ROAD AND TRANSPORTATION MASTER PLAN

WEST BANK AND GAZA STRIP

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Annex 1 – Diagnostic: Transport Sector in West Bank and Gaza Strip

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1. Introduction

This annex provides an overview of the existing situation of transport sector in West Bank and Gaza Strip. Palestinian transportation is herein described considering the following aspects/ sub-sectors:

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The goal is to retrace the multi-faceted sector of transport, focusing on each of the transport sub-sectors currently operating in both the West Bank and the Gaza Strip.[1]

The data and the information presented in this Annex derive from both existing studies and literature and new and unprecedented survey campaigns, carried out for this specific purpose. All the collected data and information presented here were used as the basis on which hinging and developing the NTMP, which multi-modal proposal is fully described in the "Final Master Plan Report".

[1] World Bank. 2007. West Bank and Gaza - Transport Sector Strategy Note. Washington, DC. © World Bank. https://www.openknowledge.worldbank.org/handle/10986/12584

2. Institutional Framework

The institutional framework of transport sector in West Bank and Gaza Strip is here analyzed to guarantee a better understanding of all the actors involved in its management: from the most official ones, like the MoT, to the non-key stakeholders, appointed with minor assignments. The following table introduces briefly the institutional structure of transport sector in West Bank and Gaza Strip.

Tab 1. The Institutional Framework for Palestinian Transport Sector, 2015

Public institution	Responsibility	Related bodies
The Ministry of Transport (MoT)	Policy development and implementation Manages the traffic and transport regulatory system	Traffic Higher Council Civil Aviation Authority Port Authority
The Ministry of Public Works and Housing (MoPWH)	Responsible for the maintenance and rehabilitation of roads in areas "A" and "B" outside municipalities and village councils ("C" areas are managed by Israel)	
Ministry of Planning (MoP)	Responsible for regional planning and policy formulation including the transport system	
The Palestinian economic council for Development and Reconstruction (PECDAR)	Established in 1993 before the other ministries of the PA in order to manage and implement donor-financed projects including road rehabilitation and construction. Still manages some road projects financed by donors	
The local government units LGUs (municipalities and village councils)	Responsible for planning, development and maintaining road network within their immediate jurisdiction.	Donors channel funding to these local governments through the Municipal Development and Lending Fund (MDLF)
Ministry of Agriculture	Responsible for development and management of rural roads	
General Administration for Crossings and Borders (GACB)	Is supposed to manage, operate, and develop all terminals and crossings with outside (including Israel).	
Ministry of Local Government (MoLG)	Is responsible for endorsing roads planned by LGUs	Supreme organizing council
Ministry of Finance	It collects fees, taxes and fines and channel funds to other ministries through the general budget and channel 50% of MoT revenues to LGUs.	

Palestinian Government and Constitution

The West Bank and Gaza Strip government and politics work within the framework of the rules and regulations laid down in the Constitution of West Bank and Gaza Strip, which was written in 1968.
The Constitution states that there is a House of Representatives, composed of 150 individuals, representing the Palestinian people, all elected according to the Constitution and election law. Moreover, the executive branch is represented by the Council of Ministers, composed by a Prime Minister and the Ministers (half of them are members of the House of Representatives).
As for the transport field, the Constitution sets the right to move for the Palestinian citizens, as its Article 31 states that "Citizens shall have the right to choose their place of residence and to travel within the state of West Bank and Gaza Strip. No person may be denied the right to travel from West Bank and Gaza Strip except by a legally issued court order. Likewise a Palestinian may not be deported or prevented from returning to his country, and may not be extradited."
The development and the regulation of the transport sector is ruled by the Ministry of Transportation.

Ministry of Transport (MoT)

The MoT has the jurisdiction over transport infrastructure networks, to be considered in its multi-modal character: air transport, maritime transport, rail transport, and road transport.

As it concerns Road Transport, the MoT is responsible of, but not limited to, the following issues: the release of vehicles' licenses; the formulation of transport-related regulations; the identification of the country's needs of transport [2], and the promotion of the level of safety on roads. The last task is carried out in collaboration with the Higher Council of Traffic, composed by the MoT, the MoNE, the Head of Police, the MoLG, the MoPWH, and the LGUs.
The public transport service currently operational in West Bank and Gaza Strip involves also private actors. For instance, vehicles used for collective transportation are owned and operated by individuals or private firms and are organized by local unions, constantly interacting with the MoT.

Air Transport is also managed by the MoT, through the Palestinian Civil Aviation Authority (CAA), that employs 362 workers, in charge of the administration and operation of the air transport facilities. The CAA has eight departments, including engineering and maintenance, air transport and air safety. During 1999, the use of the airport was limited because of Israeli restrictions and of the Gaza issues. As a result, almost only the Palestinian Airlines utilized it.

MoT's control on Maritime Transport is accomplished by Palestinian Seaport Authority (PSA) that was established in 1999 to supervise the construction of the port and its operation.
In that period the "Sea Port Protocol" was signed with the Israeli government, to provide the legal framework for the management and regulation of the seaport. Today the Seaport Authority offices in Gaza are open and the employees are on duty, attending also workshops and training sessions abroad, but the seaport of Gaza is not functioning.

Finally, Rail Transport is organized and supervised by two MoT Departments: 1) the General Directorate of road transport and railway, in charge with the rehabilitation of the *Hijaz* railway[3], and; 2) the General Directorate of Engineering roads and railways, appointed with the tasks of studying and proposing new plans for rail transport.

Ministry of Public Works and Housing (MoPWH)

The MoPWH plays a key-role in the Palestinian transport sector, being responsible over passage and regional roads.[4] It is in charge of the opening, rebuilding, renovation and maintenance of the road network and it has a comprehensive database of road conditions based on GIS program.
The Ministry of Public Works & Housing has published road standards manuals, including Geometric Design Manual, Road Construction Manual, Procurement Manual, and Maintenance Guide, and has developed the Roads Law, which has not been approved yet.

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[2]The MoT's department in charge with this task is the Department of Transport on Roads and Controller General of Traffic. This Department sets the goals to reach, and guarantees the minimum standard quality for the road transportation.
[3]Hijaz Railway management falls also under the responsibility of the Minister of Waqf.
[4]Regional Roads are by definition the roads located outside municipalities' boundaries.

Ministry of Local Governments (MoLG)

The Ministry of Local Governments is responsible for the roads located within the boundaries of cities and villages as well as for the master plans designed by the LGUs. In particular, it carries out the road projects for the different LGUs, through the Municipal Development, Lending Fund and through other donors.
Finally, the MoLG is part of the "Regional Committee for the planning, organization and construction in each Governorate" that is composed also of the following public institutions: MoT, MoNE, Civil Defence, LGUs and MoTA.

Local Government Units (LGUs)

The LGUs are the authorities that administrate the cities and the villages, having various functions set by the Regulation no.2 (1998). One of the most important tasks of LGUs is to identify, organize and manage the parking areas located in the urban areas. Moreover, the LGUs, have the responsibility of the opening, reconstruction, construction and rehabilitation of roads. Given their direct involvement in the transport sector, LGUs receive part of the MoT's yearly incomes.

Unions and Private Sector Works

The Unions and Private Sector work in Transport Sector are private organizations, with a mere consultative role in the formulation and development of policies and laws related to the transport sector.

Other Non-Key Stakeholders

Beside the bodies described so far, there is also a number of Ministries and Authorities with minor assignments on transport sector. They are:

- MoPAD, that is the PNA representative for PTMP in negotiation with the Israel;
- MoTA, ensuring that roads do not damage any tourist area or archaeological site;
- MoNE, controlling the imported vehicles licenses;
- EQA, monitoring the presence of pollution in residential areas and, eventually, applies pollution reduction measures;[5]
- PECDAR;
- MDLF, and;
- MoJ, performing different achievements on the transport sector.

Transport Data Management

The collection of data on transport sector is institutionalized yet, and several discrepancies exist about the declared data availability by all the stakeholders involved. Although many past attempts aimed at reaching a shared and systematized system, today each body collects the data related to its area of control and responsibility: the municipalities[6] own the data related to their master plan; the MoPWH has the data on the roads located outside of the boundaries

[5]The EQA produces also EIA (Environmental Impact Assessment) for every project in the transport sector.
[6]Currently, only 18 municipalities in the West Bank have GIS units, with the possibility of collecting all the data on roads and traffic.

of cities and villages; and the MoLG has its own GIS database, storing relevant data on roads and traffic in the areas where there are no municipalities.
Nevertheless, data sharing among the different ministries and related departments or directorates were improved and the MoT is now connected via automated system with its directorates in the West Bank, receiving information also from Gaza. This system is then connected with the Police department that can have therefore access to traffic data.
The general system for the collection of data is the following: each directorate sends its updates, via written correspondence, to its own Ministry and each directorate has GIS units allowed only to read the collected data. Then, at a central level, the Ministry collects and keeps updated all the received data.

3. Sectoral Funding

The analysis of the system of funding for the transport sector reported here aims at providing an overall description of the financial management of transport sector in West Bank and Gaza Strip, as well as at identifying the main financial issues, obstacles and challenges faced by the sector.
The data on which the analysis is based were collected mainly during interviews with key personnel of MoT and other institutions;[7] documents' reviews and internet sources were also helpful.

The Local Private Institutions and Donor Countries

Funding is a limiting factor for both the development of the transportation sector and the maintenance of its infrastructure. Most funds come from international donors and are spent to finance rehabilitation and upgrading of roads, and very little is allocated for the construction of new roads. The allocated funds by the PNA for the transportation sector and for roads are very limited and mostly used to finance the Ministry of Public Works and Housing that is responsible of road maintenance. Finally, taxes collected by transport sector are not re-directed exclusively to transportation and very often are used for other purposes.

Local Private Institutions
While the infrastructure and the management of the Palestinian transportation system are entirely public, the vehicles are completely owned by private sector. Although private ownership represents strength from an economic view of point, the structure of ownership may be construed as a threat. Passenger and commercial vehicles are owned by individuals and family firms with limited initiative for business development.
The role of local private institutions in Palestinian transport sector does not consist only in the ownership structure of the fleet. On the contrary it involves also large institutions like PRICo that, during the last ten years, carried out pivotal projects of public-private partnership (PPP). Using the BOT Scheme, PRICo was the promoter of the implementation of the new public transport station in Al Bireh(1997)[8] and the new bus station in Bethlehem (2000).[9]

International Donors
International aids to West Bank and Gaza Strip is crucial for many economic and political reasons.[10] The existing aid coordination structure was set up in 2005 to provide international investors with a coherent technical assistance and financial support based on national priorities. At the local level, the coordination structure comprises of a Local Development

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[7]Interviews where held with DM of Transport, Ammar Yasin, Wael Rashid from MoTand Ali Shaath from PIEFZA.Emails with certain questions with Sireensabi from MoP
[8]For the new Central Station for buses and Shared Taxis in Al-Bireh$5.5m were invested. PRICo has been operating the project since 2000 and is constantly developing the facilities and transmission lines that service all districts of Palestine, as well as the nearby communities. A commercial ground level floor was included in the project as the building is located in the heart of the CBD area Al-Bireh/Ramallah. The commercial ground level yield$1.7m as goodwill during the entire period for which the municipality is entitled to 25% of the amount. PRICo pays also an annual amount of $150,000 to the municipality according to the contract.
[9]The costs for the new bus station in Bethlehem were approximately $5.5m. This Station has been providing all transport services for the tourist sector in the city since 2000. The Station provides services to residents as well, since it is located in the centre of the city. According to the contract, PRICo collects $58 for each bus up to 80 buses and the municipality receives 25% of the proceeds above that number. No other revenues are received by the municipality.
[10]Governance and Social Development Resource Centre, Role of Aid in the Occupied Palestinian Territories, 2010.www.gsdrc.org/docs/open/HD720.pdf

Forum (LDF) and a Four Strategy Groups (SGs), namely: 1) The Governance Strategy Group 2) The Economic Strategy Group 3) The Social Development Strategy Group and 4) The Infrastructure Strategy Group. In addition, the SGs are supported by the work of thirteen main sub-groups and a Task Force on Project Implementation (TFPI). The LDF, SGs, SWGs and TFPI are supported by the Local Aid Coordination Secretariat (LACS).
According to the Query Wizard for International Development Statistics (QWIDS) issued by OECD[11] , the international aids to West Bank and Gaza Strip increased from $179m in 1993 to $2609m in 2013. This increase entailed a variation of the GDP ratio from 14% to 39%, corresponding to a GDI variation from 11% to 29%. During this period, the largest donors were Multilateral Agencies (UNRWA, USAID, UAI, EU) and individual European countries that donated around $551m, partially invested in the transport sector to which $23m (0.88% of total donations) were allocated in 2013.[12] The funds allocated to the transport sector were used for different kind of projects: road rehabilitation, road development, border crossing infrastructure, and damage assessment studies (on Yasser Arafat International Airport and Gaza Sea Port).

The Revenues of Transport Sector in West Bank and Gaza Strip

The taxation of transport sector is relatively high in West Bank and Gaza Strip. Revenues from taxation can be differentiated between: 1) Domestic revenues, and; 2) Clearance revenues. Domestic Revenues are collected directly from the Palestinian people while Clearance Revenues are earned as a result of the commercial transactions between West Bank and Gaza Strip and Israel, and collected by the PNA and by Israeli authority that transfer the net revenues to the Ministry of Finance through monthly clearance sessions. Clearance revenues are much higher than Domestic Revenues.[13] Generally all the revenues collected by MoT are transferred to the MoF which in turn keeps 50% and transfers the other 50% to the Local Government Units (LGUs). Ideally, LGUs should use the revenues to proceed for transport-related projects but in practice, clearance between the MoF and the LGU take place and as a final result these funds are rarely used to improve or rehabilitate the transport sector. In 2014, the MoT collected around $59m but the amount of funds re-invested in transport sector is not easily identifiable.
The revenues can be divided into Tax-Revenues and Non-Tax-Revenues whereas the former consists in Customs duties, V.A.T. and Petroleum Excises, and the latter consists in vehicles registration fees, driving license fees, professional license fees and fines. Customs duties are imposed in various percentages on goods imported from third parties, depending on the Israeli tariff structure.[14] Custom duties on cars depend on the stated cost: if the country of origin is a non-European country, a 7% of the stated cost is added before calculating the customs duties on the vehicle. In addition, the custom rate is 50% of the cost for vehicles with engine of less than 2000 CC and 75% of the cost for larger engines, while commercial vehicles (including cab taxis or buses) are generally exempted from the payment.
V.A.T. is currently at 16% and it is applicable only on commercial vehicles, both destined for passenger and freight traffic; vehicles for personal use are exempted from paying V.A.T. The value of V.A.T. can vary from $100 to $1100 depending on the manufacturing's year and vehicle's capacity (no of seats, truck loading, etc.).

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[11]See http://stats.oecd.org/qwidsfor more details.
[12]These data result from the combination of two different sources: World Bank, West Bank and Gaza -Transport Strategy Note, 2007, and QWIDS studies.
[13]Fiscal Developments & Macroeconomic Performance: Fourth Quarter and Fiscal year 2011, Ministry of Finance, 2011 at (http://www.lacs.ps/documentsShow.aspx?ATT_ID=5480)
[14]PALTRADE, https://www.paltrade.org/en_US/page/how-to-import-

Petroleum Excises represent the predominant form of tax among the Clearance revenues, being by far one of the main sources of income for Palestinian government. The most recent available data show that in 2011 the revenues from Petroleum Excise amounted to $457m.[15] The enforcement of traffic regulations falls under the responsibility of Traffic Department of the Palestinian Police, established in 1994. The efficiency of the enforcement system for transport sector is questionable due to the lack of control on most connecting roads in area C and the inability of traffic officers to move easily to many areas, especially isolated villages. However, enforcement system is acceptable within area A.

[15]Fiscal Developments & Macroeconomic Performance: Fourth Quarter and Fiscal year 2011, Ministry of Finance, 2011 at (http://www.lacs.ps/documentsShow.aspx?ATT_ID=5480)

4. Legal and Regulatory Framework

Legislations regulating the transport sector in West Bank and Gaza Strip are characterized by complexity, and often by lack of clarity, harmony and integration, blending among currently effective laws and annulled/ineffective ones. This could be attributed to the variety of laws sources and to the authority governing West Bank and Gaza Strip at the time.
Some of these legislations go back to the British occupation era, many of which are still effective and valid. To mention some: Air Navigation Law of 1936 and Wreckage and Salvage Law (Chapter 155 of 1926), among others. Some of these laws were enacted by the Jordanians during their rule of the West Bank and are similarly still effective, such as Law Decision #3 of 1961 issued by Laws Interpretation Office and Arab Countries Civil Aviation Council of 1966. Parallel to these laws are Egyptian laws effective in the Gaza Strip during its Egyptian rule between 1948 and1967; e.g. General Governor #120 of 1960.
Israel's expansion policy had led to new phenomena introducing the Military Orders related to land use, Palestinian citizens and others. Despite the several restrictions of international conventions, such as Article 43 of The Hague Convention of 1907 in which it is clearly stated that the ability of the occupation authorities to change laws effective in occupied lands is very restricted to the highest degree. In that context and framework, the Israeli authorities had issued numerous military orders which are still effective in the Palestinian areas. A case in point is Military Order # 531 of 1976 concerning the control of garages and car maintenance and repair workshops. This law is still effective in the Gaza Strip. Military Order # 1404 of 1993, pertinent to transportation, and Military Order # 1436 of 1996, pertinent to the operation of border crossings with Jordan are still effective in the West Bank.
In 1995, the PNA enacted Law # 3 which set forth the establishment of a traffic department which was attached to the Police General Directorate. After that, a number of transportation sector laws had been passed. Law # 95 of 1995 was issued to establish a Palestinian fund for victims of traffic accidents. Another law, Law # 173 of 1996, was passed to establish a Palestinian institution for air transport. A third law, Law # 6 of 1999, was enacted to manage Gaza International Airport. However, the most prominent event was on September 17, 2000 when the Traffic Law # 5 of 2001 was enacted.

The description of Palestinian legal and regulatory framework is here organized as follows:

- International and Regional Conventions and Agreements, and;
- National Laws and Legislations.

The latter part provides a detailed insight regarding Traffic Law, deduction and allocation of roads and expropriation processes.

The International and Regional Conventions and Agreements

<u>The Agreement on International Roads in the Arab Mashreq</u> [16]
The Agreement on International Roads in the Arab Mashreq is a United Nations (ESCWA) multilateral treaty signed in 2001. This Agreement was ratified by 13 countries (Syria, Iraq, Jordan, West Bank and Gaza Strip, Lebanon, Kuwait, Egypt, Saudi Arabia, Bahrain, Qatar,

[16]The full text of the Agreement is available here: https://treaties.un.org/doc/source/RecentTexts/11_B_33E.pdf

United Arab Emirates, Oman and Yemen) [17] and covers more than 31,400km of international roads (23 major routes), representing the basis for a network with unified specifications built in conformity with international standards. The aim of the treaty is mainly to achieve a homogeneous network capable of supporting and promoting intra-regional land trade and tourism. The Agreement contains several technical specifications relating to the construction, the upgrade and the maintenance of roads, and sets also the technical standards for signs, signals and markings used on international roads. In the last years, some progress has been made in the implementation of the Agreement, still there are several specific requirements that need to be fulfilled. Moreover, we need to highlight the fact that some countries (United Arab Emirates, Bahrain, Iraq and West Bank and Gaza Strip itself) needed years only to ratify the agreement after its signature, so there is still a long way to guarantee a functional and effective road system in the Arab Mashreq.

The Agreement on International Railways in the Arab Mashreq[18]

Under the coordination of the United Nations (ESCWA) another important treaty for the Arab Mahreq was ratified: the Agreement on International Railways in the Arab Mashreq. This Agreement was adopted in 2003 *«in consideration of the fact that railways are of international importance in the Arab Mashreq and should therefore be accorded priority in the formulation of national plans for the construction, maintenance and development of the national railway networks of the Parties hereto, while ensuring that the alignment of routes and lines that do not currently exist are in conformity with feasibility studies to be carried out by the countries concerned»* (art.1). This treaty involves more than 19,528km of international railways, distributed over six major routes running North-South and ten running East-West. It entered into force in 2005, after the ratification by Egypt, Jordan, Lebanon, and Syria; West Bank and Gaza Strip has not signed it yet.

Oslo Accords

The Oslo Accord, signed in 1993 in Washington between Israel and Palestine[19], mainly states that the two states decide that the territories of Judea, Samaria and the Gaza Strip would be free from the Israeli control and convene on the establishment of a Palestinian Authority for their government and on that Israel stops denying the West Bank and Gaza Strip national sovereignty.

As for the transport field, with the Oslo Accords West Bank and Gaza Strip ceded control of the airspace and of the territorial waters to Israel which made external travel of Palestinians from Gaza very difficult and required also the cooperation of the State of Israel. The accords nevertheless established that the Palestinians could build an airport in the area, the reason for which Gaza Airport was built and opened in 1998, connecting West Bank and Gaza Strip to some Arab countries

As for maritime transport, in the Oslo Agreements the two countries agreed to work toward the building of a seaport in Gaza.

Finally, also land transport was affected by the Oslo Accords since they established the subdivision of Palestinian territories into the areas A, B, and C and this subdivision has been causing several management issues of land transport over the last years.

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17 In the late 90's these countries decided to have an agreement with the purpose of developing their trans-boundary transport system. In 1999 in Beirut the idea took real form, as these States issued a joint declaration in which they agreed on the start of the development of the Integrated Transport System in the Arab Mashreq (ITSAM).

18 The full text of the Agreement is available here:https://treaties.un.org/doc/source/recenttexts/11_c_4e.pdf

19 The Oslo Accords are a set of agreements between the government of Israel and the Palestine Liberation Organization (PLO): the Oslo I Accord, signed in Washington, D.C., in 1993 and the Oslo II Accord, signed in Taba in 1995. The first Oslo Accord was signed in the presence of PLO chairman Yasser Arafat, Israeli Prime Minister Yitzhak Rabin and U.S. President Bill Clinton.
https://en.wikipedia.org/wiki/Oslo_Accords , https://en.wikipedia.org/wiki/Oslo_I_Accord

The accord in general is judged by many to have failed due to the lack of power balance between the two bodies, the lack of mediation from other countries, the increase of power gained by Israeli settlers and Hamas, both contrary to the peace.

Regional Agreements

The Economic and Social Commission for Western Asia (ESCWA) is established by Economic and Social Council resolution n. 1818. It is one of the five regional commissions under the administrative direction of the United Nations Economic and Social Council and includes 17 member-states: Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Oman West Bank and Gaza Strip, Qatar, Saudi Arabia, Sudan, Syrian Arab Republic, United Arab Emirates, Yemen, Libya, Morocco and Tunisia.

During its 19th session, ESCWA adopted resolution n. 213 on the establishment of a committee on transport within the Commission that, on May 1999, declared a statement on the adoption and development of the Integrated Transport System in the Arab Mashreq (ITSAM), as part of the ESCWA's credo and belief that transport is a strategic sector for cooperation and integration in among the ESCWA countries, also in the light of contemporary globalization.

National Laws and Legislations

Traffic Law

Article 125 consists in nine chapters and is subdivided as follows:

- Chapter 1 - Definition of terms;
- Chapter 2 – Vehicle registration and licensing;
- Chapter 3 – car maintenance and safety;
- Chapter 4 – Vehicle driving licenses;
- Chapter 5 – Rules and traffic conduct;
- Chapter 6 – Buses and taxis;
- Chapter 7 – Fees;
- Chapter 8 – Penalties;
- Chapter 9 – general and transitional provisions.

However, despite being a qualitative leap in regulation of the Palestinian transportation sector, in terms of unifying legislation regulating traffic sector in the West Bank and Gaza Strip, it annulled old laws effective there[20]. The law paved the way for the establishment of the Higher Council of Traffic and for secondary legislations for the law including secondary by laws and resolutions.

In order to keep pace with accelerating developments, Ministry of Public Work (MoPW) had to develop a draft law for roads, whereas meanwhile, the Ministry of Transportation (MoT) authored the new Draft Traffic Law and the respective bylaw.

The present Traffic Law, however, has a number of shortcomings, including:

- Technical errors and legal contradictions in the Law's provisions.
- Certain provisions are deficient and unclear.
- The Law does not cover all issues relating to traffic.

[20] This has annulled Transport Law # 23 of 1929 and it has also annulled Military Order # 354 of 1970 which was effective in the Gaza Strip. It has also annulled Law # 49 of 1958 and Military Order # 1310 of 1992, which was effective in the West Bank.

- The Law does not provide for sanctions on traffic violations.
- The Law does not take account of administrative issues to maintain road safety and security and protect citizens' lives and properties.

Traffic Law # 5, Article 118, adopted in 2000 paved the way for the establishment of the Higher Council of Traffic. Its main tasks are summarized as below:

- draw up the general policy of traffic facilities and the setting up of plans, means and methods to improve them
- identify the tasks and responsibilities of ministries, bodies and parties/authorities in charge of implementing the traffic facility plans
- form local traffic committees.

Division of Responsibilities among governing levels

Article 1 of Traffic Law # 5 of 2000 defines the city road as "every road that falls within the responsibilities of the local authority". A sign shall be located at the city entrance. This sign demarcates the road entrance to a city. Another sign is located at the boundary of the city site for exiting traffic, which demarcates the limit/end of municipality road limits.

Article 118 of Traffic Law #5 stipulates that the Higher Council of Traffic shall be tasked with determination of the tasks and responsibilities of ministries, local bodies/ authorities when it comes to implementation of **traffic facility plans**.

Article 14 of the Traffic by-laws, issued in accordance with Cabinet Decision # 393 of 2005, has granted the local council authorities the powers to issue regulations of their own after getting approval from the competent authority. This includes the power to issue the following regulations:

- Validity of vehicles drawn by animals (horses and donkeys) and issuance of necessary licenses to them after collection of due fees.
- Registration of two-wheel or three-wheel ordinary bicycles and issuance of necessary licenses to them after collection of due fees and determination of durability conditions for them,
- Issuance of license plates for carriages driven by animals and bicycles and determination of measurement of these plates, as well as their shape, type and rules pertinent to their installation.

Article 2/20 of City, Village and Building [Regulation] Law # 79 of 1966 defines the road authority as "the Ministry of Public Works pertinent to roads off municipality limits". It also means the municipality and local village councils within their limits. Article 34/4/E of the same law states that falling within the city master plan shall be subject to municipality supervision in terms of asphalting, maintenance, water, sewage disposal and other infrastructural matters.

Land Expropriation for Roads

Expropriation of private land for roads is based on effective law provisions and on the basis of the provisions of Expropriation Law # 2 of 1953. This law stipulates that the "expropriation decision shall be taken by the cabinet". This means the government shall decide on this, and the final approval shall be signed by the head of the PNA. This shall be done after its publication in the official gazette. Article 13 of this law stipulates that if the expropriation of parts of land would preclude utilization of remaining parts, the authority, for whom the expropriation is made for, may acquire the remaining plots if their owner desired.

Disputes over the amount of repatriation (compensation) to be paid are regulated through Article 15 of the same law[21].

It is worth noting here that the aforementioned texts of the Expropriation Law and the texts of City and Village Regulation Law # 79 of 1966 should be taken into due consideration. Article 58 of this law does not authorize the landowner, whose piece of land has been expropriated, to ask for compensation except for expropriated lands, which exceed 30% of the total land area. Pertaining to challenges, which face expropriation of lands for roads, it is related to the presence of the Israeli occupation and its control of most Palestinian lands. Expropriation of land in Area C cannot be done with the approval of the Palestinian Higher Planning Council. It has to get approval of the Higher Planning Council, which belongs to the Israeli Civil Administration headquartered in Beit El Settlement.

Another challenge which might face expropriation of land for roads is associated with the financial ability of the local authority to pay for the expropriated land particularly when the land is classified as too expensive and the road which would pass through it could cause heavy damage to it. This means that the local authority shall be obliged to pay 70% of the value of total land area expropriated.

[21]In such a case, the court shall take into consideration the following rules when it determines the amount of compensation:

- It shall not affect the estimation of lease allowance because expropriation would be done without the land owner's consent.
- It shall take into consideration price of neighboring plots of land, adjacent to land to be expropriated, which belongs to same type regardless of the price for the purposes of the facility
- That amount shall be considered the price of land which would be acquired if sold publically in the market by a person interested in the purchase on condition that the value of land or right or utility shall be estimated at the time of the publication of the cabinet decision in the official gazette regardless of any improvements or installation made on it or built on it after date of publication of the aforementioned decision.
- When it comes to estimation of lease allowance, necessary to be paid in return for renting the land, the court shall determine the annual lease allowance for the land owner taking into consideration the value of its lease on the date of the publication of the cabinet's decision pertinent to land expropriation.
- Upon estimation of repatriation/compensation to be paid, for damage and disruption caused, as a result of establishing any right or facility or imposition of any restriction on exercise of any right pertinent to land ownership, the court shall estimate this compensation on the basis of the amount which would decrease the estimated value of the land in accordance with the previous items due to establishment of the aforementioned ownership right or imposition of that restriction.
- If the value of that piece of land decreased, due to expropriation, this drop of its value shall be taken into consideration. However, the amount to be added shall not exceed in all cases half of the value which the land owner deserves in line with the provisions of this article.
- The court shall also take into consideration any damage inflicted or might be inflicted on the owner as a result of separating the expropriated land from other plots belonging to that landowner or as a result of exercising the powers authorized by this law.
- Taking into consideration the provisions of Article 17 of this law, the due amount shall not be paid to the land owners unless a certificate was produced and issued by registration officer.

5. Road Transport Sector

Existing Road Network

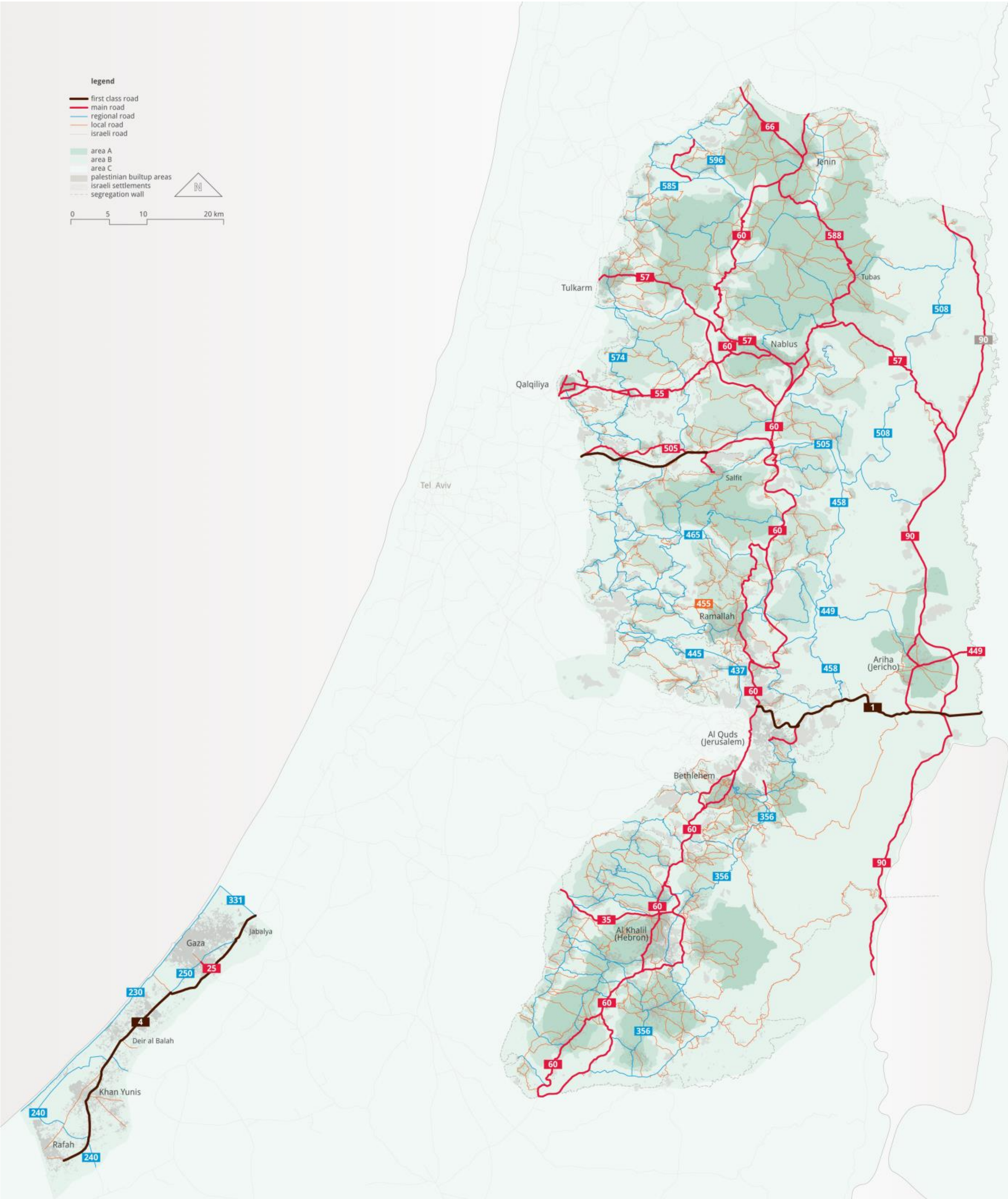
Currently, road transport sector represents the backbone of Palestinian transportation, since all the types of movements – people/ goods, private/ public, systematic/ occasional – occur along the existing road network both in West Bank and Gaza Strip where no other modes of transport are supplied.
Therefore, road transport sector can be considered the main transport sub-sector as well as road network can be deemed the major transport infrastructure.
Palestinian road network was analyzed with thorough survey campaigns, carried out on March and April 2016 for the most parts of the road network, for a total length of approximately 1,100 Km of main, regional and local roads of West Bank and Gaza Strip.
The survey was carried out in collaboration with the experts from MoPHW and MoT.
For more details, refer to ¶Annex 5 – Road Inventory and Condition Survey.

The results of the surveys revealed that the current Palestinian road network is composed of:

- First-class Roads (Main Roads);
- Second-class Roads (Regional Roads);
- Third-class Roads (Regional Roads), and;
- Local Roads (Paved and Unpaved Roads).

The complete Palestinian road network is shown in the following figure.

Figure 1. Existing Road Network with Hierarchy



In West Bank, the main roads are:

- Road n°90, Eastern Backbone (Main road);
- Road n°60, Central Backbone (Main Road);
- Roads n°437, n°1, n°417, n°398 and n°3157, Central Backbone (By-pass Roads);
- Roads n°1, n°35, n°57, n°55+505 (Transverse Roads).

The overall road network length is about 3,715.13 km split as follows.

- Main roads 656.55 km;
- Regional roads 1,127.92 km;
- Local roads 1,473.75 km;
- Unpaved roads 456.91 km.

In Gaza Strip, the main roads are:

- Road n°230, Western/Coastal Backbone (Main road);
- Road n°4, Internal Backbone (commonly known as Salah al Din) (Main Road);
- Roads n°240, n°250 (Secondary and By-pass Roads).

The overall road network length is about 290 km split as follows.

- Main roads 90 km;
- Regional roads 200 km.

Road Monitoring and Maintenance

Palestinian road transport was studied through reference to available Technical Reports, International Conventions, Road Design Standards Handbooks in addition to a series of meetings with the executive and technical staff of the MoPWH, in particular, with their GIS Unit and with the Directorate of Roads.
The Directorate of Roads conducts methodological condition survey on West Bank and Gaza Strip road network, for road maintenance and general asset management purposes.
The results of these surveys are reported in a series of detailed sheets, for segments of road, generally ranging in length between 1000 meters and 3000 meters.
The road condition survey is periodically updated, for each segment, every 6 months. The GIS referenced information is electronically filed and uploaded on A4 format. The complete road condition information filing hosts some 100s of A4 sheets, which are also periodically summarized and data-base entered, for statistical and operations management purposes.
No verification audit is carried out on the technical information contained in the condition survey sheets, hence the responsibility for eventual cross checking of the information is left to each surveying team or head surveyor; the Directorate of Roads, though, checks accuracy and completeness of the reports and their update.

The information contained in the A4 Condition Survey Sheets include (in Arabic):

- file search name of road
- code of road (West Bank and Gaza Strip identification use coding system)
- road number (Israel use road numbering)
- name of road
- relevant Governorate
- road classification
- road linking (to/from)
- road width
- start point of road stretch
- end point

- PCR (pavement condition rating – Very good, Good, Fair, Poor and Very poor)
- type of rehabilitation needed, if warranted
- existing check points/obstacles
- paving quality
- culverts
- guardrails
- median and side lines
- concrete structures
- date of survey
- additional notes.

Figure 2. Road Condition Information Filing Sample #1 (MoPWH)

Palestinian National Authority
Ministry of Public works and Housing
Directorate of roads - GIS Unit

السلطة الوطنية الفلسطينية
وزارة الاشغال العامة والاسكان
الادارة العامة للطرق - وحدة نظم المعلومات الجغرافية

التاريخ: 2014/11/17

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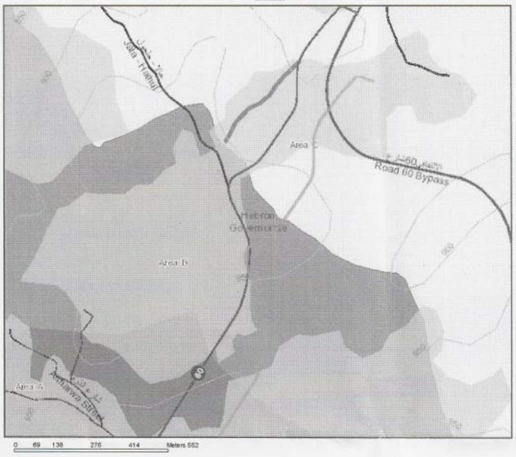

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رمز الشارع	50003
رمز الشارع	50003
إسم الشارع	القدس - الخليل (شارع 60) (حلحول)
المحافظة	الخليل
تصنيف الشارع	رئيسي
طول الشارع:	1867
عرض الشارع	6
بداية الشارع	مفرق حلحول الشمالي (حواور)
نهاية الشارع	دوار الذروة (مدخل حلحول)
حالة الشارع	مقبول
بحاجة إلى إنشاء جديد	لا
رقم الشارع	60
حواجز اسرائيلية	

		الكمية التقديرية للحفريات (م3)	0
بحاجة إلى وجه اسفلت كامل	لا	الكمية التقديرية لوجه الاسفلت(م2)	0
بحاجة إلى ترقيعات	الشارع بحاجة الى ترقيعات	الكمية التقديرية للترقيعات	200 +
بحاجة إلى إعادة تأهيل	لا		
عدد العبارات الموجودة	0	عدد العبارات المقترحة	0
عدد الحواجز الوقائية	3 موجودة - 2 مقترحة	الطول التقديري للحواجز الوقائية الموجودة	110
بحاجة دهان	الشارع بحاجة الى دهان	الطول التقديري للحواجز الوقائية المقترحة	100
عدد عيون القطط	الشارع بحاجة الى عيون قطط	عدد الاشارات المرورية	الشارع بحاجة الى اشارات مرورية
بحاجة إلى توسعة	لا	بحاجة إلى إنارة	لا
الكمية التقديرية للخرسانة م3	0	الطول التقديري للبيسكورس م3	0
تاريخ الكشف	1/7/2013		

ملاحظات عامة 1 — تم إعادة فتح الشارع مؤخرا بعد إغلاق إسرائيلي لسنوات

ملاحظات عامة 2 — يتم حالياً اعمال توسعة للشارع من طرف بلدية حلحول وهو قيد العمل حتى الآن . « USaid »

Al Bireh Um Al Sharayet P.o.box 3961 Ramallah Tel:2987888 Fax 2987890
Gaza Al Rimal the south - Arab league st Tel 082829232
Fax:082968475

البيرة ام الشرايط ص.ب 3961 رام الله هاتف:022987888 فاكس:2987890
غزة الرمال الجنوبي شارع الجامعة العربية هاتف: 082829232
فاكس: 082968475

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Figure 3. Road Condition Information Filing Sample #2 (MoPWH)

http://10.111.73.62/mpwh/ReportGovernorate.aspx

Palestinian National Authority
Ministry of Public works and Housing
Directorate of roads - GIS Unit

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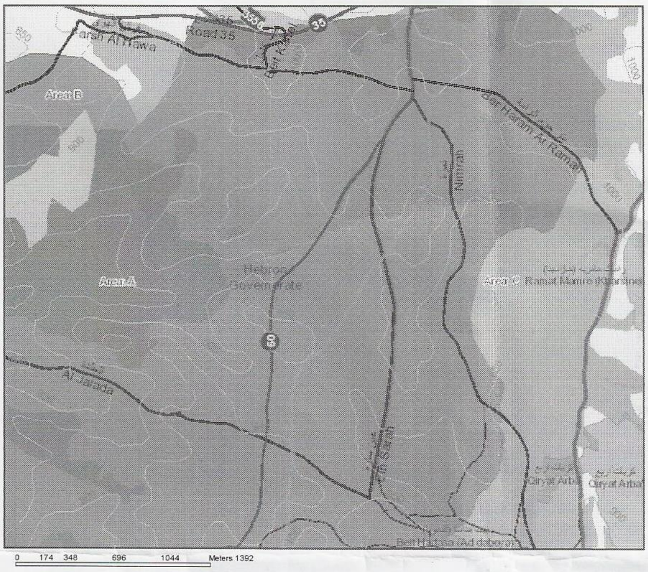

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رمز الشارع	50006
إسم الشارع	القدس - الخليل (شارع 60) (شارع السلام)
المحافظة	الخليل
تصنيف الشارع	رئيسي
طول الشارع:	4289
عرض الشارع	12
بداية الشارع	جسر حلحول
نهاية الشارع	مفرق السبع (المدرسة الشرعية)
حالة الشارع	مقبول
بحاجة إلى إنشاء جديد	لا
رقم الشارع	60
حواجز اسرائيلية	

		الكمية التقديرية للحفريات (م3)	0
بحاجة إلى وجه اسفلت كامل	لا	الكمية التقديرية لوجه الاسفلت(م2)	0
بحاجة إلى ترقيعات	الشارع بحاجة الى ترقيعات	الكمية التقديرية للترقيعات	0
بحاجة إلى إعادة تأهيل	لا		
عدد العبارات الموجودة	0	عدد العبارات المقترحة	0
عدد الحواجز الوقائية	0	الطول التقديري للحواجز الوقائية الموجودة	0
بحاجة دهان	الشارع بحاجة الى دهان	الطول التقديري للحواجز الوقائية المقترحة	0
عدد عيون القطط	لا	عدد الاشارات المرورية	لا
بحاجة إلى توسعة	لا	بحاجة إلى إنارة	لا
الكمية التقديرية للخرسانة م3	0	الطول التقديري للبيسكورس م3	0
تاريخ الكشف	1/7/2013		
ملاحظات عامة 1	ضمن حدود بلدية الخليل ، شارع اتجاهين مع جزيرة وسطية		
ملاحظات عامة 2			

لا يوجد تعديل

2015

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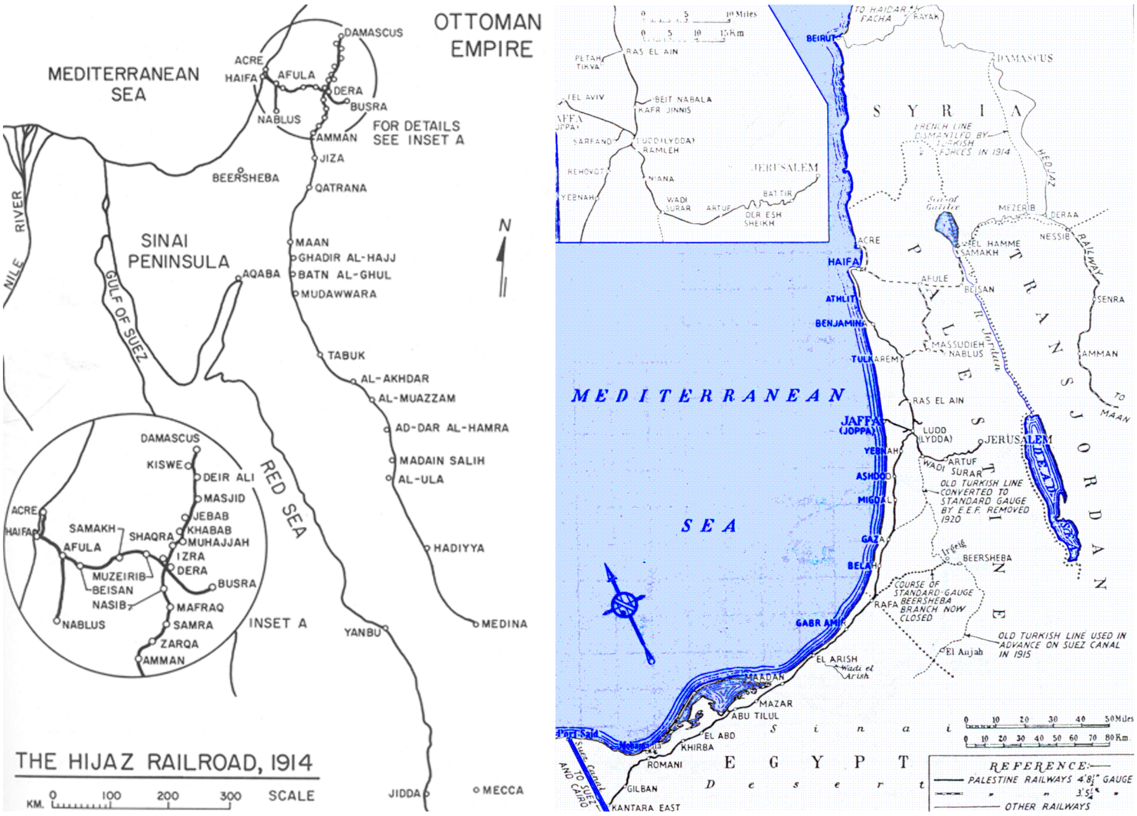
6. Rail Transport Sector

Rail Transport Historical Overview

Transport system in West Bank and Gaza Strip does not offer any rail service. Nevertheless, in the past some railways used were operating across the Palestinian territories and recently the interests towards rail transport has risen again among the local authorities and stakeholders involved in the sector.
The analysis of rail transport herein presented offers a brief overview of the past experiences, provides a set of guidelines for the development of future projects and describes the proposal shown in the vision of the transport master plan draft by the MoT in 2015.
At present, in the West Bank and Gaza Strip no railway line is in operation, but it should be reminded that at the beginning of the last century some sections of the Hijaz Railway were opened in that area.
Some of these lines are still present, albeit in disuse, in the North of the West Bank (Jenin – Nablus, Tulkarm – Nablus) and along the Gaza Strip. The railway line in the West Bank, operating until 1940, is a narrow gauge line (1050 mm) and potentially connectable to Hejaz Railway operating between Damascus and Amman. The railway line in the Gaza Strip has a standard gauge (1435 mm) and a length of 34 km from North to South direction.

Figure 4. Hijaz Railroad: 1914 (left), 1930s (right)

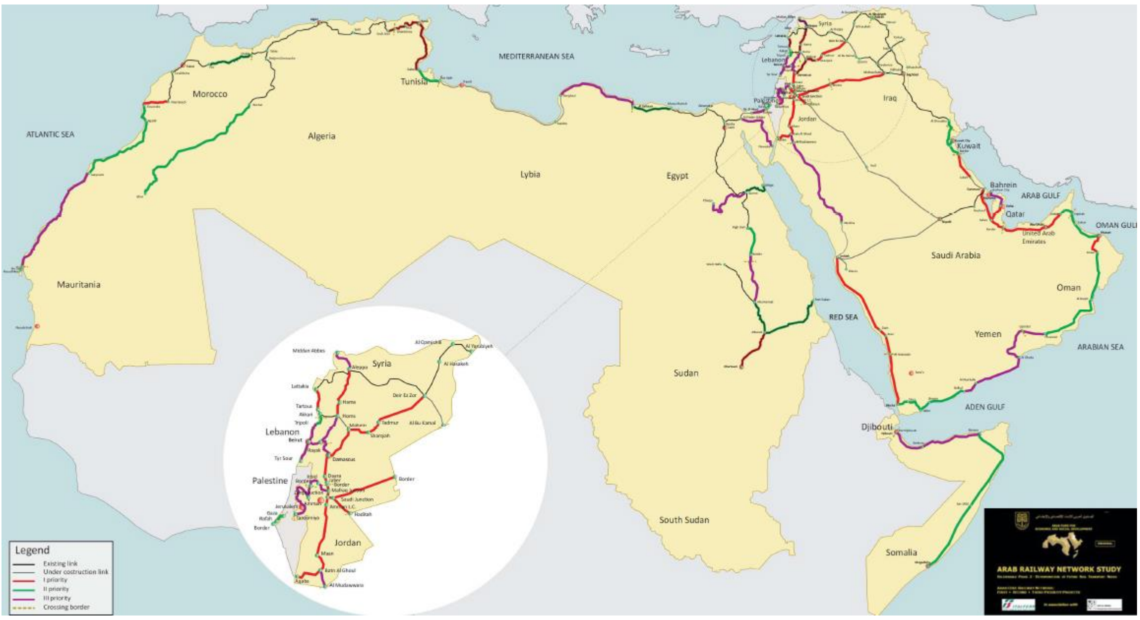


Since the Camp David Accords (1978)[22], a high-speed rail line to connect the two Palestinian territories has been repeatedly proposed.

In 2012, the Arab Fund for Economic and Social Development financed the so-called “Arab Railway Network Study”.[23] As stated in the final report, the entire Project is based on the awareness that due to the inclination of Arab countries to establish local and regional railway networks, and in view of the economic and social benefits of the railway transport as a reliable and safe transport alternative, it has become crucial the outline of a comprehensive scheme of the Arab railway network, incorporating both existing and planned rail networks, allowing:

- the connection of these networks in major axes;
- the definition of its elements, specifications and operating procedures, and;
- the lay down of the groundwork to link the Arab region with neighboring countries.

Figure 5. Arab Core Railway Network (Macro Axes 1, 2, 3, 4, 5 and 6). Project Priorities



The Project consisted in the execution of a transport study aimed at systematizing, analyzing and planning infrastructural interventions directed at the creation of a railway network able to integrate the entire Arab world (all the member countries of the Arab League Countries were involved: Egypt, Iraq, Jordan, Lebanon, Saudi Arabia, Syria, Yemen, Libya, Sudan, Morocco, Tunisia, Kuwait, Algeria, United Arab Emirates (UAE), Bahrain, Qatar, Oman, Mauritania, Somalia, Palestine, Djibouti).

[22] Camp David Accords, agreements between Israel and Egypt signed on September 17, 1978, that led in the following year to a peace treaty between those two countries, the first such treaty between Israel and any of its Arab neighbors. Brokered by U.S. Pres. Jimmy Carter between Israeli Prime Minister Menachem Begin and Egyptian Pres. Anwar el-Sādāt and officially titled the “Framework for Peace in the Middle East”.

[23] The full name of the report is: Arab Railway Network Study. REF T/1-1-1/1103, June 2012. The study was developed by Italferr (Italy) and Dar Al Omran (Jordan). The Project of the Arab Rail Network aims therefore at the creation of an interoperable, complete and modern regional railway system.

This infrastructural work, involving a vast territory measuring 13.3 million km² including North Africa and a huge portion of the Middle East, represents one of the milestones of a more immense general project dedicated to economic development and improving the living conditions of about 278 million Arab citizens

A MoT Vision for Rail Transport Sector

In 2015, the MoT presented its Vision for a Transport Master Plan showing also the link between Gaza Strip and the West Bank, that beside unifying the two Palestinian regions, could also open the way for future connections with Egypt in the South and Jordan in the East.
Mot Vision for rail transport sector is presented in the following figures showing two different options.

Figure 6. Rail transport options from the Master Plan Vision by MoT – Option 1, 2015

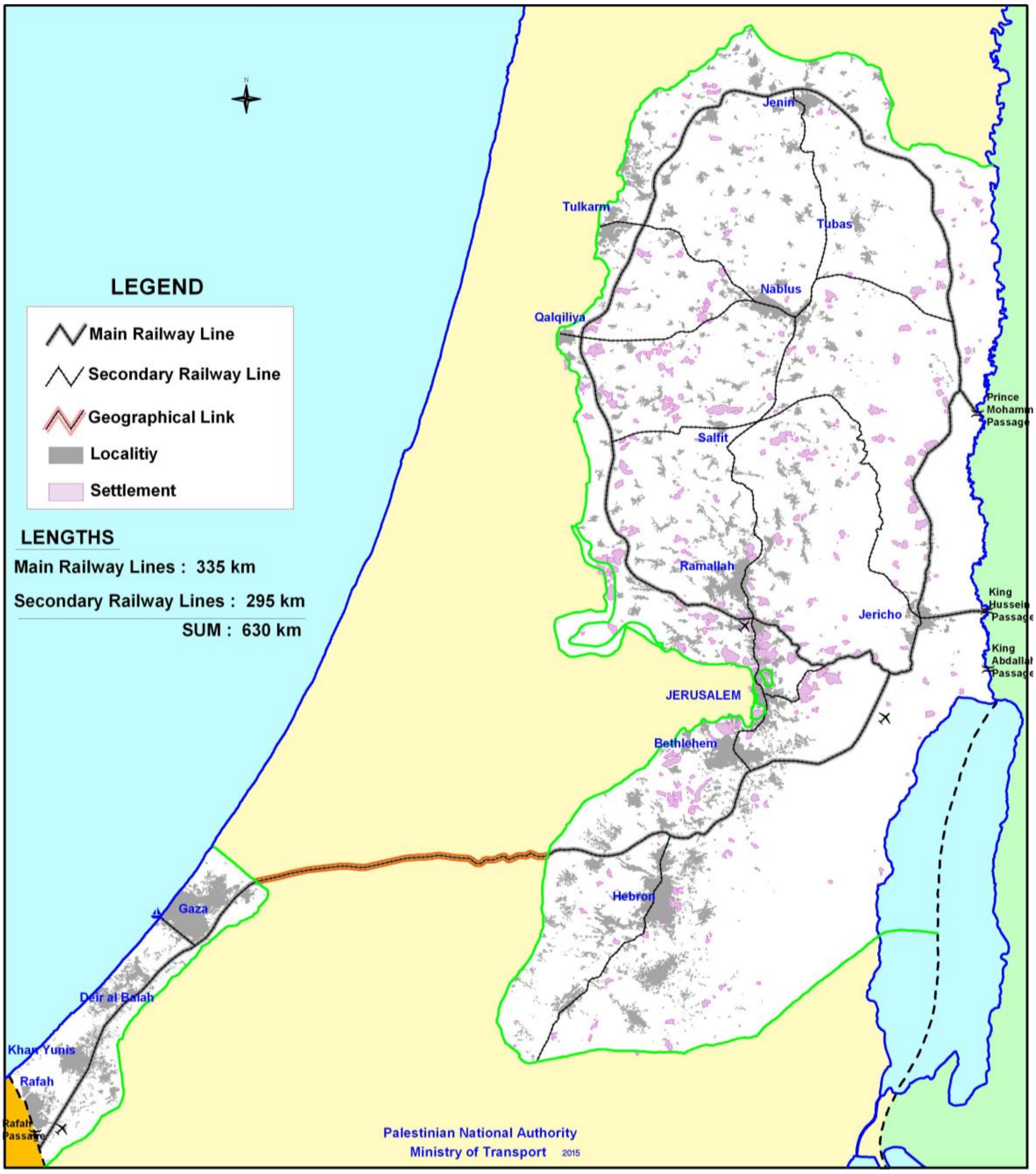
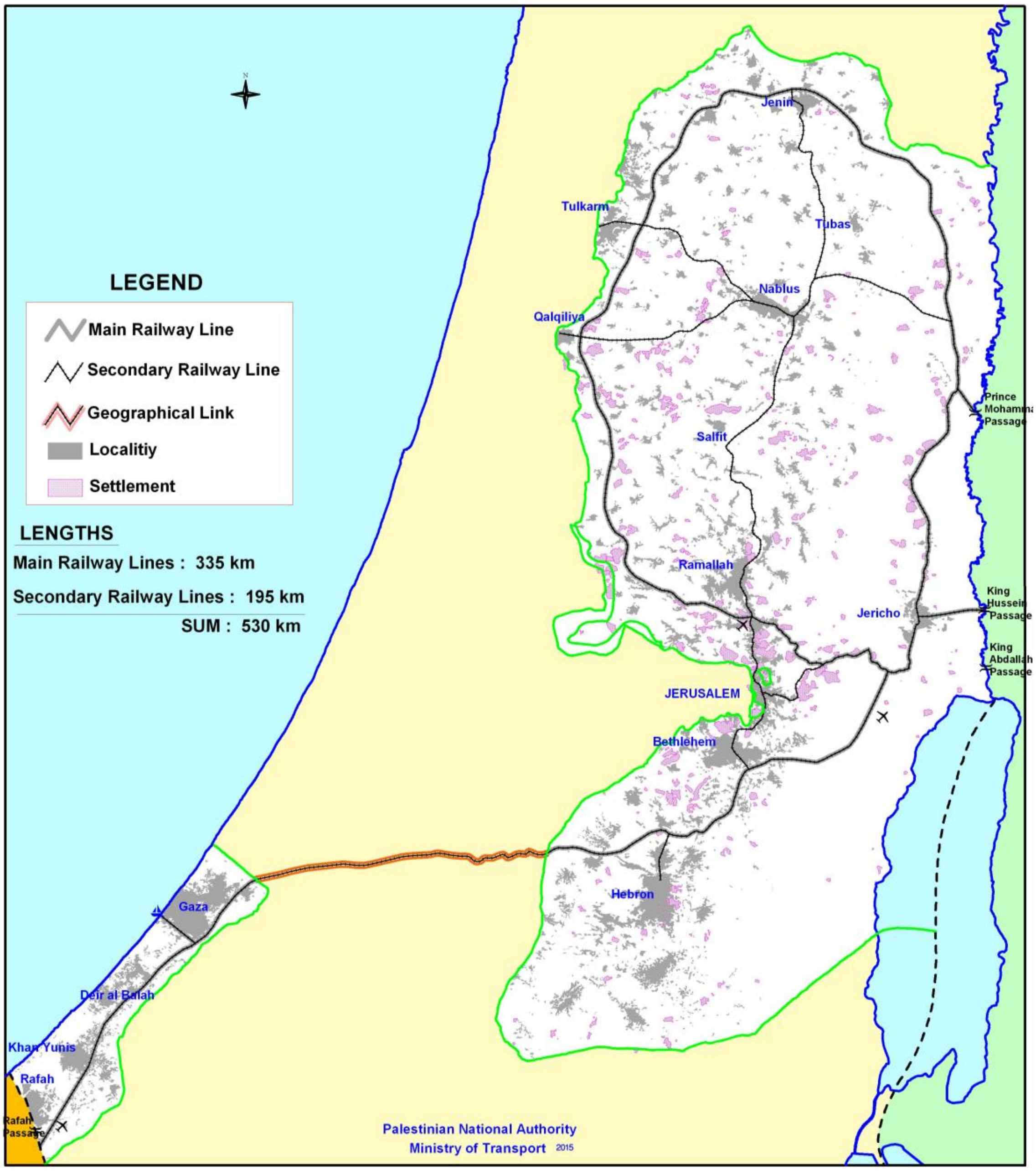


Figure 7. Rail transport options from the Master Plan Vision by MoT – Option 2, 2015



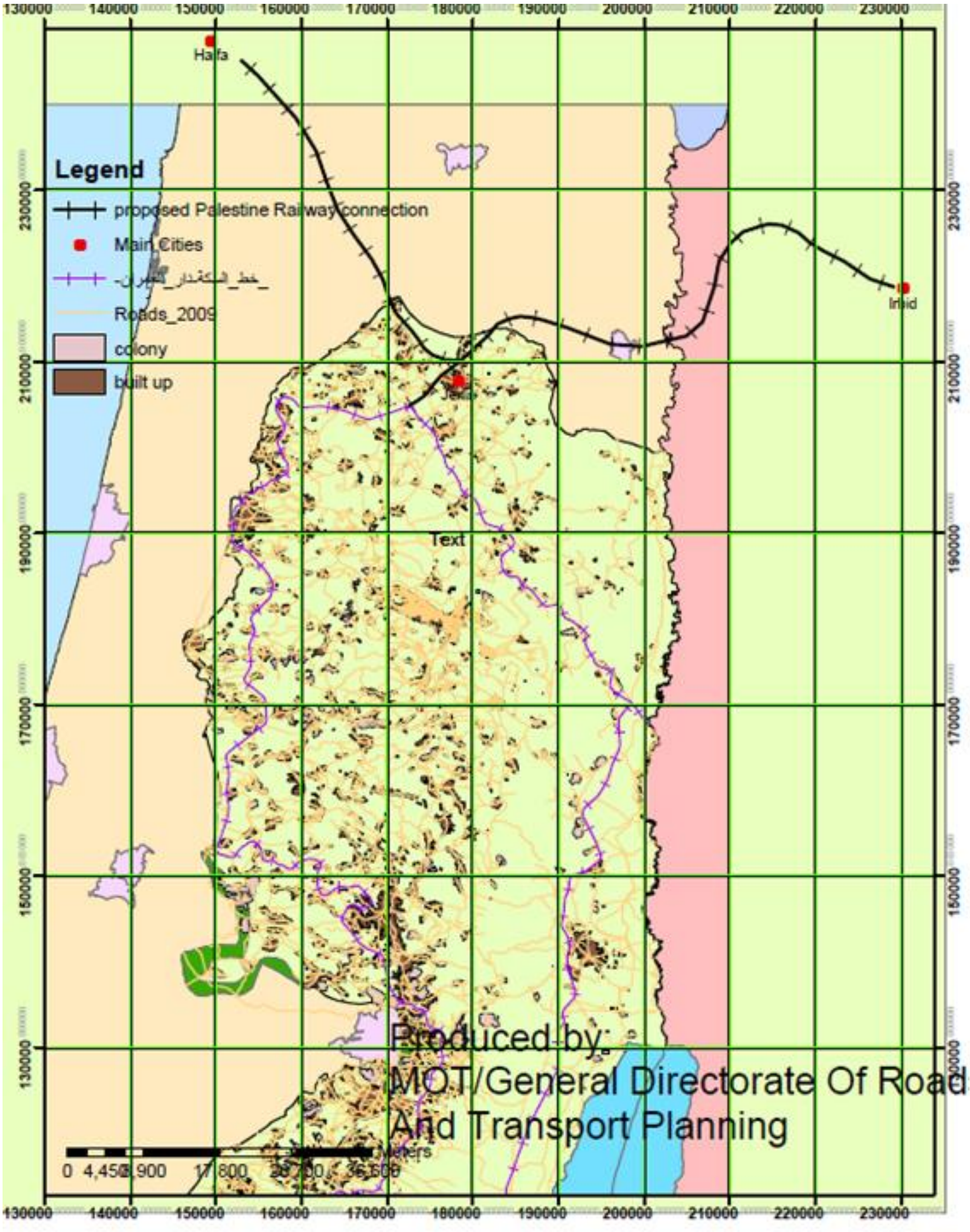
MoT vision for rail transport sector was studied and assessed with an *ad hoc* SWOT Analysis.

Tab 2. SWOT Analysis of Rail Transport Master Plan Vision, MoT 2015

Rail Transport Master Plan Vision (MoT, 2015)	
Strengths	Weaknesses
• High potential for socio-economic development through internal and external connections; • Possibility to evaluate railway integration system with different transportation system for passengers is possible; • Possibility to evaluate railway integration system with different transportation system for freight is possible; • Demographic indicators prospect a good potential for rail transport demand; • Concentration of population in coastal areas and in urban centers with high density; • Potential high demand for passenger transport; • Potential good demand for freight transport; • Possibility of participation/intervention of public/ private investors; • Possibility of participation/intervention of local/ international investors; • Increase of global safety in transportation; • Fast transport system reducing also road traffic congestion; • Increase of transportation capacity; • More environmental-friendly transportation system, and; • Financial feasibility, due to the general transport cost reduction on the medium and long term.	• Unstable political situation of the country and region; • Possible resistance by stakeholders of road transport; • Initial large investments of capital; • Incoherence among the gauges of the existing rail tracks; • Rail transport might not access isolated regions, already accessible by traditional lorries; • High management cost of rail transport services; • Need of modern infrastructure and intermodal exchange system to avoid bottle neck, and; • Minor flexibility for the geographical distribution of rail services.
Opportunities	Threats
• Further population growth with increase of domestic and international mobility demand; • Possibility of further investments and increase of transport capacity also with neighboring countries, and; • Continuous modernization of infrastructure and intermodal capability.	• Difficulty to perform good previsions due to regional political instability; • Difficulty to attract investment due the regional political instability, and; • Risk of uncontrolled increase of costs.

Moreover, in 2015 MoT General Directorate of Road and Transport Planning presented the proposal for renewing the Jezreel Valley Railway, reactivating the railway between Tulkarm, Jenin and Nablus, with a possible extension to the North (Damascus, Syria). The main aim of this proposal is to link the northern part of West Bank to the international railroads connecting Irbid-Amman, in Jordan, to the port of Haifa, Israel.
MoT proposal for the renewal of Jezreel Vallety Railway is shown in the following figure.

Figure 8. The proposal of rail connection with the Haifa-Amman line, 2015



Recently, within the framework of EuroMed 2016, the proposal for a railway link connecting West Bank to Gaza Strip was reconsidered.

7. Air Transport Sector

Currently air transport passengers from West Bank and Gaza Strip can only rely on airports located in the neighboring countries.[24]
The same occurs for Palestinian Airlines - the only active Air Operator's Certificate registered under PCAA - which small fleet of Fokker F-50 aircraft has recently resumed operation that cannot be performed from West Bank and Gaza Strip nor from the old base in Al Arish airport, in North Sinai Governorate of Egypt.
Air transport supply is therefore not available inside Palestinian Territories, nevertheless three different aviation facilities exist, albeit damaged and/or in disuse:

- Yasser Arafat International Airport IATA: GZA, ICAO: LVGZ
  located in the Gaza Strip, near Rafah, close to the border with Egypt and Israel;
- Gaza Airstrip - IATA: GHK, ICAO: LLAZ
  located in the Gaza Strip near Khan Younis;
- Qalandiya Airport - IATA: JRS, ICAO: LLJR
  located between Jerusalem and Ramallah close to Qalandiya check-point.

A thorough survey[25] of each site was performed over two separate missions: a first over a period of 5 days, limited in scope to the West Bank and East Jerusalem, and; a second over a period of 3 days when access was finally granted to the Gaza Strip.[26]

The key map below shows the locations of the aviation facilities listed above.

Figure 9. Aviation Facilities (Disused and Damaged) in Palestinian Territories

24Currently the biggest part of Palestinian inbound and outbound air passengers travel via Ben Gurion International Airport (IATA: TLV, ICAO: LLBG) in Tel Aviv and via Queen Alia International Airport (IATA: AMM, ICAO: OJAI) in Amman.
25The survey included also potential sites for new greenfield airport(s) in both Gaza Strip and the West Bank. The main objective of the on-site survey was to perform an initial assessment of the identified locations, as included in the Plan, and evaluation of the readiness of the Civil Aviation sector in West Bank and Gaza Strip and the collection of additional information and data for the correct gauging of air transport demand in the region.
26The survey team was not given the chance to access the Gaza Strip during the initial mission, although the status of the airport facilities in the Gaza Strip were discussed during conversation with the Palestinian Authorities.

Y. Arafat International Airport (IATA: GZA, ICAO: LVGZ) Survey

Yasser Arafat International Airport's key infrastructures have suffered extensive damages and none of them can be potentially eligible for a quick rehabilitation.
The Terminal, VIP Terminal, Airport Office Building, ramp and runway would require demolition from their current state, before a re-construction program could be launched.
As illustrated in the attached pictures, it appears that after the initial damages occurred in 2001/2002, the site was used as source of material and very little is left of the runway/apron asphalt and various aggregate material. The area, though, is still in the availability of the Palestinian Authorities and was been encroached, despite the lack of viable land. The site is only marginally used for agricultural use and pasture (mostly dromedaries).
More complex is the status of the original access system, which currently suffers from encroachment and extensive deterioration.

Figure 10.Source: Y.Araft International Airport Site Survey






Gaza Airstrip (IATA: GHK, ICAO: LLAZ) Survey

Gaza Airstrip is conveniently located between the recently refurbished Salah al-Din Road and the new Coastal Road, being currently completed and includes mainly farmland, dotted with greenhouses. Gaza Airstrip was not given adequate maintenance since 2004 and the tarmac of the runway has been partially covered by sand and debris and, as a result, it reduced in width and length.

The survey confirmed that the site can be compatible with the proposal of a new airport, nevertheless Local Authorities revealed that the area is already earmarked for urban and residential development, although the actual zoning plans do not formally confirm this type of land use for the area.

Qalandiya Airport (IATA: JRS, ICAO: LLJR) Survey[27]

The airport experienced substantial activity, included international operations, until 1967, under a Jordanian designation: OJJR. Since 1967 is had been used for domestic-only (Israel) traffic until 2000. It was not used for civil traffic ever since.
The survey was possible only from the East Jerusalem side, passed the Qalandiya check-point; the area is, in fact, encircled by the border wall built by the Israeli authorities as shown in the flowing pictures, taken during the site survey.
The asphalt runway appears, as it is shown, in acceptable conditions, although without certifiable markings and lighting systems.
The airport area is sealed off and the existing facilities show evident signs of lack of maintenance and proper care, most worrisome is the encroachment of the residential area to the North of the airport.
The multi-storey buildings clearly penetrate the airport obstacles protection surfaces (transitional), as per the ICAO Annex 14 recommended practices, thus preventing a possible re-certification of the airport for civil use.

Figure 11. Qalandiya Airport Site Survey

Specific analyses were performed using GIS tools and ICAO criteria, in order to verify the respect of international standards.

[27] Also known as Jerusalem International Airport.

The results of the analyses confirm that the aerodrome does not meet international standards, with regards to penetration of airport protection surfaces, as illustrated in the figure below (taken from Air Support's 3D surface simulation and control system).

Figure 12. Qalandiya Airport: 3D Surface Simulation and Control System #1

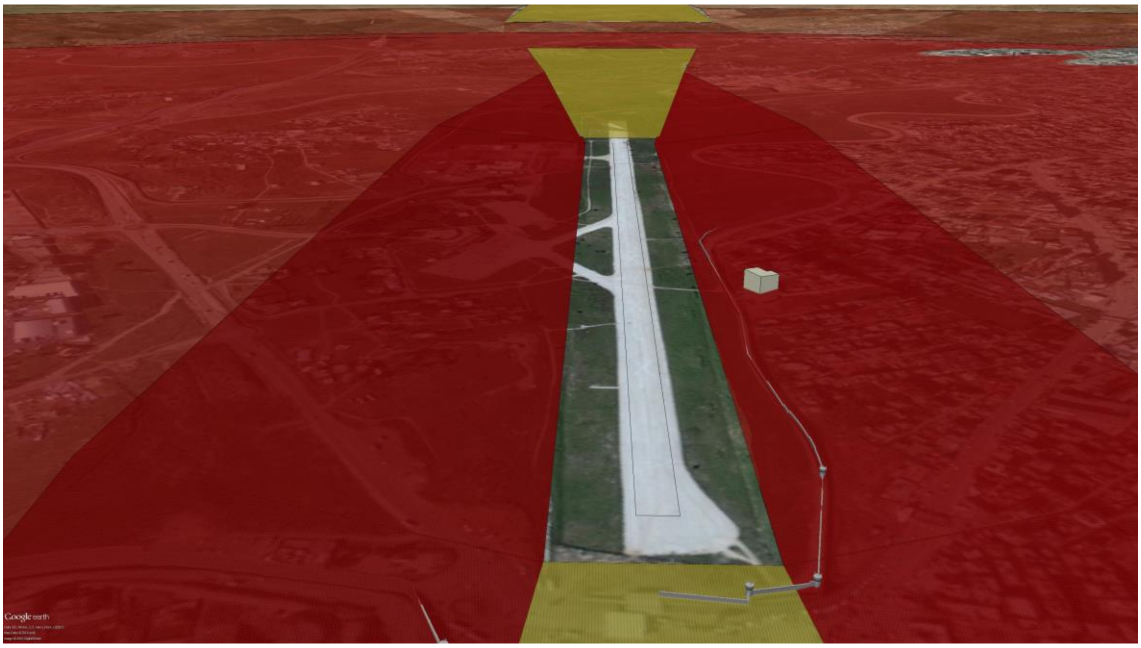


Figure 13. Qalandiya Airport: 3D Surface Simulation and Control System #2

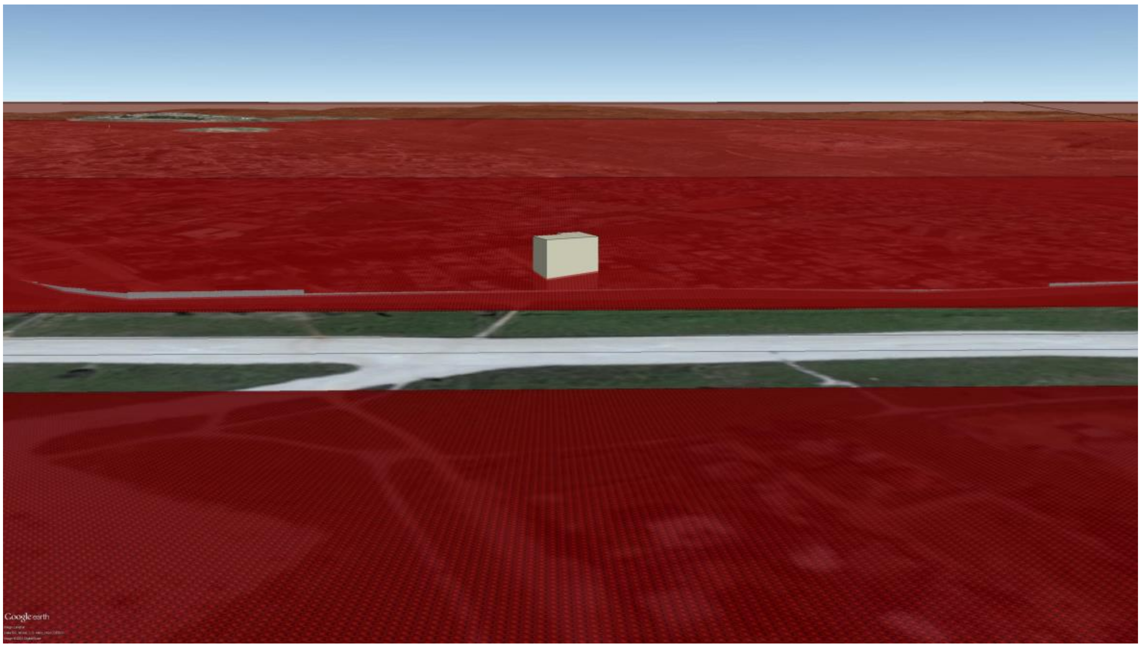


Figure 14. Qalandiya Airport: 3D Surface Simulation and Control System #3

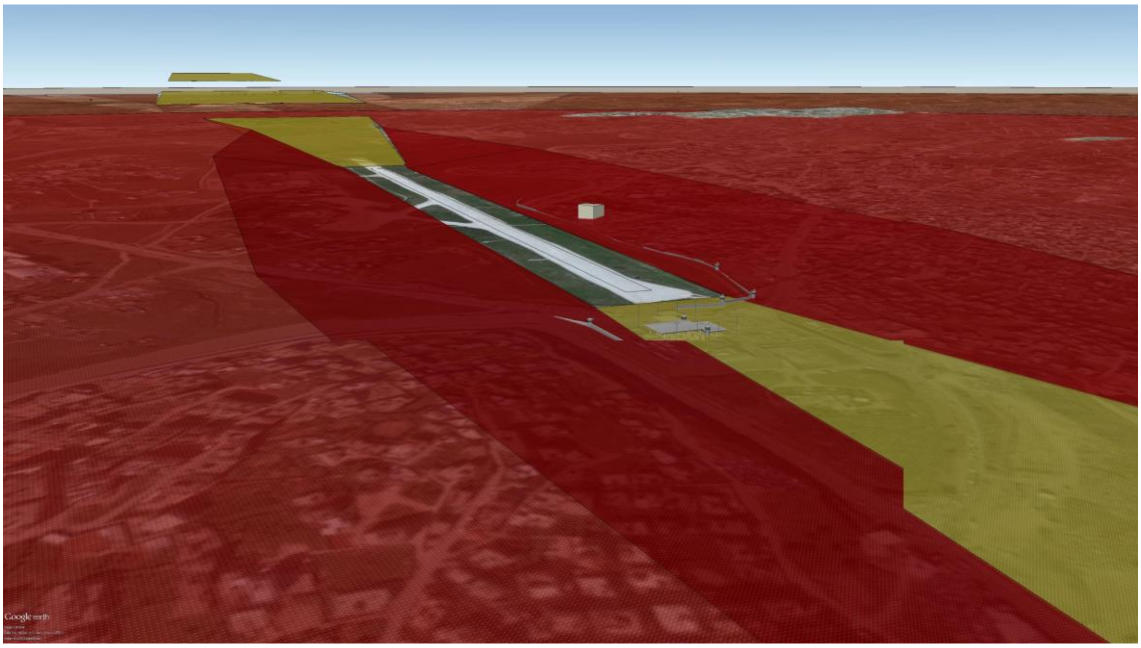


Figure 15. Qalandiya Airport: 3D Surface Simulation and Control System #4

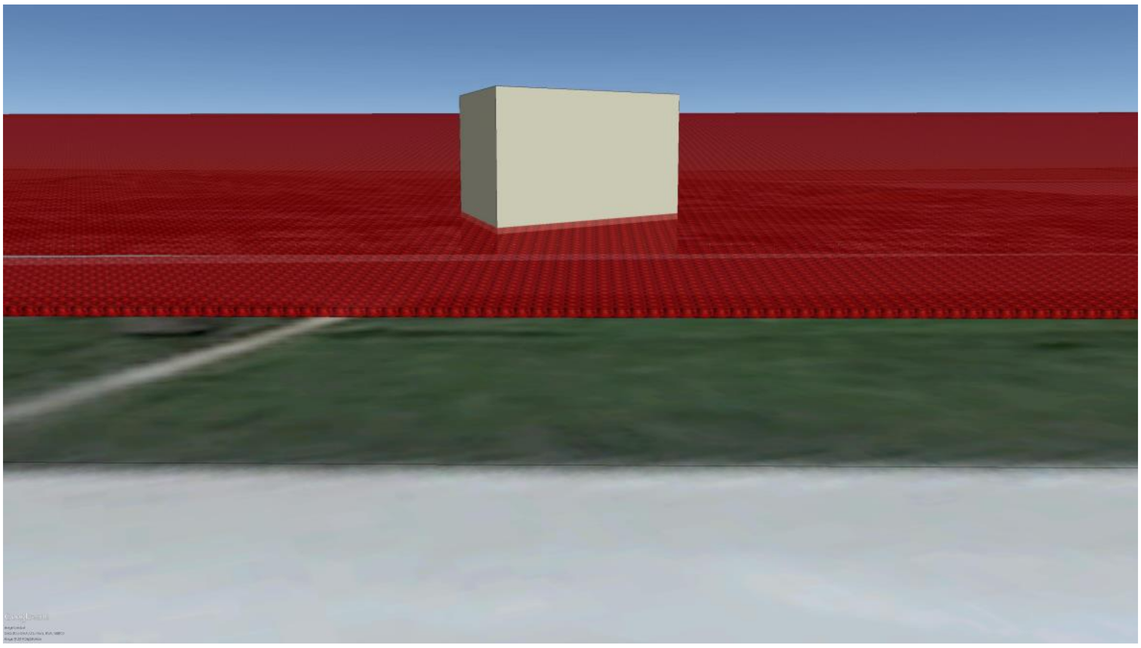


Figure 16. Qalandiya Airport: 3D Surface Simulation and Control System #5

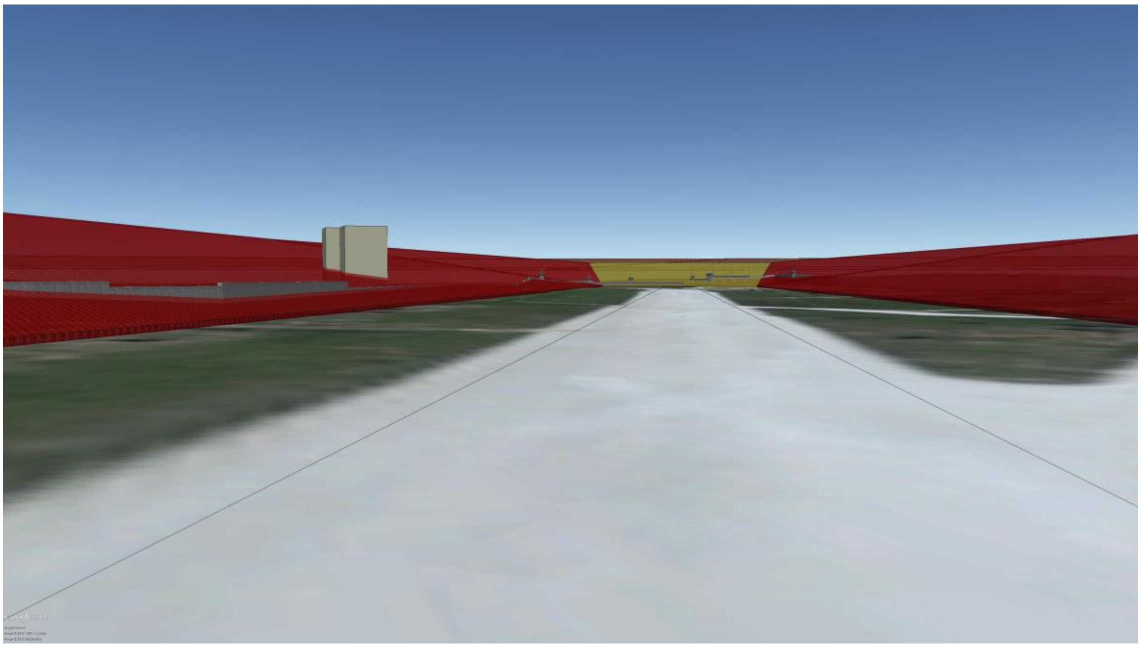


Figure 17. Qalandiya Airport: 3D Surface Simulation and Control System #6

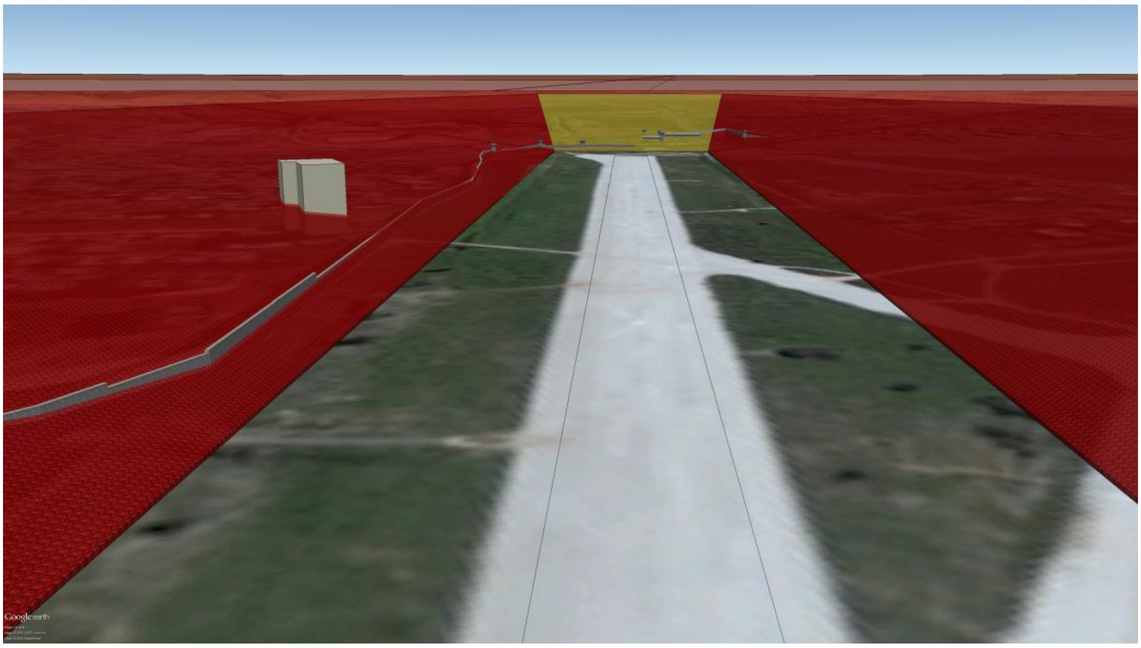


Figure 18. Qalandiya Airport: 3D Surface Simulation and Control System #7

Figure 19. Qalandiya Airport: 3D Surface Simulation and Control System #8

8. Maritime Transport Sector

In Gaza Strip there is a single fishing port located in Gaza City. This port was built between 1994 and 1998 and today is controlled by the Palestinian Naval Police force. Currently, an offshore rubble mound breakwater protects the harbor basin from the wave actions. The main breakwater is characterized by a length approximately of 1000m and it is made with very different materials, rocks, sediments, wrecks.
The lee breakwater has a length of approximately 300m. The basin diameter is around 400m and the water depth of the harbor basin is about 5m. The port entrance channel is around 160m wide.

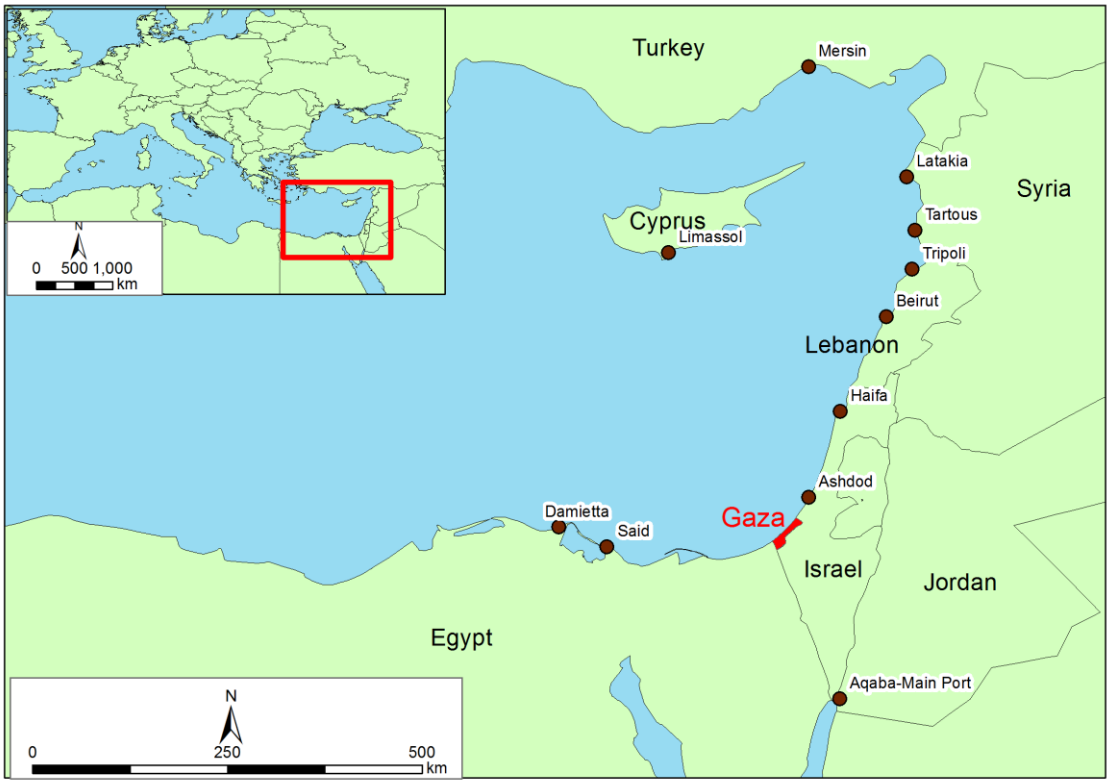
Figure 20. View of the Gaza fishing port (Map data: Google, DigitalGlobe)

Analysis of Existing Ports in the Region

Before proceeding to carry out a complete diagnosis of maritime transport sector in West Bank and Gaza Strip, an analysis on main existing ports in the Middle East is carried out, with the aim of presenting the context and the eventual competitors with proposed new maritime transport facilities in Gaza Strip.
The following figure and table introduce the principal ports located along the Eastern coast of Mediterranean Sea, between Turkey and Egypt.

The consecutive paragraphs provide detailed information on the considered Port Facilities.[28]

Figure 21. The Main Ports in Easter Mediterranean Sea



Tab 3. Principal nearest ports to Gaza.

Port	Country	Distance from Gaza port [nautical mile]
Mersin	Turkey	317
Latakia	Syria	260
Tartous	Syria	227
Tripoli	Lebanon	214
Beirut	Lebanon	172
Haifa	Israel	107
Ashdod	Israel	37
Aqaba	Jordan	530
Limassol	Cyprus	202
Said	Egypt	108
Damietta	Egypt	160

[28] Source Data: www.worldportsource.com.
Tripoli Port has been neglected since today is under expansion, with quay length up to 2,200 m and its draft up to 12 m of depth.

Mersin International Port – MIP, Turkey

MIP lies on the north end of Mersin Bay off the Mediterranean Sea. The General Directorate of Turkish State Railways (TCDD) is the port authority.

MIP is protected by two breakwaters of 2800 and 1525 meters; inside the breakwaters, the depth varies between 14 and 14.5 meters. Vessels less than 15 thousand GRT can enter and leave the port at any time, but vessels more than 15 thousand GRT and vessels carrying dangerous goods can only berth and unmoor in the daytime.

Figure 22. Mersin International Port

MIP is the only port in Turkey with the capacity to provide all port services in the same port area. Indeed, it provides services to all types of cargoes, including containers, general cargoes, project cargoes, Ro-Ro, dry bulk and liquid bulk, passenger services and direct dry bulk handling services from ship to container.

Tab 4. Mersin International Port: Main Characteristics

Total Port Area	**110 Hectares**
Total Berth	21
Depth	14m - 10m
Container Handling Capacity	1,800,000Teu / Year
General Cargo Handling Capacity	1,000,000Tons / Year
Dry Bulk Cargo Handling Capacity	8,000,000Tons / Year
Liquid Bulk Cargo Handling Capacity	750,000Tons / Year
Ro-Ro Handling Capacity	150,000Units-Vehicles /Year
Berth Cranes	
Gantry Crane	7
Mobile Crane (MHC)	7
Pilotage-Towage-Mooring Services	24/7hour

Tab 5. *Mersin International Port: Berth Characteristics.*[29]

Berths	Lengths [m]	Depth [m]
No. 1 Passenger quay	155	9.15
No. 2-3 local Trade	275	9.15
No. 4 general cargo	156	9.3
No. 5-6 general cargo	300	9.3
No. 7-8 containers	40	14
No. 9-10 containers	400	11.12
No. 11 Ro.Ro	40	11
No. 12-13 containers	310	12
No. 14 Dry bulk	275	10
No. 15 Dry bulk	275	15
No. 16 general cargo	69	9
No. 17-19 general cargo	490	4-6
No. 20-21 general cargo o	253	12
No. 22 Free zone	65	4
No. 23-24 Free zone	300	14
No. 25-26 Free zone Oil Terminals	270	9.2

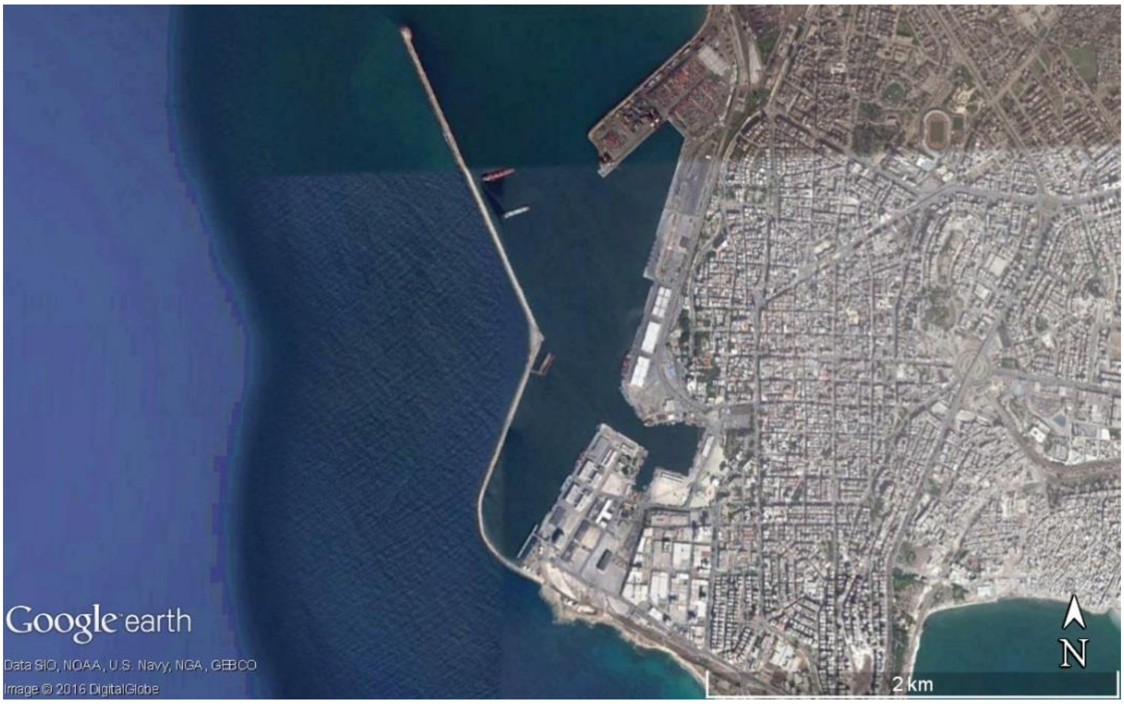
Figure 23. Mersin International Port: Berths Map

[29] source: www.soylushipping.com

An average volume of 22 million tons of cargo per year is handled at Mersin International Port. In particular, on the basis the maritime traffic data of 2015 and 2016, the port handled 3.8 million tons of non-containerized cargo and 713.5 thousand TEUs.[30]

<u>Latakia Port, Syria</u>
Latakia Port is the main seaport in Syria, which Authority is: Latakia Port General Company. The main channel for Latakia Port is 3,166 meters long and 14.5 meters deep; Port total area covers 150 hectares of land and 135 hectares of water surface.
Latakia Port contains 23 quays, with a total length of 4280 meters with alongside depths from 3.5 to 13.3 meters. They can accommodate vessels up to 240 meters in length, and the port facilities serve tankers, container ships, and vessels carrying general, bulk, and roll-on/roll-off cargoes.
The Port of Latakia has ample handling and storage capacity. Its grain silos can accommodate 35 thousand tons, and it has a refrigeration warehouse with capacity for 1500 tons of cargo. The Port of Latakia contains 14 open yards covering a total area of 50 hectares, and it offers 23 closed stores with total area of 12.8 hectares. Handling area for general cargoes covers about 185 thousand square meters, and the container terminal covers 430 thousand square meters with capacity for from 15 to 17 thousand containers.
In 2008, the port handled about 8 million tons of cargo. A general statistics of the handled cargo between 2002 and 2008 are shown in the following table

Figure 24. Latakia.Latakia Port



Tab 6. Latakia Port: general statistics of the cargo handled between 2002 and 2008 (millions of tons).

[30] Source: en.mersinport.com.tr

Year	2002	2003	2004	2005	2006	2007	2008
Imports *	3.6	3.9	5.0	6.2	6.9	6.3	6.8
Exports *	0.9	1.0	1.0	1.1	1.2	1.4	1.3

Tartous Port, Syria

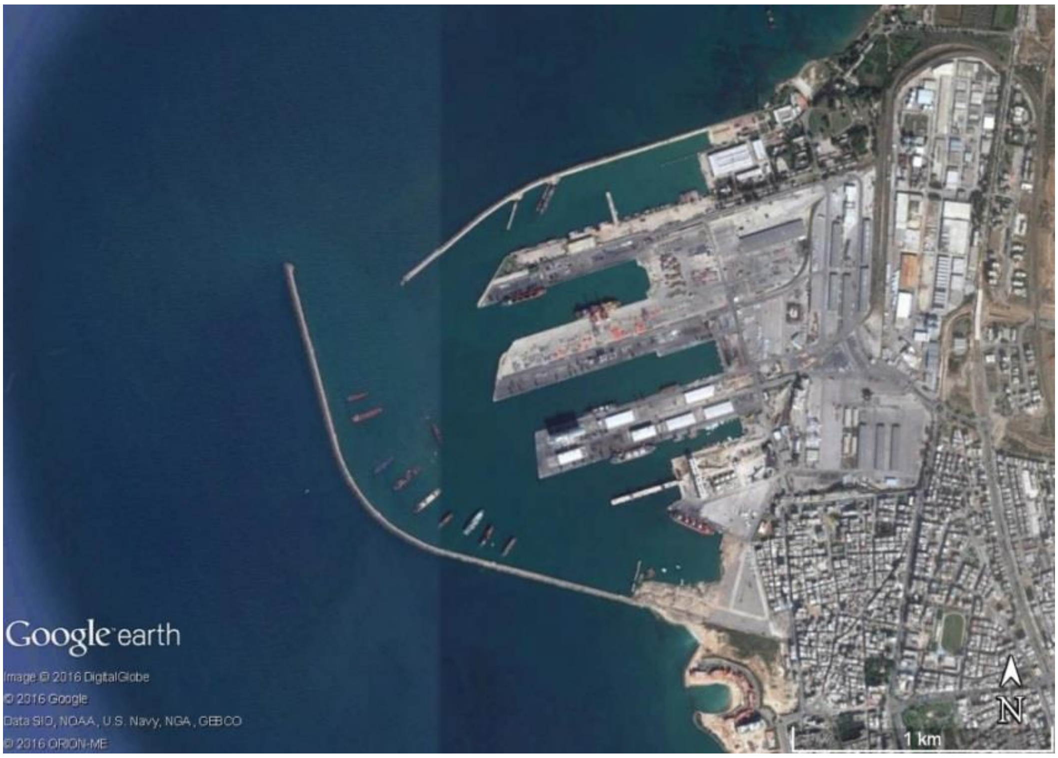
The Tartous Port Authority is responsible for managing the Port of Tartous. This public company is responsible for operating the port and its facilities.

The Port of Tartous covers 300 hectares, including 180 hectares of land and 120 hectares of water surface. Protected by a main breakwater of 2,650 m and a secondary breakwater of 1620 m, the entrance channel is 200 m wide and 14.5 m deep. Tartous Port contains three main piers for most cargoes as well as a pier for handling phosphates and a berth for sulphur. The total length of berths is 6400 m.

The major cargoes handled at the Port of Tartous included metals (3 million tons), corn (2 million tons), phosphate (1.8 million tons), and cereals (1.5 million tons). Other important cargo groups included cement (951 thousand tons), marble (826.9 thousand tons), sugar (634.5 thousand tons), foodstuffs (622.4 thousand tons), wood (489.3 thousand tons), cars (223.3 thousand tons), oils (201.3 thousand tons), fertilizers (143.3 thousand tons), and chemicals (120.7 thousand tons). Cargoes less than one hundred thousand tons included containers, sulphur, animals, iron, coal coke, equipment, and others.

The Port of Tartous handled 41.6 thousand TEUs of containerized cargo in 2008, including 21.5 thousand TEUs of imports and 20 thousand tons of exports.

Figure 25. Tartous Port



Beirut Port, Lebanon
The Port of Beirut is located centrally between three continents (Asia, Africa, and Europe).

Figure 26. Beirut port. The quay 16 is the container terminal. (Map data: Google, DigitalGlobe and TerraMetrics)

The Port of Beirut covers an area of 120hectares, and its four water basin cover one hundred hectares of water surface. The port contains over 5.6km of quays, including 1.6km of general cargo quays with depths from 8 to 10.5 meters, 1,334m for containers operation with depth between 10.5m and 13m and 220m bulk quay with 13m depth. The container quay, No. 16 is 1100m long which 600m with 15.5m depth e 500m with 16.5m depth. The container terminal has a 600,000m^2 stacking area with 800 reefer points and total capacity for 1.200.000 TEUs per year.
The Terminal's equipment includes: [31]12 ship-to-shore post panamax gantry cranes, with a 60-meter outreach; 2 mobile harbour cranes; 39 rubber tired gantry (RTG) cranes with a 40-ton capacity each; 14 reach stackers; 4 top loaders; 8 empty handlers; 58 Terminal Trucks; 4 terminal tractors; 5 six-wheel trucks; 4 goose necks; 69 trailers.
The port has been selected as a transhipment hub for the second and third largest container shipping companies in the world, Swiss-based Mediterranean Shipping Company (MSC) and French-based Compagnie Maritime d'Affrètement - Compagnie Générale Maritime (CMA-CGM).

The following table shows the annual cargo handled between 2002 and 2008.

[31] Source: www.bctc-lb.com

Tab 7. General cargo and containers handled at Beirut Port, between 2002 and 2008 (millions of tons)[32]

Year	total
2012	7.3
2013	8.3
2014	8.3
2015	8.2
2016*	5.2

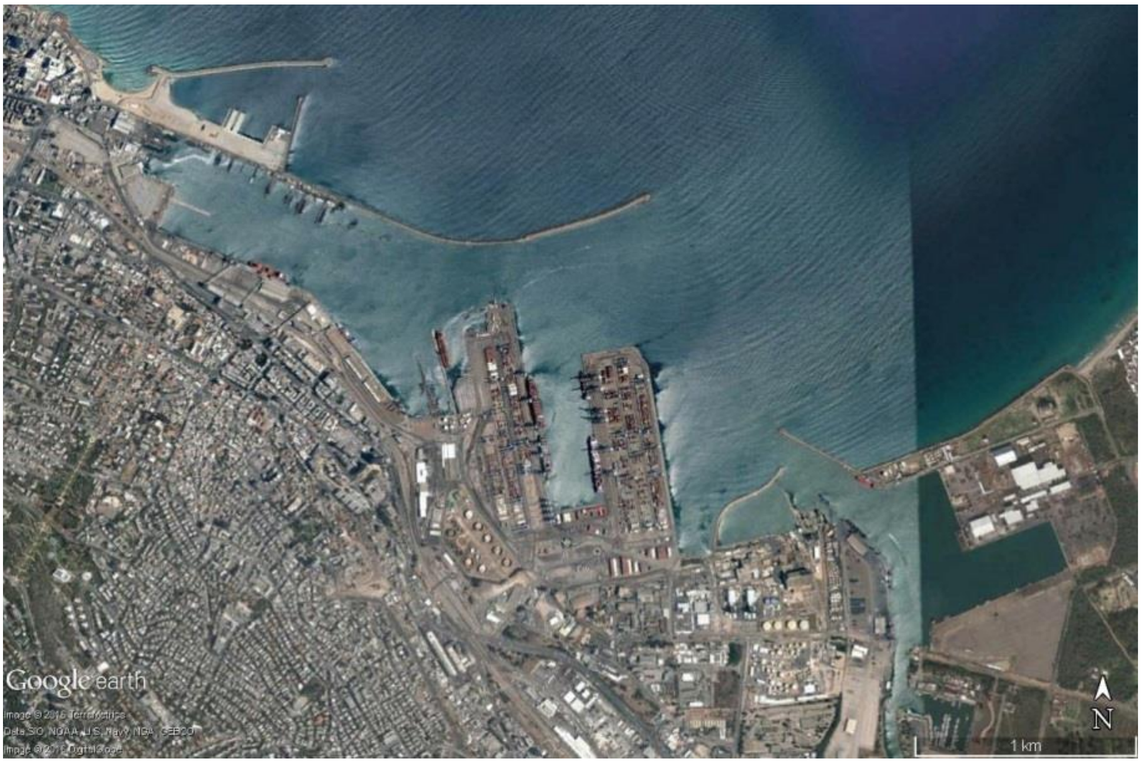
Tab 8. Local and Transshipment Traffic at Beirut Port, between 2012 and 2016[33]

Year	Local	Transhipments	total
2012	634,969	406,787	1,041,756
2013	758,338	358,996	1,117,334
2014	764,451	445,962	1,210,413
2015	798,589	331,695	1,130,284
2016	488,923	181.573	670,496

[32] The values of 2016 are relative of the period January to July. (source: www.portdebeyrouth.com).
[33] The values of 2016 are relative of the period January to July. (source: www.portdebeyrouth.com)

Haifa Port, Israel
The Port of Haifa lies on the shores of the Bay of Haifa on northern Israel's coast on the Mediterranean Sea.

Figure 27.Haifa port. (Map data: Google, DigitalGlobe and TerraMetrics)



Haifa port is located on a natural protected bay on Israeli northern coast. In northwest side the port basin is protected by a breakwater which is approximately 2,830 m long. The entrance channel between the breakwaters is 180 m wide and 13.8 m deep. Vessels with draft to 13 m can safely anchor in the port.
The port authority for the port is the Israeli Ports and Railway Authority. The port employs over 1,000 people, with the number rising to 5,000 when cruise ships dock in Haifa.
The port served 2602 commercial vessels in 2011 carrying 21.8 million tons of cargo. Local container (8.2 million tons) traffic accounted for 40% of all cargo moving through the port in 2011. Container transshipments (over 5.6 million tons) represented 27% of the total cargo volume in the port. Oil (2.8 million tons or 14%) and bulk grain (2.7 million tons or 13%). The port also handled more than 1.4 million tons of bulk cargo and one million tons of liquid chemicals, representing 6% and 5% of cargo volume, respectively.
In 2011, the Port of Haifa handled more than 1.2 million TEUs of containerized cargo.
In 2012, the Port of Haifa had a record year in container traffic, reaching almost 1.4 million TEUs, an 11% increase over 2011 and an 8% increase over the previous record set in 2010. Figure 26 shows container traffic in Haifa port.[34]

34 Source: www.haifaport.co.il

Ashdod Port, Israel

The Port of Ashdod is IsraelI economic gateway, accounting for 60% of the country's ocean-going trade. Located just 40 km southwest of Tel Aviv, the port is the closest port to Israel most important commercial centre and transportation networks.

Figure 28. Ashdod port. (Map data: Google, DigitalGlobe and TerraMetrics)

This port includes 1,150m extension to its main breakwater and 1.7 thousand m of new quays with alongside depths up to 15.5m. Three piers in the southern part of the Port of Ashdod support bulk and liquid cargoes with fully-computerized systems. Most of Israel's mineral exports to Europe and America pass through these piers.

The Port of Ashdod's surrounding area contains warehouses, a grain silo, cold storage, container cleaning and repair services, and an office complex.

The Port of Ashdod handled 16.2 million tons of cargo in 2007 and 808.7 thousand TEUs of containerized cargo.[35]

[35] Source: Israel strategic ports development plan 2055

Aqaba Port, Jordan

The Port of Aqaba is the only port in Jordan, owned and operated by the Aqaba Port Corporation. In particular, Aqaba Port Authority was established in 1952 by a royal decree and took its present name (Aqaba Ports Corporation, APC) in 1978. APC is a governmental body with an independent character responsible for establishing, developing, maintaining and operating port activities (receiving of ships, handling and storing cargo).

The port is situated in southern Jordan on the north shore of the Gulf of Aqaba on the Red Sea, and is the Jordan's only maritime outlet.

The port can be divided in the Main Port, the Middle Port and the Southern Port.

The main port is located close to the town of Aqaba. It comprises 12 berths with a total length 2120meters. These berths are used for handling general cargo, grain and phosphate export. These berths serve vessels of up to 70,000tons displacement with a draft of up to 14.4meters.

Figure 29. Port of Aqaba: Main port.

The Middle Port comprises 7 berths with a total length of 1000meters. These berths are used for handling containers, rice, livestock, cement, and passengers.

Figure 30. Port of Aqaba: Middle port. (Map data: Google, DigitalGlobe and TerraMetrics)

The Southern Port (Industrial) comprises 4 berths with a total length 640meters (see Figure 30). These berths are used for handling oil, timber, and serve the imports & exports of the industrial complex products such as fertilizers, sulphur, salt, potash and chemicals.

Figure 31. Port of Aqaba: Southern Port

Detailed statistics of cargo handled at Aqaba Port (2010 – 2013) follows.[36]

Tab 9. Maritime traffic for Aqaba port between 2010 and 2103

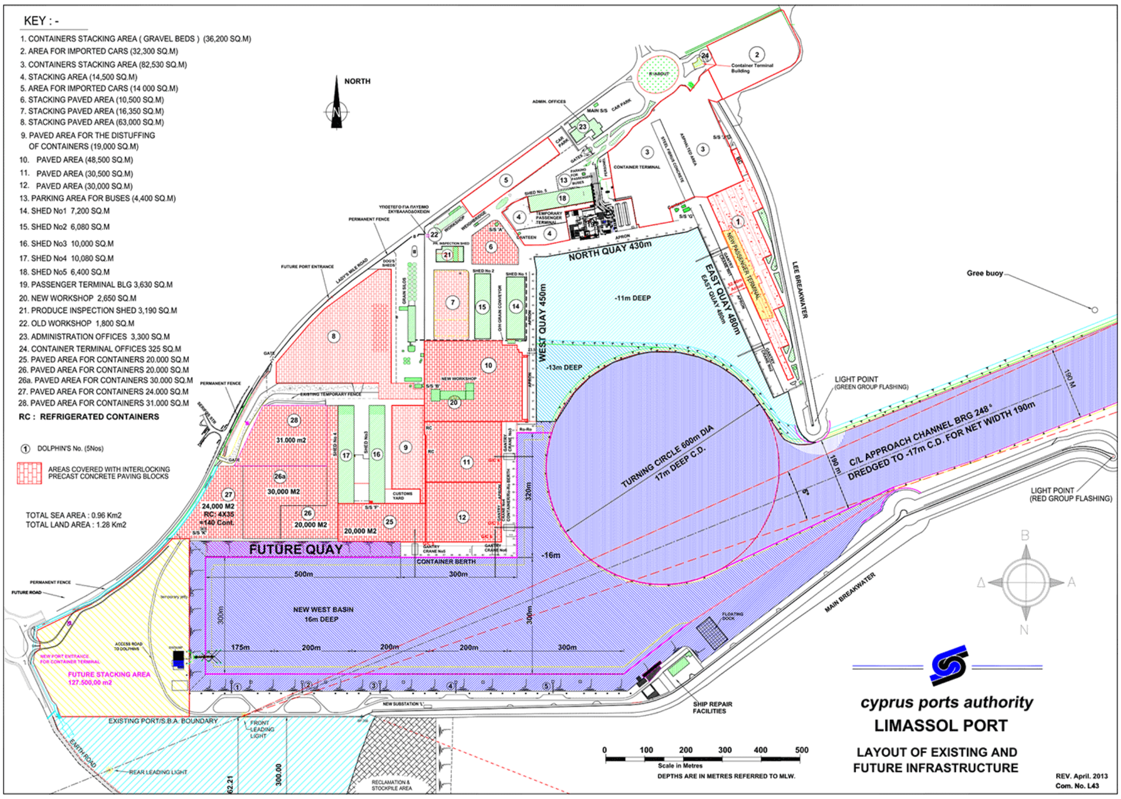
	2010 YEARLY PRODUCTIVITY 2010	2011 YEARLY PRODUCTIVITY 2011	2012 YEARLY PRODUCTIVITY 2012	2013 YEARLY PRODUCTIVITY 2013
TOTAL SHIPS	2902	2892	3083	2885
G.C.	97	72	116	130
CONTAINERS	533	497	451	444
RO-RO	318	315	357	421
PASSENGERS	1259	1318	1455	1222
CRUISE	151	113	107	112
DRY BULK	313	333	268	262
LIQUID BULK	190	187	253	217
MISCELIANEOUS	41	57	76	77
NO. OF PASSENGERS	914937	810754	925354	726920
ARRIVAL	427441	386232	435652	345638
DEPARTURE	487496	424522	489702	381282
ARRIVAL NUW.-AQABA	353003	314956	335769	231186
DEPART. NUW.-AQABA	413375	354628	389665	266961
ARRIVAL TOURISTS	74438	71276	99883	114452
DEPART. TOURISTS	74121	69894	100037	114321
TOTAL HANDLING	16851258	19183596	19354782	16315608
IMPORTS (TONS)	8795570	10208427	11943770	11784359
LOCAL IMPORTS	8196357	9579417	11270166	11119533
TRANSIT IMPORTS	599213	629010	673604	664826
IMPORTS (TONS)	8795570	10208427	11943770	11784359
LIQUID BULK	4909701	5895720	7144702	6208893
CEREALS	1573572	1914676	2135105	2419090
SUGAR	21150	40157	24578	53559
STEEL & IRON	94052	108180	317144	541216
WOOD & CORK	174891	132170	221664	181823
CONS. MATER.	26616	9032	9468	27039
MISCELIANEOUS	1995588	2108492	2091109	2352739
EXPORTS (TONS)	8055688	8975169	7411012	4531249
DRY BULK	7102996	8031888	6230922	3553783
GENERAL CARGO	952692	943281	1180090	977466
NO. OF TRUCKS	234440	248430	2722066	294546
WEIGHT IN TONS	5640226	6107573	6792939	6677516
DISCHARGED PHOSPHAT	4203064	5364289	4316063	1472390
BY TRUKS (TON)	2099640	3446489	2791783	511635
BY RAIL WAGONS (TON)	2103424	1917800	1524280	960755
NO. OF TRUCKS PHOSPH/	62802	95854	71656	12740

[36] Source :www.aqabaports.com.jo

<u>Limassol Port, Cyprus</u>
The Port of Limassol is located in the Eastern Mediterranean. The biggest part of Cyprus cargo importation and exportation is handled Limassol Port.
The port is capable of handling vessels up to 250m size for berthing in 14m of water. It is entered through an approach channel, which is 15 m deep and 190 m wide between the ends of two breakwaters.
At Limassol Port the quays have a total length of 2,070 meters. In particular, northern quay is 430m length with maximum depth of water 11m; western quay is 450+320m with depth variable from 11m to 16m and 50 m ramp with 16m maximum depth of water. Eastern 480 m with maximum depth of water 11m; southern quay is 300 m length with maximum depth of water 16m. There is also a quay on the southern site of the eastern quay of 40m length and with 11m maximum depth of water.

Figure 32. Limassol Port

Figure 33. Limassol Port: detailed description of the port structures [37]



In the land area of the port, the Authority has covered and open spaces for the storage of cargo: covered spaces comprising 5 warehouses of total area 39,760m²; open storage spaces, for conventional cargo of 157,000m²; stacking areas for containers 344,400m².
The following table shows the data of the cargo handled between 2009 and 2015 provided by the Cyprus Port Authority.

Tab 10. Maritime traffic for Limassol port (2009- 2015) [38]

	2009	2010	2011	2012	2013	2014	2015*
Containers (TEUs)	353,682	348,356	345,738	307,396	277,215	307,660	143,802*
CARGO (millions of tonnes)	3.6	3.8	3.7	3.3	3.0	3.2	1.4 *
Ship Traffic	3,741	3,405	3,328	3,163	3,430	2,933	1,352*

[37] Source: www.cpa.gov.cy
[38] Source: www.cpa.gov.cy- The values of 2015 are relative of the period January to June.

Port Said, Egypt

The Port Said Port Authority (PSPA) is responsible for managing and operating the port which includes Port Said West and Port Said East.

Port Said West occupies over three million square meters, including 1.3 million square meters of land and 1.7 million square meters of coastal waters.

Port Said West has capacity to handle 12.2 million tons of cargo per year, including 4.9 million tons of general cargo, 2.5 million tons of dry bulk and 4.7 million tons of containerized cargo in 800 thousand TEUs. It can also handle 300 thousand passengers a year. The port contains total warehouse area of 90 thousand square meters and total container yard area of 435 thousand square meters. Port Said East covers 35 square kilometres, including 1.5 square kilometres of water surface and 33.5 square kilometres of land area. The port is the location of the new Suez Canal Container Terminal and it has capacity to handle 2.2 million TEUs of containerized cargo totalling 6 million tons each year.

Figure 34. Port Said West

Figure 35. Port Said East

In 2007, Port Said West and Port Said East imported a combined total of 12.8 million tons of cargo, dominated by transhipments of 10.3 million tons (6.6 of those at Port Said East). Port Said handled imports of 1.2 million tons of dry bulk, 1.1 million tons of containers, and 123 thousand tons of general cargoes.
Exports passing through Port Said West in 2007 totalled 12.4 million tons of cargo, including 10 million tons of transhipments (6.5 million tons each through Port Said East). Port Said West also exported two million tons of containerized cargoes in 2007.

Port of Damietta, Egypt
The Damietta Port Authority governs the port on the Damietta branch of the Nile. The port covers an area of about 25 square km. The approach channel to the Port of Damietta is 11.3 km long, 300 meters wide, and has a depth of 15 meters. The port has capacity to handle 5.6 million tons of cargo per year.

Figure 36. Damietta Port

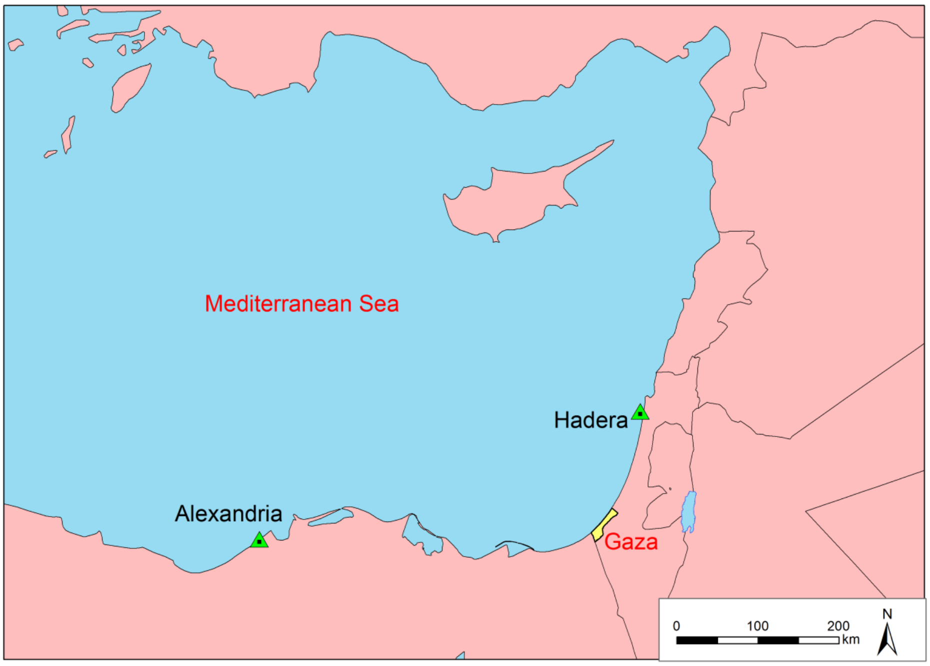
The port has 14 berths with a total of 3.3 km in length. The berths can divide as: container berths with a length of 1050m and a depth of 14.5m; cargo berths with a length of 800 and with a deep of 12m; dry bulk berths with a length of 67 m and with a deep of 12m; liquid bulk berths with a length of 225m and with a deep of 12; grains berths with a length of 600m and with a deep of 14.5m; multi-purpose berths with a length of 600m and with a deep of 14.5m; gas and methanol berths with a length of 1100m and with a deep of 14.5m; cargo berths with a length of 511m and with a deep of 12m.
The port of Damietta handled 19 million tons of non-containerized cargo and 9 million tons of containerized cargo in 2015. The total number of the handling container for 2015 is approximately of 707 thousand TEUs.

Meteocean Analysis

<u>Tide analysis</u>

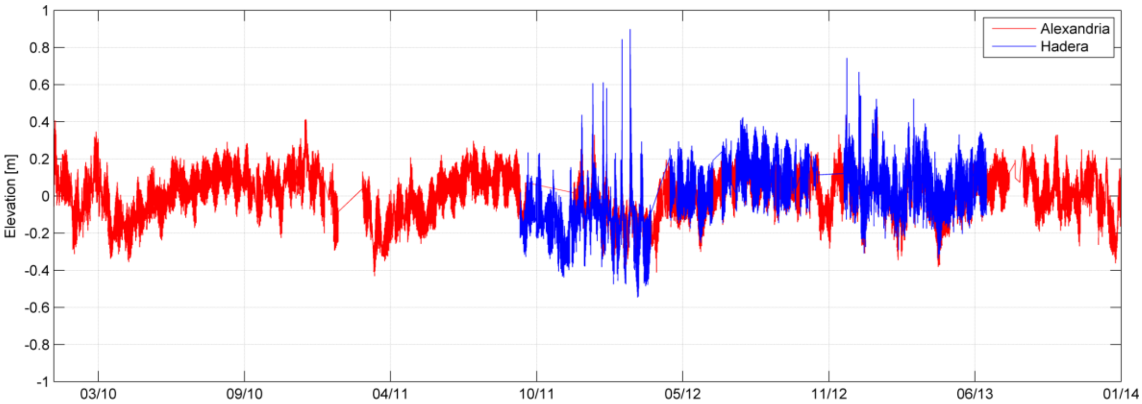
The sea level variations were analyzed using the data gathered at two stations located close to the study area: Alexandria (Egypt) and Hadera (Israel).

Figure 37. Location of the Alexandria and Hadera tide stations.



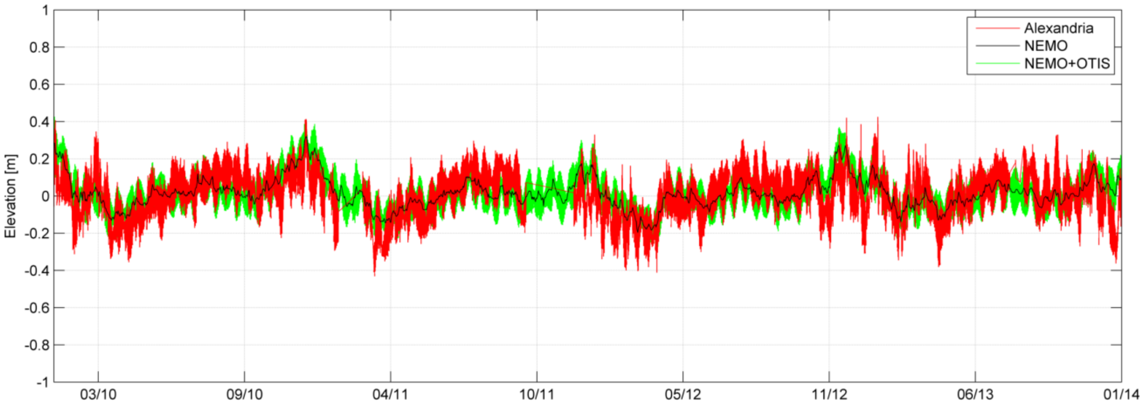
The two available datasets are characterized by a limited period of observations: namely from 2010/01/01 to 2016/01/31 for Alexandria and from 2011/10/01 to 2013/06/30 for Hadera.
The variations of the sea level are almost similar for the two stations. However, in some case the Hadera data show much higher values than those of the Alexandria station. Such data could represent outlier values. However, the time series are too short to confirm such a hypothesis.
The analysis of Alexandria data shows that maximum excursion of the sea level is in the range -0.40 to 0.40m.

Figure 38. Comparison of the sea level elevation as observed by the stations of Alexandria and of Hadera.



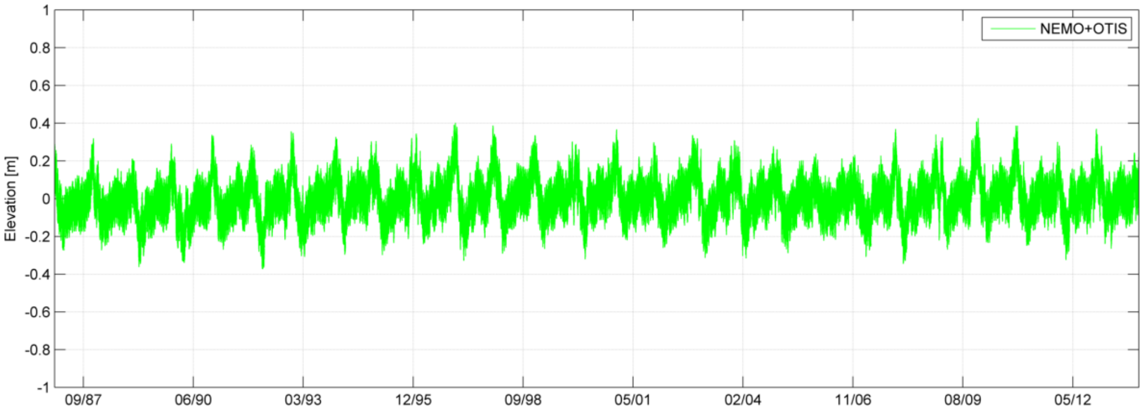
In order to extend the analysis to a longer period than the one of the Alexandria data, the output data from the NEMO model were summed up to the OTIS data. The NEMO data are estimated daily, while the OTIS data provide tidal constituents with a time resolution of 1 hour.
The tide is the sum of two components: the astronomical tide and the rise of water generated by meteorological events. The daily mean of the astronomical tide is next to zero, then the mean sea level coincides approximately with the mean of the meteorological tide. Moreover, generally the meteorological events have duration greater than a day and then the mean value is not significantly different from values that have really occurred.
The following figure shows the comparison of the sea level elevation observed at the stations of Alexandria, the NEMO data, and sea elevation estimated adding the NEMO data and OTIS data.

Figure 39. Comparison of the sea level elevation as observed at the station of Alexandria, the NEMO data, and sea elevation estimated adding the NEMO data to the OTIS data.



The behavior of the Alexandria data and the sea elevation estimated adding the NEMO data to the OTIS data are almost similar.
The following shows the time series of the NEMO + OTIS sea elevation extended from 1987-01-01 to 2013-12-31. Also in this dataset the sea elevation varies in the range between -0.40 and 0.40m.

Figure 40. Sea level elevation estimated adding the NEMO data to the OTIS data for the period 1987-01-01 to 2013-12-31.

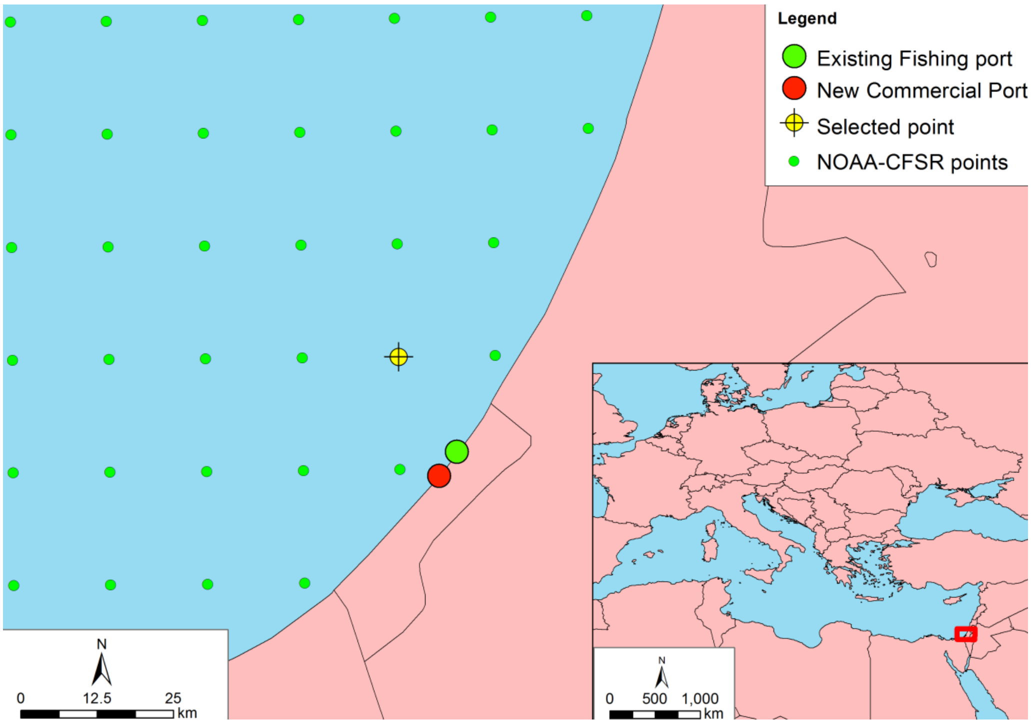


Therefore, from the effected analysis it can be stated that tide in the Gaza Strip have a limited range of oscillation between -0.40 and 0.40m.

Wind

Knowledge of the wind regime is important for the characterization of the wave climate in a given area. The analyses of the wind characteristics were effected on the basis of the CFSR data. This data set covers the period 1979/01/01 up to 2009/12/31 (thirty-one years) with a three hour time resolution (eight data per day). The data were extracted at a point close to study area; the WGS84 coordinates of such a point are: latitude 31.6667° and longitude 34.3333°.

Figure 41. Location of NOAA-CFSR point.



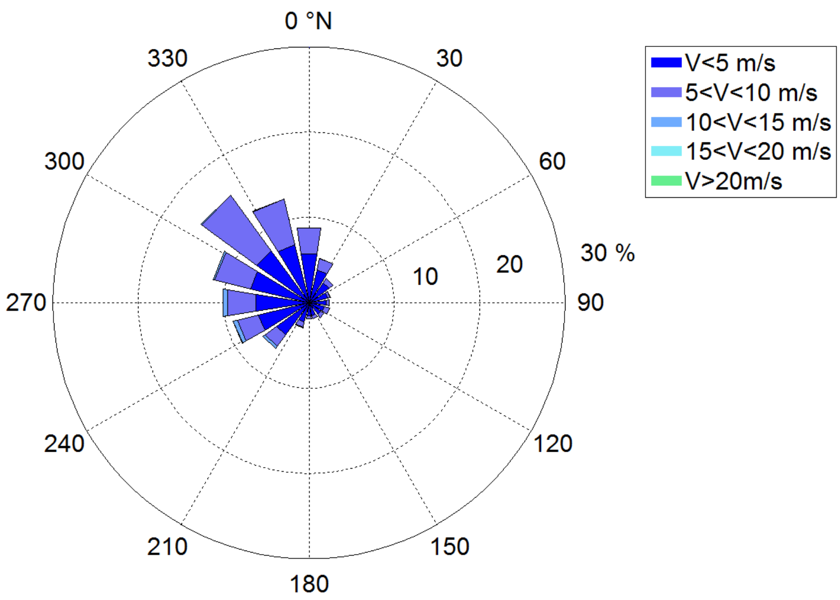
Tab 11. Frequency of occurrence of wind data in terms of wind velocity and direction.

		V [m/s]				
		<5	5÷10	10÷15	15÷20	>20
Dir [°N]	0	5.77	3.06	0.03	-	-
	22.5	3.96	1.40	0.01	-	-
	45	2.88	0.61	-	-	-
	67.5	2.22	0.36	-	-	-
	90	2.00	0.43	-	-	-
	112.5	1.87	0.63	0.01	-	-
	135	1.68	0.50	0.01	-	-
	157.5	1.53	0.39	0.01	-	-
	180	1.55	0.38	0.01	-	-
	202.5	2.33	0.63	0.05	-	-
	225	4.69	1.65	0.31	-	-

	247.5	6.08	2.54	0.50	0.02	-
	270	6.33	3.32	0.51	0.02	-
	292.5	7.05	4.30	0.21	0.01	-
	315	7.53	8.02	0.08	-	-
	337.5	7.02	5.50	0.01	-	-

The NOAA data set covers the period 1979/01/01 up to 2009/12/31 (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Figure 42. Characterisation of wind data in terms of wind velocity and direction (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



The seasonal frequencies of occurrence are shown in the following tables and figures.

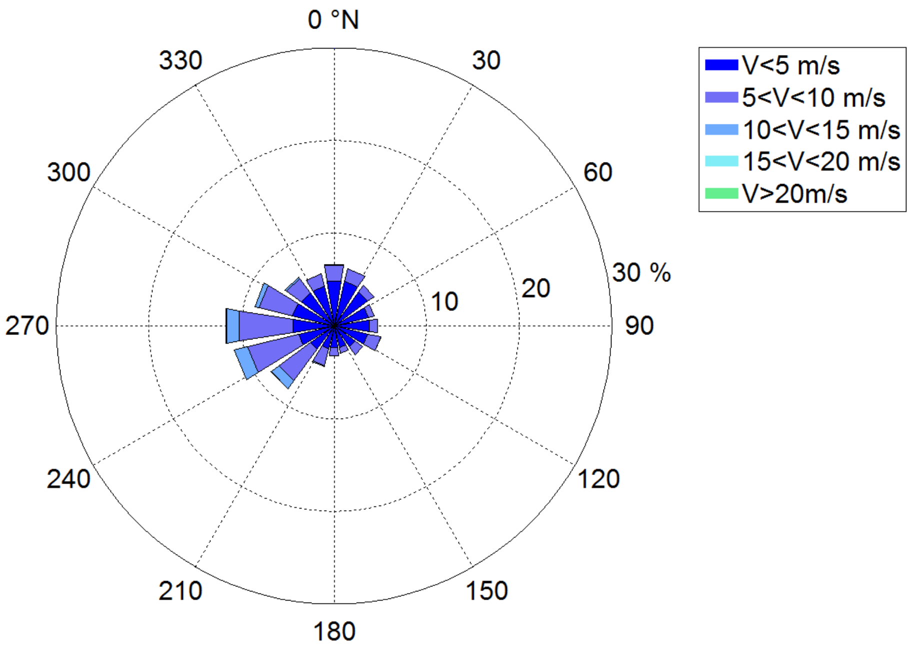
Tab 12. Frequency of occurrence of wind data in terms of wind velocity and direction

		V [m/s]				
		<5	5÷10	10÷15	15÷20	>20
Dir [°N]	0	4.87	1.78	0.03	-	-
	22.5	4.95	1.39	-	-	-
	45	4.51	0.87	-	-	-
	67.5	3.84	0.62	-	-	-
	90	3.84	0.93	-	-	-
	112.5	3.73	1.43	0.03	-	-
	135	2.80	1.03	-	-	-
	157.5	2.43	0.61	-	-	-
	180	2.37	0.88	-	-	-
	202.5	2.56	1.80	0.16	-	-

		<5	5÷10	10÷15	15÷20	>20
	225	3.10	4.21	1.09	-	-
	247.5	3.95	5.62	1.49	0.05	-
	270	4.45	5.92	1.36	0.08	-
	292.5	4.61	3.75	0.46	-	-
	315	4.37	1.95	0.20	-	-
	337.5	4.44	1.34	0.02	-	-

The data refer to the months: December, January, and February (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Figure 43. Wind rose estimated using NOAA wind data for the months: December, January, and February (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



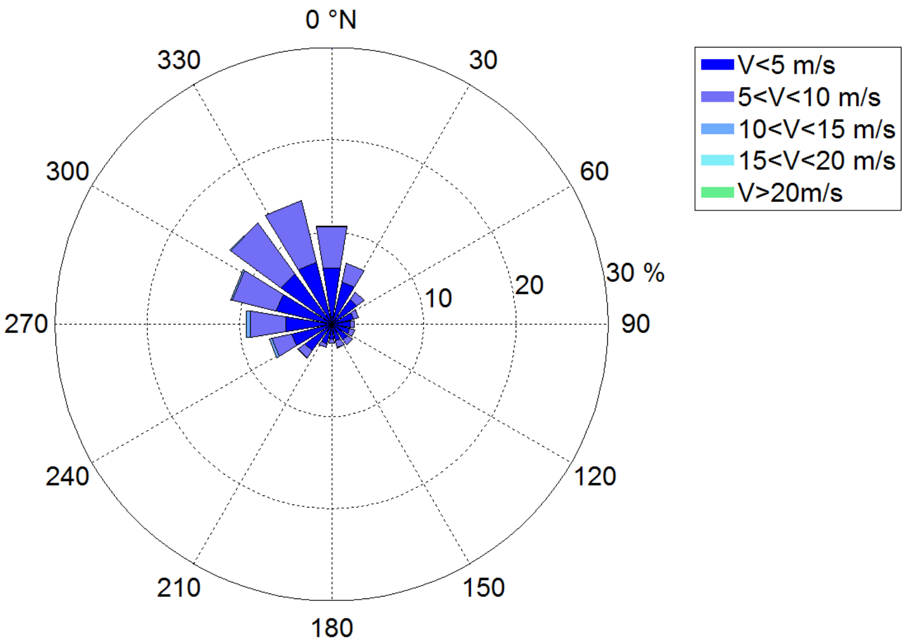
Tab 13. Frequency of occurrence of wind data in terms of wind velocity and direction

		V [m/s]				
		<5	5÷10	10÷15	15÷20	>20
Dir [°N]	0	6.18	4.54	0.05	-	-
	22.5	4.72	2.07	0.04	-	-
	45	3.36	0.99	-	-	-
	67.5	2.48	0.52	-	-	-
	90	2.07	0.42	0.01	-	-
	112.5	2.02	0.59	0.02	-	-
	135	2.11	0.67	0.03	-	-
	157.5	1.85	0.76	0.02	-	-
	180	1.64	0.46	0.02	-	-
	202.5	2.22	0.35	0.02	-	-

	225	3.59	0.92	0.07	-	-
	247.5	4.46	2.17	0.35	0.02	-
	270	5.06	3.87	0.46	-	-
	292.5	6.17	4.90	0.21	-	-
	315	6.76	6.82	0.07	-	-
	337.5	6.92	6.89	0.02	-	-

The data refer to the months: March, April, and May (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Figure 44. Wind rose estimated using NOAA wind data for the months: March, April, and May (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



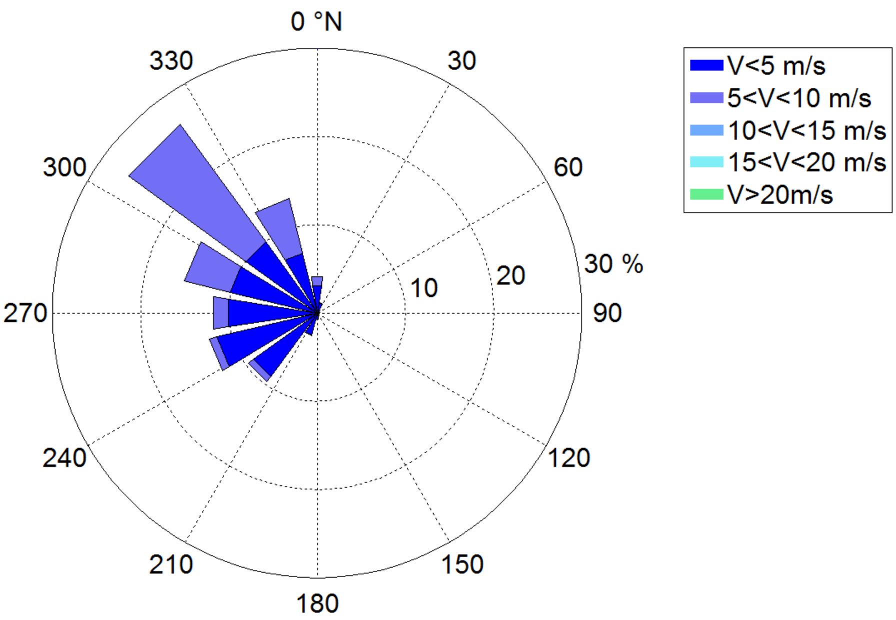
Tab 14. Frequency of occurrence of wind data in terms of wind velocity and direction

		V [m/s]				
		<5	5÷10	10÷15	15÷20	>20
Dir [°N]	0	3.15	0.97	-	-	-
	22.5	1.11	0.09	-	-	-
	45	0.38	0.02	-	-	-
	67.5	0.29	0.01	-	-	-
	90	0.25	0.01	-	-	-
	112.5	0.21	-	-	-	-
	135	0.32	-	-	-	-
	157.5	0.40	-	-	-	-
	180	0.74	-	-	-	-

	202.5	2.61	0.02	-	-	-
	225	8.96	0.70	-	-	-
	247.5	11.68	0.91	-	-	-
	270	10.20	1.68	-	-	-
	292.5	10.10	5.35	-	-	-
	315	9.95	16.48	-	-	-
	337.5	6.98	6.39	-	-	-

The data refer to the months: June, July, and August. (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Figure 45. Wind rose estimated using NOAA wind data for the months: June, July, and August. (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



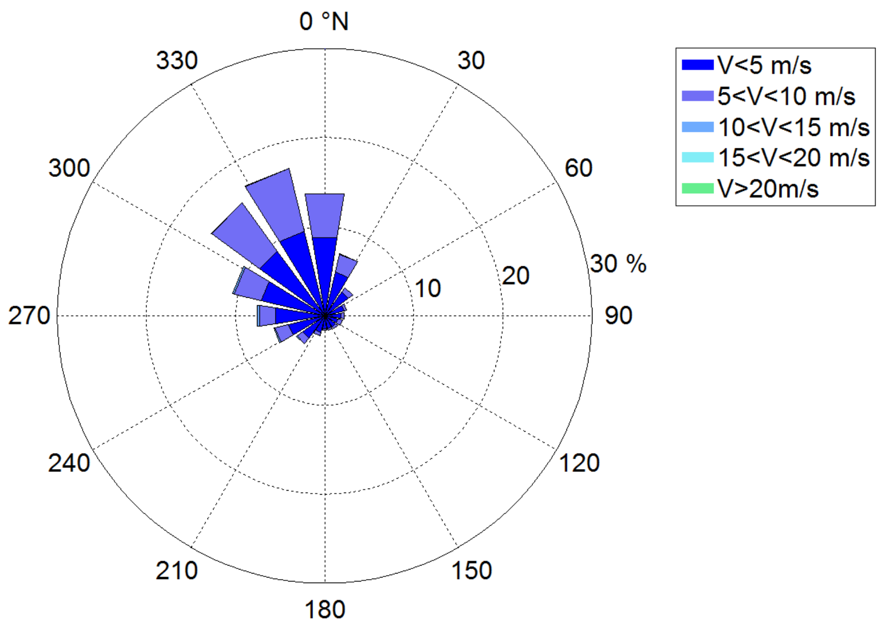
Tab 15. Frequency of occurrence of wind data in terms of wind velocity and direction.

		V [m/s]				
		<5	5÷10	10÷15	15÷20	>20
Dir [°N]	0	8.91	4.96	0.02	-	-
	22.5	5.07	2.05	-	-	-
	45	3.31	0.58	-	-	-
	67.5	2.29	0.28	-	-	-
	90	1.87	0.39	-	-	-
	112.5	1.55	0.51	-	-	-
	135	1.52	0.29	-	-	-
	157.5	1.45	0.18	-	-	-
	180	1.46	0.19	-	-	-

	202.5	1.91	0.35	0.02	-	-
	225	3.04	0.79	0.08	-	-
	247.5	4.18	1.53	0.16	-	-
	270	5.56	1.85	0.23	-	-
	292.5	7.29	3.17	0.18	-	-
	315	8.99	6.69	0.04	-	-
	337.5	9.70	7.33	-	-	-

The data refer to the months: September, November, and October.
(source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Figure 46. The data refer to the months: September, November, and October.
(source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



<u>Extreme event analysis</u>
The extreme event analysis was performed on the annual maximum series. More in details, the original series of the annual maximum wind speed were clustered into 16 classes of direction having amplitude of 22.5°.
Moreover an omnidirectional analysis has been carried out by considering the full dataset.
Several probability distributions were adopted: Gumbel, Log-normal, Weibull, Pareto and Generalized Extreme Value Distribution (GEV).
The Kolmogorov–Smirnov test was used to verify all the empirical probability distributions.
The Kolmogorov–Smirnov statistic allowed a distance between the empirical distribution function of the sample (F_n) and the cumulative distribution function of the reference distribution (F_{obs}) to be quantified.
The cumulative frequency of the observed data, sorted in ascending order, was estimated using the following equation (Weibull frequency):

$$F_{obs} = \frac{i}{N+1} \qquad (1)$$

where i indicate the i-th value and N is the number of samples.
The Kolmogorov-Smirnov test is divided into the following phases:

assume that the theoretical distribution fits the sample;
calculate the quantity:

$$D_n = \max \left|F_{obs}(x_I) - F_n(x_I)\right| \qquad \forall \quad i = 1,\dots, N \quad (2)$$

fix a level of significance α;

compare the D_n value with the critical value of D_n^*.

The hypothesis is accepted only if the value of D_n is smaller than D_n^*. The values of D_n and D_n^* estimated for the above mentioned probability distributions are shown in the following tables. The values of the extreme wind velocity for different return period and for different probability distributions are shown in the following tables; the comparison between the probability distributions and the observed data are shown in the following figures.

Theoretical value of D_n^* for different values of the significance level α. The values of D_n^* are referred to a number of 31 samples.

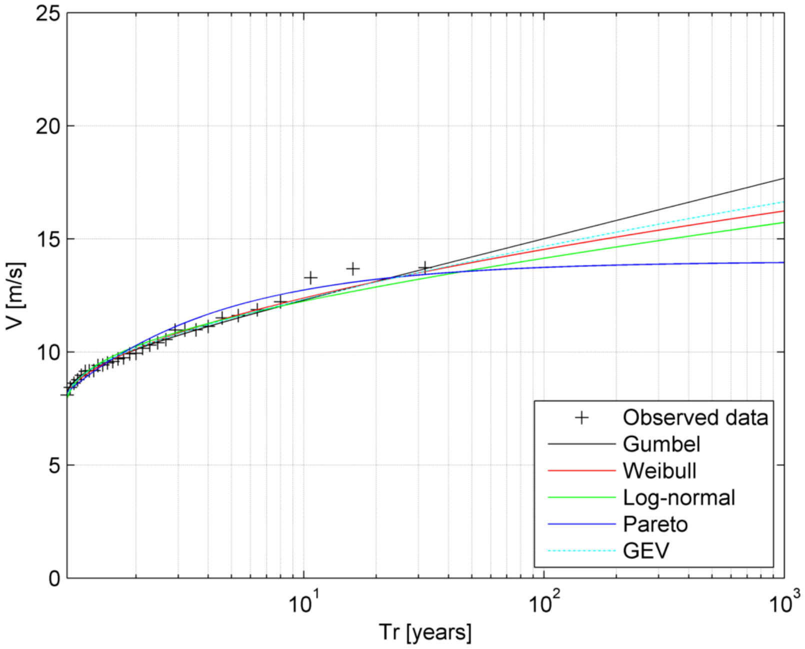
level of significance	α=0.20	α=0.15	α=0.10	α=0.05	α=0.01
D_n^*	0.187	0.199	0.214	0.238	0.285

Tab 16. Kolmogorov test: maximum difference between the theoretical distributions and the cumulative distribution of the observed data. In red the values greeter than D_n^*(α=0.05).

	D_n				
Dir [°N]	Gumbel	Weibul	Log-Normal	Pareto	GEV
0	0.063	0.053	0.088	0.092	0.062
22.5	0.110	0.127	0.139	0.130	0.132
45	0.099	0.125	0.121	0.128	0.075
67.5	0.072	0.102	0.104	0.134	0.071
90	0.112	0.088	0.079	0.090	0.095
112.5	0.064	0.053	0.056	0.075	0.051
135	0.130	0.103	0.155	0.127	0.115
157.5	0.070	0.063	0.072	0.111	0.066
180	0.119	0.088	0.097	0.158	0.088
202.5	0.093	0.091	0.105	0.098	0.090
225	0.121	0.158	0.119	0.265	0.118
247.5	0.149	0.072	0.101	0.209	0.066
270	0.079	0.051	0.071	0.063	0.068
292.5	0.082	0.087	0.101	0.170	0.075
315	0.092	0.060	0.067	0.140	0.065

337.5	0.092	0.092	0.138	0.103	0.101
omnidirectional	0.111	0.111	0.087	0.195	0.100

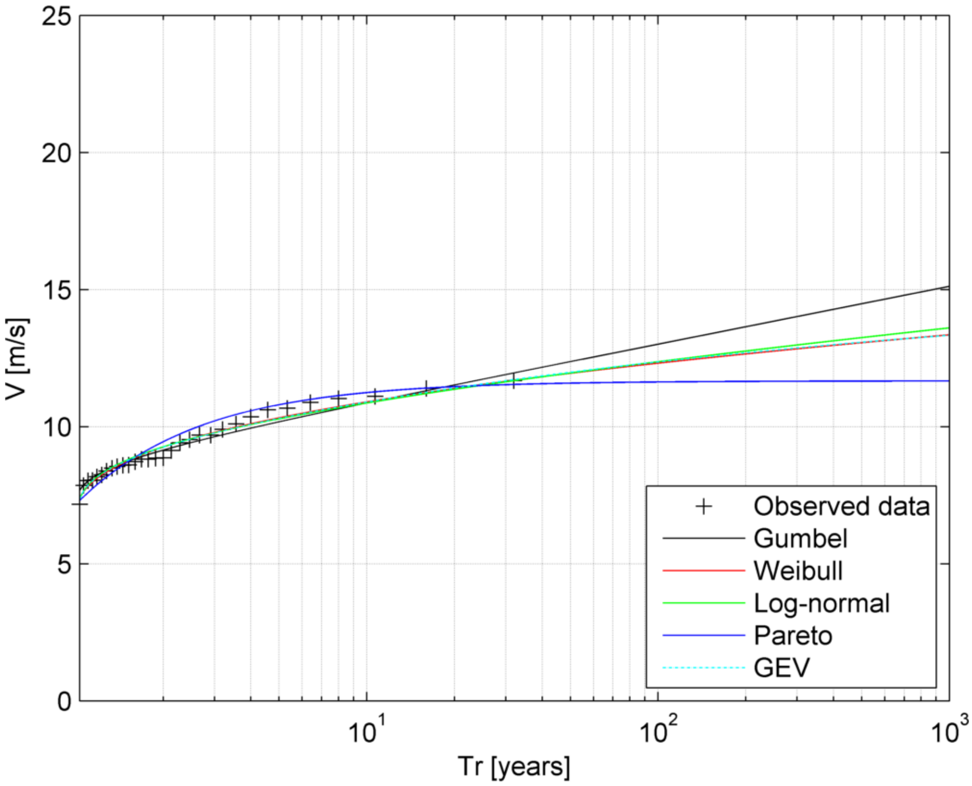
Figure 47.Analysis of extreme events of wind data. Direction -11.25 °N ÷11.25 °N.
(source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 17. Extreme events of wind data. Direction -11.25 °N ÷11.25 °N.
(source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	10.10	10.14	10.25	10.29	10.16
5	11.42	11.55	11.52	11.99	11.49
10	12.29	12.38	12.24	12.74	12.32
20	13.12	13.10	12.87	13.21	13.08
30	13.60	13.49	13.21	13.40	13.50
40	13.94	13.76	13.45	13.51	13.79
50	14.20	13.95	13.62	13.58	14.01
100	15.01	14.54	14.15	13.74	14.67

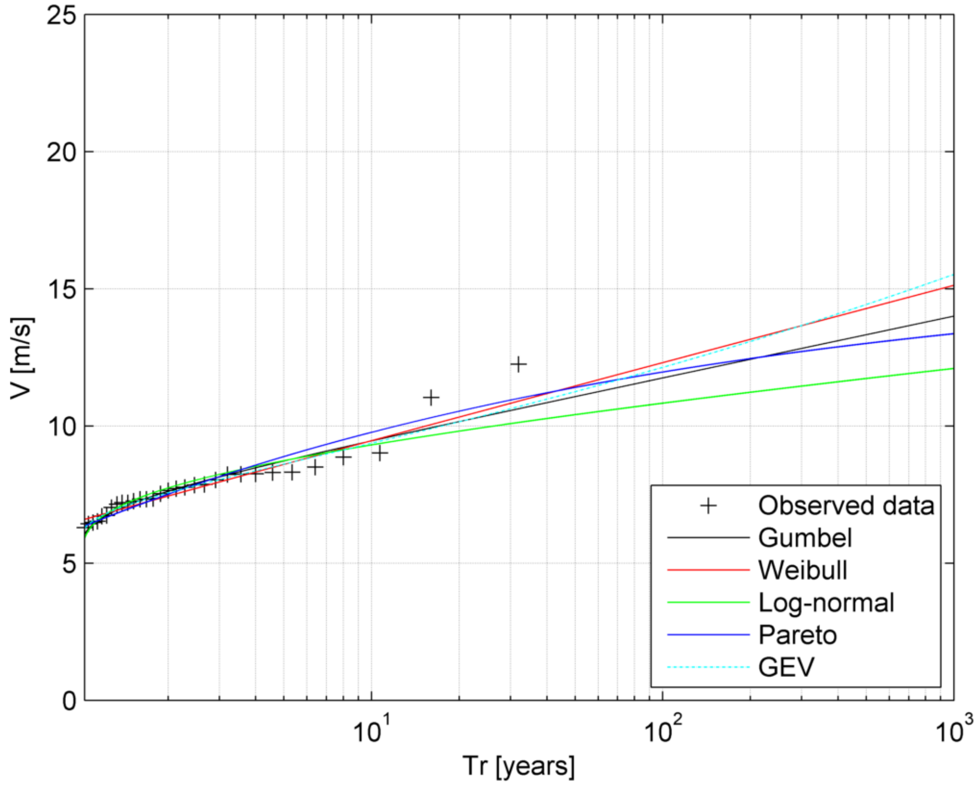
Figure 48. Analysis of extreme events of wind data. Direction 11.25 °N ÷ 33.75 °N
(source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 18. Extreme events of wind data. Direction 11.25 °N ÷ 33.75 °N
(source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	9.14	9.25	9.26	9.45	9.25
5	10.18	10.33	10.29	10.80	10.30
10	10.86	10.91	10.86	11.24	10.90
20	11.52	11.40	11.37	11.46	11.41
30	11.90	11.65	11.64	11.53	11.68
40	12.17	11.82	11.82	11.57	11.85
50	12.37	11.95	11.96	11.59	11.98
100	13.01	12.32	12.37	11.63	12.36

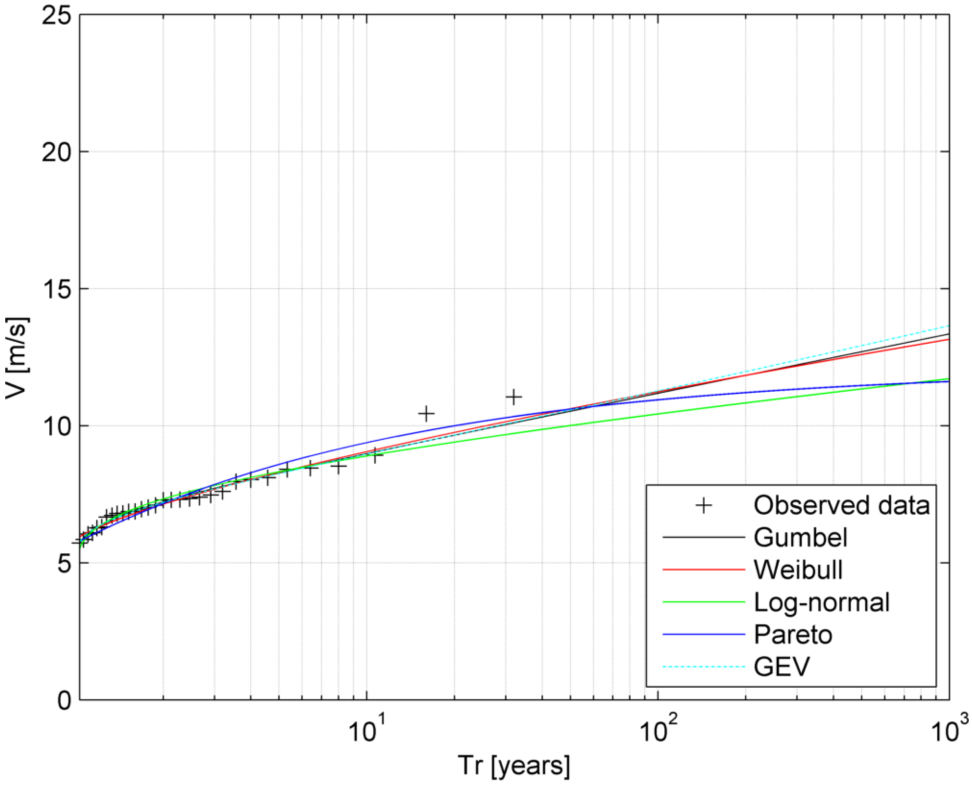
Figure 49. Analysis of extreme events of wind data. Direction 33.75°N ÷ 56.25 °N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 19. Extreme events of wind data. Direction 33.75°N ÷ 56.25 °N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	7.61	7.44	7.74	7.51	7.56
5	8.72	8.60	8.74	8.88	8.61
10	9.45	9.46	9.31	9.77	9.37
20	10.16	10.32	9.81	10.54	10.15
30	10.56	10.82	10.09	10.94	10.62
40	10.85	11.18	10.27	11.21	10.97
50	11.07	11.45	10.41	11.41	11.25
100	11.75	12.30	10.83	11.97	12.13

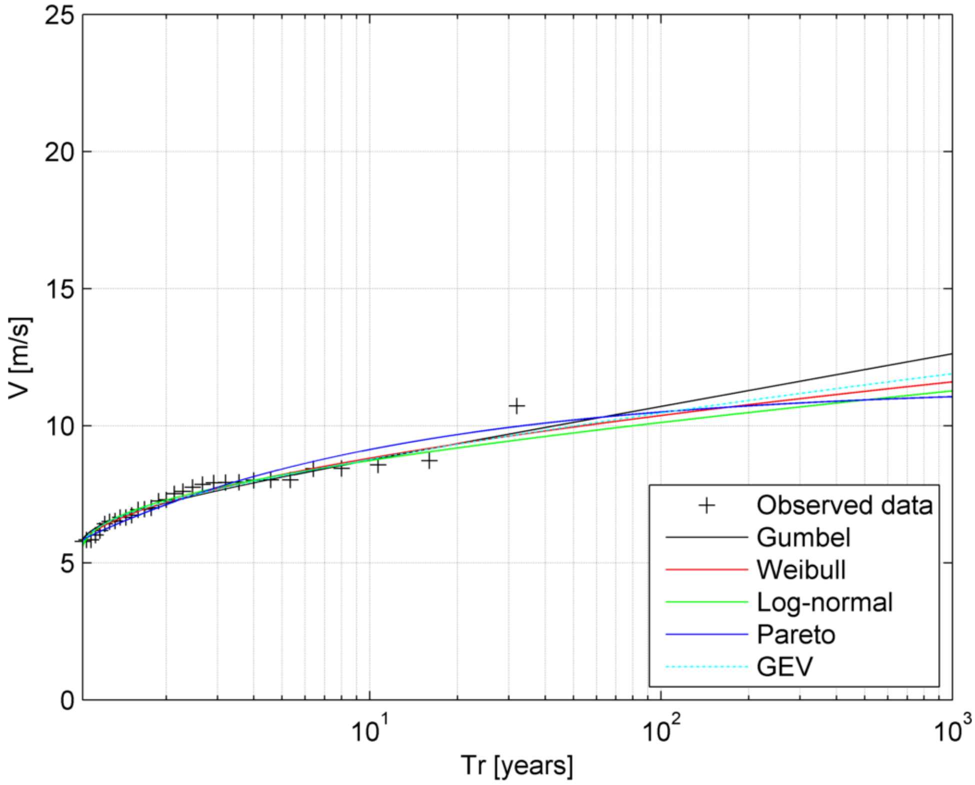
Figure 50.Analysis of extreme events of wind data. Direction 56.25 °N ÷ 78.75°N
(source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 20. Extreme events of wind data. Direction 56.25 °N ÷ 78.75°N
(source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	7.21	7.14	7.32	7.16	7.20
5	8.27	8.29	8.32	8.58	8.25
10	8.98	9.05	8.90	9.38	8.96
20	9.65	9.75	9.40	10.00	9.66
30	10.04	10.14	9.68	10.29	10.06
40	10.32	10.41	9.86	10.47	10.35
50	10.53	10.62	10.01	10.60	10.57
100	11.18	11.24	10.43	10.94	11.27

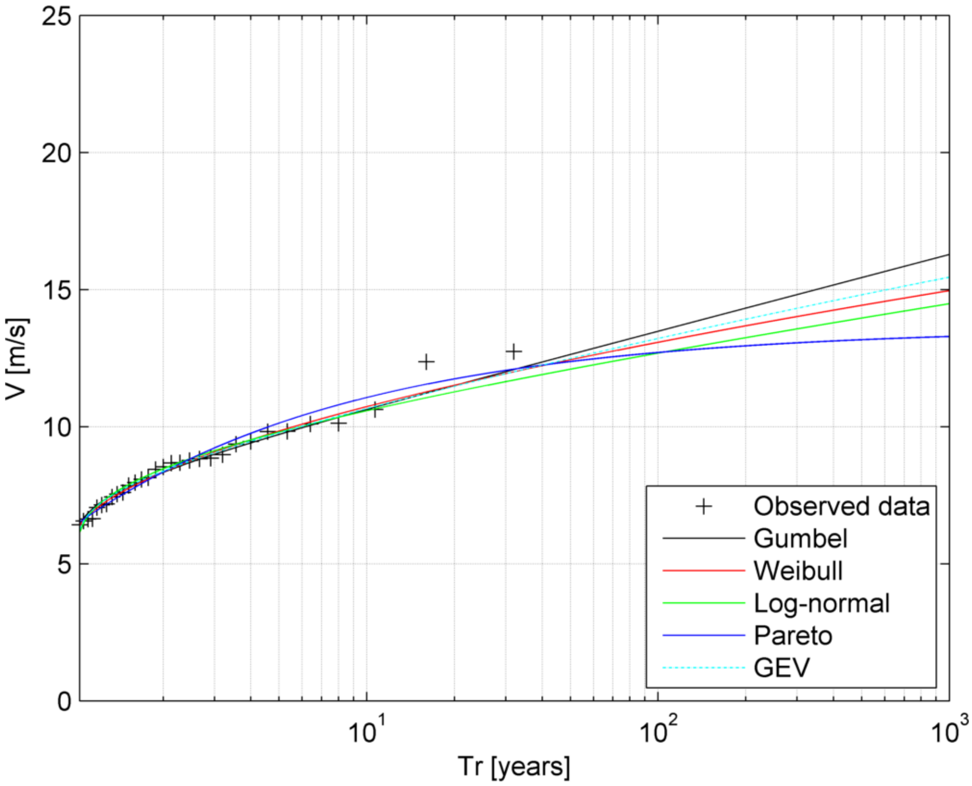
Figure 51. Analysis of extreme events of wind data. Direction 78.75 °N ÷ 101.25°N
(source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 21. Extreme events of wind data. Direction 78.75 °N ÷ 101.25°N
(source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	7.18	7.20	7.28	7.12	7.22
5	8.12	8.22	8.20	8.42	8.18
10	8.75	8.82	8.73	9.13	8.78
20	9.35	9.34	9.19	9.68	9.32
30	9.69	9.62	9.44	9.94	9.62
40	9.94	9.81	9.61	10.10	9.83
50	10.12	9.95	9.73	10.21	9.99
100	10.70	10.37	10.12	10.50	10.47

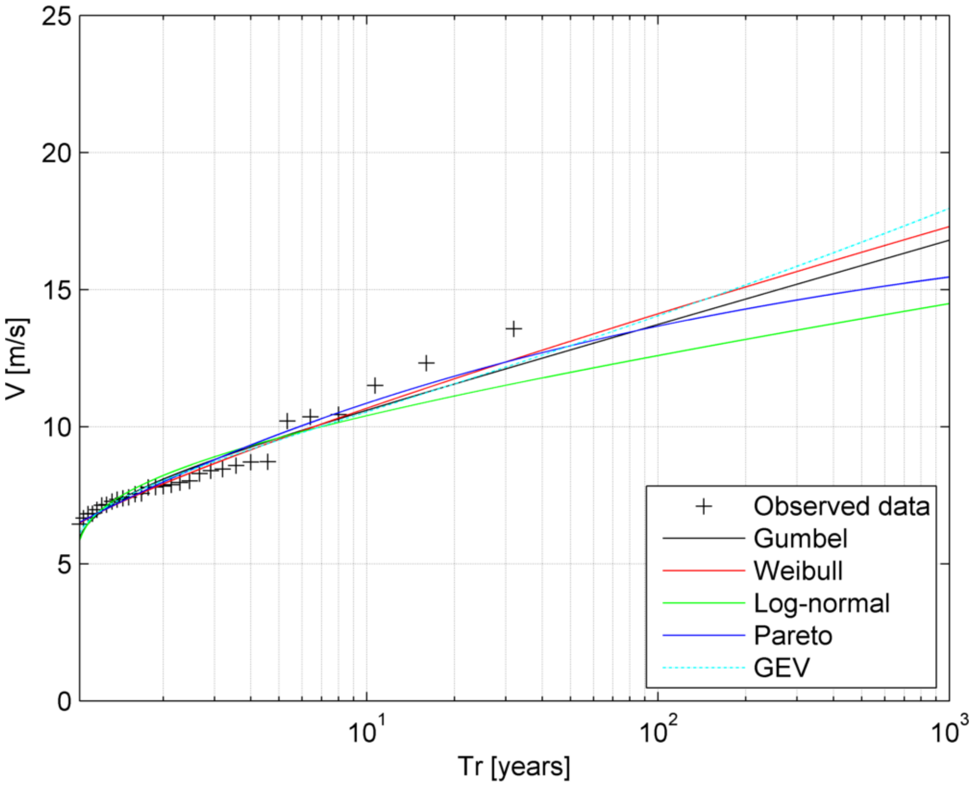
Figure 52.Analysis of extreme events of wind data. Direction 101.25 °N ÷ 123.75°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 22. Extreme events of wind data. Direction 101.25 °N ÷ 123.75°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	8.34	8.35	8.47	8.35	8.38
5	9.71	9.84	9.80	10.13	9.77
10	10.62	10.73	10.58	11.06	10.66
20	11.50	11.51	11.27	11.75	11.47
30	12.00	11.93	11.64	12.06	11.93
40	12.35	12.22	11.90	12.25	12.24
50	12.63	12.44	12.10	12.38	12.49
100	13.48	13.08	12.69	12.71	13.21

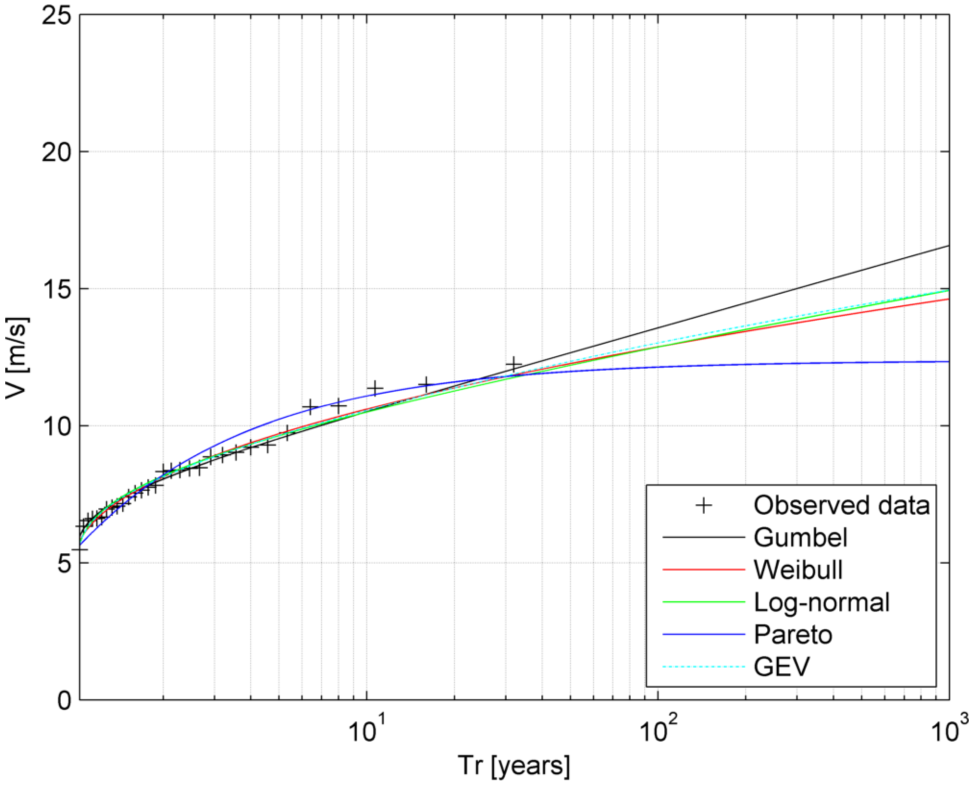
Figure 53. Analysis of extreme events of wind data. Direction 123.75 °N ÷ 146.25°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 23. Extreme events of wind data. Direction 123.75 °N ÷ 146.25°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	8.08	7.92	8.22	7.98	8.04
5	9.59	9.54	9.59	9.73	9.51
10	10.59	10.67	10.40	10.85	10.53
20	11.55	11.74	11.12	11.84	11.56
30	12.10	12.36	11.51	12.35	12.17
40	12.49	12.78	11.78	12.70	12.61
50	12.79	13.11	11.98	12.95	12.95
100	13.72	14.11	12.60	13.67	14.04

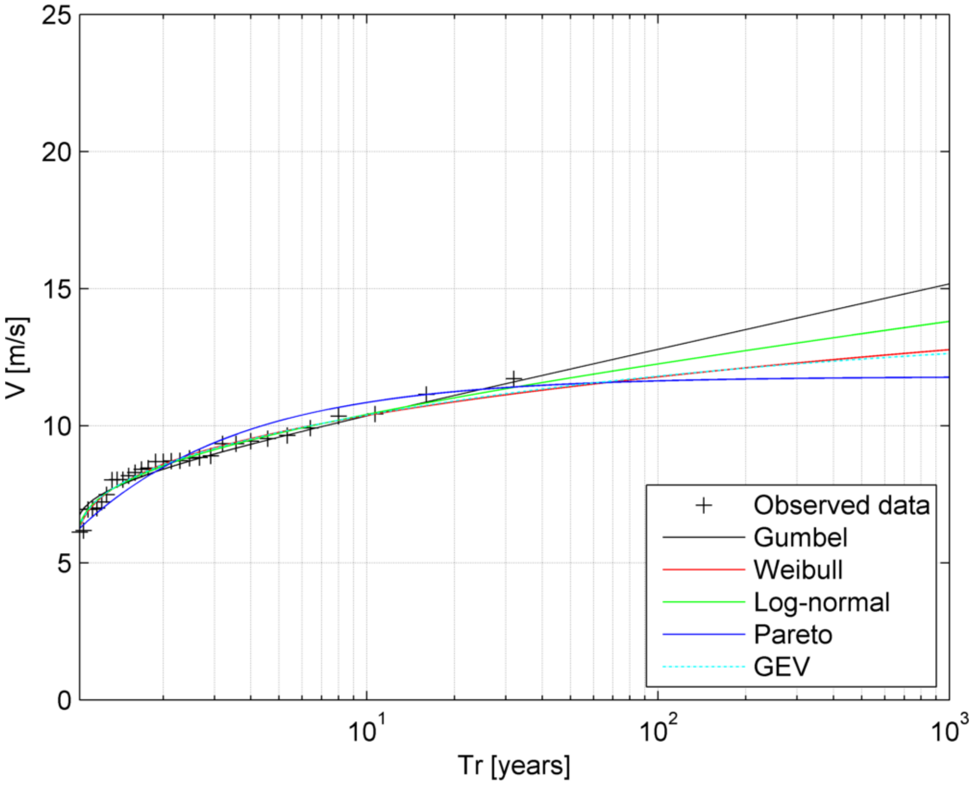
Figure 54.Analysis of extreme events of wind data. Direction 146.25 °N ÷ 168.75°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 24. Extreme events of wind data. Direction 146.25 °N ÷ 168.75°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	8.05	8.13	8.17	8.21	8.14
5	9.53	9.70	9.63	10.23	9.64
10	10.50	10.60	10.49	11.08	10.56
20	11.44	11.37	11.27	11.59	11.37
30	11.98	11.78	11.69	11.79	11.81
40	12.36	12.06	11.98	11.90	12.12
50	12.65	12.27	12.20	11.98	12.34
100	13.56	12.88	12.87	12.14	13.02

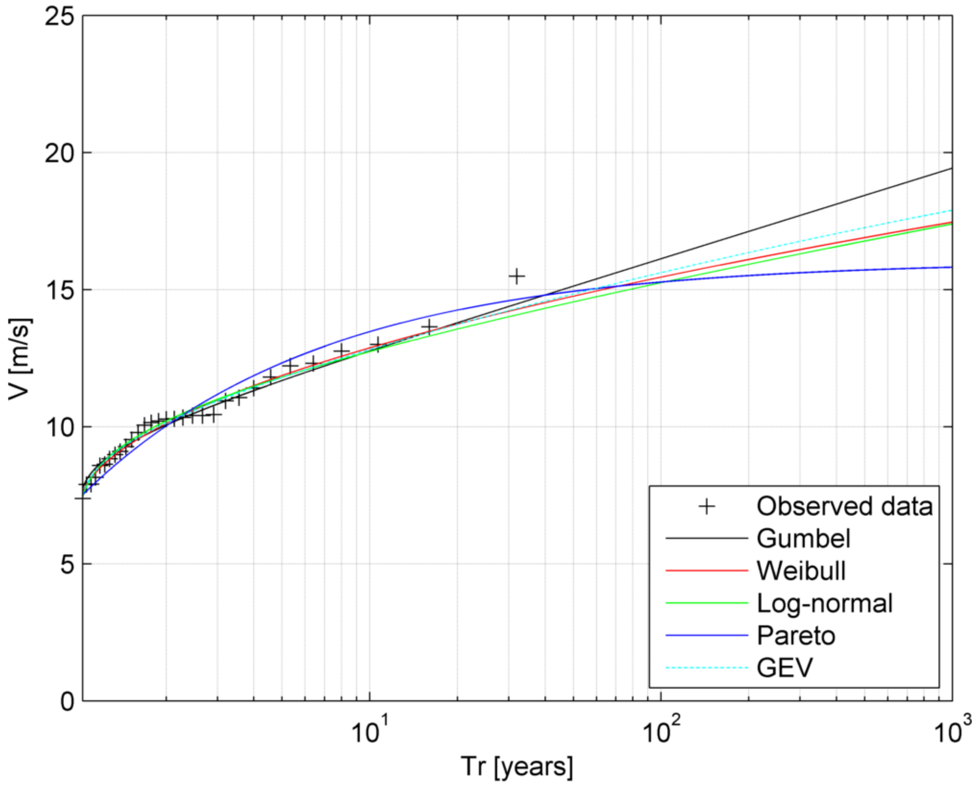
Figure 55. Analysis of extreme events of wind data. Direction 168.75 °N ÷ 191.25°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 25. Extreme events of wind data. Direction 168.75 °N ÷ 191.25°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	8.41	8.59	8.53	8.49	8.57
5	9.58	9.77	9.72	10.17	9.76
10	10.36	10.37	10.41	10.85	10.39
20	11.10	10.87	11.02	11.24	10.91
30	11.53	11.13	11.35	11.39	11.17
40	11.83	11.30	11.57	11.47	11.34
50	12.06	11.42	11.74	11.52	11.46
100	12.78	11.78	12.25	11.63	11.81

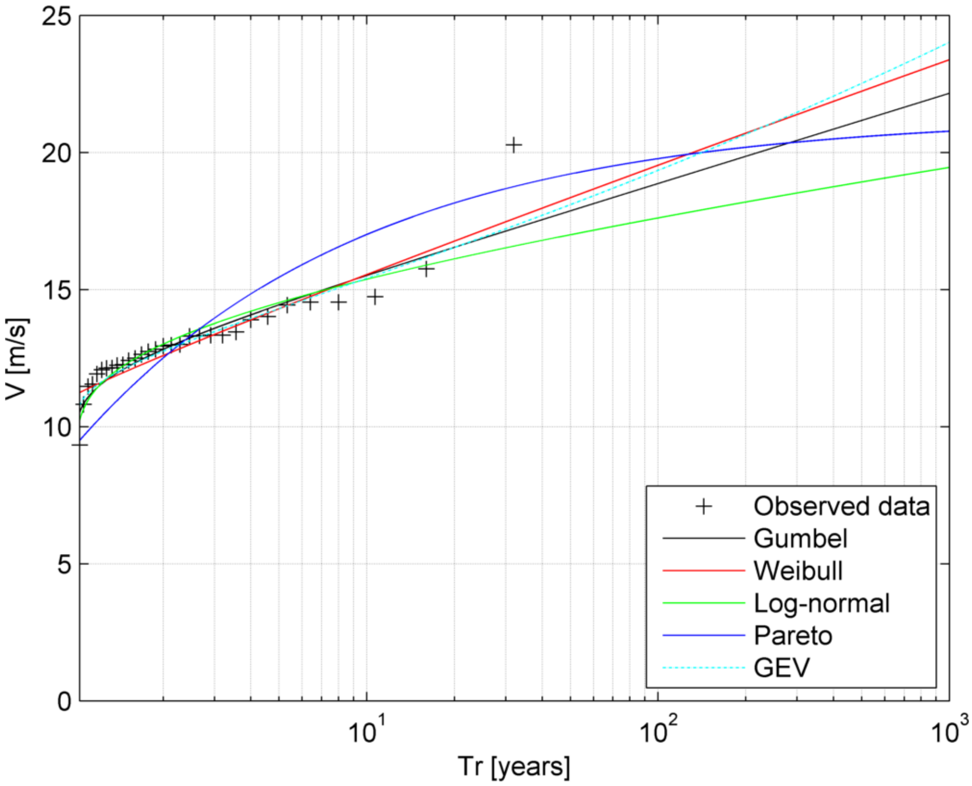
Figure 56.Analysis of extreme events of wind data. Direction 191.25 °N ÷ 213.75°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 26. Extreme events of wind data. Direction 191.25 °N ÷ 213.75°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	10.06	10.12	10.21	10.03	10.14
5	11.68	11.86	11.80	12.33	11.79
10	12.76	12.87	12.74	13.46	12.81
20	13.79	13.74	13.56	14.25	13.73
30	14.38	14.21	14.01	14.60	14.23
40	14.80	14.52	14.32	14.80	14.57
50	15.12	14.76	14.55	14.94	14.84
100	16.12	15.45	15.25	15.28	15.62

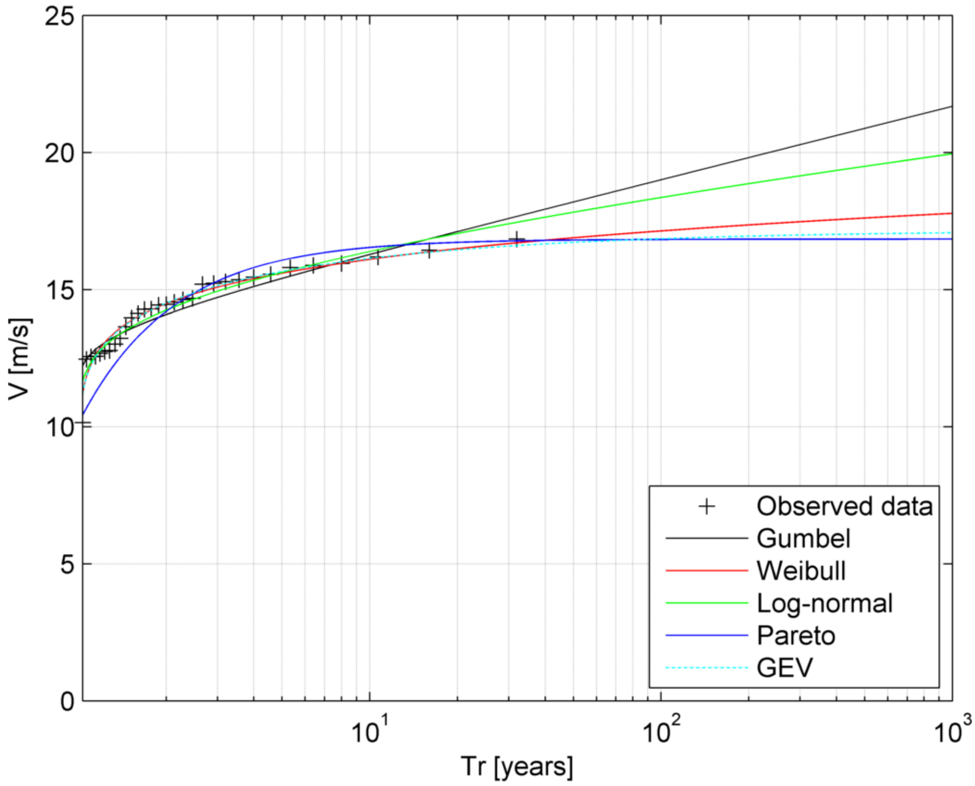
Figure 57.Analysis of extreme events of wind data. Direction 213.75 °N ÷ 236.25°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 27. Extreme events of wind data. Direction 213.75 °N ÷ 236.25°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	12.82	12.59	13.01	-	12.75
5	14.44	14.30	14.52	-	14.30
10	15.51	15.55	15.38	-	15.41
20	16.54	16.77	16.12	-	16.54
30	17.13	17.47	16.52	-	17.22
40	17.55	17.97	16.79	-	17.71
50	17.87	18.35	17.00	-	18.10
100	18.86	19.53	17.62	-	19.35

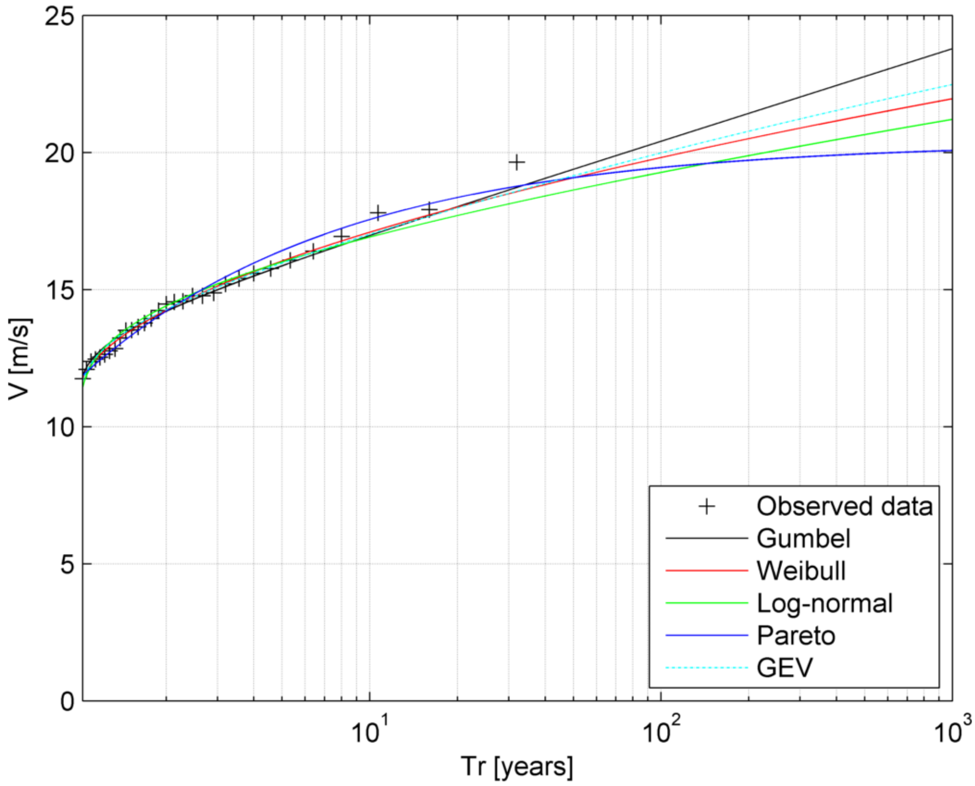
Figure 58. Analysis of extreme events of wind data. Direction 236.25 °N ÷ 258.75°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 28. Extreme events of wind data. Direction 236.25 °N ÷ 258.75°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	14.09	14.49	14.25	14.20	14.51
5	15.40	15.60	15.62	16.07	15.66
10	16.28	16.11	16.39	16.54	16.14
20	17.11	16.49	17.05	16.72	16.45
30	17.59	16.68	17.40	16.77	16.59
40	17.93	16.80	17.64	16.79	16.67
50	18.19	16.89	17.82	16.81	16.72
100	19.00	17.14	18.36	16.83	16.85

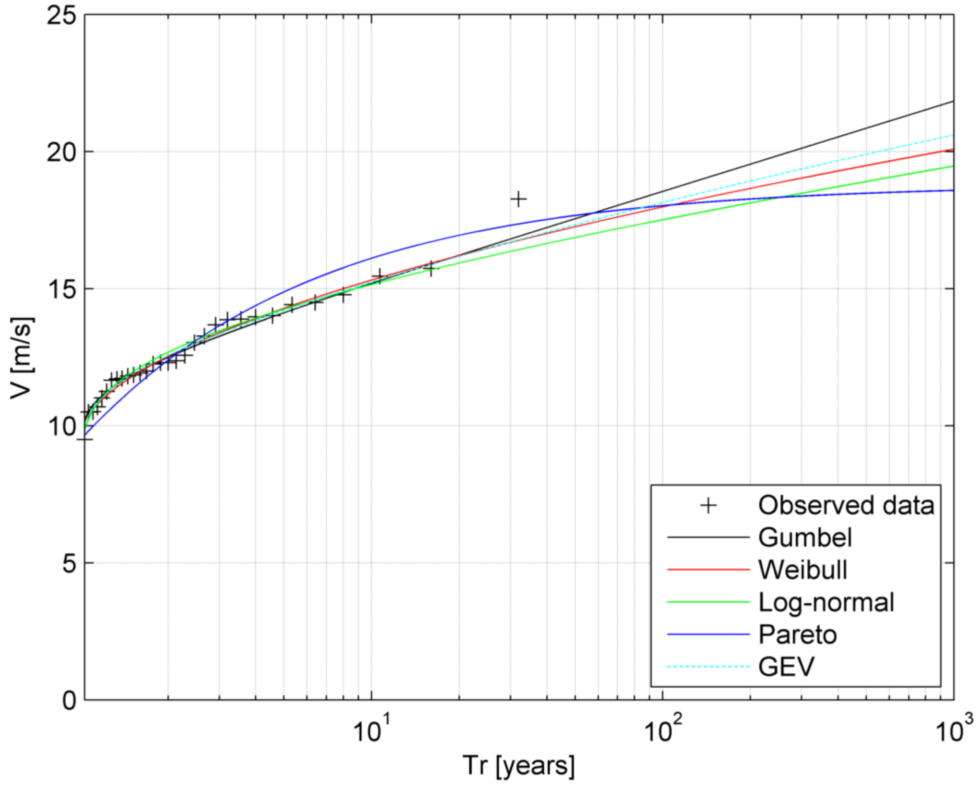
Figure 59. Analysis of extreme events of wind data. Direction 258.75 °N ÷ 281.25°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 29. Extreme events of wind data. Direction 258.75 °N ÷ 281.25°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	14.21	14.25	14.41	14.21	14.27
5	15.87	16.04	16.01	16.42	15.96
10	16.97	17.09	16.91	17.55	17.01
20	18.02	18.00	17.70	18.36	17.97
30	18.63	18.49	18.12	18.72	18.50
40	19.05	18.83	18.41	18.93	18.87
50	19.38	19.08	18.63	19.08	19.15
100	20.40	19.81	19.28	19.45	19.98

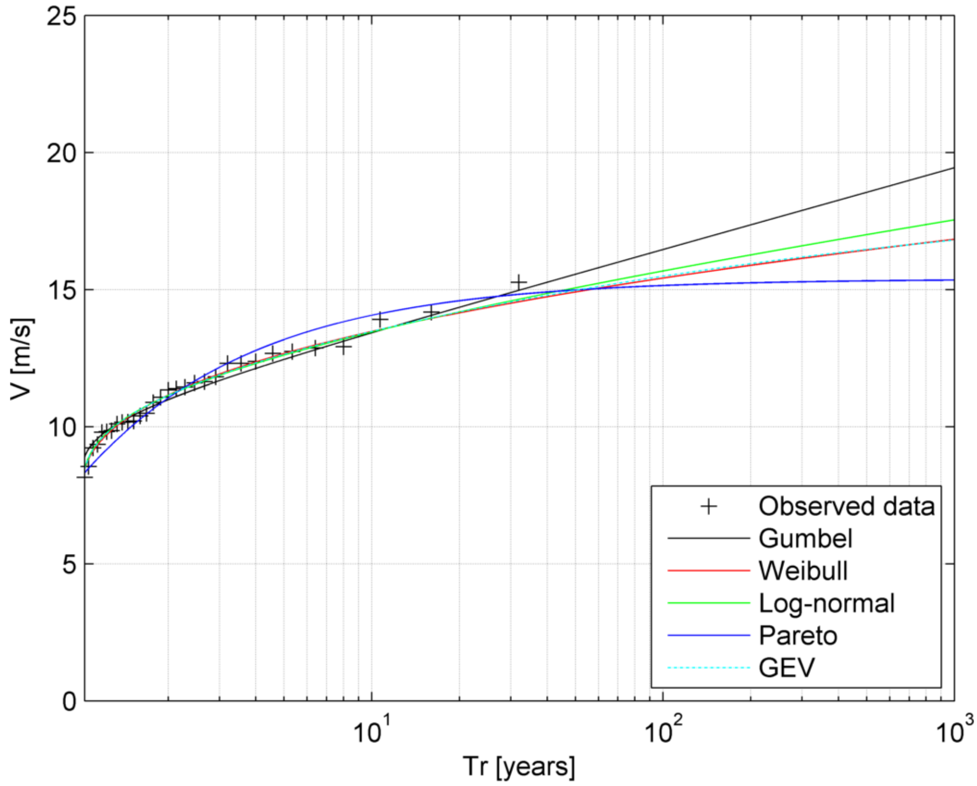
Figure 60. Analysis of extreme events of wind data. Direction 281.25 °N ÷ 303.75°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 30. Extreme events of wind data. Direction 281.25 °N ÷ 303.75°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	12.50	12.53	12.68	12.39	12.56
5	14.11	14.28	14.25	14.88	14.21
10	15.19	15.31	15.15	16.10	15.23
20	16.21	16.20	15.93	16.94	16.17
30	16.80	16.68	16.35	17.31	16.69
40	17.22	17.01	16.64	17.52	17.05
50	17.54	17.25	16.86	17.67	17.32
100	18.54	17.98	17.51	18.02	18.14

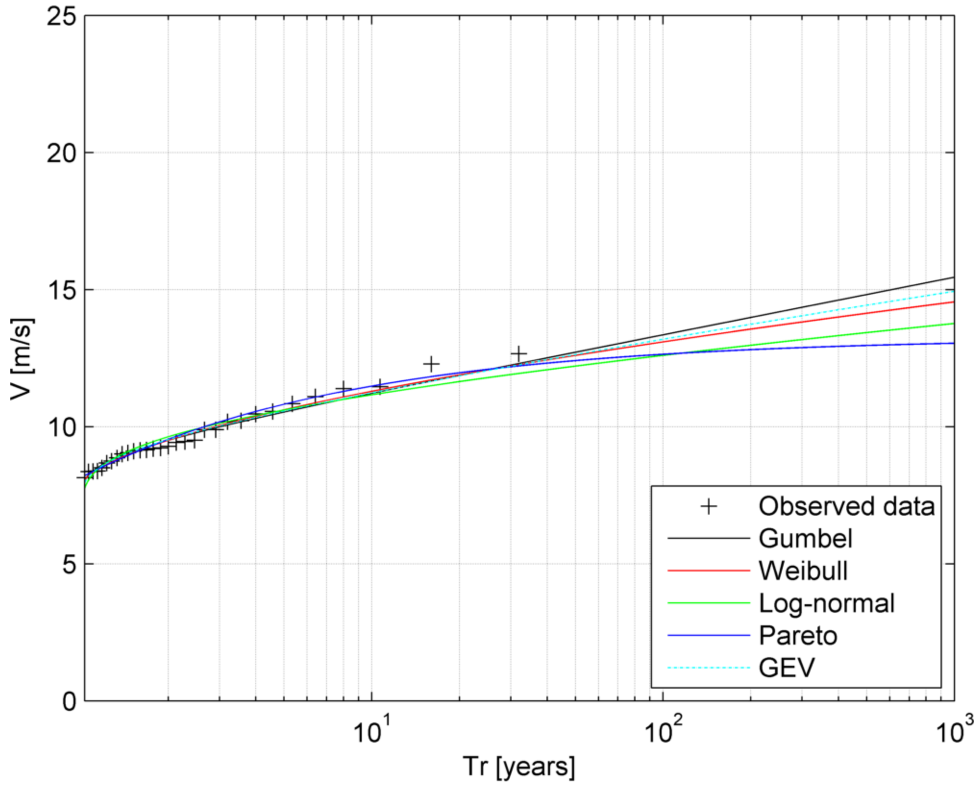
Figure 61.Analysis of extreme events of wind data. Direction 303.75 °N ÷ 326.25°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 31. Extreme events of wind data. Direction 303.75 °N ÷ 326.25°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	10.98	11.16	11.14	11.04	11.14
5	12.45	12.67	12.61	13.18	12.64
10	13.42	13.48	13.45	14.06	13.47
20	14.35	14.15	14.19	14.59	14.18
30	14.89	14.51	14.59	14.80	14.55
40	15.26	14.74	14.86	14.91	14.79
50	15.56	14.92	15.07	14.99	14.97
100	16.46	15.42	15.68	15.15	15.49

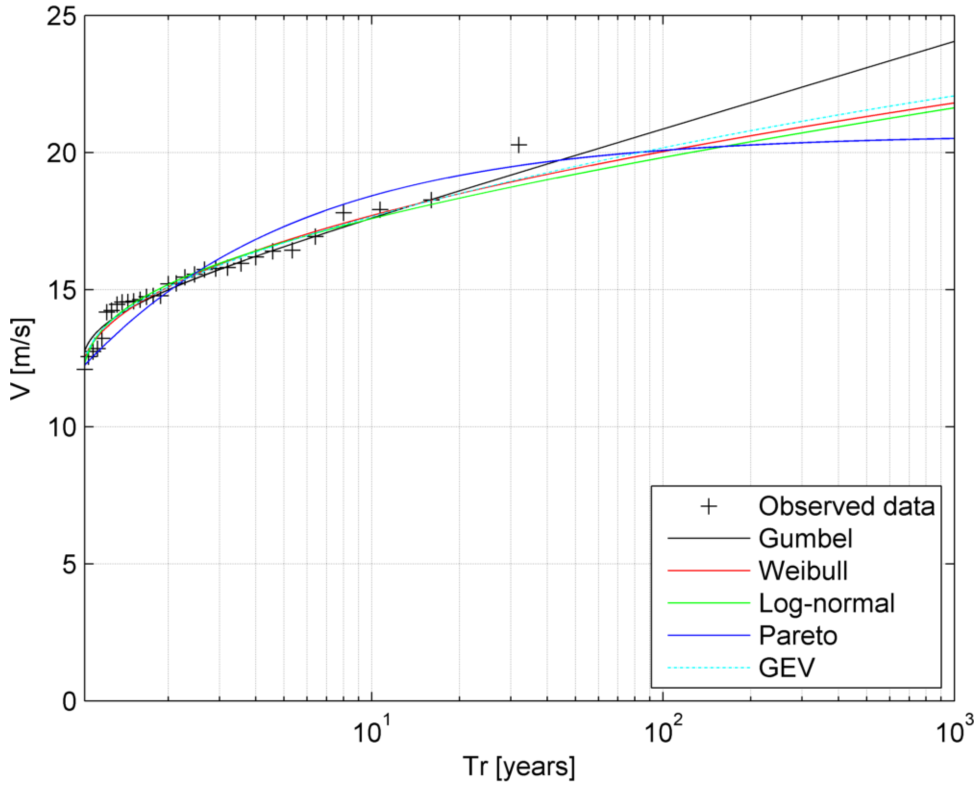
Figure 62. Analysis of extreme events of wind data. Direction 326.25 °N ÷ 348.75°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 32. Extreme events of wind data. Direction 326.25 °N ÷ 348.75°N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	9.50	9.50	9.63	9.54	9.52
5	10.53	10.62	10.61	10.82	10.57
10	11.21	11.29	11.17	11.48	11.24
20	11.87	11.89	11.65	11.97	11.85
30	12.25	12.22	11.90	12.19	12.20
40	12.51	12.44	12.08	12.32	12.45
50	12.72	12.60	12.21	12.41	12.63
100	13.35	13.09	12.60	12.64	13.19

Figure 63. Omnidirectional analysis of extreme events of wind data (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 33. Omnidirectional extreme events of wind data (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Wind velocity [m/s]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	14.99	15.10	15.19	14.93	15.10
5	16.56	16.76	16.72	17.30	16.70
10	17.60	17.70	17.58	18.42	17.66
20	18.60	18.49	18.33	19.16	18.50
30	19.17	18.92	18.73	19.48	18.95
40	19.57	19.20	19.00	19.66	19.26
50	19.89	19.41	19.21	19.78	19.49
100	20.85	20.04	19.82	20.08	20.17

Offshore Wave Analysis

Geographical fetches and effective fetches

The analysis of fetches and winds is performed here in order to understand the characteristics of waves. In the following two figures geographical fetches of Gaza are shown.

The information of the coast limits were extracted from the map named "Chart of international series – Mediterranean Sea" (Genoa, 1982) of the Italian Navy Hydrographic Institute (NHI). The scale of the NHI chart is 1: 2.250.000.

The principal directions characterised by the largest fetches are located within the sector 270 ÷ 25 °N.

Figure 64. Geographical fetches of the study area.

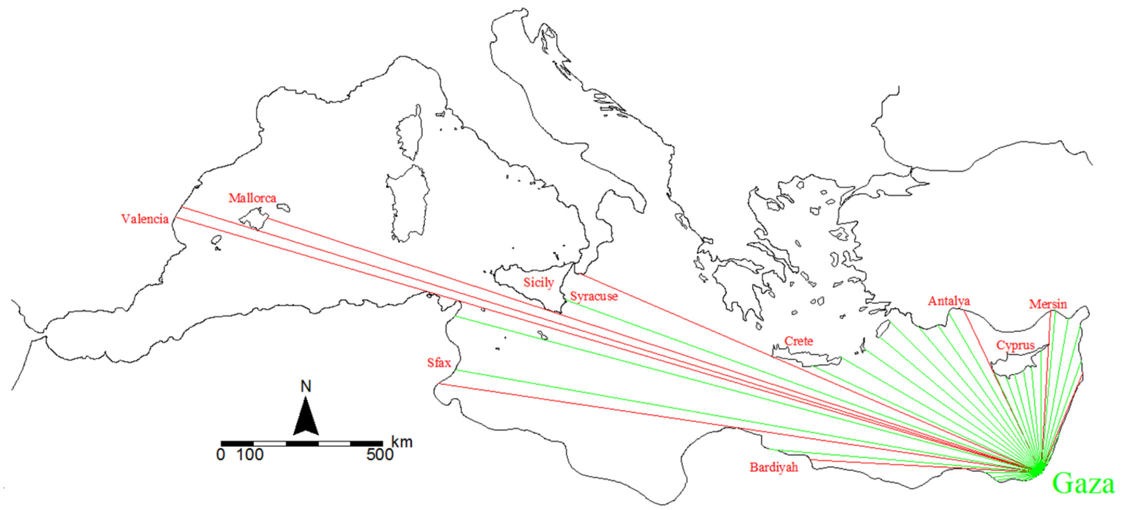
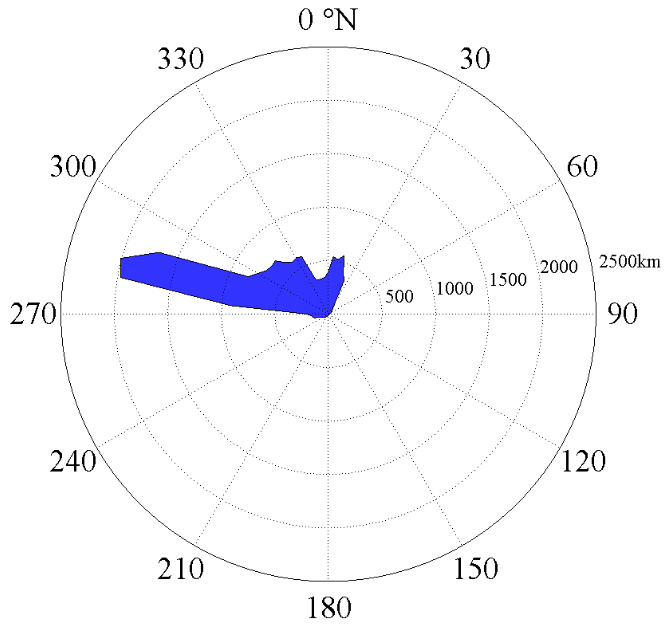


Figure 65. Polar diagram of the geographical fetches of Gaza Strip.

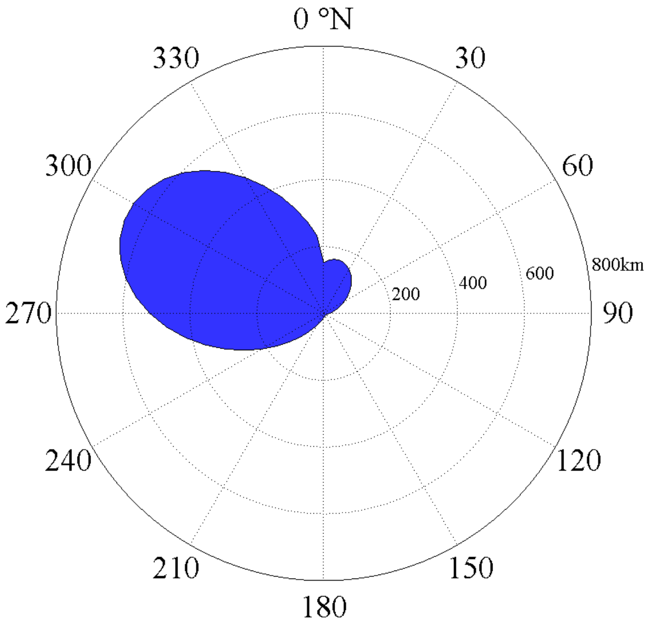


However, when the wind blows over an area, it transfers energy to the water surface in the direction of the wind and all the directions close to it. To take into account such phenomena the effective fetch is considered here.
The effective fetch is determined using the following relationship (Saville, 1954):

$$F_{eff\varphi} = \frac{\sum_{\varphi_i=\varphi-90^\circ}^{\varphi+90^\circ} x_i \cos^3(\varphi_i - \varphi)}{\sum_{\varphi_i=\varphi-90^\circ}^{\varphi+90^\circ} \cos^2(\varphi_i - \varphi)} \qquad (3)$$

where $F_{eff\varphi}$ is the effective fetch in the direction φ, x_i is the length of i-th geographical fetch, and φ_i is the angle of *i-th* geographical fetch.
The principal directions characterised by the effective fetch are located in the sector 290 ÷ 310°N where F_{eff} is in the range 600 ÷ 650km.

Figure 66. Polar diagram of the effective fetches of Gaza Strip.



<u>Analysis of offshore wave data</u>
The analyses of the wave characteristics were performed on the basis of NOAA - CFSR data. Such a data set covers the period 1979-01-01 to 2009-12-31 (thirty-one years) with a time resolution of three hour (eight data per day). The data were extracted at a point close to the study area: WGS84 coordinates 31.6667° N and 34.3333° E.
As it can be observed, the dominant directions are in the sector 290 ÷ 310 °N. This result is in accordance with the analysis of both the wind data and the effective fetch.

Tab 34. Frequencies of occurrence of wave data in terms of significant wave height (Hs) and wave direction (Dir) (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

	Hs [m]										
Dir [°N]	0-0.5	0.5-1.0	1.0-1.5	1.5-2.0	2.0-2.5	2.5-3.0	3.0-3.5	3.5-4.0	4.0-5.0	5.0-6.0	>6.0
0	2.30	2.86	0.50	0.09	0.02	0.00	-	-	-	-	-
10	0.45	0.15	-	-	-	-	-	-	-	-	-
20	0.09	0.03	-	-	-	-	-	-	-	-	-
30	0.05	0.02	-	-	-	-	-	-	-	-	-
40	0.05	0.01	-	-	-	-	-	-	-	-	-
50	0.03	0.01	-	-	-	-	-	-	-	-	-
60	0.03	0.02	-	-	-	-	-	-	-	-	-
70	0.03	0.02	-	-	-	-	-	-	-	-	-
80	0.05	0.02	-	-	-	-	-	-	-	-	-
90	0.04	0.02	-	-	-	-	-	-	-	-	-
100	0.03	0.02	-	-	-	-	-	-	-	-	-
110	0.07	0.03	-	-	-	-	-	-	-	-	-
120	0.06	0.02	-	-	-	-	-	-	-	-	-
130	0.09	0.02	-	-	-	-	-	-	-	-	-
140	0.06	0.01	-	-	-	-	-	-	-	-	-
150	0.07	0.01	-	-	-	-	-	-	-	-	-
160	0.05	0.01	-	-	-	-	-	-	-	-	-
170	0.05	0.01	-	-	-	-	-	-	-	-	-
180	0.05	0.02	-	-	-	-	-	-	-	-	-
190	0.05	0.03	-	-	-	-	-	-	-	-	-
200	0.06	0.03	-	-	-	-	-	-	-	-	-
210	0.07	0.03	-	-	-	-	-	-	-	-	-
220	0.06	0.03	0.01	-	-	-	-	-	-	-	-
230	0.04	0.03	0.00	-	-	-	-	-	-	-	-
240	0.03	0.04	0.01	-	-	-	-	-	-	-	-
250	0.04	0.05	0.01	-	-	-	-	-	-	-	-
260	0.05	0.08	0.02	0.00	0.00	-	-	-	-	-	-
270	0.05	0.15	0.06	0.01	0.00	-	-	-	-	-	-
280	0.41	0.77	0.32	0.12	0.04	0.01	-	-	-	-	-
290	4.13	12.86	5.63	2.29	1.04	0.48	0.28	0.16	0.11	0.01	-
300	2.89	19.10	7.59	2.35	1.08	0.60	0.30	0.15	0.12	0.03	-
310	1.94	7.43	2.42	0.69	0.31	0.12	0.07	0.02	0.01	-	-
320	1.00	2.60	0.47	0.08	0.03	0.01	0.01	0.01	0.00	-	-
330	0.76	1.48	0.18	0.03	0.03	0.01	0.00	0.00	0.00	-	-
340	0.79	1.85	0.27	0.04	0.02	0.01	0.01	0.00	0.00	-	-
350	1.37	3.42	0.85	0.14	0.04	0.01	0.00	-	-	-	-

Extreme events analysis

The wave data were used to estimate the offshore extreme events.

Storms have been identified by using the method of the Peak Over Threshold (POT). For this study a threshold of 2.00 m was adopted. In particular, the sea storms were identified using the following definition: a sea storm is "a sequence of sea states in which Hs exceeds a fixed threshold, and it does not fall below this threshold for a continuous time interval greater than 12 hours" (Boccotti, 2000). For each direction, all sea storms were identified, and the maximum value of Hs was selected.

The analyses were carried out for 16 classes of direction, each with an angle of 22.5°.

The extreme analyses were carried out for the directions with a significant number of events lager than the threshold (2m). In particular, the directions considered are the following: 0, 270, 292.5, 315, and 337.5 °N.

Figure 67.Analysis of extreme events of wave data. Direction -11.25 °N ÷ 11.25 °N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

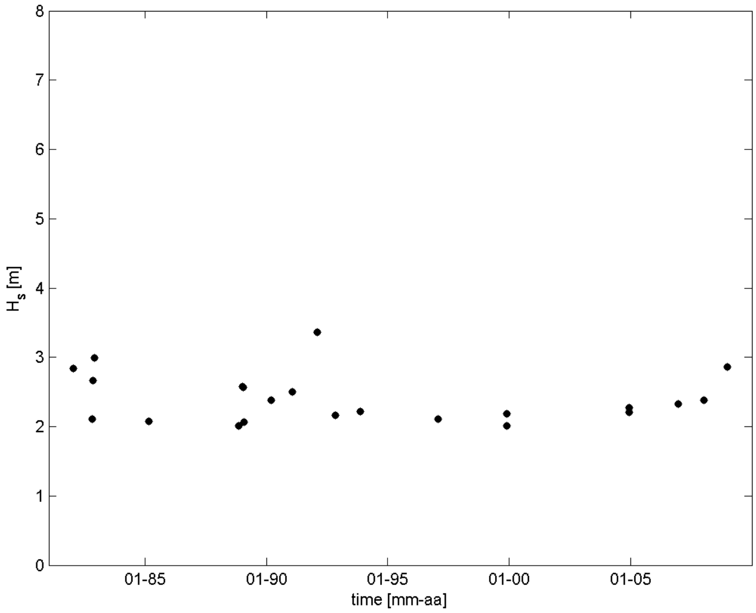


Figure 68. Analysis of extreme events of wave data. Direction 258.75 °N ÷ 281.25 °N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

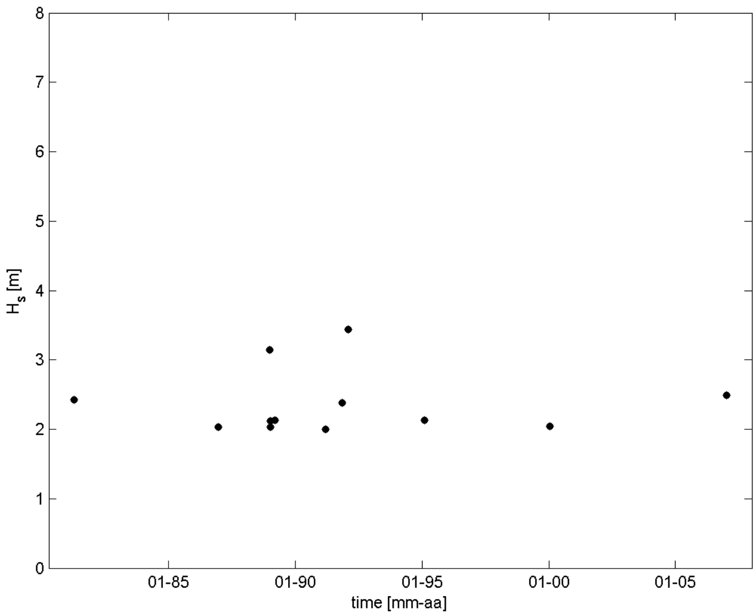


Figure 69. Analysis of extreme events of wave data. Direction 281.25 °N ÷ 303.75 °N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

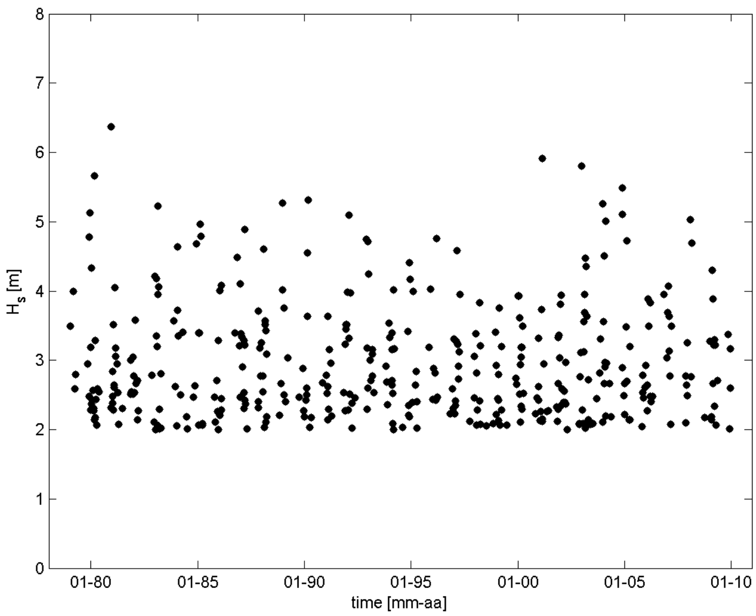


Figure 70.Analysis of extreme events of wave data. Direction 303.75 °N ÷ 326.25 °N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

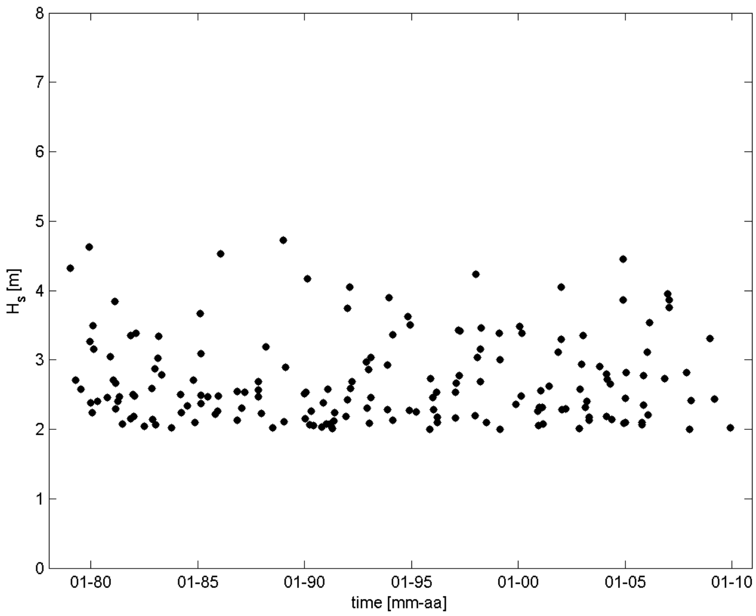


Figure 71.Analysis of extreme events of wave data. Direction 326.25 °N ÷ 348.75 °N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

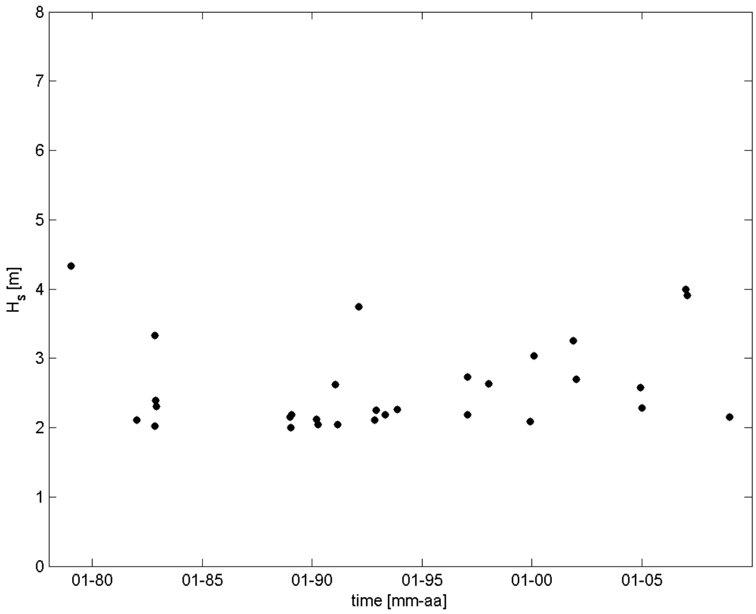
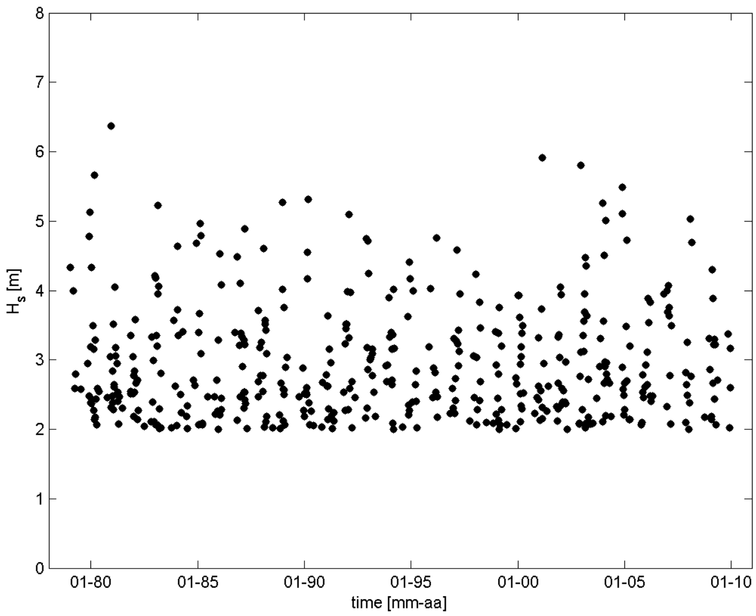


Figure 72.Analysis of extreme events of wave data: omnidirectional (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Several probability distributions were adopted to model the distribution of the extreme wave height: Gumbel, Log-normal, Weibull, Pareto and Generalized Extreme Value Distribution (GEV). The Kolmogorov–Smirnov test was used to verify the empirical probability distributions. The comparison between the probability distributions and the observed data are shown in the following figures.
Furthermore, for each direction, there are three tables that show:

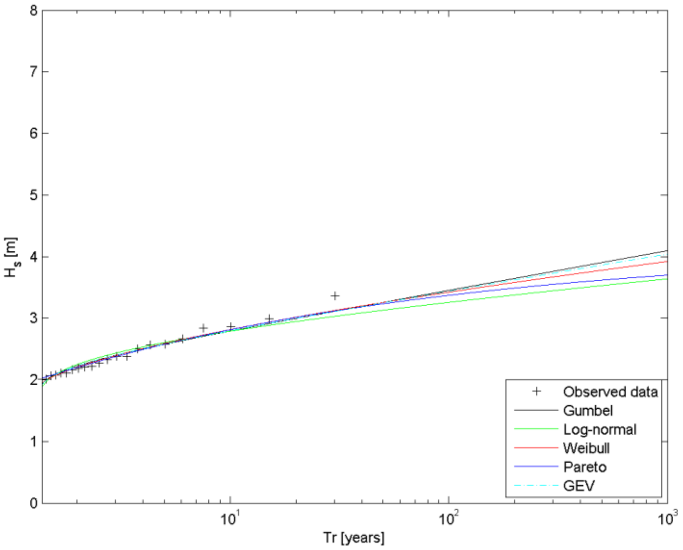
- The values of D_n^*
- The values of D_n
- The extreme significant wave height classified as a function of return period and the probability distributions.

The return period of an event with Hs greater than or equal to $\overline{H}$ was estimated using the following relation:

$$F_n(Hs \geq \overline{H}) = 1 - \frac{1}{\lambda \cdot T_r} \qquad (4)$$

where F_n is the probability that Hs is greater or equal to $\overline{H}$ and λ is the sample intensity equal to the ratio between the number of extreme events and the total number of years of observation.

Figure 73.Analysis of extreme events of wave data. Direction -11.25 °N ÷ 11.25 °N. (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 35. Kolmogorov test: values of D_n^* corresponding to different values of α.

	α =0.20	α =0.15	α =0.10	α =0.05	α =0.01
D_n^*	0.221	0.235	0.253	0.281	0.337

Tab 36. Kolmogorov test: maximum difference between the theoretical distributions and the cumulative distribution of the observed data. Direction -11.25 °N ÷ 11.25 °N.

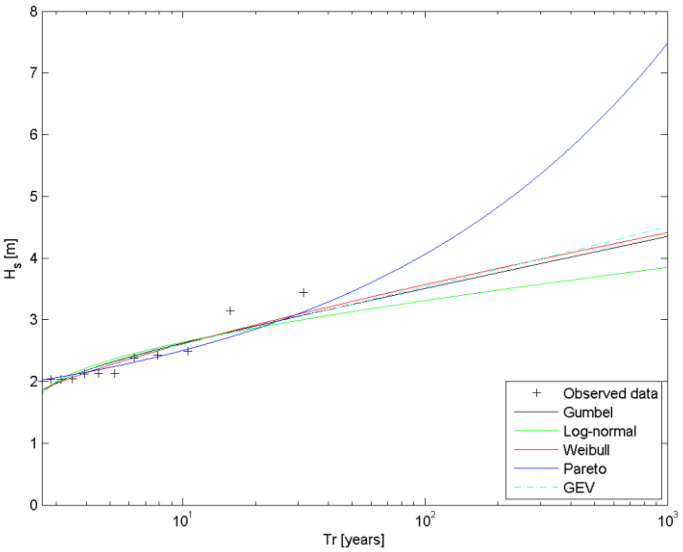
	Gumbel	Weibull	Log-Norm	Pareto	GEV
D_n	0.098	0.074	0.125	0.067	0.098

Tab 37. Analysis of extreme events of wave data. Direction -11.25 °N ÷ 11.25 °N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Hs [m]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	2.22	2.20	2.25	2.20	2.22
5	2.57	2.59	2.60	2.58	2.58
10	2.79	2.81	2.79	2.81	2.79
20	2.99	3.01	2.94	3.01	2.99
30	3.11	3.12	3.03	3.11	3.11
40	3.19	3.20	3.09	3.18	3.19

50	3.25	3.25	3.13	3.23	3.25
100	3.45	3.42	3.26	3.37	3.44

Figure 74. Analysis of extreme events of wave data. Direction 258.75 °N ÷ 281.25 °N. (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 38. Kolmogorov test: values of D_n^* corresponding to different values of α.

	α =0.20	α =0.15	α =0.10	α =0.05	α =0.01
D_n^*	0.296	0.313	0.338	0.375	0.449

Tab 39. Kolmogorov test: maximum difference between the theoretical distributions and the cumulative distribution of the observed data. Direction 258.75 °N ÷ 281.25 °N.

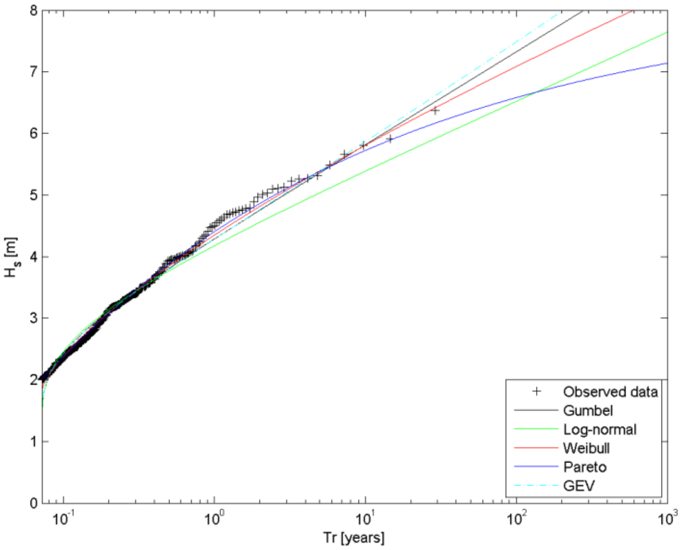
	Gumbel	Weibull	Log-Norm	Pareto	GEV
D_n	0.193	0.159	0.227	0.183	0.191

Tab 40. Analysis of extreme events of wave data. Direction 258.75 °N ÷ 281.25 °N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Hs [m]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	1.69	1.65	-	-	1.72

5	2.30	2.26	2.34	2.23	2.29
10	2.62	2.61	2.64	2.50	2.60
20	2.90	2.92	2.87	2.85	2.89
30	3.06	3.09	2.99	3.09	3.05
40	3.16	3.21	3.07	3.29	3.16
50	3.25	3.30	3.13	3.46	3.25
100	3.51	3.57	3.31	4.06	3.53

Figure 75.Analysis of extreme events of wave data. Direction 281.25 °N ÷ 303.75 °N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 41. Kolmogorov test: values of D_n^* corresponding to different values of α.

	α =0.20	α =0.15	α =0.10	α =0.05	α =0.01
D_n^*	0.053	0.056	0.060	0.067	0.081

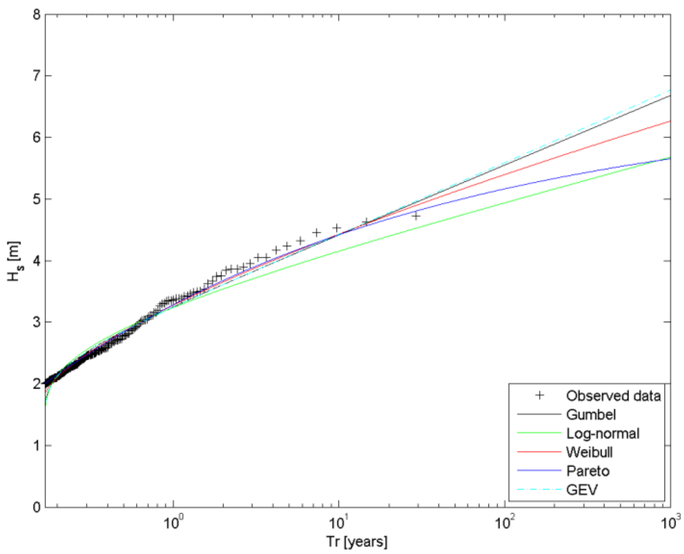
Tab 42. Kolmogorov test: maximum difference between the theoretical distributions and the cumulative distribution of the observed data. Direction 281.25 °N ÷ 303.75 °N.

	Gumbel	Weibull	Log-Norm	Pareto	GEV
D_n	0.085	0.065	0.096	0.033	0.081

Tab 43. Analysis of extreme events of wave data. Direction 281.25 °N ÷ 303.75 °N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Hs [m]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	4.75	4.81	4.55	4.86	4.76
5	5.36	5.39	5.03	5.38	5.39
10	5.81	5.80	5.38	5.72	5.86
20	6.27	6.20	5.73	6.02	6.35
30	6.53	6.43	5.93	6.18	6.63
40	6.72	6.59	6.07	6.28	6.83
50	6.87	6.71	6.18	6.36	6.99
100	7.32	7.08	6.52	6.58	7.48

Figure 76.Analysis of extreme events of wave data. Direction 303.75 °N ÷ 326.25 °N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 44. Kolmogorov test: values of D_n^* corresponding to different values of α.

	α =0.20	α =0.15	α =0.10	α =0.05	α =0.01
D_n^*	0.080	0.085	0.092	0.102	0.122

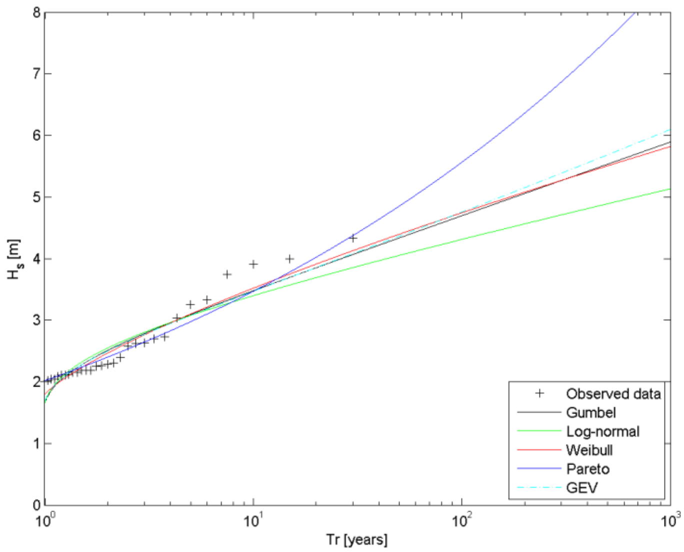
Tab 45. Kolmogorov test: maximum difference between the theoretical distributions and the cumulative distribution of the observed data. Direction 303.75 °N ÷ 326.25 °N.

	Gumbel	Weibull	Log-Norm	Pareto	GEV
D_n	0.093	0.086	0.111	0.054	0.092

Tab 46. Analysis of extreme events of wave data. Direction 303.75 °N ÷ 326.25 °N. (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Hs [m]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	3.61	3.65	3.54	3.67	3.61
5	4.07	4.11	3.90	4.12	4.07
10	4.42	4.43	4.15	4.42	4.42
20	4.76	4.73	4.39	4.68	4.77
30	4.96	4.91	4.53	4.81	4.98
40	5.10	5.03	4.63	4.90	5.12
50	5.21	5.12	4.71	4.97	5.24
100	5.55	5.40	4.94	5.16	5.59

Figure 77.Analysis of extreme events of wave data. Direction 326.25 °N ÷ 348.75 °N (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 47. Kolmogorov test: values of D_n^* corresponding to different values of α.

	α =0.20	α =0.15	α =0.10	α =0.05	α =0.01
D_n^*	0.190	0.202	0.218	0.242	0.290

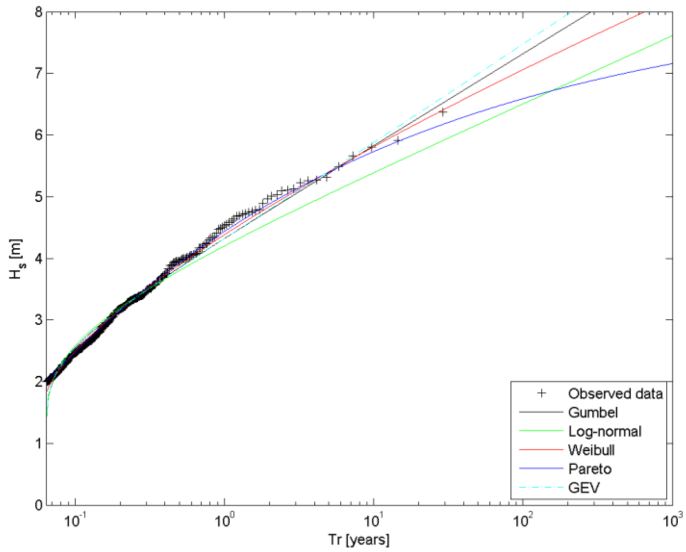
Tab 48. Kolmogorov test: maximum difference between the theoretical distributions and the cumulative distribution of the observed data. Direction 326.25 °N ÷ 348.75 °N.

	Gumbel	Weibull	Log-Norm	Pareto	GEV
D_n	0.175	0.149	0.204	0.123	0.172

Tab 49. Analysis of extreme events of wave data. Direction 326.25 °N ÷ 348.75 °N. (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Hs [m]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	2.51	2.46	2.55	2.40	2.50
5	3.09	3.10	3.07	2.97	3.07
10	3.48	3.52	3.40	3.47	3.47
20	3.85	3.91	3.69	4.02	3.85
30	4.06	4.13	3.85	4.37	4.08
40	4.22	4.28	3.96	4.63	4.24
50	4.33	4.39	4.05	4.85	4.36
100	4.69	4.74	4.31	5.56	4.75

Figure 78. Analysis of extreme events of wave data: omnidirectional (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Tab 50. Kolmogorov test: values of D_n^* corresponding to different values of α.

	α =0.20	α =0.15	α =0.10	α =0.05	α =0.01
D_n^*	0.050	0.053	0.057	0.064	0.076

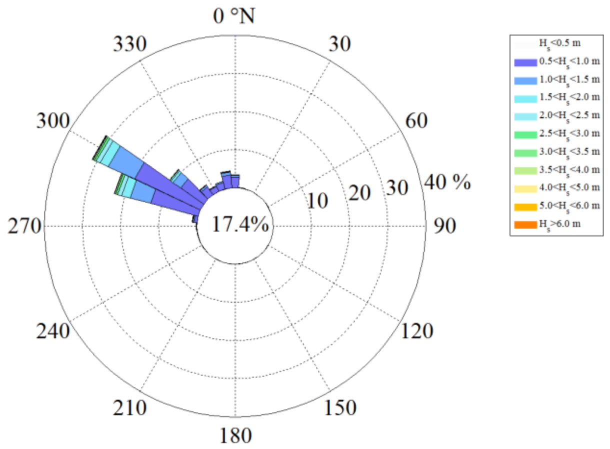
Tab 51. Kolmogorov test: maximum difference between the theoretical distributions and the cumulative distribution of the observed data. Direction 22.5 ±11.25 °N.

	Gumbel	Weibull	Log-Norm	Pareto	GEV
D_n	0.088	0.071	0.093	0.035	0.084

Tab 52. Analysis of extreme events of wave data: omnidirectional. (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).

Tr	Hs [m]				
	Gumbel	Weibull	Log-normal	Pareto	GEV
2	4.78	4.84	4.57	4.88	4.79
5	5.38	5.40	5.04	5.39	5.41
10	5.83	5.81	5.39	5.73	5.88
20	6.27	6.20	5.73	6.03	6.35
30	6.54	6.42	5.92	6.18	6.63
40	6.72	6.57	6.06	6.29	6.83
50	6.87	6.69	6.17	6.37	6.99
100	7.31	7.06	6.50	6.59	7.47

Figure 79. Wave climate estimated using NOAA wave data (source data: NOAA-CFSR; WGS84 coordinates: latitude 31.6667° and longitude 34.3333°).



Onshore Wave Analysis

The estimate of the wave characteristics (wave height, period and direction) close to Gaza was carried out using the numerical model SWAN. This model allows the wave propagation using a spectral method to be simulated.
The following sections describe: the numerical model, the computational grid, the boundary conditions, the results of the numerical model.

Numerical model
The wave propagation is carried out using SWAN, which is a third-generation spectral model developed by Delft University Technology (Booij et al., 1999). The model estimates the space and time variations of the action density according to the following equation (expressed in cartesian coordinates with the x axis directed toward the coast):

$$\frac{\partial N_s}{\partial t}+\frac{\partial c_x \cdot N_s}{\partial x}+\frac{\partial c_y \cdot N_s}{\partial y}+\frac{\partial c_\sigma \cdot N_s}{\partial \sigma}+\frac{\partial c_\theta \cdot N_s}{\partial \theta}=\frac{S_{ss}}{\sigma} \qquad (5)$$

where:
N_s is the action density equal to the energy density spectrum divided by the relative frequency;
t is the time;
x and y are the coordinate of the generic point;
σ is the frequency;
θ is the direction of the wave;
c_x and c_y are the group velocities components along the x and y directions;
c_σ and c_θ are the group velocities components in the frequency domain and in the direction domain.
S_{ss} is the source/sink term representing all physical processes that generate, dissipate, or redistribute wave energy.
The value of S_{ss} are estimated by Swan using the following relationship:

$$S_{ss}=S_{in}+S_{nl}+S_{ds}+S_{bot}+S_{surf} \qquad (6)$$

where S_{in} represents the momentum transfer of wind energy to wave generation, S_{nl} is the energy transfer due to nonlinear wave–wave interactions, S_{ds} is the dissipation of the energy due to white-capping (deep water wave breaking), S_{bot} is the dissipation of the wave energy due to bottom friction, and S_{surf} is the energy dissipation due to depth-induced wave breaking.

Computational grid
The data used to reconstruct the morphology of the seabed were obtained from the archive of General Bathymetric Chart of Oceans (GEBCO). GEBCO (released 2010) provides global bathymetry data sets for the world oceans with a resolution equal to 30 arc-second (approximately 1km) (GEBCO, 1999).
The computational domain analyzed here was discretized using a non-orthogonal adaptive grid. In the case being, the computational domain was discretized using 29382 nodes and 57771 triangular elements. The grid resolution has been assumed constant for depths smaller than 30m and greater than 50m, while it varies linearly in the range 30 ÷ 50m. Accordingly, the mesh size is 100 m for depths less than 30 and 1000m for the depths greater than 50 m, while the grid dimension varies linearly between 100m to 1000m for depths in the range 30 ÷ 50m.

Figure 80. Computational grid used to simulate wave propagation.

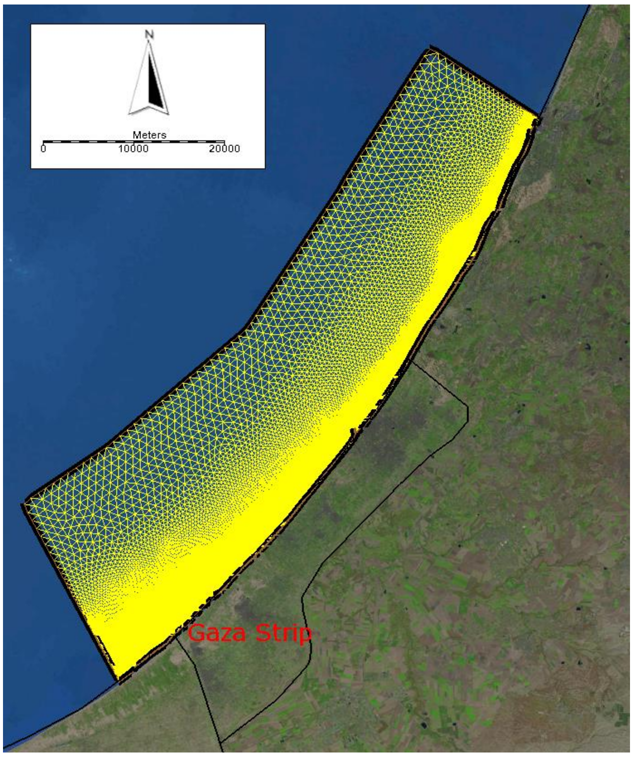
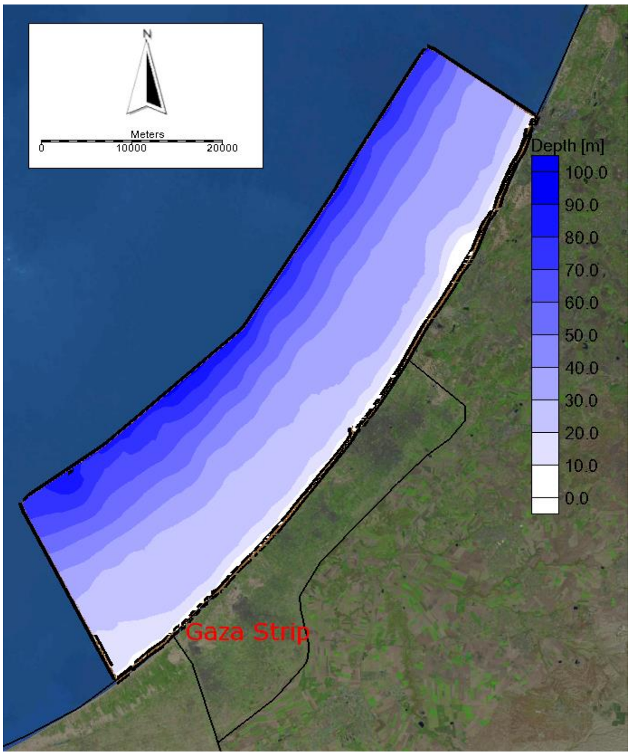


Figure 81. Bathymetry within the computational domain.



<u>Boundary conditions</u>

Only the classes characterized by frequencies greater than 0 were simulated.

The definition of the boundary conditions on the contours with variable depth was carried out by adopting a specific procedure. For each node on the contour the significant wave height and wave direction were estimated using the offshore wave data. The wave characteristics were estimated using the following relationship (Boccotti, 2000):

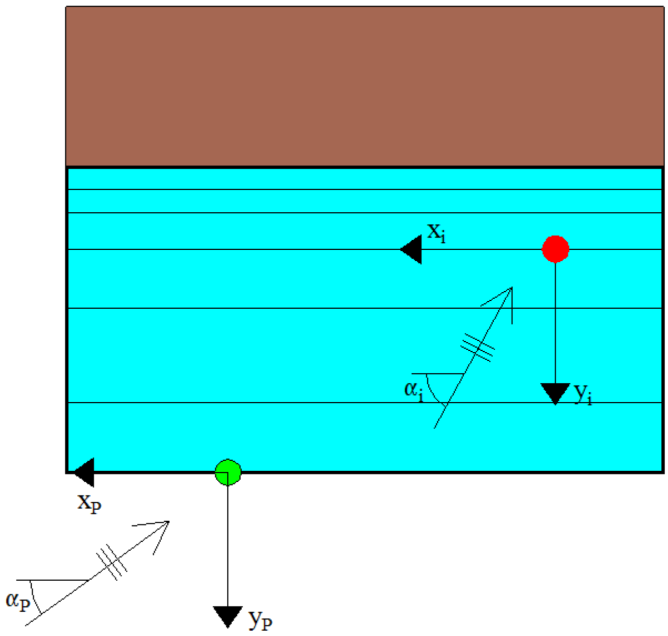
$$H_i^2 \cdot \left[1+\frac{2\cdot k_i \cdot d_i}{\sinh(2\cdot k_i \cdot d_i)}\right]\cdot \sin(\alpha_i)\cdot\cos(\alpha_i) = H_P^2 \cdot \left[1+\frac{2\cdot k_P \cdot d_P}{\sinh(2\cdot k_P \cdot d_P)}\right]\cdot \sin(\alpha_P)\cdot\cos(\alpha_P) \quad (7)$$

where the subscript *i* indicate the i-th node of the contour, the subscript *P* indicate the characteristics at the offshore point, *H* is the wave height, *k* is the wave number, *d* is the water depth and α is the angle between the wave direction and the relative x axis. The angle of i-th point is estimated using the Snell law:

$$\frac{1}{c_i}\cdot\cos\alpha_i = \frac{1}{c_P}\cdot\cos\alpha_P \quad (8)$$

where *c* indicates the group velocity. Thus, Eq. 8 is used to calculate the angle α_i at the water depth d_i, once angle α_P is known.

Figure 82. Schematic representation of the method used to estimate the boundary conditions.

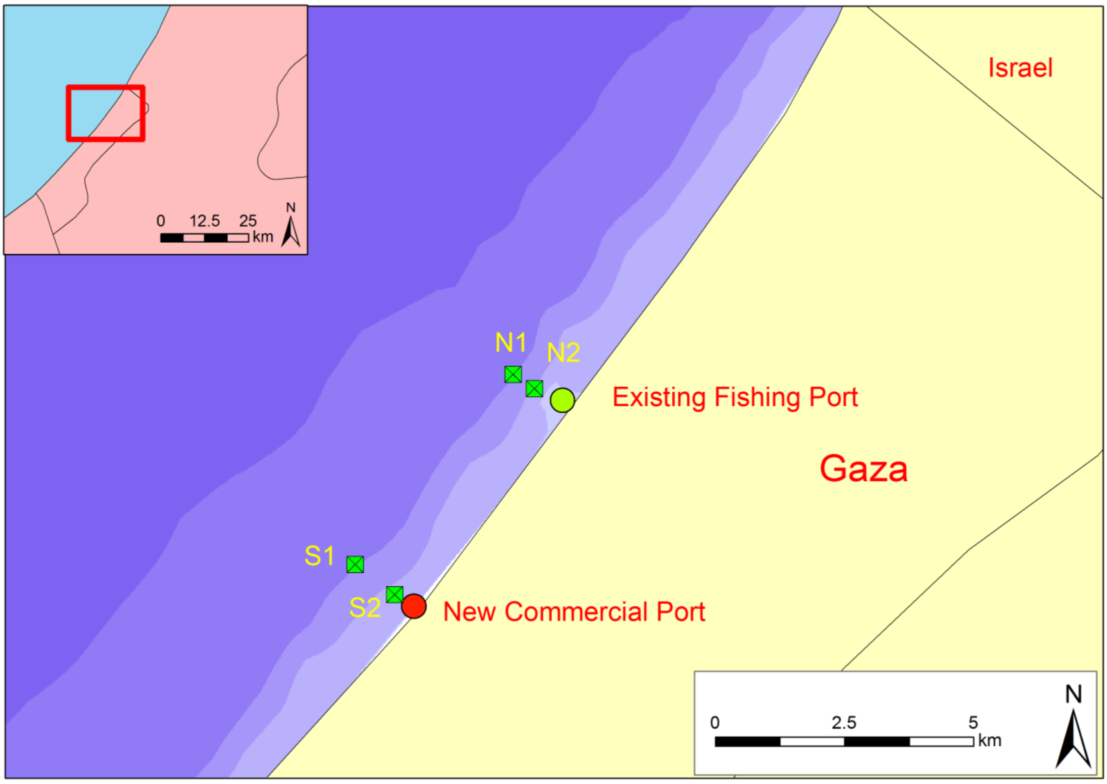


Eq. (7) is based on the assumptions that the wave period is invariant and that the wave characteristics are independent on x and that they depend only on y.

<u>Analysis of results</u>
The results of the numerical model SWAN are shown in Annex – A. The wave data were extracted at 4 nearshore control points near the coast. The localization of such 4 points are shown in Figure 67.
The points S1 and N1 are at a depth of 15 m; the points N2 and N2 are at depth of 7m. The coordinates of the 4 points are reported in table 45.

The points N1 and N2 were selected in front of the existing Gaza fishing port, while point S1 and S2 were selected near the site at which the new commercial port was planned and contracted in 2000.

Figure 83. Localization of 4 nearshore control points, which wave data have been extracted.



Tab 53. Coordinates of the four points (UTM-WGS84 and WGS84).

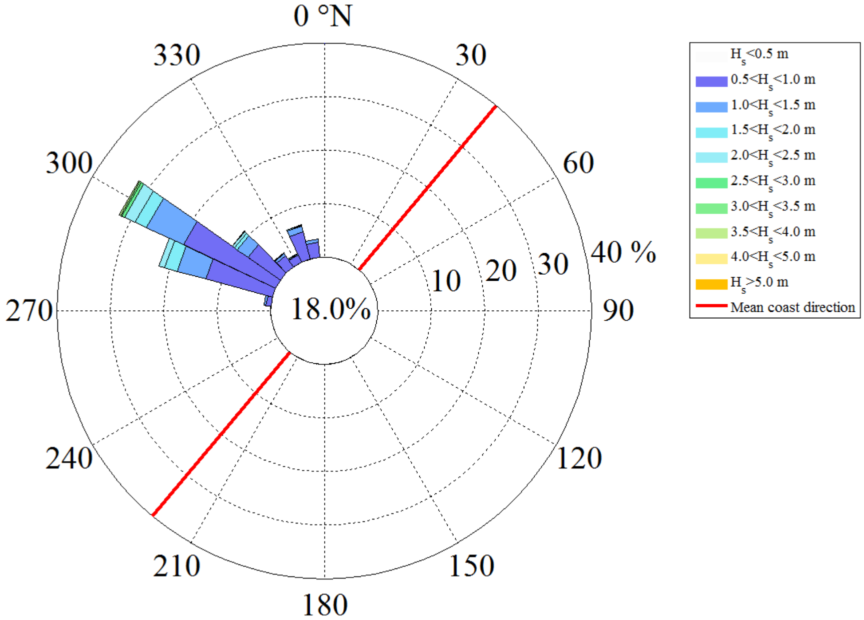
Name	X [East m]	Y [North m]	Depth [m]	longitude [°]	latitude [°]
N1	634930	3489242	15	34.421	31.530
N2	635343	3488966	7	34.426	31.528
S1	631881	3485569	15	34.389	31.497
S2	632639	3484988	7	34.397	31.492

A frequency analysis on the nearshore wave motion is shown in the following tables, while wave climate at each point control are illustrated in the following figures.

Tab 54. Frequency of occurrence of the significant wave height and the wave direction. Control point N1 (depth approximately of 15m).

	Hs [m]								
Dir [°N]	0.25	0.75	1.25	1.75	2.25	2.75	3.25	3.75	4.5	>5
0	18	-	-	-	-	-	-	-	-	-
10		-	-	-	-	-	-	-	-	-
20		-	-	-	-	-	-	-	-	-
30		-	-	-	-	-	-	-	-	-
40		-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-
70		-	-	-	-	-	-	-	-	-
80		-	-	-	-	-	-	-	-	-
90		-	-	-	-	-	-	-	-	-
100		-	-	-	-	-	-	-	-	-
110		-	-	-	-	-	-	-	-	-
120		-	-	-	-	-	-	-	-	-
130		-	-	-	-	-	-	-	-	-
140		-	-	-	-	-	-	-	-	-
150		-	-	-	-	-	-	-	-	-
160		-	-	-	-	-	-	-	-	-
170		-	-	-	-	-	-	-	-	-
180		-	-	-	-	-	-	-	-	-
190		-	-	-	-	-	-	-	-	-
200		-	-	-	-	-	-	-	-	-
210		-	-	-	-	-	-	-	-	-
220		-	-	-	-	-	-	-	-	-
230		-	-	-	-	-	-	-	-	-
240		-	-	-	-	-	-	-	-	-
250		-	-	-	-	-	-	-	-	-
260		-	-	-	-	-	-	-	-	-
270		0.13	0.04	-	-	-	-	-	-	-
280		0.93	0.38	0.02	-	-	-	-	-	-
290		12.86	5.63	2.42	1.08	0.01	-	-	-	-
300		19.10	7.59	2.35	2.16	0.58	0.31	0.23	0.01	-
310		7.43	2.42	0.69	0.43	0.07	0.02	0.01	0.03	-
320		2.60	0.47	0.08	0.05	0.02	0.01	-	-	-
330		1.48	0.18	0.10	0.04	0.01	-	-	-	-
340		5.27	1.12	0.19	0.02	-	-	-	-	-
350		2.86	0.58	-	-	-	-	-	-	-

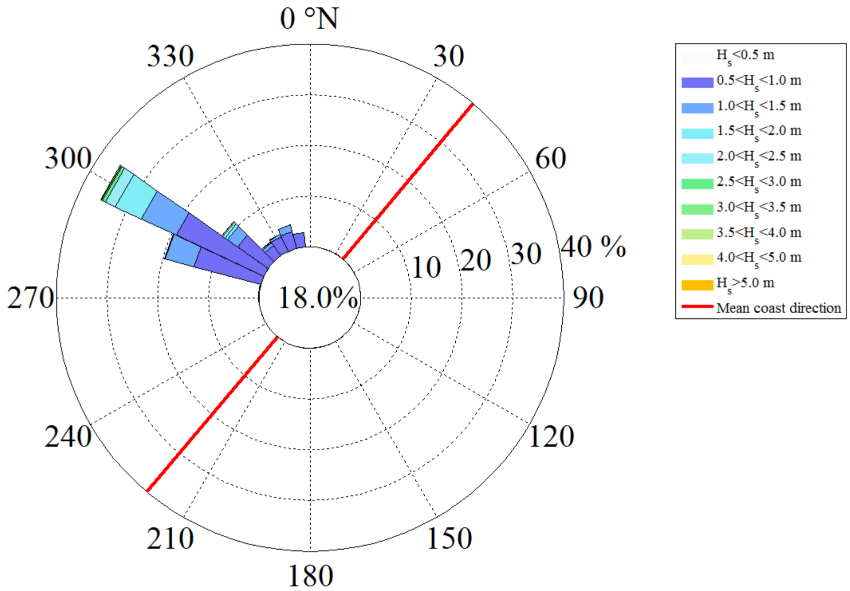
Figure 84. Wave climate at control point N1 (depth approximately of 15m). The red line indicated the mean coast direction.


0 °N
30
60
90
120
150
180
210
240
270
300
330
10
20
30
40 %
18.0%
H_s<0.5 m
0.5<H_s<1.0 m
1.0<H_s<1.5 m
1.5<H_s<2.0 m
2.0<H_s<2.5 m
2.5<H_s<3.0 m
3.0<H_s<3.5 m
3.5<H_s<4.0 m
4.0<H_s<5.0 m
H_s>5.0 m
Mean coast direction

Tab 55. Frequency of occurrence of the significant wave height and the wave direction. Control Point N2 (depth approximately of 7m).

	Hs [m]									
Dir [°N]	0.25	0.75	1.25	1.75	2.25	2.75	3.25	3.75	4.5	>5
0	18	-	-	-	-	-	-	-	-	-
10		-	-	-	-	-	-	-	-	-
20		-	-	-	-	-	-	-	-	-
30		-	-	-	-	-	-	-	-	-
40		-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-
70		-	-	-	-	-	-	-	-	-
80		-	-	-	-	-	-	-	-	-
90		-	-	-	-	-	-	-	-	-
100		-	-	-	-	-	-	-	-	-
110		-	-	-	-	-	-	-	-	-
120		-	-	-	-	-	-	-	-	-
130		-	-	-	-	-	-	-	-	-
140		-	-	-	-	-	-	-	-	-
150		-	-	-	-	-	-	-	-	-
160		-	-	-	-	-	-	-	-	-
170		-	-	-	-	-	-	-	-	-
180		-	-	-	-	-	-	-	-	-
190		-	-	-	-	-	-	-	-	-
200		-	-	-	-	-	-	-	-	-
210		-	-	-	-	-	-	-	-	-
220		-	-	-	-	-	-	-	-	-
230		-	-	-	-	-	-	-	-	-
240		-	-	-	-	-	-	-	-	-
250		-	-	-	-	-	-	-	-	-
260		-	-	-	-	-	-	-	-	-
270		0.14	-	-	-	-	-	-	-	-
280		0.15	0.1	-	-	-	-	-	-	-
290		13.64	5.95	0.16	0.01	0.01	-	-	-	-
300		19.1	7.59	5.68	2.16	0.58	0.31	0.11	0.01	-
310		7.43	2.42	0.69	0.43	0.08	0.03	0.13	0.04	-
320		2.6	0.65	0.17	0.01	0.01	0.01	-	-	-
330		3.33	0.45	0.06	0.02	-	-	-	-	-
340		3.42	1.43	0.02	-	-	-	-	-	-
350		2.86	-	-	-	-	-	-	-	-

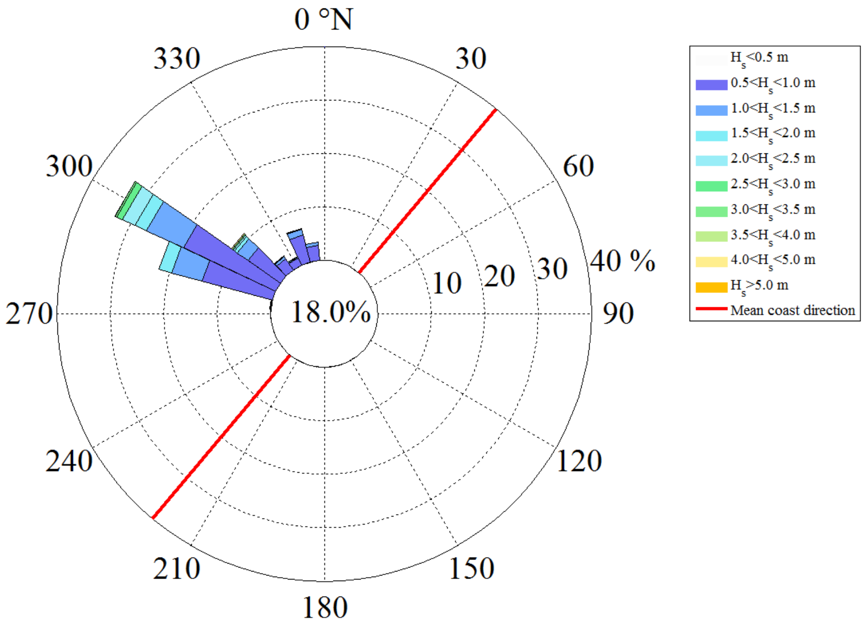
Figure 85. Wave climate at control point N2 (depth approximately of 7m). The red line indicated the mean coast direction.



Tab 56. Frequency of occurrence of the significant wave height and the wave direction. Control point S1 (depth approximately of 15m).

	Hs [m]								
Dir [°N]	0.25	0.75	1.25	1.75	2.25	2.75	3.25	3.75	4.5	>5
0	18	-	-	-	-	-	-	-	-	-
10		-	-	-	-	-	-	-	-	-
20		-	-	-	-	-	-	-	-	-
30		-	-	-	-	-	-	-	-	-
40		-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-
70		-	-	-	-	-	-	-	-	-
80		-	-	-	-	-	-	-	-	-
90		-	-	-	-	-	-	-	-	-
100		-	-	-	-	-	-	-	-	-
110		-	-	-	-	-	-	-	-	-
120		-	-	-	-	-	-	-	-	-
130		-	-	-	-	-	-	-	-	-
140		-	-	-	-	-	-	-	-	-
150		-	-	-	-	-	-	-	-	-
160		-	-	-	-	-	-	-	-	-
170		-	-	-	-	-	-	-	-	-
180		-	-	-	-	-	-	-	-	-
190		-	-	-	-	-	-	-	-	-
200		-	-	-	-	-	-	-	-	-
210		-	-	-	-	-	-	-	-	-
220		-	-	-	-	-	-	-	-	-
230		-	-	-	-	-	-	-	-	-
240		-	-	-	-	-	-	-	-	-
250		-	-	-	-	-	-	-	-	-
260		-	-	-	-	-	-	-	-	-
270		0.13	0.04	-	-	-	-	-	-	-
280		0.93	0.38	0.01	-	-	-	-	-	-
290		12.86	5.63	2.42	1.56	-	-	-	-	-
300		19.1	7.59	2.35	1.08	1.17	0.31	0.11	0.16	-
310		7.43	2.42	0.69	0.31	0.19	0.02	-	0.01	-
320		2.6	0.47	0.08	0.05	0.02	0.01	-	-	-
330		1.48	0.18	0.1	0.04	0.01	-	-	-	-
340		5.27	1.12	0.19	0.02	-	-	-	-	-
350		2.86	0.58	-	-	-	-	-	-	-

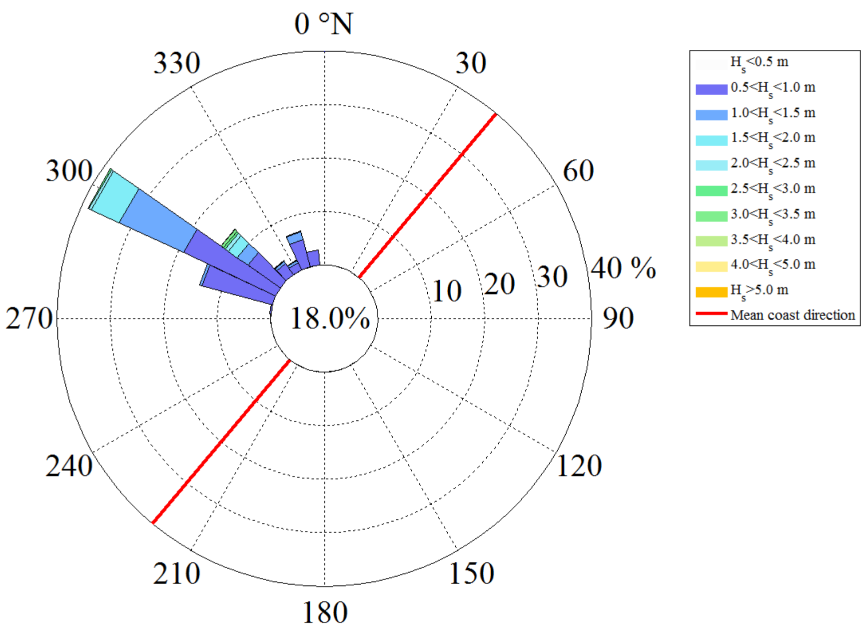
Figure 86. Wave climate at control point S1 (depth approximately of 15m). The red line indicated the mean coast direction.



Tab 57. Frequency of occurrence of the significant wave height and the wave direction. Control point S2 (depth approximately of 7m).

	Hs [m]									
Dir [°N]	0.25	0.75	1.25	1.75	2.25	2.75	3.25	3.75	4.5	>5
0	18	-	-	-	-	-	-	-	-	-
10		-	-	-	-	-	-	-	-	-
20		-	-	-	-	-	-	-	-	-
30		-	-	-	-	-	-	-	-	-
40		-	-	-	-	-	-	-	-	-
50		-	-	-	-	-	-	-	-	-
60		-	-	-	-	-	-	-	-	-
70		-	-	-	-	-	-	-	-	-
80		-	-	-	-	-	-	-	-	-
90		-	-	-	-	-	-	-	-	-
100		-	-	-	-	-	-	-	-	-
110		-	-	-	-	-	-	-	-	-
120		-	-	-	-	-	-	-	-	-
130		-	-	-	-	-	-	-	-	-
140		-	-	-	-	-	-	-	-	-
150		-	-	-	-	-	-	-	-	-
160		-	-	-	-	-	-	-	-	-
170		-	-	-	-	-	-	-	-	-
180		-	-	-	-	-	-	-	-	-
190		-	-	-	-	-	-	-	-	-
200		-	-	-	-	-	-	-	-	-
210		-	-	-	-	-	-	-	-	-
220		-	-	-	-	-	-	-	-	-
230		-	-	-	-	-	-	-	-	-
240		-	-	-	-	-	-	-	-	-
250		-	-	-	-	-	-	-	-	-
260		-	-	-	-	-	-	-	-	-
270		0.05	-	-	-	-	-	-	-	-
280		0.27	-	-	-	-	-	-	-	-
290		13.64	0.52	0.00	-	-	-	-	-	-
300		19.10	13.22	5.72	0.49	0.28	-	-	-	-
310		7.43	2.42	2.07	0.72	0.36	0.57	0.05	-	-
320		2.60	0.47	0.08	0.05	0.02	0.01	-	-	-
330		1.48	0.45	0.12	0.02	0.01	0.01	-	-	-
340		5.27	1.56	0.06	0.00	-	-	-	-	-
350		2.86	-	-	-	-	-	-	-	-

Figure 87. Wave climate at control point S2 (depth approximately of 7m). The red line indicated the mean coast direction.



<u>Extreme events analysis</u>

The boundary conditions were defined by using the results of the Generalized Extreme Value Distribution. Indeed, such a distribution allows to perform a conservative analysis.

The wave period was estimated using the following relationship (Boccotti, 2000):

$$Tp = 8.5 \cdot \pi \cdot \sqrt{\frac{Hs}{4 \cdot g}} \qquad (9)$$

where g indicates the gravity acceleration (9.806m/s^2).

The following tables report the results at point N1, N2, S1 and S2.

The locations of the four nearshore control points are shown in the following figures.

Tab 58. Extreme wave data at control point N1 (depth approximately of 15m).

Tr [anni]	Offshore			Depth = 15 m		
	Dir	Hs	Tp	Dir	Hs	Tp
	[°N]	[m]	[s]	[°N]	[m]	[s]
2	0.00	2.22	6.36	343.43	1.78	6.23
5		2.58	6.85	342.00	2.03	6.64
10		2.79	7.13	341.20	2.17	7.07
20		2.99	7.38	340.48	2.31	7.53
30		3.11	7.52	340.09	2.39	7.53
40		3.19	7.61	339.83	2.44	7.53
50		3.25	7.68	339.63	2.48	7.53
100		3.44	7.90	339.03	2.61	8.02
2	270.00	1.72	5.59	279.40	1.53	5.49
5		2.29	6.46	281.56	1.97	6.23
10		2.60	6.88	282.73	2.20	6.64
20		2.89	7.24	283.74	2.42	7.07
30		3.05	7.44	284.35	2.54	7.53
40		3.16	7.58	284.73	2.62	7.53
50		3.25	7.69	285.02	2.69	7.53
100		3.53	8.01	285.90	2.90	8.02
2	292.50	4.76	9.30	300.52	4.15	9.10
5		5.39	9.90	301.21	4.70	9.70
10		5.86	10.33	301.68	5.12	10.33
20		6.35	10.74	302.13	5.54	11.00
30		6.63	10.98	302.38	5.78	11.00
40		6.83	11.15	302.55	5.94	11.00
50		6.99	11.27	302.70	6.06	11.00
100		7.48	11.66	303.13	6.40	11.72
2	315.00	3.61	8.10	313.21	3.21	8.02
5		4.07	8.61	313.09	3.59	8.55
10		4.42	8.97	313.02	3.89	9.10
20		4.77	9.32	312.96	4.20	9.10
30		4.98	9.51	312.92	4.38	9.70
40		5.12	9.65	312.89	4.51	9.70
50		5.24	9.76	312.88	4.61	9.70
100		5.59	10.08	312.83	4.92	10.33
2	337.50	2.50	6.74	329.46	2.19	6.64
5		3.07	7.48	328.08	2.64	7.53
10		3.47	7.94	327.27	2.95	8.02
20		3.85	8.37	326.57	3.25	8.55
30		4.08	8.61	326.19	3.43	8.55

40		4.24	8.78	325.94	3.56	8.55
50		4.36	8.91	325.75	3.66	9.10
100		4.75	9.30	325.19	3.97	9.10

Tab 59. Extreme wave data at control point N2 (depth approximately of 7m).

Tr [anni]	Offshore			Depth = 7 m		
	Dir	Hs	Tp	Dir	Hs	Tp
	[°N]	[m]	[s]	[°N]	[m]	[s]
2	0.00	2.22	6.36	336.72	1.68	6.23
5		2.58	6.85	334.94	1.93	6.64
10		2.79	7.13	334.01	2.08	7.07
20		2.99	7.38	333.20	2.23	7.53
30		3.11	7.52	332.78	2.32	7.53
40		3.19	7.61	332.49	2.37	7.53
50		3.25	7.68	332.28	2.42	7.53
100		3.44	7.90	331.63	2.56	8.02
2	270.00	1.72	5.59	284.09	1.45	5.49
5		2.29	6.46	286.79	1.90	6.64
10		2.60	6.88	288.05	2.15	7.07
20		2.89	7.24	289.08	2.39	7.07
30		3.05	7.44	289.69	2.52	7.53
40		3.16	7.58	290.06	2.61	7.53
50		3.25	7.69	290.35	2.68	7.53
100		3.53	8.01	291.20	2.90	8.02
2	292.50	4.76	9.30	302.55	3.82	9.10
5		5.39	9.90	303.23	4.08	9.70
10		5.86	10.33	303.67	4.24	10.33
20		6.35	10.74	304.02	4.38	11.00
30		6.63	10.98	304.22	4.44	11.00
40		6.83	11.15	304.35	4.49	11.00
50		6.99	11.27	304.37	4.52	11.00
100		7.48	11.66	304.50	4.61	11.72
2	315.00	3.61	8.10	311.54	3.14	8.02
5		4.07	8.61	311.42	3.45	8.55
10		4.42	8.97	311.36	3.65	9.10
20		4.77	9.32	311.33	3.83	9.10
30		4.98	9.51	311.32	3.93	9.70
40		5.12	9.65	311.31	3.98	9.70
50		5.24	9.76	311.30	4.03	9.70
100		5.59	10.08	311.29	4.16	10.33
2	337.50	2.50	6.74	324.72	2.11	6.64
5		3.07	7.48	323.18	2.58	7.53

10		3.47	7.94	322.31	2.89	8.02
20		3.85	8.37	321.55	3.16	8.55
30		4.08	8.61	321.15	3.31	8.55
40		4.24	8.78	320.89	3.41	8.55
50		4.36	8.91	320.70	3.48	9.10
100		4.75	9.30	320.16	3.69	9.10

Tab 60. Extreme wave data at control point S1 (depth approximately of 15m).

Tr [anni]	Offshore			Depth = 15 m		
	Dir	Hs	Tp	Dir	Hs	Tp
	[°N]	[m]	[s]	[°N]	[m]	[s]
2	0.00	2.22	6.36	345.98	1.85	6.23
5		2.58	6.85	344.89	2.11	6.64
10		2.79	7.13	344.26	2.27	7.07
20		2.99	7.38	343.69	2.41	7.53
30		3.11	7.52	343.38	2.50	7.53
40		3.19	7.61	343.16	2.56	7.53
50		3.25	7.68	343.00	2.61	7.53
100		3.44	7.90	342.51	2.75	8.02
2	270.00	1.72	5.59	280.60	1.51	5.49
5		2.29	6.46	282.46	1.96	6.23
10		2.60	6.88	283.47	2.20	6.64
20		2.89	7.24	284.34	2.43	7.07
30		3.05	7.44	284.98	2.55	7.53
40		3.16	7.58	285.32	2.63	7.53
50		3.25	7.69	285.58	2.70	7.53
100		3.53	8.01	286.37	2.92	8.02
2	292.50	4.76	9.30	301.34	4.20	9.10
5		5.39	9.90	302.03	4.76	9.70
10		5.86	10.33	302.50	5.18	10.33
20		6.35	10.74	302.97	5.61	11.00
30		6.63	10.98	303.25	5.84	11.00
40		6.83	11.15	303.45	5.99	11.00
50		6.99	11.27	303.61	6.10	11.00
100		7.48	11.66	304.09	6.41	11.72
2	315.00	3.61	8.10	314.97	3.27	8.02
5		4.07	8.61	314.93	3.67	8.55
10		4.42	8.97	314.89	3.97	9.10
20		4.77	9.32	314.85	4.28	9.10
30		4.98	9.51	314.83	4.47	9.70
40		5.12	9.65	314.81	4.60	9.70

50		5.24	9.76	314.79	4.70	9.70
100		5.59	10.08	314.75	5.02	10.33
2	337.50	2.50	6.74	331.73	2.25	6.64
5		3.07	7.48	330.72	2.72	7.53
10		3.47	7.94	330.09	3.05	8.02
20		3.85	8.37	329.51	3.36	8.55
30		4.08	8.61	329.18	3.55	8.55
40		4.24	8.78	328.95	3.69	8.55
50		4.36	8.91	328.78	3.79	9.10
100		4.75	9.30	328.25	4.12	9.10

Tab 61. Extreme wave data at control point S2 (depth approximately of 7m).

Tr [anni]	Offshore			Depth = 7m		
	Dir	Hs	Tp	Dir	Hs	Tp
	[°N]	[m]	[s]	[°N]	[m]	[s]
2	0.00	2.22	339.48	1.71	6.23	339.48
5		2.58	338.30	1.98	6.64	338.30
10		2.79	337.69	2.15	7.07	337.69
20		2.99	337.17	2.31	7.53	337.17
30		3.11	336.89	2.40	7.53	336.89
40		3.19	336.71	2.46	7.53	336.71
50		3.25	336.57	2.50	7.53	336.57
100		3.44	336.15	2.65	8.02	336.15
2	270.00	1.72	290.21	1.39	5.49	290.21
5		2.29	293.38	1.85	6.64	293.38
10		2.60	294.77	2.12	7.07	294.77
20		2.89	295.92	2.36	7.07	295.92
30		3.05	296.54	2.49	7.53	296.54
40		3.16	296.96	2.58	7.53	296.96
50		3.25	297.28	2.65	7.53	297.28
100		3.53	298.23	2.85	8.02	298.23
2	292.50	4.76	308.51	3.52	9.10	308.51
5		5.39	309.53	3.67	9.70	309.53
10		5.86	310.16	3.77	10.33	310.16
20		6.35	310.69	3.84	11.00	310.69
30		6.63	310.97	3.88	11.00	310.97
40		6.83	311.15	3.91	11.00	311.15
50		6.99	311.26	3.93	11.00	311.26
100		7.48	311.60	3.99	11.72	311.60
2	315.00	3.61	315.47	3.05	8.02	315.47

5		4.07	315.25	3.27	8.55	315.25
10		4.42	315.13	3.40	9.10	315.13
20		4.77	315.15	3.51	9.10	315.15
30		4.98	315.35	3.57	9.70	315.35
40		5.12	315.48	3.61	9.70	315.48
50		5.24	315.44	3.64	9.70	315.44
100		5.59	315.77	3.72	10.33	315.77
2	337.50	2.50	328.65	2.17	6.64	328.65
5		3.07	327.88	2.65	7.53	327.88
10		3.47	327.46	2.94	8.02	327.46
20		3.85	327.12	3.16	8.55	327.12
30		4.08	326.95	3.27	8.55	326.95
40		4.24	326.85	3.34	8.55	326.85
50		4.36	326.77	3.38	9.10	326.77
100		4.75	326.54	3.52	9.10	326.54

Sediment transport

In the last decades, several studies on the littoral sediment transport along the coast of Gaza Strip have been carried out. The following table reports a brief list of the most relevant ones.

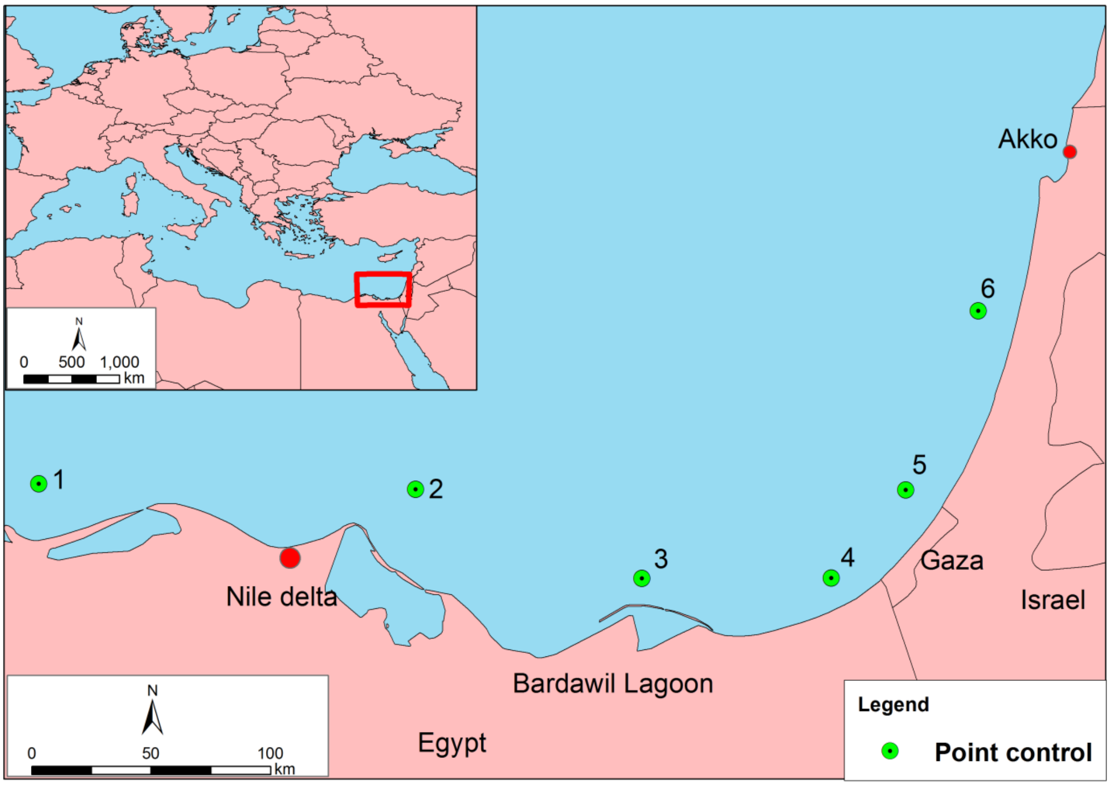
Tab 62. Sediment transport analyses for the study area.

Authors	Year	Topic
Inman et al.	1976	Application of nearshore processes to the Nile Delta
Goldsmith et al.	1980	Sediment transport model of the southeastern Mediterranean coast
Carmel et al.	1984	Transport of Nile sand along the south eastern Mediterranean cost
Carmel et al.	1985	Directional wave measurement at Haifa, Israel, and sediment transport along the Nile littoral cell
Abualtayef et al.	2012	The impact of Gaza Fishing harbor on the Mediterranean coast of Gaza
Abualtayef et al.	2013	Mitigation measures for Gaza coastal erosion

The main results of such studies can be summarized as follows:

- mineralogical analyses of the coastal sediments from Alexandria eastward to Sinai and Israel show that the Nile River has been the source of sediment for beaches up to Akko. As indicated by Carmel et al. (1984), this suggests that the coastline from Nile delta up to Akko has to be considered a littoral cell. In general, littoral cell contains a complete cycle of sedimentation including sources, transport paths, and sinks.
- construction of the Low Aswan dam in 1902 and the High Aswan dam in 1964 has almost completely interrupted the Nile River sediment discharge to the sea;
- currently, the principal sediment source is the erosion of Nile delta (Inman,1976);
- Bardawil lagoon sandbar continues to act as a significant source of sediment (Inman,1976);
- the sediment transport gradually decreases going away from the Nile delta (860 x 10^3 m^3 $year^{-1}$) toward Gaza (190 x 10^3 m^3 $year^{-1}$) (Carmel et al., 1985).

Figure 88. Littoral cell localization.



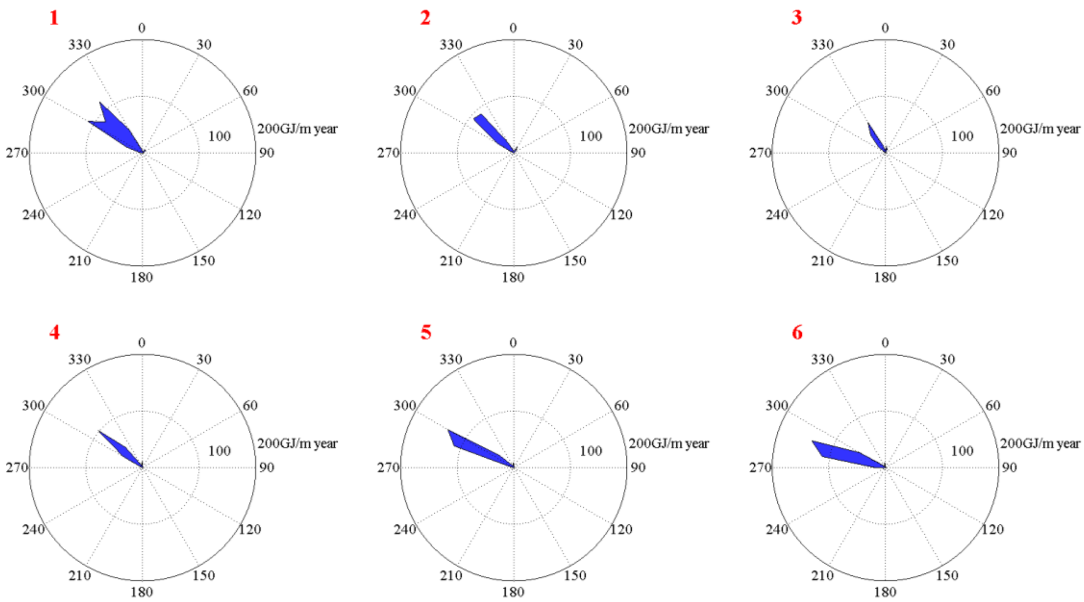
For a generic direction θ the wave energy was estimated by means of the following relationship:

$$E_\theta = \sum_{i=1}^{n} \frac{1}{8} \cdot \rho \cdot g \cdot H_{s,i}^2 \cdot L \cdot \frac{ns}{T_m} \cdot f_{\theta,i} \qquad (10)$$

where ρ is the water density, L is the wave length, T_m is the mean wave period, *ns* is the number of second in one year, $f_{\theta,i}$ is the occurrence frequency of the wave with the significant wave height $H_{s,i}$

The analysis illustrated in the following figure shows that waves characterized by the greatest energy come from sector 270 ÷ 330°N. These waves generate a long-shore sediment transport, which is directed from west-to-east and southwest-to-northeast.

Figure 89. Wave energy distribution at the 6 control points.



More in detail, the study performed by Abualtayef *et al.* (2012) was focused on the impact of Gaza fishing harbor. The authors analyzed the temporal pattern of shoreline change. The analyses were carried out using image processing technique (ERDAS) and Geographical Information System platform. Five satellite Landsat images were used for the years: 1972, 1984, 1998, 2003, and 2010. The study allowed to observe: the accretion of shoreline on the South of Gaza port with a growth rate of 16 x 10^3 m^2 $year^{-1}$; the erosion on the North side of Gaza port with an erosion rate equal to 14 x 10^3 m^2 $year^{-1}$.

Tab 63. Sediment transport analysis of the impact of Gaza fishing harbor (Abualtayef et al. ,2012).

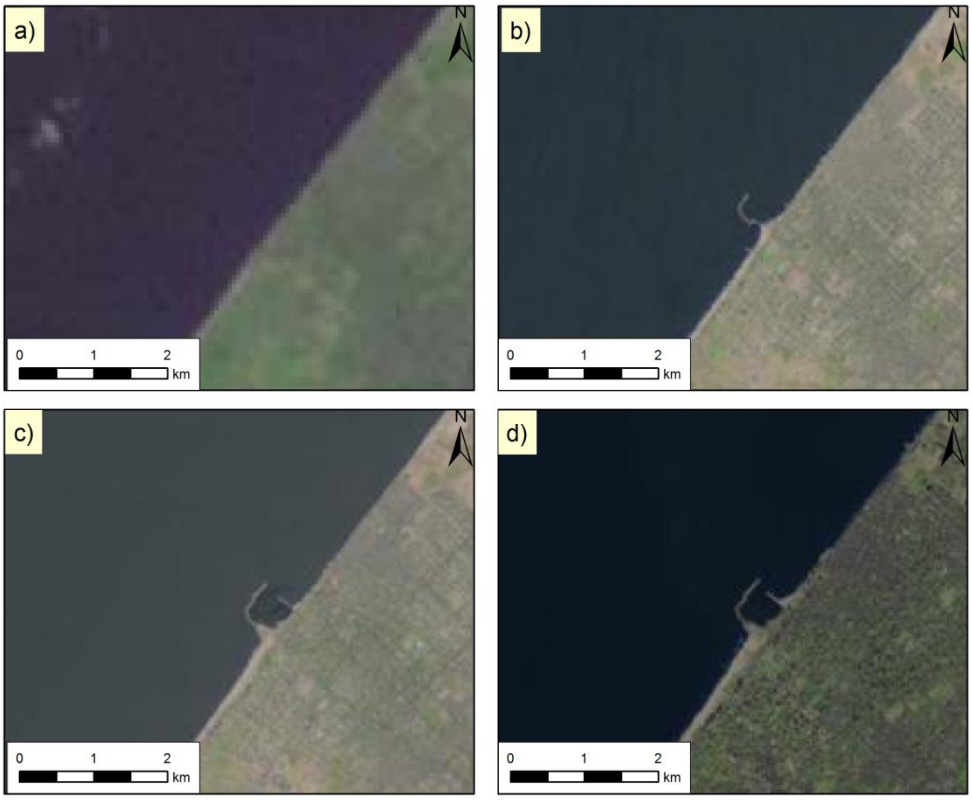
Years	Erosion	Accretion
[-]	[area x 10^3 m^2 $year^{-1}$]	[area x 10^3 m^2 $year^{-1}$]
1972 - 1984	180	122
1984 – 1998	200	224
1998 - 2003	8	190
2003 - 2010	143	70
Total (1972 - 2010)	531	606

The temporal evolution of the shoreline follows:
a) shows the situation before the port construction;
b) shows an intermediate phase of the port construction;
c) shows the final configuration of the port;
d) point out the accretion of shoreline on the South of Gaza port.

The satellite images were downloaded from the web of the U.S. Geological Survey's Earth Resources Observation (USGS). The characteristic of the satellite images are:

a) is a Landsat Multispectral Scanner image (data acquisition 1992, resolution 60m);
b) and c) are Landsat Thematic Mapper images (data acquisition 1998 and 2002, resolution 30m);
d) is an Operational Land Imager (OLI) image (data acquisition 2015, resolution 30m).

Figure 90. Evolution of the shoreline: a) 1992; b) 1998; c) 2002; d) 2015. (Map data: U.S. Geological Survey's Earth Resources Observation)



The analysis of the evolution of the shoreline close to the fishing port of Gaza demonstrates that a relevant sediment transport from South to North is present. Therefore, each future infrastructure that will be built in shallow water will impact on the morphology of the shoreline.

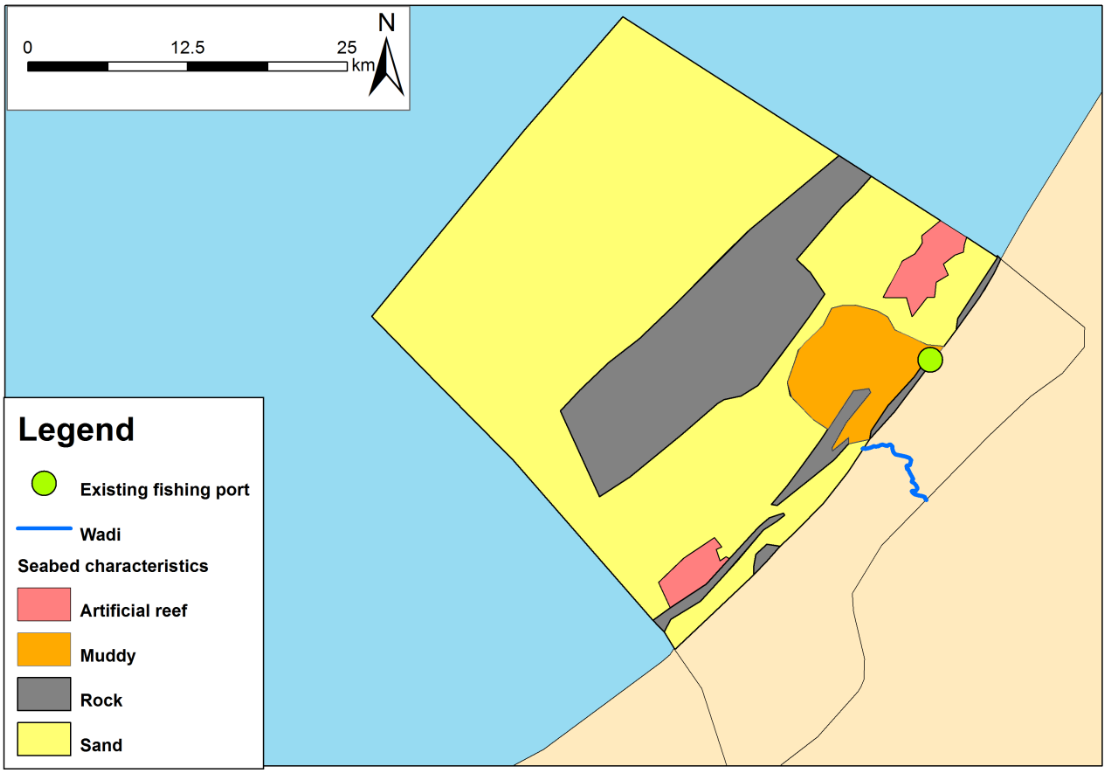
Additional information on Gaza Strip

Additional information which could be useful for the port design are reported in the following sections.

Sea bottom sediments

Going from sea to land, the coastal profile can be divided into the seabed, the beach, the dune face or Kurkar cliffs, and the adjacent body of the dune or cliff plateau (Afifi, 2003).
The sea bottom sediments mainly consist of sand up to 25m depth and there are some muddy places near the Wadi Gaza. Down to a depth of 100m, the seabed is irregular with rocky grounds (Ali, 2002). On the beach and near the shoreline of the Kurkar outcrops and rocky ridges can be seen at many locations.

Figure 91. Seabed characteristics. (Source: Gaza Coastland Marine Environmental Action Programme, Ministry of Environmental Affair, 2006)



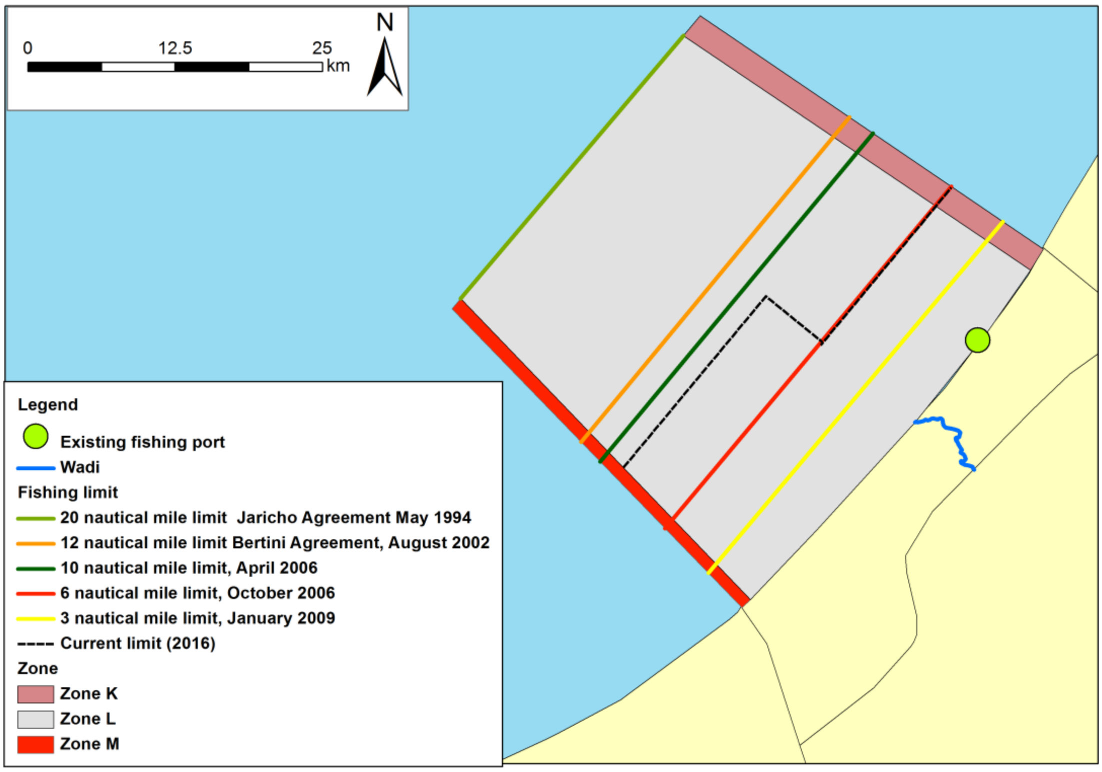
Land use

The protection plan approved by the Superior Planning Council (August 2005) indicated the reserved green areas, located in the North part and in the South part of the Gaza Strip.

Figure 92. National Protection Plan: the green areas in the map indicate the reserved areas.

Fishing limits
Currently fishermen can operate within a bounded zone as a result of the limits imposed by Israel and Egypt. In particular, a "Maritime Activity Zone K", 1.5 nautical miles wide, was established as a "security" buffer from the Israeli sea boundary inside Gaza's territorial waters. A similar "Maritime Activity Zone M" one nautical mile wide was demarcated as a buffer on the sea border with Egypt. The offshore area in between these security zones was designated as "Maritime Activity Zone L" within which Palestinian fishermen were allowed to fish. However the offshore fishing limit has undergone many changes.
The Gaza-Jericho Agreement of May 1994 established a fishing limit for Gaza at 20 nautical miles from the shore. In August 2002, the Bertini Agreement restricted Gaza's fishing limit to 12 nautical miles from shore.
In April 2006, as part of the ever-tightening noose around Hamas-ruled Gaza, the Israeli Navy began enforcing a 10 nautical mile limit on Gaza fishermen.
In October 2006, it changed its mind and reduced the limit to 6 nautical miles. After the Israeli military assault on Gaza in December 2008 and January 2009, even the larger fishing boats cannot venture more than 3 nautical miles from shore owing to the Israeli Navy enforcing a new limit.
Currently the fishing limit is 9 nautical miles South of Wadi, while it is 6 nautical miles North of Wadi. These limits were confirmed by the technicians of the Gaza Port Authority during the meeting of the 9th May 2016.

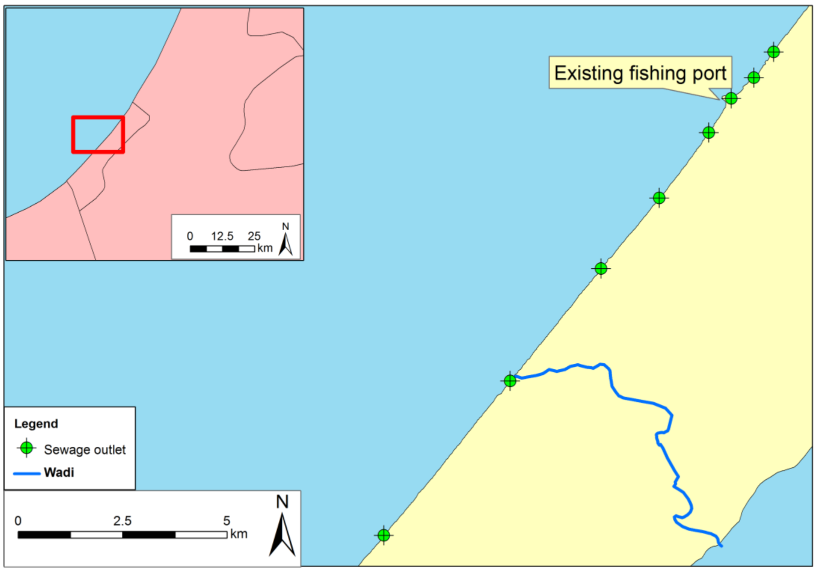
Figure 93.HistoricalEvolution of Fishing Limits in Gaza Strip



Sewage Outlet

The raw sewage is considered the major source of marine pollution in Gaza Strip. Sewage water discharge points are concentrated on the beaches of Gaza city, Al Shate' refugee camp and Deir El Balah.

Figure 94. Location of the main sewage outlets in Gaza Strip (Source: Gaza Strip Mapping Movement and Access, GISHA, 2013).



Another sewage outlet is also located into the fishing port basin, as shown in the following figure.

Figure 95. Sewage outlet inside the fishing port basin (photo extracted from the report "Waste Water and Marine environment in the Gaza strip" by Dr. Abed El Fattah Nazmi Abed Rabu).

9. Public Transport

The Palestinian public transport is analyzed in its most crucial aspects, namely: 1) Organizational-Institutional Setup; 2) Supply, and; 3) Demand. The analysis that follows is finalized at retracing a comprehensive description of public transport system currently operating in West Bank and Gaza Strip and at identifying issues and problems affecting the transport sub-sector.

Public Transport Organization-Institutional Setup

The organizational set-up of public bus transport has not fundamentally changed since its inception under the British mandate with permits of route concessions to private companies. The main authority for public transit is the MOT, which is responsible for the official issuing of permits, licenses, tariffs, regulations, policy and monitoring of the public transport sector. The police force is normally responsible for inspections of registration validity of vehicles, the maximum number of passengers, and some safety aspects. The infrastructure of terminals at main hubs and stations is mainly the responsibility of municipalities.

Public Transport Supply

The public transport system in the West Bank consists primarily of bus services, shared-taxis, and cab taxis, whereas shared-taxi is the most used and common mode. All public transit modes are privately owned and operated.

Bus public transport in the West Bank and Gaza strip is very poor. There are 239 public transport bus routes assigned by the MOT for 86 private bus operating companies in the West Bank.[39] In the Gaza Strip, there are roughly one to five bus companies in operation with a fleet of less than 100 buses. The 933 buses in the West Bank include 320 full size (more than 39 seats), 10 medium-size buses (26-39 seats) and 603 mini-buses (less than 26 seats).
Bus public transport is mainly operated without fixed schedule or stops. Normally buses, particularly mini buses, depart when full or close to being full. Few routes have set bus schedules, but in most cases, the schedule is not reliable. Bus daily operation times are generally limited to daytime hours only. The in-vehicle travel time for buses is comparable to private vehicles, especially on inter-city routes. However, the out-of-vehicle time, particularly waiting and transfer times could be significant since there are no bus schedules or the bus schedules are not reliable. Furthermore, the walking time to bus routes could also be significant, even though there are mostly no regular stops. The bus fares are fixed, normally lower than shared taxis, and certainly lower than cab taxis. However, fares are not highly competitive with private vehicle costs. For a single private vehicle occupancy, the public transit in the West Bank and Gaza Strip is still most economical, but much less comfortable and convenient.
Status is a significant criterion for mode choice in West Bank and Gaza Strip and the Middle East in general. For two passengers in a private vehicle the cost is comparable to public buses,

[39]The number of routes presented here comes from the document: "Table of Vehicles and Routes for Public Transport" received by Mr. Yousef Darawshi, Deputy General Traffic Observer at MoT, on May 18, 2015.
This document shows an enormous increase of routes provision, if compared with the data presented in the World Bank report no. T7717-GZ "Technical Assistance in the Passenger Transport Sector Development", April 2009. In 2009 the registered routes of public transport in Palestine were154 operated by 86 operators; in 2015 the routes are 239, but the number of operators is just 89.

particularly for the variable costs (fuel, maintenance, etc.), but for three or more passengers the private vehicle is certainly more economical than any public transport mode in the West Bank and Gaza Strip, including buses. Hence, car pooling among colleagues is a common practice, which in turn could become a profit generators for car owners.

The perceived bus safety records is generally good; however, with the increase percentage of mini-buses, there appears to be a tendency of such mini buses to speed during peak periods at uncongested segments in order to maximize the number of roundtrips during these peak periods. 12% of the bus fleet in the West Bank is older than 20 years, which, according to MOT prescriptions,[40] should not be operational.
Beside the buses used for public transport purposes, three other types of buses are licensed by the MOT: 1) touristic buses; 2) buses for hire for special purposes, and; 3) buses owned by schools or private companies for student and/or employee transport. The MOT records for the West Bank shows that there are 5 touristic bus companies with 34 buses, 5 bus companies for hire for special purpose with 89 buses and 1080 buses are licensed for schools and private companies for student and/or employee transport.[41]
Public transport buses operate on diesel fuel, thus they significantly contribute to air and noise pollutions.

Figure 96. Typical Buses and Minibuses, Ramallah, 2015

<u>Shared taxis</u> may be classified as para-transit or semi-transit as they do not meet the basic requirement of public transport services, i.e. set travel times or time schedule. There are 369 intercity and 48 intra-city shared taxi routes in the West Bank and there is a number of intercity and intra-city routes in the Gaza Strip, but without any accurate estimate of their numbers. A shared taxi should operate according to its pre-assigned route, otherwise the shared taxi is used as a taxicab; despite said regulations, there are substantial infringements. The routes have a start and final stop with no set intermediate stops. Shared taxis depart only when they are full and they may discharge and pick-up passengers anywhere within theirpreset route. The inter-city and peri-urban shared taxis are usually seven passengers, while intra-urban taxis are usually four passengers. The travel times for inter-city shared taxis are comparable, on the average less than that of private passengers; the out-of-vehicle times could be significant, especially waiting times during off-peak periods at low traffic volume routes, since shared-taxis only depart when they are full.

Buses and Shared Taxi compose a network made of hubs and routes and are spread in all the West Bank whereas Ramallah and Nablus are the main two hubs. East Jerusalem used to be

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[40]MoT, Ministry of Transport Records – West Bank Registered Public Transit Buses as of July 2015, July 2015
[41]MoT, cited from: World Bank report no. T7717-GZ "Technical Assistance in the Passenger Transport Sector Development", April 2009

the main public transport hub for the West Bank and Gaza Strip until Israel has created numerous and severe travel restrictions to East Jerusalem. However, if such restrictions are removed (particularly for the scenario of an independent Palestinian State), East Jerusalem is expect to regain its prominence as the main transport hub. Two main international border crossing points have public transport service, namely the Jordan River Bridge border crossing in the West Bank and the Rafah border crossing between the Gaza Strip and Egypt. Minimum public transport operations are also allowed at the border crossings between the West Bank and Israel, namely at Bayt Hanoun and Qalandiya check-point.

Figure 97. Typical Buses and Minibuses, Ramallah, 2015

Cab taxi could be classified as para-transit. They do not have fixed routes or schedules. They generally only operate within cities or villages near a city. Each office is assigned and located to one of the governorates. Fares are usually flat per the entire city or fixed fare between two generally outlined zones within the city. There was a serious attempt by the MOT to enforce a meter fare based on distance and idle time, but taxis in the West Bank and Gaza Strip mostly do not use it. This mode is usually not a common commute mode for passengers. It is mostly used for social, shopping or other special events. Almost all cab taxi operate on diesel fuel and significantly contribute to air and noise pollutions.

Figure 98. Typical Buses and Minibuses, Ramallah, 2015

Public Transport Infrastructure and Services

The only public transport service in the West Bank and the Gaza Strip is bus and share taxi terminals and stops. Bus terminals in the Palestinian cities are located in the city centres. Usually there is only one bus stop per route, and often two or more routes share one bus stop in the terminal. Often bus stops at terminals are not assigned to any bus company or route and operate on a first come first served basis. There are bus terminals in the main cities in the West Bank and Gaza Strip. Most of the terminals are not adequate and are in poor conditions. Bus public transit suffered the decline in ridership in the past three decades and buildings have replaced some of the former bus terminals (like in Ramallah and in Al Bireh); currently Hebron and Bethlehem have relatively the best bus terminals for about 10 full size buses each, while East Jerusalem has two bus terminals that can only have limited lines. There are mostly no organized bus storage areas for overnight or off-peak peak periods for buses. This causes some inconvenient parking of buses in various unsuitable locations in cities and towns.
Beside bus terminals, there are also shared taxi terminals in the form of parking lots, parking garages, or street curb areas at the origins and final destinations of shared taxi routes. Thus, in every major city there are one or several locations for shared taxi terminals, designated for several routes. Shared taxi terminals are also located outside of the main urban area, close to big attractors, like universities.

Public Transport Demand

Due to the lack of ongoing and/or undergone studies investigating current demand for public transport in West Bank and Gaza Strip, at the moment there is not reliable related travel demand data. A full fledges traffic count campaign is being conducted in around 100 locations in West Bank and Gaza. The observed traffic data will constitute a solid 4-hour sample of modal split during the peak interval during a regular weekday. Other previous studies have revealed that around 25 to 50% of traffic is composed of shared and cab taxis, resulting in a high number of movements that take place by public transport.
Some data about non-domestic movements demand is also available, through Palestinian government's constant monitoring of transits at the Terminal in Jericho to/and from the Jordan Bridge border crossing, showing that each day around 5,000 passengers cross the al Karama border crossing in both directions.[42]

Identification of Issues and Problems

Some of the main issues and problems that face the public transport sector in the West Bank and the Gaza Strip are:

- Travel restrictions by Israelis;
- Unstable political, economic and social conditions;
- Israeli policies for restriction of purchase of certain buses and taxis, such as European and US vehicle;
- Poor transportation infrastructure;
- Difficulty of enforcement of regulations by the Palestinian National Authority, especially in areas C of the West Bank (more than 60% of the West Bank) where Israel retains full control. Hence, there are significant numbers of none registered vehicles in villages in the West Bank that act as private vehicles and vehicles for hire (shared or cab taxis), some for these vehicles are in poor conditions and have no insurance;

[42] Israeli Ports Authority website (http://www.iaa.gov.il/en-US/borders/alenbi/Pages/Statistic.aspx), Accessed July 2015

- The existing system of concession for bus routes is not efficient;
- Poor management by operators;
- Public transport in West Bank and Gaza Strip has a rather poor image and it is perceived as an unreliable mode of transport.
- Use of public transport buses for special events (weddings, school trips, social/political events, etc.,) disrupts the bus regular service;
- High number of shared taxis and cab taxis used for public transport compared to buses, which are inefficient compared to buses for high demand routes.
- There is an essential need to replace old buses, more than 60% of all buses are older than 10 years and more than 90% of full size buses are older than 10 years.
- There is a need for bus maintenance centres;
- There is a need for a better planning and management of transport vehicles, drivers, and schedules.

Ongoing and Future Projects for Public Transport

Beside the “Road and Transportation Master Plan for Gaza and the West Bank” there is only one more project currently ongoing and dedicated to public transport: the ORIO Project. Funded by the Netherlands (32.5 million €) ORIO aims at redefining the existing system of concession for bus routes by identifying three main areas of concession, namely: the north, the centre, and the south regions of the West Bank. The final goal is to improve the quality of public transport provision establishing regular and scheduled bus services covering each of the aforesaid areas.

10. Border Crossings

The Border Crossings between West Bank, Gaza Strip and the neighbouring countries are important components of the national and regional transport network. An in-depth analysis of the current situation of border crossings in West Bank and Gaza Strip is here presented. Further to a brief description of the current situation of border crossings with neighbouring countries border crossing agreements and protocols are illustrated highlighting their influence on operational efficiency and road traffic generation. Policy changes and alterations in overall political conditions had often affected transportation costs and that had had a direct impact on the rate of investment and growth of the economy, hence influencing significantly the economy, in general, and internal and external trade, in particular. The 2006 Investment Climate Assessment showed that in 2000 nearly 60% of West Bank enterprises made a significant share of their sales outside of their home city but by 2006 this number had dropped to less than 40%. The Palestinian Central Bureau of Statistics (PCBS) also reports a decline in the number of establishments engaged in internal trade in the overall Palestinian territory; from 49,491 in 2004 to 43,912 in 2006.[43] The restrictions on movement of goods and services are reflected in higher labour transport costs: *"[...] Constraints on trucks carrying cargo in the form of stationary and flying checkpoints, requirements for back-to-back transfers of cargo at selected locations, closure of main roads to Palestinian registered trucks, and restrictions on road maintenance activities within the West Bank result in long transit times transit times are almost doubled in two of the selected routes, Ramallah-Nablus and Hebron-Jenin, and in the case of the route between Ramallah and Jerusalem travel times are four times higher than under no restrictions."* [44]

Border Crossing with Neighboring Countries

The main border crossings with **Jordan** are:

- Al Karama Bridge;
- Damyeh Bridge;
- King Abdullah Bridge, and;
- Al Maleh Bridge.

The only border crossing with **Egypt** is:

- Rafah Border Crossing.

The main Crossing Points (CPs) between the **West Bank and Israel** are:

- Al Jalameh Crossing Point;
- Bisan Crossing Point;
- Taybeh/ Farun Crossing Point (Sha'ar Ephraim), and;
- Tarqumiya.

These are not recognised by the Palestinians and considered as illegal, despite calling them as Trade Facilitation Crossings.
At these CPs, operations are back-to-back for Palestinian trucks, while no restrictions are imposed on Israeli trucks, allowing these to operate as door-to-door carriers.

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[43]World Bank Report No. 46807, December 2008
[44]World Bank Report No. 46807, December 2008

There is a few other crossing points that are dedicated for passengers only. Some of these are open for Palestinians, while all of these are open to Israelis. These include Qalandia Check Point between Jerusalem and Ramallah, Bethlehem Crossing between Jerusalem and Bethlehem, Al Jib Crossing northwest of Jerusalem, Al Zayyem east of Jerusalem, Qalqilya-Kfar Saba crossing in the northwest, Al Thahiriyah crossing in the south, located south of Hebron, etc.

The main Crossing Points (CPs) between the **Gaza Strip and Israel** are: Karem Abu Salem Crossing Point (Kerem Shalom); al Montar Crossing Point (Karni); al Shujaieh Crossing Point (Nahal Oz), and; Sufa.

In addition, there is one other CP which is dedicated for passengers only, whether these are Palestinians, Israelis, or internationals. This crossing point is located at Beit Hanoun (Erez).
Recent unpublished information on operations of Gaza Strip Crossings Karem Abu-Salem and Rafah reveals that there had been a total of 13,302 truckloads which entered Gaza Strip during June to August 2014.
The following figures provide detailed information on the border crossings and crossing points.

Figure 99. Border Crossings with Neighbouring Countries (Map), 2015

Figure 100. Border Crossing and Crossing Points Locations (Table), 2015

	with Jordan			
1	**Al Karama (Karameh/ King Hussein/ Shunna/ Allenby) Bridge**			
	Location	Located on Jordan River 5km east of Jericho		
	Status	In operation		
	Use	Passenger and Freight		
	Customs	1993/2000: Israeli and Palestinian,	until 2000-to-date: Israeli only	
	Traffic Volumes	2010: ¬ 15,000 trucks	2011: ¬ 22,500 trucks	2012: ¬ 30,000 trucks
2	**Damiya (Prince Muhammad) Bridge**			
	Location	Located on Jordan River about 30km north of al Karama Bridge		
	Status	Not in operation: closed since 2002		
	Use	Previously for passenger and freight, then for freight only		
3	**King Abdullah Bridge**			
	Location	Located just north of the Dead Sea, on Jordan River		
	Status	Not in operation: damaged and closed since 1948		
4	**Al Maleh Bridge**			
	Location	Located at the furthest northern point on the border with Jordan on River Jordan		
	Status	Not in operation: damaged and closed since 1948		
	with Egypt			
5	**Rafah Crossing**			
	Location	South of Gaza Strip		
	Status	Not in operation regularly		
	Use	Passenger and Freight, until the Access and Movement Agreement - AMA		
		Passengers only (2006)	Passengers occasionaly (current)	
	with Israel from the West Bank			
6	**Al Jalameh Crossing Point**			
	Location	Located north of Jenin		
	Status	In operation		
	Customs	Israeli		
7	**Bisan Crossin Point**			
	Location	Located north of Jordan Valley		
	Status	In operation		
	Use	Specific agricultural commodities/ Palestinian workers working inside the green line		
	Customs	Israeli		
8	**Taybeh/ Fahrun (Sha'ar Ephraim) Crossing Point**			
	Location	Located west of Tulkarm		
	Status	In operation		
	Use	Palestinians with special permit		
	Customs	Israeli		
9	**Tarqumiya Crossing Point**			
	Location	Located west of Hebron		
	Status	In operation		
	Use	Palestinians with special permit		
	Customs	Israeli		
	with Israel from the Gaza Strip			
10	**Karem Abu Salem (Karem Shalom) Crossing Point**			
	Location	Located in the south east on the connecting borders with Egypt and Israel		
	Status	In operation		
	Use	Commercial, humanitarian goods and fuel		
	Customs	Israeli		

11	**Al Montar (Karni) Crossing Point**			
	Location	Located just east of the Industrial Estate of Gaza		
	Status	Not in operation since 2007 (trucks)	2008 (cement line)	2011 (grain conveyor)
	Use	Specific agricultural commodities/ Palestinian workers working inside the green line		
	Customs	Israeli		
12	**Al Shujaieh (Nahal Oz) Crossing Point**			
	Location	Located east of Gaza City		
	Status	Not in operation since 2010		
	Use	(Previously) Mainly fuel		
	Customs	Israeli		
13	**Sufa Crossing Point**			
	Location	Located in the south east of the Gaza Strip		
	Status	Not in operation since 2011		
	Customs	Israeli		
14	**Bayt Hanun (Erez) Crossing Point**			
	Location	Located in the north of Gaza Strip, close to Jabaliya		
	Status	In operation		
	Use	Commercial and humanitarian goods		
	Customs	Israeli		

A thorough survey campaign of all existing Border Crossing Points was carried out. The results are reported in *¶AX.14 – Border Crossing Survey.*

Border Crossing Agreements and Protocols

There is reference to movement, access, and border crossing arrangements in almost all the agreements between the Palestinians and Israelis starting from the Declaration of Principles on Interim Self-Government Arrangements signed in Oslo on September 13, 1993. Despite this, the vast majority of the related agreements in this regard were frozen or bypassed by the Israeli authorities for claimed reasons, including those related to security.
The parts of the agreements related to border crossing, movement, and access between the Palestinians and Israelis are illustrated hereafter:

- 1993, Declaration of Principles on Interim Self-Government Arrangements (Oslo Accords);
- 1994, Agreement on the Gaza Strip and Jericho Area;
- 1994, Paris Economic Protocol;
- 1998, Wye River Memorandum;
- 1999, Sharm al Sheik Memorandum;
- 1999, Gaza Seaport Agreement;
- 1999, Protocol Concerning Safe Passage between the West Bank and the Gaza Strip, and;
- 2005, Agreement on Movement and Access. 7.8 Road Transport.

11. Freight and Logistics

Institutional Framework of Freight and Logistics

Several Palestinian Institutions are currently involved in freight and logistics, providing different supports to this strategic sector, namely: 1)Policy setting; 2)Trade facilities and logistics and; 3) Business services.

Institutions for Policy Setting
The following list provides information concerning the Institutions involved in the setting of policies for freight and logistics in West Bank and Gaza Strip:

- MoNE, responsible for: dealing with foreign trade card ,import licenses solving crossing point problems; foreign company registration; issui the certificate of origin; re-exporting transaction, and exporter certificates;
- MoPAD, ensuring the implementation of a Palestinian-owned development agenda, and directing the coordination among donor bodies and PNA institutions;
- MoF, in charge of managing customs, border authorities and collecting the taxes on imports/exports, when applied;
- PSI, providing free advice to industry and service providers on conformity to market entry requirements into the State of West Bank and Gaza Strip, or for Palestinian exporters targeting worldwide markets;
- MoA, responsible for the national rural and agriculture development and the post-harvest handling of agricultural products and food industry;
- MoT, responsible for the implementation of policies and actions in support of transport development in the State of West Bank and Gaza Strip;
- MoH, maintaining the quality standards for food imported and exported and responsible for issuing the certificate of health.

Institutions for Trade Facilities and Logistics
The following list provides information concerning the Institutions concerned with the actual delivery of trade and export solutions to both public and private stakeholders of freight and logistics in West Bank and Gaza Strip:

- PCBS, responsible for: establishing a comprehensive and unified statistical system to serve Palestinian authorities as an instrument of guidance for diagnosing problems and evaluating progress made; participating effectively in building administrative records and central registers to meet the administrative, and; statistical needs of Palestinian society, and Publishing a statistical yearbook annually;
- PFI, serving as a key institution to guide exporters through various procedures;
- MoPAD, ensuring the implementation of a Palestinian-owned development agenda, and directing the coordination among donor bodies and PNA institutions;
- PFCCIA, helping local chambers of commerce to meet the requirements of the global business environment, and creating links to global markets and works with small and medium enterprises to improve their performance;
- PALTRADE, holding the mandate for developing exports, advocating for a business enabling environment and fostering international business practices and standards among Palestinian professionals;
- PIPA, promoting the State of West Bank and Gaza Strip's advantages to investors while keeping a close eye on legal developments and their impact on the private sector;

- PSI, providing free advice to industry and service providers on conformity to market entry requirements into the State of West Bank and Gaza Strip, or for Palestinian exporters targeting worldwide markets, and;
- PBA, defends the interests of its members and the private sector at large in order to improve the business climate in the West Bank and Gaza Strip.

Institutions for Business Services
The following list provides information about the associations, or major representatives, of commercial service providers used by exporters to effect international trade transactions.

- PSC, committed to strengthening Palestinian shippers' capacities through collective negotiations, cooperative agreements, advisory services, training workshops, study tours, tailor-made services, and providing up-to-date information, and;
- PIEA, represents the interest of its members by lobbying the PNA and institutions for policies and regulations in favor of streamlining.

Freight and Logistics Traffic Volume

The total of traffic volume of freight and logistics in West Bank and Gaza Strip is composed of both domestic and international traffic. The available data about these two types of traffic are released by the PCBS that reveals that in 2012 the total domestic trade traffic accounted for about $2,8m[45] and that it was composed by wholesale and retail trade (60%), wholesale trade (26%), and wholesale and retail trade for motor vehicle (14%). Concerning the international trade activities, the latest data published by the PCBS show that in 2012 the total traffic was of $277,000 circa, composed by 43%of imports and 57% of exports.[46]
The main groups of countries interested by the Palestinian exports and imports were:
Asian Countries (exports: $790,978 / imports::$4,350,773);
Asian Arab Countries (exports: $81,472 / imports::$171,484), and;
EU Members (exports: $13,153 / imports::$455,472).[47]

Freight and Logistics Traffic Routes

Freight and Logistics routes in West Bank and Gaza Strip can be distinguished into domestic and international routes. Before proceeding to the description of the commercial routes currently operating in West Bank and Gaza Strip, a brief introduction about the role of Israel in the sector is necessary. Indeed the majority of Palestinian foreign trade is controlled and logistically managed by Israel, because of its control over ports and airports, while domestic Palestinian trade between the West Bank and the Gaza Strip goes through routes that are also controlled by Israel.[48] In 2013Israel accounted for 92% of the total value of Palestinian territories' trade with its main partners, 92% of total imports and 91% of exports.[49]
Domestic Freight Routes
The main internal trade routes within the West Bank include:

- Jenin-Hebron Road (Road No. 60);

[45]PCBS, Internal Trade Statistics 2012
[46]PCBS, Foreign Trade Statistics 2014. In 2013 the total international traffic increased reaching $322,115 (42% of imports and 58% of exports).
[47]PCBS, Foreign Trade Statistics 2014.
[48]PalTrade, Logistics Strategy.
[49]PCBS, Foreign Trade Statistics 2014.

- Tukarm-Nablus Road (Road No. 57);
- Hebron – Al Karama Road (Road No. 60 and Road No. 1);
- Jordan Valley Road (<u>Road</u> No. 90), and;
- Ramallah-Jerusalem, through Baytunia crossing point.

The main internal trade routes within the Gaza Strip include:
- Salah Eddin Road, and;
- Al Karama Road.

Freight and logistics traffic between the West Bank and the Gaza Strip used to go through the Crossing Points with Israel using within Greenline network. However, there has been almost no freight traffic between these regions since the Israeli tight closure on Gaza Strip, started in 2007.

Figure 101. Domestic freight route map Map; source: Shaath, A., and Hamdan, M., International Trade and Transport Facilitation for West Bank and Gaza Strip. Working Paper for MoT

<u>International Freight Routes</u>

Palestinian international trade with the bordering countries of Israel, Egypt and Jordan occurs through several border crossings located along the Palestinian borders.
Palestinian International Trade with other countries located in Europe, Asia, and America is conducted through Israeli facilities such as Ben Gurion International Airport, Haifa Seaport, Ashdod Seaport, and Eilat Port.
Palestinian enterprises are mainly dependent on Israeli facilities for international trade. Since 2000 Israel has been imposing complex security measures, including a system of checkpoints/roadblocks, and cumbersome customs and overland transport procedures at all crossing points. As a result, market access benefits are lost by the prohibitive transaction costs facing Palestinian shippers (exporters and importers). This has been eroding the competitiveness of Palestinian exports, posing trade barriers of greater significance than tariffs. It is estimated that Palestinian trade-related transaction costs in 2003 were already at least 30% higher than those accrued at the eve of the crisis (September 2000).[50] The set of restrictions imposed on Palestinian international trade contradicts the Paris Protocol, which grants Palestinian and Israeli traders equal treatment ad border crossings.[51]

[50]Report on UNCTAD assistance to the Palestinian people, 2007.
[51]Palestine Trade Center PALTRADE, Trade Impediments, Volume 1, Issue 5, August, 2005.