SAPIENZA
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FUTURE DEMAND FORECAST AND PROJECT DEVELOPMENT OF AFRO-MEDITERRANEAN RAILWAY NETWORK CONNECTING MOROCCO, ALGERIA, TUNISIA, LIBYA AND EGYPT

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In executing this connectivity, I am sure that this can bring a faster development and economic growth as you can see that the countries with greater internal and global connectivity are the countries with higher HDI and economic development.

I want to dedicate this Master thesis to my parents for their endless love and support, and their persistent confidence in my ability to complete this journey.

GEORGY KALLUKALAM TOM

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Abbreviations and Acronyms

AMRN	Afro-Mediterranean Railway Network
ADT	Average Daily Traffic
AFESD	Arab Fund for Economic and Social Development
AMCEN	African Ministerial Conference on the Environment
ANESR F	Agence Nationale d'Etudes et de Suivi de la Realisation des Investissements
ARC	Aqaba Railways Corporation
ARNS	Arab Railway Network Study
Bin	Billion
BOT	Built Operate Transfer
CEA	Project Cost - Effectiveness Analysis
CEN	European Committee for Standardization
CENELEC	Comite Europeen de Normalisation Electrotechnique
CIA	Central Intelligence Agency
CBA	Cost Benefit Analysis
CIT	International Rail Transport Committee
CIV	Uniform Rules concerning the Contract of International Carriage of Passengers
COTIF	Convention concerning International Carriage by Rail
CTFM	Comite des Transports Ferroviaires Maghrebins - Maghreb Railway Transport
EL	Existing Link
ERTMS	European Rail Traffic Management System
ESCWA	UN Economic and Social Commission for Western Asia
ES	Environmental Sustainability Index
EU	European Union
EUROMED	Euro-Mediterranean
GCC	Cooperation Council for the Arab States of the Gulf
GDP	Gross Domestic Product
GSM-R	Global System Mobile Radio
JICA	Japan International Cooperation Agency
UCN	International Union for Conservation of Nature
LGV	Ligne a grande vitesse - High Speed Line
MCA	Multi-Criteria Analysis
MEDA	Mediterranean Countries
MEnA	Ministry of Environmental Affairs
Mio	Million
ML	Missing Link
MOCH	Ministry of Construction and Housing
MOT	Ministry of Transport
NG	Narrow gauge
O\D	Origin - Destination
ONCF	Office Nationale des Chemins de Fer - National Railways Office
OTIF	Intergovernmental Organisation for International Carriage by Rail
pkm	Passenger-kilometer
RIC	Agreement governing the exchange and use of coaches in international traffic
RID	Regulations concerning the International Carriage of Dangerous Goods by Rail

RIV	Regulations governing the reciprocal use of wagons in international traffic
RTAP	Regional Transport Action Plan
SG	Standard gauge
SMCF	Societe Marocaine des Chemains de Fer - Moroccan Railways Company
SNCFT	Societe Nationale des Chemins de Fer Tunisiens - Tunisian Railways National
SREAP	Sub-regional environmental action plans
TEU	Twenty-foot Equivalent Unit
tkm	Ton-kilometer
TLC	Telecommunication
TOR	Terms of Reference
TS s	Technical Specifications for Interoperability
UACF	Arab Union of Railways
UAR	African Union for Railways
UC	Under Construction Link
UIC	Union Internationale des Chemins de Fer - International Union of Railways
UP	Upgrading Link
USD	United States Dollar
UT	Traffic Units
VEC	Valued Environmenal Components
WB	World Bank

1. Introduction

This Report includes the results of the of the Afro-Mediterranean Railway Network Study, defined "FUTURE DEMAND FORECAST AND PROJECT DEVELOPMENT OF AFRO-MEDITERRANEAN RAILWAY NETWORK CONNECTING MOROCCO, ALGERIA, TUNISIA, LIBYA AND EGYPT" and draws findings on the future implementation of the African Railway Network.

This will give the statement on the need for the Afro Mediterranean railway network between the countries (Morocco, Algeria, Tunisia, Libya, Egypt) and result in the sustainable social and economic development of the country.

For the purpose of the study the extensive data's aimed at identifying the status of the existing and planned railway lines and the development pains of Afro-Mediterranean have been taken from the AFSED report of Arab railway network study and documents of national and regional value of the African Mediterranean countries.

At first analytical study on the different characteristics of the existing and planned railway lines, as well as of the regions crossed by those lines including its sub-composition in terms of "missing links", links "to be upgraded", existing sections considered "suitable" for the purposes of an integrated regional network or lines "under construction" was carried out.

Research Background

Transportation is one of the most pervasive activities in any society or economy, since it enables the movement of people and goods from where they are to where they wish, or they are planned to be. Among other transportation services, public transport systems contribute to a large share of the movement of people, and therefore have an extremely important socio-economic role. Having a paramount importance for the quality and the stability of any socio-economic system, public transport planning, design and operations contribute to the equilibrium and the sustainable evolution of any region. Its importance for the founding, shaping and growth of urban agglomerations has been widely recognised, and the planning and design of transport services has had a major role in determining the locations of cities, their size, form and structure.

Transport and mobility are indispensable elements of socio-economic development in any country, and between countries. The free movement of people and goods is one of the foundations underpinning the creation of the European Union. Exercising this right is one of the main reasons for creating this common area of exchange and community. In fact, the European Commission's own White Paper on transport, European transport policy for 2010: time to decide, recognises that mobility is a right and even a conquest resulting from the community transport policy implemented since 1992. Ultimately, free movement is one of the key expressions of the concept of freedom. The right to mobility is therefore a right recognised in Europe but this does not mean the right to a specific mobility model. Actually, a right to sustainable, universal mobility is recognised and these two adjectives appear in the EU's White Paper on Transport.

In many regions the urban landscape is changing, and monocentric cities are transformed into polycentric urban areas, which in turn have an impact on transportation characteristics such as trip lengths and mode choices. These features indirectly affect social characteristics such as urban densities and the distribution/dispersion of activities. Mobility may on the other hand be a determining factor in social exclusion. Social exclusion can occur to individuals or entire communities of people, which are systematically blocked from rights, opportunities and resources (e.g. housing, employment, healthcare, civic engagement, democratic participation and due process) that are normally available to members of society and which are key to social integration, for instance, if lack of access to public transport or a vehicle prevents a person from getting to a job, training course, job centre or doctor's surgery, entertainment venues. Car ownership and access to a car vary widely.

Expansion for the transport system

Public transport efficiency is therefore a powerful instrument to influence the city structure and growth, as much as the latter determines the potential demand for public transport. Public transport strongly determines the accessibility of an area, therefore its attractiveness for locating activities depending on the resulting land uses and prices, which in turn creates mobility needs. This completes a cycle, where the same accessibility of the different activity locations determines car dependency (or independency), trip frequencies, modal splits, and ultimately the observed spatio-temporal traffic patterns and passenger flows, which finally determine the travel costs for each transport sub-system.

On the other hand, improved accessibility increases travel speeds and therefore reduces the gradient of the accessibility line. Improved accessibility therefore means the same distance can be travelled over a shorter period of time, but it also means that a greater distance can be travelled over the same period of time.

Energy consumption and efficiency

It is not possible to discuss the role of public transport in sustainable urban development without discussing the energy consumption associated with the different means of transport. Targets for urban expansion and for the accessibility of cities and regions are needed to limit the increasing daily number of kilometres travelled by transportation users, which in combination with modal split target, determine the total energy consumed/wasted by the mobility, and the related negative externalities caused by it.

As stated by the Brundtland Commission of the United Nations in 1987, “sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” In accordance to this definition, the higher the consumption of non-renewable fuel, the less sustainable the mean of transport should be considered.

By final energy we intend the amount of energy consumed in the vehicle's tank or at its connection with the electricity grid. From an energy point of view, railway transport always consumes less per ton in movement than road transport, since it has less mechanical resistance. In comparison with road transport, the railway energy problem lies in the use of greater tares for equivalent transport, especially in passenger rail, notably increasing gravity resistance (gradients) and acceleration resistance and, to a lesser extent, mechanical resistance. Establishing a unit of consumption that allows us to compare railways with the other modes of transport is not easy. The different types of resistance that affect final energy consumption are, in turn, affected by the layout of the line, how it is used, the vehicle characteristics (e.g. vehicle category, age, fuel type, tare), features provided for passengers (auxiliary equipment, air conditioning), driving behaviour (e.g. aggressive style), the meteorology (e.g. rain, wind speed), etc.

Energy consumption in urban zones (in MJ/person-km), taking into account the average occupancy of the vehicles in urban zones (Source: UITP).

	Construction	**Operation**	**Total**
Bicycle	0.5	0.3	**0.8**
Tram	0.7	1.4	**2.1**
Bus	0.7	2.1	**2.8**
Heavy rail way	0.9	1.9	**2.8**
Petrol car	1.4	3.0	**4.4**
Diesel car	1.4	3.3	**4.7**

2. Aim

This paper is intended to review the Mediterranean African railway network connecting Morocco, Algeria, Tunisia, Libya and Egypt through railway and to determine the cost effectiveness of the project for the priority of its implementation.

Objective of the project

- "To provide a comprehensive vision for the need of the integration and linkage of the Mediterranean Africa networks connecting Morocco, Algeria, Tunisia, Libya and Egypt, as well as measures to reduce the inter-African transportation costs and to increase its efficiency and safety, both for goods and passengers
- To determine the corridor locations for the railway linkage between Morocco, Algeria, Tunisia, Libya, Egypt as well as neighbouring states, in addition to drawing their technical specifications
- Important issues affecting the interoperability of the network and uniformed in order to ensure the possibility of different systems to inter-operate.
- To highlight missing sections for the railway linkage between these countries and tabulating the lengths of these section in each Country's territories.
- To provide the preliminary features and priorities of various railway lines on the basis of cost effectiveness of the link.

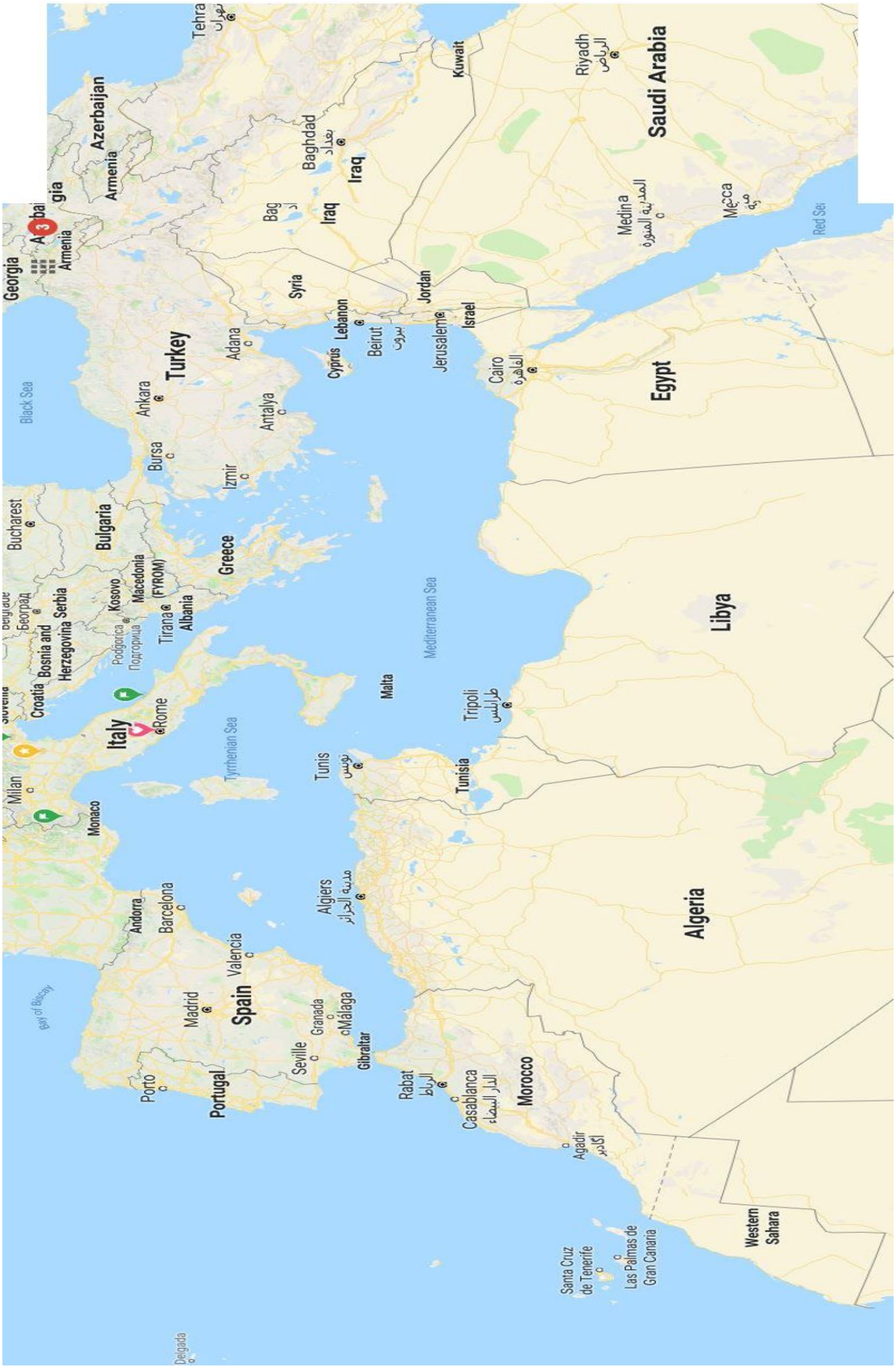
The investment’s benefit (cost effectiveness) is also a relevant topic of my thesis in order to have the priority of its construction. In this "project cost-effectiveness" is used as the essential indicator to establish the ranking of priorities, having in mind on the one side the very objective of this project, which is to serve traffic, and from the other the economic and social scope of the future railway network, which will serve as integration of the regional economies, favouring trade exchanges and human mobility.

The total cost for the implementation of infrastructure of African Mediterranean railway network by means of an overall assessment of the works to be carried out (and costs to be born) for the implementation of the missing sections of the network and the upgrading of the existing sections for this the data are obtained from inspection Report of AFSED.

The integration of railway increases the accessibility to these regions from the Mediterranean part of Europe through the Mediterranean Sea and on the other part to form a linkage to the Arab railway network, thus help in the development of these countries. This improve the travel time, travel distance, and travel costs directly affect the mobility and accessibility of the region.

This will also give the statement on the need for the Afro Mediterranean railway network between the countries (Morocco, Algeria, Tunisia, Libya, Egypt) and change to the social and economic development of the country.

Figure 2.1 shows the globe view of countries along the Mediterranean Sea



3. Research methodology

Data research was difficult in some Countries because of lack of data or data represented in much aggregated terms, not useful for the analysis. Most of the data used and method for research have been provided by AFESD, ITALFERR, DAR AL OMRAN, CIA and national transport studies were available and have been used for the demand model.

Main studies used in the Report are from:

Statistics Bureau of Countries and in some case Customs web-site were important sources in order to estimate variables needed for the model implementation, as population and employment per administrative zone for passenger demand or import and export for freight demand.

As regards passenger transport demand analysis, socio-economic data, such as population, number of employees and respective historical trends, have been obtained, per each Country, from databases of National institute of Statistics and National statistical Bureau. Furthermore, details have been collected using Google map

DATA ANALYSIS

As mentioned in data collection methodology two sets of data is collected.

The data regarding the project's demand forecasts, technical and operational features is reviewed analytically in consideration with European standards in practice.

The infrastructure characteristics such as rolling stock, train capacity, station locations, stop patterns and train operations plan are systematically assessed and stated.

RESEARCH ASSUMPTIONS AND LIMITATIONS

Several assumptions and limitations were considered while developing the thesis and in overall research process. Both assumptions and limitations may, in certain ways, limit the findings of this research. However, without those assumptions, with limited data availability is impossible. In general, the assumptions and limitations applied in this research are as follows:

- Making use of direct GIS tools to identify the travel pattern and other parameters is not achievable by research of this magnitude. Instead, this research uses Google Map's GIS services. In fact, network analysis is a traditional GIS capability that Google is performing.

- Population and other social indicators were necessary for respective years. But, in some countries the last census was not even accessible. Thus, these values are estimated with necessary assumptions.

SUMMARY

The general approach and outline of the research methodology is carried out as per the above-mentioned procedures and criteria.

As regards freight transport demand analysis, per each Country, in-coming and out-coming freight volumes have been obtained from the website "Global Edge", which includes data from other databases such as World Bank and CIA Fact books, and the trade statistic database of PIERS (a comprehensive database of waterborne trade activity in the world http:IIwww.piers.com), in which the monetary values of import- export freight traffics, per partner or commodity, are reported.

Traffic by sea data have been collected from websites of Transport Ministry and Port Authority for each port of each Country.

Data collection has been affected by numerous difficulties connected to the high heterogeneity of available Moreover, analogies and assumptions among Countries are taken where absence of data has been found.

For the task of cost estimation of the missing and upgrading lines the data and specific costs adopted in previous studies tender documents by ITALFERR and AFESD (i.e. the Study for railway development Strategy, ITALFERR Studies in Egypt and Syria etc.) are taken.

Macro-economic indicators were primarily obtained from the World Bank web site, http://data.worldbank.org/.

4. Identification of time horizons and economic scenarios

The investments costs will be considered "as they are" at the present time. In order to identify priorities, it was decided to adopt a unique economic scenario (in terms of GDP variation and consequently transport demand variation). Economic growth based on the estimated trend related to socio-economic variables. Economic growth was precisely related to the uncertainties that now do not allow to draw reliable assumptions about a possible geographical unevenness as regards local growths. This uniqueness in terms of possible economic growth is anyhow an approach that is limited to the study.

The GDP per capita is between 2,000 and 10,000 USD in Libya, Algeria, Tunisia, Morocco, Syria and Egypt

It should be noticed that a criterion of classification based on GDP per capita has a rough correspondence with other social criteria. This is quite expected, but the following table and diagrams better clarify the adopted criteria.

Table 4.1 shows - Classification of countries based on their socio-economic parameters

Country	GDP (current million USD)	GDP per capita (current USD)	Health expenditure per capita (current USD)
Libya	62,360.45	9,713.58	298.88
Algeria	140,576.53	4,028.50	173.04
Tunisia	39,560.91	3,792.08	211.17
Morocco	91,374.71	2,811.03	119.85
Egypt	188,412.88	2,270.05	101.39

Source: World Bank

The above table gives an idea about the rough accordance between the basic criterion (the GDP per capita) and other social parameters, like per-capita health expenditure. Such accordance is clearly noticeable inside the next pictures.

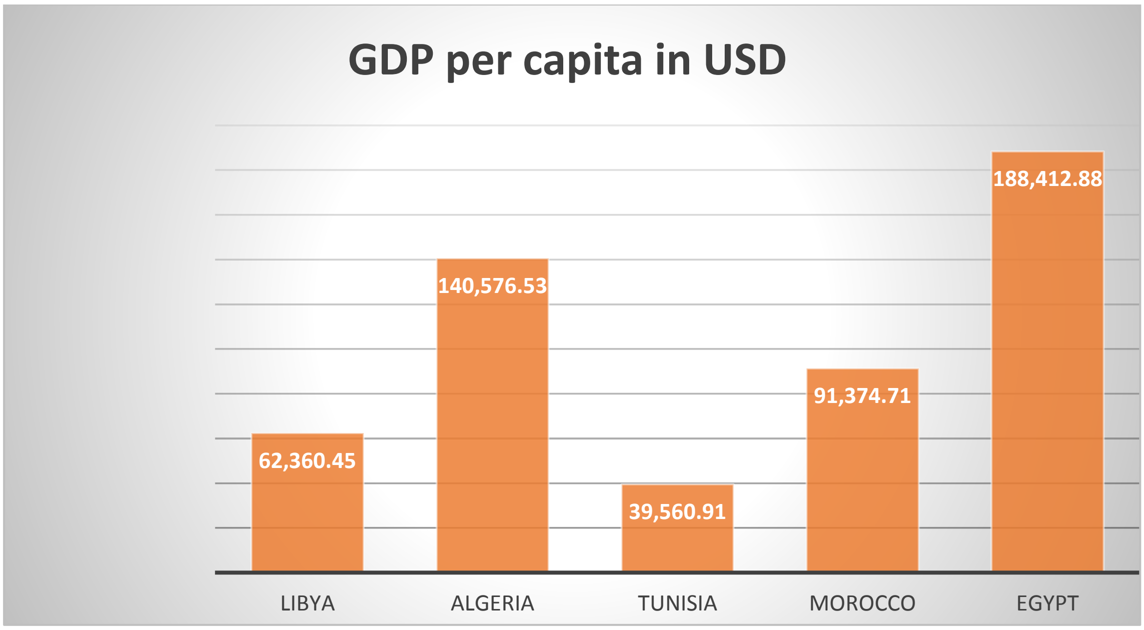


Figure 4.1 shows - GDP per capita

The second picture Figure is referred to the per-capita health expenditure, which is a welfare indicator.

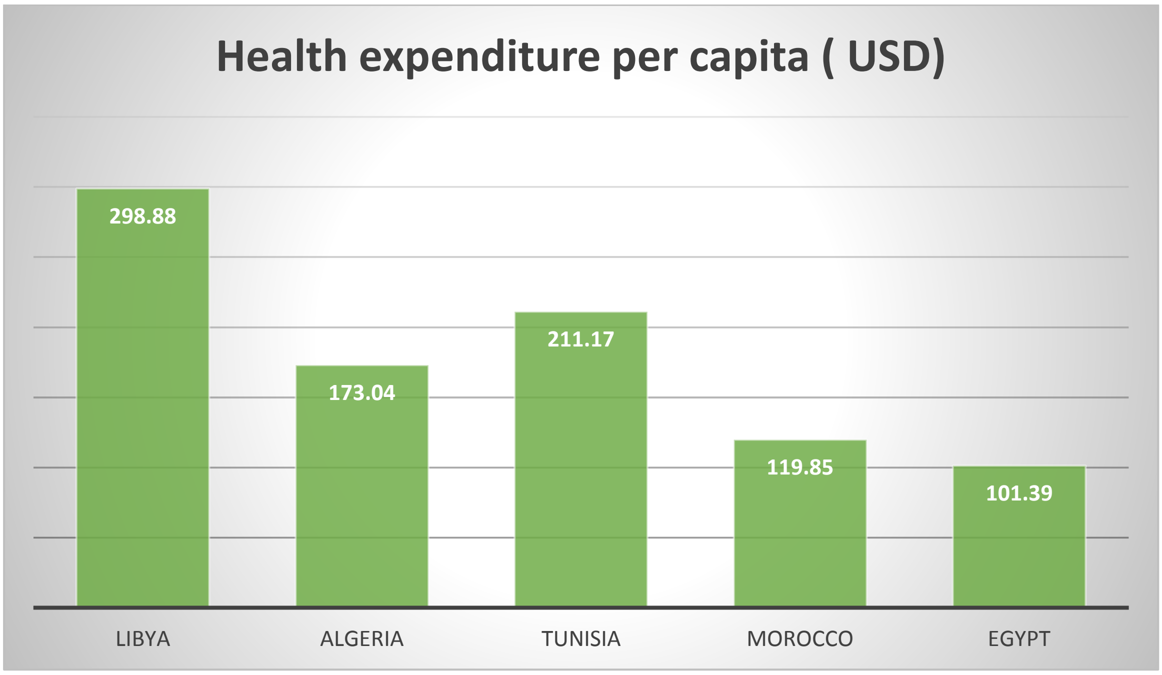


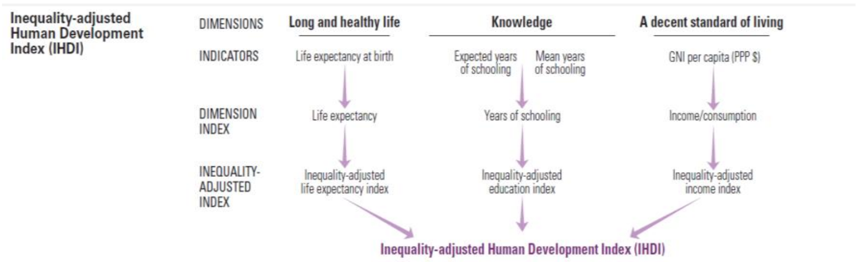
Figure 4.2 shows- Health expenditure per capita.

All data referred to Source: World Bank.

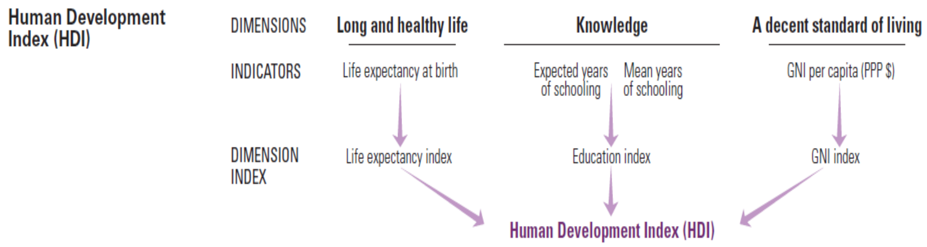
4.1 Inequality-adjusted Human Development Index (IHDI) and Human Development Index (HDI)

The IHDI combines a country's average achievements in health, education and income with how those achievements are distributed among country's population by "discounting" each dimension's average value according to its level of inequality. Thus, the IHDI is distribution-sensitive average level of HD. Two countries with different distributions of achievements can have the same average HDI value. Under perfect equality the IHDI is equal to the HDI but falls below the HDI when inequality rises.

The difference between the IHDI and HDI is the human development cost of inequality, also termed – the loss to human development due to inequality. The IHDI allows a direct link to inequalities in dimensions, it can inform policies towards inequality reduction, and leads to better understanding of inequalities across population and their contribution to the overall human development cost. A recent measure of inequality in the HDI, the Coefficient of human inequality, is calculated as an average inequality across three dimensions.



The HDI was created to emphasize that people and their capabilities should be the ultimate criteria for assessing the development of a country, not economic growth alone.The health dimension is assessed by life expectancy at birth, the education dimension is measured by mean of years of schooling for adults aged 25 years and more and expected years of schooling for children of school entering age. The standard of living dimension is measured by gross national income per capita. The HDI simplifies and captures only part of what human development entails. It does not reflect on inequalities, poverty, human security, empowerment, etc.

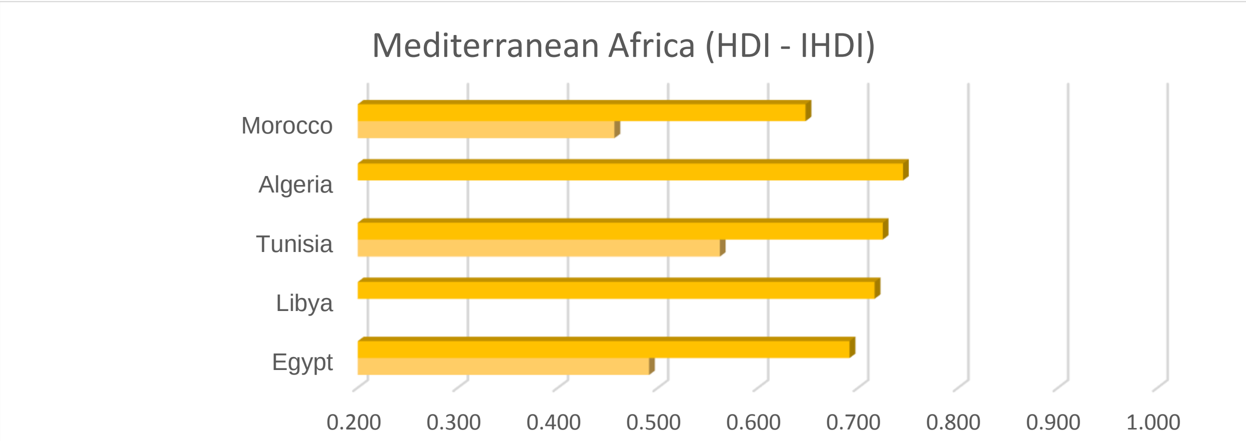


The table below can help us to know the growing trend of the countries with respect to HDI and IHDI of the countries. This will be helpful for the future study of the project.

Table 4.1.1 shows HDI-IHDI of Mediterranean Africa 2016

Ranking	Mediterranean Africa (HDI - IHDI)	HDI	IHDI	HDI-IHDI
123	**Morocco**	0.647	0.456	0.191
83	**Algeria**	0.745		0.745
97	**Tunisia**	0.725	0.562	0.163
102	**Libya**	0.716		0.716
111	**Egypt**	0.691	0.491	0.200

The figure 4.1.1 below shows the difference of inequality in HDI 2016



In connecting the Afro-Mediterranean railway between African countries it will also be a connection to the Mediterranean Europe which can bring development. This connection will also be a part of the Arab core railway and thus having a relationship with the eastern Africa and Arab Countries.

The table and figure below show the HDI of the Mediterranean Europe, Mediterranean Africa and eastern and southern part of Mediterranean Africa. The HDI of these countries are compared in order to understand the level of development of neighbouring countries of the study area. The higher the HDI of the neighbouring countries and having an effective connectivity will result in the faster economic development.

Table 4.1.2 shows the HDI of South of Afro-Mediterranean

Sahelian Africa (HDI)	2000	2007	2010	2015
Chad	0.3	0.338	0.37	0.396
Ethiopia	0.283	0.378	0.411	0.448
Mali	0.297	0.36	0.404	0.442
Mauritania	0.444	0.475	0.487	0.513
Niger	0.255	0.298	0.323	0.353
Nigeria		0.481	0.5	0.527
Senegal	0.381	0.435	0.455	0.494
Sudan	0.399	0.444	0.463	0.49
-	0.337	0.401	0.427	0.458
HDI growth rate		0.80%		0.63%

Table 4.1.2 shows the HDI of Afro-Mediterranean countries

Mediterranean Africa (HDI)	2000	2007	2010	2015
Egypt	0.612	0.651	0.671	0.691
Algeria	0.644	0.697	0.724	0.745
Morocco	0.53	0.589	0.612	0.647
Libya	0.732	0.757	0.756	0.716
Tunisia	0.654	0.701	0.714	0.725
-	**0.634**	**0.679**	**0.695**	**0.705**
HDI growth rate		0.56%		0.29%

Table 4.1.2 shows the HDI of Mediterranean Europe

Mediterranean Europe (HDI)	2000	2007	2010	2015
Spain	0.825	0.854	0.867	0.884
Italy	0.828	0.866	0.872	0.887
France	0.849	0.877	0.882	0.897
Greece	0.801	0.853	0.86	0.866
Croatia	0.749	0.8	0.808	0.827
Montenegro		0.774	0.792	0.807
Albania	0.662	0.713	0.738	0.764
Bosnia and Herzegovina		0.71	0.711	0.75
Serbia	0.709	0.749	0.757	0.776
Slovenia	0.824	0.869	0.876	0.89
Turkey	0.653	0.705	0.737	0.767
-	**0.767**	**0.797**	**0.809**	**0.829**
HDI growth rate		0.38%		0.35%

Table 4.1.2 shows the HDI of Northern Europe

Northern Europe (HDI)	2000	2007	2010	2015
United Kingdom	0.866	0.892	0.902	0.91
Norway	0.917	0.936	0.939	0.949
Belgium	0.873	0.874	0.884	0.896
Finland	0.856	0.876	0.878	0.895
Sweden	0.877	0.897	0.901	0.913
Switzerland	0.888	0.914	0.932	0.939

Netherlands	0.878	0.905	0.911	0.924
Germany	0.86	0.903	0.912	0.926
Ireland	0.857	0.908	0.909	0.923
	0.875	**0.901**	**0.908**	**0.919**
HDI growth rate		0.32%		0.21%

Figure 4.2.1 below shows the graphical representation of HDI trends of the neighbouring countries

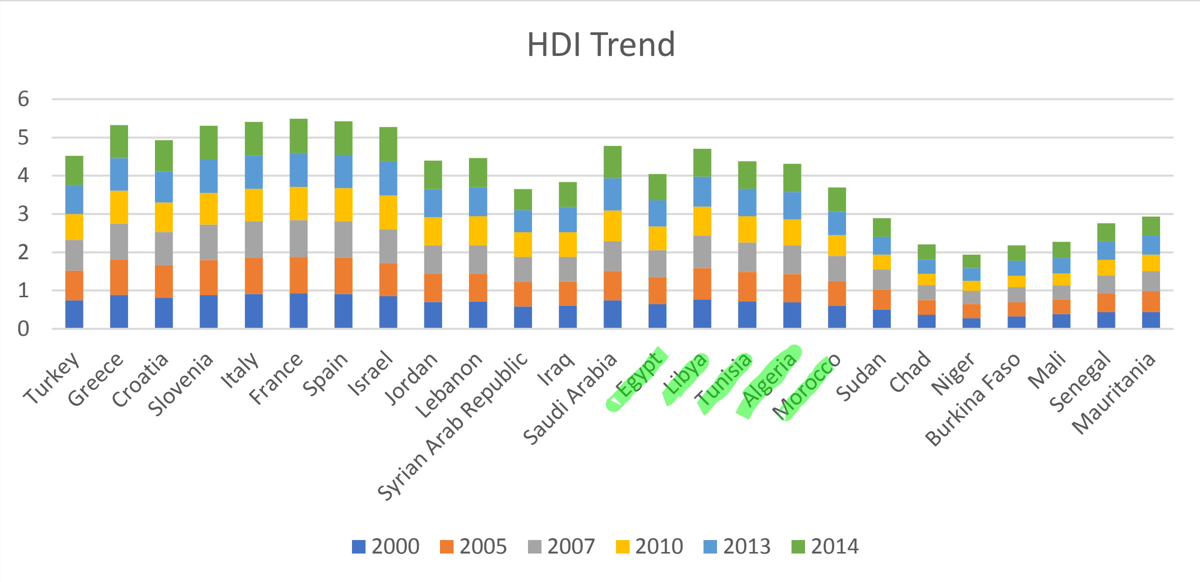
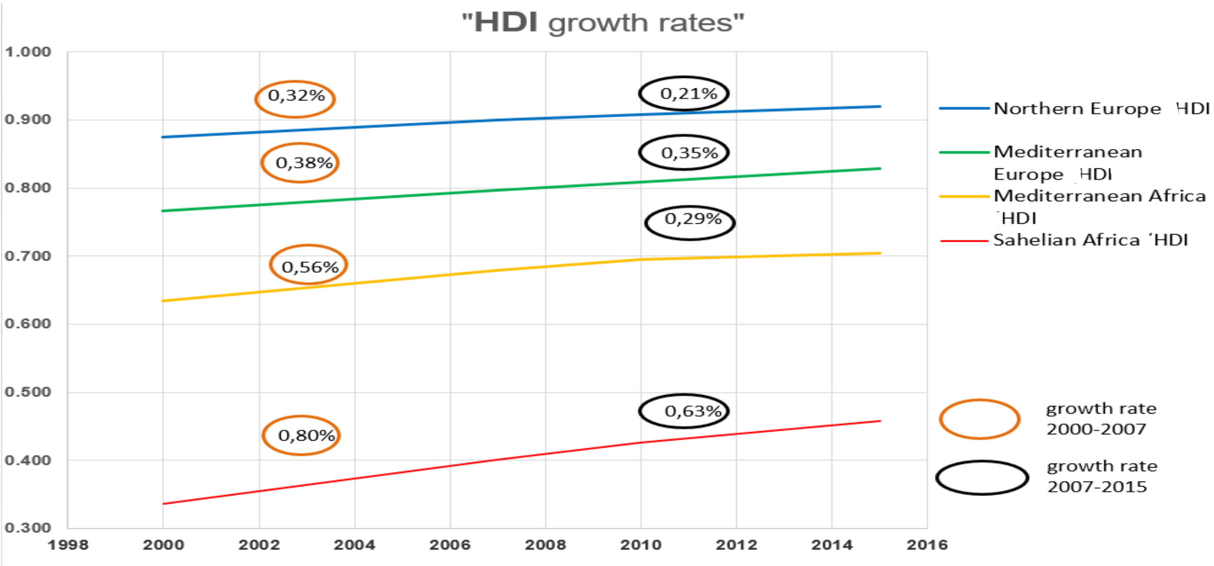


Figure 4.2.2 below shows the HDI growth Rate of above and below of Mediterranean Regions



In the figure above, we can see the HDI growth rate of the region around the Mediterranean Sea and it is understood that the growth rate of Afro-Mediterranean region after 2008 doesn't shows much development which is critical for the development of African regions. This can be brought by having a national and international connectivity of these region and which is important for the future growth.

5. African Mediterranean railway forming the Afro-Mediterranean Network

Report taken from the ESCWA/UACF studies of 2002 is considered as the "Regional Axes" for my Afro-Mediterranean Network. It is done to complete with the original according to which a preliminary concept of possible route alignments for the railway line was to be done in light of ESCWA agreement. The general overview of the Core of Afro-Mediterranean railway Network produced is based on this concept.

The detailed definition of the axis connecting Morocco, Algeria, Tunisia, Libya, Egypt is actuality taken from the report study and inspection report of ITALFERR

Considering the proposal introduced by ITALFERR a list of priorities is taking into consideration for the project cost-effectiveness (in lesson 9 for the results of the cost-effectiveness procedure) was obtained.

In the following sub-paragraphs, a graphical description of the axes has been introduced. For each country a graphical representation is shown detail:

- the existing lines (E) and the lines under construction (UC), in our approach considered similarity to existing lines in good conditions;

- the missing links (ML) and the sections of lines were a rehabilitation is needed (in the following "upgrading lines", UP), subdivided according to "homogeneous sections", taken into consideration.

Tables 5.1 shows the "homogeneous sections" and their characteristics for each country for future development.

country	Start of section	End of section	length(km)	Type
morocco	Morocco Border	Laayoune	820	ML
morocco	Laayoune	Agadir	616	ML
morocco	Agadir	Essaouira	150	ML
morocco	Essaouira	Marrakech	184	ML
morocco	Marrakesh	Casablanca	246	E
morocco	Casablanca	fez	319	E

morocco	Fez	Oujda(Algeria Border	314	UP
Algeria	Oujda(Algeria Border)	Tabia	178	E
Algeria	Tabia	Algier	471	E
Algeria	Algier	Setif	299	E
Algeria	Setif	Souk Aras	358	E
Algeria	Souk Aras	Tabia	47	UP
Algeria	Tabia	Redjem Demouche	75	E
Algeria	Redjem Demouche	Bechar	500	E
Algeria	Bechar	Ghar	840	ML
Tunisia	Mechta El Argoub	Beja	85	UP
Tunisia	Beja	Tunis	105	UP
Tunisia	Tunis	Gabes	370	ML
Tunisia	Gabes	Ras Ajidir	180	ML
Libya	Ras Ajidir	Assidra	810	UC
Libya	Assidra	Benghasi	366	UC
Libya	Benghasi	Imm Saad/Al Salloum	610	ML
Egypt	Imm Saad/ Al Salloum	Marsa Matruh	216	UP
Egypt	Marsa Matruh	Alexandria	293	E
Egypt	Alexandria	Benha	155	E
Egypt	Benha	El Firdan Bridge	127	E
Egypt	El Firdan Bridge	Bir el abd	85	UC
Egypt	Bir El Abd	Rafah	126	ML
Egypt	El Firdan Bridge	Nuweba	370	ML
Egypt	Benha	Quene	654	E
Egypt	Quena	High Dam	288	E
Egypt	Quena	Safaga	235	UP
Egypt	Quena	Kharga	230	ML

Egypt	Highn Dam	Sudan Border	229	ML
		Total ML+UP	5727	
		Total	10951	

Afro-Mediterranean Railway network connecting Morocco, Algeria, Tunisia, Libya and Egypt. Data from Italferr data base

6. Forecasts and projections of future growth in rail traffic

6.1 Demand analysis methodology used for the indicator of effectiveness

The aim of the demand analysis was the determination of traffic units (passengers x km) +(tons x km) on sections, assuming the network (Mediterranean Africa network) as completed and in operation in 2040.

As usual in transport demand studies, I have considered the "traffic units" as the sum of passengers and freight-tons transferred per km from the Annual Statistical Reports by UIC known as the “standard" freight train traveling along the European network (with similar standards to those intended for rail network) is composed of about 22 wagons, each ones carrying an average weight of 25 tons of goods. Hence the weight of the typical freight train is on average of about 550 tons. Likewise, a "standard” long-distance train on the same network can bring up to 800 passengers in the peak time and busiest routes (with values dropping in the soft hours and along lower volume routes). Assuming a load factor for passenger trains of about 70%, is of about 560 passengers, number that is similar to the average amount of tons carried by a standard freight train. Considering the resulting level of capacity occupation associated to each train and the equal importance of freights and passengers for the future plan, the sum of the values of (passengers x km) and (tons x km) was adopted as a valid indicator of the transport effectiveness of the rail links under study.

Given the diversity of available sources and the socio-economic differences among the various Countries of the Afro Mediterranean countries, the demand analysis was conducted per Country and considering, reliable national and international studies approved by Ministries of Transport or similar Entities when available.

Therefore, to obtain Country O/D matrices for passenger and freight traffic volumes, for Countries where specific studies were completed traffic flows were estimated using already approved data, while in the other cases (where similar studies were not available) a gravitational model was developed calibrated on the basis of the flows deduced from the existing studies.

The integration of the freight demand analysis with a regional traffic model, based on the commercial exchange’s statistics (import export by commodity), was not carried out due to fact that the bulk of data needed for this approach was not available

The following are the presentation of the procedures and methods applies respectively to the passenger and freight demand analysis.

Passenger Demand

As far as the estimation of rail passengers' demand is concerned, for Countries where international studies already determined traffic flows on the future Afro Mediterranean Railway Network, the relevant data were taken.

In cases, where no studies were available, I always considering the level of accuracy of a "strategic planning study" of the nature of the one being carried out, according to the methodology set out in the following steps

1. An administrative-based zoning was made, taking into consideration representative zones of Governorates, Provinces, Regions, Countries or aggregation of them, the number of chosen zones for each Country was a function of the complexity of the Rail Network to which flows had to be assigned. The reason of this choice consists in the chance to use socio-economic data usually censed and published for these territorial units. Some of the steps here below described have been also represented in a graphical form to better clarify the procedure followed.

2. To each zone a centroid (i.e. an idea point where all movements in origin and in destination from to the zone are reasonably supposed to be allocated according to geographical and socio-economic considerations) has been associated.

3. In order to perform the distribution model, the distance between centroids was calculated according to the shortest distance (Dij).

4. To each generic centroid I, the Population (Pi) and the number of Employees (Ei) obtained by national statistical bureaus were then assigned in some Countries (i.e. Libya, Egypt) where data on employees per Governorate were absent. Employees as a percentage of the Population, in analogy with other nearby countries;

5. Using the growth trends derived from the World Bank databases, all values of population and Employees were brought to 2010;

6. For the calculation of rail flows (2010) of Afro Mediterranean Railway Network, the following formula has been adopted from the generic centroid i to the generic centroid j:

$$F_{ij,2010} = K^{C}_{RMC} \,.\, (365 \,.\, K^{C}_{G} \,.\, P_{i,2010} \cdot \frac{(E_{j,2010})^{\beta 1} .\ (D_{ij})^{-\beta 2}}{\sum_{x=1}^{N}[(E_{x,2010})^{\beta 1} .\ (D_{ix})^{-\beta 2}]})$$

- $F_{ij,2010}$ represents only the generated annual flows from the centroid i to the centroid j on the railway network on 2010
- K^{C}_{RMC} The rail model share for the network built
- $P_{i,2010}$ represents the population as of 2010 of the zones with centroid i,
- $E_{j,2010}$ represents the estimated number of employees as of 2010 of the zone with centroid j,
- D_{ij} the shortest distance between centroids i and j,
- N the number of centroids in the considered Country,
- β1 the weight of the attractiveness of movements between the centroids,
- β2 the weight of the impedance to the movements between the centroids.

7. A calibration of the parameters K^{c}_{RMS}, K^{C}_{G}, β1 and β2 was carried out using data available for countries where passenger flows were already estimated. Through this process, the same values for the coefficients β1, and β2 (β1 = 1 and β2= 2), were obtained for a Countries, whereas parameters K^{c}_{RMS} and K^{C}_{G} were identified by mean of different values, of Country were identified.

8. To consider the potential demand of transport to and from foreign countries, when international traffic data were available, the traffic flows to and from neighbouring countries were estimated and were distributed to centroids based on the same values of attractiveness, impedance and modal spit used for domestic traffics.

9. Using the subdivision based on the GDP values, trends of growth up to 2040 has been divided by groups and estimated as follows

a. from 2010 to 2020: a yearly GDP growth of 75% compared with that of the previous decade,

b. from 2020 to 2030: a yearly GDP growth of 50% compared to that of the previous decade,

c. from 2030 to 2040: a yearly GDP growth of 25% compared to that of the previous decade.

Such assumptions introduced and can be considered as prudential and bring to acceptable results for the purpose of the study. These assumptions are again deeply considered during the next Cost Benefit Analyses Phases

Using the above growth rates, a preliminary estimate of the annual flows as of year 2040 (Fij,2040) was obtained, in terms of passengers per year, applying the following formula:

$$F_{ij,2040} = F_{ij,2010} \cdot (1 + R_{10-20}^{C})^{10} \cdot (1 + R_{20-30}^{C})^{10} \cdot (1 + R_{30-40}^{C})^{10}$$

10. In the next paragraphs of this Chapters, aimed at describing the demand analysis carried out for each Country - or for aggregation of countries -, the O/D passenger matrices resulting from the above described process, obtained for 2010, together with the passenger flows assigned to the network at the time horizon of 2040, are given.

The assignment of these flows was then made through an "All or Nothing" algorithm applied

Freight Demand

For what concerns the estimation of demand for rail freight traffic, for all countries in my study insist was made to international studies where either freight flows on the future railway network were already determined or O\D rail or multi-modal matrices between the main origin and destinations of traffic were at least identified. In all other cases, where no such studies were available is considered, per Country, as follows.

1. Beyond the centroids identified for the purpose of passenger demand analysis, the freight zoning was carried out by adding specific centroids representing the main origins and destinations of regional (international) movements (freight traffic in and out of the considered Country), generality represented by ports (existing or fictitious to represent the handing of freights volumes carried out by different ports belonging to the same zone) and land border crossings. These additional centroids have been identified in correspondence of the points where railway network crosses the borders of the Country (to simulate connections by land). The others simulating the sea connections, have been located near the coasts (one for each zone facing to the sea).

Differently from the passengers' analysis, in this case the regional component is predominant and therefore this step was essential to duly estimate the freight flows.

2. Using import and export data to and from other Countries published by port authorities, by national statistical bureau or by international studies and databases (generality expressed in tons/year), regional freight traffics moved along the aforesaid individual border centroids (ports and lands border crossings) were assigned on the national networks, by means of a "All or Nothing" algorithm.

3. where data were available only in monetary terms, they were converted in tons/year using correction coefficients per commodities derived from investigations on customs sites (in particular, the database of Algerian customs at web address http:IIwww.douane.gov.dzIcnisIstatIent_statis.asp contained very detailed statistics).

4. For countries with significant international sea freight volumes (generally with the rest of the word), these values were evaluated and then distributed among the fictitious ports proportionality to the freight volumes handed by the main ports simulated.

5. The assignment of incoming and outgoing freight volumes associated to internal zones were carried out by using the population figure as an indicator of the attractiveness of goods and the employees’ number as an indicator of generation of goods.

6. By means of this procedure, freight multimodal O\D matrices as of 2010 of national plus regional value (in particular, for Maghreb countries, of regional value since national movements are negligible) were obtained, representing the current volumes of freights moved across the multimodal transport network. Rail O/D matrices as of 2010 were then obtained using the modal spit factors identified in the following Table.

7. Then proceeded to the assignment of the relevant volumes on the homogeneous sections of the regional network applying an "All or Nothing" algorithm and using the growth trends as set in the following Table (similarity to what already indicated for the passenger analysis).

The following tables 6.1.1 summarizes for each Country

- The parameters used for the demand analysis and rail traffic assignments in Table , namely: population-GDP annual rates up to 2010, traffic generation factors, rail modal shares, passenger and freight annual growth rates, elasticity factors.

Table 6.1.1 shows the parameters used for the demand analysis

<table>
<tr><th>Country</th><th>Population-annual rate up to 2010</th><th>GDP - annual rate up to 2010</th><th>Passenger Traffic Generation Factor (KG)</th><th>Railway Modal Share (KRMS)</th><th>Passenger Rail Traffic-average annual rate up to 2010</th><th>Freight Rail Traffic average annual rate up to 2010</th></tr>
<tr><td>Morocco</td><td>1.16%</td><td>5.11%</td><td rowspan="5">0.95%</td><td rowspan="5">7,5% Pax
15% Fre</td><td rowspan="5">3.00%</td><td rowspan="5">4.60%</td></tr>
<tr><td>Algeria</td><td>1.50%</td><td>3.78%</td></tr>
<tr><td>Tunisia</td><td>0.97%</td><td>4.66%</td></tr>
<tr><td>Libya</td><td>2.05%</td><td>4.39%</td></tr>
<tr><td>Egypt</td><td>1.88%</td><td>4.82%</td></tr>
</table>

- The methods, variables and sources used.
- the base year and the growth trend analysis

For all countries (Morocco, Algeria, Tunisia, Libya, Egypt)

Passenger Rail Traffic- average annual rate 2010-2020 = 2.30%

Passenger Rail Traffic- average annual rate 2020- 2030 = 1.20%

Passenger Rail Traffic- average annual rate 2030-2040 = 0.30%

Freight Rail Traffic- Average annual rate 2010-2020=4.60%

Freight Rail Traffic- Average annual rate 2020-2030=4.30%

Freight Rail Traffic- Average annual rate 2030-2040=2.30%

Table 6.1.2 shows – Methods and variables used for rail traffic assignment per Country

County	Flows on homogeneous sections Passenger Traffic	Flows on homogeneous sections Freight Traffic
Morocco	M (P, E, D)	M (TS, P,E,BP)
Algeria	M (P, E, D)	M (TS, P,E,BP)
Tunisia	M (P, E, D)	M (TS, P,E,BP)
Libya	M (P, D)	M (TS, P,BP)
Egypt	M (P, D)	M (TS, P,BP)

M (P, E, D) = by Model (Variables = Population, Employment, Distance);

M (P, D) = by Model (Variables = Population, Distance);

6.1.1 Morocco

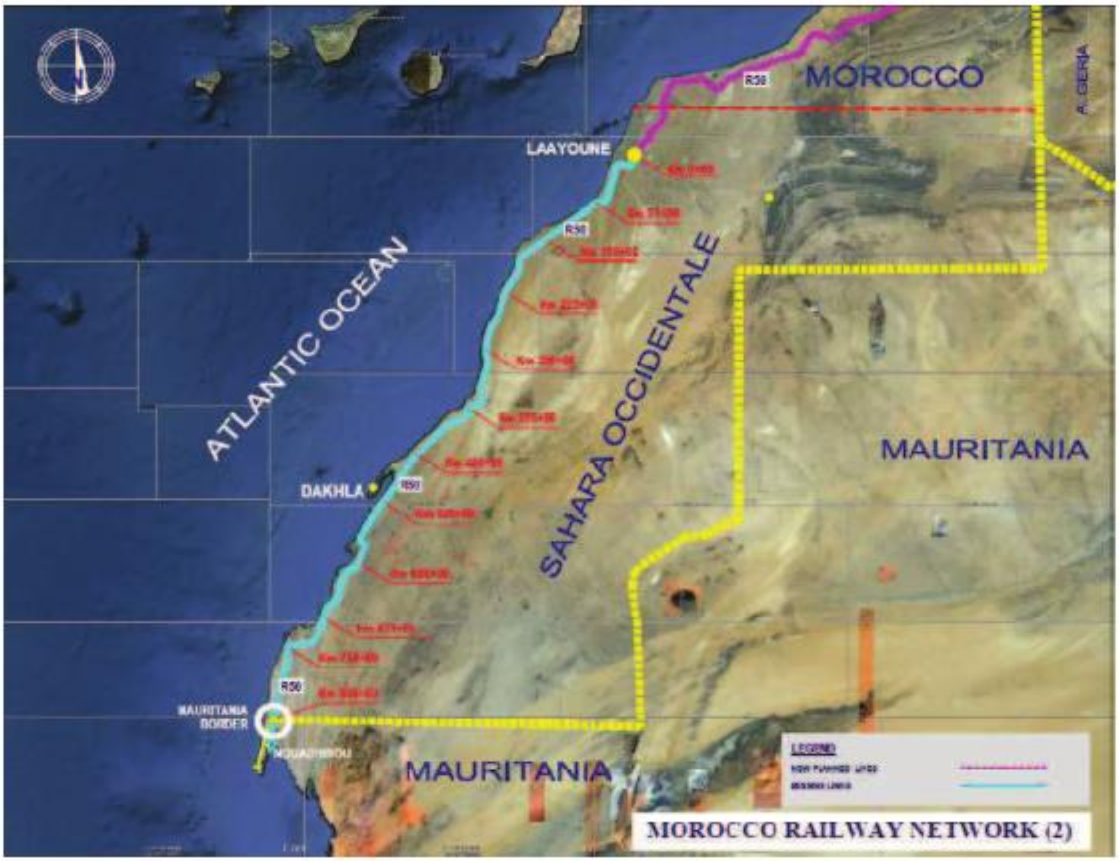
<u>Rail network involved in analysis</u>

Morocco is the most western Country of the study area runs from the Algerian border to south, in the Western Sahara region, following the Mediterranean and the Atlantic coast of the Country and touching the important cities of Fes, Tanger, Rabat, Casabianca, Agadir and Laayoune. It links Morocco to Algeria in the north and Mauritania in the south and it will be the main route for transit of the traffic flows of passenger inside the Country and of freight towards and from Morocco ports.

Figure 6.1.1.1 below shows the globe transportation view of Morocco

LAMBERT CONFORMAL CONIC PROJECTION; STANDARD PARALLELS 27°00'N 36°00'N 803604AI (G04626) 3-15

Figure 6.1.1.2 below shows the current and future rail network of Morocco is represented



Data sources for analysis

About passenger demand data, the main source of data has been from the website of the "Royaume Du Maroc Haut - Commissariat Au Plan Activate", where socio-economic data such as population and number of employees for each region are reported (Census, 2004). In order to forecast the population up to 2010, the average annual and national population growth rates provided by the world Bank database have been applied to census data.

Main sources for freight demand data have been the website "Global Edge" and the trade statistic database of PIERS, in which the monetary values of import-export freight traffics of Morocco are reported, and the "Royaume du Maroc - Ministere de l equipment et du transport", for the freight traffic handled by each port.

Rail Passenger demand analysis

In order to estimate the domestic rail passenger demand, Morocco has been subdivided in the four zones

illustrated in the figure below (named Mor_1, Mor_2, Mor_03 and Mor_04). Regional rail passenger demand has been assumed negligible.

To each zone, a centroid reasonably located according to geographical and socio-economic considerations has been associated.

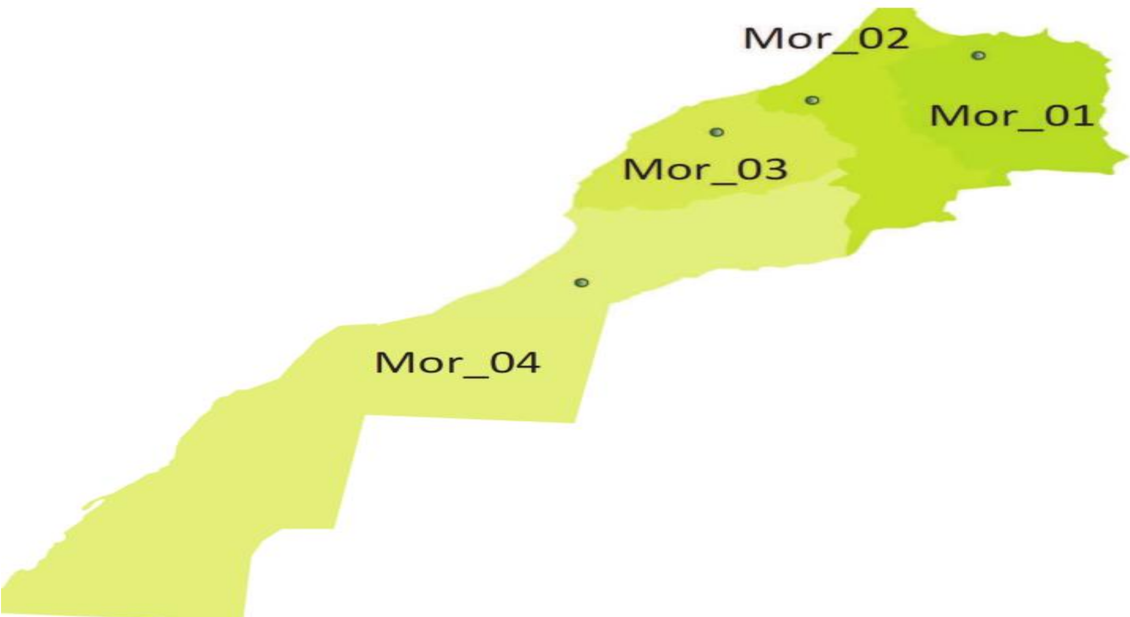


Figure 6.1.1.3 shows Zones and Centroids

In the following table, the area, the population and employees per zone are summarized

Table 6.1.1.1 Shows - Current Population and Employees per zone

Zone ID	Regions	Major City Name	Area (Km^2)	Estimated Population 2010	Estimated Employees 2010
Mor_01	Fès-Boulemane Oriental Taza-Al Hoceima-Taounate	Fes Oujda Taza	126,850	5,621,727	1,572,433
Mor_02	Rabat-Salé-Zemmour-Zaer Meknès-Tafilalet Tanger-Tétouan Gharb-Chrarda-Béni Hssen	Rabat Meknès Tangier Kenitra	37,876	9,377,499	2,849,268
Mor_03	Grand Casablanca Marrakech-Tensift-El Haouz Doukkala-Abda Chaouia-Ouardigha Tadla-Azilal	Casablanca Marrakech Safi Khouribga Beni Mellal	70,195	12,545,796	3,925,512
Mor_04	Sous-Massa-Draa Guelmin - Es Semara Laayoune-Boujdour-Sakia El Hamra Oued Ed-Dahab-Lagouira	Agadir Guelmim El Aaiún Dakhla	384,065	4,105,171	1,097,029

For the purpose of carrying out a distribution model, the distances between centroids have been calculated. The obtained matrix of the distances follows.

Table 6.1.1.2 Shows - Distances between centroids

Dij (km)	Mor 1	Mor 2	Mor 3	Mor 4
Mor 1	-	385	578	1,126
Mor 2	385	-	180	790
Mor 3	578	180	-	610
Mor 4	1,126	790	610	-

The current O\D matrix of the potential domestic rail passenger traffic, estimated considering the rail network entirely completed already in the year 2010, is reported below. It can be observed that the higher estimated flows are those from the zone Mor_03 (which includes Marrakech, Casabianca, Safi, etc.) to the zone Mor_02 (which includes Rabat, Meknes. Tangier, Kenitra) and vice versa.

The total number of the estimated passenger movements per year by rail amounts about to 16,462,000.

Table 6.1.1.3 Shows - Current O\D matrix of potential rail passenger traffic

O/D (pax/ year)	Mor 1	Mor 2	Mor 3	Mor 4
Mor 1	-	1,076,460	700,206	120,689
Mor 2	1,076,460	-	5,214,302	330,116
Mor 3	700,206	5,214,302	-	789,258
Mor 4	120,689	330,116	789,258	-

Rail Freight demand analysis

In order to estimate the regional rail freight demand, the same subdivision of Morocco in four zones (named Mor_01, Mor_02, Mor_03 and Mor_04), identified for the passenger demand analysis, has been maintained. Moreover, six external centroids, to simulate import-export traffic flows with the other countries of the study area and the rest of the world, have been added. Two external centroids have been identified at the borders with Algeria and Mauritania (named ALG border and MAU border) for the simulation of the connection by land. The other four external centroids, simulating the sea connections (and named P_Mor_1, P_Mor_2, P_Mor_3, and P_Mor_4), have been located beside the coast (one for each zone). Each external centroid is a fictitious port which handles the amount of freights handled by the main ports belonging to the same zone. Domestic rail freight demand has been assumed negligible.

At the beginning, the import-export from to the other countries has been estimated for the year 2008. The results are shown in the table below.

Table 6.1.1.4 Shows - Morocco estimated import/export per partner

Partner	Estimated Export by Rail (tons)	Partner	Estimated Import by Rail (tons)
Rest of the world	6,351,688	Rest of the world	8,364,844
Algeria	33,518	Algeria	234,471
Mauritania	7,735	Mauritania	1,750
Tunisia	25,139	Tunisia	48,994
Libya	15,470	Libya	20,997
Egypt	12,892	Egypt	80,490
Sudan	0	Sudan	0

Subsequently, the total amount of arriving departing freight volumes by sea from to the rest of the world has been calculated. The total import-export freight volumes were distributed among the four fictitious ports proportionality to the freight volumes handled by the main ports simulated. Obtained results are reported in the next table.

Table 6.1.1.5 Shows - Total arriving/departing freight volumes by sea per zone (or fictitious port)

ID Port	Ports	Freight (tons)	% FRE
P Mor 1	Nador	2,502,147	0.04
P Mor 2	Tanger I Kenitra	4,437,571	0.07
P Mor 3	Casabianca I Mohammadia I Safi I Jorf Lasfar	53,432,749	0.79
P Mor 4	Agadir I Layounne I Dakhia I Tan Tan	7,112,087	0.11
	TOTAL	67,484,554	1

At the same time, the total import and export values have been distributed among all the zones proportionality to their population and number of employees. In particular, the percentage of population has been used to distribute the import volumes, since it has been assumed to represent a measure of the consumption of goods, while the percentage of employees has been used to distribute the export volumes, since it has been assumed to represent a measure of the production of goods. Obtained results are reported in the next table.

Table 6.1.1.6 Shows - Distribution percentages of population and employees for each zone

ID Zone	Estimated Population 2010	% POP	Estimated Employees 2010	% EMP
Mor o1	5,621,727	0.18	1,572,433	0.17
Mor o2	9,377,499	0.3	2,849,268	0.3
Mor o3	12,545,796	0.4	3,925,512	0.42
Mor o4	4,105,171	0.13	1,097,029	0.12
TOTAL	31,650,193	1	9,444,242	1

The current O\D matrix of the potential rail freight traffics, estimated considering the rail network entirely completed already in 2010, is reported below. The matrix refers only to inside-outside movements of freight volumes crossing Algeria and Mauritania borders by land and with the rest of the world by sea and vice versa. The inside-inside movements and outside-

outside movements of freight volumes were considered negligible. It can be observed that the higher estimated freight flows are those ones exchanged between the zone Mor_03 (which includes Marrakech, Casabianca, Safi, etc.) and the external centroid P_Mor_03 (simulating the ports of Casabianca, Mohammadia, Safi and Jorf Lasfar) and vice versa.

The total estimated exported freight volumes by rail per year amounts to about 6.446 million of tons, while the total estimated imported freight volumes by rail per year amounts to about 8.751 million of tons.

Table 6.1.1.7 shows O/D matrix of potential rail freight traffic

O/D (tons year)	Mor 1	Mor 2	Mor 3	Mor 4	P Mor 1	P Mor 2	P Mor 3	P Mor 4	MAU	ALG
Mor 1	N.A				39,211	69,540	837,332	111,452	1,288	14,488
Mor 2					71,050	126,007	1,517,255	201,952	2,334	26,253
Mor 3					97,887	173,604	2,090,362	278,235	3,215	36,169
P Mor 1	51,638	93,569	128,913	36,026	N.A					
P Mor 2	91,581	165,945	228,627	63,892						
P Mor 3	1,102,722	1,998,146	2,752,898	769,328						
P Mor 4	146,776	265,960	366,420	102,400						

6.1.2 Algeria

Rail network involved in analysis

Algeria represents the biggest Country of the Maghreb area. It runs from west border with Morocco to the east border with Tunisia and connects important cities like Oran, Oued Tlelat, Chlef, Algier, Thenia, Bouira, Setif, Constantine, Annaba. In Algeria (mainly constituted by the coastal corridor defined as "Rocade Nord" has also a vertical development, since it has a branch that links the so-called railway line "Rocade Nord", following the coast line, and runs from Tabia to Bechar and to Mauritania borders

Figure 6.1.2.1 shows the globe transportation view of Algeria

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The figure 6.1.2.2 below represents the current and future rail network of Algeria

The "Rocade Nord" was clearly considered as the main regional corridor of the Algerian Railway Network, due to the fact that it joins the most important ports and cities where main economic and administrative activities are concentrated, while the "Rocade des Hauts Plateaux" does not open a "new" international connection with Algeria and Morocco, but it only supports the main line in order to provide an additional capacity for the traffic flows - especially for the freight traffic.

Additionally, the same "Schema Directeur Sectoriei Ferroviaire" prepared by the Algerian Ministry of Transports in 2007 attributes to the "Rocade des Hauts Plateaux" a complementary, national, role to the main axis (Rocade Nord) considered in my study. It was then clarified that, in any case, the mentioned "Rocade des Hauts Plateaux" was obviously considered in the transportation analysis, in order to fully estimate the future regional passenger and freight traffic.

I am also aware in aimed connection represents a good opportunity to well join the city of Annaba to Beja included in a "regional" new corridor that will allow significant reduction of the journey time from 4 to quite 2 hours for the Annaba-Tunis in case of an high speed services.

Lastly, with reference to the section Bechar-Ghar (linking Algeria with the Mauritanian Border), potentiality very important according to the Algerian counterpart, it was clarified that it was included in the Arab Core Railway

However, its characteristics are indeed more nationality oriented since the connection serves freight traffics from internal mines to the exporter ports, located internality to Algeria, and therefore not giving a great contribution to the regional connection.

Data source For Analysis

With reference to passenger demand data, the main source has been the website of the "Office National des Statistiques", where socio-economic data such as population and number of employees per wilaya updated to 2009 have been collected In order to project the population up to 2010, the average annual and national population growth rates providing by the World Bank database have been applied to census data.in order to project the number of employees up to 2010, the growth rate obtained by the harmonization of parameters and reported in the correspondent table has been applied to census data.

Main sources for freight demand have been the website "Global Edge" and the trade statistic database of PIERS, in which the monetary values of import-export freight traffics of Algeria are reported, and the "Statistic Yearbook of trade ports", published by the Transport Ministry of Algeria - Port Direction - for what concerns the freight traffic handled by each port.

Rail Passenger demand Analysis

In order to estimate the domestic rail passenger demand, Algeria has been subdivided in five zones (named Alg_01, Alg_02, Alg_03, Alg_04, Alg_05) resulted by an aggregation of wilaya. Regional rail passenger demand has been assumed negligible. To each zone, a centroid, reasonably located according to geographical and socio-economic considerations, has been associated

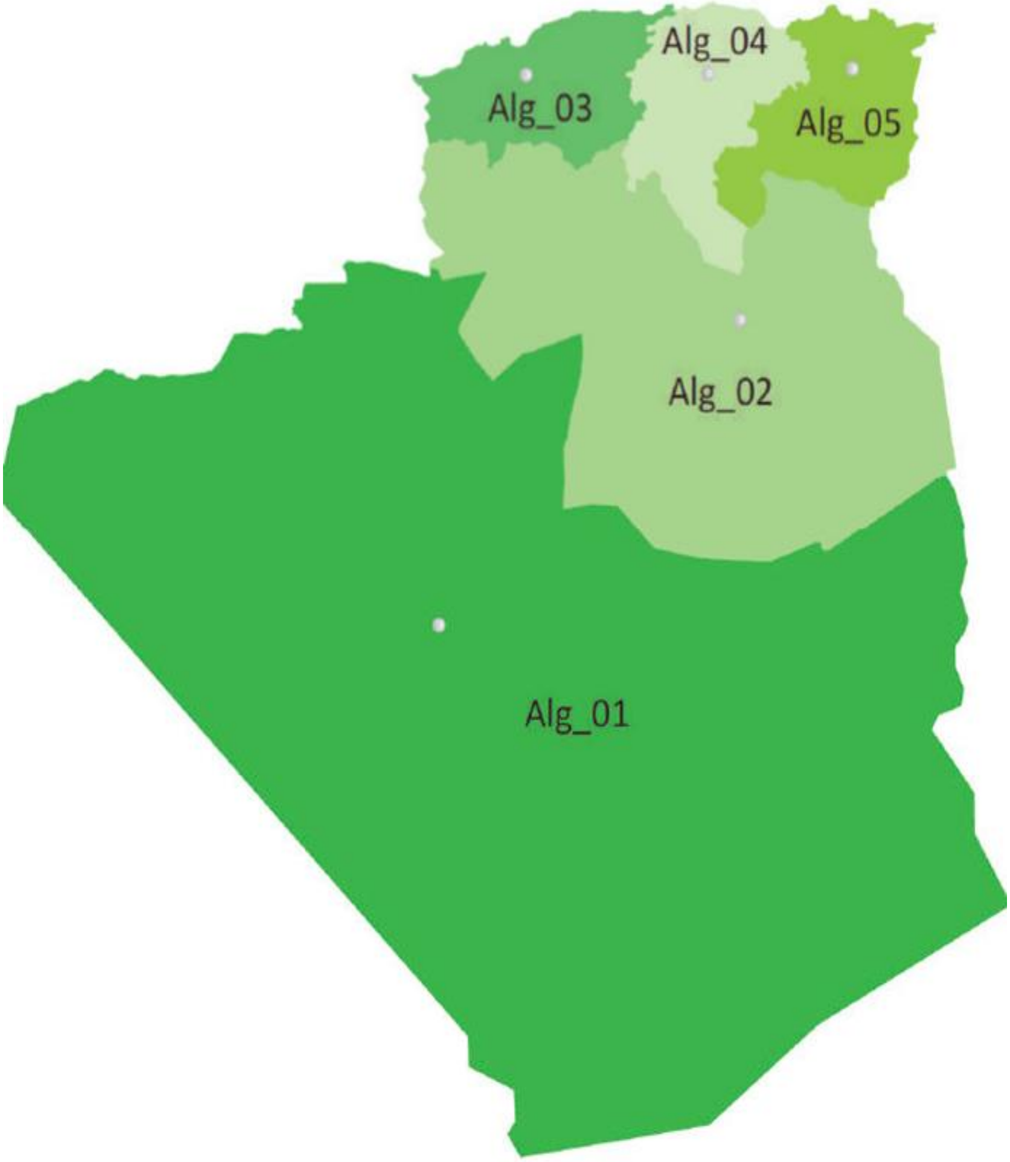


Figure 6.1.2.3 shows - Zones and centroids.

The table 6.1.2.1 shows the area, the population and the employees per zone.

Zone ID	Governorates	Area (Km^2)	Estimated Population 2010	Estimated Employees 2010
Alg_01	Adrar Béchar Tamanghasset Illizi Tindouf	Adrar Béchar Tamanghasset Illizi Tindouf	953,663	285,014
ALg_02	Laghouat Ouargla El Bayadh El Oued Naama Ghardaïa	Laghouat Ouargla El Bayadh El Oued Naama Ghardaïa	2,398,810	679,844
Alg_03	Chlef Tlemcen Tiaret Sidi Bel Abbes Saïda	Chlef Tlemcen Tiaret Sidi Bel Abbes Saïda	7,651,572	3,050,231
	Mascara Mostaganem Oran Tissemsilt Tipasa Aïn Defla Aïn Témouchent Relizane	Mascara Mostaganem Oran Tissemsilt Tipasa Aïn Defla Aïn Témouchent Relizane		
Alg_04	Blida Béjaïa Bouira Tizi Ouzou Algiers Djelfa Sétif Médéa M'Sila Bordj Bou Arréridj Boumerdès	Blida Béjaïa Bouira Tizi Ouzou Algiers Djelfa Sétif Médéa M'Sila Bordj Bou Arréridj Boumerdès	12,216,650	4,149,621
Alg_05	Oum el-Bouaghi Batna Biskra Tébessa Jijel Skikda Annaba Guelma Constantine El Tarf Khenchela Souk Ahras Mila	Oum el-Bouaghi Batna Biskra Tébessa Jijel Skikda Annaba Guelma Constantine El Tarf Khenchela Souk Ahras Mila	8,317,062	2,757,265

In order to apply the distribution model, the distances between centroids have been estimated. The obtained matrix of distances is reported below.

Table 6.1.2.2 Shows - Distances between centroids

Dij (km)	Alg 1	ALg 2	Alg 3	Alg 4	Alg 5
Alg 1	-	1,153	1,290	1,477	1,725
Alg 2	1,153	-	748	620	585
Alg 3	1,290	748	-	446	770
Alg 4	1,477	620	446	-	370
Alg 5	1,725	585	770	370	-

The current O/D matrix of the potential domestic rail passenger traffic, estimated considering the rail network entirely completed already in the year 2010, is reported below. As can be seen, the more elevated value generated by the model is concentrated in the north zones Aig_03, Aig_04 and Aig_05, that are located near the coast. The total number of the passenger movements by rail amounts about to 16,404,000 during the year and for both directions

Table 6.1.2.3 shows- Current 0\D matrix of potential rail passenger traffic

O/D (pax/year)	Alg 1	ALg 2	Alg 3	Alg 4	Alg 5
Alg 1	-	29,880	100,278	101,966	50,491
Alg 2	29,880	-	227,688	422,453	321,527
Alg 3	100,278	227,688	-	2,832,326	644,740
Alg 4	101,966	422,453	2,832,326	-	3,470,440
Alg 5	50,491	321,527	644,740	3,470,440	-

Rail Freight Demand Analysis

Domestic rail freight demand has been assumed negligible.

At the beginning, the import-export from to the other countries has been estimated for the year 2008. The results are shown in the table below.

Table 6.1.2.4 shows - Estimated import and export per partner

Partner	Estimated Export by Rail (tons)	Partner	Estimated Import by Rail (tons)
Rest of the world	14,877,017	Rest of the world	7,473,531
Tunisia	165,351	Tunisia	53,815
Libya	9,186	Morocco	16,675
Morocco	137,793	Mauritania	3,032
Egypt	117,889	Egypt	32,592
Mauritania	0	Libya	0
Sudan	0	Sudan	0

Subsequently, the total amount of arriving departing freight volumes by sea from to the rest of the World have been calculated. Obtained results are reported in the next table.

Table below 6.1.2.5 shows - Total arriving/departing freight volumes by sea per zone (or fictitious port)

ID	Port	Freight	% FRE
P_Aig_3	Oran I Mostaganem I Arzew I Tenes I Ghazaouet	73,025,383	0.56
P_Aig_4	Bejaja I Aiger	26,080,690	0.2
P_Aig_5	Annaba I Skikda I Djendjen	31,223,479	0.24
	Total	13,029,552	1

Table below 6.1.2.6 shows - Distribution percentages of population and employees for each zone

Zone	Population 2010	% POP	Employees	% EMP
21	953,663	0.03	285,014	0.03
22	2,398,810	0.08	679,844	0.06
23	7,651,572	0.24	3,050,231	0.28
24	12,216,650	0.39	4,149,621	0.38
25	8,317,062	0.26	2,757,265	0.26
TOTAL	31,537,757	1	10,921,975	1

The current O/D matrix of the potential rail freight traffics, estimated considering the rail network entirely completed already in the year 2010, is reported below. The matrix refers only to inside-outside movements of freight volumes crossing Morocco and Tunisia borders and with the rest of the World by sea and vice versa. The inside-inside movements and outside-outside movements of freight volumes have not been computed (n.c.).

As can be observed, the higher value of the estimated export and import flows are those one exchanged between the zone Alg_04 (which includes Alger, Setif, Medea, BBA, etc) the external centroid P_Aig_03 (simulating the ports of Bejaja and Alger) and vice versa.

The total estimated export freight volumes by rail per year amount about to 15.307 million of tons, while the total estimated import freight volumes by rail per year amount to about 7.579 million of tons

Table 6.2.3.7 shows 0\D Matrix of potential rail freight traffic

O/D (tons year)	Alg 1	ALg 2	Alg 3	Alg 4	Alg 5	P Alg 3	P Alg 4	P Alg 5	MOR	MAU	TUN
Alg 1						216,703	77,394	92,656	3,582	0	7,602
Alg 2						516,902	184,609	221,012	8,545	0	18,133
Alg 3		NA				2,319,165	828,279	991,606	38,336	0	81,358
Alg 4						3,155,057	1,126,815	1,349,008	52,154	0	110,682
Alg 5						2,127,964	759,993	909,854	35,176	0	74,651
P Alg 3	108,862	259,668	1,165,042	1,584,956	1,068,992						
P Alg 4	38,879	92,739	416,090	566,060	381,786						
P Alg 5	46,546	111,026	498,137	677,680	457,069						
MOR Border	504	1,268	4,046	6,459	4,398			NA			
MAU Border	92	231	736	1,174	800						
TUN Border	2,613	6,572	20,964	33,471	22,787						

6.1.3 Tunisia

<u>Rail network involved in analysis</u>

Tunisia runs from the north-west to the south-east of the Country, starting from Ghardimou (Algeria border) and arriving in Ras Ajdir (Libya Border). The macro-axis runs mostly near the coast and passes through the main localities of Tunisia like Beja, Tunis, Sousse and Sfax.In the figure below, the current and future rail network is represented.

Figure 6.1.3.1 shows globe transportation view of Tunisia

Figure 6.1.3.2 shows - Rail network in Tunisia

From Arab Rail Network Study dar al omran

<u>Data source for analysis</u>

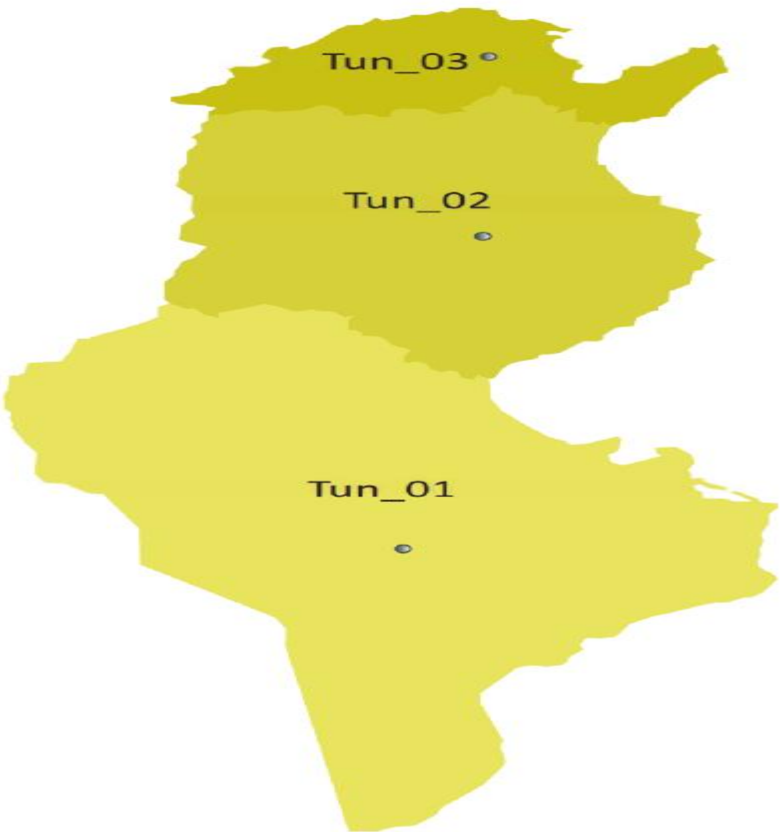
Regarding to passenger demand data the main source has been from the website of the "National institute of Statistics - Tunisia" where socio-economic data such as population and number of employees for each province, updated to 2004, are reported. In order to project the population up to 2010, the average annual and national population growth taxes providing by the world Bank database have been applied to census data. In order to project the number of employees up to 2010, the growth tax obtained by the harmonization of parameters and reported in the correspondent table has been applied to census data. Main sources for freight demand data have been the website "Global Edge" and the trade statistic database of PIERS, in which the monetary value of import-export freight traffics of Morocco are reported, and the "Institute National de la Statistique - Annuaire Stitistique de la Tunisie" for the freight traffic handled by each port.

Rail passenger demand analysis

In order to estimate the domestic rail passenger demand, Tunisia has been subdivided in three zones (named Tun_01, Tun_02 and Tun_03) illustrated in the figure below. Regional rail passenger demand has been assumed negligible.

To each zone it has been associated a centroid reasonably located according to geographical and socio- economic considerations.

Figure 6.1.3.3 shows - Zones and centroids



In the following table, the area, the consistency of population and employees per zone are reported.

Table 6.1.3.1 shows - Current Population and Employees per zone

Zone ID	Province	Major City Name	Area (Km^2)	Estimated Population 2010	Estimated Employees 2010
Tun_01	Gabès Gafsa Kebili Medenine Tataouine Tozeur	Gabès Gafsa Kebili Medenine Tataouine Tozeur	90,445	1,559,270	429,334
Tun_02	Kairouan Kasserine Kef Mahdia Monastir Sfax Sidi Bou Zid Siliana Sousse Zaghouan	Kairouan Kasserine El Kef Mahdia Monastir Sfax Sidi Bou Zid Siliana Sousse Zaghouan	48,346	4,460,299	1,383,316
Tun_03	Ariana Béja Ben Arous Bizerte Jendouba Manouba Nabeul Tunis	Aryanah Béja Ben Arous Bizerte Jendouba Manouba Nabeul Tunis	15,859	4,398,868	1,548,234

In order to perform the presented distribution model, the distances between centroids have been calculated. The obtained matrix of distances is reported below.

Table 6.1.3.2 shows - Distances between centroids

D_{ij} (km)	Tun 1	Tun 2	Tun 3
Tun 1	-	330	508
Tun 2	330	-	188
Tun 3	508	188	-

The current o\d demand matrix of potential rail passenger traffic, assigned considering the rail network entirely completed already in the year 2010, is reported below.

The current O\D matrix of the potential domestic rail passenger traffic, estimated considering the rail network entirely completed already in the year 2010, is reported below. It can be observed that the higher estimated flows are those one from the zone Tun_02) to the zone Tun_03 and vice versa. The total number of the estimated passenger movements per year by raii amounts about to 5,419,000.

Table 6.1.3.3 shows - Current matrix O\D matrix of potential rail passenger traffic Rail freight

O/D (pax year)	Tun 1	Tun 2	Tun 3
Tun 1	-	371,202	176,727
Tun 2	371,202	-	2,161,516
Tun 3	176,727	2,161,516	-

Rail freight demand analysis

In order to estimate the regional rail freight demand, the same subdivision of Tunisia in three zones (named Tun_1, Tun_2 and Tun_3), identified for the passenger demand analysis, has been maintained. Moreover, five external centroids, to simulate import-export traffic flows with the other countries of the study area and the rest of the world have been identified. Two external centroids have been identified at the borders with Algeria and Libya (named ALG border and L B border) for the simulation of the connection by land. The three external centroids, simulating the sea connections (and named P_Tun_1, P_Tun_2 and P_Tun_3), have been located beside the coast (one for each zone). In particular, each external centroid is a fictitious port which handles the amount of freights handled by the main ports belonging to the same zone.Domestic rail freight demand has been assumed negligible.

At the beginning, the import-export from to the other countries has been estimated for the year 2008. The results are shown in the table below.

Table 6.1.3.4 shows - Estimated import-export per partner

Partner	Estimated Export by Rail	Partner	Estimated Import by Rail
Rest of the	4,400,531	Rest of the	4,582,133
Libya	476	Libya	263,786
Algeria	476	Algeria	177,215
Morocco	207,442	Morocco	16,296
Mauritania	91,826	Mauritania	509
Egypt	53,764	Egypt	48,887
Sudan	3,330	Sudan	4,074

Subsequently, the total amount of arriving departing freight volumes by sea from to the rest of the world have been calculated. import-export total freight volumes were distributed among the three fictitious ports proportionality to the freight volumes handled by the main ports simulated. Obtained results are reported in the next table.

Table 6.1.3.5 shows - Total arriving/departing freight volumes by sea per zone (or fictitious port)

ID port	Port	Freight (tons)	% FRE
P Tun 1	Gabes I Tarzis	11,647,000	0.06
P Tun 2	Sfax I Sousse	19,254,000	0.1
P Tun 3	Tunis I Gouiette I Rades I Bizerte	155,337,000	0.83
	TOTAL	186,238,000	1

At the same time, the total import and export values have been shared among all the zones proportionality to their population and number of employees. In particular, the percentage of population has been used to share the import, since it has been assumed to represent a measure of the consumption of goods, while the percentage of employees has been used to share the export, since it has been assumed to represent a measure of the production of goods. Obtained results are reported in the next table.

Table 6.1.3.6 shows - Distribution percentages of population and employees for each zone

ID Zone	Estimated Population	% POP	Estimated Employees	% EMP
Tun 1	1,559,270	0.15	429,334	0.13
Tun 2	4,460,299	0.43	1,383,316	0.41
Tun 3	4,398,868	0.42	1,548,234	0.46
TOTAL	1o,418,437	1.00	3,360,884	1.00

The current O\D matrix of the potential rail freight traffics, estimated considering the rail network entirely completed already in the year 2010, is reported below. The matrix refers only to inside-outside movements of freight volumes crossing Algeria and Libya borders by land and with the rest of the world by sea and vice versa. The inside-inside movements and outside-outside movements of freight volumes has been not computed (n.c.).

It can be observed that the higher estimated freight flows are those ones exchanged between the zone Tun_3 (which includes Beja, Bizerte, Manouba, Tunis, etc.) and the external centroid P_Tun_3 (simulating the ports of Tunis, Goulette, Rades, Bizerte) and vice versa.

The total estimated export freight volumes by rail per year amount about to 4.757 millions of tons, while the total estimated import freight volumes by rail per year amount about to 5.092 millions of tons.

Table 6.1.3.7 - Current O\D matrix of potential rail freight traffic

O\D (tons year)	Tun o1	Tun o2	Tun o3	P Tun o1	P Tun o2	P Tun o3	ALG Border	LIB Border
Tun o1	NC			24,691	40,818	329,309	13,481	22,396
Tun o2				118,741	196,294	1,583,658	64,829	107,704
Tun o3				129,329	213,798	1,724,878	70,610	117,308
P Tun o1	25,940	124,747	135,871					
P Tun o2	42,882	206,223	224,613					
P Tun o3	345,966	1,663,763	1,812,127		NC			
ALG Border	29,038	83,063	81,919					
LIB Border	47,406	135,604	133,737					

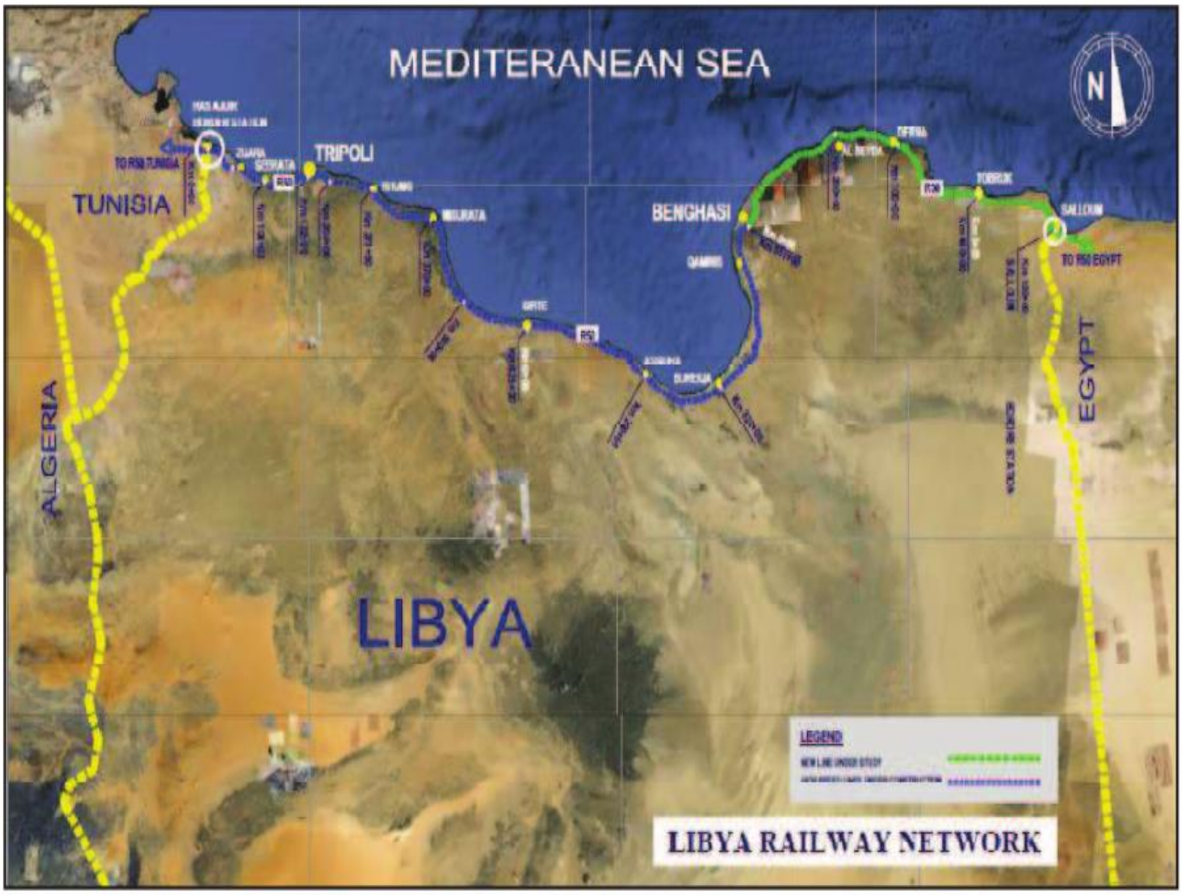
6.1.4 Libya

<u>Rail network involved in analysis</u>

Libya which runs from the west to the east of the Country, starting from Ras Ajdir (Tunisia Border) and arriving in Imm Saad / Ai Salloum (Egypt Border). The macro-axis runs along the coast passing through the main localities of Libya like Tripoli, Misurata, Benghazi and Tobruk.

Figure 6.1.4.1 shows the globe view of Libya.

Figure 6.1.4.2 shows - Rail network in Libya



<u>Data source for analysis</u>

Regarding to passenger demand data, the main source has been by the website of Statoids, where the population per each province, updated to 2006, is reported. In order to project the population up to 2010, the average annual and national population growth taxes providing by the World Bank database have been applied to census data. The number of employees has been assumed as the 25% of the population of each province according to considerations on the average employment rate of the other countries of the study area.

Main sources for freight demand were the website "Global Edge" and the trade statistic database of PIERS.

Rail passenger demand analysis

In order to estimate the domestic rail passenger demand, Libya has been subdivided in three zones (named Lib_01, Lib_02 and Lib_03) illustrated in the figure below. Regional rail passenger demand has been assumed negligible. To each zone it has been associated a centroid reasonably located according to geographical and socio- economic considerations

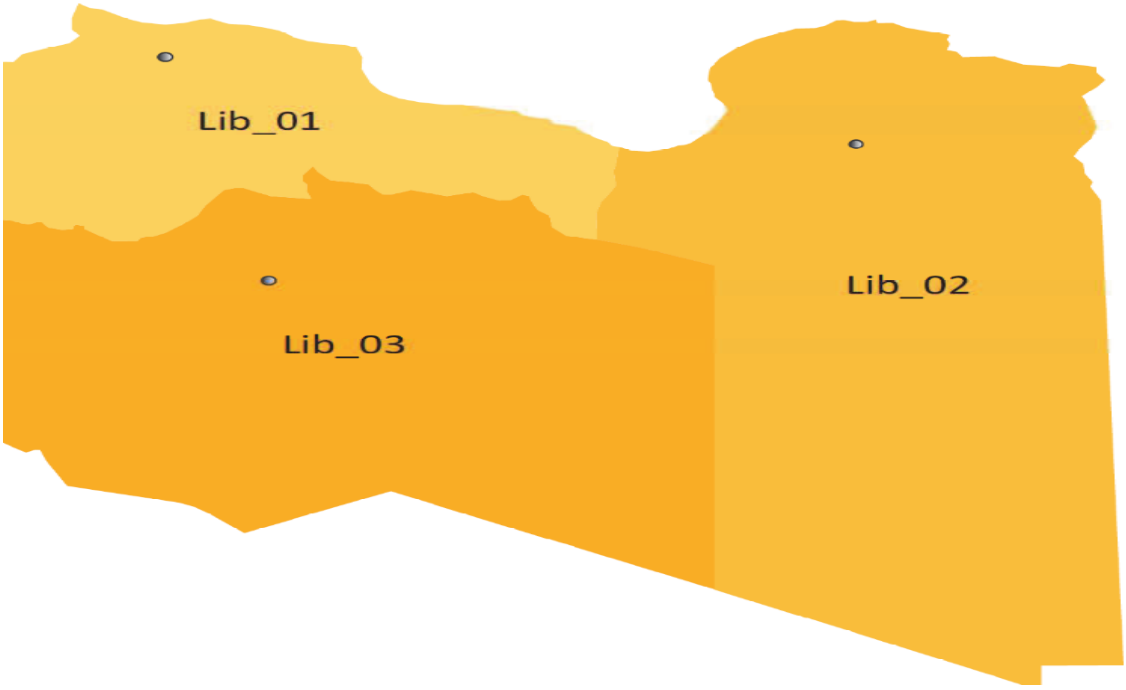


Figure 6.1.4.3 shows - Zones and centroids

In the following table, the area, the consistency of population and employment per zone are summarized.

Table 6.1.4.1 shows - Current Population and Employees per zone

Zone ID	Province	Major City Name	Area (Km^2)	Estimated Population 2010	Estimated Employees 2010
Lib_01	Sirt/Surt Misrata Al Murgub Tarabulus Al Jfara Az Zawiyah An Nuqat al Khams Al Jabal al Gharbi Nalut	Sirte Misrata Al Khums Tripoli Al 'Aziziyah Az Zawiyah Zuwarah Gharyan Nalut	198,557	3,843,607	960,899
Lib_02	Al Butnan Darnah Al Jabal al Akhdar	Tobruk Darnah Al Bayda	232,220	1,515,818	378,953

	Al Marj Benghazi Al Wahat Al Kufrah	Al Marj Benghazi Ajdabiya Al Jawf			
Lib_03	Al Jufrah Wadi Al Shatii Sabha Wadi Al Hayaa Ghat Murzuq	Houn Adiri Sabha Awbari Ghat Murzuq	133,858	471,570	117,893

In order to perform the presented distribution model, the distances between centroids have been calculated. The obtained matrix of the distances is reported below.

Table 6.1.4.2 shows – distance between centroids

Dij (km)	Lib 1	Lib 2	Lib 3
Lib 1	-	1,047	777
Lib 2	1,047	-	1,307
Lib 3	777	1,307	-

The current O\D matrix of the potential domestic rail passenger traffic, estimated considering the rail network entirely completed already in the year 2010, is reported below. It can be observed that the higher estimated flows are those one from the zone Lib_02 to the zone Lib_03 and vice versa.

The total number of the estimated passenger movements per year by rail amounts about to 3,033,000.

Table 6.1.4.3 Shows the O\D matrix of potential rail passenger traffic

O/D (pax/year)	Lib 1	Lib 2	Lib 3
Lib 1	-	1,004,196	468,454
Lib 2	1,004,196	-	43,774
Lib 3	468,454	43,774	-

Rail freight demand analysis

Because of the regional freight traffic data about Libya are currently not available, freight demand flows have been estimated by matching regional traffic data of the other countries of the study area. The results of the analysis are reported in the table below.

Table 6.1.4.4 shows - Current O\D matrix of potential rail freight traffic

O/D (tons	MAU	MOR	ALG	TUN	LIB	EGY	SUD
MAU	-	n.c.l.	n.c.l.	n.c.l.	0	0	0
MOR	n.c.l.	-	n.c.l.	n.c.l.	15,470	12,892	0
ALG	n.c.l.	n.c.l.	-	n.c.l.	9,186	117,889	0
TUN	n.c.l.	n.c.l.	n.c.l.	-	207,442	32,353	7,613
LIB	0	20,997	0	263,786	-	69,386	0
EGY	0	63,503	63,503	80,159	333,130	-	n.c.l.
SUD	0	0	0	4,017	0	n.c.l.	-

6.1.5 Egypt

<u>Rail network involved in analysis</u>

Egypt is the Country of the Maghreb area runs from the Libyan border towards Jordan and Palestine in the north and towards Sudan in the south of the Country. Moreover, it is also composed by a crossing section running from Kharga to Kena and to Safaga port on the Red Sea.

The figure 6.1.5.1 below shows the globe view of Egypt.

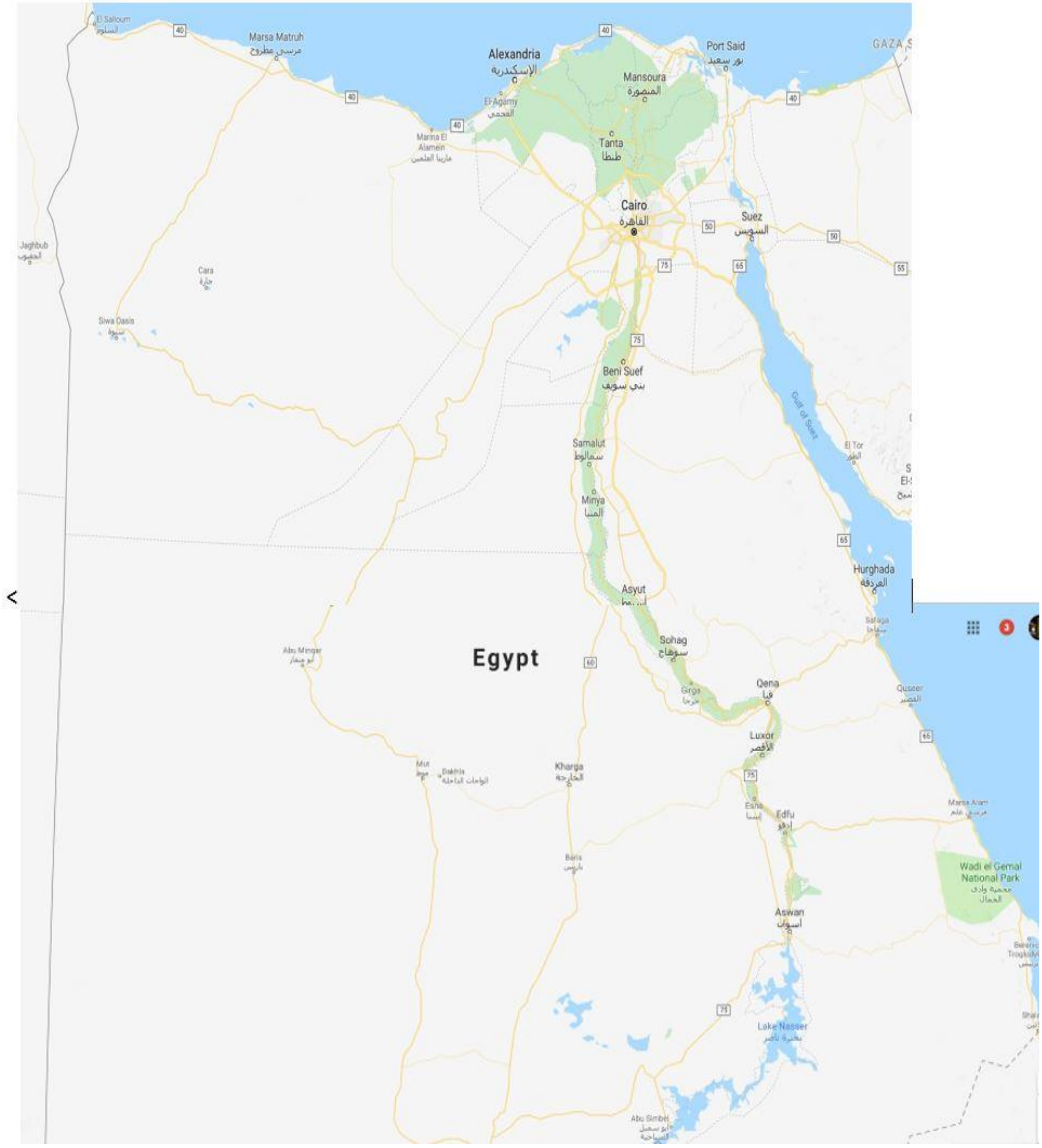


Figure 6.1.5.2 below shows the current and future rail network of Egypt and is represented.

<u>Data sources for analysis</u>

Regarding to passenger demand data, the main sources for the analysis have been represented by the website "Egypt State information Service" and by the internet database of CAPMAS (Central Agency for Pubic Mobilization and Statistics), where the population per governorate, updated to 2010, is reported.

The number of employees has been assumed as the 25% of the population of each governorate according to considerations on the average employment rate of the other countries of the study area.

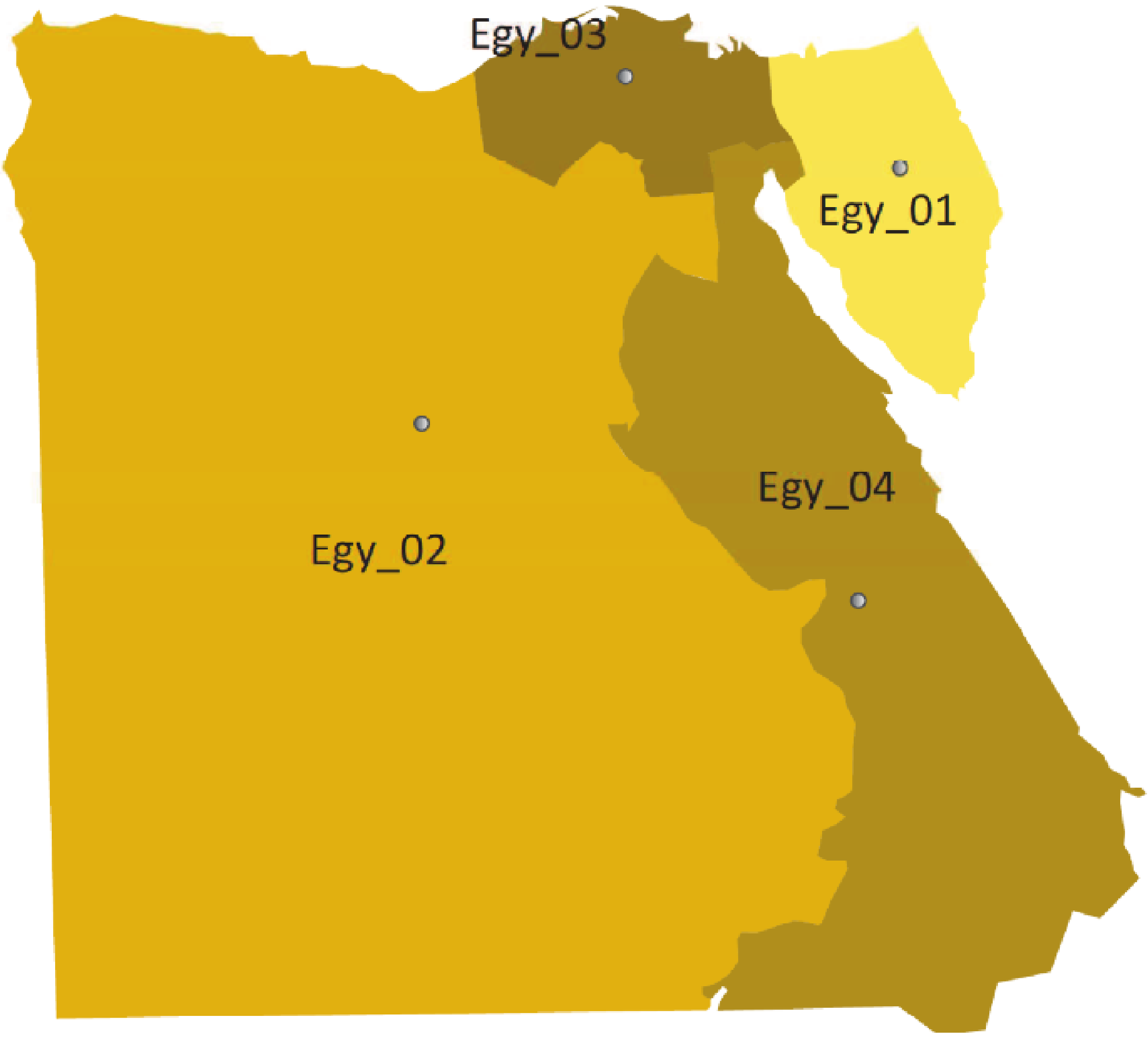
Main sources for freight demand data have been the website of "Global Edge" and the trade statistic database of PIERS, in which the monetary value of import-export freight traffics of Egypt are reported, and the website of the Ministry of Transport - Maritime Transport Sector for freight traffic handled by each port.

Finally, another source has been represented by "The study on multimodal transport and logistics system of the Eastern Mediterranean region and master plan in the Arab Republic of Egypt" realized by J CA (Japan international Cooperation Agency) in the year 2008.

Rail Passenger demand analysis

In order to estimate the domestic rail passenger demand, Egypt has been subdivided in four zones (named Egy_01, Egy_02, Egy_03 and Egy_04), illustrated in the figure below. To each zone it has been associated a centroid, reasonably located according to geographical and socio-economic considerations.

Figure 6.1.5.3 shows - Zones and centroids



In the following table, the area, the consistency of population and employees per zone are summarized.

Table 6.1.5.1 show- Current Population and Employees per zone

Zone ID	Governorates	Major City Name	Area (Km^2)	Population 2010	Estimated Employees 2010
Egy_01	North Sinai South Sinai	Arish el-Tor	30,888	529,012	132,253
Egy_02	Beni Suef Faiyum Giza Matruh Minya New Valley	Beni Suef Faiyum Giza Mersa Matruh Minya Kharga	606,953	16,154,548	4,038,637
Egy_03	Alexandria	Alexandria	27,572	41,659,732	10,414,933
	Beheira Cairo Dakahlia Damietta Gharbia Ismailia Kafr el-Sheikh Monufia Port Said Qalyubia	Damanhur Cairo Mansura Damietta Tanta Ismailia Kafr el-Sheikh Shibin el-Kom Port Said Banha			
Egy_04	Aswan Asyut Luxor Qena Red Sea Sharqia Sohag Suez	Aswan Asyut Luxor Qena Hurghada Zagazig Sohag Suez	211,517	19,252,126	4,813,032

In order to perform the presented distribution model, the distances between centroids have been estimated. The obtained results are reported below.

Table 6.1.5.2 shows - Distances between centroids

D_{ij} (km)	Egy 1	Egy 2	Egy 3	Egy 4
Egy 1	-	764	330	989
Egy 2	764	-	536	952
Egy 3	330	536	-	765
Egy 4	989	952	765	-

The current O\D matrix of the potential domestic rail passenger traffic, estimated considering the rail network entirely competed already in the year 2010, is reported below. It can be observed that the higher estimated flows are those from to the zone Egy_03, that is the most populated zone and where are located important cities like Cairo, Alexandria, Benha and Damanhur. The total number of the estimated passenger movements per year by rail amounts about to 40,359,000

Table 6.1.5.2 shows - Current O\D matrix of potential rail passenger traffic

O/D (pax /year)	Egy 1	Egy 2	Egy 3	Egy 4
Egy 1	-	31,636	682,406	36,537
Egy 2	31,636	-	10,126,438	1,530,462
Egy 3	682,406	10,126,438	-	7,772,181
Egy 4	36,537	1,530,462	7,772,181	-

Rail Freight demand analysis

In order to estimate the regional rail freight demand, the same subdivision of Egypt in four zones (named Egy_01, Egy_02, Egy_03 and Egy_04), identified for the passenger demand analysis, has been maintained. Moreover, eight external centroids, to simulate import-export traffic flows with the other countries of the study area and the rest of the world have been identified. four external centroids have been identified at the borders with Libya, Sudan, Israel and Jordan (named L B Border, SUD Border, SR Border, JOR Border) for the simulation of the connections by land. The other four external centroids, simulating the sea connections (and named P_Egy_01, P_Egy_02, P_Egy_03, and P_Egy_04), have been located beside the coast (one for each zone). In particular, each external centroid is a fictitious port which handles the amount of freights handled by the main ports belonging to the same zone

Domestic rail freight demand has been assumed negligible.

At the beginning, the import-export from to the other countries has been estimated for the year 2008. The results are shown in the table below.

Table 6.1.5.3 shows the Estimated import-export per partner

Partner	Estimated Export by Rail (tons)	Partner	Estimated Import by Rail (tons)
Rest of the world	9,293,275	Rest of the world	11,878,325
Libya	333,130	Algeria	137,554
Sudan	221,739	Libya	69,386
Tunisia	80,159	Tunisia	24,346
Algeria	63,503	Mauritania	1,217
Morocco	123,883	Morocco	7,304
Mauritania	0	Sudan	12,173
Israel	12,492	Israel	12,173
Jordan	280,037	Jordan	23,129

Subsequently, the total amount of arriving departing freight volumes by sea from to the rest of the world have been calculated. import-export total freight volumes were distributed among the four fictitious ports proportionality to the freight volumes handled by the main ports simulated. Obtained results are reported in the next table.

Table 6.1.5.4 shows the Total arriving/departing freight volumes by sea per port

ID Port	Port	Freight	% FRE
P Egy 1	Ei Arish	5,540,000	0.08
P Egy 2	Marsa Matruh	5,540,000	0.08
P Egy 3	Aiexandria I Dekheiia I Damietta I Port Said	46,377,000	0.666
P Egy 4	Suez I Sokhna I Adabiya I Safaga	12,159,000	0.175
	TOTAL	69,616,000	1

At the same time, the total import and export values have been shared among all the zones proportionality to their population, assuming the percentage of population as a measure of the production and of consumption of goods. Obtained results are reported in the next table.

Table 6.1.5.5 shows the Distribution percentages of population for each zone

ID Zone	Estimated Population 2010	% POP
Egy 1	529,012	0.01
Egy 2	16,154,548	0.21
Egy 3	41,659,732	0.54
Egy 4	19,252,126	0.25
TOTAL	77,595,418	1

The current O\D matrix of the potential rail freight traffics, estimated considering the rail network entirely competed already in the year 2010, is reported below. The matrix refers only to inside-outside movements of freight volumes crossing Libya, Sudan, Israel and Jordan borders by land and with the rest of the world by sea and vice versa. The inside-inside movements and outside-outside movements of freight volumes has been not computed (n.c.).

It can be observed that the higher estimated freight flows are those ones exchanged between the zone Egy_03 (which includes important cities like Cairo, Alexandria, Benha and Damanhur) and the external centroid P_Egy_03 (simulating the ports of Alexandria, Dekheila, Damietta and Port Said) and vice versa. The total estimated export freight volumes by rail per year amount about to 10.347 million of tons, while the total estimated import freight volumes by rail per year amount about to 12.165 millions of tons.

Table 6.1.5.6 shows the Current O\D matrix of potential rail freight traffic

O\D (tons/year)	Egy_01	Egy_02	Egy_03	Egy_04	P_Egy_1	P_Egy_02	P_Egy_03	P_Egy_04	LIB Border	SUD Border	ISR Border	JOR Border
Egy_01	*n.c.*	*n.c.*	*n.c.*	*n.c.*	5,042	5,042	42,208	11,066	3,683	1,512	85	1,909
Egy_02	*n.c.*	*n.c.*	*n.c.*	*n.c.*	153,967	153,967	1,288,906	337,922	112,484	46,164	2,601	58,301
Egy_03	*n.c.*	*n.c.*	*n.c.*	*n.c.*	397,054	397,054	3,323,860	871,441	290,075	119,048	6,707	150,347
Egy_04	*n.c.*	*n.c.*	*n.c.*	*n.c.*	183,490	183,490	1,536,049	402,717	134,052	55,016	3,099	69,480
P_Egy_01	6,444	196,795	507,500	234,530	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*
P_Egy_02	6,444	196,795	507,500	234,530	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*
P_Egy_03	53,948	1,647,432	4,248,437	1,963,321	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*
P_Egy_04	14,144	431,919	1,113,844	514,738	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*
LIB Border	1,635	49,925	128,748	59,498	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*
SUD Border	83	2,534	6,535	3,020	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*
ISR Border	83	2,534	6,535	3,020	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*
JOR Border	158	4,815	12,417	5,738	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*	*n.c.*

7. Rail operation models for the network

Some of important issues affecting the interoperability of the network are in Reported below. The most important issues to be considered and uniformed in order to ensure the possibility of different systems to inter-operate are as follows

a. Existence of connection

b. Type of operation, referring to both passenger and freight traffic

c. Technical standards for interoperability, such as:

- o Track gauge
- o Mass per axle
- o Gabarit
- o Signalling system
- o Type of traction in line

d. customs procedures

For the purpose of establishing the cost of the projects needed to complete an interoperable Afro-Mediterranean Railway Network in these countries, an initial ranking of the most needed projects are taken, while leaving the analysis of border crossing procedures to the following steps of the Study, not directly (or not so importantly) connected with the costing estimation needed for the completion of the African Railway Network.

Assumptions on the operational models of the Arab Core Railway Network .

In the following, brief considerations are given to explain the considerations regarding these issues:

- o track gauges and mass per axle choices along the different Country networks;
- o choices regarding signalling systems to be adopted;
- o border crossing installations.

Even though at this stage it has not foreseen the electrification along the missing links of the Arab Core Railway Network, some indications on the electrification option are also provided at the end of the present chapter.

7.1 Track gauges

Morocco, Algeria, Libya, Egypt at present almost have standard gauge for the operation of the passenger and freight trains. The exception is encountered in Tunisia, where the sections Tunis-Susah - Sfax - Gabes (total length 415 Km) are operated by narrow gauge.

Considering that the total existing length of railway axes object of the Study is 10996 Km, the narrow-gauge extension represents only the 3.77%.

In present in my Study, the above narrow-gauge sections have been foreseen to be replaced by new standard gauge lines, therefore all these countries will run at standard gauge (1,435mm).

In fact, Tunisian Railway Company (SNCFT), in the "Developing Plan for High Speed Lines LGV by establishing new lines between Tunisia, Algeria and Libya for High Speed passenger trains and freight traffic adopting the standard gauge.

7.2 Mass per axle and gabarit in Railway Network

The adopted mass per axle and gabarit on the existing lines varies between Countries and even within lines of the same Country.

The standardization of these important parameter for the inter-operability of the lines require a deep rehabilitation of the structures or, more often, a new structure to be constructed outside the line.

In the present Study, for the new lines the axle load that could be 25 tons. For lines requiring upgrading, if it has been assumed only the rehabilitation of the permanent way, the axle load has not been modified, while for some important section, the upgrading consists mainly in a new line, new standard axle load and gabarit have been adopted for cost estimation purpose.

7.3 Interoperable Signalling systems for Afro-Mediterranean Railway Network

ERTMS/ETCS is the acronym of European Rail Traffic Management System and it is the European Train Control System to achieve the train interoperability and safety

The ERTMS/ETCS is a signalling standard for trains traveling through an international and heterogeneous network and it keeps a "common language" that connects the track side system (ground) and the train side system (on board). The UNISIG standard defines the procedures for the ground and the on-board signalising information exchange, identifying the transmission techniques and the message format.

The ERTMS/ETCS equalizes the incompatibilities among the national train rules, since each Country has an own rail "language" to manage the train traffic. The ERTMS/ETCS system assists the driver providing all the required information and checking step the driver conducts to undertake high safety level.

I have assumed this technology as a standard for the entire Arab Core Railway Network.

Here below, a brief description of the different level associated to this signalling standard and a technical and economical comparison between level 1 and level 2.

Considering the different characteristics associated to Level 1 and 2 of ETRMS/ETCS systems, even knowing that some countries have planned for some specific lines the direct implementation of Level 2.

As a unified signaling standard for the future rail network and the relevant cost level have therefore been considered in the costing estimation presented in the following chapter.

7.3.1 ERTMS/ETCS Levels

The functional structure of ERTMS/ETCS

The kernel comprises the on board equipment with the elements:

- Train Interface Unit
- Driver Machine Interface
- Data Recording
- Kernel
- Odometer
- Balise Transmission Module

- Loop Transmission Module
- Euroradio
- GSM-R mobile unit

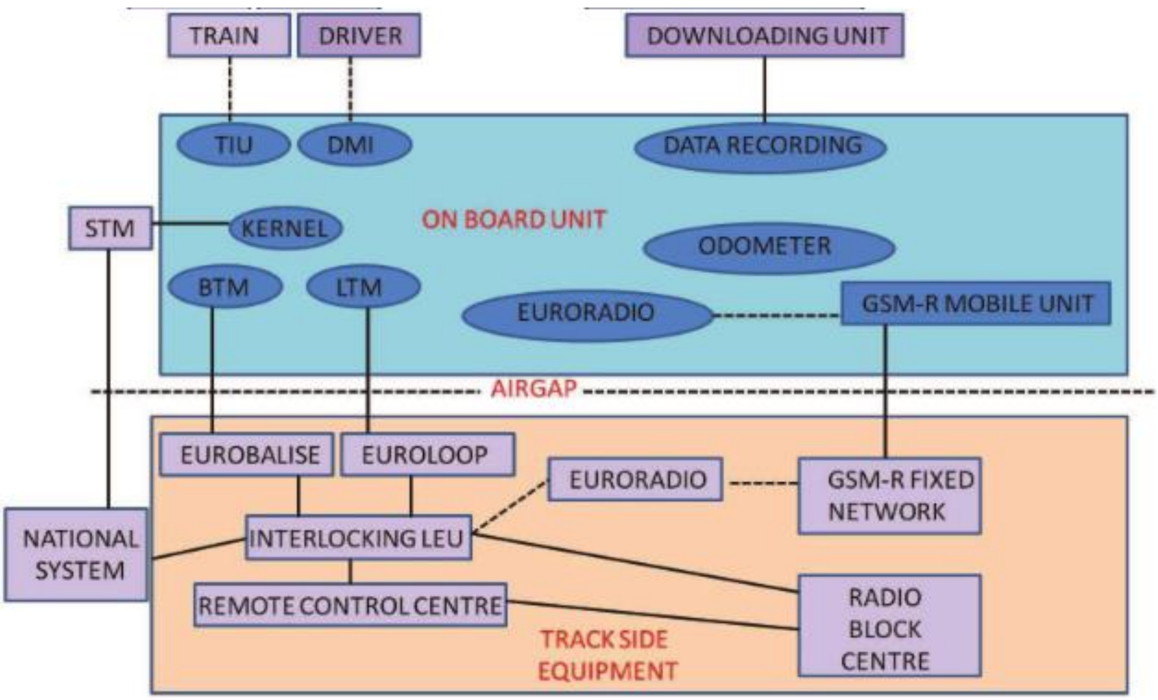
and the track side equipment with the elements:

- Eurobalise,
- Euroloop, a radiating cable in the foot of the rail to provide continuous information between Eurobalises
- Euroradio interface
- GSM-R fixed network, is the radio inking among RBC and trains
- Interlocking
- Line Side Electronic Unit is an electronic device among the interlocking system and the switchable Eurobalise. The Encoder gain the interlocking information (as train spacing, signal aspect) and build "the message" for the eurobalise
- Remote Control Centre
- Radio Block Centre, collect via radio and from the on board unit, the train positioning (evaluate by odometer and fixed balises) and refresh the movement authority regarding the interlocking status (track occupancy, switch status)

For the data exchange between on board and track side the following devices are used:

- Eurobalise for unidirectional intermittent transmission from track side to train. It is a fixed or switchable device to move a 1023 bit message (on line gradient, speed information and movement authority) from the LEU to the train on board unit.
- Euroloop for unidirectional continuous transmission from track side to train
- Euroradio interface device with link ETCS with GSM-R for bidirectional continuous data transmission

Figure 7.3.1 below shows the functional structure of ERTMS/ETCS



The figure 7.3.1 shows to what degree the interfaces between on board and track side systems as well as external system are harmonized.

Due to the great variety of configurations in the signalising equipment's (interlocking, line side signals, track occupancy proving device) which are used on the various line, ERTMS/ETCS has been conceived with several application level:

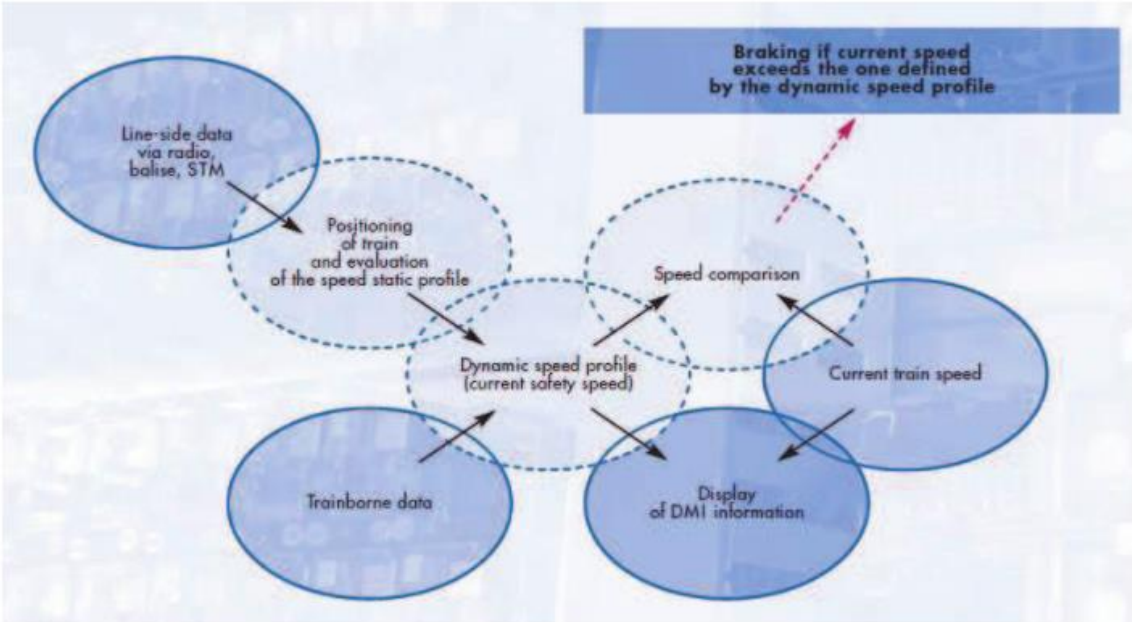
- Level 0, covers operation of ERTMS/ETCS equipped trains on lines not equipped with

ERTMS/ETCS

- Level STM, used to run of ERTMS/ETCS equipped trains on lines equipped with national control and command systems
- Level 1, more detail in the next paragraph
- Level 2, more detail in the next paragraph

The ERTMS/ETCS system behaviour is consistent in the application levels 1, 2, 3 and in each one the on-board equipment can achieve basically the same functionality as shown in the figure 7.3.2

Figure 7.3.2 shows the onboard equipment functionality of ERTMS



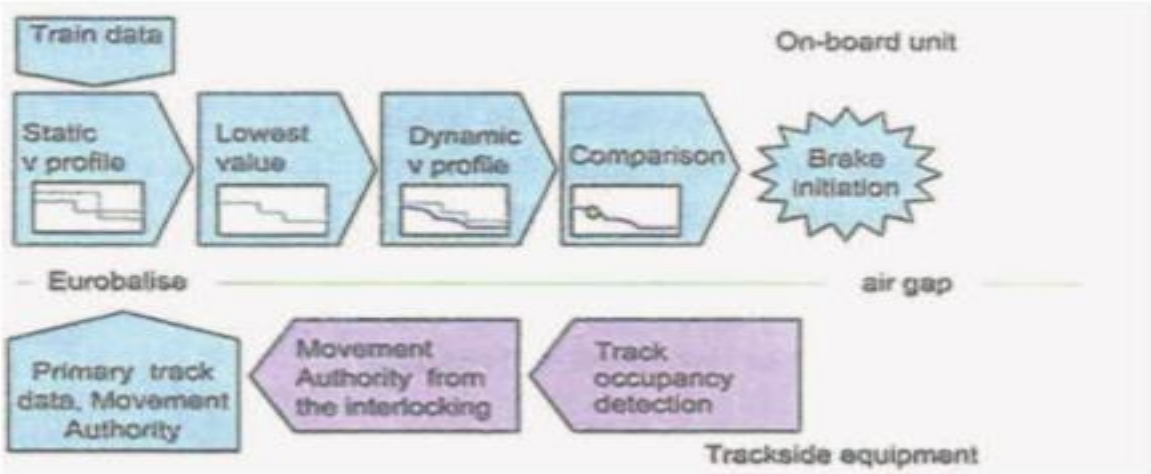
<u>ERTMS/ETCS Level 1</u>

In the application level 1 the train position is detected by track side occupancy controlling device which are inked with interlocking. Fixed or variable data is transmitted from track to trains by eurobalises.

In level 1 application, continuous data infill by means of radiating cables in the foot of the rail can be used. The infill information is needed for two main reasons:

- Line capacity. Train which passes a signal at warning can proceed after clearance of the next signal without delay and at the allowed maximum speed if infill information is received before reaching the next signal. That leads to shorter device intervals and spacing between trains
- Safety. Trains which start against a stop signal without authorization are fully protected even in application with minimal overlap, as there is no need to define a release speed with which a train can pass a signal at danger.

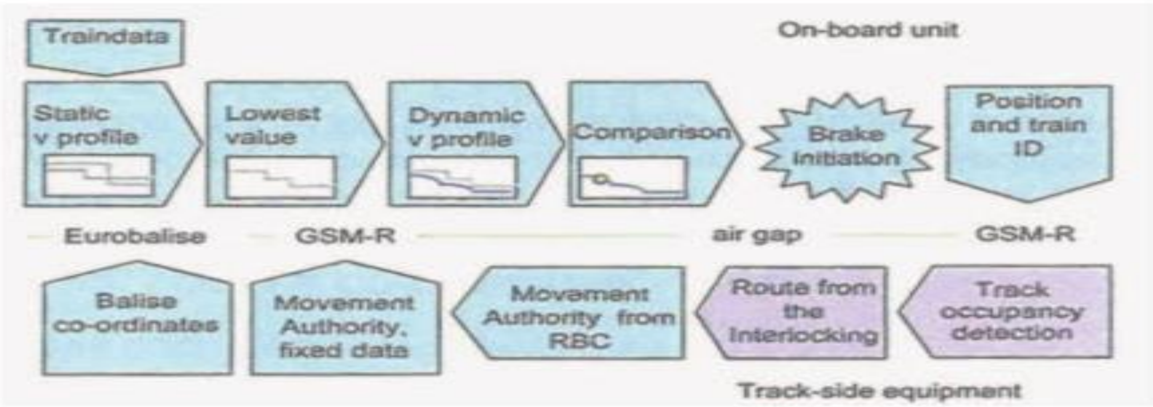
Figure 7.3.3 shows ERTMS level 1



In level 1 train operation with eurobalise and euroloop infill both the eurobalise and euroloop data transmission channel are active. The basic information is transmitted via the eurobalise, what enables also trains without euroloop receivers to run over the line section. The trains with euroloop receiver obtain without delay an update of information in case of a change of the signal aspect

<u>ERTMS ETCS Level 2</u>

Figure 7.3.4 shows ERTMS level 2



In the application level 2 ERTMS/ETCS uses GSM-R radio to exchange data between the track side radio block centre and the trains. The interlocking reports the status of the objects controlling the routes of the trains to the RBC which, in turn, generates the correct movement authorities for the different trains in the section. In normal level 2 operation (as level 1 with euroloop) line side signals are no longer necessary. The traditional block control with track side occupancy proving device is kept. On track side the interface between the radio block centre and the interlocking as well as the remote-control centre have not commonly specified. This is the major obstacle in the application of level 2 as project specific solutions are required. Eurobalises are used for the recalibration of odometry and for transmitting some fixed infrastructure data to the trains.

COMPARISON between Level 1 and Level 2

The main advantages of the ERTMS system are safety and interoperability, which are valid for both Levels. There are, however, major differences between ERTMS Level 1 and Level 2, especially in terms of costs and investments. Starting from a technical point of view the table below runs over the differences in terms of equipment

Figure 7.3.5 shows technical point of view of ERTMS

	On board	Track-side				
ERTMS/ETCS level	Check of train integrity	Data transmission	Lineside electronic units	Lineside signals	Track occupancy detection	Radioblock
1	no	balises+loops *(option)*	yes	yes	yes	no
2	no	balises+radio	no	no	yes	yes

considering the interoperability as the first goal, Level 2 ensures similar benefits to those of Level 1, but greater cost to provide the system with additional expensive components like the GSM-R network and the RBC (one every 100 kilometres). Level 1 is therefore the first step for interoperability as requires lower initial investments, fewer components, allows upgrading to level 2 and doesn't affect national investment pain which consider level 2, since the two systems are completely well- suited (with level 2 on board equipment).

The table 7.3.6 below shows the ratio between level 1 and level 2

	ERTMS/ETCS Lev.1 [€/km DT]	ERTMS/ETCS Lev.2 [€/km DT]	ERTMS ONBOARD [€/OBU]
R&D	20 000	130 000	60 000
Investments	90 000	770 000	300 000
R&D + Inv.	110 000	900 000	360 000
O&M	30 000	200 000	80 000
LCC	140 000	1 100 000	440 000

DT: double track; OBU: on board unit; R&D: research and development; O&M: operation and maintenance: Life Cycle Cost. (source: U C, ERTMS implementations Benchmark, Final Report - September 2009)

The average prices shown in the above synoptic table are indicative of the comparative level of costs associated to Level 1 and Level 2, as resulting from an ERTMS Platform Working Group, but do not represent the unit costs to be considered for any project, since they represent only the costs associated to installation along the line (and not the installations in the control centres in the stations). In particular, considered an average price for ERTMS Level1 installation of about 300,000 €/km (all included)

Border crossing installation for Network

This cost represents a very minor percent of the total cost, so it has been assumed equal for all countries. The assumed cost refers to civil and technological works for the operation of the railway movement across the border, like administrative building, stopping temporary parking of the roiling stock during the inspections, signalling/telecom for the operation of the railway.

7.4 Electrification for network

The power electrical traction system is composed by the following principal elements:

- High voltage lines
- Electrical substations (ESS)
- Contact lines
- Medium/low voltage auxiliaries supply system for no-traction loads
- Remote command and control system.

Each Electrical Substations supplies sections of contact lines generally through two power electrical transformer. The main difference is 25 kV and 2x25 kV is the presence of autotransformer posts. At last, three autotransformer posts are located between electrical substations with the terminals connected respectively to the contact lines and the feeders, and the central terminal connected to the rail.

Power flows from ESS to the train through a double voltage system (50 kV), and the train is supplied at 25 kV.

Table shows7.3.1 the unit costs for one railway track electrification components, in both 2x25 kV and simple 25KV architecture

ELECTRIFICATION, 2X25KV and 1x25 KV options	**Unit**	**Quantity**	**Cost (Euro) 2x25KV**	**Cost (Euro) 2x25KV**
High voltage line	Km	1	300.000	300.000
Contact line for 2x25 kV electrical traction system, stations secondary tracks, command and control system	Km	1	360.000	330.000
Neutral section	Km	1	410.000	350.000
Parallel Post (2x25) with Autotransformer (PP)	N.	1	1.350.000	
Sectioning post (SP)	N.	1		350.000
Electrical Substations (EES)	N.	1	4.500.000	4.000.000
Remote command and control system (DOTE)	N.	1	1.800.000	1.800.000

Table 7.3.2 shows cost for one railway track electrification of 200 km length, the following cost estimation are done

	2x25 kV electrification system			***1x25 KV electrification system***		
	unit cost(euro)	**Quantity**	**cost (Euros)**	**Unit cost (euro)**	**Quantity**	**cost (Euro)**
High voltage line	300.000,00	4,00 km	1.200.000	300.000	6,00 Km	1.800.000
Contact line	360.000,00	200,00km	72.000.00	330.000	200,00Km	66.000.000
Neutral section	410.000,00	9,00 N	3.690.000	350.000	13,00 N	4.550.000,00
Parallel Post (2x25) with auto transformer	1.350.000,00	11,00 N	14.850.000			
Sectioning post	N	-		350.000	17,00 N	5.950.000
Electrical Substations	4.500.000,00	4,00 N	18.000.000	4.000.000	6,00 N	24.000.000
Remote command and control system	1.800.000,00	1,00 N	1.800.000	1.800.000	1,00 N	1.800.000
Total cost (Euros)			111.540.000			104.100.000

8. cost estimation of Infrastructural needs for the connection

8.1 Introduction

- Preliminary findings together with preliminary concept of a possible route alignment for the railway line and jointly with the inception Report on April 2011 of AFESD, contained the details of the Arab network railway axes and findings on missing links and existing lines which needed upgrading to meet the required standards.

In this I have examined in detail each missing link and section requiring upgrading works, in order to establish reliable capital cost evaluations, which were needed for the assessment of priority rating of their execution, according to the criteria of project cost-effectiveness introduced.

As described missing link and an existing section need upgrading works, the costs consisting in

- civil works
- technologies and
- cost of land

was calculated.

In this, all the Capital costs have been estimated needed for the execution of the rail projects along Morocco, Algeria, Libya, Tunisia and Egypt (Rolling stock investment was not taken into account in this)

8.2 Methodology adopted for costs estimation

The evaluation of the construction costs was developed with the purpose to obtain an important input data to establish the priority of the missing /upgrading links of connecting the railway network.

The methodology adopted allowed the development of the cost estimation activity with an acceptable range of uncertainty, suitable and adequate for a "strategic planning study" of the nature of the one being carried out.

Furthermore, the unavoidable uncertainties associated to the cost estimation were almost equally reflected into each one of the links examined, being therefore the resulting priority list substantially unaffected by this phenomenon.

In addition, to better consider the local constraints affecting the different infrastructure projects under evaluation, each possible alignment route by making extensive use of satellite maps, taking note of the topographical conditions (plain - hill - mountainous - sand dunes-urban areas) that, of course, imply a notable difference in cost per Km.

The actual cost estimation, refers to a single-track railway line, with passing station fixed in a range of 12-20 Km.

In the estimation, no cost has been allocated for workshops and maintenance yards because they shall be examined considering the Country's network and they represent very minor costs. It is worthwhile to mention that, in addition to the capital cost estimation above described for missing and upgrading links, the need of the implementation of the technological system (signalling telecom) for those sections of lines that currently do not require upgrading.

However, this further evaluation was not considered (low investment costs versus generally high traffics would result in immediate top priorities)

The total railway estimated cost for missing links has been obtained by the sum of:

Infrastructure cost: composed by several components which main items have been grouped under the following components:

- Earthworks (fill-cut for railway and crossing roads platform);
- Permanent way (rails, sleepers, ballast-sub-ballast - switches);
- Drainage and structures (box and pipe culverts, wadi bridges, viaducts, tunnels, road overpass and underpass);
- Miscellaneous works (fence, noise barrier);
- Civil works and buildings for stations.

Technological cost: include the costs of implementation of an interoperable signalling and telecom system for the main line, stations, passing stations and crossing border installation. Considering advantages and disadvantages of the systems in use in Europe, a preliminary decision was to target the implementation of the European Railway Traffic Management System (ERTMS) developed under the authority the European Union to ensure inter-operability across national borders, equipped with level 1 ETCS systems.

Land acquisition cost: it has been established a right of way width and a unit cost of the different crossed land (desert, agricultural, urban areas). This cost has been indicated separately, since in general it is not taken into consideration by international Financing institutions.

Based on the average unit cost of the main costing items that was known in a several different countries (grouped in three macro-areas with a comparable GDP), a specific table of parametric cost (cost per Km length of infrastructure) have been prepared for the different morphological conditions of each missing upgrading link. The complete set of the used parametric cost.

8.3 Detailed description of cost estimation

The sections crossing Morocco - Algeria - Tunisia - Libya and Egypt

The missing links have been analysed by investigating a possible corridor in a large scale of satellite maps; the estimated total length is 4,725 Km.

The geometrical characteristics may be able to permit, in almost the whole length (except urban areas), a speed of more than 200 Km/h for passenger trains, respecting the minimum standard of 160 Km/h for no electrified lines. Of course, diesel tilting passenger trains could be used to run at 200 Km/h.

Within the upgrading links list, the following rehabilitation works have been considered:

- The rehabilitation of the permanent way and updates technological systems of Nouadhiou- Morocco border.

- the rehabilitation of the section Fez - Tazah and Tazah - OujdaIAigerian border, in Morocco, mainly consisting in a new single line with a geometric characteristic permitting a speed of more than 200 Km/h and reducing the present length of about 40 Km;

- the rehabilitation (as alternative to the new coastal connection from Annaba) of the line from Souk Ahras to Mecha El Arghoub (Algeria- Tunisia border), in Algeria, providing a new single line that will permit a minimum speed of 160 Km/h and a reduction of 5 Km length;

- the rehabilitation of the Tunisian section Algeria - Tunisian border - Beja - Tunis, mainly consisting in a new single line with a geometric characteristic permitting a speed of more than 200 Km/h and reducing the present length of about 15 Km.

Total length of evaluated upgrading sections: 1041 Km.

The following table 8.3.1 shows the most important figures regarding the connection

COUNTRY	km of Missing	Km of upgrading links	Cost of Missing links (Millions of USD)	Cost of upgrading link (Millions of USD)	Total cost including land acquisition cost (Millions of USD)
Morocco	1,770	314	9,115.40	1,471.20	11,372.60
Algeria	840	47	2,401.00	384	2,785.00
Tunisia	550	190	1,400.90	2,061.10	3,462.00
Libya	610		2,307.70		2,307.70
Egypt	955	496	4,537.90	582.2	5,120.10
TOTAL	4,725	1041	15,225.20	4498,5	25047.4

The cost of civil works for the sections planned under study has been obtained from some press news of internet, while the cost of land and technologies has been from AFESD.

9. Cost Effective Analysis

9.1. Method used in Cost-effective analysis

After having estimated the traffic flows running across a theoretically completed Afro-Mediterranean Rail Network then estimated the costs associated to the projects, now to obtain the right solutions all the input obtained are used to produce an evaluation for substantial use of the "Project Cost-Effectiveness" criteria.

The method of "Project Cost Effectiveness" proposed was based on the assessment of a "significant indicator" represented by the ratio between forecasted transported tonnes*km plus Pax*km - "transport units" as explained in previous Chapter - and the corresponding investment costs, needed to allow such flows along completely new or rehabilitated railway lines. This simple and practical method to serve passenger and freight traffic. Also (according to EU Guide Cost Benefit Analysis of investment Projects, the "cost-effectiveness analysis" (CEA) is a recognized tool widely used especially the project that, for a given output level, minimizes the costs, or, alternatively, for a given cost, maximizes the output level. CEA results are useful for those projects whose external benefits are very difficult, if not impossible, to be evaluated in quantitative terms, while costs can be predicted more confidently.

The analysis was carried out in a way to identify for each of them a theoretical sequence of projects for future implementation. However, the elements obtained made possible to extend such evaluation also to the entire network. the application of the cost effectiveness analysis was subject to a final check to aimed at verifying the consistency of the results.

The Cost Effectiveness Index is a good practical tool for ranking or priority purposes since the total traffic units are proportional to the benefits produced by the Project and therefore the ratio between traffic units and investment cost is a ranking measure of the Benefits over Cost ratio.

This is perfectly true in homogeneous areas where the order of magnitude of unit costs of investment and of parameters producing benefits are similar. But in our case the Study areas includes countries with macroscopic differences both in investment unit prices and in unit values related with the Project benefits.

While the differences in investment unit prices are reflected in the property evaluated investment costs, the difference in the unit values of benefits (benefits per unit of traffic) is not considered in the standard CEI formula.

The CEI formula is

$$CEI = \frac{K1\ x\ Pax * km + K2\ x\ Ton * km}{Investment\ Cost}$$

K1 and K2 being correction factors representing the different unit levels for passenger traffic units and freight traffic units respectively.

For instance, one of the main benefits of a railway project for passengers is generated by the value of the saved journey time. This is a linear function of the per capita income. In general, also other benefits are a function of the GDP per capita level. Therefore, the K1 correction factor could be the ratio between the average per capita income of countries and the general average per capita income of country.

Also, freight traffic unit benefits are somehow affected by the per capita income levels, but with a much lower rate therefore, for simplicity, this distortion was neglected, and K2 was always kept equal to 1.

It was also noted that, after the application of this correction factor, reasonable priority ranking results, also in line with other Feasibility studies conducted in the area, were obtained.

As a final step of this procedure, the following substantial results:

• The identification of a priority of projects for afro-Mediterranean Core

Railway Network

• The identification of three groups of priority projects (subdivided in short term, medium term and long term) for the entire afro-Mediterranean Railway Network, based on logical assumptions on funds allocation at different time horizons and timeline for practical implementation of the rail projects.

• The corresponding data on lengths and costs associated to each one.

For each country, the following tables and maps are presented:

a. description of projects considered in all countries, all the details like length, type of link (ML, UP, E, UC), Pax flows at 2040, freight flows, traffic units and cost effectiveness indicator.

b. Priority according to the value of the cost-effectiveness indicator, with details also about the single costs for their realization, the progressive cost, the progressive cost per km and the total length.

The total cost estimated for the realization of the identified projects (building of Missing Links and execution of Upgrading works) amounts to 19.92billion USD with an average cost per km of 4,36 Million USD/km.

Table 9.1.1 show the cost for each link considered

Country	Start of section	End of section	Length (km)	Type	Cost (USD)
Morocco	Morocco Border	Laayoune	820	ML	3,029,695,579
Morocco	Laayoune	Agadir	616	ML	3,398,546,007
Morocco	Agadir	Essaouira	150	ML	1,215,810,840
Morocco	Essaouira	Marrakech	184	ML	1,471,319,590
Morocco	Marrakech	Casabianca	246	E	
Morocco	Casabianca	Fez	319	E	
Morocco	Fez	Oujda (Algeria Border)	314	UP	2,257,209,900
Algeria	Oujda (Algeria Border)	Tabia	178	E	
Algeria	Tabia	Algier	471	E	
Algeria	Algier	Setif	299	E	
Algeria	Setif	Souk Aras	358	E	
Algeria	Souk Aras	ta Ei Argoub I Ghardimou (Tunisia Bo	47	UP	383,994,000
Algeria	Tabia	Redjem Demouche	75	E	

Algeria	Redjem Demouche	Bechar	500	E	
Algeria	Bechar	Ghar (Mauritania Border)	840	ML	2,400,982,776
Tunisia	echta Ei Argoub I Ghardimou (Tunisia Bord	Beja	85	UP	633,176,780
Tunisia	Beja	Tunis	105	UP	767,700,627
Tunisia	Tunis	Gabes	370	ML	1,496,191,584
Tunisia	Gabes	Ras Ajdir (Libya Border)	180	ML	564,944,452
Libya	Ras Ajdir (Libya Border)	Assidra	810	UC	
Libya	Assidra	Benghasi	366	UC	
Libya	Benghasi	mm Saad I Al Salloum (Egypt Border)	610	ML	2,307,658,026
Egypt	mm Saad I Al Salloum (Egypt Border)	Marsa Matruh	261	UP	277.353.159
Egypt	Marsa Matruh	Alexandria	293	E	
Egypt	Alexandria	Benha	155	E	
Egypt	Benha	El Firdan Bridge	127	E	
Egypt	El Firdan Bridge	Bir el Abd	85	UC	
Egypt	Bir el Abd	Rafah (Border)	126	ML	454.312.851
Egypt	El Firdan Bridge	Nuweba	370	ML	2.286.902.955

Data

Egypt	Benha	Quena	654	E	
Egypt	Quena	High Dam	288	E	
Egypt	Quena	Safaga	235	UP	304.845.088
Egypt	Quena	Kharga	230	ML	711.993.081
Egypt	Highn Dam	Sudan border	229	ML	1.084.657.891
Total					**19,927,230,161**

Source AFSED

Table 9.1.2 shows the passenger flow and freight flow considered in each link

Country	Start of section	End of section	Length (km)	Type	Pax Flow (pax/year)	Freight flow (t/year)
Morocco	Morocco Border	Laayoune	820	ML	154,519	589,428
Morocco	Laayoune	Agadir	616	ML	2,575,314	3,545,989
Morocco	Agadir	Essaouira	150	ML	2,575,314	3,545,989
Morocco	Essaouira	Marrakech	184	ML	14,858,348	15,864,467
Morocco	Marrakech	Casabianca	246	E	14,858,348	15,864,467
Morocco	Casabianca	Fez	319	E	15,454,799	8,779,621
Morocco	Fez	Oujda (Aigeria Border)	314	UP	3,940,355	3,448,898
Algeria	Oujda (Algeria Border)	Tabia	178	E	7,902,153	4,567,749
Algeria	Tabia	Algier	471	E	9,763,840	18,702,231
Algeria	Algier	Setif	299	E	16,290,015	13,598,039
Algeria	Setif	Souk Aras	358	E	9,318,847	11,920,913
Algeria	Souk Aras	ta Ei Argoub l Ghardimou (Tunisia Bo	47	UP	9,318,847	11,920,913
Algeria	Tabia	Redjem Demouche	75	E	9,763,840	2,273,906
Algeria	Redjem Demouche	Bechar	500	E	2,604,847	4,486,254

Algeria	Bechar	Ghar (Mauritania Border)	840	ML	586,922	4,486,357
Tunisia	echta El Argoub I Ghardimou (Tunisia Bord	Beja	85	UP	4,855,977	9,863,680
Tunisia	Beja	Tunis	105	UP	4,855,977	9,863,680
Tunisia	Tunis	Gabes	370	ML	5,626,876	5,744,666
Tunisia	Gabes	Ras Ajdir (Libya Border)	180	ML	1,137,920	2,070,928
Libya	Ras Ajdir (Libya Border)	Assidra	810	UC	2,085,477	1,325,484
Libya	Assidra	Benghasi	366	UC	1,313,850	1,325,484
Libya	Benghasi	mm Saad I Al Salloum (Egypt Border)	610	ML	771,626	1,325,484
Egypt	mm Saad I Al Salloum (Egypt Border)	Marsa Matruh	261	UP	728.23	878.658
Egypt	Marsa Matruh	Alexandria	293	E	23.546.095	7.477.551
Egypt	Alexandria	Benha	155	E	27.241.628	21.680.141
Egypt	Benha	El Firdan Bridge	127	E	26.072.424	22.042.859
Egypt	El Firdan Bridge	Bir el Abd	85	UC	779.387	2.082.886
Egypt	Bir el Abd	Rafah (Border)	126	ML	779.387	2.082.886
Egypt	El Firdan Bridge	Nuweba	370	ML	779.387	2.394.433
Egypt	Benha	Quena	654	E	19.395.269	8.085.154
Egypt	Quena	High Dam	288	E	19.395.269	8.085.154
Egypt	Quena	Safaga	235	UP	310.324	1.337.934
Egypt	Quena	Kharga	230	ML	242.743	1.337.934

Egypt	Highn Dam	Sudan border	229	ML	1.357.669	4.583.173

Table 9.1.3 shows the calculated cost effectiveness for each link

Country	Start of section	End of section	Length (km)	Type	Traffic Units ((pax+t)*km/year)	Effectiveness/cost (((pax+t)*km/year) /US$)
Morocco	Morocco Border	Laayoune	820	ML	610,036,706	0.2
Morocco	Laayoune	Agadir	616	ML	3,770,722,537	1.11
Morocco	Agadir	Essaouira	150	ML	918,195,423	0.76
Morocco	Essaouira	Marrakech	184	ML	5,652,997,949	3.84
Morocco	Marrakech	Casabianca	246	E	7,557,812,475	
Morocco	Casabianca	Fez	319	E	7,730,779,910	
Morocco	Fez	Oujda (Algeria Border)	314	UP	2,320,225,527	1.03
Algeria	Oujda (Algeria Border)	Tabia	178	E	2,219,642,675	
Algeria	Tabia	Aigier	471	E	13,407,519,252	
Algeria	Algier	Setif	299	E	8,936,527,929	
Algeria	Setif	Souk Aras	358	E	7,603,834,133	
Algeria	Souk Aras	ta Ei Argoub I Ghardimou (Tunisia Bo	47	UP	998,268,727	2.6
Algeria	Tabia	Redjem Demouche	75	E	902,830,920	
Algeria	Redjem Demouche	Bechar	500	E	3,545,550,297	

Algeria	Bechar	Ghar (Mauritania Border)	840	ML	4,261,554,273	1.77
Tunisia	echta Ei Argoub I Ghardimou (Tunisia Bord	Beja	85	UP	1,251,170,839	1.98
Tunisia	Beja	Tunis	105	UP	1,545,563,978	2.01
Tunisia	Tunis	Gabes	370	ML	4,207,470,492	2.81
Tunisia	Gabes	Ras Ajdir (Libya Border)	180	ML	577,592,658	1.02
Libya	Ras Ajdir (Libya Border)	Assidra	810	UC	2,762,878,128	
Libya	Assidra	Benghasi	366	UC	965,996,331	
Libya	Benghasi	mm Saad I Al Salloum (Egypt Border)	610	ML	1,279,237,266	0.55
Egypt	mm Saad I Ai Salloum (Egypt Border)	Marsa Matruh	261	UP	419.397.577	1,51
Egypt	Marsa Matruh	Alexandria	293	E	9.083.723.630	
Egypt	Alexandria	Benha	155	E	7.582.874.144	
Egypt	Benha	El Firdan Bridge	127	E	6.110.640.932	
Egypt	El Firdan Bridge	Bir el Abd	85	UC	244.151.841	
Egypt	Bir el Abd	Rafah (Border)	126	ML	360.646.330	0,79

Egypt	El Firdan Bridge	Nuweba	370	ML	1.174.313.209	0,51
Egypt	Benha	Quena	654	E	17.961.204.451	
Egypt	Quena	High Dam	288	E	7.922.605.941	
Egypt	Quena	Safaga	235	UP	387.340.613	1,27
Egypt	Quena	Kharga	230	ML	363.555.681	0,51
Egypt	Highn Dam	Sudan border	229	ML	1.360.452.794	1,25
Total					**83,026,408,425**	

9.2 Result of Cost-Effectiveness Analysis

In the cost effectiveness study, it can be seen that total amount or cost for the complete construction of Afro-Mediterranean railway is about 20 billion USD which amounts to 27 billion increase of traffic units which is the benefit. The average cost effectiveness in connecting Morocco, Algeria, Tunisia, Libya and Egypt for the construction of 10951 km is 1.09 km/year/USD. In comparison with the same scenario in Arab countries, which was similar have proved theoretically the connection will result in the social and economic development (study report of Arab railway network report by AFESD) which is effective. The reason I have taken the Arab countries for my comparison is because of the social, geopolitical and geographical similarity which can in future be a part of the network.

This cost effectiveness has been considered in giving priority for the construction of each link. The priority has been found and are listed below in the table according to the cost-effectiveness of each link.

Table 9.1.4 shows the priority of each link according to the cost effectiveness

Priority	**Country**	**Start of section**	**End of section**	**Length (km)**	**Type**	**Traffic Units Km/year/ USD**	**Effectivenss /cost**
1	Egypt	El Firdan Bridge	Nuweba		ML	1.174.313.209	0,51
2	Egypt	Quena	Safaga	235	UP	387.340.613	1,27
3	Egypt	Quena	Kharga	230	ML	363.555.681	0,51

4	Egypt	Highn Dam	Sudan border	229	ML	1.360.452.794	1,25
5	Morocco	Essaouira	Marrakech	184	ML	5,652,997,949	3.84
6	Tunisia	Tunis	Gabes	370	ML	4,207,470,492	2.81
7	Algeria	Souk Aras	ta Ei Argoub I Ghardimou (Tunisia Bo	47	UP	998,268,727	2.6
8	Tunisia	Beja	Tunis	105	UP	1,545,563,978	2.01
9	Tunisia	echta Ei Argoub I Ghardimo u (Tunisia Bord	Beja	85	UP	1,251,170,839	1.98
10	Algeria	Bechar	Ghar (Mauritani a Border)	840	ML	4,261,554,273	1.77
11	Egypt	mm Saad I Ai Salloum (Egypt Border)	Marsa Matruh	261	UP	419.397.577	1,51
12	Morocco	Laayoune	Agadir	616	ML	3,770,722,537	1.11
13	Morocco	Fez	Oujda (Algeria Border)	314	UP	2,320,225,527	1.03
14	Tunisia	Gabes	Ras Ajdir (Libya Border)	180	ML	577,592,658	1.02
15	Egypt	Bir el Abd	Rafah (Border)	126	ML	360.646.330	0,79
16	Morocco	Agadir	Essaouira	150	ML	918,195,423	0.76

17	Libya	Benghasi	mm Saad I Al Salloum (Egypt Border)	610	ML	1,279,237,266	0.55

10. Envision

10.1 Introduction

Envision is a framework that provides the guidance needed to initiate the systemic change in the planning, design, construction, and long-term operation of physical civil infrastructure. Although the system is best applied at the initial planning phase of a project, it can be readily applied at any point in a project's life cycle, and is used by infrastructure owners, engineers, planners, designers, and other sustainability professionals as a vehicle for incorporation of sustainable elements into infrastructure projects of any type, size, or complexity. Envision is the product of a collaboration between the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design and the Institute for Sustainable Infrastructure (ISI). ISI was founded by the American Public Works Association (APWA), the American Society of Civil Engineers (ASCE), and the American Council of Engineering Companies (ACEC). Since its launch in 2012, many infrastructure owners have adopted the use of Envision their as standard for planning and design of their projects, and thousands of individuals have become credentialed as an Envision Sustainability Professionals (ENV SP). The primary objective of Envision is to encourage use of sustainability principles through ease and wide availability, such that it fosters an increase in sustainable infrastructure throughout our built environment. The structure of Envision provides its users the capability to perform an extensive self-assessment of their projects to aid in identifying gaps in which sustainability improvements could be instituted. Envision is comprised of multiple categories, each containing several credits that encourage the project team to not only do the "project right" but identify the "right project". Should the project team be interested in validating their project, an optional independent, third-party ISI verification program is available that provides an Envision is a decision-making guide, not a set of prescriptive measures. Envision provides industry-wide sustainability metrics for all types and sizes of infrastructure to help users assess and measure the extent to which their project contributes to conditions of sustainability across the full range of social, economic, and environmental indicators.

Fundamentally, Envision is about supporting higher performance through more sustainable choices in infrastructure development. The framework provides a flexible system of criteria and performance objectives to aid decision makers and help project teams identify sustainable approaches during planning, design, and construction that will carry forward throughout the project's operations and maintenance and end-of-life phases. Using Envision as a guidance tool, owners, communities, designers, contractors, and other stakeholders can collaborate to make more informed decisions about the sustainability of infrastructure.

Envision is an objective framework of criteria designed to help identify ways in which sustainable approaches can be used to plan, design, construct and operate infrastructure projects. Envision assesses not only individual project performance, but how well the infrastructure project contributes to the efficiency and long-term sustainability of the communities it serves. In this way, Envision not only asks, "Are we doing the project right?" but also, "Are we doing the right project?"

Envision is a rating system and best practice resource to help you become successful in implementing sustainability into your infrastructure projects. It measures the sustainability of an infrastructure project from design though construction and maintenance. It can be used by infrastructure owners, design teams, community groups, environmental organizations, constructors, regulators, and policy maker to:

- Meet sustainability goals
- Gain public recognition for high levels of achievement in sustainability
- Help communities and project teams collaborate and discuss, "Are we doing the right project?" and, "Are we doing the project right?"
- Make decisions about the investment of scarce resources
- Include community priorities in civil infrastructure projects

The Envision tools can also help your design team:

- Secure community participation
- Assess costs and benefits over the project lifecycle
- Evaluate environmental benefits
- Use outcome-based objectives

- Reach higher levels of sustainability achievement

10.2 Purpose of Envision

To foster a dramatic and necessary improvement in the performance and resiliency of our physical infrastructure across the full spectrum of sustainability. Envision provides the framework and incentives needed to initiate this systemic change. As a planning and design guidance tool, Envision provides industry-wide sustainability metrics for all infrastructure types.

<u>OVERVIEW</u>

• A holistic sustainability rating system for all types and sizes of civil infrastructure

• Guide for making more informed decisions about the sustainability of projects

• Framework of criteria and performance objectives to help project teams identify sustainable approaches during

- planning
- design
- construction
- operation
- reconstruction

<u>STRUCTURE</u>

Fact Sheet

Envision provides the framework and incentives needed to foster a dramatic and necessary improvement in the performance and resiliency of our physical infrastructure across the full spectrum of sustainability. As a planning and design guidance tool, Envision provides industry-wide sustainability metrics for all infrastructure types.

The Envision sustainable infrastructure rating system is a comprehensive framework of 60 criteria that encompass the full range of environmental, social, and economic impacts that should be assessed to determine how a project has incorporated sustainability. These 60 sustainability criteria, called ‘credits’, are arranged in five categories as mentioned

- Quality of Life
- Leadership
- Resource Allocation
- Natural World
- Climate and Risk

The Envision Checklist is a free-standing assessment tool for comparing sustainability alternatives or to prepare for a more detailed sustainability assessment. Structured as a series of Yes/No questions of the above categories

The project team be interested in validating their project, an optional independent, third-party ISI verification program is available that provides an objective review of the project, as well as an avenue for public recognition of the project. This third-party verification allows the project team to demonstrate the owner's commitment to sustainability through a transparent and industry-recognized system. As with many projects, public acceptance is critical, and the use of this nationally recognized standard is a valuable tool to convince citizens that their resources are being wisely invested

<u>BENEFITS</u>

Infrastructure investments with:

- Long-term viability
- Lower cost
- Few negative impacts on the community
- Potential to save owners money over time
- Credibility of a third-party rating system

WHERE DOES ENVISION APPLY?

- Covers the roads, bridges, pipelines, railways, airports, dams, levees, landfills, water treatment systems, and other civil infrastructure

• Used by infrastructure owners, design teams, community groups, environmental organizations, constructors, regulators and policy makers

10.3 How Envision works

• Go to www.sustainableinfrastructure.org to download Envision at no cost

• Learn to use Envision better with the Envision Sustainability Professional (ENV SP) training

• Use Envision to guide planning, design, and construction projects to reduce environmental footprint and support the larger goal of improved quality of life

• Evaluate and recognize infrastructure projects that use transformational, collaborative approaches to incorporate sustainability throughout a project's life

ENVISION TOOLS

Envision Rating System

• An in-depth planning guide and rating system to improve the sustainability aspects of infrastructure projects.

• Includes a guidance manual and online scoring system.

• No cost to download or use for project planning and self-assessment.

• Optional independent, third-party review, called verification, offered by ISI.

• Verification qualifies projects to become eligible for recognition and awards.

Envision Pre-Assessment Checklist

• An educational tool that helps users become familiar with the sustainability aspects of infrastructure project design.

• A self-assessment to quickly compare project alternatives.

• Structured as a series of yes/no questions based on the Envision rating system criteria.

• No cost to download or use.

ENVISION SUSTAINABILITY PROFESSIONALS

ENV SPs are credentialed practitioners trained by the ISI in the use of the Envision rating system

• Both online and in-person training is available

• ENV SPs work to guide the project team to achieve higher levels of sustainability and to document project sustainability accomplishments.

• An ENV SP must be involved in a project for it to be eligible for an Envision award.

ENVISION AWARD LEVELS

Recognition Level Total Applicable Points (%)

Bronze Award 20

Silver Award 30

Gold Award 40

Platinum Award 50

VERIFICATION

ISI's independent third-party project verification program is a transparent process to confirm that a project meets Envision evaluation criteria.

• Helps rate payers and voters have confidence that the project has good value

• Enables projects to become eligible for Envision awards

• Easy to use online process

• After submitting the assessment project verification takes 90 days to complete

CREDIT LEVELS OF ACHIEVEMENT

Envision credits define multiple levels of achievement in order to better evaluate performance and encourage incremental project improvement.

1|Improved - Performance that is above conventional

2|Enhanced - Sustainable performance that adheres to Envision principles

3|Superior - Sustainable performance that is noteworthy

4|Conserving - Performance that has achieved essentially zero impact

5|Restorative - Performance that restores natural or social systems

Innovation Points Envision provides innovation points for projects that advance sustainable infrastructure practices or show exceptional performance beyond expectations.

ENVISION VERIFICATION COSTS

Project Size ($) Non-Member Price

Up to 2 M - $3,000

2-5 M - $8,500

5-25 M - $17,000

25-100 M - $25,000

100-250 M - $33,000

Over 250 M Contact ISI for large or multi-phase projects

*Registration fee $1000. Verification fee based on project size.

10.4 Analysis to Envision

In this thesis for a holistic sustainable rating for this project, guide for making more informed decisions about the sustainability of projects and to have a Framework of criteria and performance objectives to help project teams identify sustainable approaches during planning, design, construction, operation and reconstruction I have considered the credit of first phase of envision which is The Quality of Life.

The reason I have considered the Quality of Life is its relevance of its credits in analysing before starting the project, Is this project sustainable and are we doing the right project?

10.4.1 Quality of Life

This addresses a project's impact on host and affected communities, from the health and wellbeing of individuals to the wellbeing of the larger social fabric as a whole. These impacts may be physical, economic, or social. Quality of Life focuses on assessing whether infrastructure projects align with community goals, are incorporated into existing community networks, and will benefit the community in the long term. Community members affected by the project are considered important stakeholders in the decision-making process.

The category is further divided into three subcategories: Purpose, Wellbeing and Community.

PURPOSE

The Purpose subcategory addresses the project's impact on functional aspects of the community, such as growth, development, job creation, and the general improvement of quality of life. Positive results from infrastructure projects can include community education, outreach, knowledge creation, and worker training.

WELLBEING

As integral parts of the community, sustainable infrastructure projects address individual comfort, health, and mobility. During construction and operation, physical safety of workers and residents are ensured, and nuisances minimized (including light pollution, odours, noise, and vibration). Attention is also given to encouraging alternative modes of transportation and incorporating the project to the larger community mobility network. Infrastructure owners are encouraged to enable access and mobility to enhance community liability.

COMMUNITY

It is important that the project respects and maintains or improves its surroundings through context-sensitive design. While infrastructure primarily is driven by engineering parameters, its visual and functional impacts should be considered during design. Depending on whether the project is located in a rural or urban setting, this may include preserving views and natural features or incorporating the local character of the built environment into the design.

These categories is further divided into their subcategories and are shown below:

1 PURPOSE

QL1.1 Improve Community Quality of Life

QL1.2 Stimulate Sustainable Growth & Development

QL1.3 Develop Local Skills and Capabilities

2 WELLBEING

QL2.1 Enhance Public Health and Safety

QL2.2 Minimize Noise and Vibration

QL2.3 Minimize Light Pollution

QL2.4 Improve Community Mobility and Access

QL2.5 Encourage Alternative Modes of Transportation

QL2.6 Improve Site Accessibility, Safety & Wayfinding

3 COMMUNITY

QL3.1 Preserve Historic and Cultural Resources

QL3.2 Preserve Views and Local Character

QL3.3 Enhance Public Space

In this thesis I have considered only some categories of first phase of Envision mentioned above to describe is this project sustainable and so important, and Are we doing the right project?

10.4.1.1 Purpose

This credit addresses the extent to which the project contributes to the quality of life of the host community: the community in which the constructed works is situated and directly affects. This determination is based on how well the project team has identified and assessed community needs, goals and objectives, and incorporated them into the project. Relevant community plans are assumed to be a viable expression of those needs, goals, objectives and aspirations. In a real sense, they are the community's expression of their desired quality of life.

When operational, the constructed works is expected to contribute to the efficiency and effectiveness of community infrastructure, while having minimal impact on the environment. Its benefits should be seen as equitably distributed throughout the community. A project designed to benefit one community may have adverse effects on others.

The purpose of this credit is to recognize projects that provide significant benefits to affected communities, as well as reduce or eliminate negative impacts. Positive effects on all important dimensions of performance may not be practical. Thus, the credit seeks a net positive impact.

If the project team can show that the affected community (or communities) has an existing project assessment and approval process that verifies that the project is in concert with community goals and objectives, and that the project has gone through that process successfully, then that success will constitute achievement of this credit.

Figure 10.4.1.1.1 shows the venn diagram of sustainable development

10.4.1.1.1 Improve Community Quality of Life

QL1.1 Improve Community Quality of Life

RELATED ENVISION CREDITS

QL1.2 Stimulate Sustainable Growth and Development, QL1.3 Develop Local Skills and Capabilities, QL2.2 Minimize Noise and Vibration, QL2.3 Minimize Light Pollution, QL2.4 Improve Community Mobility and Access, QL3.1 Preserve Historic and Cultural Resources, QL3.2 Preserve Views and Local Character, QL3.3 Enhance Public Space, LD1.4 Provide for Stakeholder Involvement, LD2.2 Improve Infrastructure Integration, RA1.4 Use Regional Materials, NW1.3 Preserve Prime Farmland.

A. Has the project team identified and taken into account community needs, goals, plans and issues?
B. Has the project team sought to align the project vision and goals to the needs and goals of the host and affected communities?
C. Has the project team sought to identify and address potential adverse impacts to the host and affected communities?
D. Have the affected communities been meaningfully engaged in the project design process?
E. Are the affected communities satisfied that the project is addressing their immediate and long-term issues, needs, and goals?
F. Have the project owner and the project team designed the project in a way that improves existing community conditions and rehabilitates infrastructure assets?

In this project, afro-Mediterranean railway connecting Morocco, Algeria, Libya, Tunisia and Egypt, it is expected to contribute to efficiency and effectiveness of the community mobility system and there by linking a strong relationship between the countries. During the running stage of this project it is sure that these places through which the railway is connecting will have higher GDP rate than now and the other neighbouring countries which means that there will be a marginal socio-economic development.

According to my perspective this will have minimal impact to the community: - Now a days the fright and passengers who travel through these countries use road as their major mode of transportation that result in a lot of pollution in to the atmosphere. These can be minimized by the achieving this project.

Commensurate with my studies in these regions, there are around 83 billion traffic units have been calculated which will be served by this project, which result in a net positive impact. By interlinking this network, it can form a part of the Arab railway network and can have strong relationship with these countries and connect to ports with southern part of the European region through the Mediterranean Sea.

In chapter 6 Demand forecasting, I have clearly mentioned the total demand flow of freight and passenger of each centroids according to geographical and socio-economic consideration associate with each zone. This project will serve the community need for mobility and accessibility to these regions which result in increased quality of life and natural environments, social determinants of health and well-being. And it can also open the door to visionary community planning and design which is the major goal for the plan for the thesis. This project can serve many job opportunities to the people nearby this area and can also serve the responsibility for the development by meeting travel requirement of people and transport requirement of goods. This can change the way people live and travel.

10.4.1.1.2 Stimulate Sustainable Growth and Development

QL1.2 Stimulate Sustainable Growth and Development

RELATED ENVISION CREDITS

QL1.1 Improve Community Quality of Life, QL1.3 Develop Local Skills and Capabilities, RA1.2 Support Sustainable Procurement Practices, RA1.4 Use Regional Materials, NW1.3 Preserve Prime Farmland.

A. Does the project create a significant number of new jobs during its design, construction, and operation?
B. Does the completed project create new capacity or increase the quality of existing, operating, recreational or cultural capacity for business, industry, or the public?
C. Does the completed project measurably improve community productivity?
D. Does the project improve community attractiveness for compatible businesses and industries, improve recreational opportunities, and generally improve the socioeconomic conditions of the community?
E. As part of the delivery of the completed project, does the project rehabilitate, restore, create, or repurpose existing community infrastructure assets in the natural and/or built environment, and, in doing so, improve community prospects for sustainable economic growth and development?

According to this project it can ensure a Sustainable economic growth, to create the conditions that allow people to have quality jobs that stimulate the economy while not harming the environment. Job opportunities and decent working conditions are also required for the whole working age population. This will meet the need to increased access to financial services to manage incomes, accumulate assets and make productive investments. Increased commitments to trade, banking and agriculture infrastructure will also help increase productivity and reduce unemployment levels. This may also result in attracting tourists, exchange of culture and habitat resulting the development of the local regional people. It can also result in good social, economic and political relationship and I am sure that this connection can reduce the gap and increase political relationship between the countries which is a major problem for the development.

Rail is a low carbon transport mode, and railway operators are working hard to continually improve their environmental performance. Rail plays a positive role in society, by providing millions of green jobs and offering access to employment and leisure opportunities. Rail also benefits the global economy by enabling congestion-free access to employment and facilitating freight deliveries.

This is why I believe that rail should have a central role in the sustainable development of truly sustainable transport systems. I am pleased to present to you this thesis on Railways as it is the most important for the Sustainable Development of the countries and it help in creating relationship with neighbouring countries.

10.4.1.1.3 Develop Local Skills and Capabilities

QL1.3 Develop Local Skills and Capabilities

A. What is the expected degree to which the project will contribute to local employment, training, and education, with an emphasis on the most needy and/or disadvantaged groups through project planning, design, and construction?

B. How will the project contribute to long-term community competitiveness?

RELATED ENVISION CREDITS

QL1.1 Improve Community Quality of Life, QL1.2 Stimulate Sustainable Growth And Development.

According to this project it can bring a number of new entrants to development in many sectors, it is vital that the existing workforce is upskilled to meet the challenges of new technology and a changing sector. This in change will have an effect of increase in job opportunities and skilled labours

The plays a part through, for example, the focus in the Rail Supply Group’s sector strategy 'Fast Track to the Future' on promoting innovation and identifying key technology areas. In future of our networks will need more work force that needs to be upskilled to deal with 'all technical and operational side (Signalling, electrical control, telecoms, ticketing, station management and traffic management systems). The need for upskilling will become more urgent.

Innovation plays a critical role in driving growth and productivity across our economy. The sector must successfully engage with young people, parents and teachers to increase the number and diversity of those coming into the transport sector. However, this is a complex landscape with much work already underway within the sector and through broader government backed activity. Rather than developing further new initiatives or working in isolation, employers and professional institutions must come together and focus on core activities that have shown demonstrable results. Only if we change the perceptions of transport and engineering can we change the career choices of the next generation, irrespective of their gender, ethnicity or background.

Table 10.4.1.1.3.1 shows Self-assessment checklist of Envision

				Y	N	NA	
1	QUALITY OF LIFE	PURPOSE	QL1.1 Improve community quality of life	y	0	1	y of 0
2			QL1.2 Stimulate sustainable growth and development	y	0	0	y of 0
3			QL1.3 Develop local skills and capabilities	y	0	0	y of 0
4		COMMUNITY	QL2.1 Enhance public health and safety	y	0	0	y of 0
5			QL2.2 Minimize noise and vibration	0	N	1	0 of 0
6			QL2.3 Minimize light pollution	0	N	1	0 of 0
7			QL2.4 Improve community mobility and access	y	0	0	y of 0
8			QL2.5 Encourage alternative modes of transportation	y	0	0	y of 0
9			QL2.6 Improve site accessibility, safety and wayfinding	y	0	1	y of 0
10		WELLBEING	QL3.1 Preserve historic and cultural resources	0	0	2	0 of 0
11			QL3.2 Preserve views and local character	y	N	0	y of 0
12			QL3.3 Enhance public space	y	0	0	y of 0
			TOTAL	7	3	6	7 of 10

NA 38%
No 19%
Yes 44%

Figure 10.4.1.1.2 shows the Guidance for envision check list

Quality of Life

1. Purpose

QL 1.1 Improve Community Quality of Life

*Infrastructure projects are seen as contributors to community quality of life if they support sustainable, long-term economic growth and community development, while reducing or eliminating negative impacts on the host community or other affected communities. Broad community endorsement validates this contribution.
*Addressing relevant community needs, goals and issues involves reviewing published plans and related materials, and discussions with community leaders and stakeholder groups.
*Reducing or eliminating potentially negative impacts generaly requires a reasonably complete impact assessment.
*Community endorsement normally involves published statements by community leaders and/or stakeholder groups.

QL 1.2 Stimulate Sustainable Growth and Development

*Growth in employment and increased productivity contribute to sustainable growth and development.
*An infrastructure project can make a contribution by providing short and long term employment in the local community across a broad skill base.
*The project can also contribute by improving access to transportationand and facilities, and by increasing increasing capacity and quality. This can improve productivity.
*Improving overall access, capacity and quality while enhancing cultural and recreational opportunities can make the community a more attractive place to live, work and do business.

QL 1.3 Develop Local Skills and Capabilities

*If they are of sufficient scope and duration, infrastructure projects can assist in the development of valuable and lasting skills and capabilities in the host and nearby communities.
*Assistance begins with commitments for hiring and training of local workers for the project. The commitment should be to fill the on-site job ranks with local workers, except when the requisite skills are not available.
*Extending the commitments to using local suppliers and specialty firms will improve the local knowledge and skill base.
*Incorporating specific programs for increasing the education, experience and skills base of local workers and employers will enhance local capacity and long term competitiveness.

Figure 10.4.1.1.3 shows the Envision Check List

Quality of Life

1. Purpose

QL 1.1 Improve Community Quality of Life

Intent: Improve the net quality of life of all communities affected by the project and mitigate negative impacts to communities.

Metric: Measures taken to assess community needs and improve quality of life while minimizing negative impacts.

Assessment Questions:	Yes	No	N/A	
Are the relevant community needs, goals and issues being addressed in the project?	◉	○	○	?
Are the potentially negative impacts of the project on the host and nearby communities been reduced or eliminated?	◉	○	○	?
Has the project design received broad community endorsement, including community leaders and stakeholder groups?	○	○	○	?
Total	2	of	2	

QL 1.2 Stimulate Sustainable Growth and Development			
Intent: Support and stimulate sustainable growth and development, including improvements in job growth, capacity building, productivity, business attractiveness and livability.			
Metric: Assessment of the project's impact on the community's sustainable economic growth and development.			
Assessment Questions:	**Yes**	**No**	**N/A**
Will the project contribute significantly to local employment?	◉	○	○
Will the project make a significant increase in local productivity?	◉	○	○
Will the project make the community more attractive to people and businesses?	◉	○	○
Total	3	of	3

QL 1.3 Develop Local Skills and Capabilities			
Intent: Expand the knowledge, skills and capacity of the community workforce to improve their ability to grow and develop.			
Metric: The extent to which the project will improve local employment levels, skills mix and capabilities.			
Assessment Questions:	**Yes**	**No**	**N/A**
Does the project team intend to hire and train a substantial number of local workers?	◉	○	○
Does the project team intend to use a substantial number of local suppliers and specialty firms?	◉	○	○
Will the project, through local employment, subcontracting and education programs, make a substantial improvement in local capacity and competitiveness?	◉	○	○
Total	3	of	3

11. Conclusion

Considering the comprehensive vision for the need of the integration and linkage of the Mediterranean African networks connecting Morocco, Algeria, Tunisia, Libya and Egypt. In the first section I have considered the economic scenario of each country on basis of GDP, Health expenditure and HDI index. For analysing the growth rate trend I have also considered HDI of the neighbouring countries and regions of my study area.

Then for study, I have tabulated the existing link, under construction link, upgrading link and missing link. Considering the possibility of development of the organizational structure and implementation vision to 2040. This project will be convenient to privilege the internal and external connection by train among these countries and it can also be a part of the Arab railway network. It is possible to consider an upgrade of the system give birth of new scenario in social and economic development.

In conclusion, the following aggregate results are obtained.

- Out of a total length of 11,000 km of railway lines forming Afro-Mediterranean connecting Morocco, Algeria, Tunisia, Libya and Egypt, 4952 km needs relevant construction works or substantial rehabilitation activities and some need to be constructed.
- The total cost estimated for the total entire construction for the connection is about 19 billion USD with an average cost per km 4.02MUSD/km and 25 billion including land accusation.
- For each country, it is sub divided into zones and to each zones a centroid is located according to the geographical and socio-economic consideration. The main cities of the regions are considered and estimated the total population and total employees. The O/D matrix between centroid was calculated and Distribution model have been applied in order to have the passenger rail flow and growth rate were used to have the passenger flow of year 2040.
- The freight zoning was also carried out and data from the port authorities the regional freight movement were gathered and estimated the total freight moment of each countries.

The Important issues affecting the interoperability of the network are considered and are uniformed. The most important issues to be considered for the possibility of different systems to inter-operate are explained are as follows

a. Existence of connection- all lines are designed according to the standard gauge

b. The traction of the railway is powered by 25X2 kv electric high voltage lines

c. Mass per axle is considered as 25 tons and places where new lines have to be considered is new standard axle load and gabarit have been adopted.

d. for the traffic management for the rail ERTMS level 1 has been adopted for the signalling standard for the trains travelling through an international and heterogeneous network. Having adopted it serve common language that connect the track side and the train side system.

While calculating the cost of the projects needed to complete an interoperable Afro-Mediterranean Railway Network the above rail operational models are used in the network.

The cost effectiveness analysis was carried out by calculating the total traffic units of the network connection, considered it as the total benefit of the network and the ratio between traffic units and total cost of the project. The analysis was carried out in a way to identify the theoretical subsequence of the Project for future implementation.

Furthermore, I have introduced Envision as a tool which can be used in planning, design, construction and long-term operation of physical civil infrastructure for the sustainable development of the project. For any it is best to be applied in the planning phase of the project.

With the help of this sustainability rating system, I was able to self-assessment my project with one of the categories of envision “Quality of life”. The reason why I considered is its relevance of its credits in analysing before the starting of a project.

With the help of envision checklist I was able to clearly answer the purpose of my thesis and how it is going to improve community quality of life, stimulate sustainable growth and development and develop local skills and capabilities.

I have also come to some conclusion that the implementation of this project can bring a great development to afro Mediterranean region, as in future it can bring an international relation with the Mediterranean Europe through Mediterranean Sea, with major developed Arab countries by being a part of Arab core railway network. As we see that, the countries with the highest internal and global connectivity are the once with the with highest development and HDI.

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