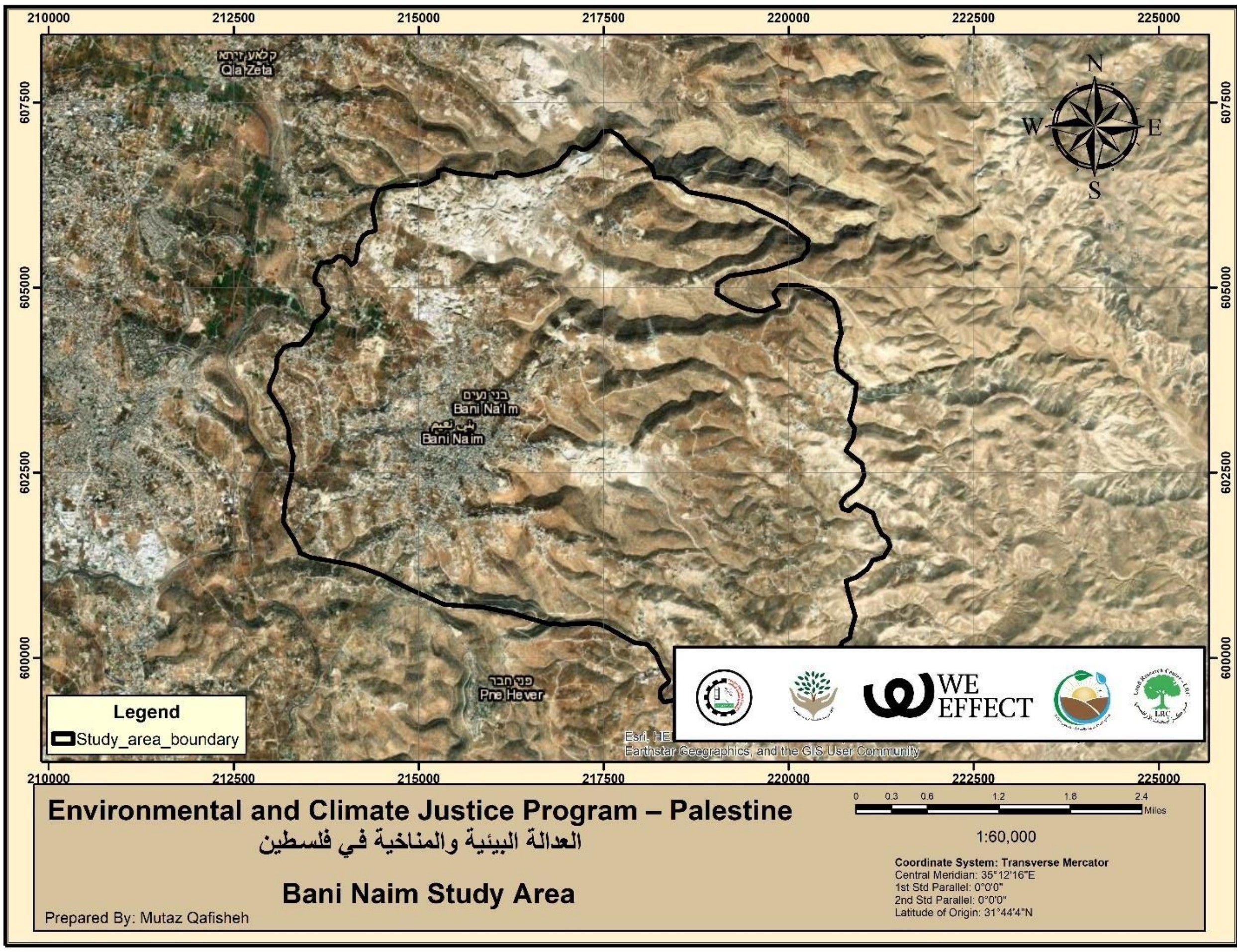

Figure 1 Bani Naim Study Area.

1.3 Research Background

We may date the age of the dimensional stone sector of Palestine more than 10,000 years ago from the construction of Jericho fortes; then, through the stones of the Palestinian monuments, it is possible to reveal the unlimited history and legends of this unique land in the world.

In the last 20 years, the Palestine Industrial Stone Sector has had massive development. Palestinian stones were exported to the world, mainly at the beginning under the name "Jerusalem Stone" or as the "Stones of the Holy Land." The geology of Palestine is rich in limestones with different colors and textures, from light beige to dark brown, from grey to yellow and pink; rock formation is classified as Archean crystalline rocks and the Carboniferous, Cretaceous, Tertiary, and Post-Tertiary.

The stone sector is one of Palestine's most significant and active industries. According to the Union of Stone and Marble of Palestine 2016, this sector contributes approximately 25% of Palestine's overall industrial revenue and 4.5% of the total Palestinian revenue.

Between 2016 and 2018, the Palestine Stone and Marble Center PSMC and the Union of Stone and Marble of Palestine USM established a comprehensive study of the stone sector in Palestine. Accordingly, a survey of the Stone cutting manufacturing was conducted, and it included the location, type of activities, production rate, and number of employees, among other parameters. The research showed that the Hebron district occupied a significant role in this sector due to the concentration of stone quarries and related activities. The research showed that the total number of stone facilitates in Westbank is around 1181 facilities, 405 of which are located in Hebron district. However, the study shows that Bani Naim has around 50 facilities, including stone quarries, stone crushing, workshops, and stone factories. The following table resents the wholistic view. Table 1 includes a summary of stone activities in Palestine.

Table 1: Number of Stone Facilities

Governorate	Hebron	Bethlehem	Jenin	Jerusalem	Nablus	Qalqilya	Ramallah	Salfeet + Tubas	Tulkarm
Factories	185	187	74	5	80	7	10	45	9
Quarries	142	34	11	0	36	0	5	24	0
Workshops	65	22	29	10	55	30	20	28	20
Crushers	13	9	8	0	10	0	1	5	2
TOTAL	405	252	122	15	181	37	36	102	31

Nevertheless, the importance of the stone sector in Palestine and the stone production activities are associated with enormous environmental consequences. Including soil, air, and water contaminations. Impacting agriculture, natural, and human health.

In this study, we focus on the impact of stone activity on air pollution in terms of particulate matter, namely Pm 2.5 and Pm 10 micrometers. Moreover, there is the possibility of establishing green belts around the pollution sources to mitigate dust transportation around built-up areas and agriculture fields in the Bani Naem Areas.

The research accordingly established a minor review for similar studies related to the research scope; consequently, F. Cappelletti et al. l Utilized air quality monitoring stations and dispersion modeling to evaluate the spatial distribution of particulate matter (PM10 and PM2.5). The research shows that the dust concentration could reach a round 500 meters, which required the implementation of a dust control measurement. S. K. Singh et al. 's research concentrated on the health repercussions of dust pollution from stone pulverizing operations in India. The research shows that stone facilities workers are three to four times more likely to be diagnosed with respirable silica dust, leading to enlarged respiratory illnesses such as silicosis and asthma. Additionally, Al-Hurban and Al-Awadhi evaluated the effects of quarrying activities on the environment in Kuwait. The main finding of the Al-Hurban and Al-Awadhi study presented that the air quality was significantly reduced by quarrying activities, which could have long-term effects on the environment and people's health. A dust control measure was introduced by Gillies et al. l. This study assessed how well different dust suppression technologies, such as water sprays and chemical suppressants, could reduce dust emissions from stone quarries. Ngo et al. investigated and assessed the impact of quarries in Vietnam. This study examined how Vietnamese rural populations were exposed to dust from adjacent quarry activities. Health surveys and air quality monitoring were conducted to determine the effect on locals. According to the study, respiratory complaints were more common in populations within one kilometer of the quarry. They found a clear correlation between local inhabitants' heightened health risks and proximity to quarry activities.

The issue of dust pollution, particularly from quarrying and stone-cutting industries, has been a significant environmental and public health concern in Palestine. Several studies have explored these industries' environmental, health, and socioeconomic impacts, with a growing emphasis on using Geographic Information Systems (GIS) for spatial analysis and mitigation strategies. This literature review synthesizes key findings from relevant studies, focusing on Palestine, and highlights the role of GIS in understanding and addressing dust pollution.

Salem (2021) comprehensively evaluated Palestine's stone and marble industry, highlighting its environmental, geological, health, and socioeconomic impacts. The study revealed that quarrying contributes significantly to air pollution, particularly by generating particulate matter (PM2.5 and PM10), which poses serious health risks to nearby communities. The research emphasized the need for stricter regulations and mitigation measures to reduce dust emissions and protect public health.

Similarly, Qanazi and Zawawi (2021) explored the environmental sustainability of the stone industry in Palestine, noting that while the sector is economically vital, it has severe environmental consequences, including soil erosion, water contamination, and air pollution. The authors recommended the adoption of green technologies and better land-use planning to mitigate these impacts.

GIS in environmental studies has gained traction in Palestine, particularly for mapping and analyzing dust pollution. A study by the Applied Research Institute – Jerusalem (ARIJ) (2023) utilized GIS to map the spatial distribution of dust pollution from stone-cutting industries in the West Bank. The study identified hotspots of dust pollution and correlated them with wind patterns, topography, and land use, providing valuable insights for targeted mitigation efforts.

Another study by the Palestinian Environmental Quality Authority (2022) employed GIS to assess the impact of quarrying activities on air quality in Hebron. The research used spatial analysis to model the dispersion of particulate matter and identified areas most affected by dust pollution. The findings underscored the importance of integrating GIS into environmental monitoring and policy-making processes. The aforementioned studies emphasize the significance of applying GIS analysis regarding air pollution in Bani Naim.

The health impacts of dust pollution in Palestine have been well-documented. A report by the Palestinian Ministry of Health (2023) highlighted the increasing prevalence of respiratory diseases in communities near quarries and stone-cutting facilities. The study linked high levels of PM2.5 and PM10 to cases of asthma, bronchitis, and other respiratory conditions, particularly among children and the elderly.

The Palestinian Medical Relief Society (2021) also investigated the health effects of air pollution in Palestine, focusing on the stone industry. The study found that prolonged exposure to quarry dust significantly increases the risk of cardiovascular diseases and lung cancer. The authors called for immediate action to reduce dust emissions and improve air quality monitoring.

Several studies have proposed mitigation strategies to address dust pollution in Palestine. The Palestinian Hydrology Group (PHG) (2023) recommended the establishment of green belts around quarries to reduce dust dispersion. The study used GIS to identify optimal locations for green belts based on wind patterns, topography, and land use. The findings suggested that strategically placed vegetation could significantly reduce dust levels in nearby communities.

Similarly, the Union of Agricultural Work Committees (UAWC) (2022) explored using green belts as a sustainable solution to dust pollution. The study highlighted the effectiveness of Mediterranean cypress and carob trees in capturing dust particles and improving air quality. The authors emphasized community involvement in establishing and maintaining green belts.

Palestine's lack of standardized air quality regulations has been a recurring issue in the literature. The Palestinian Standards Institution (PSI) has yet to establish permissible limits for PM2.5 and PM10, leaving communities vulnerable to high levels of dust pollution. A study by the Palestinian Environmental NGOs Network (PENGON) (2022) called for adopting international air quality standards and implementing real-time air quality monitoring systems to protect public health.

The U.S. Environmental Protection Agency (EPA) (2021) provides well-established standards for particulate matter, which could serve as a model for Palestine. The EPA's primary standards for PM2.5 (35 $\mu g/m^3$ over 24 hours) and PM10 (150 $\mu g/m^3$ over 24 hours) protect public health, particularly vulnerable populations such as children, the elderly, and those with pre-existing health conditions.

Despite its environmental and health impacts, the stone industry remains a cornerstone of the Palestinian economy. According to the Union of Stone and Marble in Palestine (USM), the sector contributes approximately 5% to the Gross Domestic Product (GDP) and employs thousands of workers. However, the industry's environmental footprint necessitates balancing economic growth and environmental sustainability. Studies have called for adopting cleaner production technologies and stricter environmental regulations to ensure the industry's long-term viability.

Integrating GIS and remote sensing technologies has proven invaluable in dust pollution studies. A study by the Land Research Centre (LRC) (2022) used satellite imagery and GIS to monitor land-use changes and dust pollution in the West Bank. The research identified areas of high dust concentration and linked them to quarrying activities, providing a basis for targeted interventions.

Similarly, the MA'AN Development Centre (2023) utilized GIS to model the impact of dust pollution on agricultural productivity in Palestine. The study found that dust deposition on crops reduces yields and affects food security. The authors recommended using GIS-based land-use planning to minimize the impact of dust on agricultural areas.

Community engagement is crucial for the successful implementation of dust mitigation strategies. The Palestinian Agricultural Relief Committees (PARC) (2022) emphasized the importance of involving local communities in environmental decision-making. The study highlighted the role of education and awareness campaigns in promoting sustainable practices and reducing dust pollution.

Policy recommendations from various studies include establishing green belts, adopting international air quality standards, and implementing real-time air quality monitoring systems. The research also calls for greater collaboration between government agencies, NGOs, and the private sector to address the environmental and health impacts of the stone industry.

GIS has become a powerful tool for mapping and analyzing dust pollution, enabling targeted mitigation efforts. While the stone industry remains economically important, there is an urgent need for stricter regulations, cleaner production technologies, and community engagement to ensure environmental sustainability and public health. Future research should focus on the long-term effectiveness of green belts, adopting air quality standards, and integrating GIS into environmental policy-making.

Mishra and Singh utilized geospatial analysis through remote sensing imageries to investigate quarry dust pollution. The study mapped dust pollution from Indian quarries using remote sensing and GIS methods. Dust plumes and their dispersion patterns were analyzed using a combination of ground-based observations and satellite photography. Remote sensing offered an affordable way to track extensive dust pollution, with important ramifications for environmental management and regulatory compliance.

Mwangi et al. emphasized the importance of raising public awareness regarding dust pollution associated with stone manufacturing. This study evaluated how the Kenyan population perceived and understood dust pollution from quarrying operations. Surveys and focus groups were held to collect information. According to the report, communities lacked the means to address the issue even if they were aware of the health hazards. Addressing dust pollution and its effects requires community involvement and education.

Gupta and Sharma examined cutting-edge dust reduction techniques in the stone sector, such as fogging devices and electrostatic precipitators. The study tried to determine how well they reduced dust emissions; field tests were carried out. The study demonstrated that cutting-edge technologies provided sustainable solutions for the stone sector by drastically lowering dust emissions.

1.4 Problem Statement

The Bani Naim area experiences significant air pollution due to intensive stone industrial activity, resulting in substantial dust generation and transport; the dust pollution adversely affects public health, agricultural productivity, and the environment. Current dust mitigation strategies are insufficient, and a comprehensive approach is needed to address this issue effectively.

1.5 Goal

To develop and evaluate a green belt strategy, informed by GIS analysis and PM2.5 and PM10 measurements, for mitigating dust pollution originating from stone industrial activities in the Bani Naim area and to recommend outdoor PM standards.

1.6 Objectives

1. Quantify and characterize dust pollution: Measure and analyze PM2.5 and PM10 concentrations and distribution patterns in the Bani Naim area, explicitly identifying the contribution from stone industrial facilities.
2. Spatial analysis of dust pollution: Utilize GIS to map and analyze the spatial distribution of dust pollution concerning stone industrial facilities, topography, wind patterns, and surrounding land use (residential, agricultural).
3. Design and propose green belt scenarios: Develop different green belt scenarios, considering species selection, placement (location, size, configuration), and density, using GIS and relevant modeling tools.

4. Assess the effectiveness of green belts: Evaluate the potential impact of the proposed green belt scenarios on reducing PM2.5 and PM10 concentrations through modeling or pilot studies.
5. Outline recommendations for green belt implementation: Provide specific and practical recommendations for establishing and maintaining effective green belts, including species selection, planting strategies, and community involvement.
6. Propose outdoor PM standards: Based on the research findings and relevant international guidelines, recommend appropriate outdoor PM2.5 and PM10 standards for the Bani Naim area.
7. Raise awareness and promote stakeholder engagement: Disseminate research findings and recommendations to relevant stakeholders, including local communities, stone industry operators, and policymakers, to promote the adoption of sustainable dust mitigation strategies.

1.7 Research Methodology

The research methodology section expounds upon the research methodology, consisting of several primary components. The first component elucidates the research methodology adopted to investigate the topography, while the second focuses on land cover analysis.

The research adopts an applied environmental research approach, which contains dust field measurements, spatial analysis, and environmental modeling, and it ends with suggestions for developing a green belt strategy to mitigate the pollution in the researched area; accordingly, the following work packages and phases were implemented in this research regarding the mitigation of dust pollution in the study area:

1.7.1 Work Package 1 (Topography)

The first work package was designed to develop several analyses on the topography of the study area as it is one of the factors impacting the transportation of dust through the study area.

- Phase 1:
  Establishing A Digital Elevation Model (DEM) is a 3D illustration of the Earth's surface, showing elevation at various points. It is a grid of cells, each with an assigned elevation value. DEMs are shaped from LiDAR, satellite imagery, photogrammetry, and topographic maps. They are used extensively in GIS and various other fields for terrain analysis. Figure 2 shows that the elevation ranges from 461 to 976 meters above the mean sea level.

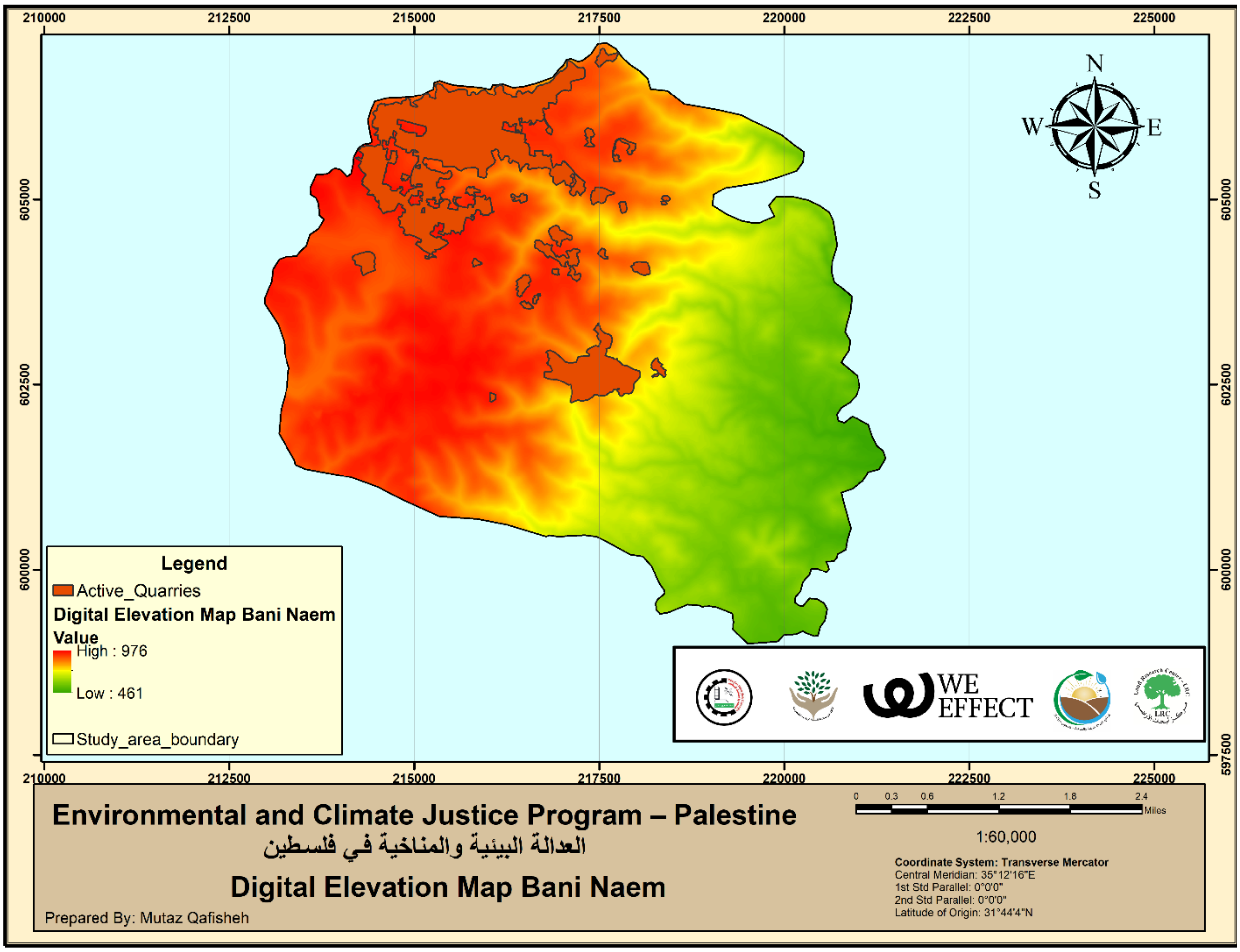

Figure 2 Bani Naim Digital Elevation Model (DEM).

- Phase 2:

  In order to establish an analysis of the land aspect—which is crucial as the study area is in mountain regions and many land aspects may be established—the current phase is built on the work started in the previous phase. This phase is particularly crucial since it analyzes which areas will most likely receive dust by integrating it with the wind direction analysis. An aspect map is a visual depiction of a slope's compass direction. It classifies topography into north, south, east, and west directions, as well as their intermediate locations, and it is derived from a Digital Elevation Model (DEM). Aspect maps are valuable resources in several disciplines, including hydrology, ecology, and agriculture. They aid in comprehending how variations in temperature, moisture distribution, and solar exposure affect vegetation patterns throughout a region. Figure 3 shows the aspect map of the study area.

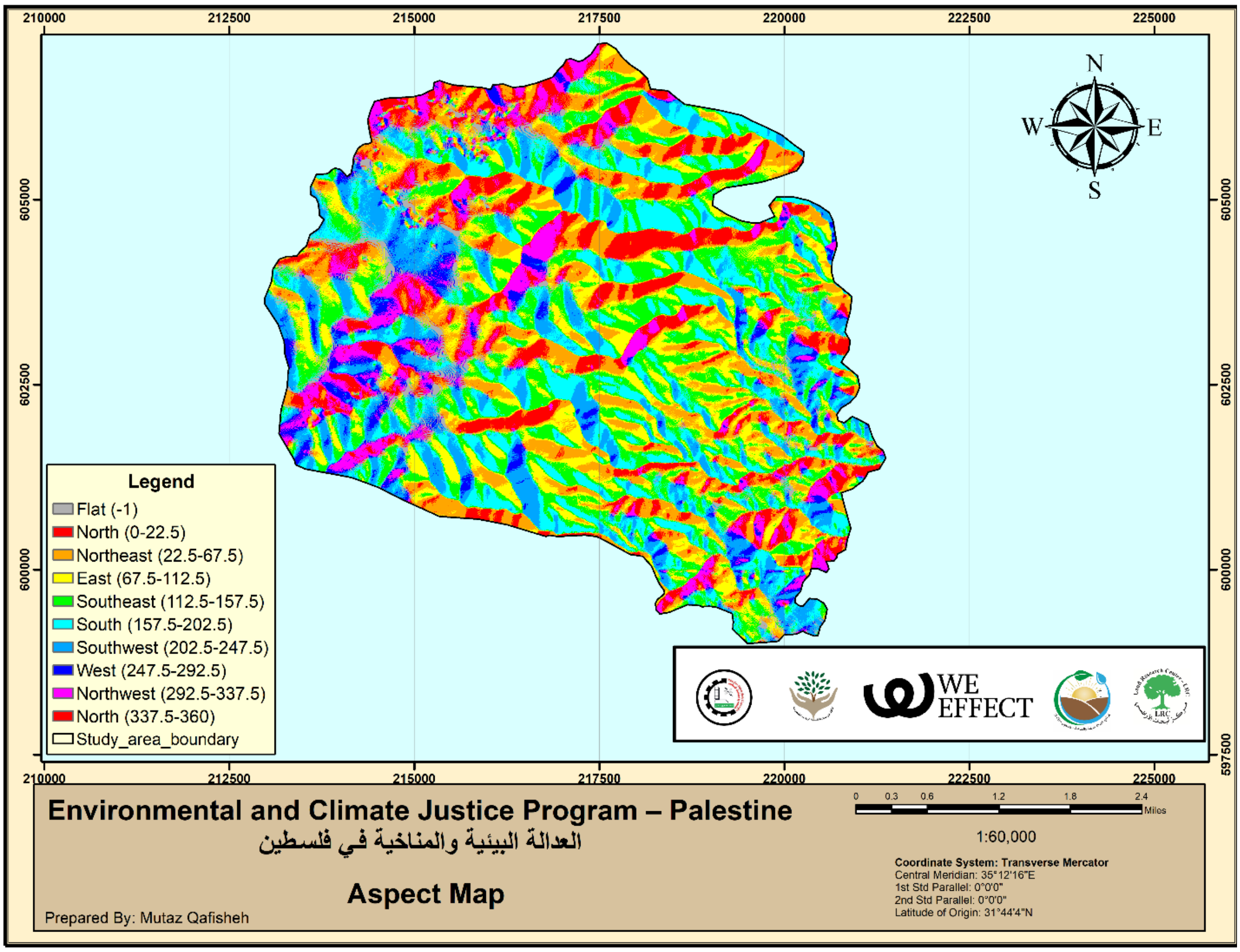

Figure 3: Bani Naim Aspect Model.

1.7.2 Work Package 2 (Land Cover Analysis)

The second work package was considered to progress analyses on the land cover of the study area as it is crucial to be familiar with land use in the study area and to establish suitable interventions in order to mitigate dust pollution.

In order to understand various environmental and societal processes, it is essential to analyze land cover, which includes the physical materials that cover the Earth's surface, including natural elements such as vegetation, water bodies, and bare soil, as well as artificial structures. Analyzing land cover can reveal deforestation patterns, urbanization, agricultural changes, and the effects of natural disasters. By analyzing how land cover changes over time, we can learn much about ecosystems' health, resource management's effectiveness, and human activity's effects on the landscape.

Land cover is studied using a variety of analytical methodologies, including remote sensing, which uses satellite imaging and aerial photography to map and monitor land cover on a broad scale. Figure 4 and Table 2 show the land cover of the current study areas. It is worth mentioning that the table below represents the cross-ponding area for each land cover category.

Table 2: Study Area Land Cover

Land Cover	Area squared meters	Percentage
Agricultural	10594	24
Residential Areas	10480	24
Open Areas	17894	41
Active Quarries	5165	12
Total	44133	

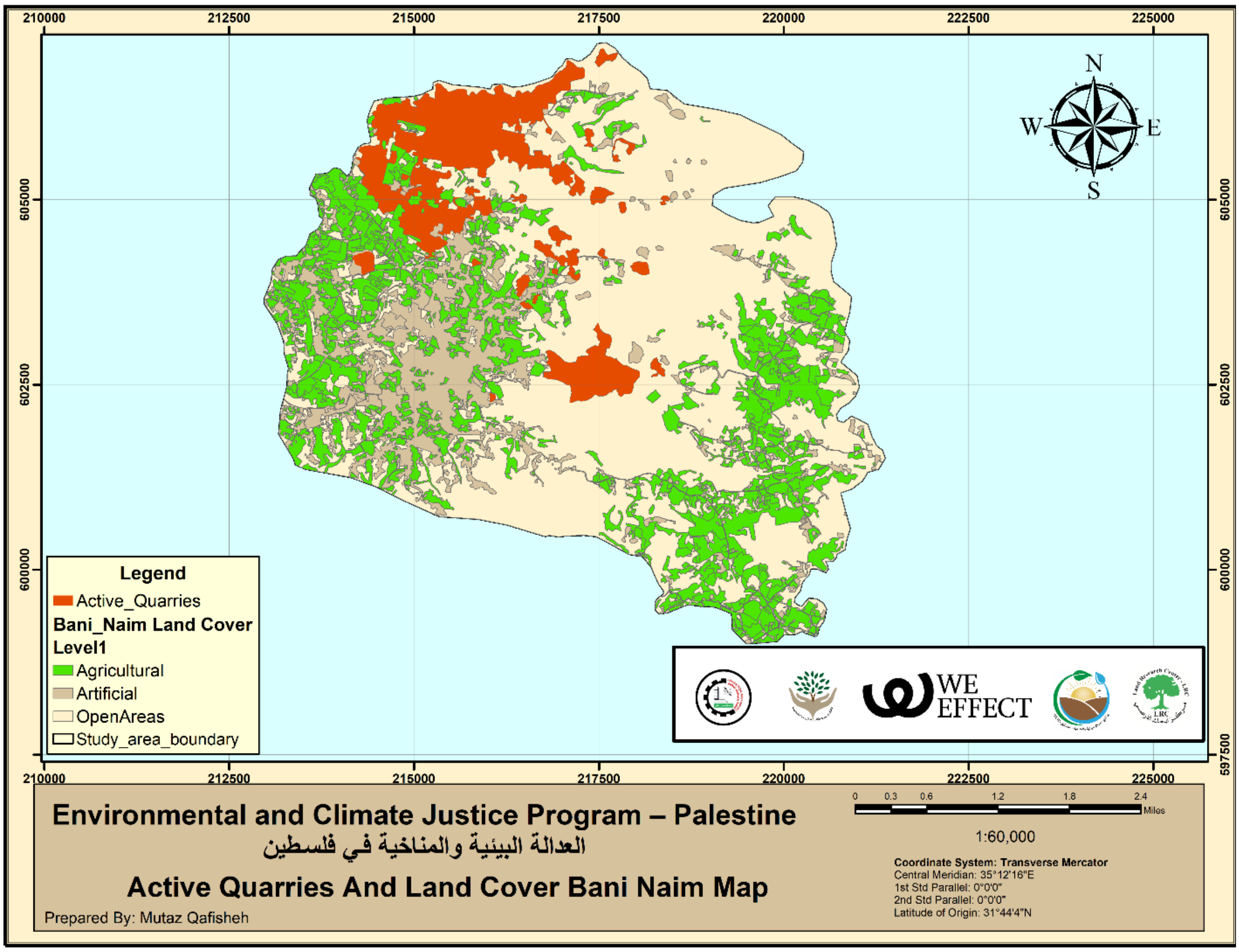

Figure 4 Bani Naim Land Cover.

1.7.3 Work Package 3 (Road Network)

The third work package was established to analyze the distribution of the road network in the study area, as the area contains industrial activities related to quarry manufacturing. Accordingly, the transportation of quarry products will aid the transportation of dust pollution. Subsequently, the research performs several analyses regarding the road network. Figure 5 shows the Bani Naim Road network.

Roadways, especially unpaved ones, significantly impact dust transportation. Dust is created when soil particles are dislodged by vehicle traffic. Long-distance transport of this dust can impact human health, visibility, and air quality. Additionally, it can damage ecosystems, taint water sources, and deteriorate infrastructure: traffic volume, vehicle speed, road surface conditions, and climate influence dust emissions' intensity. Effective dust control techniques are essential to lessen these adverse effects and safeguard people's and the environment's health. These include paving roads, using dust suppressants, and implementing traffic management plans. Figure 5 shows the classification of the transportation road network.

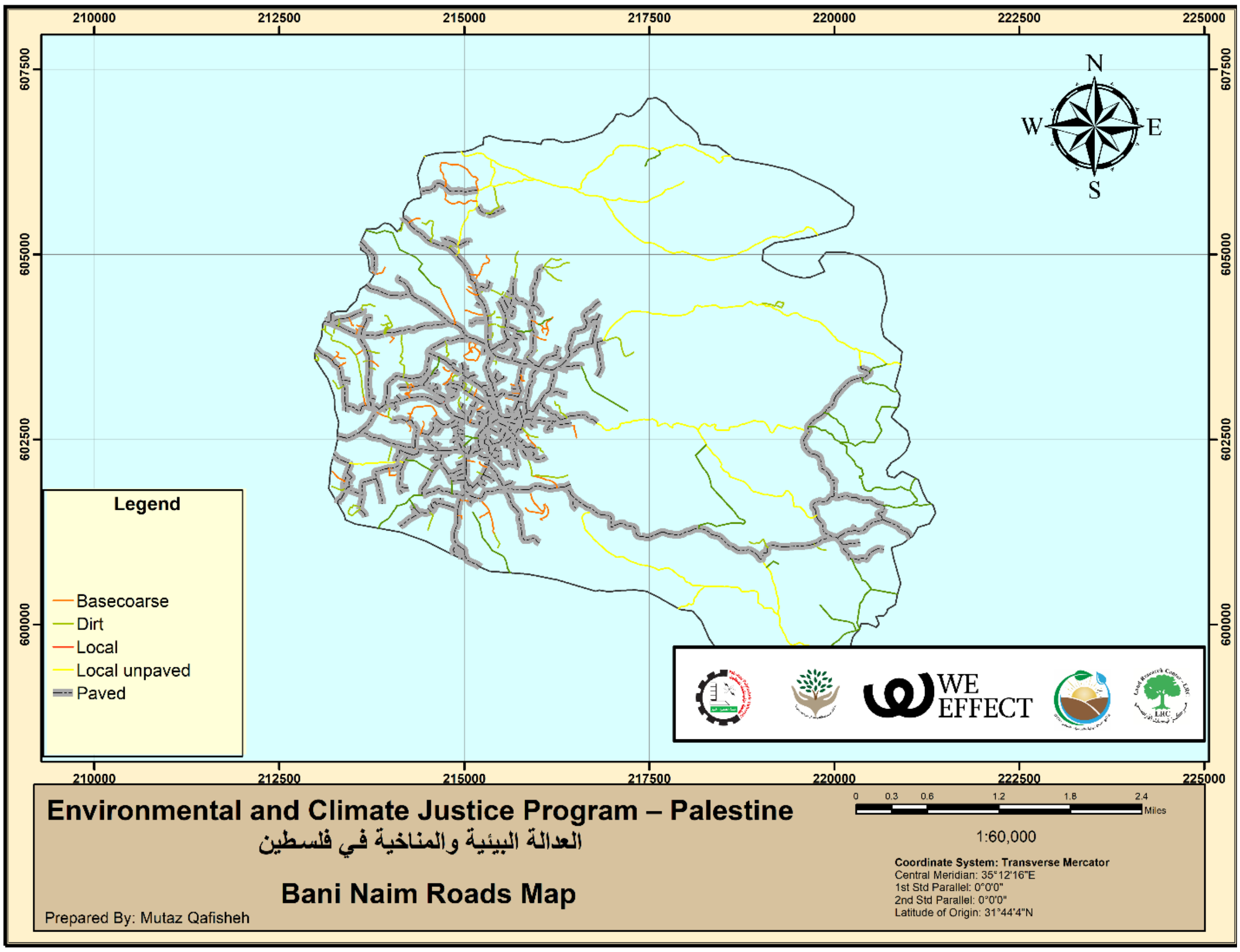

Figure 5: Bani Naim Road Network.

1.7.4 Work Package 4 (Rainfall Distribution)

The fourth work package is dedicated to analyzing the impact of rainfall and soil type on dust pollution. Accordingly, the following two phases are established.

- Phase 1:

Rainfall can affect dust transportation in both positive and negative ways. Moderate rainfall can decrease dust production, which can bind soil particles together. Heavy rains, however, have the potential to degrade soil and accelerate the movement of sediments, which could eventually result in more dust. Rainfall patterns can also influence dust storm generation.

Because dry soil is easily damaged by heavy rain, periods of dryness followed by high rainfall can provide ideal conditions for dust storms. Therefore, rainfall's effect on dust movement is complicated and contingent on several variables, including soil type, frequency, and rainfall intensity. Figure 6 shows the distribution of rainfall belts in mm per year. It is worth highlighting that rainfall varies from around 550 mm annually in the northwest region to 300 mm in the southeast.

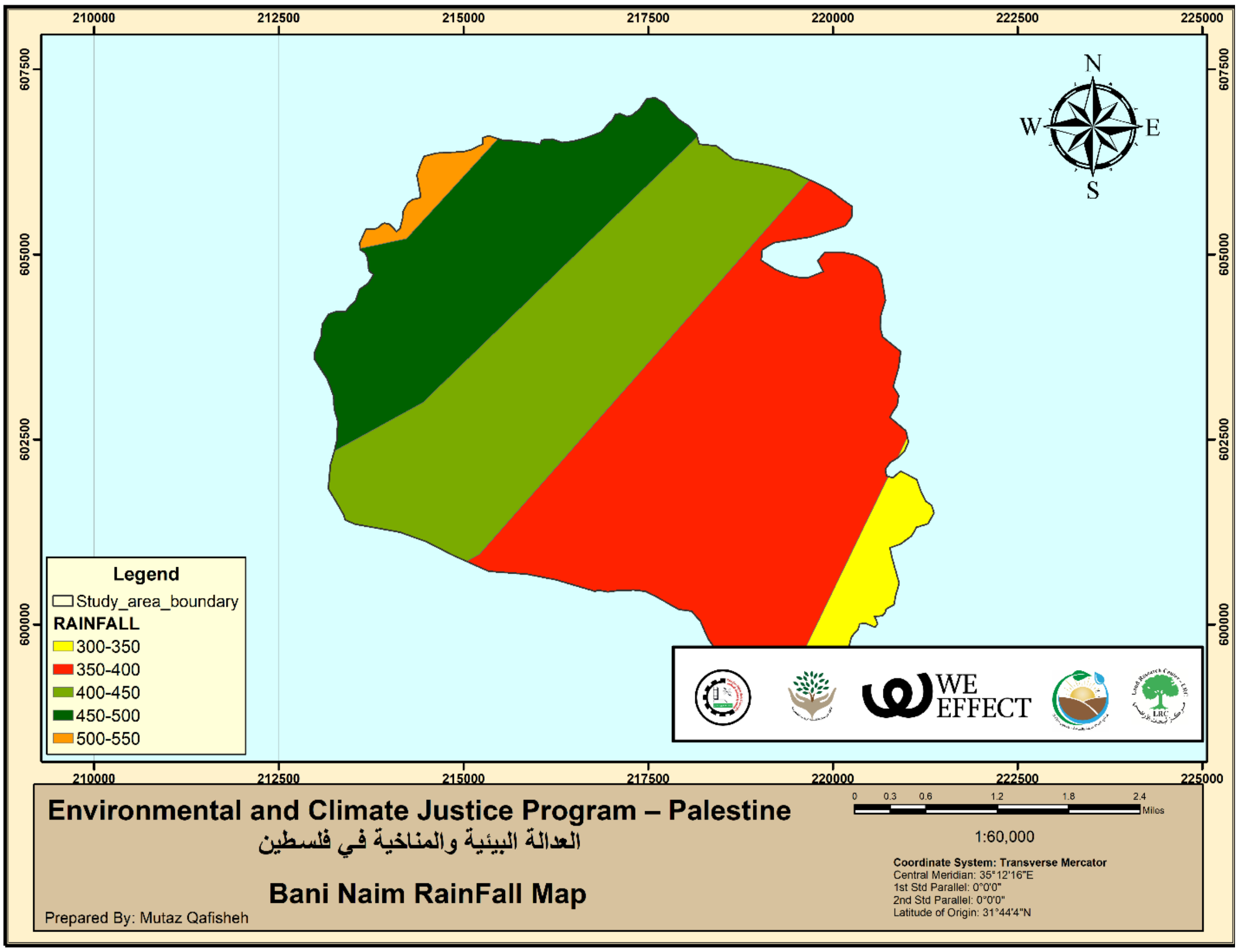

Figure 6: Bani Naim Rainfall Distribution.

- Phase 2:

The previous phase illustrates the impact of rainfall intensity on dust production and transportation. Accordingly, it is worth highlighting that rainfall impact and soil type are invoked together in terms of dust production and transportation. The study area contains several soil types, such as Loessial Arid and Brown Lithosols, especially in the southern areas where brown soils are common. These soils are distinguished by their low fertility, stony composition, and shallow depth. They are frequently found on foot slopes and hilltops, and because of their thin construction and shallow soil depth, they are prone to erosion. These soils are difficult to work with and must be managed carefully to avoid further deterioration. Terra Rossas, Brown Rendzinas, and Pale Rendzinas are abundant in Palestine's Mediterranean region. These soils are distinguished by their dark hue and high calcium carbonate concentration, which are usually formed from limestone parent material. Generally, they are productive and ideal for farming, especially in regions with enough rainfall. These soils must be adequately conserved because they might be prone to erosion, particularly on slopes. Figer 7 shows the distribution and the classification for each soil type.

Table 3: Study Area Land Cover

Land Cover	Area squared meters	Percentage
Brown Litholsols And Loessial Arid Brown Soils	16329	37
Terra Rossas, Brown Rendzinas And Pale Rendzinas	619	2
Brown Rendzinas And Pale Renzinas	27185	61
Total	44133	

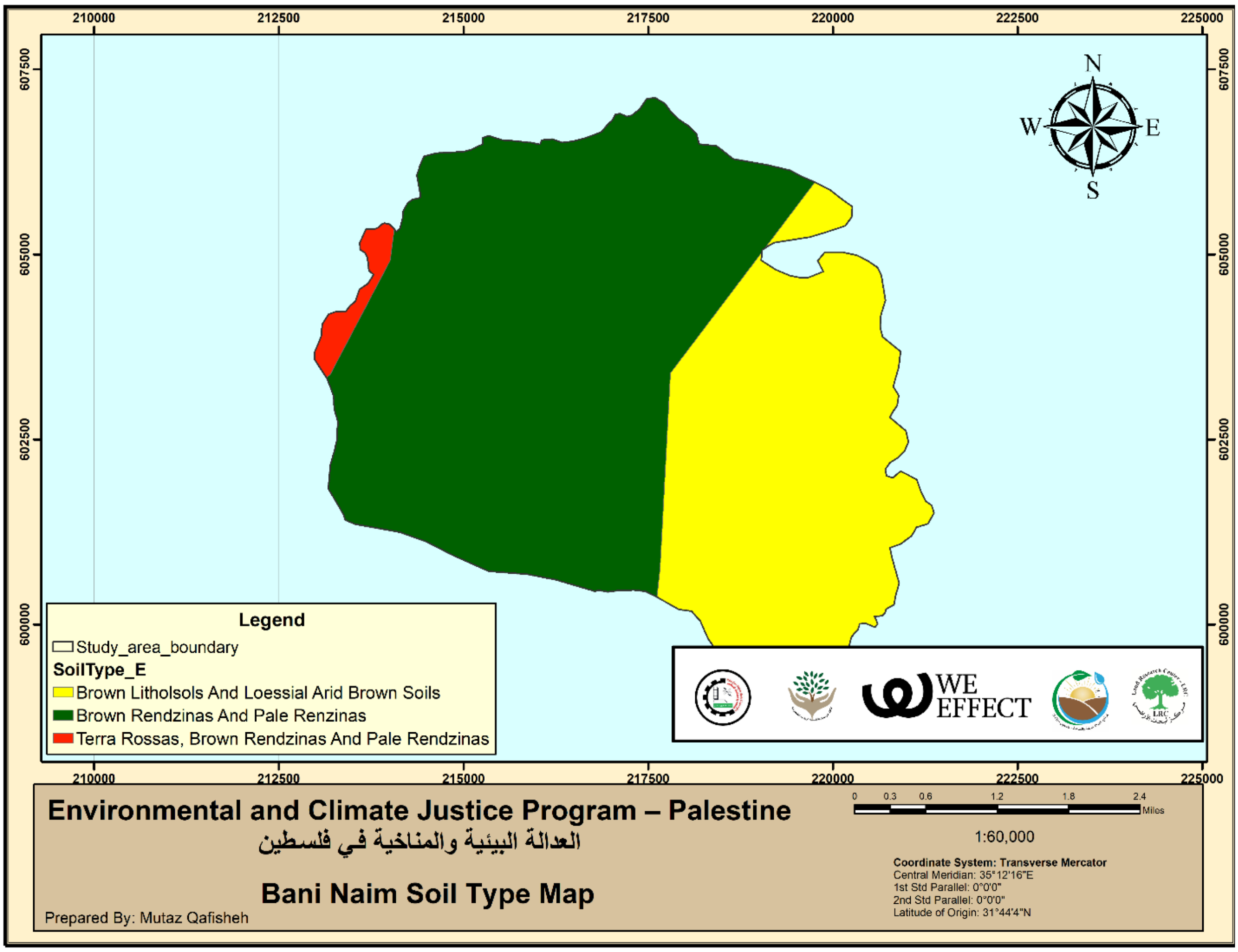

Figure 7 Bani Naim Soil Types.

1.7.5 Work Package 5 (Dust Distribution)

The fifth work package contains comprehensive research regarding dust production, transportation, and environmental conditions impacting the dust creation and transference.

- Phase 1:

The research has reached the analysis stage of dust particle size, concentration, and impact. Accordingly, stone quarry operations can produce a large dust volume, harming the environment and human health. Several variables affect the size of the dust particles generated in quarries, including:

- Stone type: The size of the dust particles generated can be affected by the hardness and friability of various stone types.
- Extraction techniques: Certain stone-extraction operations, such as drilling or blasting, can produce dust particles of various sizes.
- Processing techniques: Finer dust particles may be produced by crushing and grinding the extracted stone after it has been extracted.
- Weather: Humidity, wind direction, and speed can impact dust particle deposition and dispersion.

The typical sizes of dust particles from stone quarries are as follows:

- Particles more significant than 10 micrometers (μm) are considered coarse dust. These particles tend to settle fast and are typically heavier.
- Particles of acceptable dust range in size from 2.5 to 10 μm. These particles can enter the respiratory system more deeply and remain suspended in the atmosphere for extended periods.
- Particles smaller than 2.5 μm are known as ultrafine dust. Due to their ability to enter the circulation and pierce deeply into the lungs, these particles pose the greatest threat to human health.

- Phase 2:

The quarries and stone production activities have several environmental impacts, including:

- Air pollution: Dust can worsen respiratory health and reduce visibility by contributing to air pollution. Furthermore, quarries produce dust during extraction and processing, which can settle on plants, clogging their stomata (pores on leaves) and limiting their photosynthetic ability. Accordingly, it might gradually weaken or kill the plants.
- Soil erosion: Dust can cause soil erosion, which reduces agricultural output by causing topsoil to be lost.
- Water pollution: Dust can contaminate water supplies, harming human health and aquatic habitats.
- Noise pollution: Quarry operations have the potential to produce noise pollution, which can annoy both human populations and wildlife.

- Phase 3:

One important factor considered as a significant factor in dust transportation and depositions is the wind speeds and directions invoked in deposition and dust particle lifting. Accordingly, the research finds the significance of highlighting the impact of wind.

- Phase 4:

Dust transportation is considered a complex phenomenon to model; several considerations must be considered. Here is a breakdown of these key elements:

- Wind Direction and Speed
    - The threshold wind speed is defined as the ability of the wind to move dust particles off the ground, at specific wind speed is needed. The size of the particles and the properties of the soil affect this threshold.
    - Wind Direction: The course of dust transport is determined by the direction of the prevailing winds. Dust can travel great distances on persistent winds.
    - Wind Shear: Variations in wind direction or speed with altitude, or wind shear, can affect the deposition and dispersion of dust.

The wind threshold can be defined as how fast the wind blows to raise dust particles off the ground. Accordingly, to elaborate on these points, it is important to understand several factors affecting the aforementioned threshold. More illustrations can be found in table 4.

- Elements Influencing the Threshold:

  - Particle Size: Lower wind speeds are needed to lift smaller particles.
  - Texture of the Soil: Compacted, clay-rich soils have higher thresholds than loose, sandy soils.
  - Soil Moisture: Compared to moist soil, dry soil has lower thresholds.
  - Surface Roughness: Compared to rough surfaces, smooth surfaces have lower thresholds.

Table 4: Threshold Wind Speeds for Different Particle Sizes

Particle Size (µm)	**Threshold Wind Speed (m/s)**	**Threshold Wind Speed (km/h)**
10	2-3	7.2-10.8
50	5-7	18-25.2
100	8-10	28.8-36
200	12-15	43.2-54

It is worth mentioning that there is no single universal threshold wind speed. Studies have shown that for typical desert soils, threshold wind speeds can range from 5 to 15 meters per second. It is worth noting here that the Palestinian Meteorological Department wind observation taken on the Hebron station, which can be extended more or less to the research area, shows the average speed during the period extended from 2013 to 2020 is 4 km/h. However, the 4km/h denotes the average daily speed of the wind speed, and the same data provided by the Palestinian meteorological department revealed that the maximum value of the wind's average daily speed can reach 30 km/h. Additionally, the same data exposed that the dominant wind directions are west-northwest. Accordingly, the research justifies the establishment of the aspect map. With current knowledge of the wind speed and directions, we can assume that the area with slope direction towards the north, northwest, and west directions will be impacted more by dust pollution.

- Wind direction effluence: The winds can blow in several directions, including horizontal, vertical, or even axial directions. Accordingly, dust particles can be kept in the atmosphere by strong vertical wind, which is called shear wind, which inhibits their deposition. However, dust can be spread out across a vast area due to horizontal wind. Moreover, wind turbulence potentially impacts the mixing of dust and air.

- Phase 5:
  In order to model the distribution pattern of dust particles, the research utilized Interpolation techniques called kriging, which can be broadly categorized into deterministic and geostatistical approaches. Deterministic methods, such as Inverse Distance Weighted (IDW) and Spline interpolation, derive interpolated values directly from surrounding measured points or predefined mathematical functions that govern

surface smoothness. In contrast, geostatistical methods, exemplified by kriging, leverage statistical models that incorporate autocorrelation—the statistical interdependencies among sampled locations. This consideration of spatial relationships enables geostatistical techniques to generate predictive surfaces and quantify these predictions' associated uncertainty or accuracy.

Kriging assumes that inter-sample distances and directions reflect a spatial correlation structure that can elucidate surface variation. To estimate values at unsampled locations, the Kriging algorithm employs a mathematical function fitted to a set of neighboring points or all points within a specified radius. The kriging workflow is iterative, encompassing exploratory statistical analysis, variogram modeling, surface generation, and, optionally, variance surface analysis. This method is particularly well-suited to datasets exhibiting spatially correlated distance or directional bias, finding frequent application in disciplines such as soil science and geology.

- Phase 6:

The current phase represents the dust observations taken between 24/11/2024 and 18/12/2024. In order to model the dust distribution well, the research established several measuring points inside and outside the study regions; these points are extended to make observations inside the active quarry area. It is worth mentioning that the dust measurements are repeated for several days for some point in order to check the measurement stability. The total number of locations where the measurements were held is points. Figure 8 shows the distribution of dust pollution measured locations.

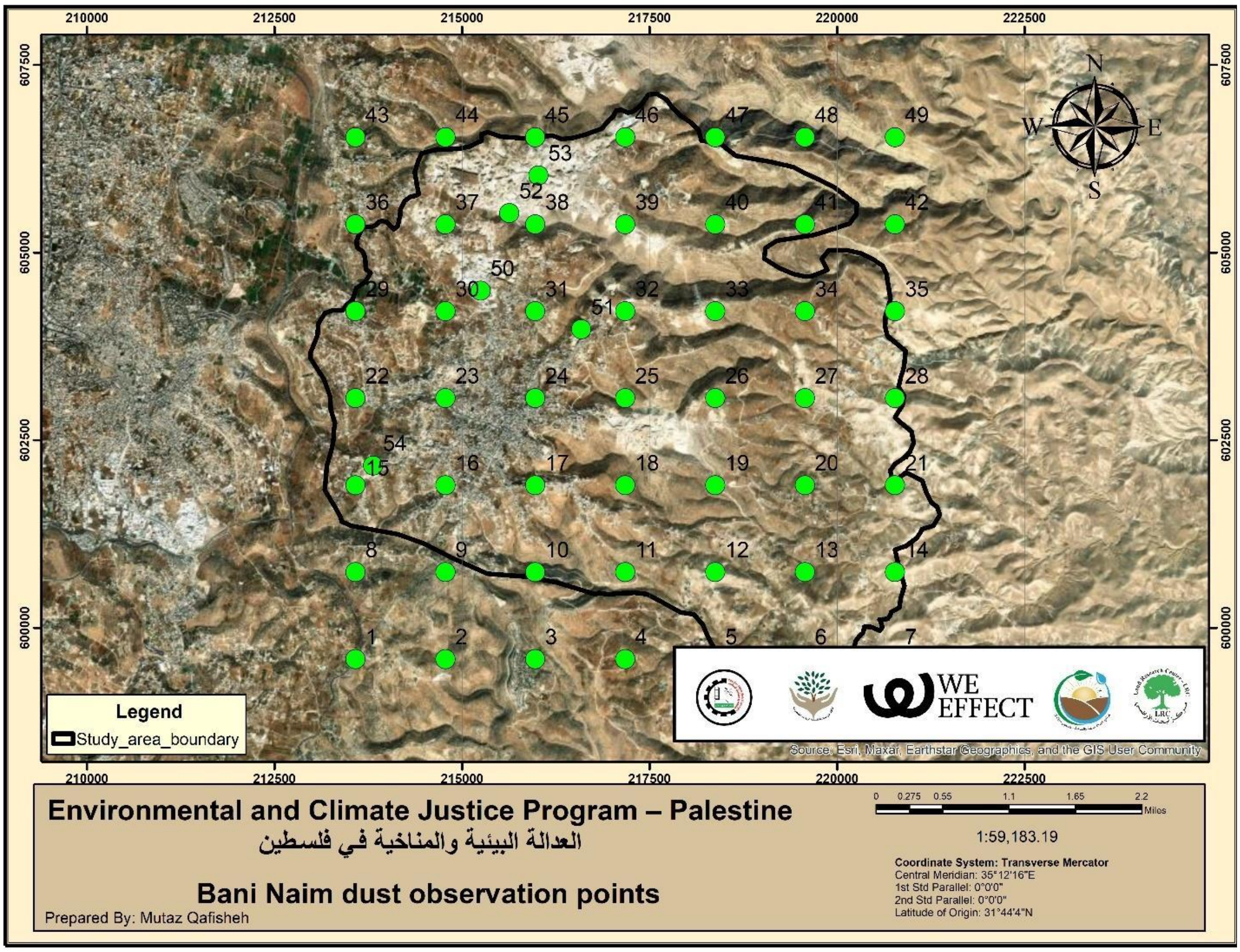

Figure 8: Dust Observation Points.

- Phase 7:

The current phase was dedicated to investigating the suitable devices and methodology in order to investigate the impact of the dust pollution in terms of Pm2.5 and 10 Mm observations, followed by phase number six, which was designed to equally distribute the measurements locations as well as establishing measurement's location adjacent to the quarry's activities. Based on the points identified by colleagues in the Geographic Information Department, the specified locations were reached, and measurements were initiated using the measurement devices.

There are two main measurements to determine air pollution by dust:

1. **Concentration of Particulate Matter**
- The concentration of airborne particles is measured in units such as micrograms per cubic meter (µg/m³).
2. **Size and Number of Particles**
- Particles are usually measured in micrometers (µm).
- Particles are classified by size into:

-PM10: Particles with a diameter of less than 10 micrometers.

-PM2.5: Particles with a diameter of less than 2.5 micrometers.

Combining concentration and particle size measurements comprehensively assesses dust-related air pollution levels.

The following is a description of the devices used for measuring dust pollution.

During the study, three devices were used to take air pollution readings, as follows:

1. **The Kanomax Digital Dust Monitor – Model 3442**

The unit measures 0.1 to 10µm particle size aerosol contaminants such as fumes, dust, smoke, and mists. It is also suitable for clean office settings, harsh industrial workplaces, construction and environmental sites, and outdoor applications.

Measuring Object: Airborne Particle Matter 0.1 to 10 µm

Measuring Range: 0.001 to 10.0 mg/m3

Accuracy : +/- 10% of reading

https://kanomax-usa.com/wp-content/uploads/2020/12/3443_Manual.pdf?x16379

2. **Environmental Devices Haz-Dust EPAM-5000 Environmental Particulate Air Monitor**

Sensing range: .001-20.0 mg/m3

Particle size range: 0.1-100 µm

Precision: +/- 0.003 mg/m3 (3 µm/m3)

Accuracy: +/-10%

Sampling flow rate: 1.0 – 4.3 liters/minute

https://www.skcltd.com/images/pdfs/EPAM-5000-manual.pdf

3. **CEM DT-9880 Air Particle Counter**

Easy and accurate readings for particle counter, detectors, air temperature relative humidity, and most surface temperature measurements.

Channel : 0.3, 0.5, 1.0, 2.5, 5.0, 10µm

Flow Rate: 2.83L/min

https://www.tme.eu/Document/90cc4a5c572834c619a0a186b1b18d08/DT-9880.pdf

Figure 9: Dust Observation Instruments.

- Phase 8: Dust Particles Analysis

It is worth mentioning that the research measured several indicators related to dust pollution, including the concentration of particulate matter 2.5 and 10 µm/m³ and the number of particles for the aforementioned particulate matter size in the unit of µm. In addition, the temperature and humidity were taken similarly. Accordingly, the GIS tool was utilized to understand how these particles are distributed and concentrated in the study area. Figures 10 and 11 show the number of measured particles with sizes equal to 2.5 and 10 µm.

The research extended the measurement to investigate the concentration of these particulates and the concentration of each cubic meter. Accordingly, Figures 12 and 13 show the concentration of equal 2.5 and 10 µm/m³.

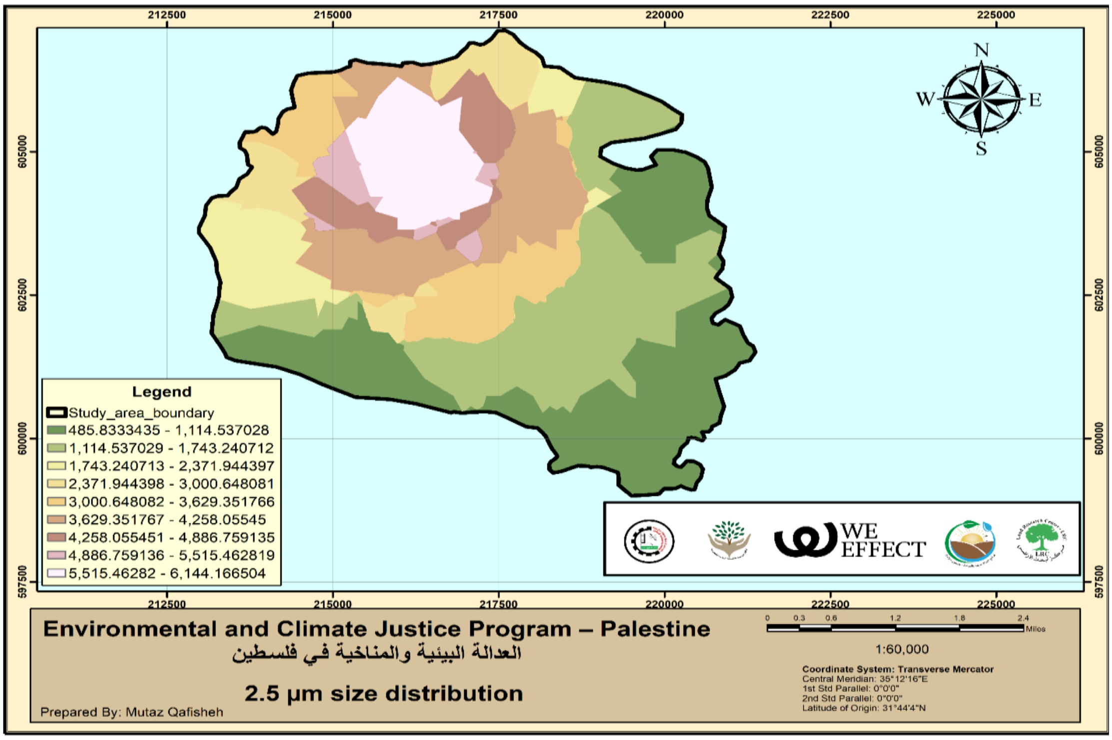

Figure 10: Pm (2.5) µm Size Distribution.

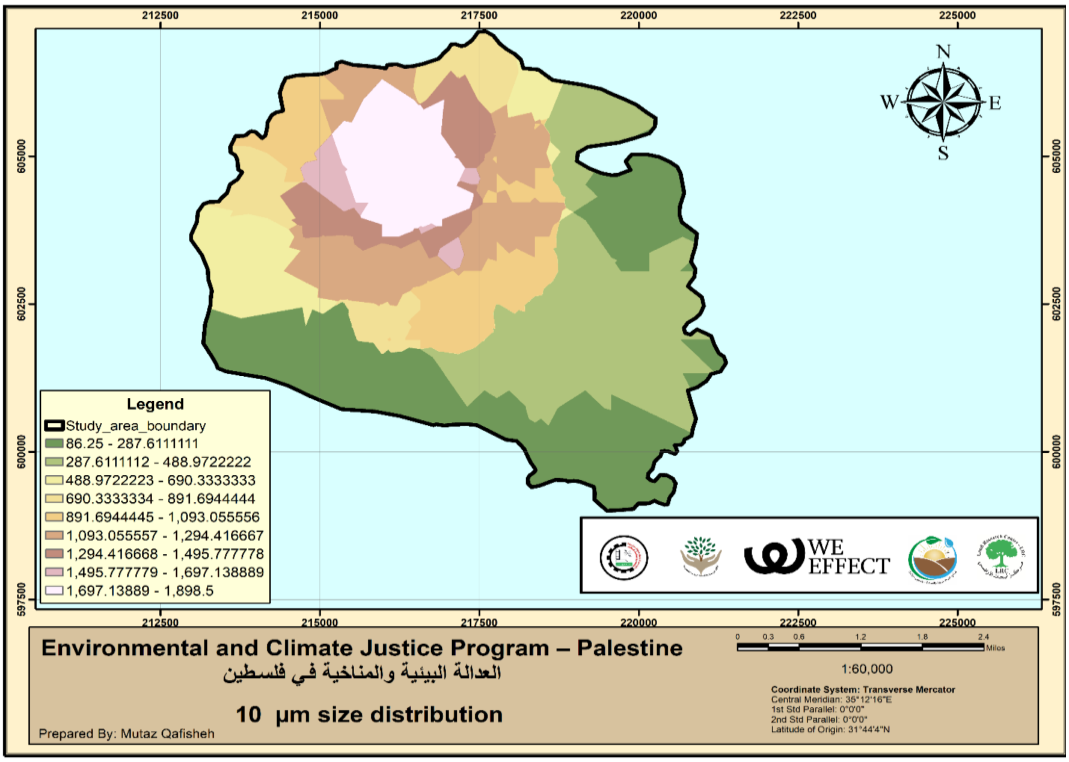

Figure 11: Pm (10) µm Size Distribution.

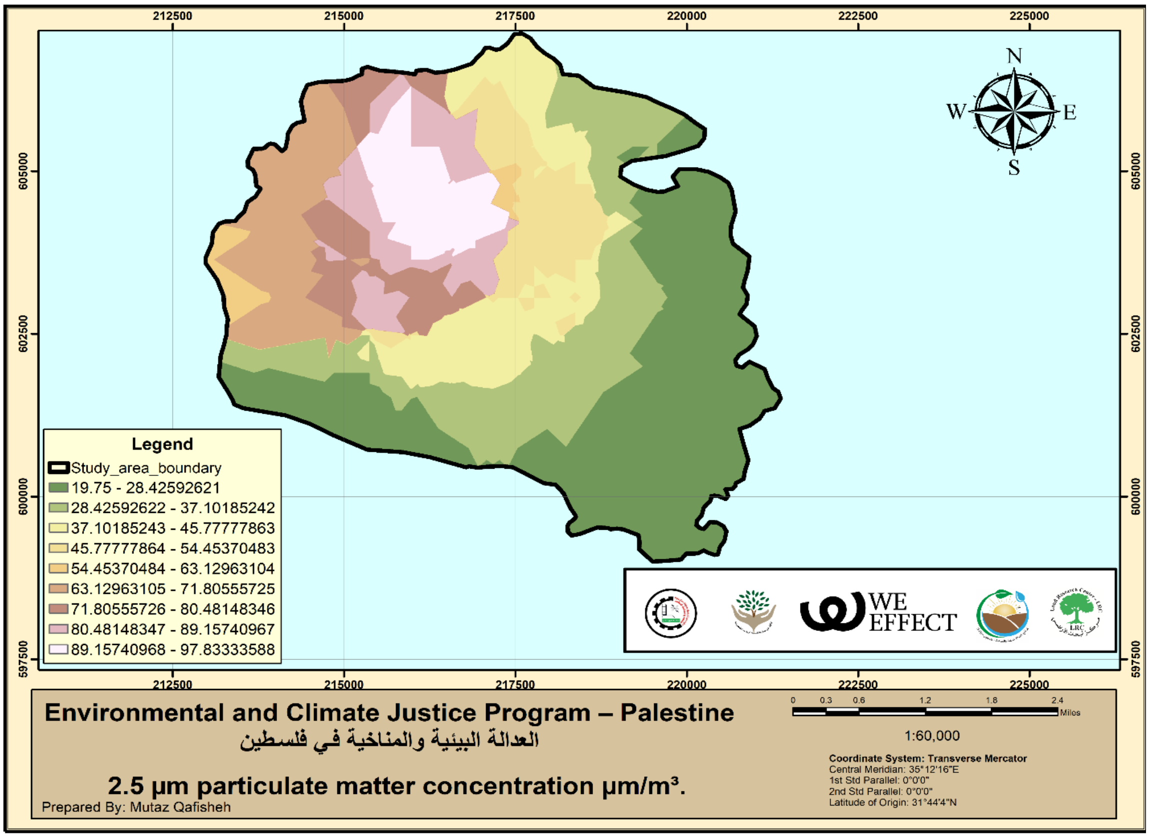

Figure 12: Pm (2.5) µm Particulate Matter Concentration µm/M³.

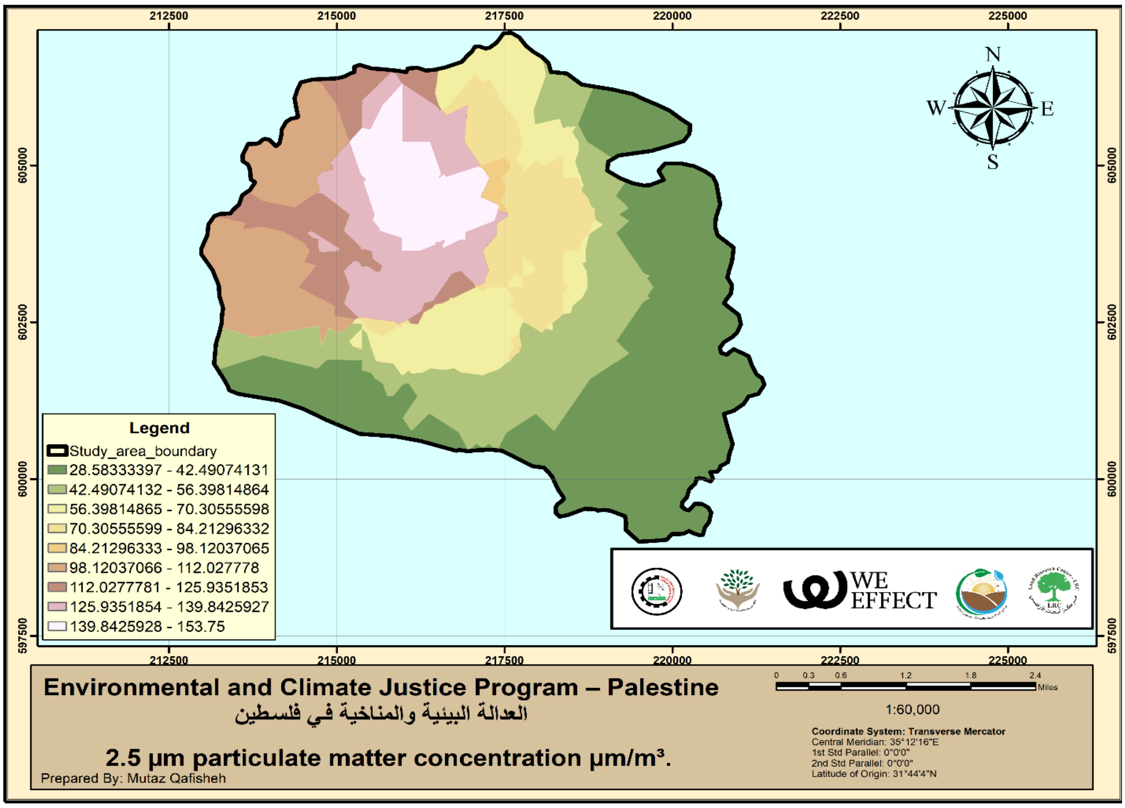

Figure 13: 10 µm Particulate Matter Concentration µm/M³.

1.7.6 Work Package 6 (Criteria Analysis and Air Pollution Score)

The current work package is designed to investigate the impact score for each research variable. Accordingly, the research developed a score from one to ten for each variable, where 10 represents the highest dust pollution impact. However, the value one represents the lowest impact regarding the pollution impact.

The Euclidean distance between each raster cell and the closest source cell is determined by the Euclidean Distance tool in GIS. Analyzing closeness to elements such as roads, aquatic bodies, or sites of interest is made easier using this. It can find locations that are more or less accessible, or that satisfy particular distance-based requirements by knowing how far these attributes are. The tool is frequently used in many applications, including environmental impact assessments, network analysis, and site selection.

- Phase1:

The research supposes that dust pollution will impact the area near active quarries more than the area far away from stone production activities. Accordingly, the following table and map show the impact score table criteria and the map score for the active quarries surrounding the area. Table 5 and Figure 13 represent visualization regarding distance score criteria.

Table 5: Distance from Active Quarries Score

Distance between the quarry and the surrounding areas (m)	Distance from Active Quarries Score
0 - 406	10
406 - 813	9
813 - 1,219	8
1,219 - 1,626	7
1,626 - 2,033	6
2,033 - 2,439	5
2,439 - 2,846	4
2,846.418- 3,253	3
3,253- 3,659	2
3,659 - 4,066	1

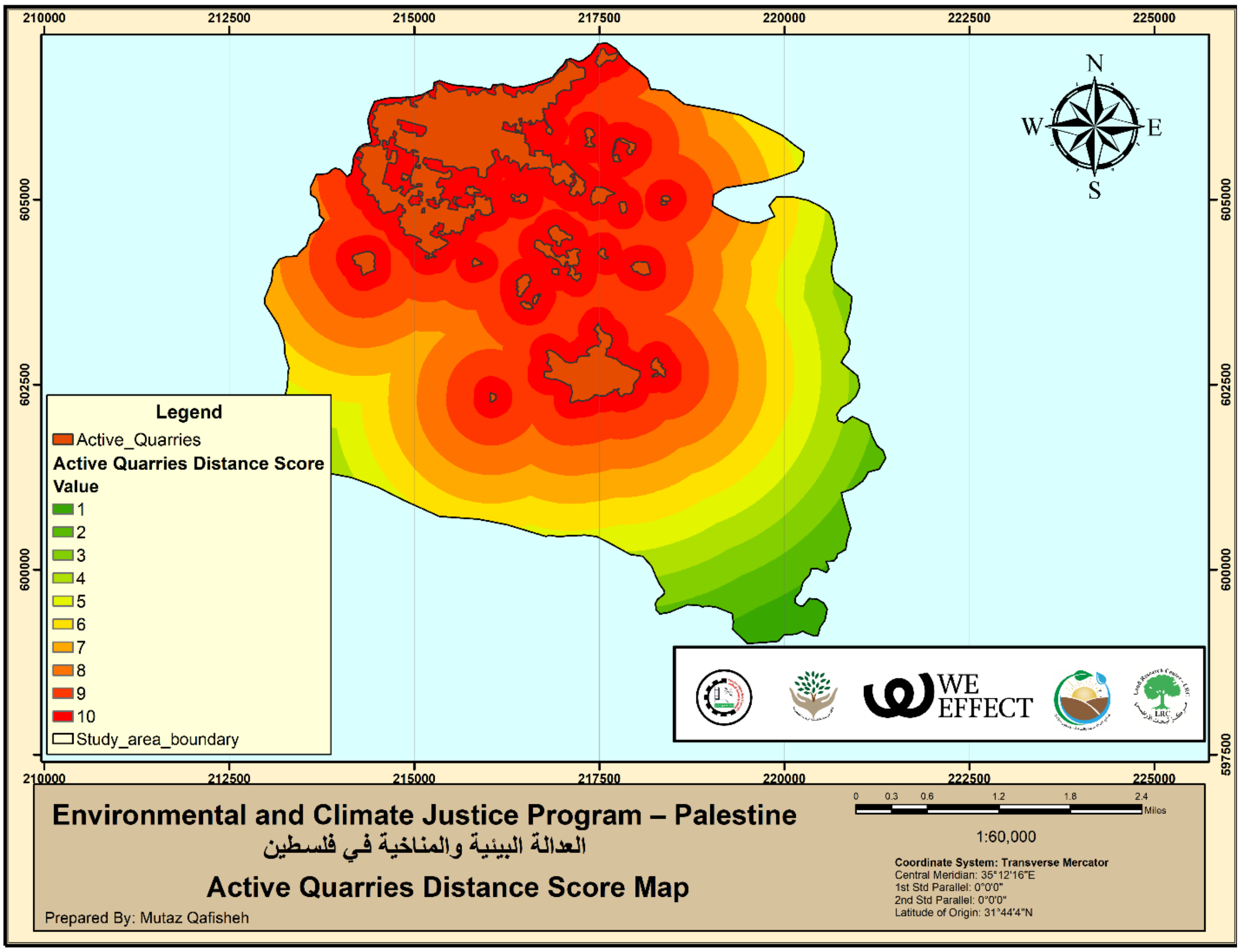

Figure 13: Distance Score from Active Quarries.

- Phase 2:

The research supposes that dust pollution will impact the area near road networks more than the area far away from exciting roads. Accordingly, the following table and map show the impact score table criteria and the map score for the area surrounding road networks. Table 6 and Figure 14 represent visualization regarding the distance from road score criteria.

Table 6: Distance from Roads Score

Distance Roads and the surrounding areas (m)	Distance From Roads Score
0 - 80.80377197	10
81 - 162	9
162- 242	8
242 - 323	7
323 - 404	6
404- 485	5
485- 566	4
566 - 646	3
646 - 727	2
727 - 808	1

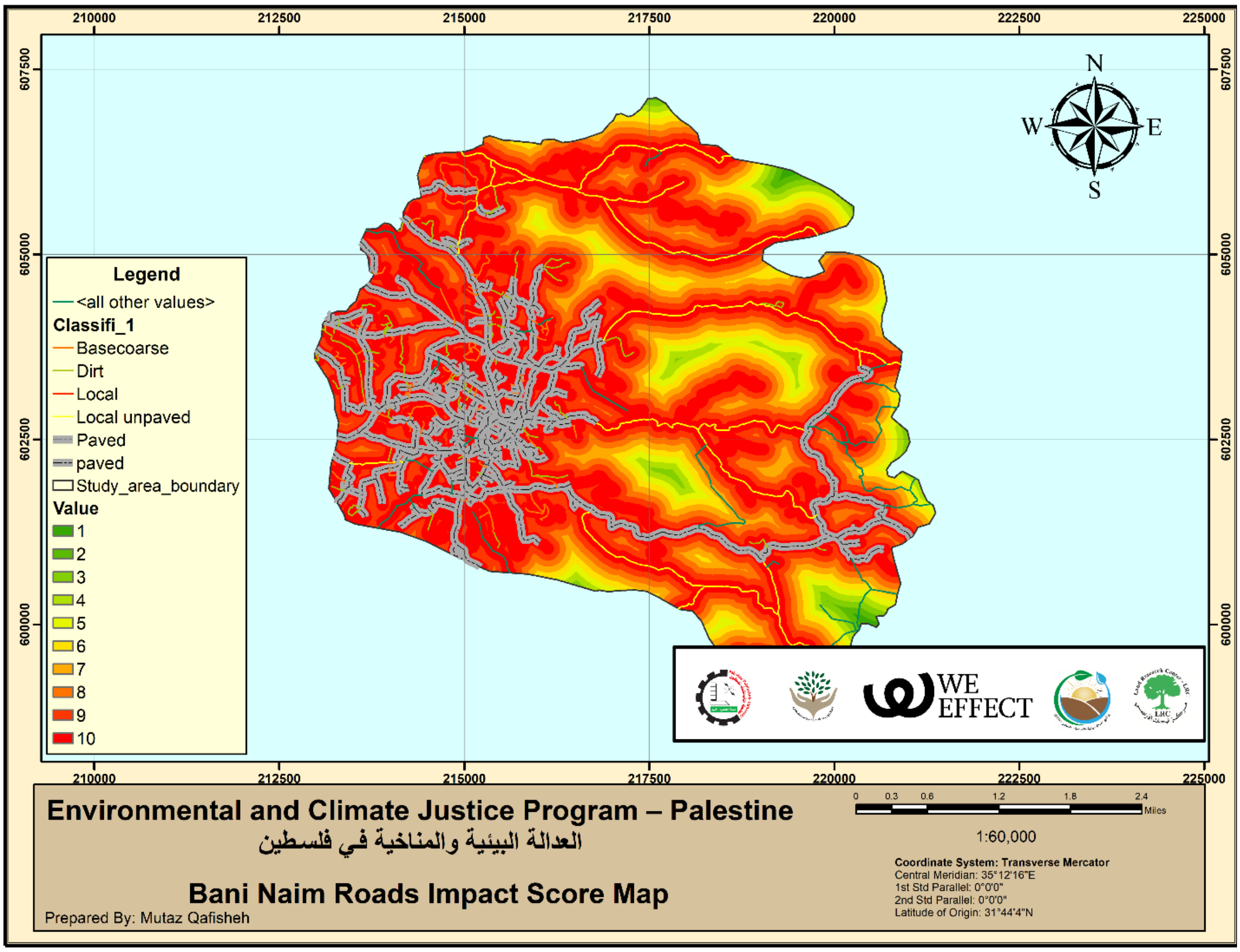

Figure 14: Distance Score from Existing Roads.

- Phase 3:

The research assumes that the areas with slopes towards the north, northwest, west, and flat will be impacted more the dust pollution in comparison with the areas having slopes towards other directions; accordingly, the following table and map show the impact score table criteria and the map score for aspects. Table 7 and Figure 15 represent visualization regarding aspect score criteria.

Table 7: Aspect Score

Aspect (Cell Slope Direction)	**Aspect Score**
Flat (-1)	10
North (0-22.5)	10
Northeast (22.5-67.5)	8
East (67.5-112.5)	5
Southeast (112.5-157.5)	4
South (157.5-202.5)	1
Southwest (202.5-247.5)	4
West (247.5-292.5)	5
Northwest (292.5-337.5)	10
North (337.5-360)	10

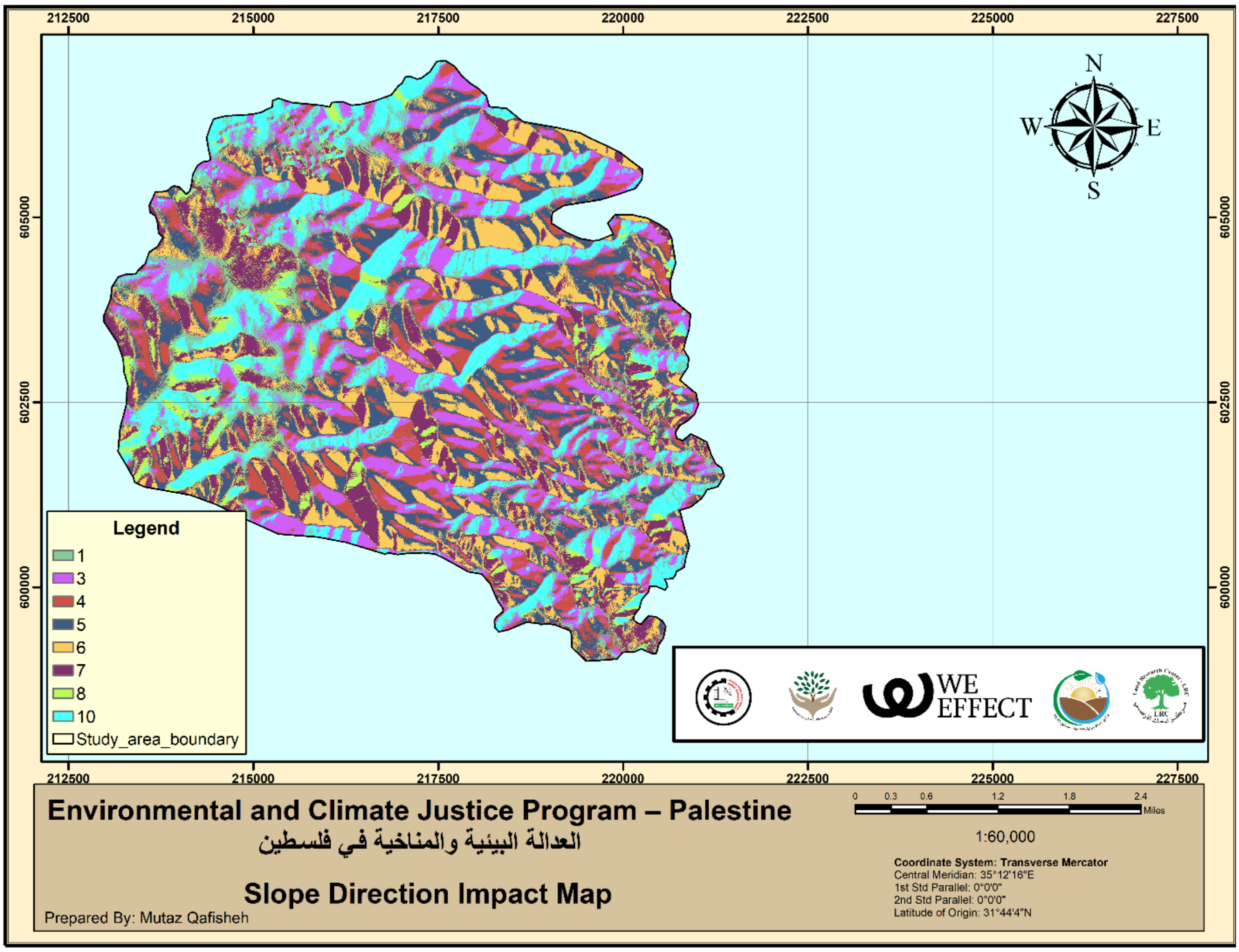

Figure 15: Aspect Score.

- Phase 4:

The research assumes that the areas with a land cover value equal to build-up or residential areas and those used for agriculture will be impacted more by dust pollution than the open area. Accordingly, the following table and map show the impact score table criteria and the map score for land cover analysis. Table 8 and Figure 16 illustrate the land cover score criteria.

Table 8: Land Cover Score

Land cover type	**Land cover Score**
Agricultural	10
Artificial	10
Open Areas	5
Active Quarries	10

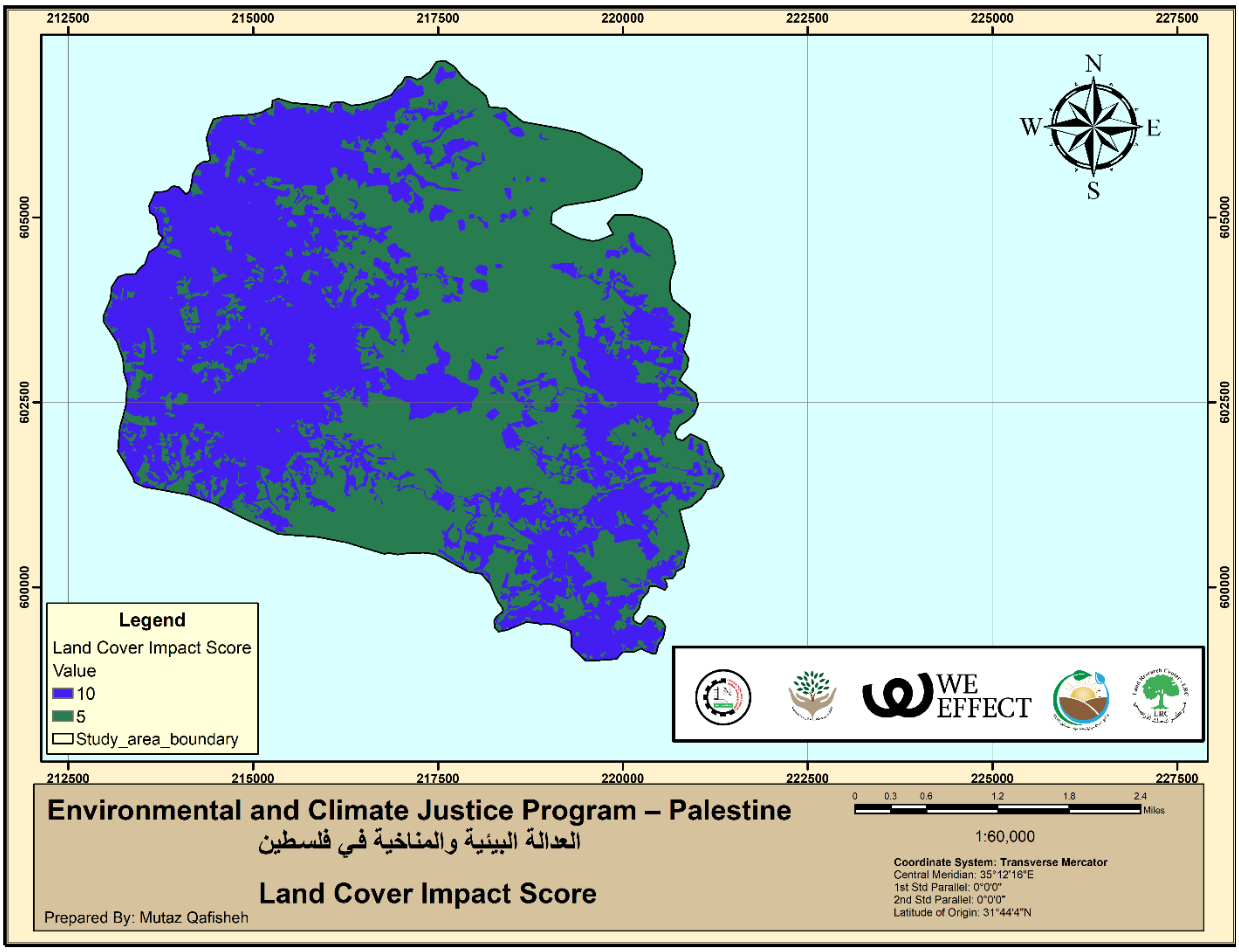

Figure 16: Land Cover Impact Score.

- Phase 5:

PM concentrations and altitude have a complicated relationship that can change based on several variables, such as:

- Weather: The dispersion and vertical distribution of PM are influenced by wind direction, speed, and atmospheric stability.
- Emission sources: PM concentration at various elevations can be influenced by the kind and location of emission sources, such as residential, commercial, and traffic.
- Geographical features: The vertical distribution of pollutants can be affected by topography, such as valleys and mountains, which can trap or disseminate them.

Generally, PM concentrations tend to decrease with increasing altitude, particularly in the lower atmosphere. This is due to the natural dispersion of pollutants as they rise into the atmosphere and are diluted by cleaner air at higher altitudes. Additional points to consider:

- Another factor is the size of the PM particles. Compared to larger particles like PM10, smaller particles like PM2.5 can be carried to higher altitudes more readily.
- Season and time of day can also affect the vertical distribution of PM. For instance, lower dispersion rates and less atmospheric turbulence at night may result in higher PM concentrations.

It is crucial to recall that there is a complicated and variable relation between PM concentrations and altitude. More research is required to completely comprehend this relationship's variables and create practical air pollution mitigation plans. Table 9 and Figure 17 show visualization regarding elevation score criteria.

Table 9: Elevation Score

Elevation ranges	**Elevation Score**
461-531	10
531-572	9
572-617	8
617-668	7
668-723	6
723-780	5
780-836	4
836-885	3
885-924	2
924-976	1

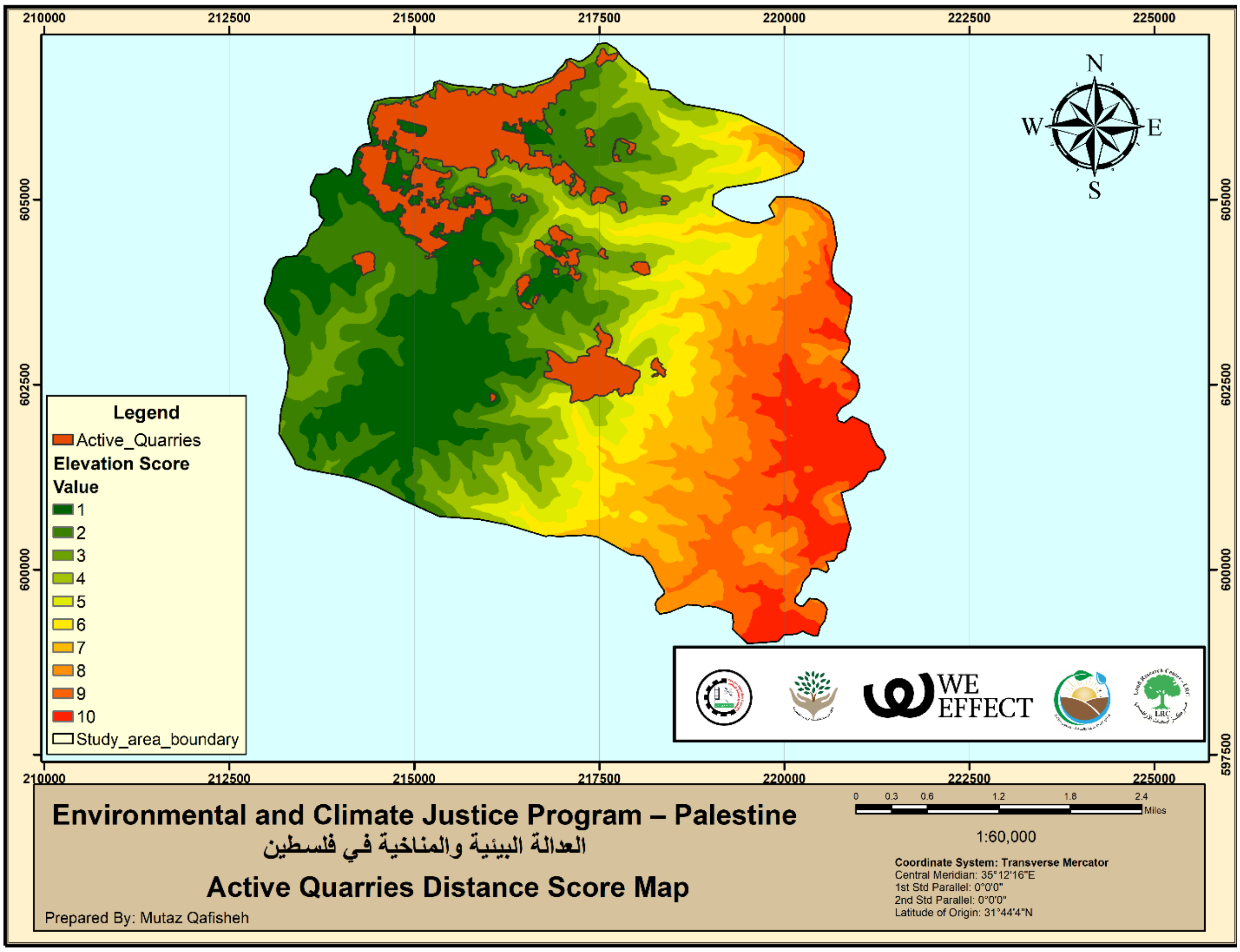

Figure 17: Elevation Impact Score.

- Phase 6:

The current phase is designed to develop a dust pollution score map where the value 10 represents the area where the concentration and the size of particulate matter are high. Conversely, areas expressing the lower concentration of particulate matter will have a value of one. In order to properly analyze the impact of all stages carried out in the work package five phase five, the research combined the analysis of all dust measurements in one impact score. Figure 16 signifies visualization regarding dust pollution score criteria.

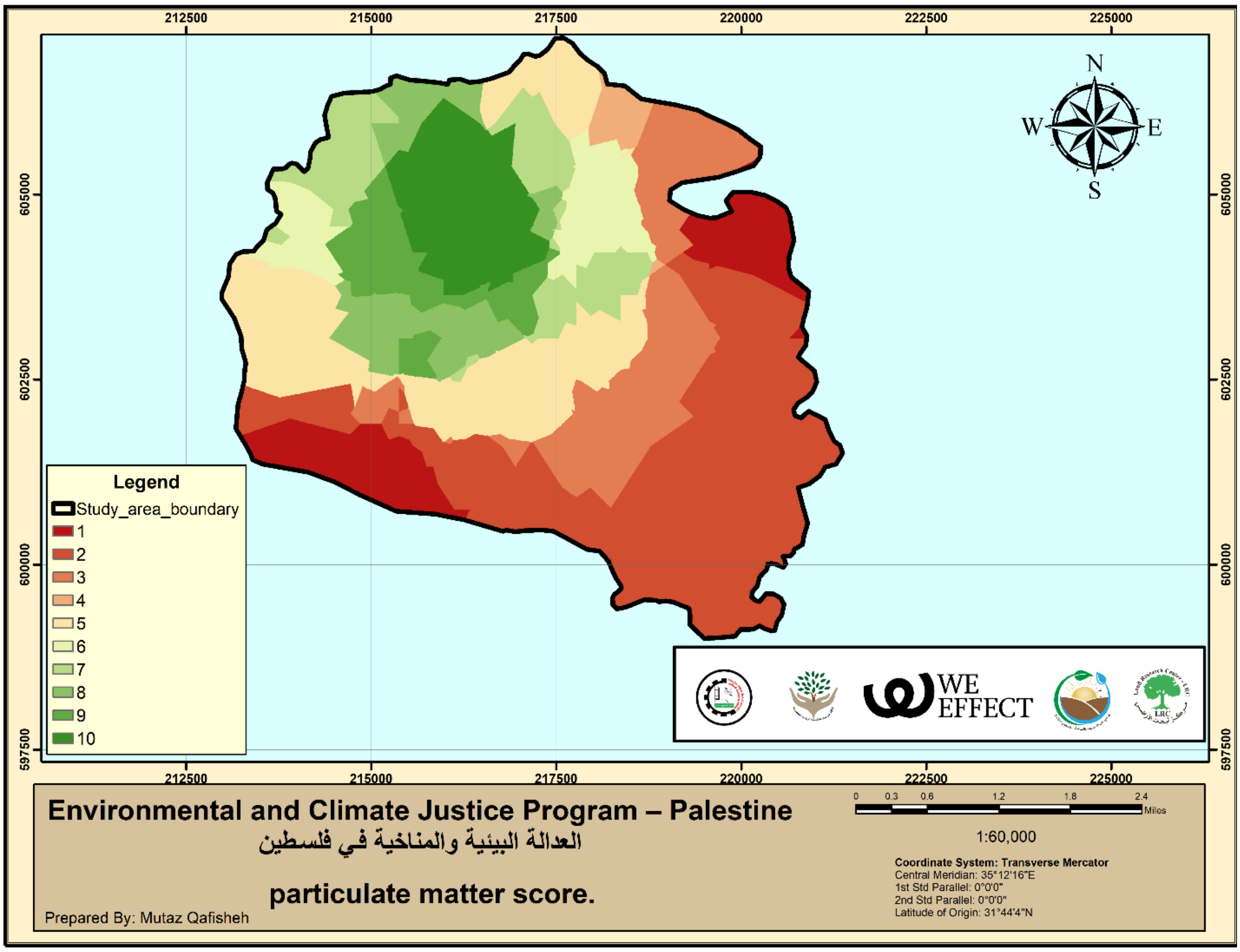

Figure 18: Particulate Matter Impact Score.

1.7.7 Work Package 7 (Overlay Analysis)

The final work package is dedicated to analyzing the areas where dust pollution has a higher impact. Accordingly, this analysis will highlight the areas where interventions are needed to mitigate the pollution. It is worth highlighting that the distribution of the impact score will also aid spatially where the interventions are required. Accordingly, the research developed the map score for all variables, showing that the ten-value area required more interventions to mitigate air pollution. Figure 19 shows that the green area in the middle of the study area is required to attract the research attention as it contains a build-up area and agriculture. As shown, quarry activities significantly impact it.

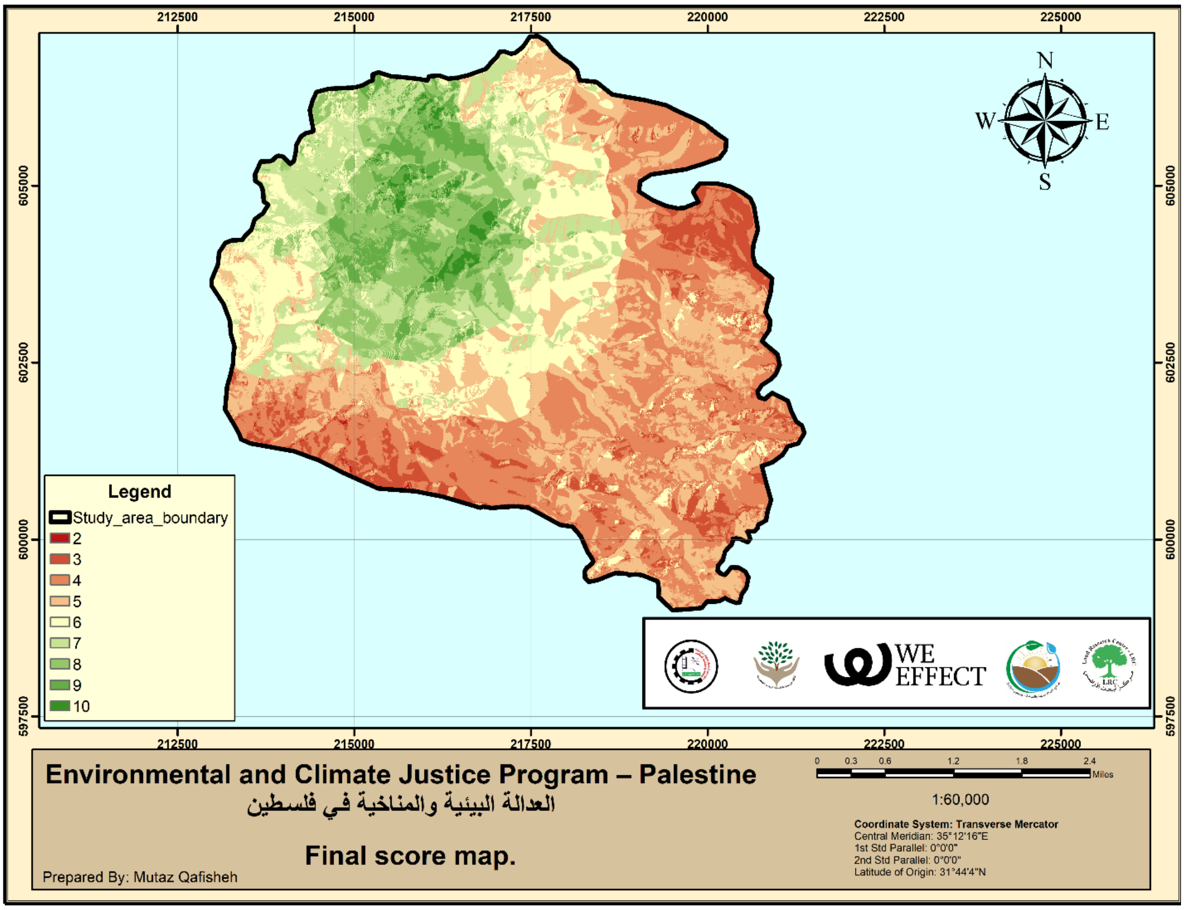

Figure 19: Particulate Matter Score Analysis.

1.7.8 Work Package 8 (Green Belt Interventions)

Measuring dust is essential for air quality, health, and safety in various environments. The methods and standards used depend on particle size and measurement techniques, with adherence to environmental regulations to ensure a healthy and safe environment.

The vegetation cover or green belt within the polluted area was divided into two central regions: - one close to or directly near the quarry and one away from the quarry and in the vicinity of buildings and houses. The plant species in this green belt were primarily selected according to the following criteria: they should be a tree, evergreen, dense vegetative growth, and non-aggressive root system if planted close to buildings and concrete foundations. More illustrations regarding the tree species can be found in the annexes section.

The following figure summarizes the flow chart, which shows the work packages utilized in this research.

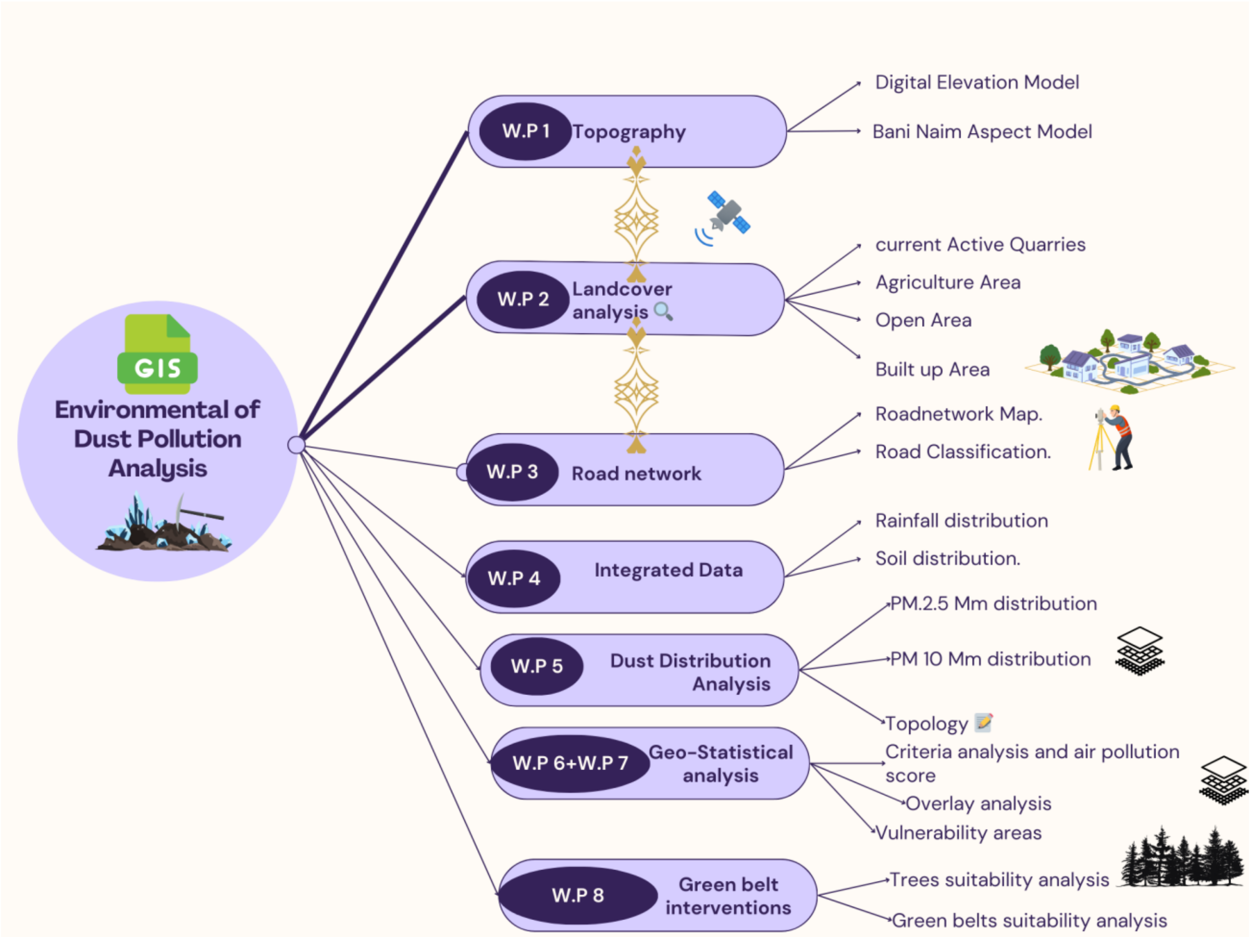

Figure 20: Research Workflow.

1.8 Results and Discussions

After the comprehensive spatial analysis, the research reaches the recommendation, discussions, and results section. Accordingly, the research first highlighted the analysis, considering several variables, including wind speed and directions, topography, land cover, road network, and particulate matter observations. The spatial analysis showed that quarry activities mainly affected the population and agricultural areas in Bani Naim. It is worth noting that the World Health Organization (WHO) and the Environmental Protection Agency (EPA) provide various standards for the maximum allowable indicators regarding particulate matter. The severity of PM 2.5 is considered more significant as a result of the ability of these particulates to penetrate the Respiratory system; accordingly, several mitigation measures can be utilized in order to mitigate the environmental impact, such as:

- Water suppression: Spraying water onto quarry operations can help reduce dust generation.
- Dust collection: Installing dust collection systems, such as baghouses or cyclones, can capture and remove dust particles from the air.
- Vegetation barriers: Planting trees and shrubs around quarries can help filter dust and reduce its dispersion.

- Proper planning and management: Careful planning and management of quarry operations can minimize dust generation and its impacts.

This study investigates the strategic implementation of vegetation barriers to mitigate the environmental impact of quarry operations. Specifically, it advocates for using the Mediterranean cypress (*Cupressus sempervirens*) due to its evergreen nature, local climate adaptability, and effective disruption of dust dispersal. The research proposes establishing a dual green belt barrier system in the northern section of the study area, adjacent to active quarries; accordingly, it maximizes pollution capture at the source. These barriers, designated A and B, would comprise 2706 and 1719 Mediterranean cypress trees, respectively, spanning approximately 4 km (Belt A) and 2.5 km (Belt B). Furthermore, a third green belt, designated C, consisting of approximately 1100 carob trees (*Ceratonia siliqua*) and extending for 4 km, is recommended to mitigate wind speed before it reaches the quarry sites. The strategic placement of these barriers, particularly A and B, near quarry activities in the northwest region is hypothesized to reduce pollution from the quarries significantly. The spatial configuration of these proposed green belts within the study area is illustrated in Figure 20. It is worth highlighting that the implementation of a 1.5-meter spacing for Cupressus sempervirens and a 4-meter spacing for Ceratonia siliqua within the greenbelts framework results in calculated areal coverages of 8 km², 5 km², and 32 km² for Belts A, B, and C, respectively. These quantitative differences in green belt extent will likely have significant implications for localized ecological processes and regional environmental mitigation.

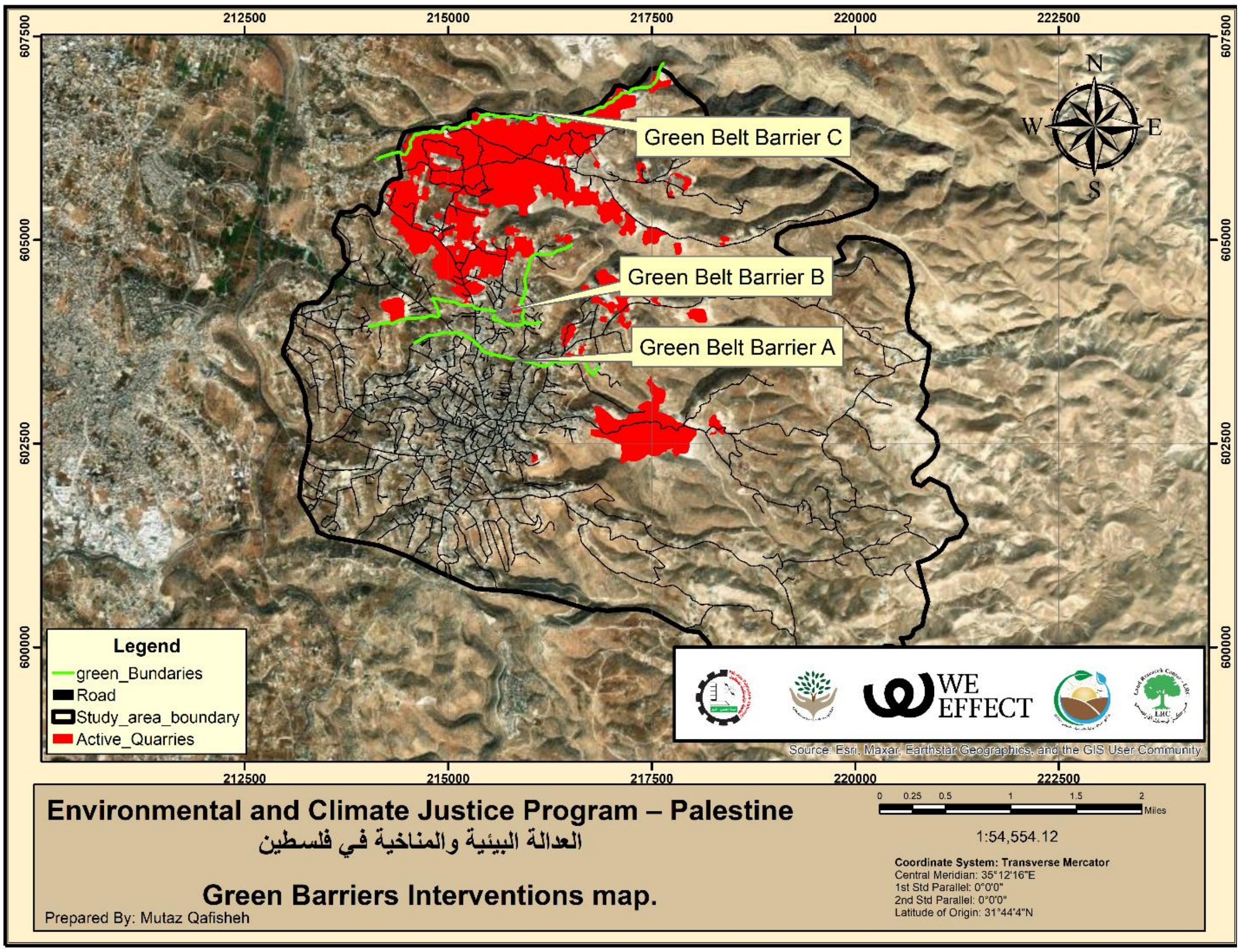

Figure 21: Green Barriers Locations Map.

1.8.1 The Importance of Clean Air for Human Health and The Environment

The importance of clean air for humans and the environment is immense, as it plays a crucial role in sustaining life and maintaining ecological balance.

Importance of Clean Air for Humans:

- Supports Breathing: Clean air provides sufficient oxygen, which is essential for respiration and the functioning of vital body processes.
- Enhances Health: Breathing clean air reduces the risk of respiratory diseases such as asthma and allergies and minimizes exposure to harmful pollutants.

1.8.2 Importance of Clean Air for The Environment

1. Supports Plant Life: Plants rely on clean air containing carbon dioxide for photosynthesis, producing oxygen vital for all living organisms.
2. Maintains Ecological Balance: Clean air helps reduce pollutants that contribute to climate change, such as carbon dioxide and methane.
3. Preserve Soil and Water Quality: Clean air limits the accumulation of harmful chemicals contaminating soil and water.
4. Promotes Biodiversity: Clean air supports the survival and growth of various species, protecting biodiversity from the adverse effects of pollution.

1.8.3 Quarry Dust and Its Risks to Human Health

Quarry dust is a serious environmental and health issue that poses significant risks to humans and the surrounding environment. This dust consists of fine particles released during quarries' extraction and crushing of stones and minerals. Prolonged exposure to quarry dust can lead to various health problems.

Dust concentrations in the air refer to the number of solid particles suspended in the atmosphere. These particles can originate from natural sources or human activities. They vary in size, with smaller particles referred to as fine particulate matter (PM10, PM2.5), representing particles with diameters less than 10 micrometers or 2.5 micrometers, respectively.

1.8.4 Dust Concentrations and Their Risks

PM2.5 is more dangerous to human health than PM10 due to its smaller size, allowing it to penetrate deeper into the respiratory system, reaching the alveoli, and potentially entering the bloodstream.

- **Differences Between PM2.5 and PM10**

1. **Size:**
    - **PM2.5**: Particles with a diameter of less than 2.5 micrometers. Smaller in size, making them more capable of reaching the lungs.
    - **PM10**: Particles with a diameter of less than 10 micrometers. Larger and usually trapped in the upper respiratory tract.

2. **Health Effects**
    - **PM2.5**: This can cause serious health issues, including heart disease, asthma, reduced lung function, and even premature death.
    - **PM10**: Affects the upper respiratory system (e.g., nose and throat), potentially causing inflammation and respiratory problems, but it is less likely to penetrate deeper into body tissues.

1.8.5 Air Quality Standards

The Clean Air Act requires EPA to set two types of outdoor air quality standards: primary standards to protect public health and secondary standards to protect the public against adverse environmental effects. The law requires that primary standards be "requisite to protect public health with an adequate margin of safety," including the health of people most at risk from PM exposure. These include people with heart or lung disease, children, older adults, and people of lower socioeconomic status. Secondary standards must be "requisite to protect the public welfare" from known and anticipated adverse effects.

EPA is retaining the levels of the existing secondary standards for PM2.5 and PM10 to address PM-related effects such as ecological effects, damage to materials, and climate impacts. Those standards are a 24-hour PM2.5 standard of 35 µg/m3 and a 24-hour standard of 150 µg/m3 for PM10.

1.8.6 Palestine Standards Institution PSI

The office of the Palestinian Standards Institution in Hebron was contacted regarding this matter. It stated that there is no Palestinian specification for dust air pollution.

Therefore, we request that the relevant parties be contacted to determine and adopt values.

1.8.7 Comments on the Measurements Table

The measurements were taken over two weeks, from the end of November to the beginning of December 2024. More regarding the dust measurements can be found in Annex B, Particulate Matters Observation Measurements.

- Readings 4, 5, and 10 were monitored on several different days, and the readings were the same to ensure the stability of the readings on the different monitoring days and the device's accuracy.
- Some measurements were taken concentrated near some industrial activities located in residential areas.
- PM2.5 is part of PM10: PM2.5 fine particles are part of the total PM10 concentration. This means PM2.5 includes particles with a diameter of 2.5 micrometers or less, while PM10 includes particles of up to 10 micrometers.
- To obtain the most accurate and reliable values, readings taken on rainy days were excluded.
- The highlighted rows show the measurements of dust exceeding the EPA standards in terms of the highest allowable concentration of Pm 2.5 or 10 micrometers.

1.9 Recommendations

The following recommendations are vital in order to sustain the project:

1. The Mediterranean cypress was required to maintain irrigation, especially during the first three years.
2. The green barrier area is highly recommended to be protected, especially from overgrazing.
3. The research recommends that the Bani Naim Municipality update the green belts' land use in future urban plans.
4. We recommend contacting the Palestinian Standards Institution to define and approve permissible limits for dust pollution.
5. Extending the project timeline by one year is strongly advised. This extension is crucial for capturing dust measurements across various environmental conditions and multiple academic semesters, providing a more comprehensive and robust dataset. A more extended observation period will allow data collection during diverse weather patterns, seasonal changes, and potentially varying human activity levels, leading to more reliable and generalizable findings. This extended timeframe will significantly enhance the project's scientific value by accounting for potential environmental fluctuations and ensuring a more thorough understanding of dust dynamics.
6. Engaging with key stakeholders is strongly encouraged. This collaborative effort should include organizations such as the Palestinian Environmental Quality Authority, the Palestinian Standards Institution, relevant universities, the Union of Stone and Marble Industry in Palestine, and other pertinent parties. Establishing partnerships with these stakeholders is critical for developing and implementing new, comprehensive PM2.5 and PM10 standards for indoor and outdoor environments. This inclusive approach will ensure that the new standards are relevant and practical and effectively address Palestine's specific needs and context. Furthermore, it will foster buy-in and promote wider adoption of the standards across various sectors.
7. Implementing comprehensive covering or shielding systems at stone industrial facilities is strongly recommended to control dust pollution generated by stone processing effectively. This is particularly crucial for stone-crushing machinery, a significant dust emission source. These systems could include enclosures, dust curtains, or other engineered solutions designed to contain and minimize the release of particulate matter into the surrounding environment. Investing in and utilizing these systems will significantly reduce dust pollution, improve air quality, and protect the health of both workers and surrounding communities. The research strongly emphasizes the importance of prioritizing installing and maintaining such systems, especially around crushing machinery, to achieve substantial and lasting dust mitigation.
8. The stone sector plays a significant role in the Palestinian economy, contributing approximately 5% to the Gross Domestic Product (GDP), as the Union of Stone and Marble in Palestine (USM) reported. The USM also indicates that around 450 registered stone processing facilities are dispersed throughout the West Bank. Given the sector's economic importance and the widespread distribution of these facilities, expanding the research methodology, both in scope and scale, is strongly recommended to encompass a wider range of areas within the West Bank. This broader investigation will provide a more comprehensive understanding of dust pollution from the stone industry across the region,

accounting for variations in facility types, environmental conditions, and proximity to populated areas. Scaling up the research will also allow for a more accurate assessment of the cumulative impact of the stone sector on air quality and public health in the West Bank.

9. This research underscores the significant benefits of establishing green belts before and behind stone industrial facilities. These green belts offer a dual advantage in mitigating dust pollution. Firstly, they act as windbreaks, reducing the velocity of incoming winds and thus limiting the initial dispersal of dust particles. Secondly, the vegetation behind the facilities can effectively capture and filter transported dust, preventing its further spread. Furthermore, the research emphasizes the importance of planting trees along the same elevation or following the contour lines of the land. This practice will facilitate the establishment and healthy growth of the green belt, ensuring its long-term effectiveness in dust control and environmental protection. By strategically positioning and cultivating these green barriers, the impact of dust pollution from stone processing can be significantly minimized.
10. The research recommends that all the stakeholders collaborate with the Palestinian environmental authority to establish a real-time station for air quality monitoring (IQAir), allowing the stakeholders to raise early warnings regarding air quality in the Bani Naim regions. Figure 21 shows the information derived from such a station implemented at the Palestine Polytechnic University. This type of station allows for tracking the air quality for 24 hours and can be used for future studies.

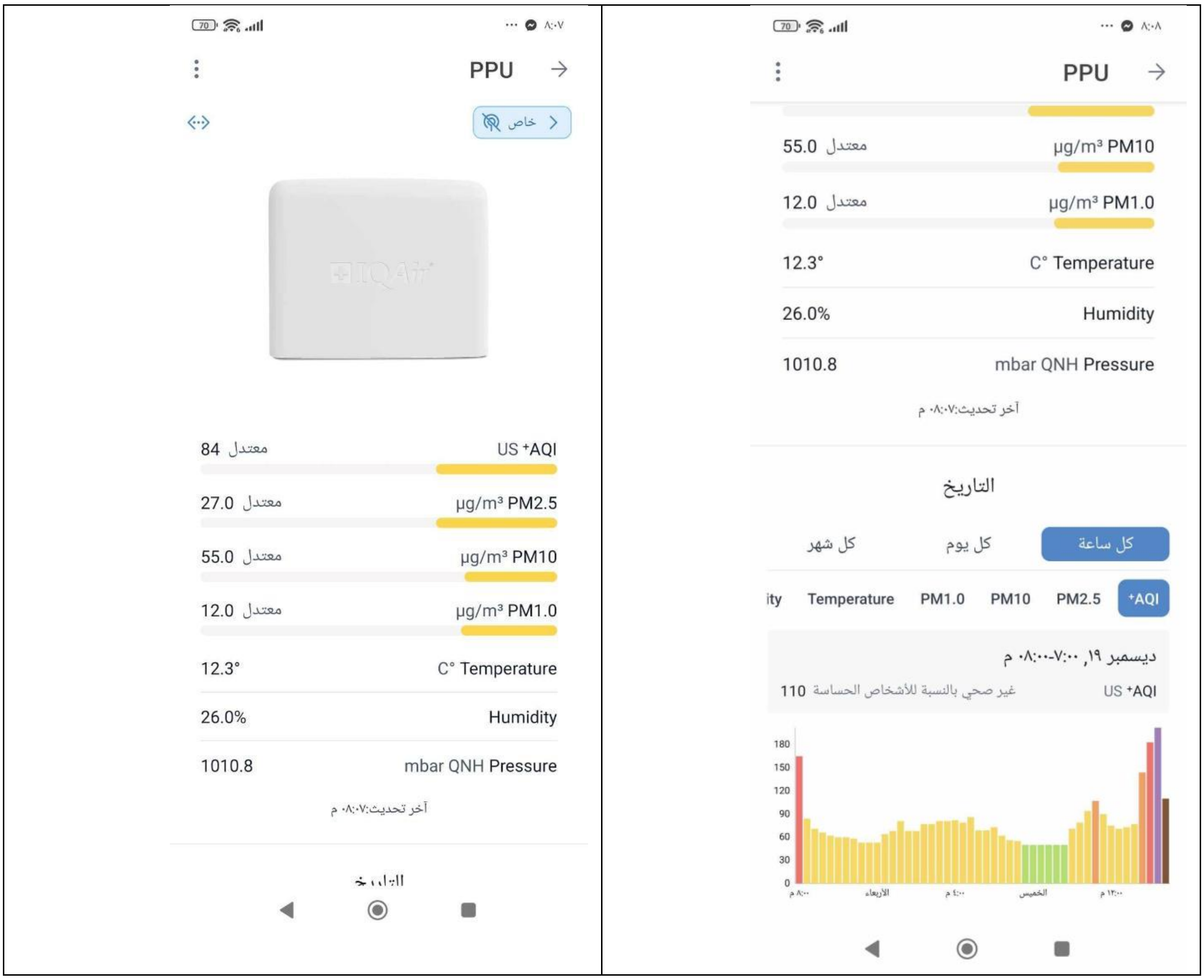

Figure 22: Air quality station example

11. The trees which fit these criteria are listed in Annex 1. Two species were given priority in planting the green belt—the Mediterranean cypress and carob trees.
12. It is recommended that the research incorporate a section dedicated to developing and outlining community awareness campaigns. These campaigns should focus on educating residents about the health risks associated with dust pollution and the positive impacts of green belts, thereby fostering public support for the project.

1.10 Annexes

1.10.1 Annex A Suggested Tree Species in The Vicinity of Stone Quarries Close to Bani Naim Town

1.10.1.1 Characteristics Of the Natural Vegetation in The Area

To the East of Bani Naim town, annual or seasonal plants, thorny and short perennial grasses, as well as many wild trees and shrubs are common in the desert, such as Retem, Gataf, and Theil trees can be found.

Several drought- and salinity-tolerant plant species, such as Sider trees, have dispersed to Bani Naim from the Jordan Valley and Dead Sea regions.

1.10.1.2 Characteristics Of the Proposed Plants at The Study Site

The research fulfills the needs of the environmental quality of the area; the most suitable trees are better evergreen than deciduous, broad-leaved than narrow-leaved, and from local tree species that are adapted to the environmental conditions and geography of the area, and most importantly, the amount of annual rainfall and soil alkalinity, for dust-resistant trees in terms of height, foliage, and nature.

1.10.1.3 Suggested Tree Species

Mediterranean cypress
Cupressus sempervirens
السرو العمودي

Evergreen green tree (13-15)	شجرة دائمة الخضرة
Upright growth habit	طبيعة النمو: عمودي قائم
Final size: 15m h X 2m d	الحجم النهائي: ارتفاع 15م X قطر 2م
Planting distance: 1.5m	مسافات الزراعة: 1.5 م
Drought tolerance: high	تحمل الجفاف: عالي
Growth: slow, especially in the first three years	سرعة النمو: بطيء في البداية (أول 3 سنوات)
Growth habit: upright and dense, windbreaker and soil stabilizer, especially in steep lands.	طبيعة النمو: كثيف ويصلح كمصدات رياح ومثبت تربة خاصة في الأراضي شديدة الانحدار
Root growth: In shallow soil, the root grows close to the surface, and it is not recommended to plant near foundations. Otherwise, it is good to plant in deep soils.	نمو الجذور: سطحي غير عميق في حال عدم وجود تربة، لا يوصى بزراعتها بالقرب من المباني والآبار والأسفلت الا إذا توفرت تربة عميقة لتخفف ضرر الجذور.
Irrigation: This needs a deep and sufficient amount, especially in the first three years. In Summer, it needs irrigation every two weeks.	الري: يتطلب رياً كافياً وعميقاً خاصة في المرحلة التأسيسية (السنوات الثلاث الأولى) والتي فيها يتأسس مجموع جذري قوي. وقد يلزم سقاية الأشجار في الصيف مرة كل اسبوعين
Recommendations: to be planted directly near quarries and dusty streets	توصيات الزراعة: يوصى بزراعتها كحزام بالقرب من بالقرب من الشوارع. المحاجر ومصادر الغبار

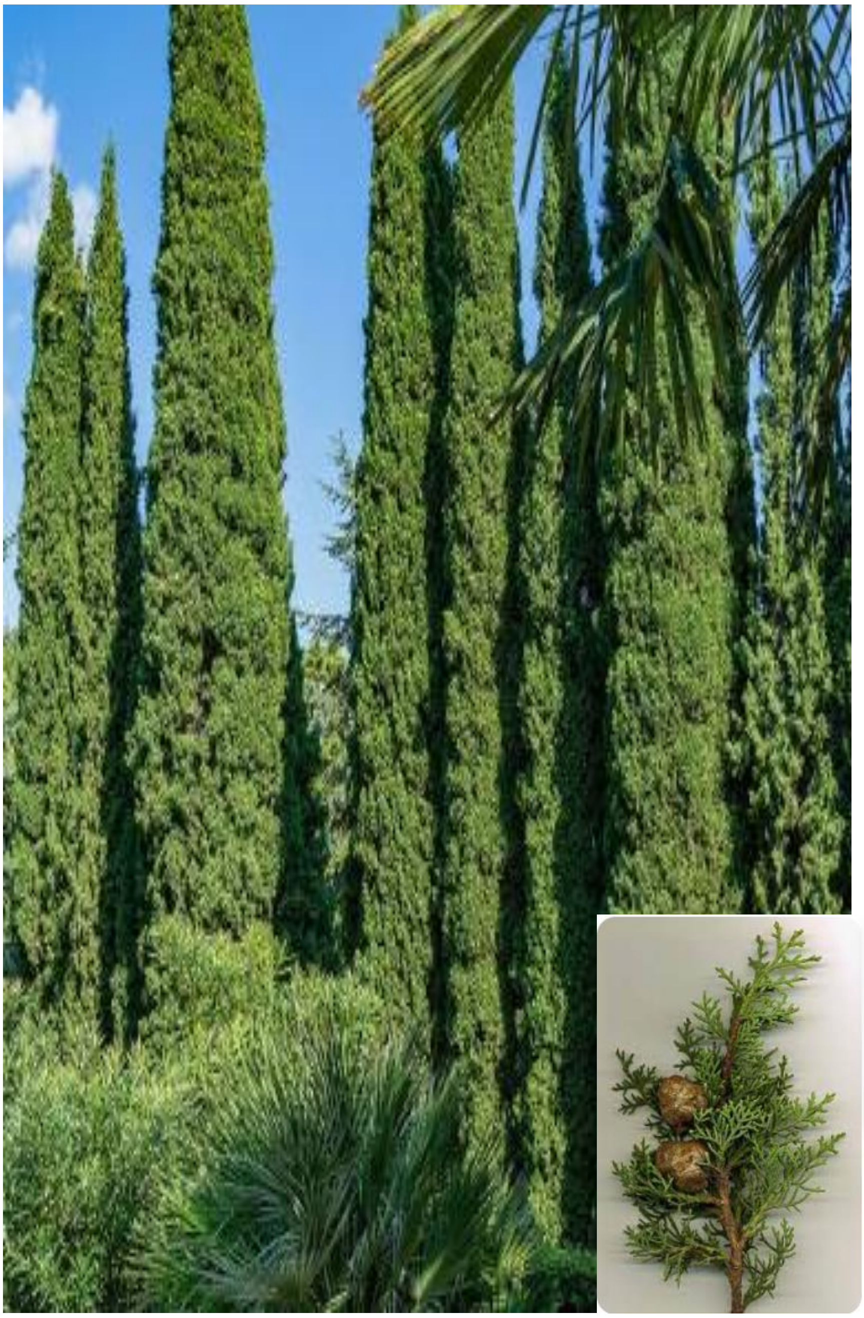

Figure 23: Mediterranean cypress

Christ's thorn jujube
Ziziphus spina-christi
السدر

Evergreen tree (11,12)	دائم خضرة ذو أوراق عريضة
Upright growth habit	طبيعة النمو: كروي الى بيضاوي
Final size: 10m h X 10m d	10م قطر X 10م ارتفاع الحجم النهائي:
Planting distance: 5.0m	مسافات الزراعة: 5.0 م
Drought tolerance: v. high	تحمل الجفاف: عالي جدا
Growth: slow, especially in the first few years	سنوات البداية (أول 3 سرعة النمو: بطيء خاصة في سنوات)
Growth habit: dense, windbreaker	طبيعة النمو: كثيف ويصلح كمصدات رياح
Root growth: deep and can penetrate deeply into the soil, which helps the tree access water from lower soil layers.	نمو الجذور: عميق ويتيح للشجرة الوصول الى أعماق بعيدة حيث يوجد ماء
The extensive root system plays a crucial role in soil stabilization and erosion control, making it valuable in arid and semi-arid regions.	مثبت للتربة ويخفف الإنجراف لذلك فهو نبات مهم في المناطق الجافة المعرضة للإنجراف. جذر مؤذي للأساسات.
It is invasive and may cause damage to nearby structures or foundations.	قابل للنمو في شتى انواع الترب سواء كانت رملية ام كلسية جيريية.
Adaptability: The root system allows trees to thrive in various soil types, including sandy and rocky soils.	بيئياً: أهمية النبات في الحد من التصحر ودعم الزراعة المستدامة خاصة في المناطق الجافة.
Irrigation: Sufficient irrigation is needed, especially in the first three years. In Summer, it needs irrigation every two to three weeks.	الري: يتطلب رياً كافياً وعميقاً خاصة في المرحلة التأسيسية (السنوات الثلاث الأولى) والتي فيها يتأسس مجموع جذري قوي. وقد يلزم سقاية الأشجار في الصيف مرة كل الى ثلاثة أسبوعين

Recommendations: It should be planted near quarries, dusty streets, and houses.

توصيات الزراعة: يوصى بزراعته كحزام بالقرب من
وكذلك قرب بالقرب من الشوارع المحاجر ومصادر الغبار
البيوت

Figure 24: Christ's thorn jujube

Carob
Ceratonia siliqua
الخروب

Evergreen tree (10)	ذات أوراق مركبة عريضة شجرة دائمة الخضرة
Round – oval shape	طبيعة وشكل النمو: كروي - بيضاوي
Final size: 8m h X 8m d	8م قطر X 8م ارتفاع الحجم النهائي:
Planting distance: 2.5m	م2.5مسافات الزراعة:
Drought tolerance: high	تحمل الجفاف: عالي
Growth: slow, especially in the first two years	سنتين سرعة النمو: بطيء في أول
Growth habit: upright and dense, windbreaker and soil stabilizer specially in rocky areas	طبيعة النمو: كثيف ويصلح كمصدات رياح ومثبت تربة خاصة في المناطق الصخرية
Deep Root System: The roots can penetrate deeply into the soil, allowing the tree to access water from lower soil layers(1). This helps the tree survive prolonged periods of drought.	عميق يخترق أعماق التربة ليصل الى نمو الجذور: الرطوبة
Soil Stabilization: The extensive root system is crucial in soil stabilization and erosion control.	يعمل على تثبيت التربة والحد من انجرافها
Adaptability: The roots are well-adapted to various soil types, including sandy and rocky soils.	متأقلم بشكل كبير للعديد من أنواع التربة خاصة الرملية والكلسية.
The roots of an aggressive root system are deep and may cause damage to nearby structures or foundations.	لا يفضل زراعة الخروب بالقرب من الأساسات والمباني
Irrigation: needs a deep and sufficient amount, especially in the first three years. In Summer, it needs irrigation every two weeks.	الري: يتطلب النبات رياً كافياً وعميقاً خاصة في المرحلة التأسيسية (السنوات الثلاث الأولى) والتي فيها يتأسس مجموع جذري قوي. وقد يلزم سقاية الأشجار في الصيف مرة كل أسبوعين

Recommendations: It should be planted directly near quarries and dusty streets. Near houses, only female trees are recommended.

توصيات الزراعة: يوصى بزراعته كحزام بالقرب من بالقرب من الشوارع. أما المحاجر ومصادر الغبار بالقرب من البيوت فيوصى بزراعة الأشجار المؤنثة فقط لأن الأشجار المذكرة تصدر رائحة كريهة في الصيف.

Figure 25: Carob trees

Aleppo pine
Pinus halepensis
الصنوبر الحلبي (القريش)

Evergreen tree (9)	شجرة دائمة الخضرة
Upright pyramidal	طبيعة وشكل النمو: هرمي قائم
Final size: 15m h X 6m d	6م قطر X 15م ارتفاع الحجم النهائي:
Planting distance: 2.5-3.0m	م2.5-3.0mمسافات الزراعة:
Drought tolerance: high	تحمل الجفاف: عالي
Growth: slow, especially in the first 5 years	سنوات)5سرعة النمو: بطيء في البداية (أول
Growth habit: upright and dense, windbreaker and soil stabilizer, especially in steep mountainous and rocky areas	طبيعة النمو: قائم و كثيف ويصلح كمصدات رياح ومثبت تربة خاصة في المناطق الجبلية الصخرية و المنحدرة
Root growth: In shallow soil, the root grows close to the surface, and it is not recommended to plant near foundations. Otherwise, it is good to plant in deep soils.	نمو الجذور: عميق ويسبب ضرر للأساسات والمباني والطرق اذا زرع على مسافات قريبة منها.
Irrigation: This needs a deep and sufficient amount, especially in the first three years. In Summer, irrigation is done every two to three weeks.	الري: يتطلب رياً كافياً وعميقاً خاصة في المرحلة التأسيسية (السنوات الثلاث الأولى) والتي فيها يتأسس مجموع جذري قوي. وقد يلزم سقاية الاشجار في الصيف مرة كل اسبوعين - ثلاثة
Recommendations: to be planted directly near quarries and dusty streets	توصيات الزراعة: يوصى بزراعتة كحزام بالقرب من وكذلك يصلح بالقرب من الشوارع المحاجر ومصادر الغبار للزراعة قرب البيوت

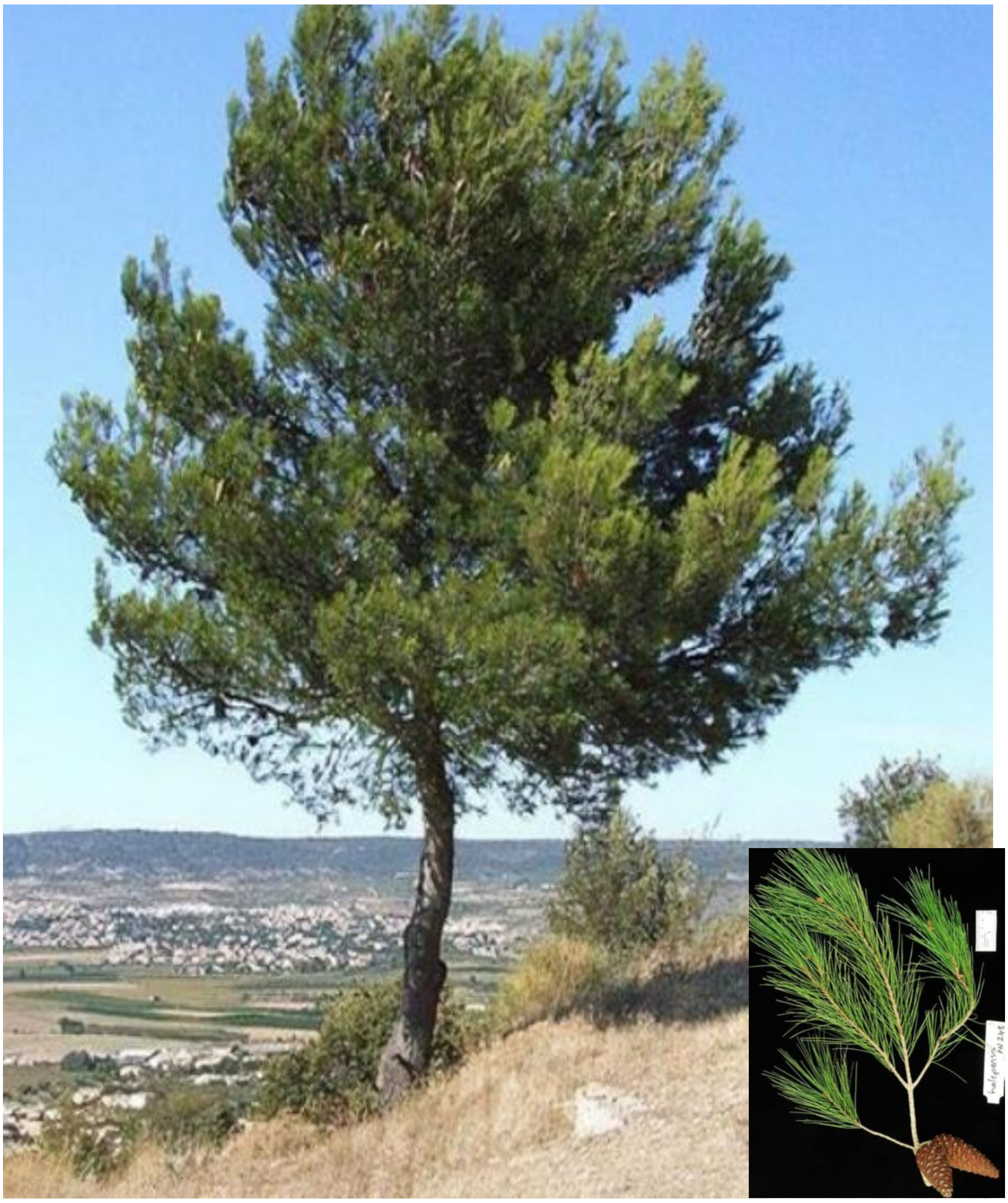

Figure 26: Aleppo pine

Acacia
Acacia saligna
الأكاسيا

Evergreen dense tree (7,8)	دائمة خضرة كثيفة النمو
Upright growth habit	طبيعة النمو: بيضاوي
Final size: 4m h X 4m d	4م قطر X 4 م ارتفاع الحجم النهائي:
Planting distance: 3.0m	م3.0مسافات الزراعة:
Drought tolerance: high	تحمل الجفاف: عالي
Growth: slow, especially in the first three years	سرعة النمو: بطيء في البداية (أول 3 سنوات)
Growth habit: dense, soil stabilizer specially in steep lands rocky.	طبيعة النمو: كثيف ومثبت تربة خاصة في الأراضي الصخرية شديدة الانحدار
It develops a prominent taproot that can penetrate deeply into the soil, making it highly drought-tolerant. The extensive network of lateral roots enhances the tree's stability and allows it to absorb nutrients and water from a broad area. Also, the root system plays a crucial role in soil stabilization and erosion control. Adaptability: The root system is well-adapted to various soil types, including sandy, loamy, calcareous, and rocky soils. Non-Invasive: While the roots are extensive, they are generally considered non-invasive and are less likely to cause damage to nearby structures or foundations.	نمو الجذور: سطحي غير عميق في حال عدم وجود تربة، لا يوصى بزراعته بالقرب من المباني والآبار والأسفلت، أما إذا توفرت تربة عميقة فلا ضرر من زراعتها قريبة من المباني. متأقلمة مع طيف واسع من أنواع الترب مثل الرملية والجيرية والطينية.
Irrigation: This needs a deep and sufficient amount, especially in the first three years. In Summer, it needs irrigation every two weeks.	الري: يتطلب رياً كافياً وعميقاً خاصة في المرحلة التأسيسية (السنوات الثلاث الأولى) والتي فيها يتأسس مجموع جذري قوي. وقد يلزم سقاية الأشجار في الصيف مرة كل أسبوعين
Recommendations: to be planted directly near quarries and dusty streets	توصيات الزراعة: يوصى بزراعتها كحزام بالقرب من بالقرب من الشوارع. المحاجر ومصادر الغبار

Figure 27: Acacia

Athel pine
الإثل

Tamarix aphylla

Evergreen tree (5,6)	شجيرة دائمة الخضرة
Upright growth habit	طبيعة وشكل النمو: دائري – غير منتظم
Final size: 15m h X 2m d	8م قطر X 8م ارتفاع الحجم النهائي:
Planting distance: 4.0m	4.0م مسافات الزراعة:
Drought tolerance: very high	جداً تحمل الجفاف: عالي
Growth: medium	سرعة النمو: متوسطة
Growth habit: medium dense, suitable for ground cover and soil stabilizer, especially in steep lands.	طبيعة النمو: متوسط الكثافة ويصلح لعمل أسيجة خضراء في الأماكن ذات التربة الفقيرة وقلة توفر مياه الري، مثبت تربة ممتاز خاصة في الأراضي الوعرة و المنحدرة.
Roots can penetrate deeply into the soil, allowing the tree to access water from lower soil layers. Also, it may spread extensively and affect nearby landscapes and vegetation. The extensive root system plays a significant role in soil stabilization and erosion control. Athel pine is highly tolerant of saline and alkaline soils, and it excretes salt through its leaves, which can affect the soil chemistry. The tree consumes water rapidly, reducing water availability for other plants.	نمو الجذور: عميق وقد يمتد الى مسافات بعيدة يؤثر فيها على نمو نباتات أخرى. مثبت تربة ويمنع انجرافها. الإثل من النباتات المميزة في تحمل الملوحة والترب القاعدية، لذلك يعتبر مثاليا في تخضير المناطق التي تتصف بهاتين الصفتين
Irrigation: This needs a deep and sufficient amount, especially in the first three years. In Summer, it needs irrigation every two weeks.	الري: يتطلب رياً مكثفاً عميقاً خاصة في المرحلة التأسيسية (السنوات الثلاث أو الأربع الأولى) والتي فيها يتأسس مجموع جذري قوي. وقد يلزم سقاية الأشجار في الصيف مرة كل اسبوعين
Recommendations: better to be planted in roadsides.	توصيات مكان الزراعة: يوصى بزراعتها على جوانب الطرق

Figure 28: Athel pine

Broom tree
شجرة الرتم

Retama raetam

Evergreen (4)	دائمة خضرة
Upright growth habit	طبيعة النمو: بيضاوي
Final size: 4.0m h X 5.0m d	5م قطر X 4م ارتفاع الحجم النهائي:
Planting distance: 1.5m	مسافات الزراعة: 5.0 م
Drought tolerance: high	تحمل الجفاف: عالي
Growth: slow	سرعة النمو: بطيء
Growth habit: light vegetative growth, good ground cover near roads, and soil stabilizer.	طبيعة النمو: المجموع الخضري مع الأوراق غير كثيف ، يصلح لتخضير المناطق المحاذية للممرات والشوارع وأيضا كمثبت للتربة
Roots grow deeply to access water from low soil layers. Also, it has soil stabilizing properties and is well adapted to various soil types, including sandy and rocky places, and, significantly, non-aggressive plants, causing no damage to infrastructure and foundations. Soil Stabilization: The extensive root system plays a significant role in soil stabilization and erosion control, making it valuable for reclamation projects. Adaptability: The roots are well-adapted to various soil types, including sandy and rocky soils. Arbuscular Mycorrhizal Fungi (AMF) Association: Retama raetam roots are associated with AMF, which help in nutrient uptake and improve soil structure. Non-invasive and less likely to damage nearby structures or foundations.	نمو الجذور: عميق بحيث يصل الى الماء على اعماق كبيرة، مثبته للتربة الخفيفة وبين الصخور، لا تسبب أضرار للمباني والأساسات، تتأقلم مع طيف واسع من أنواع التربة. الجذور تنشئ علاقة تكافلية مع فطر المايكورايزا المفيد في امتصاص العناصر خاصة الفسفور.

Irrigation: This needs a deep and sufficient amount, especially in the first three years. In Summer, it needs irrigation every two weeks.

الري: تتطلب رياً كافياً وعميقاً خاصة في المرحلة التأسيسية (السنوات الثلاث الأولى) والتي فيها ينمو مجموع جذري قوي. قد يلزم سقاية الأشجار في الصيف مرة كل أسبوعين

Recommendations: to be planted directly near quarries and dusty streets

توصيات مكان الزراعة: يوصى بزراعتها كحزام بالقرب بالقرب من الشوارع. من المحاجر ومصادر الغبار

Figure 29: Broom tree

Casuarina

الكازوارينا

Evergreen (1-3)

دائم خضرة

Upright growth habit

طبيعة النمو: عمودي قائم

Final size: 15m h X 2m d

الحجم النهائي: 15م ارتفاع X 4م قطر

Planting distance: 2.5m

مسافات الزراعة: 2.5 م

Drought tolerance: high

تحمل الجفاف: عالي

Growth: slow, especially in the first three years

سرعة النمو: بطيء في البداية (أول 3 سنوات)

Growth habit: upright and dense, windbreaker and soil stabilizer specially in steep lands.

طبيعة النمو: كثيف وتصلح كمصدات رياح ومثبت تربة خاصة في الأراضي المنحدرة

Root growth: deep tap root and extended lateral roots. This allows it to absorb nutrients and water from a broad area. Roots of Casuarina trees are associated with actinorhizal bacteria (Frankia) that fix atmospheric nitrogen. This enriches the soil with nitrogen, benefiting surrounding plants and improving soil fertility.

The extensive root system is crucial in soil stabilization and erosion control. Casuarina trees are often planted in coastal areas and on slopes to prevent soil erosion.

Thrives in various soil types, including sandy, saline, and poor soils.

Non-invasive and less likely to cause damage to nearby structures or foundations.

نمو الجذور: جذرها وتدي عميق تتفرع منه جذور جانبية يتيح لها الوصول الى الماء على اعماق كبيرة، مثبت للنيتروجين من الجو، مثبت تربة في الاراضي الرملية والمنحدرة، قادرة على العيش في انواع عديدة من الترب، وهي غير مؤذية للأبنية والأساسات الاسمنتية

Irrigation: This needs a deep and sufficient amount, especially in the first three years. In Summer, it needs irrigation every two weeks.

الري: يتطلب رياً كافياً في المرحلة التأسيسية (السنوات الثلاث الأولى) والتي فيها يتأسس مجموع جذري قوي. وقد يلزم سقاية الأشجار في الصيف مرة كل 3 اسابيع

Recommendations: It is better if planted directly near quarries and dusty streets

توصيات للزراعة: يوصى بزراعتها كحزام بالقرب من على امتداد الشوارع وتصلح   المحاجر ومصادر الغبار ايضاً كمصدات رياح بالقرب من المنازل والمناطق السكنية.

Figure 30: Casuarina

1.10.1.4 Boosting The Success of Tree Planting in Dry Areas

Even though forestry trees are tolerant to drought and high-temperature stress, their successful growth depends on the first three years of planting. Care must be taken of them to establish robust plants with healthy root systems.

Some agrochemicals in the market help establish a strong root system. They are environmentally friendly and characterized by the ability to retain moisture around the root system for long periods. Some of the most important materials in the Palestinian market that have been tried in many sites and projects are:

1- Inicium®: an organic fertilizer with a high concentration of phosphorus and amino acids that helps the growth of dense and strong root systems. It is used in nurseries for young trees and seedlings and boosts growth in open-field plantations. The application rate in irrigation water is 1.0cm/liter.

Figure 31 Organic fertilizer

2- ZEBA: A non-toxic, biodegradable starchy compound (carbohydrate polymer) with a high binding capacity with water molecules (about four hundred times). When planting, it is added/mixed with the soil to provide the needed moisture for long periods of high temperature. It can also be mixed with soluble chemical fertilizers.

Figure 32 ZEBA

1.10.2 Annex B Particulate Matters Observation Measurements.

رقم الموقع	**2.5 µm/m³**	**2.5 µm**	**10 µm/m³**	**10 µm**	**Note**
1	12	436	17	84	
2	12	413	16	88	
3	13	444	18	91	
4	23	392	33	52	
5	12	921	19	215	
6	22	420	31	68	
7	20	322	32	47	
8	18	836	29	12	
9	23	1085	37	189	
10	25	1085	41	188	
11	24	894	39	146	
12	24	454	36	90	
13	12	359	17	56	
14	20	1666	36	609	
15	18	603	26	99	
16	23	530	31	63	
17	24	778	39	82	

18	32	924	47	177	
19	42	4615	64	1487	Exceed EPA Standards
20	39	864	61	146	Exceed EPA Standards
21	26	324	36	64	
22	20	1291	34	350	
23	14	616	21	110	
24	20	489	32	56	
25	96	1762	145	466	Exceed EPA Standards
26	34	2105	53	718	
27	33	858	50	151	
28	19	462	28	89	
29	15	702	23	121	
30	92	4241	163	1088	Exceed EPA Standards
50	424	11936	673	4246	Exceed EPA Standards
31	29	633	48	82	
51	151	24049	239	7485	Exceed EPA Standards
32	25	1010	42	188	
33	25	884	39	120	
34	26	1003	39	180	

35	14	337	18	61	
36	15	657	21	114	
37	20	1429	35	387	
52	111	11034	176	3479	Exceed EPA Standards
38	23	559	32	75	
39	124	11684	177	3557	Exceed EPA Standards
40	25	355	33	77	
41	14	296	18	54	
42	12	217	17	51	
43	11	618	17	100	
44	19	642	33	103	
45	21	1535	37	459	
46	44	1375	66	725	Exceed EPA Standards
47	13	197	17	31	
48	12	124	16	23	
49	10	106	15	19	
53	54	4245	79	1011	Exceed EPA Standards
54	68	1885	108	329	Exceed EPA Standards

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