Doctorat ParisTech

THÈSE

Pour obtenir le grade de docteur délivré par

L'Institut des Sciences et Industries du Vivant et de l'Environnement (AgroParisTech)

Spécialité: SCIENCES AGRONOMIQUES ET ÉCOLOGIQUES

Présentée et soutenue publiquement par

Ibrahim DAOUD

14/12/ 2015

LES STRATÉGIES DE LA SOCIÉTÉ BÉDOUIN FACE A LA SÉCHERESSE SUR LA CÔTÉ NORD-OUEST DE L'EGYPT: UNE ÉTUDE DE CAS DU WADI NAGHAMISH

Jury

Philippe Lescoat	Professeur	AgroParisTech	**Head of the jury**
Véronique Alary	Chercheur, HDR	CIRAD	**Thesis Director**
Jean-François Tourrand	Chercheur, HDR	CIRAD	**Thesis Co-Director**
Bernard Hubert	Directeur de recherché Eremite	INRA	**Rapporteur**
Ashraf Mohamed Mostafa	Professeur	University of Alexandria (Egypt)	**Rapporteur**
Mona Osman	Professeur	Agricultural Research Center (Egypt)	**Examinator**

ParisTech Doctoral THESIS

A thesis submitted to AgroParisTech in fulfillment of the requirements
For the degree of Doctor of Philosophy

L'Institut des Sciences et Industries du Vivant et de l'Environnement (AgroParisTech)

Specialization: AGRONOMIC AND ECOLOGICAL SCIENCES

Presented and defended publicly by

Ibrahim DAOUD

14/12/ 2015

BEDOUIN SOCIETY STRATEGIES FACING DROUGHT IN NORTH WEST COASTAL ZONE OF EGYPT: A CASE STUDY OF WADI NAGHAMISH

Jury

Philippe Lescoat	Professeur	AgroParisTech	**Head of the jury**
Véronique Alary	Chercheur, HDR	CIRAD	**Thesis Director**
Jean-François Tourrand	Chercheur, HDR	CIRAD	**Thesis Co-Director**
Bernard Hubert	Directeur de recherché Eremite	INRA	**Rapporteur**
Ashraf Mohamed Mostafa	Professeur	University of Alexandria (Egypt)	**Rapporteur**
Mona Osman	Professeur	Agricultural Research Center (Egypt)	**Examinator**

RÉSUMÉ

La zone côtière du nord-ouest (NWCZ) de l'Egypte qui s'étend de la frontière du Gouvernorat d'Alexandrie à l'est jusqu'à la frontière libyenne à l'ouest, ne dépend que des précipitations pour ses activités culturales et d'élevage. Cette zone a connu de nombreuses transformations au cours de son histoire, étant considérée comme un grenier à céréales dans les temps anciens (périodes égyptiennes, grecques et romaines) pour devenir une zone à dominante élevage depuis le début du XIe siècle suite à la colonisation par une tribu Awlad Ali originaire de la Lybie. Plus récemment, au cours du vingtième siècle et plus particulièrement dans les années 60-70 avec l'appui de grands projets internationaux de développement en lien avec les politiques nationales, les éleveurs bédouins se sont largement investis dans l'agriculture pluviale (principalement l'orge) pour la consommation humaine et animale et aussi l'arboriculture dans les dépressions et le lit des oueds (principalement les plantations de figuiers, oliviers et amandiers). En raison de la faiblesse des précipitations au cours des 50 dernières années, l'arboriculture est devenue une source importante de revenus pour les ménages bédouins. Au cours des quinze années d'observation (de 1995 à 2010), la moyenne annuelle des précipitations a été d'environ 140 mm. Ainsi, cette période est considérée par la population locale comme la plus longue période de sécheresse depuis le début du vingtième siècle. La sécheresse a eu plusieurs effets négatifs sur la société bédouine dont les effets les plus cités sont la perte de pâturages et du couvert végétal, la pénurie d'eau, la dégradation des terres, et une réduction du bétail et des activités de culture.

Toutefois, cette période de 1995 à 2010 a aussi connu de nombreux autres changements dans les domaines économiques et sociaux, notamment en lien avec la sédentarisation des ménages bédouins et le développement urbain et touristique des villes côtières. Ses changements le long de la côte orientale ont engendré plusieurs opportunités pour les populations locales, notamment des opportunités de travail ou de commercialisation des produits locaux. Plus en lien avec une tradition de mobilité, les jeunes hommes ont continué d'émigrer à la recherche d'un emploi; les principales destinations étant les pays du Golfe et la Libye. Dans le même temps, les projets internationaux se sont intéressés à l'amélioration de la gestion des oueds avec notamment le renforcement des infrastructures d'eau qui ont largement contribué au développement de l'agriculture dans les lits des oueds.

Le bassin versant de Naghamish (dit wadi Naghamish), représentant l'un des 218 bassins versants de la zone côtière nord-ouest, a été choisi pour notre zone d'étude. Ce wadi a également été affecté par la période de sécheresse (1995-2011). Notre objectif a été de comprendre, voire d'évaluer, les effets de la sécheresse sur l'état des ressources naturelles et la capacité des sociétés bédouines à y faire face voire s'adapter. Pour cela, nous avons mobilisé deux principales approches socio-économiques pour analyser les comportements des ménages, ces approches étant basées respectivement sur des enquêtes semi-structurées et des entretiens ouverts. Les données et informations collectées ont été croisées avec des approches géographiques telles que la télédétection (RS) et le système d'information géographique (SIG) qui nous ont permis d'associer les changements socio-économiques avec les changements sur les ressources naturelles et leur utilisation. Une évaluation hydrologique pour les ressources en eau disponibles a été effectuée dans trois scénarios différents (humide, sec et moyenne) afin de comprendre les processus d'adaptation des familles bédouines au changement des précipitations en intégrant les trois approches socio-économique, géographique et hydrologique.

Les résultats montrent que la sécheresse de la période (1995-2010) a causé trois différents types de sécheresse dans la zone d'étude: climatiques, hydrologique et agricole. Au-delà de la multitude des changements observés, la sécheresse a été la principale raison de la baisse des effectifs du cheptel dans la zone d'étude, ainsi que de la diminution de la productivité des cultures at arboricultures, entraînant de nombreuses recompositions des activités au sein des familles bédouines. Ainsi, ont démarré des activités semi-intensives d'engraissement ovin ou d'aviculture ou de nouvelles migrations urbaines dans les secteurs publics. Ces changements d'activités se sont opérés en même temps que des changements de mode de vie liés à l'urbanisation, la modernisation des habitations, le développement des infrastructures et de l'éducation. L'étude montre aussi des changements significatifs dans la couverture végétale entre 1993 et 2011 et une pénurie d'eau en saison sèche quelle que soit l'année climatique.

Si les familles bédouines ont réussi à trouver des ajustements familiaux à la sécheresse de 1995-2010, l'absence de stratégies et d'actions collectives constituent un frein important dans la réduction des effets de dégradation des sols et dans la gestion de la ressource eau.

ABSTRACT

The North Western Coastal Zone (NWCZ) of Egypt extends from the border of Alexandria Governorate to the east to Libyan borders in the west. Considered as a rain-fed area, it depends on only the rainfall for the agriculture activity and animal breeding. The area has deep roots in history since the Egyptian, Greek and Roman periods until nowadays. Inhabited by Awlad Ali Bedouin tribes since the beginning of the eleventh century, the main activity is animal breeding of sheep, goats and camels.

More recently along the 20th Century and supported by public policies, Bedouin breeders are developed rain-fed agriculture (barley) for human consumption and feed, and also some crop and trees cultivation in the depressions and the wadi bed (figs, olives and almonds). This crop production was gradually become a significant source of income for the Bedouin society, due to the low rainfall during the last 50 years. Especially the 15 years from 1995 to 2010, the average rainfall was around 140 mm. So, the NWCZ suffered a severe drought which it is considered as the strongest and mainly longest in the Bedouin history. The drought has had several negative effects on all the Bedouin society: rangeland and vegetation cover, water scarcity, land degradation, livestock and crop activities...

However, in the same time, other changes are also impacting the NWCZ, in economic and social domains and Bedouin breeders have found alternatives to adapt to the new context. So the strong developments of tourism along the Eastern coast have opened several opportunities for local population, trades and markets for local products. In the other hand, in many Bedouin families, young men have migrated in Libya and Gulf countries to have a job. In the same time, the international programs of wadi management and water infrastructure building have allowed to develop the crop cultivation in the wadi beds.

Wadi Naghamish was selected as study area representing one of the 218 watersheds in the NWCZ. The study area was also affected by drought in the period (1995-2011). The study concentrated to evaluate the effects of drought on human, livestock and natural resources through using both socio-economic approaches based on household surveys and opened interviews and the Remote Sensing (RS) and Geographic Information System (GIS) to determine the main changes in the land cover affected by drought and other factors. In addition, we have conducted

a hydrological assessment for the available water resources in the study are in three different scenarios (wet, dry and average) seasons in order to understand the adaptive processes of Bedouin families faced to drought by combining socio-economic, geographical and resources approaches.

The results indicate that the occurrence of drought in the study area in the period (1995-2011) has caused three different types of drought: climatological, hydrological and agriculture drought. In addition to other factors, the drought was the main reason for decreasing of the livestock numbers in the study area, as well as decreasing of the crops productivity in general (figs-olive-barley). A noticeable change in the land cover was observed in the study area based on the analysis of the satellite images in 1993, 2006 and 2011. A water scarcity was noticed based on the hydrological study especially in the dry seasons.

In general in terms of socio-economic changes, results indicate some positive changes in the Bedouin society represented by an improvement of the place of women in the traditional Bedouin society and a significant increase of the proportion of learners over the last two decades. There is also noticeable change in food and water consumption with an increase of the per-capita consumption. However, the improvements of living conditions (modern houses design, water and food consumption, education, etc.) are strongly linked to the availability of infrastructures such as roads, electricity, health care and education which vary with the geographical location. So we observe important differences of living conditions according to a gradient North-South, from the coastal zone which have benefited of important infrastructure to the south zone which is remained without basic infrastructures..

Based on this first analysis and using geographical tools (GIS modeling approach), we have delineated three zones: (i) the zone 1 that covers the coastal zone with an important development of infrastructure and wadi agriculture and that extends from the coastal line to about 5 km to the south; (ii) The intermediary zone 2 that is constituted by a low plateau that extends from about 5 to 15 km and that has known a recent development of dikes in the wadi beds;; and the zone 3 which covers the upper plateau of the wadi extends from more than 15 km to 20 km in the south. This last zone was significantly affected by drought during the last 15-years and has known a high degradation of his vegetation cover and soil. The live conditions in this zone are very difficult due to the lack of electricity and the low level of rainfall to fill the cisterns for drinking water. The inhabitants are obliged to buy the water for the human and animal consumption from Matrouh or from the pipe.

Over the period 1995-2011, due to the drought, a noticeable change in livestock number in the study area has been observed in the 3 zones, with respectively a decrease of the sheep flock by 52%, 65% and 92% in zones 1, 2 and 3. The effect of drought on livestock was the highest in zone 3. Nowadays, the available alternatives for these breeders to cope with drought are very limited due to the reduction of mobility to Beheira or Siwa oasis.

In the entire case study, the family income from livestock and agriculture sector have known an important reduction; Bedouin tried to find others sources of income out of agriculture such as civil jobs in government and private sector. However due to different access to infrastructure and services (mainly education), the return of off-farm activity was only 23% in the zone 2, compared to 42-43% and 23% in the 2 first zone. In this zone 3, the return of animal breeding income still represented three-quarter percent of the total family.

Three climatic scenarios have been tested: dry (105 mm), average (140 mm) and wet 200 mm) seasons with a probability of occurring of 70%, 50% and 20%. The results show that an annual deficit of around 100,000 m3 of water is found in the wadi in the drought seasons while, in average seasons, water surplus amount of around 20,000 m3. In the rare wet season, the surplus water volume can reach to around 2.5 million m3.

Based on the analysis of satellite images in 2006 and in 2011, we can approach the magnitude of changes in the area in term of low and high vegetation, bare land and agriculture which include both of barley and trees (fig, olive and almond). Barley cultivations area were decreased by 43%, trees were increased by 18%, range land (low and dense cover) decreased by 20%.

Many coping strategies were followed by the Bedouin in the wadi such as wadi development and land reclamation in the zones 1 and 2 through establishment of different type of dikes. Some breeders have also started new activities like semi-intensive poultry farms and fattening of lambs. In addition, the other alternatives were to work in city and Libya, to increase the cisterns number to be more tolerant to drought. However, in the entire zone, the decreasing of flock size was a main strategy to be more resilience to drought.

In conclusion, farmers in the wadi Naghamish had not the same degree of ability to adapt to climate conditions, according to the availability of natural resources and the diversity of the sources income. And the diversity of sources of incomes is strongly linked to the geographical location such as the proximity to the sea and the proximity to the city that increase the access to facilities like infrastructure, electricity and water.

LIST OF ABBREVIATIONS

ANR	Agence National de la Recherche
APRI	Animal Production Research Institute
ARC	Agriculture Research Centre
CIRAD	Centre Intrenational de Recherche Agronomique pour le développement
DEM	Digital Elevation Modell
DLDD	Desertification, Land Degradation and Drought
DRC	Desert Research Centre
ELVULMED	Role of livestock activities in the process of adaptation and reducing vulnerability of Mediterranean societies facing global changes’
FAO	Food and Agriculture Organization
FMD	Foot and Mouth Disease
GIS	Geographic information system
GPS	Global Position System
GTZ	German Agency for Technical Cooperation
ICARDA	International Centre for Agriculture research in Dry Areas
ICZM	Integrated Coastal Zone Management
ILO	International labor Organization
IPBES	Intergovernmental Panel on Biodiversity and Ecosystem Services
ISO	International Organization for Standardization
IWM	Integrated Watershed Management
MCDM	multi-criteria decision-making
MEA	Millennium Eco-System Assessment
MRMP	Matrouh Resources Management Project

MSL	Mean Sea Level
NWCZ	North West Coast Zone
PPR	Peste des Petits Ruminants
QRDP	Qasr Rural Development Project
RS	Remote Sensing
RVV	Rift Valley Fever
SELMET	Systèmes d'élevage Méditerranéens et Tropicaux
SPI	The Standardized Precipitation Index
SWAT	Soil and Water Analysis Tools
TOA	Top-Of-Atmosphere
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
WB	World Bank
WFP	World Food Program
WH	Water Harvesting
WMO	World Meteorological Organization

ACKNOWLEDGEMENT

I would like to thank Dr. Veroonique Alary and Pr. Jean-Francois Torrand for their efforts for the completion of this work, as well as both Pr. Mona Osman and Pr. Fawzy Abd El-Kader for thier efforts and their support.

I would like to thank Dr. Slim Saidi for his help and support for matters relating to GIS and RS, and I would like to thank Pr. Beranrd Hubert and Pr. Ashraf Moustafa for their review of the thesis.

I would like to thank SELMET/CIRAD time; Pr. Pascal Bonnet, Pr. Philipp, Pr. Alexander, Corine, Marie-Jo, Xavier, Samir, Pr. Jacques, Pr. Jean-Pierre.

I would like to thank APRI/ARC time for their help and support; Pr. Adel Aboulnaga, Pr. Ferial Hasan, Pr. Faten Fahmy, Pr. Omar Salama, Dr. Ehab Salah, Dr. Eatedal, Pr. Mouhamed El-Shafay, Pr. Tarek, Pr. Helmy Metawy. Dr. Sherif, Dr. Taha

Finally, I would like to thank my best friends for their help in the filed work; Rabiaa Faziae, Gomma Anwar, Farag Mastour Abu Sebak, Saad Haioub, Hussain El-Gbihy, Farag El-Gbihy, Hawia Yousef, Farag Khalifa.

TABLE OF CONTENTS

INTRODUCTION 26
The main challenges in the North West coastal zone of Egypt 26
Objectives 29
Problematic and Research Question 30
CHAPTER 1: DROUGHT CHALLENGE IN THE NORTH WEST COASTAL ZONE IN EGYPT 33
Introduction 33
1.1. Geographical approach 34
1.1.1. Location 34
1.1.2. Regional climate 37
1.1.2.1. Using of rainfall data to identify drought in the NWCZ 37
1.1.2.2. Using of drought indices to identify drought in the NWCZ 42
1.1.3. Geology 49
1.1.4. Topography and geomorphologic settings 50
1.1.5. Natural resources 54
1.1.5.1. Soil 54
1.1.5.2. Natural vegetation 56
1.1.5.3. Water resources 57
1.2. Historical and social description of the zone 58
1.2.1. Rapid history of the settlement in NWCZ area 58
1.2.2. Land ownership Issue 61
1.3. Recent changes in the zone: identification of the main drivers 64
1.3.1. Long Drought (History of the Drought in the NWCZ) 64
1.3.2. History of livestock feeding in NWCZ 65
1.3.3. Population change, Urbanization 65
1.3.4. Tourism in NWCZ of Egypt 67
1.3.5. Infrastructure in the zone 68
Conclusion: 69
CHAPTER 2: REVIEW OF LITERATURE 71
Introduction 71

2.1. Drought approaches in the literature 72
2.1.1. Drought definition 72
2.1.2. Drought and land degradation 74
2.1.3. Drought in Arab region 76
2.1.4. Drought in the North Western Coast Zone of Egypt 77
2.2. Water scarcity approaches 79
2.2.1. Defecation of water scarcity in link with demand 79
2.2.2. Basic Human Water Requirements 80
2.3. Vulnerability, adaptive capacity and resilience approaches 81
2.3.1. Multiple definition and conceptual approaches 81
2.3.2. Framework to approach the vulnerability 85
Livelihood framework: 85
Socio-ecological systems and the identification of vulnerable zones (ELVULMED) 87
2.3.3. Approach of vulnerability to natural events like drought and flood 90
2.3.3.1. Vulnerability to drought 90
2.3.3.2. Vulnerability to flood 91
2.3.3.3. Social vulnerability at different scale 93
2.4. Land degradation 94
2.5. Watersheds and Integrated Watershed Management 96
Conclusion 97
CHAPTER 3: MATERIAL AND METHODS 98
Introduction 98
3.1. Choice of unit of analysis 99
3.1.1. The Wadi: the main unit of analysis to address collective vulnerability 99
3.1.2. Family: the second unit of analysis to address family vulnerability 101
3.2. Social and economic approach of adaptive process 103
3.2.1. Survey at the family scale 104
3.2.1.1. Sample 104
3.2.1.2. Questionnaires 106
3.2.1.3. Investigation or context of the survey 109
3.2.2. Mental models about livestock trends and strategies facing drought 109
3.2.3. Supplementary materials 112

3.3. Water resources management at the family and wadi level 113
3.3.1. Hydrological assessment of the watersheds 113
3.3.1.1. Data Requirement for hydrological assessment 113
3.3.1.2. Estimation of coefficient of runoff 114
3.3.1.3. Global approach of hydrological assessment 115
3.3.1.4. Flood Estimation:- 118
3.3.2. Water storage system: cistern to estimate water scarcity and satisfy the demand 120
3.3.3. Climatic scenario: quantitative evaluation of drought on the area 121
3.4. Land covers change and land degradation 122
3.4.1. GIS and Remote Sensing 122
3.4.2. Materials 122
3.4.3. Methodology 123
3.4.4. Identification of land covers drivers 125
3.4.5. Research approach frame 125
Conclusion: 127
CHAPTER 4: DESCRIPTION OF THE CASE STUDY, WADI NAGHAMISH 128
Introduction 128
4.1. Geographical approach of wadi Naghamish 129
4.1.1. Physical geography 129
4.1.1.1. Location 129
4.1.1.2. Climate 130
4.1.1.3. Topography and geomorphology 131
4.1.2. Natural resources 133
4.1.2.1. Soil of wadi Naghamish 133
4.1.2.2. Natural vegetation 136
4.1.2.3. Water resources 137
4.1.3. Social infrastructures 138
4.1.3.1. Roads 138
4.1.3.2. Education 139
4.1.3.3. Health 139
4.1.3.4. Touristic infrastructure 139
4.2. Tribal and land history in Naghamish 141
4.2.1. Tribal distribution 141

4.2.2. History of settlement in Wadi Naghamish 144
4.3. Description of the main farming systems 147
4.3.1. Farming zones in the NWCZ 147
4.3.2. Farming systems in wadi Nagamish 149
4.3.2.1. Farming systems in the coastal agricultural zone (Zone 1) 149
4.3.2.2. Farming systems in the mixed production zone (Zone 2) 150
4.3.2.3. Farming system in the pastoral zone (Zone 3) 151
Conclusion: 152
CHAPTER 5: ADAPTATION PROCESS AT THE FAMILY AND COMMUNITY LEVEL: SOCIO-ECONOMIC APPROACH 153
Introduction 153
5.1. Bedouin family unit: new identity or only adaptation to new context 154
5.1.1. Bedouin family identity: culture heritage (habits, tradition and marriage) and inheritance 154
5.1.1.1. Bedouin Culture Heritage 154
5.1.1.2. Place of women in traditional Bedouin society 156
5.1.1.3. Increase the proportion of learners 157
5.1.1.4. Perception of changes of habits and traditions 158
5.1.2. Socio-economic changes in the Bedouin society 159
5.1.2.1. Style of housing and living place 159
5.1.2.2. The designs of the houses 160
5.1.2.3. Consumption patterns changes 162
5.1.2.3.1. Water consumption 162
5.1.2.3.2. Food consumption 163
5.1.3. Family structure, housing in wadi Naghamish 164
5.1.3.1. Family structure 164
5.1.3.2. Level of education 166
5.1.3.3. Housing 166
5.1.3.4. Farm management 167
5.2. Land and cropping systems 168
5.2.1. Land access and ownerships 168
5.2.2. Cropping system 170
5.2.3. Crops productivity and crop income contribution 172
5.3. Livestock systems 175

5.3.1. Description of livestock systems per zone ... 175
5.3.1.1. Livestock composition over the last 15 years ... 175
5.3.1.2. Fattening system ... 177
5.3.2. Change of feeding systems ... 178
5.3.2.1. Feeding calendar according to climatic year ... 178
5.3.2.2. Type of supplemental after grazing period ... 180
5.3.3. Animal performance and disease ... 181
5.3.3.1. Animal performance ... 181
5.3.3.2. Diseases treatment ... 182
5.3.4. Livestock market and livestock income contribution ... 183
5.3.5. Contribution of sheep and goat in family consumption ... 184
5.4. Family income ... 185
5.5. Perception of change ... 188
5.5.1. The most famous events in the Bedouin society ... 188
5.5.2. Perception of change of climate change, social change and livestock management change ... 188
5.5.3. Perception of change of the environment: Soil and water management ... 190
5.5.3.1. Water rights ... 190
5.5.3.2. Desertification ... 190
Conclusion: ... 192
CHAPTER 6: ANALYSIS AND IMPACT OF WATER RESOURCES CONSTRAINTS UNDER DIFFERENT CLIMATE SCENARIOS ... 193
Introduction ... 193
6.1. Hydrological assessment of annual runoff volume in wadi Naghamish in different climatic scenarios ... 194
6.1.1. Delimitation of hydrological basin ... 194
6.1 2. “Average” scenario: average rainy years ... 197
6.1.2.1. Hydrological assessment of annual runoff volume ... 197
6.1.2.2. Water balance (average rainy season) ... 200
6.1.3. “Drought” scenario: “drought” years ... 201
6.1.3.1. Hydrological assessment of annual runoff volume ... 202
6.1.3.2. Water balance in drought years ... 202
6.1.4. The “wet” scenario: wet years ... 203
6.1.4.1. Hydrological assessment of annual runoff volume (wet rainy season) ... 204

6.1.4.2. Water balance in wet years 204
6.1.5. Global results of the 3 scenarios 205
6.1.6. Future of orchards 210
6.2. Role of cisterns 210
6.2.1. The diversity of cisterns in the wadi 210
6.2.2. Cisterns in Wadi Naghamish 212
6.2.2.1. Cisterns at the zone level 212
6.2.2.2. Cisterns establishment organization 215
6.2.2.3. Cisterns validity 217
6.2.3. Livestock management in relation with available water resources 219
6.2.4. Role of cistern in Crop-Livestock orientation under different climatic scenarios 222
6.2.4.1. "Average" scenario: the average years 222
6.2.4.2. "Drought" Scenario: the dry years 223
6.2.4.3. "Wet" scenarios: the wet years 224
Conclusion: 225
CHAPTER 7: HUMAN AND NATURAL FACTORS OF LAND DEGRADATION AND LAND COVER CHANGES IN WADI NAGHAMISH 226
Introduction 226
7.1. Description of changes of land covers between 2006 and 2011 in wadi Naghamish 227
7.2. Quantitative approach of the drivers of change of land cover 231
7.2.1. Main changes in land cover in zone 1 232
7.2.1.1 Change from agriculture to bare 232
7.2.1.2. Change from range (low and dense range) to bare land 237
7.2.2. Land cover change in zone 2 240
7.2.2.1. change from agriculture to range (dense and low vegetation) 240
7.2.2.2. Change from dense to low range 244
7.2.2.3. change from bare to range (dense and low) 245
7.2.3. Land cover change in zone 3 250
7.3. Land degradation 253
7.3.1. Quantitative approach of land degradation 253
7.3.2. From degradation to desertification 258
7.3.2.1. Sheet erosion 259
7.3.2.2. Rill Erosion 259

7.3.2.3. Gully erosion 260
7.4. Discussion about the aggravating or reducing factors of degradation 262
7.4.1. Causes and Factors of Land Degradation in Wadi Naghamish 262
7.4.2. Practices to combat soil erosion, reducing vulnerability to flood in Naghamish 264
Conclusion 271
CHAPTER 8: BEDOUIN STRATEGIES TO COPE WITH DROUGHT 272
8.1. Strategies cope with drought 272
8.2. Different capability to cope with drought in wadi Naghamish 274
8.2.1. Wadi Development and land reclamation 274
8.2.2. Fattening for the young lambs 275
8.2.3. The breeders became traders 276
8.2.4. Establishment of a poultry farm 276
8.2.5. Travelling and Working in Libya 279
8.2.6. Work in city 280
8.2.7. Selling the flock in order to investigate in small projects 281
8.2.8. Working as laborers in agriculture sector 281
8.2.9. Decreasing of flock size 281
8.2.10. Increase of cisterns number 282
Conclusion 283
CHAPTER 9: CONCLUSION AND DISSECTION 284
Introduction 284
9.1. Strong Drought 284
9.2. Discussion of the main hypothesis 285
9.3. Vulnerability analysis scale 289
9.3.1. At the wadi level 289
9.3.2. At the regional level 289
9.4. Research limitations 290
9.5 Summary and dissection of main results 292
9.5.1. Main changes in the Bedouin society 292
9.5.2. Agricultural production 292
9.5.3. Animal production 293
9.5.4. Farm and off-farm income 294

9.5.5. Water resources management under different scenarios. 294
9.5.6. Land cover changes 295
9.5.7. Main strategies to cope with drought 295
9.6. Summary of drought impact on wadi Naghamish 296
9.7. Further research 298
9.8. Recommendations 299
CHAPTER 10: REFERNCES 303

LIST OF FIGURES

Figure 1: Locations of NWCZ of Egypt 35
Figure 2: NWCZ zones (irrigated and rain-fed) 36
Figure 3: main watersheds in NWCZ 37
Figure 4: Climate diagram of Matrouh station 39
Figure 5: Annual rainfall data (Matrouh station) 41
Figure 6: Standardized Precipitation Index in NWCZ 45
Figure 7: Geologic map of the study area and its surroundings 50
Figure 8: Geomorphology profile and infrastructure of the coastal zone 52
Figure 9: DEM (digital elevation model), hills hade of NWCZ 53
Figure 10: Vegetation cover in NWCZ (wadi Naghamish, 2013) 57
Figure 11: Main tribes distribution in NWCZ 62
Figure 12: Tribes distribution in NWCZ 63
Figure 13: Urban sprawl of Marsa Matrouh, a comparison of its urban perimeter in 2011 and 1993 66
Figure 14: Roads network in NWCZ 68
Figure 15: Propagation of drought through the hydrological cycle and its impacts 76
Figure 16: Annual rainfall data Matrouh station 78
Figure 17: Interrelationships among water supply and use leading to regional vulnerability 80
Figure 18: the hazards-of- Place Model of vulnerability 85
Figure 19: Sustainable livelihoods framework: a checklist 86
Figure 20: Nested hierarchy model of vulnerability 87
Figure 21: DPSIR adapted by the Millennium Eco-System Assessment 89
Figure 22: Vulnerability to drought: schematic representation of causes and effects 91
Figure 23: Typical watershed 99
Figure 24: localization of wadi Naghamish 101
Figure 25: farming system in NWCZ 103
Figure 26: Location of the surveyed families by questionnaires in Wadi Naghamish 105
Figure 27: Coastline-inland rainfall distribution 116
Figure 28: relation between rainfall, land cover and runoff coefficient in West Africa 117

Figure 29: shows the effect of land slope on the runoff coefficient 118
Figure 30: frequency curves from NWCZ of Egypt area 119
Figure 31: step-by-step process for atmospheric corrections on satellite imagery 124
Figure 32: Research approach frame 126
Figure 33: Locations of NWCZ of Egypt and Naghamish 129
Figure 35: Digital elevation model and counter lines in Wadi Naghamish 131
Figure 36: hills shade and aspect in wadi Naghamish 132
Figure 37: streams and sub-basins in wadi Naghamish 133
Figure 38: soil mapping units of Wadi Naghamish 135
Figure 39: vegetation in wadi Nagamesh (Southern plateau) 137
Figure 40: Roads in Wadi Naghamish 138
Figure 41: Tourism in Naghamish 140
Figure 42: Geographical distribution of tribes in Naghamish 142
Figure 43: Trubes and clan in wadi Naghamish 143
Figure 44: Zones in wadi Naghamish 148
Figure 45: traditional Bedouin dress 155
Figure 46: the old Bedouin houses design. 160
Figure 47: Modern design of Bedouin house 161
Figure 48: head family age pyramids 165
Figure 49: sub basins and streams in wadi Naghamish used 194
Figure 50: slope in wadi Naghamish 196
Figure 51: rainfall distribution in Naghamish 196
Figure 52: runoff ratio in cells in wadi Naghamish (average years) 199
Figure 53: runoff values and volume in wadi Nghamish (average years) 199
Figure 54: the deficit or surplus in the 3 scenarios (m^3) 206
Figure 55: Annual runoff volume for wadi Naghamish for three probabilities: dry (70%), wet (20%) and average seasons (50%) 207
Figure 56: Water balance in wadi Naghamish for three probability dry(70%),wet(20%) and average seasons (50%) 208
Figure 57: runoff assessment and water balance in permanent cropland in wadi Naghamish in zone 1 and 2. 209
Figure 58 citernes design 211

Figure 59: Cistern shape 211
Figure 60: cisterns during filling in heavy storm 212
Figure 61: Cisterns distribution in wadi Naghamish 213
Figure 62: Cisterns numbers in zones in wadi Naghamish 214
Figure 63: cisterns ownership in wadi Naghamish. 215
Figure 64: Cisterns establishment organization. 216
Figure 65: Establishment rates of cisterns in wadi Naghamish 217
Figure 66: Cisterns cumulative storage capacity m3 217
Figure 67: cisterns validity in wadi Naghamish 218
Figure 68: available stored water in cisterns in wadi Naghamish in relation with water requirements in average year 221
Figure 69: poultry water consumption in Naghamish 221
Figure 70: water resources management in Naghamish in average seasons 223
Figure 71: Water resources management in Naghamish in dry seasons 224
Figure 72: Water resources management in Naghamish in wet seasons 224
Figure 73: land cover in Naghamish in 1993 228
Figure 74: land use, land cover dynamic in wadi Naghamish over the last 5 years 2006 to 2011 230
Figure 75: factors of change agriculture to bare 233
Figure 76: factors of change from range to bare 237
Figure 77: change from bar, agriculture and dense range to low range. 240
Figure 78: Death of trees as result of drought in zone 2, wadi Naghamish 2012 243
Figure 79: change from agriculture, bare and dense range to low rang 244
Figure 80: factors of change from bare to range 246
Figure 81: poultry farms in wadi Nghamish 2012 249
Figure 82: Roads in wadi Naghamish 250
Figure 83: change from dense range to low range 251
Figure 84: Fire Wooding in NWCZ. Source: MRMP 252
Figure 85: land degradation in wadi Naghamish 255
Figure 86: soil depth of wadi Naghamish 256
Figure 87: land degradation factors in wadi Naghamish 257

Figure 88: Sheet erosion 259
Figure 89: Rill erosion 260
Figure 90: Gully erosion 261
Figure 91: Examples of Rainwater Harvesting techniques with general features. 266
Figure 92: runoff in wadi stream 267
Figure 93: Dry stone dike 268
Figure 94: Cemented stone dikes 269
Figure 95: earthen dikes 270
Figure 96: Drought impact on wadi Naghamish 297

LIST OF TABLES

Table 1: Climatological normal at Matrouh station (1971-2000) 38
Table 2: Monthly rainfall Data (mm) at Marsa Matrouh (1945-2011) ……….40
Table 3: Probabilities for different standardized rainfall anomalies 43
Table 4: Standardized Precipitation Index (SPI) in NWCZ (1944-2011) 44
Table 6: Classification of drought conditions according to deciles 48
Table 7: Classification of drought conditions according to deciles in NWCZ (1944-2011) 48
Table 8: description of the sample 104
Table 10: soil mapping units of Wadi Naghamish 136
Table 11: Numbers of clan’s bayts and families for each tribe in Wadi Naghamish 143
Table 12: food consumption NWCZ, 2013 163
Table 13: food consumption NWCZ, 1964-1988 164
Table 14: family type in Naghamish 165
Table 15: average land area and type 169
Table 16: crops type and crop area in feddan and in percentage of total cultivated land in wadi Naghamish in 2013 171
Table 17: Average annual productivity (fig-olive-barley-almond) 173
Table 18: average crop gross margin (per feddan) 174
Table 19: average crop price in 2013 (in L.E. per kg) 174
Table 20: livestock number in wadi Naghamish 1995-2012 176
Table 21: flock size difference from 1995 (ELVULMED project data, 2011) 177
Table 22: Fattening system in zone 3 178
Table 23: Fattening system in zone 2 178
Table 24: animals feed calendar in three different scenarios 179
Table 25: Average feed quantity given to animals at level of zone 180
Table 26: average fodder prices 2012 in dry and rainy seasons 181
Table 27: lambing rate and mortality rate in sheep and goats 182
Table 28: the local and scientific name for animal diseases 182
Table 29: average annual coast for internal external parasite treatment 183
Table 30: average price, age and weight for animals in 2012 184

Table 31: Sheep and goats number annual self-consumption 185
Table 32: agriculture, livestock and off farm activities average annual income 186
Table 33: Perception of the main changes 189
Table 34: sub basin (cells) of wadi Naghamish Statistics 195
Table 35: Runoff volume assessment in wadi Naghamish for average years 198
Table 36: water balance in Naghamish in average years 201
Table 37: annual runoff volume assessment for Drought probability (105 mm rainfall) 202
Table 38: water balance in Naghamish in dry years 203
Table 39: annual runoff volume assessment for wet season probability (200 mm rainfall) 204
Table 40: water balance in wadi Naghamish in wet seasons 205
Table 41: change classes used in the Model 232
Table 42: Factors of change from agriculture to Bare 234
Table 43: change from range (low and dense vegetation) to bare land 238
Table 44: change from agriculture to range 241
Table 45: change from high to low vegetation 244
Table 46: Bare to range (high and low) 247
Table 47: change from high to low vegetation 251
Table 48: land degradation in wadi Naghamish 254
Table 49: Technic-economic parameters of poultry production unit developed in Coastal zone of western desert in Egypt 278
Table 50: livestock number in wadi Naghamish 1995-2012 282

INTRODUCTION

The main challenges in the North West coastal zone of Egypt

The North Western Coastal Zone (NWCZ) is located in the northwest corner of Egypt, extending for about 500 km from the west of Alexandria governorate to the Libyan borders. Most of the zone of NWCZ is located in Matrouh governorate.

Historically, the region has deep roots in history. Marmarica was a province of the Roman Empire covering the NWCZ of modern Egypt (Vetter, 2006). At the age of Alexander the Great, Marsa Matrouh was a small city, called Amonia (Rowe, 1953). During the age of the Ptolemies and the Byzantine Empire, this city was called Paraetonium and was an important sea port for the exportation of agricultural products to Rome (Abboudy, 1968). Agricultural expansion reached its zenith during the first century under the Roman Empire to supply the imperial capital, Rome, and other Italian cities in cereals (Cole & Al Torkey., 1998).

The historical literature in the zone shows that the NWCZ was one of the main grain baskets of the Roman Empire, and, before this time, an important farmland of antic Egypt and Greece. There are many indicators and remnants of the historic constructions which indicate the presence of agricultural development in the ancient Roman age. The main remnants are the cisterns, underground granaries, and the remains of small dams and dikes in the wadi systems of the NWCZ. These remnants are mainly located in the region called Marmarica in ancient times. This region covers the centers of Sidi barani to the Libyan border. Moreover, this reveals the presence of a complex water harvesting and storage system that we can find also in Sinai Peninsula (Jarvis 1936:128-129, cited in Cole & Al Torkey., 1998).

NWCZ is characteristic of dry desert area with rainfall agriculture. The rainfall is about 140 mm per year over the last century (1944 to 2011) (Matrouh Airport Rainfall station). The NWCZ has been mainly settled by a Bedouin clan, Awlad Ali, arrived from the Arabian peninsula in 950 and 951 AD (Altorki & Cole, 2006). Now, Matrouh population includes other Bedouin clans and migrant settlers arrived from the Nile valley over the last century. Awlad Ali community had a pastoral lifestyle on common lands assigned by tribe; this pastoral lifestyle was based on permanent grazing in the more inland areas (more than 50 km in the South) or seasonal transhumance in the North coastal zone (until 50 km inland), mainly winter transhumance according to rainfall.

Settling the Bedouin has been the main goal of all the public policies and of the international and national development projects implemented in the zone since the 1950s, in order to control the borders and reduce land conflicts between the tribes and between the tribes and the state. Many integrated development projects have contributed to this change through international cooperation with the food and agriculture organization (FAO), the world food program (WFP), the international labor organization (ILO), or United States Agency for International Development (USAID). The main achievements of these projects have been the settlement of Bedouin through housing establishment and rehabilitation of cisterns and dikes in wadis.

The world food program (WFP) has been active in the north-west coastal and Siwa since the sixties. The first project 1963 to 1973 aimed to increase Bedouin 'sedenterization' and favored agricultural development by decreasing erosion, improving soil resources and then socio-economic conditions. ILO (The International labor Organization) has worked in the mid-eighties to encourage the development of cooperatives, but with few successes and USAID (United States Agency for International Development) had started a project in end of seventies to develop villages. Then some integrated development projects have started. FAO has been mainly active in the NWCZ and Siwa from 1965-1970 and from 1988 to 1992. The project aimed to develop agricultural production by using modern agricultural methods, such as irrigation system and green houses. GTZ (the German Agency for Technical Cooperation) has been active through the EL Qasr Rural Development Project (QRDP) from 1988 to 1999.

In the last decade of the 20th century, a collaboration project between the World Bank and the Egyptian governorate, named Matrouh Resources Management Project (MRMP), has been implanted in the NWCZ in order to reduce poverty in Bedouin society. Many actions have deeply changed the social and natural environment of the region, mainly through the large development or rehabilitation of cisterns for human population and animal, and dikes for wadi cultivation.

So now, the traditional agricultural system is mainly based on a mixed crop-livestock system with the cultivation of barley in the depressions (lowlands) and orchard plantation in wadis beds (like figs, olive and almond). This crop and livestock activities represent the main source of income for the Bedouin in the region, who represent more than 70% of the population.

Many researchers have studied the north western coast from geological, climatological, pedagogical, sociological and economical perspectives. These studies have resulted in the accumulation of considerable volume of information related to different disciplines (Aly, 2000). However, identifying the state of the environmental constraints of climate, soil, water, and rangeland with understanding the human coping strategies of the agro-pastoral production systems could support sustainable land and water management and participatory agricultural development process in rain-fed area of the NWCZ (Abdel-Kader, et al., 2004).

Moreover, during the last 2 decades, the zone suffered from a long drought of 15-years (1995-2011), which has impacted heavily on all aspects of life in the region, such as decreasing of the livestock numbers, decreasing of the productivity in the agriculture sector and migration to cities. This type of drought is considered as a new and serious challenge for the zone that requires more deep analysis mainly in terms of adaptive strategies by farmers to anticipate future changes in the zone. Considering the social organization in the zone, mainly the tribal organization, and its links with the other official organizations or governmental organizations, we need to study the adaptive process at the regional level.

Moreover, this drought occurred during a very changing context due to the infrastructure development (education, roads, and health care units), urbanization and touristic development, and the population increase in the whole governorate. This environmental change involves new aspirations, mainly for the youth.

In the same time, this drought affected severely the natural environment, especially vegetation, water and soil. These effects are the strongest in the south part of the zone, where the rate of rainfall is below 70 mm in non-dry climate year. Several strategies as the development of new agricultural activities (as fattening or poultry, migration, etc.) have been adopted by the Bedouin communities to face the drought, but with different success according to their location (availability of natural resources), their personal and family assets (physical and human assets) and also the amplitude of the drought along the zone. So the main challenge of our research has been to define and better understand these strategies at the family and local level, using general data and specific data collected.

The agricultural sector in the North West Coast can be considered as a fragile system with limited flexibility and then a low capacity to recover its potential after an external chock. So to understand the future in the zone, we need to consider the natural resource changes at the local level with the social changes at the family or tribe level. And finally we need to integrate the institutional context, mainly the role of official agencies like the Matrouh governorate or their cooperation with international project, in interaction with the traditional organizations (tribal organization) to assess the whole evolution of the zone.

Objectives

The recent drought in the North West coastal zone offers a very specific case study to understand the effect of external chock on one local community by considering the natural and human factors.

The general objective of our study is to define and better understanding the main impacts of the drought on the Bedouin society of the North West Costal zone of Egypt, especially the effects on human activities and natural resources. The last 15-years drought is considered as one major component of the various changes that occurred in the zone. However the adaptive capacity cannot be understood without considering the other changes, mainly the urbanization and social changes during the last 2 decades.

This study is part of a collaborative research project ELVULMED on Role of livestock activities in the process of adaptation and reducing vulnerability of Mediterranean societies facing global changes, within a research program on environmental, Planet and social changes, funded by the French National research Agency between (2011-2014). This project was a collaborative project between CIRAD (centre Intrenational de Recherche Agronomique pour le développement) and INRA (Institut National de recherché Agronomique) in France, APRI (Animal Production research institute), DRC (desert research Centre) and ICARDA (International center of Agricultural research in Dry Areas) in Egypt.

The project was based on the livelihood approach developed by Ellis (2000) at the household level and Fraser (2007) at the level of socio-ecological systems. Based on the identification of key-factors of vulnerabilities, an analysis crossing political, sociological, anthropological and historical sciences, allowed to understand the adaptive process to past changes and to develop future scenarios (based on an approach of representations and perceptions). The project demonstrated the central role of livestock in the diversification of activities and the mobilization of specific resources at the family and territorial levels; and diversity being considered as a factor of risk reduction and hence resilience of systems.

In the present study the main challenge was to analyze in the same framework the households' strategies and adaptations to changes and the natural environmental changes based mainly on water and land resources.

For that, our specific objectives were:

- Evaluate the effects of the 15-years drought on agriculture and livestock activities, especially on practices, productivity and family incomes ;
- Better define the diversity of the trajectories for households, families and communities facing the drought and the social change in the zone;
- Assess the differential level of vulnerability to drought by zone according to natural resources considered as natural capital;
- Identify relevant research topics to improve the adaptation processes to the drought, either in techniques than in social domains;
- Provide recommendations to local and national authorities on the development of drought management actions, strategic plans and policy measures

Problematic and Research Question

The North West coastal zone of Egypt was exposed to an unprecedented drought that lasted from 1995 to 2011, which impacted severely the livelihood of the Bedouin community, but also the natural environment at long term.

The central research question is how to approach the impact of this last drought on the present and future community livelihood due to some long-term effects on natural resources. For that we proposed to focus our study on one geographical unit, the wadi that allows considering the diversity of farmers' strategies according to differential impact of the drought along the North-South gradient of the wadi and then different risk exposure to drought. The degree of vulnerability by zone along the wadi varies also with the difference of physical, human and social capital that we will approach.

We propose to use many approaches: quantitative and qualitative approaches to define farmers' strategies including secondary data collection, field survey, semi-structured interviews, non-participant observations and participant observations. In this process, we will confront our results from questionnaire with our local knowledge of the Bedouin society to address: What are the indigenous livelihood strategies deployed by Bedouin people to cope with drought? And how do they cope on their own without support from outside the community? How do local practices and indigenous knowledge contribute, or not, to the challenge of maintaining sustainable livelihoods?

The concept of social network will be used to take into consideration the role of the specific tribal organization in the way that the local community faces the drought. This dimension will allow approaching the social and institutional dimension in the adaptive process.

However, as mentioned before, the risk exposure to drought varies along the gradient North-South in link with the wadi geography but also the water infrastructure. Also, the natural resources are affected differently according to their initial status and the intensity and duration of the drought in link with the external water resources. So, understanding the farmers' strategies in this zone needs to consider the natural capital, mainly the water resource. So the originality of our thesis will be to consider in the same framework the water resource availability at the local level according to the geography of the zone and the social and economic resource at the family and community level. For that we will use geographical information system (GIS) and remote sensing (RS) to approach the diversity of vulnerability at the wadi level.

The main hypotheses to address the various impact of the drought are:

- The farmers are not equal facing the drought due to different natural and social capital. And social and economic resources are the main determining factors of the range and scope of adaptive responses.

- Drought is not only the causative agent of land degradation, but it shares with other factors to ultimately lead to the deterioration of land.
- Small ruminant flock in this traditional agro-pastoral society had played a contrasting role according to the location of farmers along the wadi;
- “Simple” technical practices can improve the adaptation process but they are confronted to complex social changes;

- So, it is proposed firstly to make a selected review of the literature in the North west coastal zone of Egypt (chapter 1) and on how pastoralists over the world faced to drought (chapter 2) to develop our methodology in chapter 3. In chapter 4, it is introduced our case study, the wadi Naghamish. The main results of the impact of the drought at the family level in terms of socio-economic impact and at the local level in terms of water resource management impact will be presented in chapter 5 and 6. The chapter 7 proposes an integrative approach of the vulnerability at the wadi level considering the land cover changes.

CHAPTER 1: DROUGHT CHALLENGE IN THE NORTH WEST COASTAL ZONE IN EGYPT

Introduction

In this chapter, we propose to introduce the physical, natural and social context of the North West coastal zone of Egypt and the main social and natural changes that have affected the zone since the last two decades.

This approach is mainly based on our research work within the project ELVULMED (project on the 'Role of livestock activities in the process of adaptation and reducing vulnerability of Mediterranean societies facing global changes', research project funded by the French National research Agency (ANR) from 2011 to 2014).

Three main drivers have been identified: 1. Climatic change, with the recent long drought in the zone; 2.Urbanization with touristic development in the zone; 3. Social development change due to infrastructure and policies.

So we propose to describe the main components of natural resources in the zone and the recent social and natural events. The objective is to shed light both the prevailing climate in the region, natural resources, which include vegetation, soil and water resources, and social structure. This will be a prelude to identify this arid zone. Also this description will allow clarifying the different characteristics of the area compared to the rest of Egypt.

1.1. Geographical approach

From a social-geographical point of view, we propose to divide the region into two zones: 1) the coastal zone from Alexandria to Marsa Matrouh with strong touristic development, 2) and what we can call the Bedouin area in the backland or hinterland, behind the coastal highway, and also including the coastal zone from Matrouh to Libyan border. These two zones show different socio-ecosystems. The coastal area includes several tourism villages while the hinterland includes dispersed Bedouin settlements

1.1.1. Location

The North West Coast Zone (NWCZ) is located in the Northern West corner of Egypt that extends from the Libyan borders in the west up to Alexandria in the Western delta, between longitude 29º 50’ 00’’ and 25º 10’ 00 E with about 40 km depth, between latitude 30º 50’ 00’’ and 31º 10’ 00 N. Administratively (Moustafa & EI-Mowelhi, 1999) the NWCZ corresponds to the Matrouh governorate with Marsa Matrouh city as the regional capital. Matrouh governorate extends from El-Hammam, located at 41 km from Alexandria until El-Sallum at the Libyan border, and covers a distance of 451 km along the coast. See Figure (1).

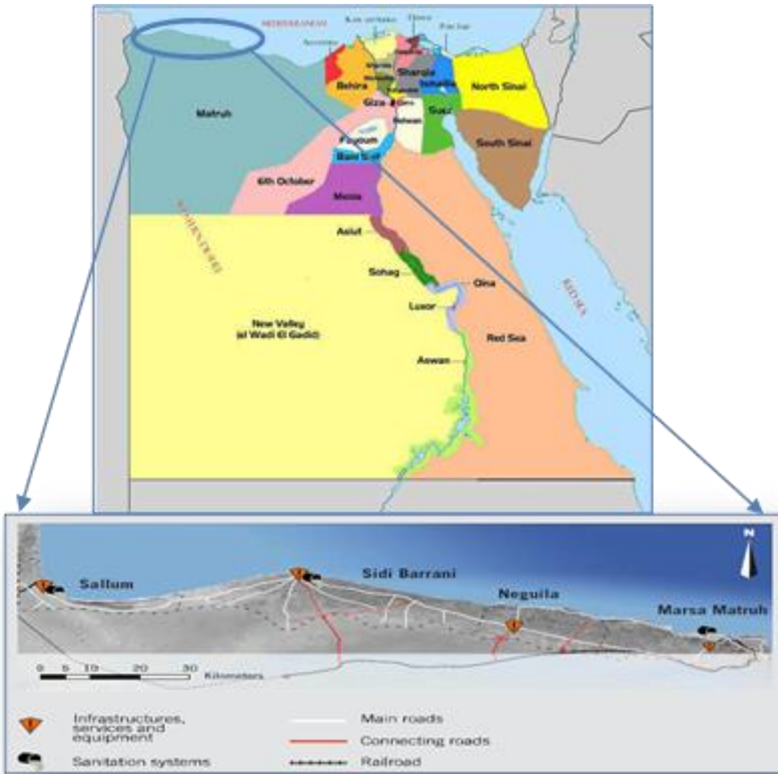


Figure 1: Locations of NWCZ of Egypt

Source: ICZM, 2009

NWCZ can be divided into two zones. The irrigated zone stretches from *Alamain* in the west to the border of Alexandria governorate in the east. This zone is connected to the Nile river water through *El-Hammam* canal. The rainfed zone stretching from Sallum in the west to the end of *Dabaa* center in the East is depending entirely on rain water as main source for the rain-fed agriculture Figure (2) shows both of the rain-fed and the irrigated zone.

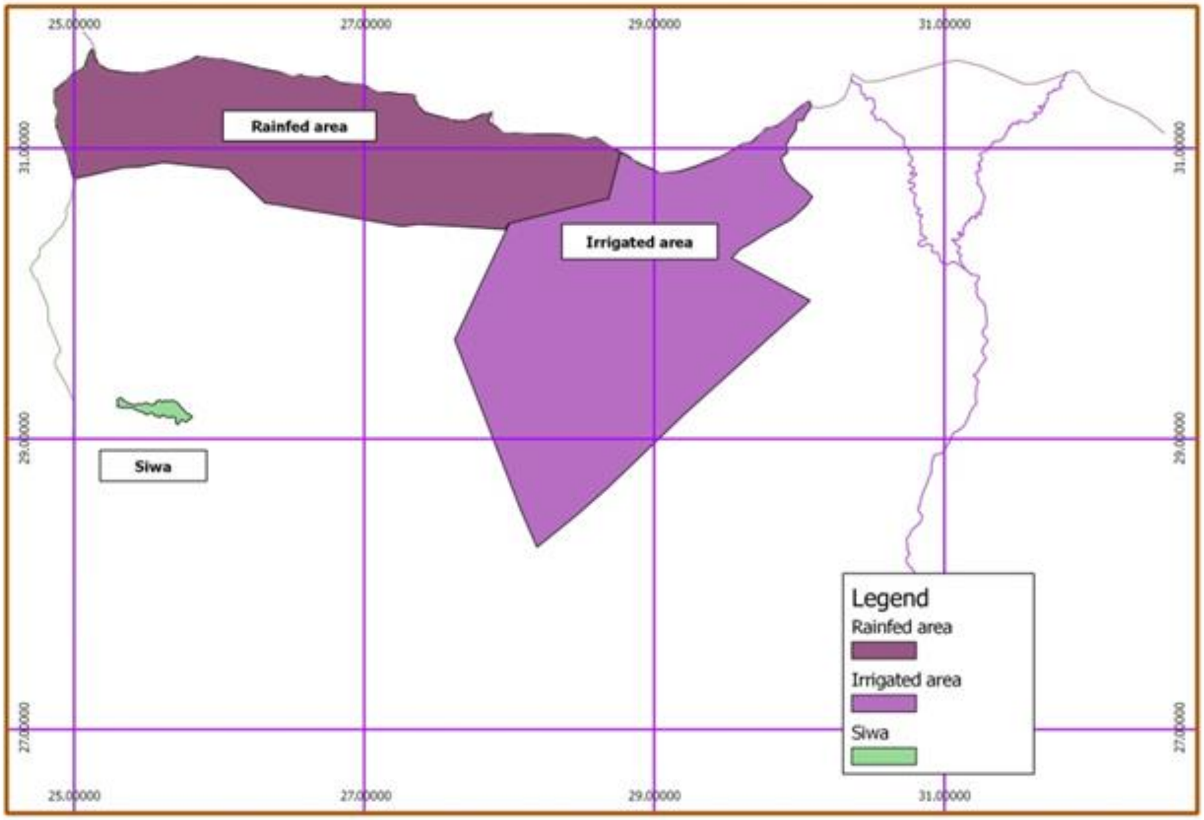


Figure 2: NWCZ zones (irrigated and rain-fed)

The rain-fed zone depends on rainfall as a main source for irrigation and drinking for both human and animals. 218 wadis have been identified in the rain-fed area (FAO, 1970). Those wadis represent the highest potential in the zone in term of soil and water. Figure (3) shows the main watersheds in the NWCZ.

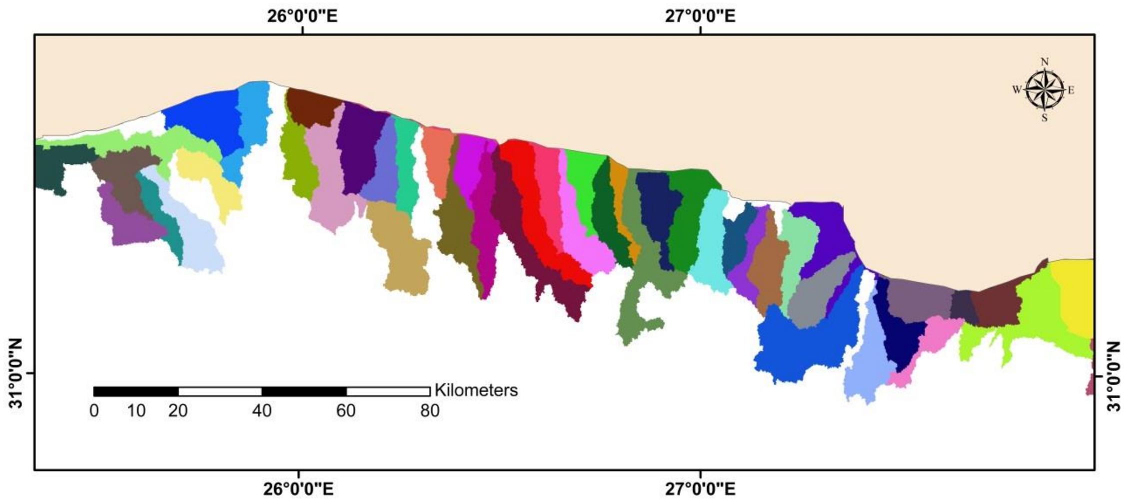


Figure 3: main watersheds in NWCZ

1.1.2. Regional climate

1.1.2.1. Using of rainfall data to identify drought in the NWCZ

The NWCZ is characterized by a Mediterranean climate. According to (Verheye & de la Rose, 2005) the main characteristic of the Mediterranean climate is that it has two well defined seasons in the year, with the rain period coinciding with low temperatures (winter) while summers are hot and almost completely dry. The same climate condition is observed in the NWCZ; and this zone is considered as an arid zone.

Table (1) and figure (4) shows the average meteorological data (1971-2000) in Matrouh station (data from Ministry of Agriculture and Land Reclamation, 2007). The maximum temperature (29.7 ºC) is recorded in (August) while the minimum (8.4 °C) is recorded in January. The annual rate maximum temperature is 25 °C. The maximum monthly rainfall is 33.2 mm in January. The maximum and the minimum values of relative humidity are recorded in July to August and April, being 73.0 % and 61.0%, respectively. Prevailing winds mainly chiefly directed northwest in the most of year months. Surface wind velocity varies from (8.1 to 11.9) km/h. Evaporation data indicate that the lowest values of evaporation (2.7 mm/day) are recorded in January while the highest value is recorded in July and June (5.9 mm/day) (Sayed, 2013).

Table 1: Climatological normal at Matrouh station (1971-2000)
Source: Sayed, 2013

Month	Temperature (^0C)			Rainfall	Relative Humidity	Wind velocity	Avg. Et_0
	Max.	Min.	Mean	Mm	%	Km/h	Mm/d
Jan.	18.00	8.40	12.80	33.2	66.0	11.5	2.70
Feb.	18.80	8.60	13.00	15.0	65.0	11.5	3.00
Mar.	20.40	10.20	15.10	12.0	63.0	11.9	3.80
Apr.	22.70	12.10	17.40	2.80	61.0	10.2	4.60
May.	25.40	14.70	20.10	2.60	64.0	9.3	5.20
Jun	28.10	18.40	23.30	2.00	68.0	9.7	5.90
Jul.	29.10	20.40	24.90	0.00	73.0	9.8	5.80
Aug.	29.70	21.10	25.50	0.60	73.0	8.9	5.60
Sep.	28.60	19.70	24.30	1.10	68.0	8.3	5.10
Oct.	26.90	16.90	21.60	15.60	67.0	8.1	4.00
Nov.	23.20	13.40	18.10	22.5	68.0	9.1	3.10
Dec.	19.50	10.10	14.10	30.20	66.0	11.1	2.80

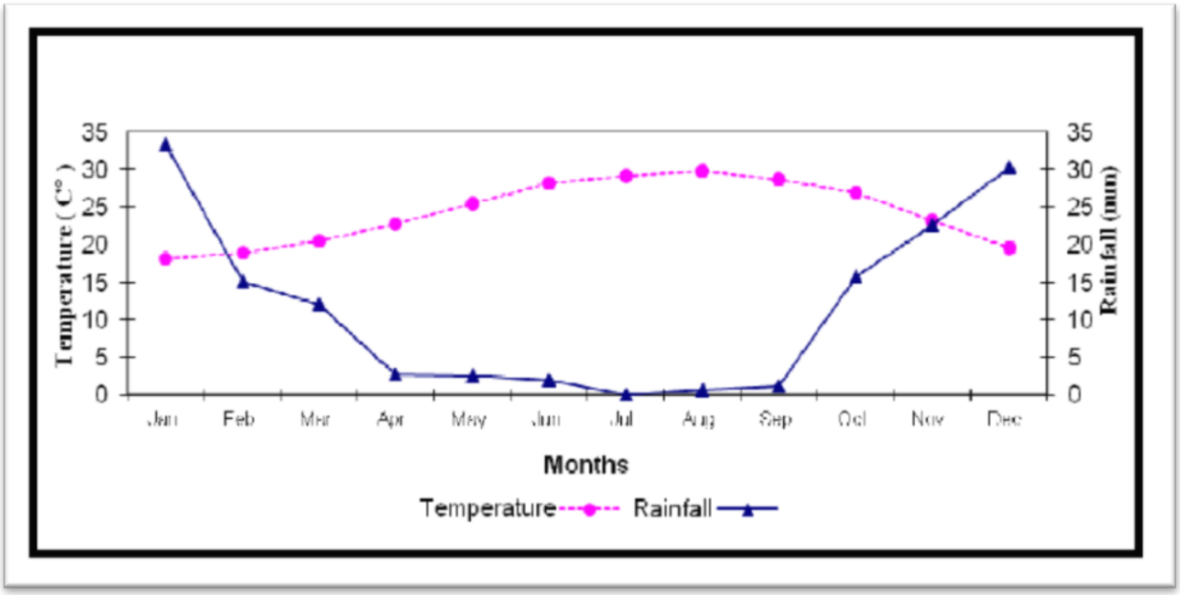


Figure 4: Climate diagram of Matrouh station

Source: Sayed, 2013

The average rainfall is around 140 mm/year (Matrouh airport climate station, cited MRMP). Table (2) and figure (5) show the rainfall data in the period from 1945 to 2011 (Wakil et al., 1999 & Climet lab. ARC. The rain comes in outbursts over short period of time. The main rainy season is between October and March and the rest of the year from April to September is almost dry Figure (4).

Table 2: Monthly rainfall Data (mm) at Marsa Matrouh (1945-2011) Wakil et al.,1999 & climate lab. ARC

Year	Sep.	Oct.	Nov.	Dec .	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Total
1944-45	4.6	0.5	37.5	18.	16.7	21.3	4.8	2.0	3.5	0.0	0.0	0.0	108.9
1945-46	0.0	0.0	46.1	25.	0.4	18.3	4.8	2.2	11.0	0.0	0.0	0.0	108.3
1946-47	2.2	12.9	14.5	1.1	14.6	1.1	4.4	0.0	0.0	0.0	0.0	0.0	50.8
1947-48	0.0	26.5	101.2	2.2	3.4	49.9	73.0	17.2	1.0	0.0	0.0	0.0	274.4
1948-49	0.0	0.5	61.5	68.	54.1	10.0	14.0	1.9	3.4	0.0	0.0	0.0	213.9
1949-50	0.0	0.3	2.6	77.	94.6	9.0	12.3	1.8	17.2	0.0	0.0	0.0	215.1
1950-51	0.0	12.6	5.4	0.6	7.2	3.6	4.2	0.5	0.0	0.0	0.0	0.0	34.1
1951-52	0.0	3.5	9.2	54.	38.9	18.8	1.3	0.0	2.8	0.0	0.0	0.0	129.1
1952-53	0.0	16.5	2.4	6.1	2.5	3.4	12.0	0.2	4.1	0.0	0.0	0.0	47.2
1953-54	0.0	0.9	51.2	16.	1.7	1.2	11.3	1.2	0.0	0.0	0.0	0.0	84.2
1954-55	0.0	3.0	33.6	40.	0.9	1.2	1.6	0.6	0.0	0.0	0.0	0.0	81.1
1955-56	0.0	4.1	46.4	74.	24.2	16.0	9.3	0.0	2.6	0.0	0.0	0.0	177.0
1956-57	0.0	41.7	16.1	76.	35.1	59.3	34.6	5.7	5.1	0.0	0.0	0.0	273.8
1957-58	9.0	41.8	18.3	60.	44.2	4.5	0.0	0.0	0.0	0.0	0.0	0.0	178.5
1958-59	0.0	55.5	1.5	31.	18.2	37.2	0.2	0.1	0.0	0.0	0.0	0.0	143.9
1959-60	0.0	4.0	0.4	18.	27.8	10.2	5.4	6.2	7.9	0.0	0.0	0.0	79.9
1960-61	0.0	0.0	29.1	16.	51.0	45.6	9.2	0.0	0.2	0.0	0.0	0.0	151.6
1961-62	0.2	2.0	9.1	20.	21.1	18.9	0.0	2.3	0.5	0.0	0.0	0.0	74.8
1962-63	6.4	19.4	0.4	5.8	5.7	9.6	14.9	8.4	1.9	0.3	0.0	0.0	72.8
1963-64	0.0	3.4	25.6	4.3	72.3	28.7	12.1	8.4	0.5	0.0	0.0	0.0	155.3
1964-65	2.5	0.0	28.8	63.	53.5	4.7	5.7	5.9	0.0	59.5	0.0	0.0	224.0
1965-66	0.0	67.5	8.5	7.8	37.5	22.1	6.2	0.0	0.0	0.0	0.0	0.0	149.6
1966-67	10.0	6.0	43.8	18.	32.0	5.0	7.7	1.9	1.0	0.0	0.0	0.0	126.0
1967-68	0.0	1.8	40.3	11.	13.5	4.0	10.4	1.8	0.0	0.0	0.0	0.0	82.9
1968-69	0.0	37.3	4.0	16.	86.6	2.8	19.0	2.2	22.5	0.0	0.0	0.0	190.7
1969-70	0.0	89.8	12.5	0.9	8.7	1.0	4.2	1.5	0.0	0.0	0.0	0.0	118.6
1970-71	0.0	5.8	25.3	17.	1.3	12.6	4.0	6.8	0.4	0.0	0.0	0.0	73.3
1971-72	0.0	0.0	19.3	33.	19.4	15.5	16.1	7.4	0.2	0.0	0.0	17.3	128.3
1972-73	0.0	2.9	11.9	61.	17.7	0.3	19.3	0.0	0.6	0.0	0.0	0.0	113.8
1973-74	0.0	1.6	58.1	6.3	102.4	21.7	19.9	9.6	0.0	0.0	0.0	0.0	219.6
1974-75	2.2	0.0	7.4	42.	6.7	15.5	3.3	2.0	0.1	0.0	0.0	0.0	80.1
1975-76	0.0	0.0	4.6	26.	28.0	18.9	7.4	2.9	8.5	0.0	0.0	0.0	96.9
1976-77	30.5	5.5	5.1	0.6	5.4	3.5	25.2	5.4	2.7	0.0	0.0	0.0	83.9
1977-78	0.2	8.4	7.7	121	58.0	0.5	25.7	3.2	0.0	0.0	0.0	0.0	225.5
1978-79	2.8	2.2	38.9	7.5	0.7	4.8	13.0	0.0	0.3	0.0	0.0	0.0	70.2
1979-80	0.0	32.5	27.6	53.	10.4	49.1	6.2	16.2	0.0	0.0	0.0	0.0	195.4
1980-81	0.2	0.0	0.0	31.	40.0	21.9	1.5	0.6	0.0	0.0	0.0	0.0	95.9
1981-82	0.0	0.3	18.4	0.0	13.5	62.9	11.7	0.4	0.7	0.0	0.0	0.0	107.9
1982-83	7.5	0.0	7.9	31.	125.1	31.3	5.7	0.0	0.0	0.0	0.0	0.0	208.9
1983-84	0.0	15.0	16.1	15.	5.6	5.7	2.4	1.2	0.0	0.0	0.0	0.0	61.6
1984-85	0.0	23.4	10.1	39.	21.2	36.3	5.5	3.8	0.7	0.0	0.0	0.0	140.1
1985-86	0.0	35.0	7.9	51.	3.2	14.3	11.4	0.2	2.5	0.0	0.0	0.0	126.4
1986-87	2.5	0.9	28.4	32.	10.9	9.6	15.0	0.3	0.6	0.0	0.0	0.0	100.8
1987-88	0.0	0.1	4.8	67.	17.9	60.2	8.7	2.8	0.0	0.0	0.0	0.0	161.6
1988-89	0.1	59.3	27.0	19.	87.0	22.8	10.9	0.0	0.0	0.0	0.0	0.0	226.1
1989-90	0.0	146.8	14.9	11.	50.6	33.8	13.4	1.9	1.3	0.0	0.0	0.0	274.5
1990-91	0.0	0.2	3.7	26.	42.8	12.1	10.4	0.5	2.9	0.0	0.0	0.0	99.5
1991-92	0.0	0.0	29.8	79.	59.3	54.2	1.2	11.0	0.5	0.0	0.0	0.0	235.1
2001/2002	0.0	12.8	7.4	25.	57.2	8.5	4.7	18.5	3.7	0.0	1.8	0.0	140.3
2002/2003	0.0	11.3	1.2	28.	12.4	42.9	29.2	6.0	2.6	3.0	0.8	0.0	138.0
2003/2004	0.0	16.5	21.6	21.	40.1	20.6	18.9	5.1	7.4	0.0	0.8	0.0	152.7
2004/2005	0.0	16.5	21.6	21.	39.9	13.4	7.6	8.4	0.0	0.0	0.8	0.0	129.9
2005/2006	0.0	4.1	16.7	41.	47.2	16.2	5.6	0.1	0.0	0.0	0.8	0.0	132.6
2006/2007	0.0	1.0	14.9	31.	33.8	31.4	2.0	8.5	15.1	0.0	0.6	0.0	138.4
2007/2008	1.6	74.1	10.2	7.6	23.0	34.7	3.9	1.6	3.6	0.0	0.6	0.0	160.9
2008/2009	0.0	13.2	0.0	20.	1.9	25.7	13.1	0.0	2.1	0.0	0.8	0.0	77.6
2009/2010	0.0	11.2	24.2	20.	5.8	9.5	0.9	0.0	0.0	0.0	0.6	0.0	72.4
2010/2011	0.0	5.1	0.0	12.	27.3	21.3	10.1	5.0	3.0	2.0	1.0	0.0	87.3

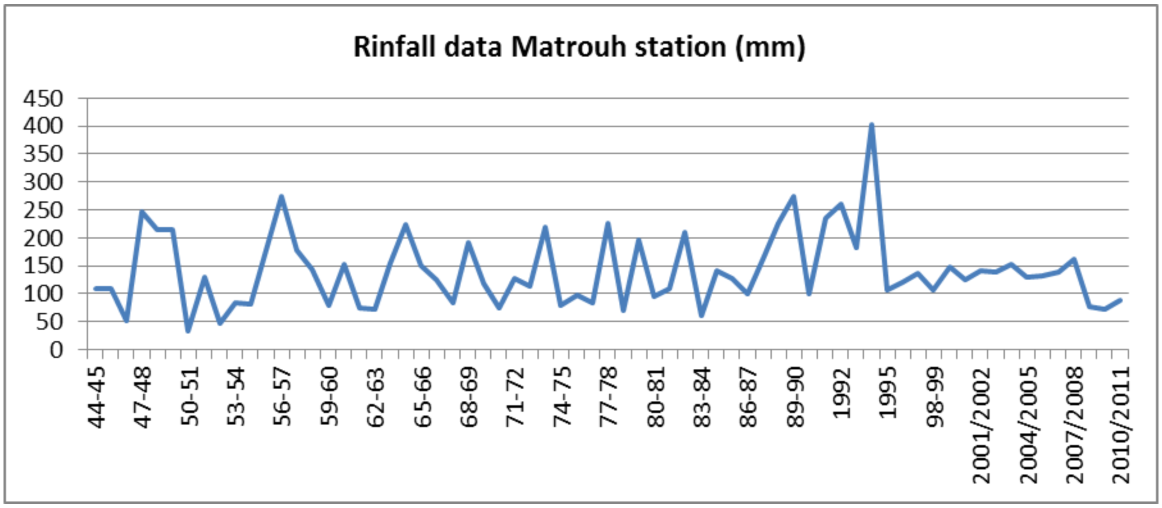


Figure 5: Annual rainfall data (Matrouh station)

According to the available rainfall data over the 16 years we can see a very dry period from 1995 to 2011. Also, over this period, the data show that 12 year was dry (with less than 140 mm of rain), while (4 years) was wet years with a rainfall more than the average. According to interviewees, the drought was a metrological drought in the dry years, while it was agricultural and hydrological drought in the other years, which means that rain, may be more than average, but they do not fall at an appropriate time for cultivations.

The NWCZ as a part of the Mediterranean area has known a noticeable change in climate. According to (Christensen et al., 2007), annual mean temperatures in Europe are likely to increase more than the global mean. Seasonally, the largest warming is likely to be in northern Europe in winter and in the Mediterranean area in summer. Minimum winter temperatures are likely to increase more than the average in northern Europe. Maximum summer temperatures are likely to increase more than the average in southern and central Europe. Annual precipitation is very likely to increase in most of northern Europe and decrease in most of the Mediterranean area. In central Europe, precipitation is likely to increase in winter but decrease in summer. Extremes of daily precipitation are very likely to increase in northern Europe. The annual number of precipitation days is very likely to decrease in the Mediterranean area. Risk of summer drought is likely to increase in central Europe and in the Mediterranean area. The duration of the snow season is very likely to shorten, and snow depth is likely to decrease in most of Europe. In this sense, we can suppose that the occurrence of last drought in the NWCZ can be considered as a result of climate changes taking place in the Mediterranean region.

1.1.2.2. Using of drought indices to identify drought in the NWCZ

Based on the available climatological data represented in perception in the NWCZ at Matrouh station in the period (1944-2011), two drought indexes are used to identify the occurrence of the drought in the zone as followed:

Using the Standardized Precipitation Index (SPI) to identify drought in the NWCZ

The Standardized Precipitation Index (SPI) – SPI is one of the indices that have been strongly suggested by many scientists because it is based on historical rainfall data only. It gives a fair idea on drought. Consequently, by this index we can monitor the different drought types (agricultural, pastoral, hydrological droughts) (Karrou & El Mourid, 2008).

The Standardized Precipitation Index (SPI) was developed by McKee et al. (1993) to serve as a "versatile tool in drought monitoring and analysis". The SPI calculation for any location is based on the long-term precipitation record for a desired period (Tigkas et al., 2013). This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero (Edwards & McKee, 1997). Table (3) shows SPI probability and drought classes. According to (Hayes, 2012) SPI is a simple index which is calculated from the long-term record of precipitation in each location (at least 30 years). (Agnew, 2000) reported that the relationship between drought duration, drought frequency, and drought time scale using the Standardized Precipitation Index (SPI):

$$\mathbf{SPI = (X_{ik} - X_i)/\sigma_i}$$

Where

σi = standardized deviation for the ith station

Xik = precipitation for the ith station and kth observation

Xi = mean precipitation for the ith station

Table 3: Probabilities for different standardized rainfall anomalies
Source: Agnew, 2000.

SPI	Probability of occurrence	Komuscu (1999) and McKee et al. (1995) drought classes
Less than -2.00	0.023	Extreme drought
Less than -1.65	0.050	
Less than -1.50	0.067	Severe drought
Less than -1.28	0.100	
Less than -1.00	0.159	Moderate drought
Less than -0.84	0.201	
Less than -0.50	0.309	
Less than 0.00	0.500	Mild drought

Based on the available annual rainfall data for NWCZ represented by Matrouh station in the period (1944-2011) and using the Drought Indices Calculator (DrinC), table (4) and figure (6) show the SPI results.

Table 4: Standardized Precipitation Index (SPI) in NWCZ (1944-2011)

Year	Rainfall (mm)	SPI	Year	Rainfall (mm)	SPI
1944 - 1945	108.9	-0.40	**1978 – 1979**	70.2	-1.22
1945 - 1946	108.3	-0.41	**1979 – 1980**	195.4	0.90
1946 - 1947	50.8	-1.77	**1980 – 1981**	95.9	-0.65
1947 - 1948	274.4	1.78	**1981 – 1982**	107.9	-0.42
1948 - 1949	213.9	1.12	**1982 – 1983**	208.9	1.06
1949 - 1950	215.1	1.14	**1983 – 1984**	61.6	-1.45
1950 - 1951	34.1	-2.37	**1984 – 1985**	140.1	0.13
1951 - 1952	129.1	-0.05	**1985 – 1986**	126.4	-0.09
1952 - 1953	47.2	-1.88	**1986 – 1987**	100.8	-0.55
1953 - 1954	84.2	-0.90	**1987 – 1988**	161.6	0.45
1954 - 1955	81.1	-0.96	**1988 – 1989**	226.1	1.26
1955 - 1956	177.0	0.66	**1989 – 1990**	274.5	1.78
1956 - 1957	273.8	1.77	**1990 – 1991**	99.5	-0.58
1957 - 1958	178.5	0.68	**1991 – 1992**	235.1	1.36
1958 - 1959	143.9	0.19	**1992 – 1993**	260.08	1.63
1959 - 1960	79.9	-0.99	**1993 – 1994**	182.14	0.73
1960 - 1961	151.6	0.30	**1994 – 1995**	401.85	2.91
1961 - 1962	74.8	-1.11	**1995 – 1996**	107.2	-0.43
1962 - 1963	72.8	-1.16	**1996 – 1997**	119.39	-0.21
1963 - 1964	155.3	0.36	**1997 – 1998**	136.14	0.07
1964 - 1965	224.0	1.24	**1998 – 1999**	107.7	-0.42
1965 - 1966	149.6	0.27	**1999 – 2000**	148.4	0.25
1966 - 1967	126.0	-0.10	**2000 – 2001**	124.2	-0.13
1967 - 1968	82.9	-0.92	**2001 – 2002**	140.3	0.13
1968 - 1969	190.7	0.84	**2002 – 2003**	138	0.10
1969 - 1970	118.6	-0.22	**2003 – 2004**	152.7	0.32
1970 - 1971	73.3	-1.15	**2004 – 2005**	129.9	-0.03
1971 - 1972	128.3	-0.06	**2005 – 2006**	132.6	0.01
1972 - 1973	113.8	-0.31	**2006 – 2007**	138.4	0.10
1973 - 1974	219.6	1.19	**2007 – 2008**	160.9	0.44
1974 - 1975	80.1	-0.99	**2008 – 2009**	77.6	-1.05
1975 - 1976	96.9	-0.63	**2009 – 2010**	72.4	-1.17
1976 - 1977	83.9	-0.90	**2010 – 2011**	87.3	-0.83
1977 - 1978	225.5	1.26			

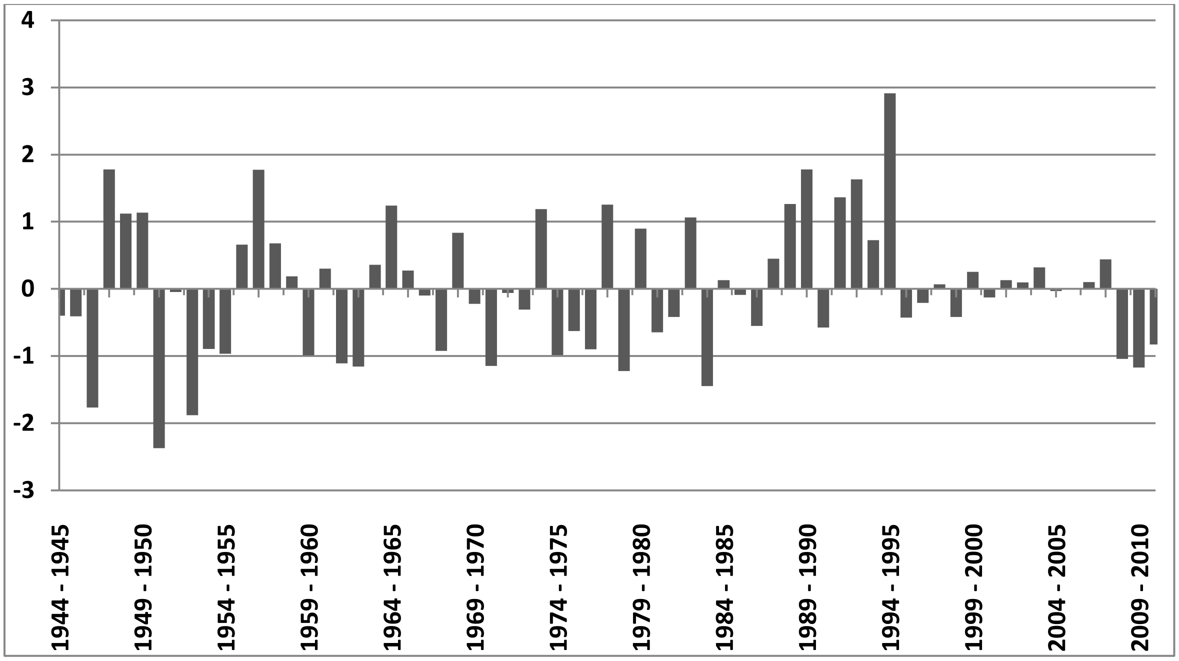


Figure 6: Standardized Precipitation Index in NWCZ (1944-2011)

Based on SPI classes values in table (4) the drought classes for the data in the period (1944-2011) can be classified as shown in table (5). The data confirm that drought is not new event in the area. Eight years in the period (1995-2011) were drought years varied between mild droughts to serve drought (in yellow). In summary, we can say it were not strong drought but continued for a long period.

Table 5: drought classes in NWCZ in the period (1944-2011) according to Komuscu (1999) and Proposed new

McKee et al. (1995)

	Mild Drought	Moderate Drought	Severe Drought	Extreme Drought
years	1995 - 1996	1959 - 1960	1983 – 1984	1950 – 1951
	1998 - 1999	1974 - 1975	1978 – 1979	1952 – 1953
	1981 - 1982	1954 - 1955	2009 – 2010	1946 – 1947
	1945 - 1946	1967 - 1968	1962 – 1963	
	1944 - 1945	1976 - 1977	1970 – 1971	
	1972 - 1973	1953 - 1954	1961 – 1962	
	1969 - 1970	2010 - 2011	2008 – 2009	
	1996 - 1997	1980 - 1981		
	2000 - 2001	1975 - 1976		
	1966 - 1967	1990 - 1991		
	1985 - 1986	1986 - 1987		
	1971 - 1972			
	1951 - 1952			
	2004 - 2005			

Rainfall Deciles

A simple meteorological drought index is the Rainfall Deciles, in which the total precipitations for the preceding three months are ranked against climatologic records. The precipitation can be divided into 10 deciles, the first decile is the precipitation amount not exceeded by the lowest 10% of the precipitation occurrences. The second decile is the precipitation amount not exceeded by the lowest 20% of occurrences. These deciles continue until the rainfall amount identified by the tenth decile is the largest precipitation amount within the long-term record. By definition, the fifth decile is the median, and it is the precipitation amount not exceeded by 50% of the occurrences over the period of record. The deciles are grouped into five classifications as shown in table (6) which presents the classification of drought conditions according to deciles (Tigkas et al, 2013). Based on Rainfall Deciles, table (7) shows the analysis of the precipitation in the NWCZ in the period (1944-2011).

Table 6: Classification of drought conditions according to deciles
Source: Tigkas et al., 2013

Decile Classifications Description	Decile Classifications Description
deciles 1-2: lowest 20%	much below normal
deciles 3-4: next lowest 20%	below normal
deciles 5-6: middle 20%	near normal
deciles 7-8: next highest 20%	above normal
deciles 9-10: highest 20%	much above normal

Table 7: Classification of drought conditions according to deciles in NWCZ (1944-2011)

year	Rainfall (mm)	Deciles classes	Year	Rainfall (mm)	Deciles classes
1944 - 1945	108.9	4.00	1978 – 1979	70.2	1.00
1945 - 1946	108.3	4.00	1979 – 1980	195.4	9.00
1946 - 1947	50.8	1.00	1980 – 1981	95.9	3.00
1947 - 1948	274.4	10.00	1981 – 1982	107.9	4.00
1948 - 1949	213.9	9.00	1982 – 1983	208.9	9.00
1949 - 1950	215.1	9.00	1983 – 1984	61.6	1.00
1950 - 1951	34.1	1.00	1984 – 1985	140.1	6.00
1951 - 1952	129.1	6.00	1985 – 1986	126.4	5.00
1952 - 1953	47.2	1.00	1986 – 1987	100.8	4.00
1953 - 1954	84.2	3.00	1987 – 1988	161.6	8.00
1954 - 1955	81.1	2.00	1988 – 1989	226.1	10.00
1955 - 1956	177	8.00	1989 – 1990	274.5	10.00
1956 - 1957	273.8	10.00	1990 – 1991	99.5	3.00
1957 - 1958	178.5	8.00	1991 – 1992	235.1	10.00
1958 - 1959	143.9	7.00	1992 – 1993	260.08	10.00
1959 - 1960	79.9	2.00	1993 – 1994	182.14	8.00
1960 - 1961	151.6	7.00	1994 – 1995	401.85	10.00
1961 - 1962	74.8	2.00	1995 – 1996	107.2	4.00
1962 - 1963	72.8	1.00	1996 – 1997	119.39	5.00
1963 - 1964	155.3	7.00	1997 – 1998	136.14	6.00
1964 - 1965	224	9.00	1998 – 1999	107.7	4.00
1965 - 1966	149.6	7.00	1999 – 2000	148.4	7.00
1966 - 1967	126	5.00	2000 – 2001	124.2	5.00
1967 - 1968	82.9	2.00	2001 – 2002	140.3	7.00
1968 - 1969	190.7	8.00	2002 – 2003	138	6.00
1969 - 1970	118.6	5.00	2003 – 2004	152.7	7.00
1970 - 1971	73.3	2.00	2004 – 2005	129.9	6.00
1971 - 1972	128.3	5.00	2005 – 2006	132.6	6.00
1972 - 1973	113.8	4.00	2006 – 2007	138.4	6.00
1973 - 1974	219.6	9.00	2007 – 2008	160.9	8.00
1974 - 1975	80.1	2.00	2008 – 2009	77.6	2.00
1975 - 1976	96.9	3.00	2009 – 2010	72.4	1.00
1976 - 1977	83.9	3.00	2010 – 2011	87.3	3.00
1977 - 1978	225.5	9.00			

In conclusion results show that in the period 1995-2011; 2 years were much below the normal; 3 years were below normal; 7 years were near normal; 4 years were above normal. Compering with results through using SPI, 8 years were varying from mild drought to severe drought based on SPI calculations. The results for both Rainfall Deciles and SPI confirm that it was continued drought and not a strong drought.

1.1.3. Geology

The Northern part of Egypt including, the NWCZ, the Nile Delta and North Sinai lie in the unstable shelf area. The main part of Egypt at the West of the Nile River is covered by thick sequences of relatively undisturbed sedimentary strata of Paleozoic, Mesozoic and Cenozoic age (Said, 1990). The North part of the Western Desert is covered mainly by thin blanket of Miocene rocks forming a vast persistent limestone plateau. It extends from the Western side of the Nile valley and delta in the East to El-Sallum city in the West and the Mediterranean coastal plain in the North to the Qattara and Siwa depression in the South at about 300 km (El-Bastwasy, 2008).

El-Asmar & Wood (2000) reported that The NWCZ of Egypt forms the northern extremity of the Miocene Marmarican homoclinal plateau, which extends from the west of Alexandria for about 500 km. This confines the coastal plain of a narrow western province which extends from Sallum to Ras El-Hekma, while eastern province which extends from Ras El-Hekma to Alexandria. The eastern region is wider than the western province and is affected by the synclinal Arab's Gulf embayment.

Sogreach (1961) and Said (1962) reported that the area under study is occupied by sedimentary rocks essentially belonging to the late Tertiary Era. Quaternary deposits are also known, and are found both in the form of alluvial terraces deposited in the wadi depressions, and as thin mantle of transported soil occurring on the top of the surrounding plateau. The fossils indurate limestone that represents the Miocene formation forms the main strata, and overlain by calcareous Pliocene and Pleistocene formations.

In the Holocene, the area was subjected to arid and semi-arid climatic conditions, which affected the features characterizing the area landscape. The tectonic movements in the quaternary Era also affected the area and resulted in the present landscape (Shata, 1971).

Yousif et al., (2013) reported that based on the field investigations of Conoco in 1986, the author proposed a geologic map (figure 7) with four stratigraphic sections named: 1. Tertiary which are exposed mainly in the southern parts of the study area, and constitute the major part of the table land;: 2. Pleistocene sediments which are also widely distributed in the study area and are mainly represented by oolitic limestone, which constitutes the main bulk of the Pleistocene sediments; Alluvial deposits which are developed in the study area along the channels of the drainage lines in the form of Wadi terraces and Wadi fillings; The structural setting can be considered as a part of the main structure, which affects the northwestern coast of Egypt.

.

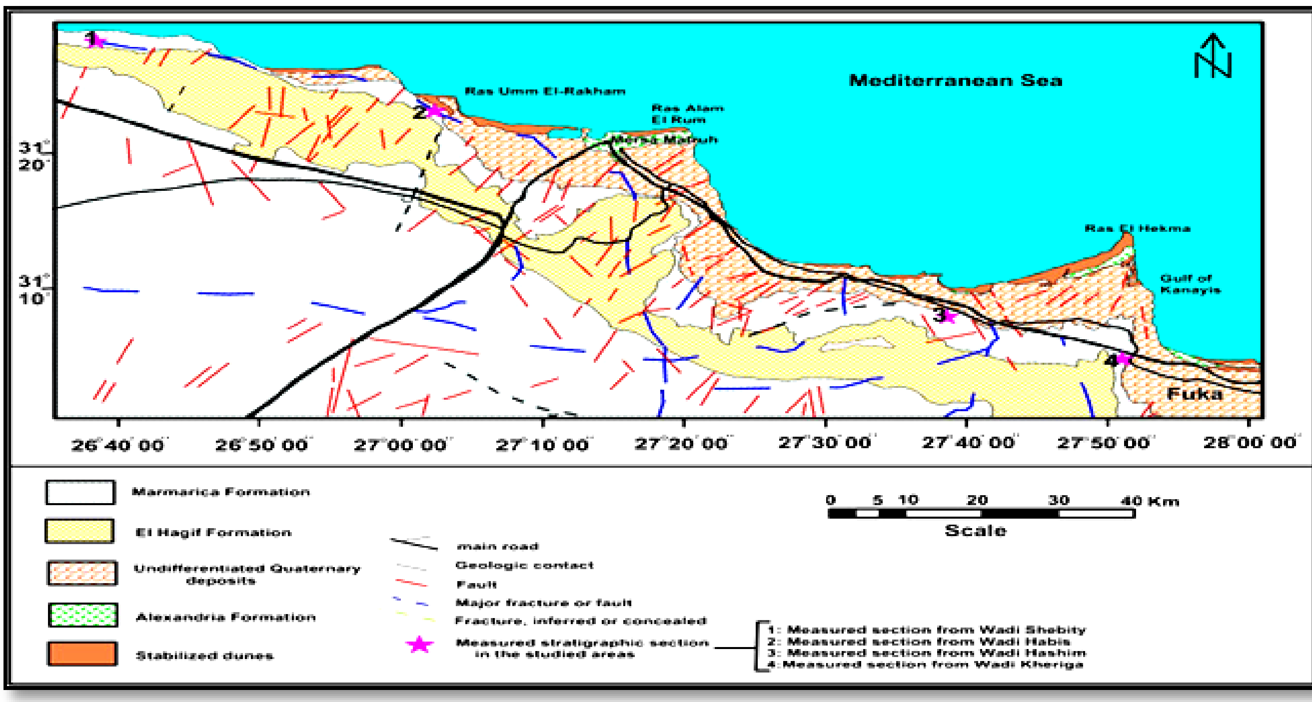


Figure 7: Geologic map of the study area and its surroundings (Conoco 1986)

1.1.4. Topography and geomorphologic settings

Moustafa & EI-Mowelhi in (1999) reported that Pavlov (1962) and La Mareaux & Hyde (1966) describe the topography of the NWCZ. The zone located between the Mediterranean Sea in the north and an escarpment of 200 m elevation in the south. The zone consists of a narrow, almost uninterrupted, band of coastal and inland sand dunes and interdunal plains. Further inland there is an alluvial plain that slopes gradually upward to the Libyan plateau. Numerous wadis formed by runoff water from the northward sloping plateau and eroded escarpment bisect the area. Soil from the plateau and upper slopes of the wadis accumulates in the lower section be1ow the escarpment to form local areas of deep and relatively more fertile soil. The morphological characteristics of the region are easily distinguished. Along the coast, one or more limestone ridges of consolidated dunes are formed; the first is at shoreline and comprises the present sand dunes. Narrow lows, some of which are marshy, lie between these ridges. Beyond the ridges follows a succession of transitional surface drainage channe1s up to the escarpment. The general slopes of the region run south to north. There are large land areas of irregular relief from a series of closed depressions surrounded by low hills. These areas are dissected by many intermittent streambeds (wadis) running from south to north.

Sayed (2013) reported that the NWCZ forms a belt about 20 km deep, which extends for about 500 km between Amria (20 km west of Alexandria) and Sallum. The NWCZ may be divided into two main physiographic provinces: the Eastern province between Alexandria and Ras El-Hikma (about 230 km West of Alexandria) and the Western province between Ras El-Hikma and Salloum. The landscape varies from the northern coastal plain to southern Figure (8). The slope of the land surface is about 5 m/km which is considered as gentle slope. This gentle slope does not accelerate surface runoff where the area has an indistinct drainage pattern. The surface runoff is captured by low lying depression where most of this surface storage evaporates. The area under investigation is situated on one of Pleistocene beach dunes which are orientated more or less parallel to the present coastal. The hills and valleys of the sea called (Inland Plain) beach dune system evolved by the variation of the sea level during the Pleistocene. Soils on the dunes are mainly formed on airborne quartzitic sand, which is alternatively shifted in the valleys by water and wind erosion (Fehlberg and Stahr, 1985).

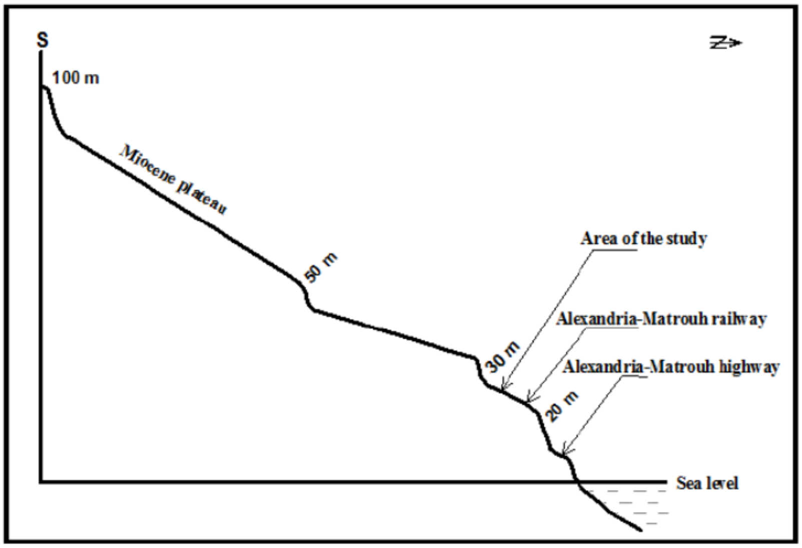
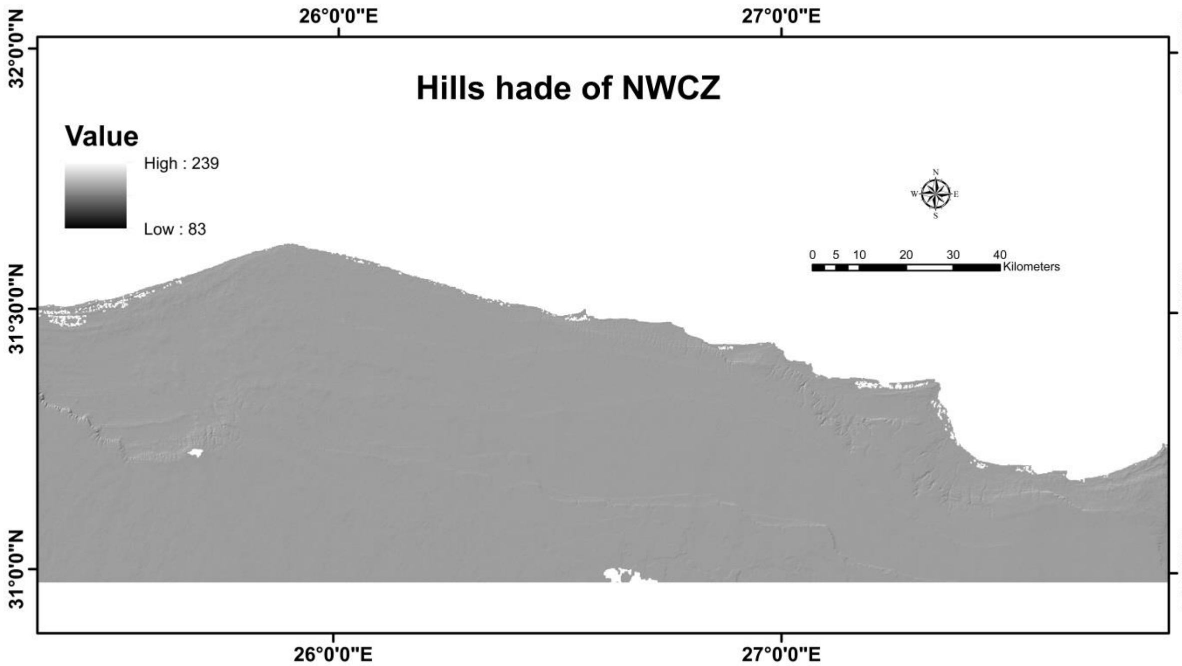


Figure 8: Geomorphology profile and infrastructure of the coastal zone (DRC, 2003)

Figure (9) shows the topography and the hills shade of the NWCZ (the rain-fed area from Matrouh to Ras El-Hekma). The elevation varies between -3 to around 230 m. Two Plateaus are showing in the Figure, the northern one include the wadis.



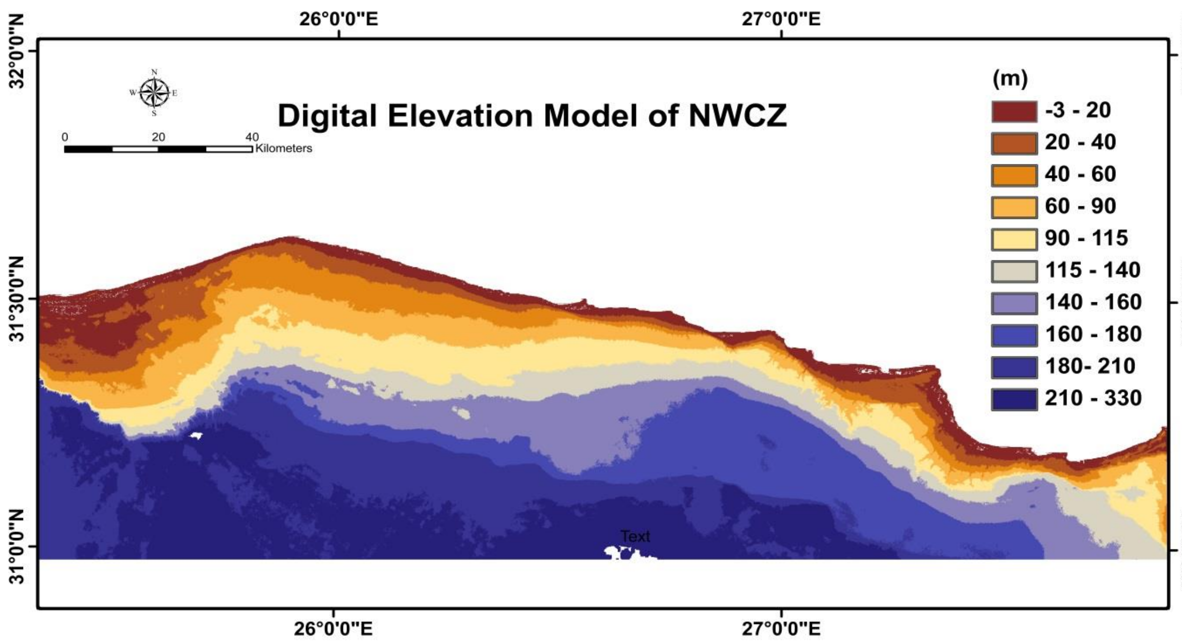


Figure 9: DEM (digital elevation model), hills hade of NWCZ

This geomorphology and topography explain the landscape in NWCZ area, and how this topography play a role in the runoff irrigation system in this rain-fed area which depend completely about the rain as main an only source of irrigation.

1.1.5. Natural resources

1.1.5.1. Soil

The soils of the NWCZ of Egypt were studied through a large number of investigations that varied greatly with respect to time, location, scope and level of details. These investigations were mainly carried out over the last fifty years. The studies showed that the soils of the NWCZ of Egypt are mainly Aridisols and that soil types and its properties are highly influenced by the geomorphic and pedogenic factors. El-Naggar & Perrier (1989) mentioned that most of the soils are alluvial, formed by water and wind action and by consequence they have no relationship to the underlying parent rock or subsoil. These soils are generally coarse in texture being sandy loams and loamy sands and have high levels of Calcium Carbonate. A portion of the soils have been formed locally on the limestone rocks and their textures tend to be from loam to clay. The calcium carbonate content is generally high, ranging from 30-70 %.

Four main soil units were identified in the study area on the basis of the geomorphologic features by several studies including, FAO (1970), Hammad (1972) and El Naggar & Perrier (1989). The four soil units are: 1) the wind-blown soils, 2) the soils of the former beach plains and dune depressions, 3) the soils of the alluvial fans and outwash plains, and finally 4) the rock lands. Each soil unit has subdivisions according to the depth of the profiles and its soil texture. The subdivisions are important as they show different potentials for agriculture production.

The wind-blown soils include the coastal dunes and inland dunes. The coastal dunes are found in a rather narrow strip along the sea shore and composed mainly of Oolitic sand that is very rich in calcium carbonate (more than 80%). The shifting Oolitic sand has distinct dune topography, predominantly deep and very loose, very limited for agriculture and this is a threat to neighboring cultivated lands. The cemented Oolitic sand is also composed of small grains of calcium carbonate, and these dunes are formed very easily to be eroded by wind and water and therefore, they are not suitable for agriculture. The inland dunes are found in large areas southeast of Sidi Barrani and are formed of quartz sand grains in the form of dunes or sand sheets.

The soils of the plain between the coastal dunes and the escarpment was formed by the action of water and wind which is generally deep with good texture ranging from sands to loams. These soils occupy the lower slopes and deltas of small wadis which receive a large amount of runoff and alluvial soil particles transported from eroded areas on the escarpment. The depth of the soil profiles range from less than 30 cm to more than 90 cm and many are classified as fine sandy loams, with 50% calcium carbonate.

Soils of the alluvial fans and outwash plains have a very slightly sloping topography and are directly or indirectly derived from limestone and have high levels of calcium carbonate. They can be classified as limited deep, moderately deep and deep soils according to the depth at which the bed rock or the caliche horizon occurs. They are composed of alluvial materials transported by runoff water from the neighboring rock lands. They are deep, homogeneous soils without gravel or grit and even without concretions. These soils were cultivated for very long time.

The soils of the escarpment, because of its elevation are subject to the action of strong winds and rainfall runoff, which subject the area to very severe erosion. Therefore, the soils are eroded and shallow (less than 30 cm). The inland rocky ridges have a thin layer of surface soil, brownish yellow in color and dry, which has been formed by sands carried by wind from other areas. In the depressions and protected flat lands of the escarpment there are the typical dry desert soils formed of a mixture of residual alluvial and Aeolian deposits. They are of medium to shallow deep ranging from 30 to 100 cm and of a sandy loam texture. The calcium carbonate content increases with depth.

El-Naggar (2008) mentioned that the frequency and distribution of the resistant minerals and weathering ratios leads to the conclusion that the studied soils are heterogeneous either due to the multi origin or due to multi-deposition regimes. He also found that the sediments of these soils are poorly and moderately sorted sediments and skewed towards the coarse fractions suggesting that the soils are transported and deposition of the parent materials by water and/or water and wind.

1.1.5.2. Natural vegetation

NWCZ is an example of the different affected coastal ecosystems in Egypt, as well as the other Arab countries. Despite the fact that the Egypt desert is considered as an arid region and the natural plant which cover the Egyptian deserts is quite low and scattered; the flora in the North West Coast is relatively rich and diverse The natural range is considered the basic source of animal feedstuff in the North-Western Coast (Abbas et al., 2008) .

NWCZ is the richest part of Egypt in flowering plants and it is recognized as one phyto-geographical region i.e., Mediterranean; and about 50% of the number of species that constitute the Egyptian flora (~ 2000 species) are found in this area (Mohamed, 2002). Out of which 154 species are confined in their distribution to this belt. Most of these species are annual weeds that flourish during the rainy season, giving the area a temporary gray grassland aspect. During the longer dry periods the characteristic woody shrubs and perennial herbs, constitute the scrub vegetation of the area, scattered sparsely in parts and grouped in denser distinct patches in favored habitats (Hegazi et al., 2005)

Since, the vegetative cover has been exposed to a severe degradation process as a result of erratic rainfall patterns and wind erosion, combined with overgrazing and demographic pressure linked to the settlement process, which occurred without technical support to adapt to new production systems (MRMP II, 2000). Figure (10) shows example for the vegetation cover in NWCZ.

Figure 10: Vegetation cover in NWCZ (wadi Naghamish, 2013)

1.1.5.3. Water resources

The hydrological pattern indicates past wetter climate conditions. On the other hand, the occurrence of alluvial terraces in these hydrological basins and their dry nature confirm the idea of development of aridity in the region as well as in the Northern region of Matrouh coastal plain (El-Hariry, 1997).

Water resources in the NWCZ can be classified into two main resources (Paver and Pretorius, 1954): the surface water storage and ground water.

Surface water storage

In the study area, rainfall precipitation constituted the main source of surface water. The rainy season begins during the latter part of October with 75% of annual rainfall occurring between October and March. The resulting runoff is collected in underground cisterns called by Bedouin (BIR) for single and ABIAR for plural. These cisterns have a volume varying between 50 and 500 m^3 storage capacities (El-Hariry, 1997). They are excavated 2 to 5 m below the ground surface. The more favorable locations for such cisterns are at the foot of limestone escarpments, which tend to funnel the runoff into the cisterns entrance.

Ground water

The second source of the water in the study area, according to (Paver and Pretorius, 1954) is ground water. The water depth of this source is proved to be at the mean sea level and is refreshed by localized precipitation. Topographic perched water table occurs at locations within the main drainage system, usually in deep eroded wadis.

1.2. Historical and social description of the zone

1.2.1. Rapid history of the settlement in NWCZ area

Many changes have affected the region over the 6 decades like:

1- Established of the houses (permanent building) instead of traditional and temporary residence like tent,
2- Development of the wadis, reclamation of the land through leveling the land surface and established of the several types of the dikes.
3- Plantation of land with orchards (mainly fig, olive and almond) that play a role of land marker.
4- The population size increase that create pressure on land resources and then conflicts;
5- Shift of Bedouin society to farmers beside animal husbandry due to new aspirations.

Following to these changes, Bedouin society shift from a pastoral or agro-pastoral model based on mobility and temporary houses to a sedentary model based on mixed crop livestock system. This process can be described in three main chronological stages along the last century.

Arrival of *Awlad Ali* Bedouin tribes

Since more than 300 years (estimated around 1670). *Awlad Ali* tribes began to decampment to NWCZ of Egypt as a result of the war that took place between them and their cousins in Libya.

It is largely recognized that *Jumiat* tribe were presented in the NWCZ before the arrival of the *Awlad Ali* tribes, and has a very long history living along the coast and parts of *Behira* governorate. Prior to the arrival of *Awlad Ali*, the *Jumiat* tribe was forced to pay tribute to the *Bani Una* and was harassed by *Hanadi*. Both the *Bani Una* and *Handi* hail from *Bani Salim* and was thus collateral relative of the *Awlad Ali*. As noted earlier, the *Awlad Ali* recounted that they came to the rescue of *Jumiat*, defeated their own relatives, and then exempted the *Jumiat* from payment of tribute (Altorki & Cole, 2006). *Jumiat* decided to contract with *Awlad Ali* and they pushed out Hanady tribe until the Delta. Now this tribe is mainly established in *Sharkia* governorate in the delta. At the end, *Awlad Ali* and *Jumiat* divided the territory from El-Sallum to Behira in West Delta: two third for *Awlad Ali* and one third for *jumiat*. It was the historic date of establishment of the main tribe, Awlad Ali in the zone. This inherited historical approach is also consistent with Ghabour, 1999 " *There are other tribes which do not belong to Awlad Ali, but to a number of different smaller tribes, like the Hanadi, nearer to the Nile Delta, who apparently were there before the Awlad Ali came*" (p.9)

Until the Second World War, these two tribes had mainly an agro-pastoral and pastoral system based on mobility.

From the mid- Nineteenth century until the beginning of the twentieth century, 1920

At that period, Bedouin society was nomadic. All lands were commons. They were moving from one place to another in search of pasture. Animal husbandry and grazing were the main profession for the Bedouin tribes. The borders between the tribes were not fixed yet. Nomadic system imposed no fixed boundaries between tribes and so Bedouin can move from place to place with any permission. Sources of drinking water for humans and animals were very limited. The only water supply was the roman cisterns and some old roman sub-ground saline water used for animal drinking. All of the water resource and supply were also common. The system based on mobility for grazing and watering imposed the tents as a mode of living.

From 1920ies to 1950ies

In the early 1920ies, the border between the tribes began to appear in the named *Haouz*, which means in the local Bedouin language land tenure. The question that can be raised is why the division appeared and why at this particular time. According to personal interviews, the main reason mentioned was the establishment of the border line break between Egypt and Libya by Italy around 1920, which occupied Libya at that time. By the border, Italy wanted to prevent free movement of the tribes between the two countries and make the tribes more stable in their land. So following to this border, tribes decided also to distribute the land between them. At this stage, one tribe can only graze on his own tribal land or need permission to graze other tribe lands. During the same period, with the mechanization and then the apparition of tractors, Bedouin community started to cultivate the land with barley. In 1948, Bedouin started to give concentrates as source for feeding animals. One of the most important features of this period is the migration of all the tribes to Beheira governorate as a result of the outbreak of the Second World War and then back again after the end of the war. Also one of the most important features of this period is the beginning of the purge of roman cisterns with the help of government.

From the sixties until now

In the sixties, the reconstruction of desert organization (called *Gihaz Tamir El Sahary* in Arabic) in cooperation with international development organizations such as FAO and WFP started to develop the area by supporting the Bedouin society to be settled. Different development actions have been implemented such as, construction of new houses in the eighties and the establishment of cisterns to save drinking water for the Bedouin community and their flocks. The extension of new water storage infrastructures were distributed to the Bedouins in the area with financial support to cultivate their land, especially in the wadis bed through establishment of earthen, dry stone and cemented stone dikes.

Those activities helped Bedouin to avoid transhumance for a long distance searching for water. At the same time, these cisterns provide them a source of water for supplemental irrigation during fig and olive seedlings. This change has encouraged the settlement of Bedouin in the zone and it is considered as the starting date for a new agro-pastoral system based on flock, annual crops and trees.

At the beginning of starting the activity of cultivation orchard in the wadis, the Bedouin were mainly interested for the financial support and not necessarily the new cropping system. But, after four years and the beginning of production of tree plantation, Bedouin have understood the importance of this new activity and they extended it to get additional income source.

The development of cash crops like figs and olive in the land has been the major factor of change in the land tenure, from common land to private land ownerships. The distribution of land has been also encouraged due to the demographic growth and pressure on land.

After the development project, Bedouin have continued in the construction of houses depending on themselves. One of the most important features of the recent period is the beginning of the distribution of the land at the level of the families. Tourism development began appearing in the region and expanded at the expense of Delta's land valleys; then occupying the most fertile agricultural soils planted with figs and olive trees. Nowadays, nomadic life ended; there is no longer any form of long mobility as in the past. And living in the Bedouin tent completely disappeared. The tent became a part of heritage just appearing in occasions.

Since this date, NWCZ is mainly inhabited by Bedouin population; 85% of them depended on an extensive dry land production system of sheep/goat – barley – fruit trees. Small areas along the coast, especially in the east are being developed as tourism villages and resorts which provide seasonal work for some Bedouins, mainly the young men (MRMP II, 2000).

1.2.2. Land ownership Issue

So, until the beginning of the twentieth century, the land was not divided among the tribes of *Awlad Ali*. The land was common and each tribe had the right of movement for any place in search of pasture and water. At the beginning of the twentieth century, the first division of land started among the tribes due to the population increase and the exodus of some branches of the tribes that were in Libya to Egypt. Prior to this date there was no paper written between tribes (no legal documents).

Now *Awlad Ali* tribe consists of six main tribes which are: *Awlad Kharouf* and *Sengor* (called also *Ali Abiad*), *Ali Ahmar*, *Qotan, Jumiat and Senena*. The Figure (11) shows the geographical distribution of the main tribes in the area. Each main tribe consists of many tribes. Each tribe consists of tribe branches. And each branch consists of several families called bait. Figure (11) and (12) show respectively the land distribution between main tribes and tribes.

Generally, *Ali Ahmar* is located in the North closed to the coastal line, while *Senena* tribes located in the South. According to this distribution, the main farming system activities in *Senena* tribes were based on camels breeding due to the need of wide area. While *Ali Ahmar* tribes were sheep and goats breeders and farmers in the costal line while the wadis are located.

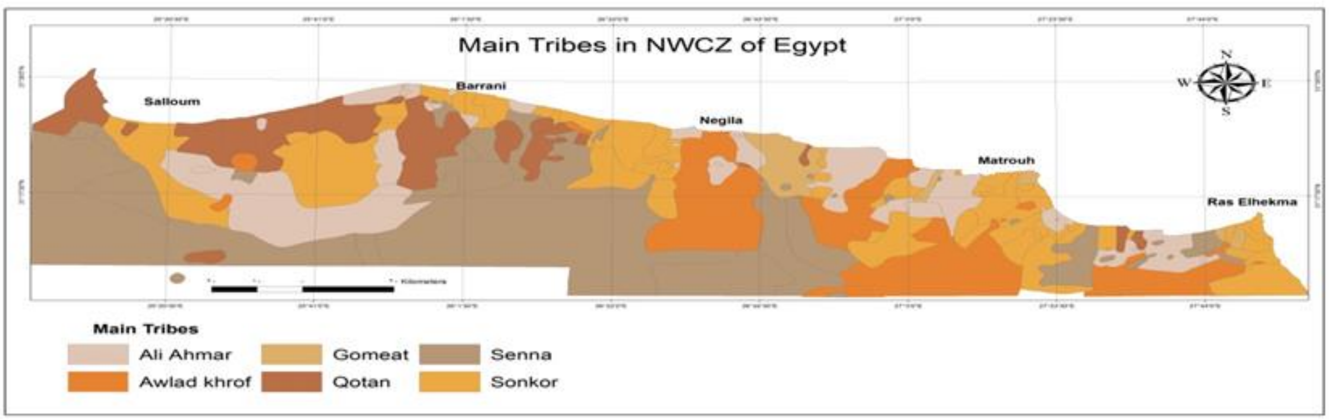


Figure 11: Main tribes distribution in NWCZ (Source: MRMP)

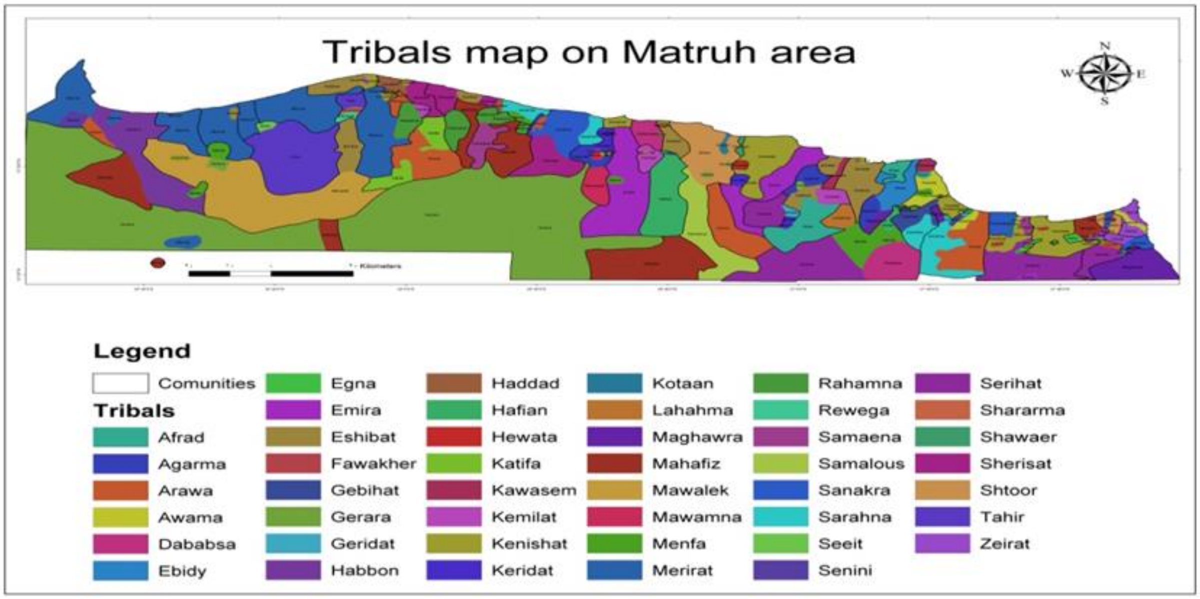


Figure 12: Tribes distribution in NWCZ (source: MRMP)

The first tribe land borders in the twenties were described on paper by distinctive natural markers such as the valley, depressions or water divided lines, or even famous old roman cisterns. The borders were fixed by placing big piles of stones, call ragma in Bedouin. At this time, all these piles of stones were associated to fixed marks like cisterns, etc.

In the past, the land tribe division concerned all land (cultivated and non-cultivated). And each tribe was responsible of the division of cultivated land (*Noas*) between bayts and families. The non-cultivated land called (*Bour*) at the tribe level remained common land. At that time Bedouin cultivated barley only in limited area, the depressions, due to the absence of machinery and tractors. They used mainly animals such as donkeys, horses and camels for tillage. There was no measure of the land area. The area was calculated by the amount of seeds that were planted in the soil. The main units of seeds measurements were (*Ardab*) which is equal to about 130 kg of barley seeds, or (*Kila*) equal to about 10 kg of barley seeds. Most of the non-cultivated land was left to grazing and to a catchment area for the barley cultivation. Anyone from the tribe had the right to use it for grazing.

With the development of machinery in the sixties (the first tractors appeared in 1965), most of the land had been cultivated with barley. This has led to many internal problems among the members of tribes due to the collective status of non-cultivated land. Moreover, nowadays, there is a new land division in link with inheritance within family.

1.3. Recent changes in the zone: identification of the main drivers

1.3.1. Long Drought (History of the Drought in the NWCZ)

Based on the collected available metrological rainfall data in the NWCZ, the average annual rainfall over the period from the year 1945 up to now is around 140 mm (see part 1.1.2.). The years less than this amount are generally considered as dry years. The rainfall values more than this can be considered as wet years.

The results show that, the drought in the area was not a new event. This is very clear from the available rainfall data and has been confirmed by various formal and informal interviews of farmers. Especially the old people mentioned that "the drought was not new for us but there are two main difference between nowadays and the past: the first one is the duration of the drought and the second the different activities of people". In the past, the drought came for a limited period and a good rain seasons followed it and removed the bad effects of the drought. The second difference is the available alternative for the local people. In the past, there were very limited activities such as a regional mobility to the irrigated land in Beheira Governorate, or local mobility from place to other in the zone like to Siwa oasis. For that reason we can notice a lot of families and tribes from the Bedouin roots in Beheira governorate. Nowadays, the alternatives and the strategies coping with drought are many. Also we can add a third difference linked to the demography in the region. The number of people and livestock in the past were less than now and then the relations between the land area and number of people and livestock were satisfied so it was difficult to observe phenomena of desertification. Nowadays the ratio between people and livestock number and the land area is very high. For that reason the desertification and land degradation are very clear. Finally currently notes that, drought appeared to be almost continuous during the last fifteen years. On the contrary, the drought in the past was not continuously

1.3.2. History of livestock feeding in NWCZ

According to our interviews, one of those most important events that induced a radical change was the introduction of concentrates in 1984. All of the old people remember well that date due two reasons: this introduction has coincided with an exceptional rain event in that year. The recorded rainfall data was 240 mm this year. Before that date there was no concentrates in the area.

Through asking the old people about feeding system in that period they replied the following:

“We were completely depending on the rain-land and grass through searching feed anywhere that they can be found”.

For that reason they were nomad, moving from place to other places searching grass and the land was common for a long time. The grazing period extended to 3 or 4 months in January, February and March. This grazing period was followed by another 2 months grazing on the dry grass. For the remaining 6 months, they had 2 choices: move to Siwa Oasis, or another Oasis in the desert; or the other was to move to Beheira Governorate (an irrigated area). The barley in that period was no used for grazing; it was just used for making flour and making bread. At that time, the lambing was just one time per year. The general shape for the animals was not so good, except during the spring period. The animal diseases were rare. Most of the Bedouin think that the diseases started since the introduction of concentrates.

The introduction of concentrates has completely changed the link with the available local resources allowed by the rain.

1.3.3. Population change, Urbanization

Marsa Matrouh city has seen a big change in urban growth in the past 20 years. The urban area of the city has increased to nearly double in the period from 1993 to 2011 Figure (13). While the urban area was about 8.5 km² in 1993, it has grown to about 15.20 km² in 2011. In general, all villages and towns in the area were facing similar patterns. This recent big boom of urbanization is due to several factors at the level of the Governorate and at the national level

Firstly, it included the increase in population, associated with the local migration of people leaving under pressure of the 10- year drought, from the rural areas of the governorate to the city. Most people migrated to the city looking for another civil job that could replace the pastoral Bedouin life (e.g. in tourism). The other type of migration was interregional, from the other Egyptian Governorates to Matrouh city due to demographic pressure in parts of Egypt. Some towns became too crowded and were offering limited chances to secure livelihoods with local work and jobs, therefore people migrated to Matrouh city searching for a better and quieter life condition. The 2011 statistics indicate that the population of the governorate was about 382,208 persons, and Marsa Matrouh City represented about 38% of the total number of the Governorate (about 145,000 inhabitants) (CAPMAS, 2013).

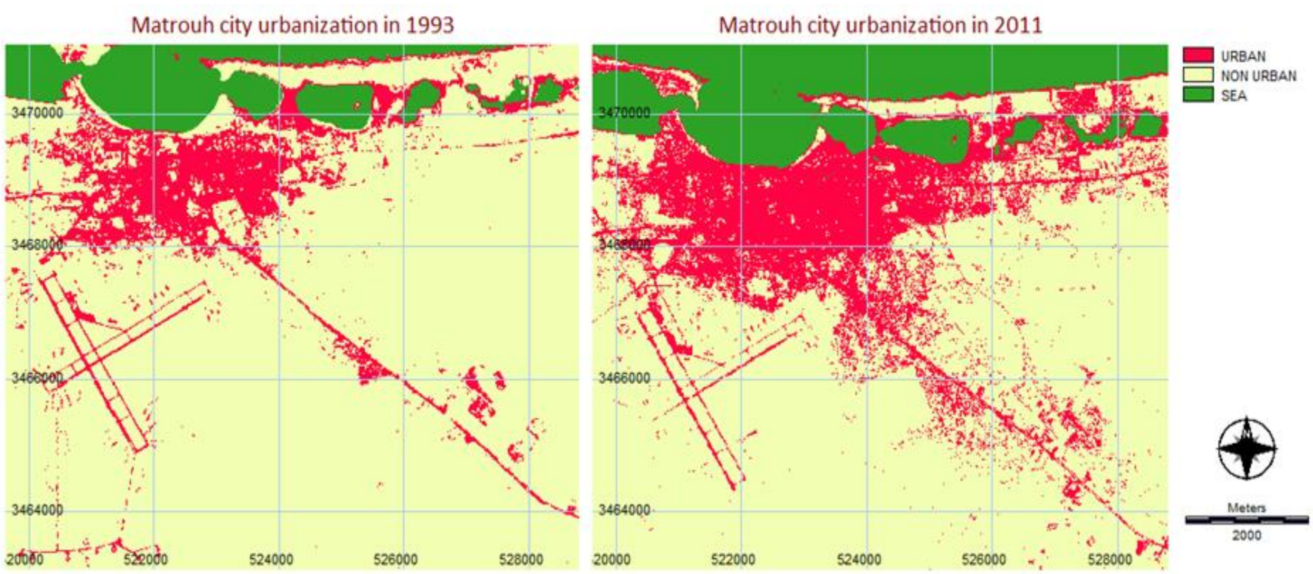


Figure 13: Urban sprawl of Marsa Matrouh, a comparison of its urban perimeter in 2011 and 1993

1.3.4. Tourism in NWCZ of Egypt

While most international tourism in Egypt still stands on the Nile River and its ancestral monuments, the development of national tourism in NWCZ has long been included in national tourism plans (Bonnet et al., 2014).

"*The history of tourism plans in Egypt before and during the study period (1974-94) can be classified into four phases. The first phase represents the strategies and plans for tourism development before the adoption of the infitah (open door) policy in 1974. The second phase is from 1974 to 1982 when tourism started to benefit from the policy of openness and thus, gain the government's attention and was therefore allocated some investment. The third phase is from 1982 to 1987, which included the first Five-Year Tourism Development Plan (FYTDP1982-87). The fourth phase is from 1987 to 1994 which included the second Five-Year Tourism Development Plan (FYTDP1987-92). The latter phase witnessed the emergence of tourism as a major contributor to the national income of Egypt*" (Attia,1999, p.159).

This development responded to the social demand for summer vacation of national citizens and had a vision for international tourism. Moreover, the area has a dramatic coastline with white sandy beaches and pristine water (Al-Abyad Beach, Agiba Beach, respectively about 20 km and 28 km west of Marsa Matruh respectively) (Jobbins & Megalli, 2006). "*It also had historical endowments from the Greek-Roman antiquities (the pharaonic temple of Amon in Siwa, Cleopatra's bath in Marsa Matrouh), or from the modern era (war sites of 1942 Alamein tank battle, headquarters of Marshal Rommel) which would have been major international tourism attraction for Europeans*" (Metwally & Abdalla, 2005, p.3).

Moreover there were hopes that such an economic driver would lead to a change in Bedouin life as it would offer employment opportunities, though only seasonal, and sustainable markets opportunities for local products. Indeed Bedouin families have found alternatives to adapt to this new context, offering agricultural products from wadi cultivation (olive and figs), rain fed crops, and livestock farming systems.

"Tourism is an important tool to achieve national development goals. The North West Coast of Egypt is a promising region for development, able to provide great economic help to the local

community and to the national economy, if it is properly managed, developed and sustained" according to (Metwally & Abdalla, 2005, p.12).

1.3.5. Infrastructure in the zone

Transport services: Network Services consists of roads in the area such as: The Alexandria northern coastal road from the intersection of Cairo, Alexandria desert region west of Alexandria Al-Ajami westward to Marsa Matrouh, and then to El-Sallum on the Libyan border, through tourist villages parallel main coastal road and through Wadi Al-natrun to El-Alamein. As for the railway station, airports and shipping, there is line of Alexandria - Marsa Matrouh and Salloum. El-Alamin, Siwa and Matruh International airports are located in Matrouh Governorate Figure (14). As for the railway station, airports and shipping, located along the coast of the Mediterranean Sea, water, electricity services, communications and other services, are now developed along the coastal part of the Mediterranean Sea (Sayed, 2013).

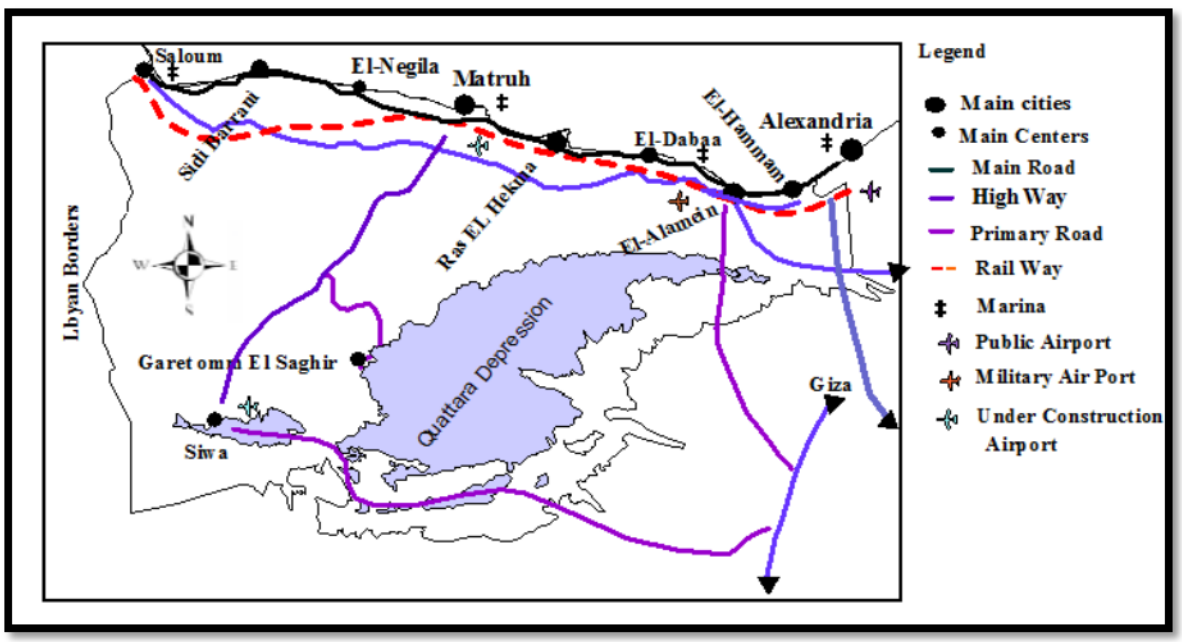


Figure 14: Roads network in NWCZ (source: Sayed, 2013)

Water supply: Drinking water supply is covered in Marsa Matruh, Neguila, Sidi Barrani and Sallum, but only Marsa Matrouh is connected to the Nile basin through the Alexandria pipeline. Sidi Barrani and Sallum have desalination plants. However, both are of an old design, under-dimensioned and therefore need to be enlarged and improved. Additionally, the water supply does not cover the whole current urban area or other rural settlements within each center (called Markaz), which represents the administrative subdivision of the governorate (for example Matrouh governorate consists of 8 centers). Therefore, water is supplied by trucks in the urban areas and the existing rainwater harvesting tanks and wells are the main sources of drinking water for most of the rural settlements. In fact, isolated settlements are very vulnerable to droughts (ICZM, 2009).

Sanitation: Marsa Matrouh has a wastewater treatment plant but it is under-dimensioned; actually some events of wastewater discharge affecting the bath quality of the lagoon water have been registered during the tourist season, when the floating population doubles the water treatment requirements. Besides, projections regarding demographic growth for the next 20 years in the study area are considering an increase of 400% (Matrouh Development Plan 2002 – 2022). In conclusion, urban areas require an urgent modernization of water related infrastructures.

Conclusion:

Natural resources in the NWCZ have a special nature compared to the rest of Egypt. This dry area is mainly dependent on rain water as main source of water in the region. The absence or lack of rain in the region affects largely the vegetation and is responsible of water shortages which reflected in both the livestock as well as on the living in the zone.

Also, the geological aspects are greatly influenced by the formation of the valleys in the region. Those valleys are planted with trees.

The social structure of the Bedouin community has special nature. Tribe is the most common social unit. The existence of the border between the tribes affect the freedom of movement among the herds but at the same time prevents a lot of social problems as a result of grazing.

Transportation and communication network in the region has seen a big jump. The water and sanitation network have been recently established in the center and major cities. However, the western region (western city of Matrouh) has no yet water facilities or sanitation, which greatly affects the tourism development in the region.

Faced to this constraining environment due to water shortage, Bedouin have shown an incredible capacity of adaptation in a variety of domain of the economic life. To understand this dynamic, but also the contrasting capacities of adaptation, we will base our analyses on the theoretical concepts of vulnerability and socio-ecological systems applied to drought events with its metrological, hydrological, agricultural and social components.

CHAPTER 2:
REVIEW OF LITERATURE

Introduction

As showed in the previous chapter, the region of North west Coast zone of Egypt has known important natural and socio-economic changes over the last 15-years years. Drought has been one of the major factors of change in this pastoral and agro-pastoral society. This natural event cannot be understood without considering its complex effects in terms of land degradation and social de- or re-composition. Additionally, this event is coupled with a global context of water shortage in the zone.

So in the review of literature, we propose to see how these two factors, a natural factor as drought and the human practices concerning water management, affect the adaptive capacity of families and communities at short and long terms. If the drought appeared as the major factor, only a combining approach of all the changes will allow understanding the new Bedouin strategies facing drought. Attention will be given to systemic approach of vulnerability. This review will allow also identifying the different approaches (concepts and methods) to analyse the adaptation process faced to drought vulnerability.

2.1. Drought approaches in the literature

2.1.1. Drought definition

Drought is a slow-onset disaster that has economic, social, and environmental consequences and it is considered as one of the most important hazards in natural science (Khoshnodifar et al., 2012). It is a normal event that can take place in almost every climate on Earth, even the rainy ones (Erian et al., 2011). "Drought is a recurrent climate process that show high variability in time and space making it very difficult to exactly identify the spatial location of such areas" (Bezdan et al., 2012,p.1). It is the consequence of a natural reduction in the amount of precipitation over extended period of time, usually a season or more in length, often associated with other climatic factors such as high temperatures, high winds and low relative humidity that aggravate the severity of the event (Sivakumar, 2005).

"*Drought maybe defined in either narrow meteorological term, in relation to expected rainfall, or in terms of impacts on potential vegetation growth (accounting for a wider range of climatic and soil factors affecting moisture availability). In meteorological terms, annual drought (the failure of two successive rainy seasons) may occur anything between 1 year in 3 and 1 year in 30 in areas such as northern Kenya*" (Barton et al., 2001, p.9). Drought is often considered as the most complex event of all natural hazards, and more farmers are affected by it than any other hazards (Khoshnodifar et al., 2012). Drought is usually a common event that takes place in almost every climate of the world, even in wet and humid regions. This is because drought is defined as a dry spell relative to its local normal condition. In arid and semi-arid zones, it is generally considered as a recurring extreme climate event over land characterized by below-normal precipitation over a period of months to years (Erian et al., 2011). In other words, drought is a temporary dry period, in contrast to the permanent aridity in arid areas. And these arid areas are prone to drought because their rainfall amount critically depends on a few rainfall events (Sun et al., 2006).

However we can note different level of rainfall to define drought. For example, in Libya, drought is occurring when annual rainfall is less than 180 mm, in USA less than 2.5 mm of rainfall in 48 hours, in Great Britain about 15 consecutive days with daily precipitation totals of less than 25 mm or even in India actual seasonal rainfall deficient by more than twice the mean deviation in India. In Indonesia, Bali, drought might be considered to occur after a period of only 6 days without rain (Ragab, 2005).

Drought is a natural and regular event which can occur when there is a combination of sustained low precipitation and high rates of evaporation, resulting in low water flows in streams, and/or low water storage levels, e.g. wells, reservoirs (LWBC, 2004).However, "*Drought is a common to every climate throughout the world. In developed countries, it affects more people than any other natural hazard and is one of the most complex and difficult natural hazards to evaluate and plan for. Drought can appear quickly or slowly, last for a season or many years, and can occur locally, regionally, or statewide*" (AMEC Earth & Environmental, 2010, p.3).

A lack of precipitation often triggers agricultural and hydrological droughts, but to understand the impact of drought, we should take into consideration the other factors, including more intense but less frequent precipitation, poor water management, and erosion. For example, overgrazing led to elevated erosion and dust storms that amplified the Dust Bowl drought of the 1930s over the Great Plains in North America (Cook et al., 2009). So drought is often combined with other factors to explain the whole impact. "*Almost every climatic zone might experience drought although the characteristics can vary significantly between regions. Drought is, unlike aridity, a temporary phenomenon and can be characterized as a deviation from normal conditions*" (Hisdal & Tallaksen, 2000).

Drought is considered as one of the major natural hazard threats to people's livelihood and community socio-economic development. Each year, disasters originating from prolonged drought not only affect tens of millions of people, but also contribute to famine and starvation among millions of people, especially in some African countries (UN/ISDR, 2007). Wiley & Sons (2011) reported that drought is a recurring extreme climate event over land characterized by below-normal precipitation over a period of months to years also it is a temporary dry period, in contrast to the permanent aridity in arid areas. It can occur over most parts of the world, even in wet and humid regions because drought is defined as a dry spell relative to its local normal condition. El Kharraz et al., (2012) defined drought as a recurrent feature of climate that is characterized by temporary water shortages relative to normal supply, over an extended period of time – a season, a year, or several years. The term is relative, since droughts differ in extent, duration, and intensity.

2.1.2. Drought and land degradation

Ecological and economic systems are also disrupted by drought. Drought, like land degradation, occurs in most parts of the world even in the humid zones. From the 1970s to the early 2000s, the percentage of the Earth's land area afflicted by serious drought has more than doubled. While the world's dry-lands continue to be the most vulnerable and threatened by desertification, land degradation and drought (DLDD), land degradation is a global phenomenon with 78% of total degraded land located in terrestrial ecosystems other than dry-lands (UN, 2012).

Kongthong (2011) reported that four definitions of drought have been proposed: meteorological, hydrological, agricultural and socio-economic, as follows (Wilhite & Glantz, 1985 ibid.; UN/ISDR, 2007, p.5-6):

Meteorological drought refers to precipitation deficiency over a specified period of time. The thresholds can be chosen, say, 30% of normal precipitation over a three-month period. They can vary from location to location, depending on needs or applications (UN/ISDR, 2007, p.5).

Hydrological drought is defined by deficiencies in surface and ground water relative to average conditions at various time of the year. Although all droughts begin with precipitation deficit, hydrological droughts occur when this deficiency is reflected through the hydrologic system. Their occurrences, hence their impacts, usually lag behind meteorological and agricultural droughts. For example, precipitation deficit may result in an almost immediate depletion of soil moisture, but it may take several weeks before its impact on reservoir levels, which will in turn affect hydroelectric power production, is felt. Other factors such as changes in land use and the dam construction may also affect the hydrological characteristics of the basin, thus affecting hydrological drought.

Agricultural drought focuses on precipitation shortages in relation to agricultural impacts, through deficiency in soil moisture. Plant water demand depends on climatic conditions, stage of growth and other plant specific characteristics. Insufficient moisture may result in low yield.

UN/ISDR (2007, p.5) remarked that “Infiltration rates vary depending on antecedent moisture conditions, slope, soil type, and the intensity of the precipitation event. Soil characteristics also differ. For example, some soils have a higher water-holding capacity, which makes them less vulnerable to drought”.

Socioeconomic definition of drought reflects relationship between the supply and demand of some commodities or economic goods with either or all of the above droughts. Its occurrence depends on the time and space processes of supply and demand; for example, if the water shortage occurs during paddy sprouts (rice seedlings) transplanting stage (Adamson & Bird, 2010, p.580).

The meteorological drought is the prime mover of all other types of droughts. The first of the sequence begins with an accumulated precipitation deficit (meteorological drought), which leads to a reduction in soil moisture content (agricultural drought). It may take several weeks before precipitation deficiencies result in soil moisture deficiencies. Agricultural impacts vary from crop to crop. Precipitation and moisture deficits continue to accumulate for several months, before hydrological drought begins to manifest itself. Finally, drought is felt as a socio-economic drought when food price increases due to reduced farm output, power ration due to reduced electrical generating capacity, etc. (UN/ISDR, 2007, p.6; Adamson & Bird, 2010, p.582). Figure (15) shows propagation of drought through the hydrological cycle and its impacts.

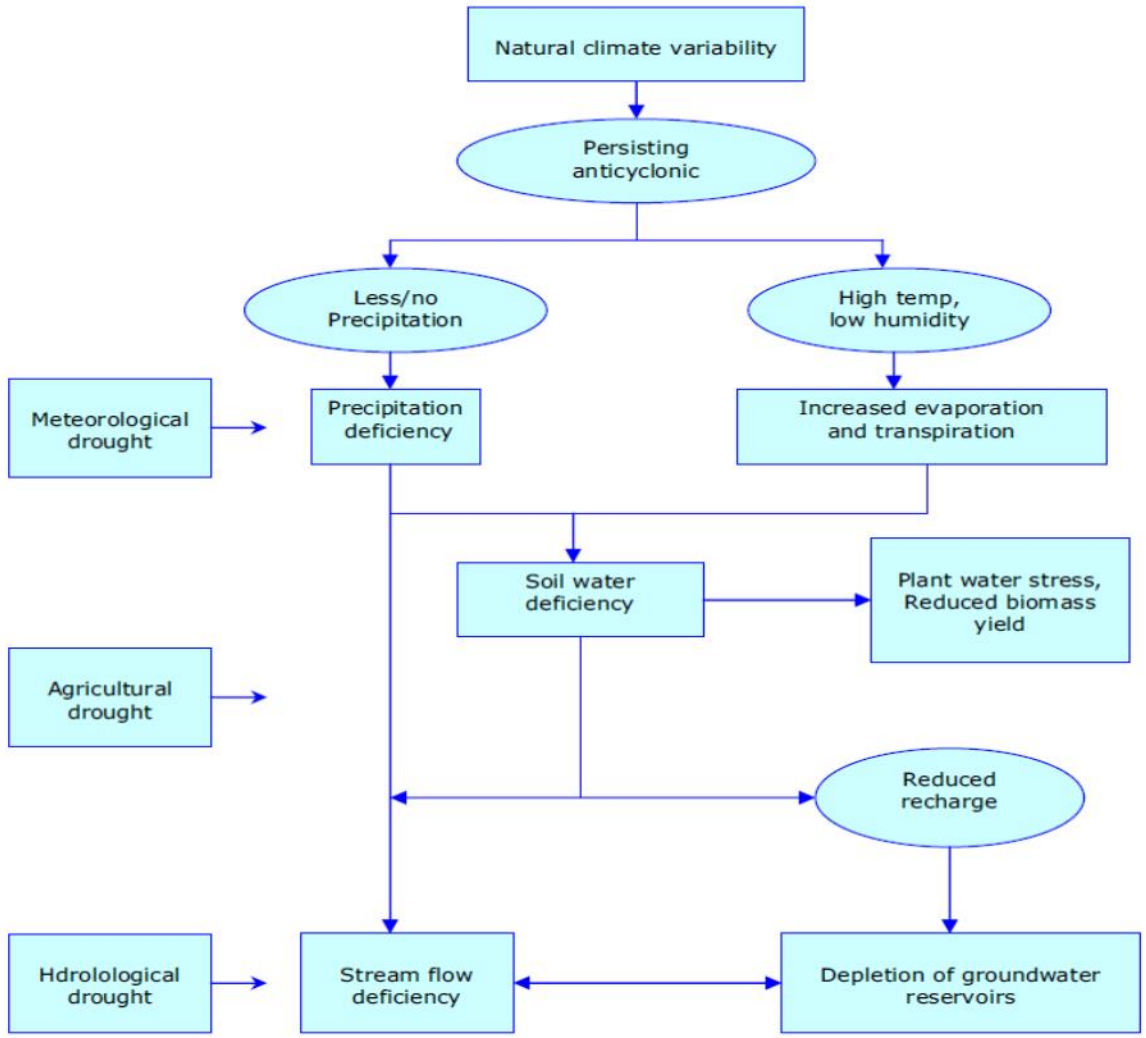


Figure 15: Propagation of drought through the hydrological cycle and its impacts (Source: Tallaksen & Van Lanen, 2003).

2.1.3. Drought in Arab region

"*Most of the Arab countries in both West Asia and North Africa (WANA Region) fall within the hyper arid, arid and semi-arid zones receiving average rainfall of up to 400 mm, with a winter growing season of 60-120 days. And this dry lands support the livelihoods of 60% of the total population living in WANA region. The region is subject to frequent droughts and agriculture is* *a major and sensitive sector of the economy in this zone. Agricultural sector consumes most of the water resources. And the majority of land is rain-fed lands strongly affected by precipitation fluctuations*" (Erian et al., 2011). According to (Erian et al., 2006), rain-fed areas that receive an annual amount of rainfall range between 120/150 – 400 mm are considered vulnerable areas to drought.

In this region, drought is considered as the major disaster occurring in the Arab region, where, the total people affected between the years 1970-2009 by drought was about 38.09 million (Abu Swaireh, 2009). The Global Assessment Report included Mauritania, Sudan and Comoros Islands as countries exposed to drought hazard. Some countries of the region were also economically vulnerable to natural hazards (GAR, 2009). In Syria drought is a recurring climatic event, bringing significant water shortages, economic losses and adverse social consequences (Erian et al., 2011).

(Hamadallah, 2001) stated that the 1999 drought caused in Syria an estimated loss of 40% of cereal grain production and a reduction in livestock production and in Jordan a production of less than 1% of cereals and less than 40% of red meat and milk.

Morocco experienced drought events during the period 1980–85 and 1990–95 that involved the import of high quantities of cereals (mainly bread wheat) to meet the needs of the population due to drought of 1999–2000, this country imported for 2001 year about 5 million tons of wheat (compared to 2.4 in normal year). As in Morocco, Tunisia suffered also drought during the same periods (1982–83 and 1993–95). In Mauritania, the two successive dry years involved crop failure and pastures production drastic reduction and hence resulted in high food and feed prices (FAO, 2002).

2.1.4. Drought in the North Western Coast Zone of Egypt

The NWCZ characterized by desert climate conditions is considered as the main rain-fed zone in Egypt with Sinai. The majority of this area is desert with limited water supplies. The only source is rainfall. And in desert conditions, rainfall precipitation varies greatly over the year and between years with wide fluctuations frequently leading to drought (Goodall & Perry, 1979).

Mean annual rainfall at the agricultural research station at Borg-el-Arab (45 km to the west of Alexandria) is 150 mm; this is a mathematical mean, and actual rainfall may be 250 mm or more ('fat' years) or 50 mm or less (lean years considered as drought). An incident of drought may be short (one year) or may be long (Kassas, 2008).

During the last two decades, the NWCZ has faced a long drought period from 1995 to 2011, with low erratic rainfall (< 150 mm) Figure (16). Scarcity of rainfall has affected farming systems and household livelihood. The Bedouin societies have diversified their farming systems, based on livestock, barley and fruit trees (Osman et al., 2012). The NWCZ has faced a long drought period from 1995 to 2011 that has negatively affected rangelands, agriculture, livestock production and household livelihood (Metawi, 2012).

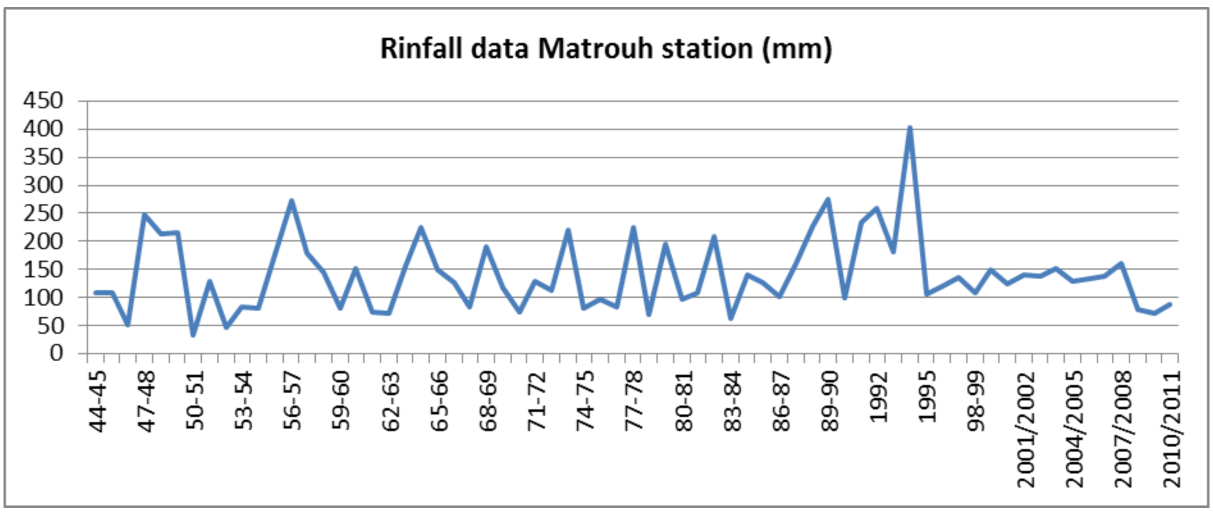


Figure 16: Annual rainfall data Matrouh station (Wakil et al., 1999 & climate lab. ARC)

However it is difficult to understand the consequence of these drought events in any context without considering the water resources.

2.2. Water scarcity approaches

2.2.1. Defecation of water scarcity in link with demand

Scarcity is a function of demand and availability, with the traditional neo-Malthusian view being that resources are essentially fixed while demand will increase with population (Meadows et al., 1992). "*Scarcity often arises because of socio-economic trends having little to do with basic needs. However defining scarcity for policy-making purposes is very difficult*" (Winpenny, 1997). According to White (2012) water scarcity can broadly be understood as the lack of access to adequate quantities of water for several uses, and it is increasingly being recognized in many countries as a serious and growing concern (White, 2012).

In 1993 Kulshreshtha in his study reported that for our subject, four aspects of water resources are important in an examination of a region's vulnerability in regards to water resource: water quantity, inter-temporal distribution, water quality, and water use requirements. The first and the second aspects are directly related to water supply, whereas the third aspect is indirectly related to demand. In fact, one could describe the supply of water as a three-dimensional concept: its annual level, distribution within the year, and its quality. These three factors interact with each other, as shown in Figure (17) to make a region vulnerable to water resources.

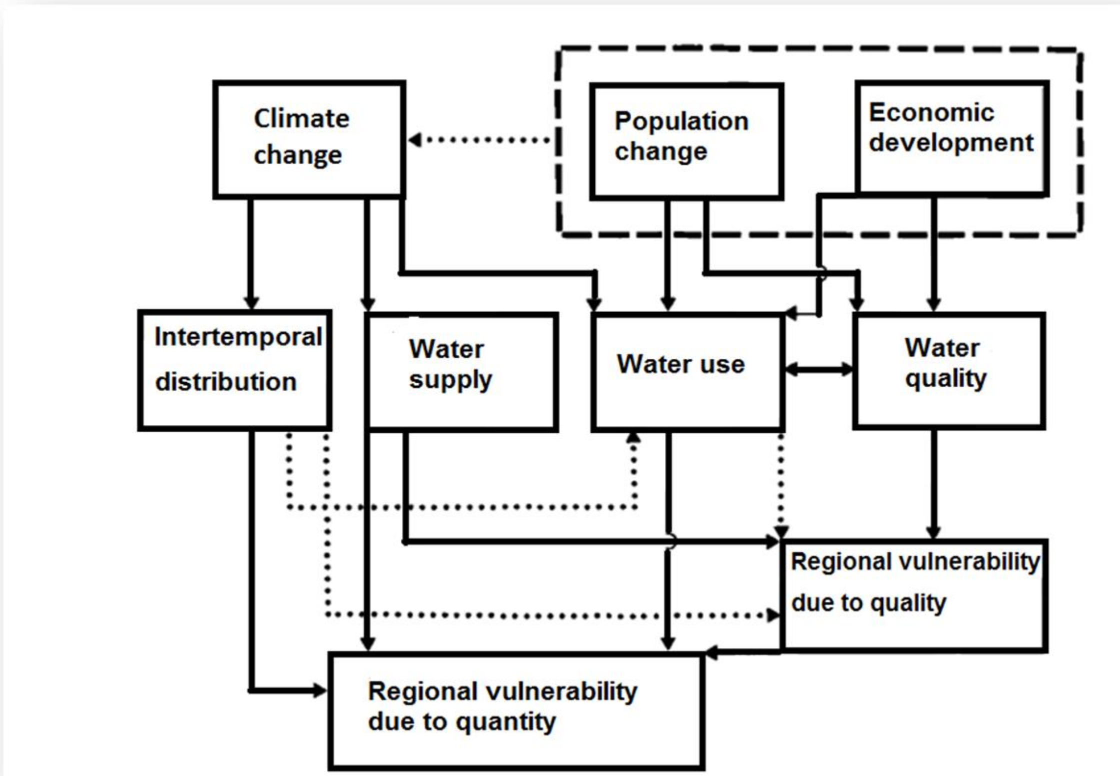


Figure 17: Interrelationships among water supply and use leading to regional vulnerability (The dotted lines show a relatively weaker effect)(Source : Kulshreshtha, 1993).

2.2.2. Basic Human Water Requirements

In international norms, the proposed water requirements for meeting basic human needs is determined with the value of 50 liters per person per day. All international organizations and water providers are recommended to adopt this overall basic water requirement as a new threshold for meeting these basic needs, independent of climate, technology, and culture (Gleick, 1996). This estimation covers all water requirements for basic human needs: drinking water for survival, water for human hygiene, water for sanitation services, and modest household needs for preparing food.

In the NWCZ, the main source of water for domestic and farming used come from cisterns. Based on experience in marginal dry-land environments in the region, the main water demands for cistern per day are human consumption including drinking, sanitary and other uses (estimated around 50 liters per person), and livestock watering (about 5 liters per head of small ruminants (sheep and goat) and 15 liters per head of camels (Ali et al., 2009). These estimations have been the basis to establish the development of plan for the establishment of cisterns in the zone. For Ali et al., (2009), most cistern users use the water very conservatively, although there are some exceptions.

2.3. Vulnerability, adaptive capacity and resilience approaches

2.3.1. Multiple definition and conceptual approaches

The concept of vulnerability can be considered as a way to describe the risk of negative impacts of both physical and social systems and has a variety of definitions depending on the research tradition from which it is being used (Brant, 2007). The concept of vulnerability has known an increasing interest since the last 2 decades and now it has several applications from different perspectives and disciplines according to the International Panel on Climate Change (IPCC, 2001).

Adger (2006, p.268) defined the vulnerability as: “the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt.” According to the author, the main components of vulnerability are exposure to perturbations or external stresses, sensitivity to perturbation, and the capacity to adapt (Adger, 2006). Aurora (2010) reported that the concept of vulnerability in the context of community development was an assessment of vulnerability of affected groups or individuals. Specifically, it described who these people are; what made them more vulnerable, and what can be done to reduce their vulnerability.

Vulnerability is often viewed as synonymous with risk. However, related to risk, vulnerability is better understood as "*a measure of a system's susceptibility*" to adverse changes in ambient conditions (Hurd et al., 2006). Vulnerability "*is essential to stress that we can only talk meaningfully about the vulnerability of a specified system to a specified hazard or range of hazards*" (Brooks, 2003,p3). While In 1996 (Cutter) defined the vulnerability as a potential for loss, is an essential concept in hazards research and is central to the development of hazard mitigation strategies at the local, national and international level. This "potential of loss" is considered either as a characteristic that inherently exists in an individual (a group or a system), or a function combining the sensitive individual and the force (stress) that the individual is sensitive to.

"*By vulnerability we mean the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard*" (Wisner et al., 2003,p 11). According to this author, several factors determine the degree to which someone's life, livelihood, property and other assets are put at risk by a discrete and identifiable event (or series or 'cascade' of such events) in nature and in society.

Vulnerability is mainly considered as a concept used in various disciplines, including biology, psychology, sociology and environmental science (Adger, 2006). "Without considering any specific context, vulnerability may be generally defined as "the quality or state of being vulnerable" (Baker et al., 2005, p. 1).

According to Cardona (2003) Vulnerability can be defined as an internal risk factor of the subject or system which exposed to a natural hazard and corresponds to its intrinsic predisposition to be affected, or to be susceptible to damage. While, in the framework of risk management, Vulnerability is belonging to consequence analysis. It defines the potential for loss to the elements at risk caused by the occurrence of a hazard, and depends on several aspects arising from physical, social, economic, and environmental factors, which are interacting in space and time (Ciurean et al., 2013).

Vulnerability is the manifestation of social, economic and political structures, and environmental setting. Vulnerability can be considered as consist of two elements; exposure to hazard and coping capability. Where, People having more capability to cope with extreme events are naturally also less vulnerable to risk (UNEP, 2002). Vulnerability can be defined as a risks induced by sensitivity and exposure to certain hazards such as (drought, floods, earthquake, and landslides, etcetera) and lack of adaptive capacities to cope with to the potential impacts (Ali, 2013).

Because the three components of vulnerability vary geographically, fluctuate over time, and differ across different systems (or different sectors of a system), vulnerability outcomes are spatially and temporarily distinct, and they also largely depend upon how the scope of the system is defined (Xiaomeng , 2007).

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007). Vulnerability is the function of exposure to any hazards or stresses and the people's coping capacity at a certain time. Logically, people who are able to cope with the extreme events are the less vulnerable to perturbation or stresses (Bankoff et al. 2004). Yohe and Tol (2002) defined vulnerability as a function of different exposures and the accompanying sensitivity towards different changes or hazards. Dow (1992) reported that the distinct feature of social vulnerability theory is its description of the possible threats to human-environment system, and threats to sustainability.

However, few studies have identified the complexity of these impacts at varying indicators, and databases to document impacts and track trends by region or sector are virtually nonexistent (Wilhite et al., 2007). Wilhelmi and Wilhite (2002) in their study based on analysis of drought literature, suggestions from Nebraska's climate and agriculture specialists, and data availability hypothesized that the key biophysical and social factors that define agricultural drought vulnerability were climate, soils, land use, and access to irrigation .

Nelson et al., (2007) defined vulnerability as the susceptibility of a system to disturbances determined by exposure to perturbations, sensitivity to perturbations, and the capacity to adapt.

So, the concept of vulnerability has been used in a range of fields within the natural and social sciences. Current theories of vulnerability are generally derived from two major fields relating to human use of environmental resources and related environmental risks. These research traditions looked at vulnerability either as lack of entitlements or vulnerability to natural hazards (Adger, 2006). The natural hazards tradition comes from research on management of floods and other natural disasters. It demonstrates that the impacts of a natural disaster vary greatly depending on the social status of those affected. The vulnerability of a human population varies depending on where it is located, how the community uses its natural resources, and the resources the people have to cope with a negative impact (Adger, 2006).

Extend of the concept of vulnerability in the context of community development was an assessment of vulnerability of affected groups or individuals. Specifically, it described who these people are; what made them more vulnerable, and what can be done to reduce their vulnerability (Aurora, 2010). In this way, the socio-ecological system has increasingly been used as the unit of analysis for vulnerability analysis due to the recognition that both the human and biological aspects of a system affect its vulnerability, adaptive capacity and resilience and must therefore be considered (Gallopín, 2006). And the social vulnerability has been used most often for projects concerned with identifying the most vulnerable members of society.

In this way, adaptive capacity, or the ability of a system to cope with a stress, is generally thought in terms of actions that can be taken to reduce future vulnerability by adjusting to current or future stresses. Often these adaptations are shaped and constrained by social, political and economic constraints (Smit & Wandel, 2006). Constraints on adaptive capacity include: wealth, technology, education, information, skills, infrastructure, access to resources and stability and management capabilities (IPCC, 2001).

In their study for Social Vulnerability, Cutter et al. (2003) reported that Social vulnerability is partially the product of social inequalities—those social factors that influence or shape the susceptibility of various groups to harm and that also govern their ability to respond; in figure (18) they show the social and biophysical vulnerabilities interact to produce the overall place vulnerability.

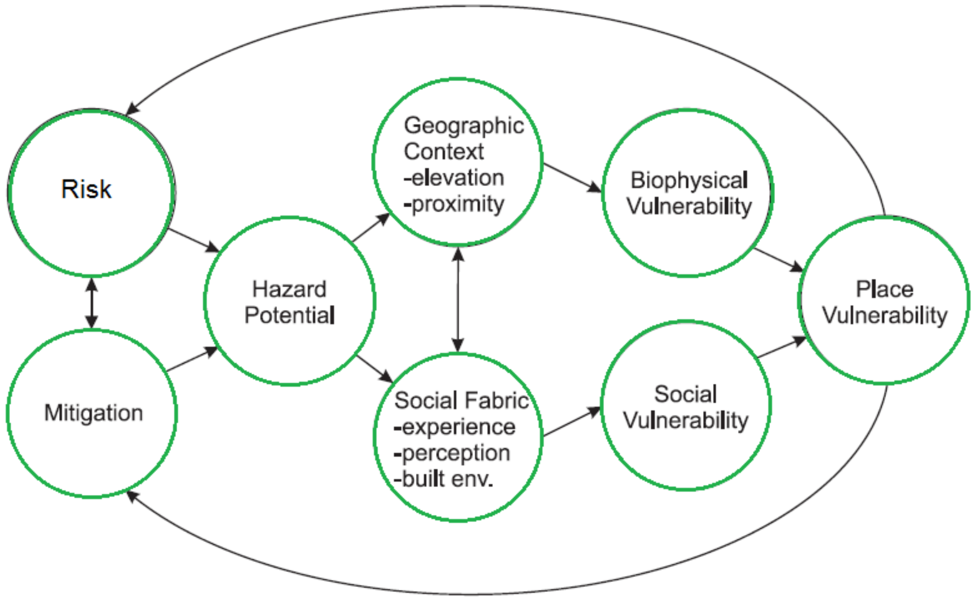


Figure 18: the hazards-of- Place Model of vulnerability (modified from Cutter, 1996)

2.3.2. Framework to approach the vulnerability

Livelihood framework:

The concept of Sustainable Livelihood (SL) is an attempt to go beyond the traditional definitions and approaches to poverty extirpation. These had been found to be too narrow because they focused only on certain aspects or manifestations of poverty, such as low income, or did not consider other vital aspects of poverty such as vulnerability and social exclusion (Krantz, 2001)

"The sustainable livelihoods frameworks in particular linked inputs (designated with the term 'capitals' or 'assets') and outputs (livelihood strategies), connected in turn to outcomes, which combined familiar territory (of poverty lines and employment levels) with wider framings (of well-being and sustainability) as shown in figure (19)"(Scoones, 2009) (see Figure 19).

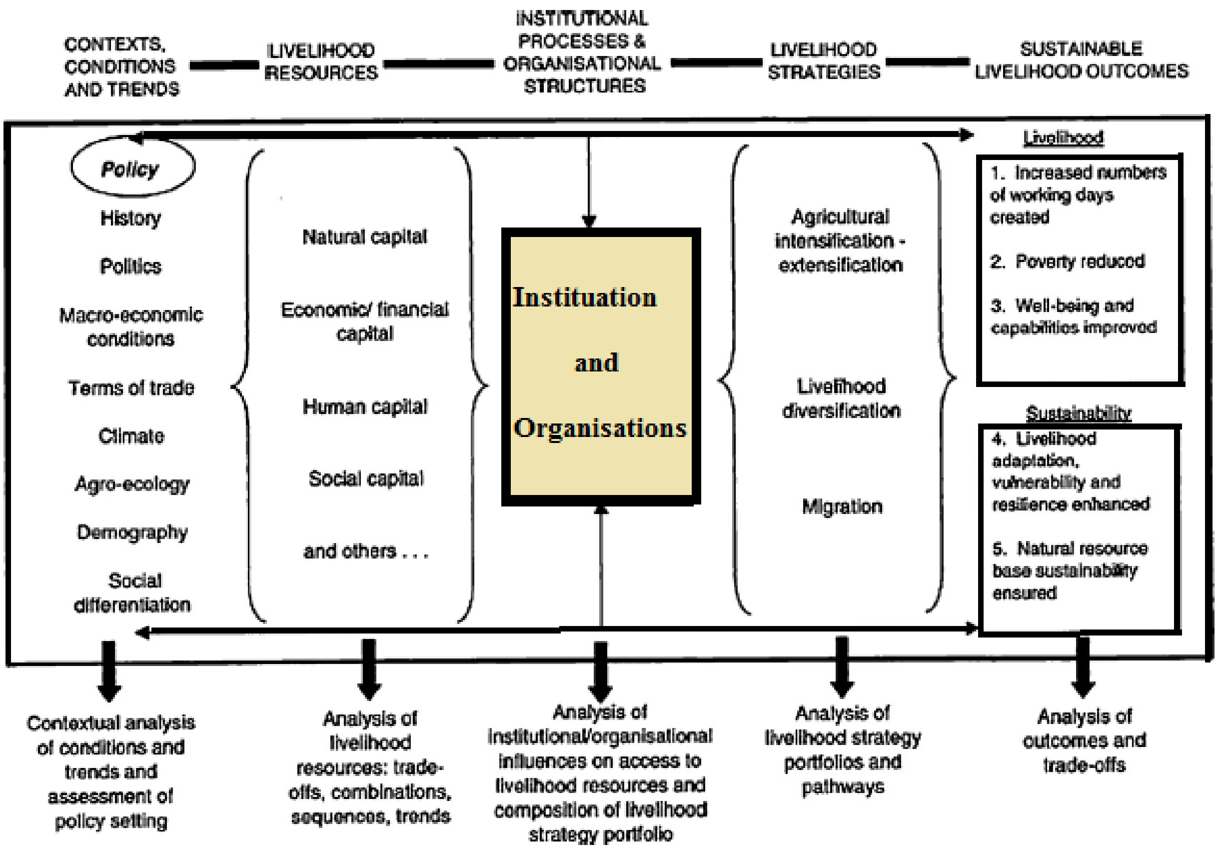


Figure 19: Sustainable livelihoods framework: a checklist (Scoones, 1998).

The basic vulnerability relationships are portrayed in Venn diagram format in Figure (20). The larger sets represent the broader stresses and forces that determine the extent of exposure, sensitivity and shape adaptive capacity at the local or community level, denoted by the smaller embedded sets (Smit & Wandel, 2006).

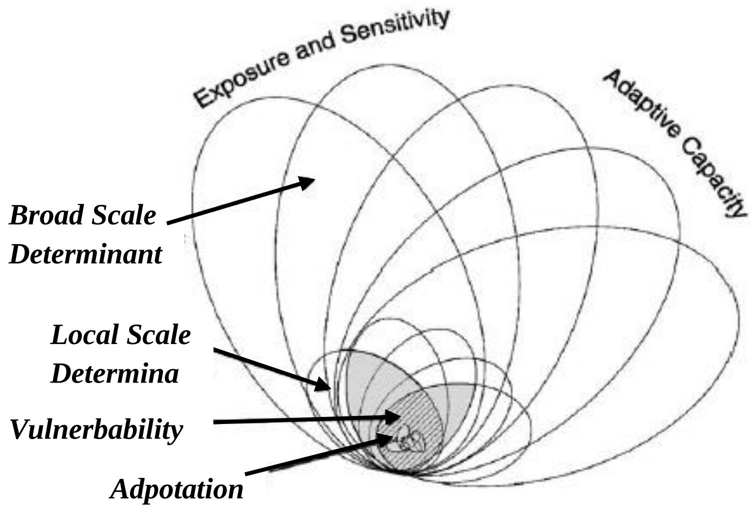


Figure 20: Nested hierarchy model of vulnerability

This approach has been applied in ELVULMED project over the whole NWCZ (Alary et al., 2014a) and it allowed putting in evidence the importance role of social capital in adaptive capacities to drought.

Socio-ecological systems and the identification of vulnerable zones (ELVULMED)

Geo-visualizing the important patterns of vulnerability applied to complex human systems like territories are of primary importance. Nowadays, geographers have broadly adopted the concept of vulnerability to study territories particularly in urban areas (D'Ercole et al., 2009). An accepted definition of the vulnerability of a territory refers to its "sensitivity" to a given change (Turner II et al., 2003), which implies to understand how an area would be affected (Veyret, 2004) given its characteristics. It refers to the measure of the potential or observed consequences of a sudden or gradual change on people and their assets, economic activities, and the environment. Therefore, vulnerability in geography is an inherent though multifaceted characteristics of a zone made of the existence in a social space of "risk and protection factors" combined, i.e. natural, artificial or social factors. Amongst those factors, the particular study of social and spatial segregation by GIS-based spatially-computed indices has been a gradually emerging method for studying the differentiation of space in a given social and spatial context.

Initiated in the early 60's (Duncan & Duncan, 1955) in USA it has been mainly applied in urban areas for the purpose of studying social & ethnic segregation or in socio economic planning (Jakubs, 1981) and sociological studies therefore contributing to the revealing of poverty niches (Massey et al., 1996).

Zoning territories based on vulnerability factors is a way of partitioning a given territory into homogenous regions with reference to the socio-economic and spatial characteristics of interest. Various sub sets of geographic science from Regional planning (Claval, 1995) to Health geography (Picheral, 2001) have been using these techniques widely to differentiate needy areas and adjust the supply of services and infrastructures. In pastoral areas, the zoning territories are often based on ecological indicators to anticipate the vulnerability to climate change in pastoral system (Dougill et al., 2010). These indicators give a measure of agro-ecological resilience related to land degradation, biodiversity, the cover of perennial, etc.

Changes and factors of change can be inserted in a theoretical model used to guide and facilitate the organization of a set of indicators for vulnerability and adaptation assessment. The DPSIR model, figure, (21), for instance, was developed specifically to assess the impact of change on the ecosystem in the NWCZ within the ELVULMED project (Bonnet et al., 2014).

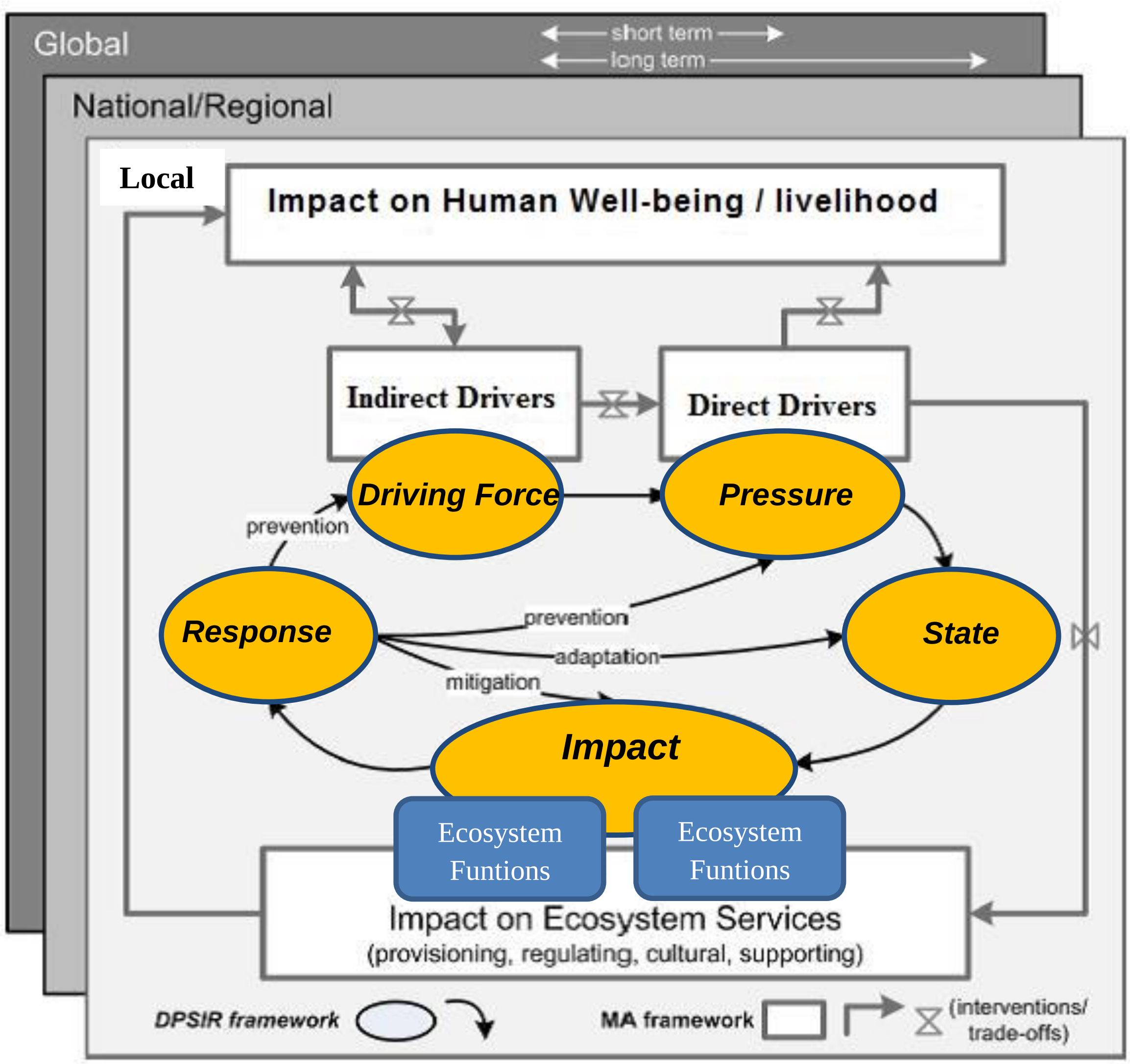


Figure 21: DPSIR adapted by the Millennium Eco-System Assessment (MEA) (Bonnet et al, 2014)

2.3.3. Approach of vulnerability to natural events like drought and flood

2.3.3.1. Vulnerability to drought

Drought vulnerability varies by region. In semi-arid regions where, limited water availability and climate variability (drought) greatly restrict natural resource productivity even under normal conditions (Krol & Bronstert, 2007). The identification of drought vulnerability indicators is an essential step for planning to drought mitigation management (Khoshnodifar et al., 2012). Rainfall variability, soil type, land topography, groundwater availability and utilization, irrigation coverage, economic strength and institutional support system are some of the key factors that determine the nature and extent of drought vulnerability in a region (Swain & Swain, 2011). Some exogenous factors like climate change do influence the level of risk and vulnerability of different livelihood groups in a region (UNDHA, 1992; Blaikie et al., 1994). In the coming decades, the extent of drought risk and vulnerability is expected to increase, irrespective of the changes in drought exposure mainly due to development pressure, population increase, and environmental degradation (ISDR, 2002). One of the main aspects of any drought mitigation and planning strategy is the 'vulnerability assessment' (Wilhelmi & Wilhite., 2002).

At the socio-economic level, vulnerability to drought is a complex of several circular causalities. Care must be taken to distinguish indicators of increased vulnerability from its assumed underlying causes, but vulnerability itself contributes to those causes. Figure (22) is a preliminary attempt to map these relationships. It indicates the complex cause and effect relationships (Barton et al., 2001).

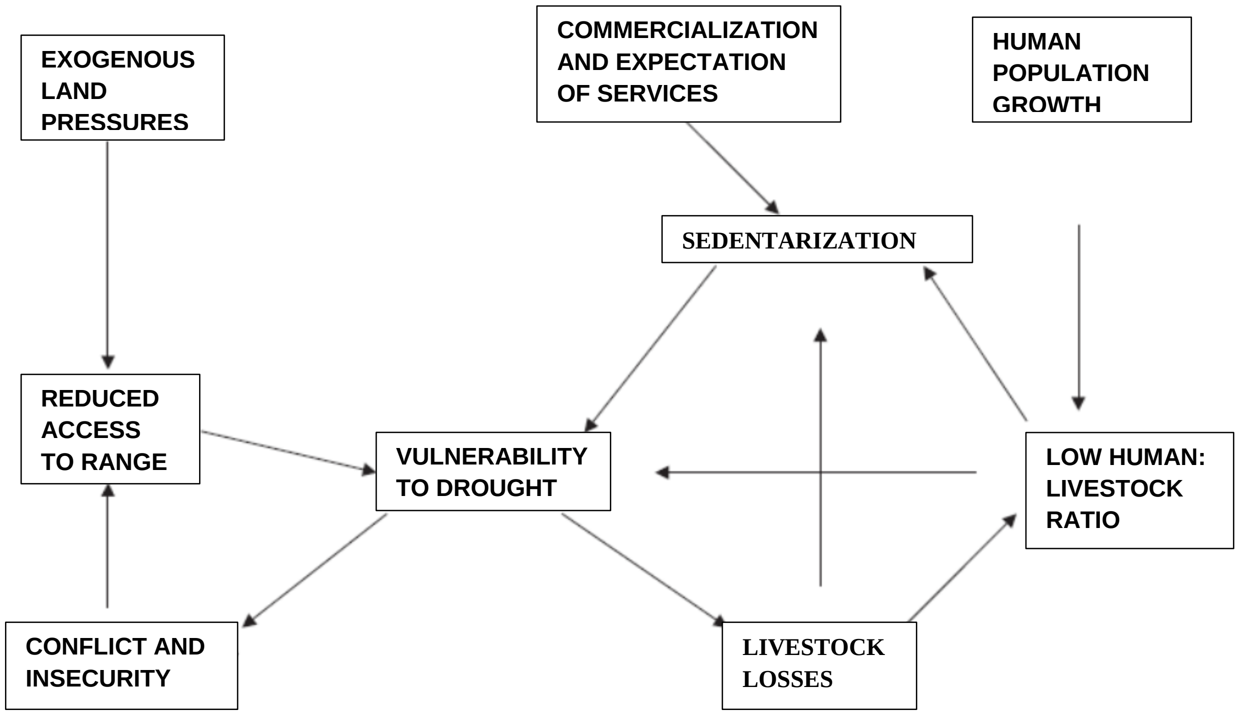


Figure 22: Vulnerability to drought: schematic representation of causes and effects (Barton et al., 2001)

2.3.3.2. Vulnerability to flood

In the literature, various definitions of the vulnerability to flood have been developed and applied depending on the needs. One of these concerns the susceptibility of a region to flood losses, which is defined via the geophysical, economic and societal attributes of a region. 'Flood vulnerability' is defined as a measure of a regions' or population susceptibility to damages (Hebb & Mortsch, 2007). Vulnerability is considered in this study as the extent of harm, which can be expected under certain conditions of exposure, susceptibility and resilience. A clear distinction between exposure to hazard and vulnerability is considered essential to analyses the flood problem, clearly distinguishing between strategies that can be adopted from an engineering perspective from those that require consideration of social issues (APFM, 2007).

Seelye et al., in (2013) reported that floods are natural events that are considered hazards only when people and property are affected. Nationwide, on an annual basis, floods have resulted in more property damage than any other natural hazard. Physical damage from floods includes the following:

- Inundation of structures, causing water damage to structural elements and contents.
- Erosion or scouring of stream banks, roadway embankments, foundations, footings for bridge piers, and other features.
- Impact damage to structures, roads, bridges, culverts, and other features from high-velocity flow and from debris carried by floodwaters. Such debris may also accumulate on bridge piers and in culverts, increasing loads on these features or causing overs topping or backwater effects.
- Destruction of crops, erosion of topsoil, and deposition of debris and sediment on croplands.
- Release of sewage and hazardous or toxic materials as wastewater treatment plants are inundated, storage tanks are damaged, and pipelines severed.

Flooding is one of the water related environmental problems. Its magnitude is very much dependent on land use practices in the watershed of each river or stream (Khalequzzaman, 1999). Ehiorobo & Izinyon in (2011) reported that, soil erosion on the other hand is mainly affected by several factors such as vegetation cover, topographic features, climatic variables and soil characteristics. Human activities and large scale developments alter vegetation cover. Surface run-off can easily wash away the soil surface from cultivated lands and erosion reduces land elevation which in turn increases flood intensity in an area (Dregne, 1987; Thapa and Weber, 1991).

Gully erosion is a highly noticeable form of soil erosion and can affect soil productivity and impair roads and water ways (Worrell, 2007). Narrow rills can be moved to gullies with a down slope orientation and with time, as a result, increased run-off undergoes progressive widening and deepening. Most of the above type of gullies tend to occur on bare soil surfaces, created by human and animal foot traffic and wheeled traffic in off-road locations and also by the grading of the soil along the sides of roads (Syresh, 2006).

In our case study, “Floods are frequents phenomena in the North West Coast since the rainfall pattern is torrential, and there are urban areas built on the existing wadi found in Marsa Matrouh and Sallum. These vulnerable areas are well-known by the local population and they were highlighted during the workshops held with the zoning team. Actually, two different vulnerable areas were detected; one due to constructions on wadi and inter-ridge areas and the other one due to storm surges and sea level raise” (ICZM, 2009, p.28).

2.3.3.3. Social vulnerability at different scale

According to Adger and Kelly (1999), social vulnerability theory provides the theoretical perspective on human capacity to withstand a variety of stressors. It was conceived that humans are directly or indirectly dependent on natural resources of ecosystems to meet their needs for survival, thus, influencing the state and condition of nature which is similarly stressed by the ecosystems-based model. In this framework, economic activities aimed to fulfill human needs exceed the ecological threshold in many ecosystems, particularly the watershed ecosystem.

Dow (1992) cited that the distinct feature of social vulnerability theory is its description of the possible threats to human-environment system, and threats to sustainability. It emphasizes the human response, coping capacity and resilience to absorb perturbation and changes from its environment. It characterizes vulnerability as “the state of individuals, groups or communities in terms of their ability to cope with and adapt to any external stress on their livelihoods and well-being”. From the point of view of Brooks (2003), social vulnerability theory can be referred to as people-based explanatory model of socio-economic vulnerability to a range of stressors and consequences. It applies to vulnerable situations and classification schemes of vulnerability factors characterized as “internal social vulnerability” or “cross-scale social vulnerability” (Brooks, 2003). He described social vulnerability as factors that determine the outcome of hazardous events of a given natural severity, which encompasses elements of the physical environment like topography, and biophysical changes, among others.

2.4. Land degradation

Land is not only mean soil resource, but it also include the water, vegetation, landscape, and microclimatic components of an ecosystem; while Land degradation refers to a temporary or permanent decline in the productive capacity of the land, or its potential for environmental management (Scherr & Yadav, 1996). According to (Ezeaku & Davidson, 2008) Land degradation can be defined as the loss of utility or potential utility through the reduction or damage to physical, social, cultural or economic features and/or reduction of ecosystem diversity. It is also the temporary or permanent decline in the productivity of land.

"Desertification is now defined in the UNCCD as land degradation in the arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities" (this definition excludes the hyper-arid lands)" (WMO, 2005,p.6). Bai ZG in (2008) defined the land degradation as a long-term decline in ecosystem function and measured in terms of net primary productivity. Degraded land can be defined as the state of land which results from the persistent decline or loss in biodiversity and ecosystem functions and services that cannot fully recover without help within decadal time scales. Land degradation, in turn, refers to the several processes that drive the decline or loss in biodiversity, ecosystem functions or services, and includes the degradation of all terrestrial ecosystems (IPBES, 2015).

Land degradation, indicated by its state of degradation in term of soil, vegetation and water resources, it is often linked to sustainability in terms of retaining its productivity. Human interventions which are causing land degradation include deforestation, overgrazing by livestock, mismanagement of agricultural land, overexploitation of the vegetative cover for domestic use, and (bio)industrial activities (Gabriels & Cornelis, 2009)

Also environmental degradation is the gradual destruction or reduction of the quality and quantity of human activities animals' activities or natural means example water causes soil erosion, wind, etc. It is viewed as any change or disturbance to the land perceived to be deleterious or undesirable (Johnson et al., 1997).

“Pressures on resources in arid and semi-arid areas have been growing in recent years. Pressures have derived from human and livestock population growth at the same time as the loss of some resources (such as land and water) to other uses (agriculture, forestry, wildlife reserves)” (Barton et al., 2001).

Land degradation and desertification in dry lands affect about two-thirds of the world’s countries, and 40 per cent of the earth’s surface, on which one billion people live (Malagnoux et al., 2007). Land degradation in these dry lands is a very complex process, which is not a single factor outcome, but it is rather an emergent property of interacting human and biophysical factors. Even though the concept of land degradation in the dry lands has been discussed for more than 30 years, there is little consensus about how it arises (for an overview, see for example Prince (2002) and Dregne (2002).

Furthermore, land degradation is a process and it occurs when one process, or a combination of processes, cause a reduction of the potential productivity of land resources (UNEP, 1992b). The processes comprise water and wind erosion, sedimentation caused by eroded soil, long-term reduction in the amount or diversity of natural vegetation relevant, and salinization and sodification. The land can be diagnosed as degraded, caused by natural processes or human activities, when it is no longer able to adequately sustain an economic function and/or the original function (ISO, 1996).

Desertification: the term desertification originated with a specific meaning, as for example in the 1977 World map of desertification (UNEP, 1977). It was subsequently widely used and misused in a broader sense. These wider meanings have sometimes been extended to almost all forms of land degradation, for example soil erosion in the humid tropics (Young, 1985).

Wahab et al., (2014) in their study in Barrani area (part of NWCZ) they found a relation between density of vegetation cover and sensitivity to desertification, where the sensitive areas are found where the vegetation cover is rather low ; while the low sensitivity areas are due to the good vegetation cover and soil quality.

Water harvesting can improve the vegetative cover, increase the carrying grazing capacity of rangeland and help halt environmental degradation. It can be an individual or community response to an environmental limitation. Practices of rainwater harvesting provide a sound basis for improved resources management, reduce cost and provide people with tools for improving the rangelands and, hence their income and livelihoods (Oweis et al., 1999).

2.5. Watersheds and Integrated Watershed Management

Morris & William in (1976) defined the watershed is defined as, the region draining into a river system, river or body of water. Watersheds are a highly desirable unit for planning because they are physical features ubiquitous across the landscape serving as the geographic foundation for political states. As planning units, watersheds transcend political boundaries. However, prior to the 1970's, most watershed management focused on solving localized problems without taking into account the interrelationship between those problems and the biophysical, economic and social elements of the larger watershed system (Heathcote, 1998). Furthermore, during most of the mid- to late- 20th century, watershed management was, politically, a top-down planning process with national concerns pre-empting local (National Research Council 1999).

Today, however, countries everywhere are exploring bottom-up watershed planning for water, natural resource and environmental management through integrated watershed management. Integrated watershed management (IWM) is a holistic problem solving strategy used to protect and restore the physical, chemical and biological integrity of aquatic ecosystems, human health, and provide for sustainable economic growth (National Research Council, 1999). IWM, in its most basic form, considers the interdependencies between science, policy and public participation (National Research Council, 1999). And it is part of land degradation management.

According to Moustafa & El-Mowelhi (1999) the concept of watershed management in the NWCZ are absent and results in the loss of both water and soil through water erosion. Detailed studies of the different watersheds including soils, topography, and rainstorms are badly needed to be able to make a proper design regarding the management of each watershed.

Integrated watershed management situations consist of multiple criteria and alternatives that must be evaluated by a decision-maker in order to achieve an objective (de Steiguer et al., 2003)

Conclusion

This chapter addressed the various studies on the approach of the interrelations between drought and related natural events like water scarcity and land degradation and the natural and social vulnerability considered as a global concept to address the whole system dynamic. These studies show the correlation of both drought and the vulnerability with water scarcity, which ultimately lead to the occurrence of the current deterioration.

The different concepts and frames presented will be the foundations upon which we propose to discuss all issues related to drought, vulnerability, scarcity and land degradation in the North West Coastal zone in Egypt to test the basic hypotheses of the thesis and develop a global frame of adaptation of the Bedouin society faced to drought.

CHAPTER 3: MATERIAL AND METHODS

Introduction

This chapter includes the materials and methods that we have used in order to define and assess the complex effects of the drought at the different scale of analysis: effects on living conditions at the farm and family level and effects on natural resources such as soil, water and vegetation cover change at the watershed level called ‘wadi’.

Related to the social and economic approaches of the farming system, the chapter includes the details of the questioner which has been used in the interviews of the study, as well as the sampling of the survey and the distribution along the study area.

We have also included all scientific methods and software’s that have been used to evaluate the land cover change, notably the RS (Remote Sensing) and GIS (Geographic information system) tools, as well as the methods of hydrological assessment and the methodology of the analysis of the land cover change factors.

The joint analysis of these effects will be done at the collective level based on the approach of land degradation at the watershed level.

3.1. Choice of unit of analysis

3.1.1. The Wadi: the main unit of analysis to address collective vulnerability

In order to understand the complex effects of drought at the collective level, we propose to focus on one socio-geographical unit. A socio-geographical unit can be considered as a social territory that shares the same resources. In NWCZ, the main geographical unit is the watershed due to the water access and land management around. A watershed, called wadi in the local community, can be defined as an area of land that drains water, sediment and dissolved materials to a common receiving body or outlet (the US Environmental Protection Agency definition). Figure (23) shows typical watershed.

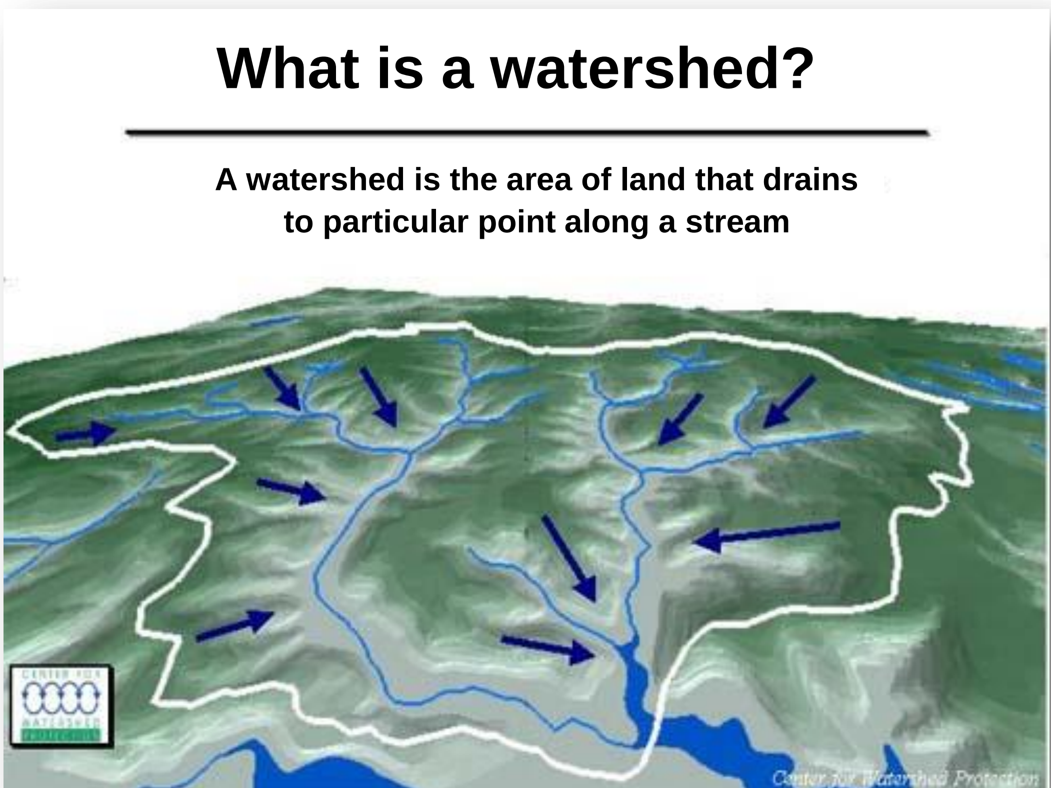


Figure 23: Typical watershed

In this scale unit, the objective is to analyze the link between the society, the herd and their territory.

The wadi is also considered as one hydrological unit, where it is supposed that water within the basin would reach ultimately to one point at the end of the downstream before reaching the sea. During the drought period, the watershed area becomes very vulnerable to the water resources. In the dry seasons the vulnerability to the water resources clearly increases. So this unit allows us to analyze the water resources management in the wadi under different climatic conditions.

As described in chapter 1, the NWCZ counts around 218 wadis (FAO, 1970). To select the wadi, we used the literature reference in order to have previous studies to conduct retrospective analysis. So we have chosen the wadi Nagamish. This wadi has been studied in the eighties (before the last 15-years drought) and this allows observing the changes in adaptive process before and after the drought. Also, this wadi is one of the largest in the Matrouh region. The wadi Naghamih extends from north to south for about 20 km. Three bio-climatic zones are represented: the coastal zone with the orchard development, the middle zone (from 5-15 km with mixed crop-livestock system) and the southern zone where the agro-pastoral system is predominant. So this is an opportunity to analyze the diversity of adaptation according to the availability of natural resources, mainly water. Moreover this wadi is settled by different tribes (five of them are represented) since the beginning of the nineteen century and allows to consider the social factors influencing resources access and opportunities. Finally this wadi located at less than 17 km from Marsa Matrouh allows considering the stakes of urbanization and social changes in our analyses. Figure (24) shows the location of wadi Naghamish.

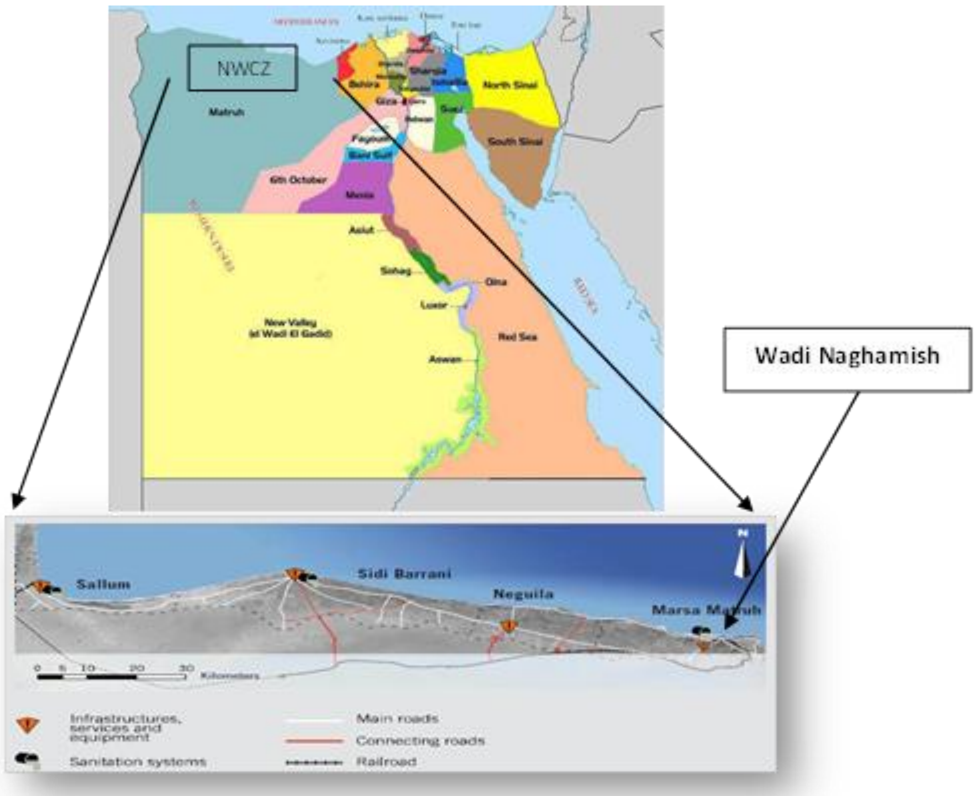


Figure 24: localization of wadi Naghamish

Source: ICZM, 2009

3.1.2. Family: the second unit of analysis to address family vulnerability

In developing or intermediary countries, it has been shown that the conditions of living of family depend not only on farm assets such as private land or herd, but on the multitude of economic and social activities developed at the whole family level (Reardon, 1997, Barrett et al., 2000). In this way, we propose to use the "farming system" concept as a framework to identify the different sub-systems of activities and interrelations between them. And we will extend the concept at the family level to include all the social and economic activities.

"*A farming system, by contrast, is defined as a population of individual farm systems that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate*" (Dixon et al., 2001, p.2). Lal & Miller (1990) defined the farming system as a resource management strategy to achieve economic and sustained agricultural production to meet diverse requirements of farm livelihood while preserving resource base and maintaining a high level of environment quality. "*Off-farm income represents an important source of livelihood for many poor farmers. Seasonal migration has been one traditional household strategy for escaping poverty and remittances are often invested in land or livestock purchases*" (Dixon et al, 2001, p.3).

So the concept of "Farming system" allows determining different groups or types of families which have similar structures, constraints or opportunities in terms of family, land and herd, that would explain a way of functioning. Generally the development of the farming system approach leads to define different types of farming systems called typology. And we can find two large categories of typologies in the literature: 1) structural typology based mainly on structural components of the farm such as family size, herd size and structure and resources availability or 2) functional typology which highlights the practices related to feeding systems, cropping systems, etc.

In our case, we propose to use the framework of farming system to help us to identify the key variables that we need to collect during the first step of data collection at the family level. This frame allows us considering the three sub-systems: the family, the land and cropping systems and the herd. But our analysis will focus on the different practices developed at the family level in response to the physical, biological and socio-economic environment and in accordance with the household goals preferences and resources. And these factors combine to influence the outputs and productions. Figure (25) shows farming system in NWCZ.

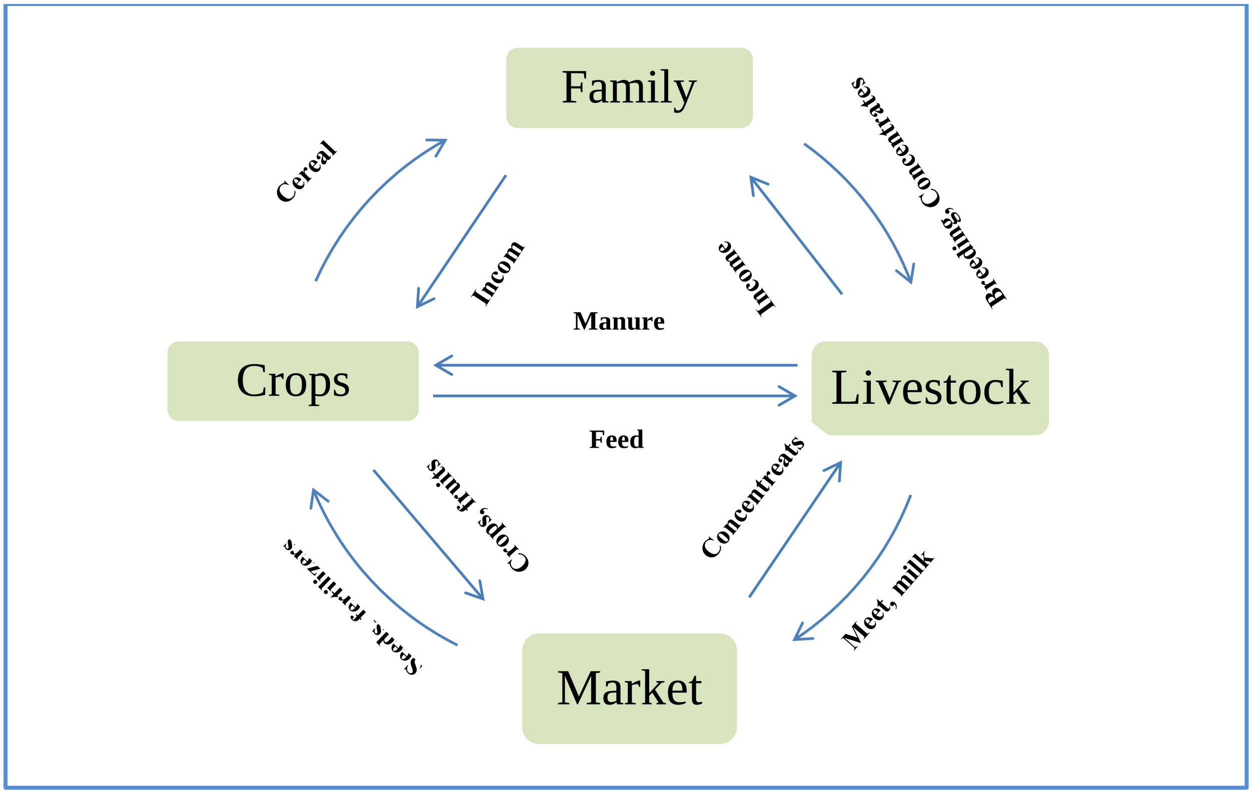


Figure 25: farming system in NWCZ

3.2. Social and economic approach of adaptive process

Understanding the social and economic adaptive processes of families to changes necessitates considering two scales of analysis: the family and the regional level. At the family level, the objective is to approach the adaptive process based on family asset (such as education, housing, herd, land, etc.) ; at the regional level the objective is to see the past and on-going changes on policies, social configuration and expected changes from key-representative persons.

3.2.1. Survey at the family scale

3.2.1.1. Sample

To understand the adaptive process of families faced to drought, we have conducted a family survey based on interviews and semi-closed questionnaires which have been implemented from the beginning of February 2012 until the end of April 2012 among a sample of 50 farmers in Wadi Naghamish. The fifty farmers selected in this survey represent the diversity of social and natural environment in the wadi (table 8, figure 26).

In Table (8), we can see that this survey includes some families of all tribes represented in the wadi, including Gnashat, Gbihat, Hafian, Menfa and Mawalek.

Table 8: description of the sample

Bio-climatic zones	Tribes	Main tribes	Number of interviews
Zone :1	Gnashat	Ali Ahmar	15
Zone :1	Mawalek	Sengor	2
Zone :2	Gbihat	Ali Ahmer	19
Zone :2	Hafian	Awalad Kharouf	5
Zone :3	Menfa	Awlad Kharouf	9

The selected sample includes farmers and breeders with different farming systems in the 3 different zones along the wadi with different activities (farm and off- farm). Figure (26) shows the locations of the families where a questionnaire was applied. Two questionnaires per day were implemented.

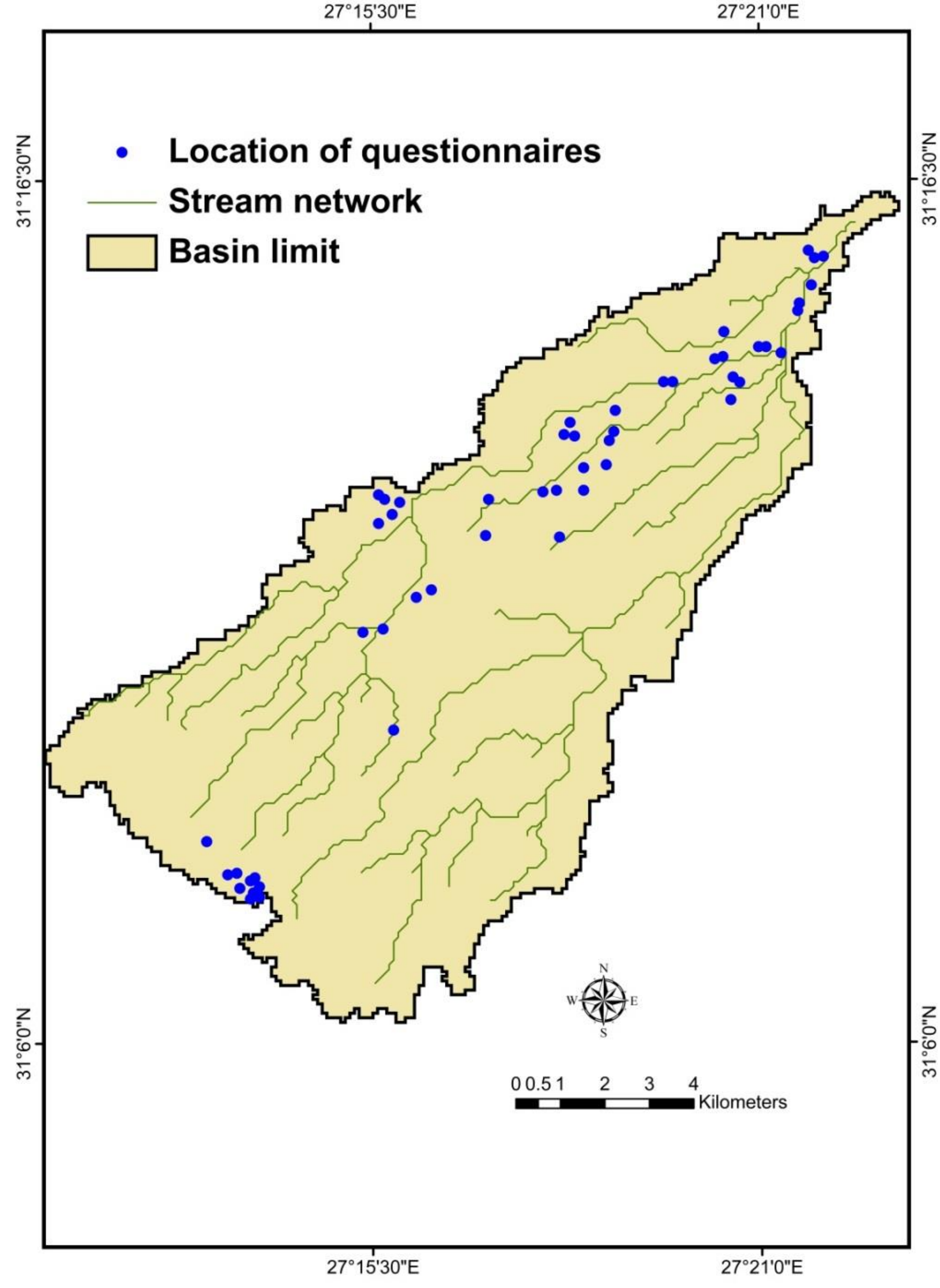


Fig 26: Location of the surveyed families by questionnaires in Wadi Naghamish

3.2.1.2. Questionnaires

The main purpose of the questionnaire was to collect data in order to better understand the Bedouin society who lives for more than fifteen years under the pressure of the drought. So, we tried as much as possible that the questionnaire covers all the topics related to the Bedouin community, including social, economic and environmental aspects, agriculture and animal production. A specific attention was done to determine the major changes that have occurred in society, especially those related to the drought and also the most important and suitable alternatives and strategies available to the Bedouin community to cope with this drought.

Based on the project ELVULMED (project on the 'Role of livestock activities in the process of adaptation and reducing vulnerability of Mediterranean societies facing global changes' – research project from 2011 to 2014) and the family questionnaire developed, we have proposed to use the same frame of questionnaire with additional parts on water availability and land degradation.

So our final questionnaire included five main parts as following:

A-Family structure, housing and off farm activities

This part is focused on the social family composition and organization. Based on the composition of each family, we have collected information on the education, responsibility and participation of each member in the decision process. This part includes also the different activities of each member in order to capture the external sources of incomes in link with the educational level to approach the changes in opportunities.

This part included the following aspects:

- ✓ Basic questions such as name of the farmer, age, tribe, village name and location
- ✓ Direct family information and construction
- ✓ Level of education of the direct adult family members (sons, daughters, wife).
- ✓ Level of education of the extended members, if they exist
- ✓ Activities of Family members
- ✓ Housing and infrastructure availability such as water supply, electricity …
- ✓ Decision-making in the family

B- Land and cropping system

This part of questionnaire includes two main sections: the approach of land access and use and the cropping system and its management and practices. This part allows understanding the land challenges in the zone and also gives indicators to estimate crop income.

The main sections of this part are:

- ✓ Type of the land (wadi, rain-fed, pastoral)
- ✓ The area of each land type
- ✓ Type of holding/tenure and from when
- ✓ Agriculture practices
- ✓ Production costs data, productivity data, and marketing data.

C- Livestock systems

This part of questionnaire focuses on the livestock system and its relations to the family and resources units. It is composed of five main sub-parts: (i) the livestock composition and livestock transactions (movements); (ii) the feeding system that is one of the main challenges in the zone in link with resource scarcity; (iii) the animal performances;(iv) the marketing practices and (v) animal diseases.

For livestock composition, we have used some retrospective approach to have the composition of the flock in 1995 in order to understand the change of livestock systems after 15-years drought.

The main subjects in this part are:

(i) livestock composition: livestock structure in 2012 (number of sheep and goats, camels and cattle owned by farmer) ; livestock structure before 1995 (number of sheep and goats, camels and cattle owned by farmer)

(ii) Feeding system: feed calendar over the year; type of supplementation during the feed calendar by considering three periods: grazing period, crop residues period and housing period; and change of feeding system after the grazing period in 2011/2012; Feeding system for fattening period.

(iii) Animal performances: Total lambing per year, main lambing period, main change in the animal management;

(iv) Animal and animal products marketing

(v) Animal diseases, especially the change in animal health, based on : Regular vaccination and types of diseases; Internal and external parasites; Proportion of herds affected by the different diseases and main losses in productivity

D- Soil and water management

This part relates to the soil and water resources in the area. The objective was to evaluate the water supply system in the area which is based on cisterns by asking the farmers:

- ✓ The number of owned cisterns, the total capacity of those cisterns, the satisfaction of the needs of the family;
- ✓ During the drought how many cubic meters does he need to transfer from the city or other water supply? And its cost. .
- ✓ How many cisterns have been established by him or by other development programs in the area, and the same questions for the different types of dikes.
- ✓ Are there any problems relate to the water right in the land of the wadi

The other part relates to the desertification in the area. We tried to understand:

- ✓ Are the farmers aware of this problem? If they aware how can they describe this problem?
- ✓ Are there any noticeable signs that indicate the occurrence of the desertification?
- ✓ How can the old farmers remember the year 1961 with the strong wind with dust and how does it affect the soil and the vegetation covers in the area?

E-Constraints and perception of climate changes

This part relates to the climate changes. We tried to understand if the farmer aware of these changes by asking them if they observed or perceived some change about:

- ✓ Soil quality.

- ✓ Water quality.
- ✓ Drought rhythm.
- ✓ Rainfall rhythm and quantity.
- ✓ Temperature degrees change.
- ✓ Shrubs population in the range land.
- ✓ Palatable plants in the rangeland.
- ✓ Animal productivity.
- ✓ Family relationships between rich and poor families.

Data of the 50 questioners were entered to ACCESS 2007 software (designed by SELMET/CIRAD). And we have used mainly descriptive analysis to understand the adaptive process at the family level.

3.2.1.3. Investigation or context of the survey

Due to my belonging to the Bedouin community and therefore my knowledge of the customs and traditions of that community, I have found great support from them and they gave me all the information to facilitate process research and study. Moreover, some friends and colleagues who came from this wadi area introduce me as researcher to all the five tribes and this allowed me to have good relations in the wadi. However, due to the topographic of the wadi, the access to some farmers and breeders was not always easy. In addition, there was some sensitivity of talking about matters related to the family which are linked to habits and traditional in the Bedouin society and also about income causing fear among farmers of taxes.

3.2.2. Mental models about livestock trends and strategies facing drought

This specific survey has been developed at the beginning of the research with the objective to have an overview on the livestock trends and the strategies facing drought. Some complementary interviews have been conducts in and out the wadi using the method based on the mental models of local stakeholders.

The concept of mental model offers an original approach to better understand how someone perceives how something works (Craik, 1967; Ford & Sterman et al., 2009; Diniz et al., 2013a). According to Jones et al. (2011), a mental model gives a simplified representation of the reality of something, allowing people to interact with their surrounding world based on their own perceptions. Moreover, Stone-Jovicich et al. (2011), Cheong et al., (2012), Lynam et al., (2012) recommended mental model approach to explain the human-environment interactions. Du Toit et al. (2011) showed how mental models help to better understand the stakeholder's points of view about a process and the factors might be brought to bear on their practices. In the same way, mental model approach is an alternative tool to analyze individual and group cognitive structures of complex systems or processes (Craik, 1967; Biggs et al. 2011; Du Toit at al., 2011; Jones et al., 2011; Diniz et al., 2013a). Furthermore, mental models are able to integrate and represent the factors of change of a system (Jones et al., 2011; Cheong et al., 2012; Diniz et al., 2013a). So they could allow sharing points of view and they are used in negotiation process.

This approach has been developed by interviews with local stakeholders aiming to collect information about the six mains following topics:

- ✓ The past, current situation and future scenarios about animal husbandry in the zone
- ✓ Main functions of livestock activity and the drivers of change over the last decades
- ✓ Significant policies impacting livestock in the zone and the local evaluation
- ✓ Hopes and fears of the breeders and other people involved in livestock sector
- ✓ Challenges, convergences and divergences about livestock, including the conflicts
- ✓ Strategies and initiatives of breeders to face drought, especially the young breeders

Twenty stakeholders have been selected to be interviewed. Six main sectors of activities are represented: scientists, extension technician, traders and inputs providers, breeders, social leaders and other sectors. The sample of the 20 key-informants has been selected with the first stakeholders, based on their knowledge of social networks of the local Bedouin society in order to achieve a good representation of the diversity of the points of view at local scale.

The table (9) presents the distribution of the stakeholders according to their sector of activities. Some stakeholders act in two or three sectors, for example a breeder who is also a social leader or a NGO member who works in a development agency.

Table 9: the distribution of the stakeholders

<table>
<tr><th>Stakeholders</th><th>Scientist</th><th>Technician</th><th>Trader</th><th>Breeder</th><th>Social leader</th><th>Other sectors</th></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td><td bgcolor="silver"></td><td></td></tr>
<tr><td>2</td><td></td><td colspan="3" bgcolor="silver"></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td bgcolor="silver"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td bgcolor="silver"></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td></td><td bgcolor="silver"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>6</td><td></td><td></td><td bgcolor="silver"></td><td></td><td></td><td></td></tr>
<tr><td>7</td><td colspan="2" bgcolor="silver"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>8</td><td></td><td></td><td></td><td bgcolor="silver"></td><td></td><td></td></tr>
<tr><td>9</td><td></td><td bgcolor="silver"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>10</td><td></td><td></td><td bgcolor="silver"></td><td></td><td></td><td></td></tr>
<tr><td>11</td><td></td><td></td><td></td><td bgcolor="silver"></td><td></td><td></td></tr>
<tr><td>12</td><td></td><td></td><td colspan="3" bgcolor="silver"></td><td></td></tr>
<tr><td>13</td><td></td><td></td><td></td><td></td><td></td><td bgcolor="silver"></td></tr>
<tr><td>14</td><td></td><td></td><td></td><td></td><td bgcolor="silver"></td><td></td></tr>
<tr><td>15</td><td></td><td bgcolor="silver"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>16</td><td></td><td></td><td bgcolor="silver"></td><td></td><td></td><td></td></tr>
<tr><td>17</td><td></td><td></td><td></td><td bgcolor="silver"></td><td></td><td></td></tr>
<tr><td>18</td><td></td><td></td><td></td><td></td><td colspan="2" bgcolor="silver"></td></tr>
<tr><td>19</td><td></td><td></td><td bgcolor="silver"></td><td></td><td></td><td></td></tr>
<tr><td>20</td><td></td><td></td><td></td><td></td><td></td><td bgcolor="silver"></td></tr>
</table>

The interviews spent around two hours, usually at home, in the farm or at the office of the stakeholders, after to have decide the date two or three days before. Some interviews have been led with the presence of another key-informant interviewed after or before. It was interesting time to share the points of views.

The report was written directly after the interview. It contented basic information about the stakeholder, his history, his activities, and his points of view or perceptions related to the six questions.

3.2.3. Supplementary materials

Supplementary materials have been collected during different research activities conducted within the research project ELVULMED. Notably I have participated at the beginning to the first phase of family survey in all the regions of Matrouh governorate. I have also participated in some specific researches and all these research work give me a great chance to be trained to other approaches like the analysis of household/family budget, social network analysis and water management as well as to improve my knowledge with quantitative and qualitative data about the livelihoods of breeders. More specifically, I have been involved in a research on the "Participation, Power and Sustainable Water Resource Management, A Case Study of The Rain-fed Desert Region of Matrouh, Egypt" with Nastassja Hoffet, 2012. The second was on "analysis of adaptations process of the Bedouin communities to global change" with Martin Vincent in 2013. The third was "Bedouin Women in the Communities of Matrouh, Egypt: Vulnerabilities, Perceptions Regarding Climate Change, and Future Prospects" with Laura Duarte, 2013.

3.3. Water resources management at the family and wadi level

3.3.1. Hydrological assessment of the watersheds

The watershed is the area of land draining into stream at a given location. Hydrological assessments of the watershed clarify the situation of water availability, potential to generate runoff and possibility to utilize this water for useful purposes within the boundary of the watershed or elsewhere.

3.3.1.1. Data Requirement for hydrological assessment

The classical hydrological assessment for any watershed needs specific data requirements as:

- topographic map with an appropriate scale and including all information of roads, important public utilizes and stream gauging stations;
- Land use map; Land ownership boundaries;
- Cropping pattern, crop part area and cultural practices;
- Physical features such as structures, which interrupt the free passage of flow;
- Rainfall, temperature, evaporation, wind, sunshine hours and relative humidity, which will be required for estimation of runoff, crop water requirement and operation of storage facilities;
- Storm duration, pattern and rainfall intensities, if available. Otherwise these have to be estimated from continuous records, hourly data which so ever is available;
- Rainfall distribution pattern over the watershed;
- Steam gauging records (stage discharge curve or runoff hydrograph) and flood marks;
- Ground water related information;
- and, general topographical information that may include streams density and drain ability.

3.3.1.2. Estimation of coefficient of runoff

The rational formula dates from the 1850s in Ire-land (Bedient and Huber, 1988). It still widely applied to analyze the runoff of a small basin responding to storms, because of its simplicity and its limited data requirements. The traditional rational method was originally developed to calculate the flood peak flow under the assumption that the intensities of both rainfall and infiltration or loss are uniformly distributed in time and space (Hua et al., 2003). According to Thompson (2006) the rational method is a simple technique for estimating a design discharge from a small watershed. It was developed by Kuichling (1889) for small drainage basins in urban areas. It has been the most popular formula in urban hydrologic design for more than hundred years (Eliasson, 2002).

Later on, with the incorporation of curves for the estimation of coefficient of runoff, the formula became a tool for transformation of rainfall into runoff volume in a drainage basin. The final equation uses three parameters i. e. rainfall, drainage area and runoff coefficient based on the topography, land uses and soils characteristics of the drainage area. The equation is as follows (Ali et al., 2000):

$$\mathbf{V = 10^3\ C.P.A}$$

Where;

V = estimated annual runoff volume (m^3)

C = runoff coefficient for annual runoff

P = annual rainfall (mm)

A = drainage area (km^2)

For the purpose of estimation of the annual runoff volume, the watershed is divided into sub-catchment areas (cells). The runoff volume for each cell is estimated for various probability of rainfall according to following expression (Ali et al., 2000):

$$\mathbf{V_{ip} = 10^3\ C_{ip}.P_{ip}.A_i}$$

Where:

Vip = estimated annual runoff volume (m^3) for cell (i) and rainfall probability.

Cip = runoff coefficient for cell (i) and rainfall probability (p).

Pip = annual rainfall (mm) for cell (i) and rainfall probability (p).

A = drainage area (km^2) for the cell.

Annual runoff volume for whole watershed is thus worked by summation of each cell (i. e. vp= ∑vip).

3.3.1.3. Global approach of hydrological assessment

a - Delineation of the catchment boundary

The boundary of the watershed has been identified using (ARCGIS10/SWAT) software (Soil and Water Assessment Tool), based on DEM (Digital Elevation Model) matters, STRM 90 m Image (Strm_41_06) downloaded from http://srtm.csi.cgiar.org/S (CGIAR.2005).

b - Delineation of the sub-catchment areas and cells

The watershed area was further divided into number of sub-catchment areas called cells or sub basins using Arc.gis SWAT. The division is based on the topography, land use, vegetation cover, soil and rainfall potential. The cells play significant role in the hydrological assessment of the watershed as they become the units of runoff generation and runoff utilization.

c- Delineation of Rainfall to the Cells

Rainfall within a watershed varies considerably. For example in the North West coast area rainfall distribution shows a reduction around 50% rainfall in 25-30 km in the south from the sea (Regner, 1995). Therefore, the cell of watershed lying in the area of low rainfall shall generate low runoff per unit area. It is highly desired that rainfall should be delineated to each cell particularly in areas of variable rainfall. Figure (27) show the rainfall distribution depending on the distance from the sea.

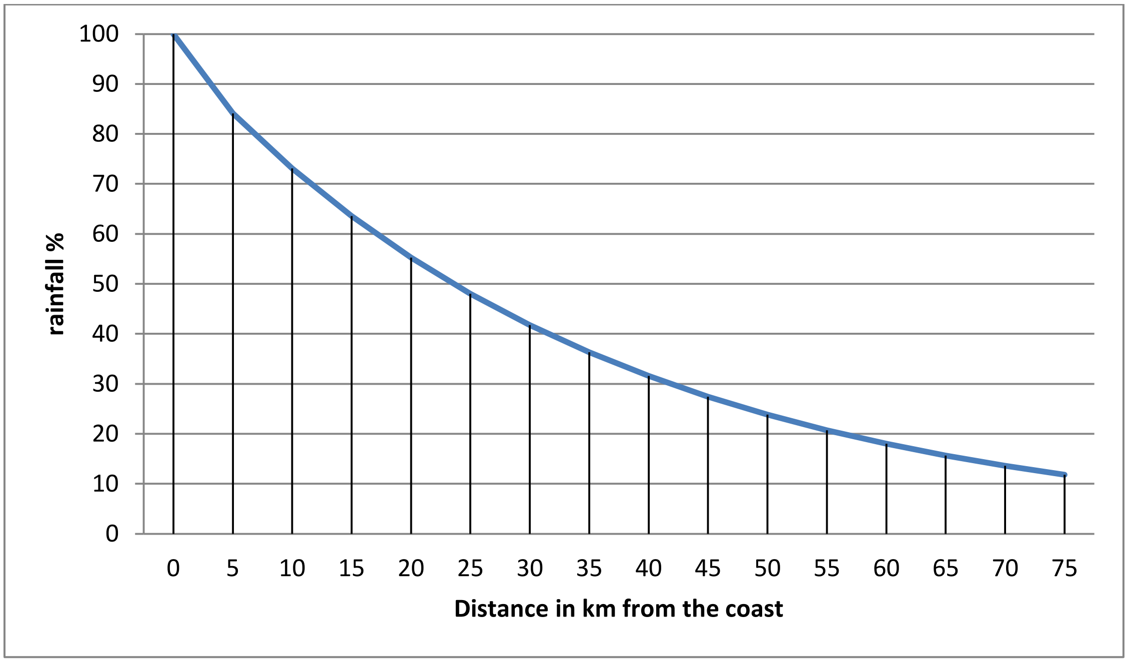


Figure 27: Coastline-inland rainfall distribution (Renger, 1995)

d - Estimation of the Annual Runoff Coefficient

Because rainfall and runoff coefficients are not available in the North West Coast of Egypt, we have used the calculated values and curves of similar areas in West African Watersheds with an annual rainfall of 100 – 200 mm, 0.5% slope, and similar land cover in order to estimate the runoff coefficient in the study watersheds and wadis. Figure (28) shows relationships between rainfall, land cover and runoff coefficient, Figure (29) shows the effect of land slope on the runoff coefficient. The runoff coefficient for the ith cell thus can be obtained by the following equation (Ali et al., 2000):-

$$C_i = C.C_i / C0.5\%$$

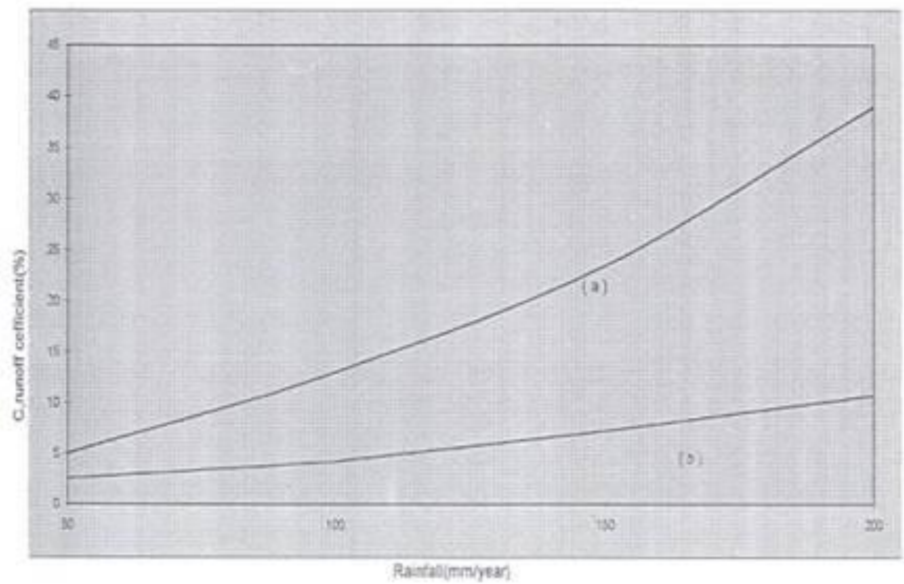


Figure 28: relation between rainfall, land cover and runoff coefficient in West Africa (Davy et al, 1976)

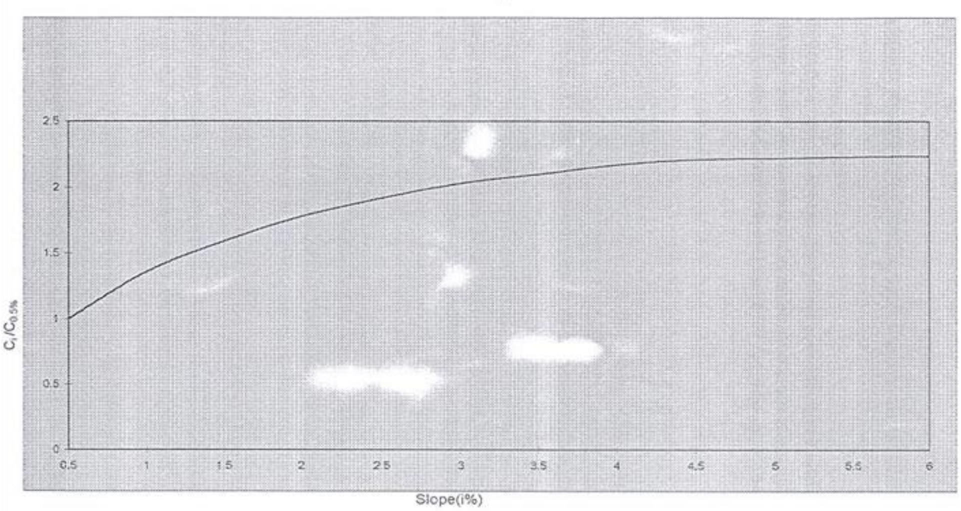


Figure (3): Effect of slope runoff coefficient (Rodier and Ribstein, 1988).

Figure 29: shows the effect of land slope on the runoff coefficient

3.3.1.4. Flood Estimation:-

The design return period is important for design and this has been selected on the basis of importance, use and life of the water harvesting structure. The flood peak for 10 years developed for the North West Cost of Egypt was utilized. It can be estimated with the use of the Rational Formula as given below (Ali et al., 2000):

$$Q = \frac{C.I.A}{3.6}$$

Where:

Q = estimated flood peak (m^3/sec)

C = runoff coefficient

I=rainfall intensity for 10-years recurrence interval (mm/hr)

A = drainage area.

Rainfall intensity was estimated from the frequency- duration –intensity curves, that were developed for the NWCZ of Egypt from rainfall data (Wakil et al., 1999.). Figure (29) shows the frequency curves from NWCZ of Egypt area.

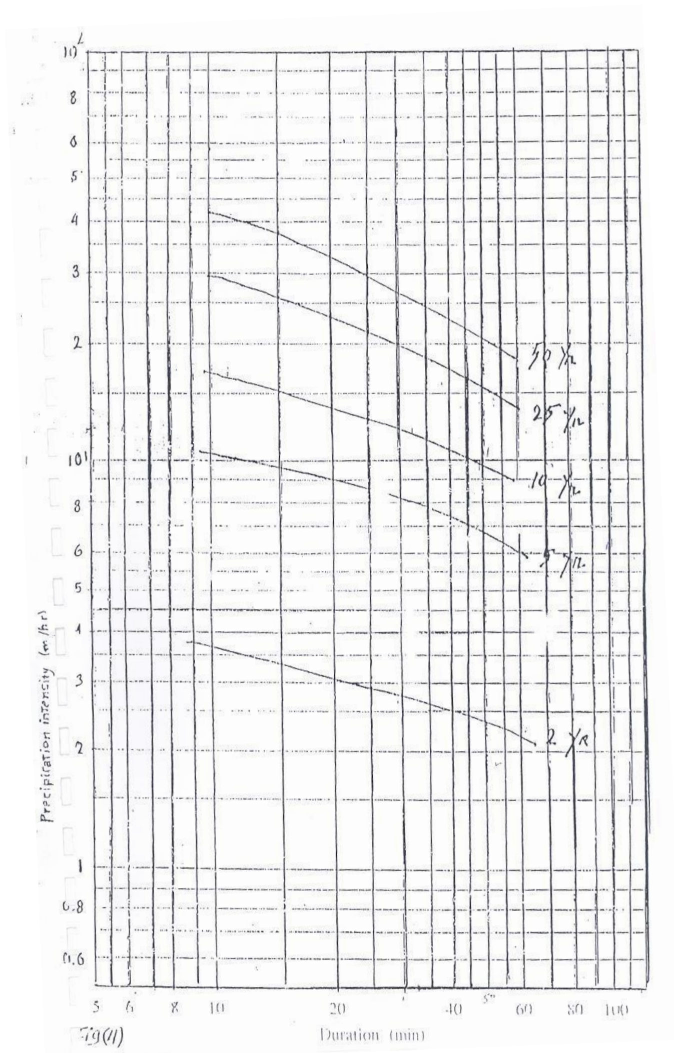


Figure 30: frequency curves from NWCZ of Egypt area

Source: (Wakil et al., 2000)

Duration of the storm is assumed to be equal to the time of concentration of stream at structure location. Time of concentration for streams was estimated by using Kirpich formula as given here under (Ali et al., 2000):

$$\mathbf{Tc = 0.0195*L^{0.77}*S^{-0.385}}$$

Where

Tc = time of concentration in minutes.

L = length of channel in meters at location of spillway.

S = slope of the channel.

The value of coefficient is taken as 0.7 for NWC of Egypt area while for other areas it can be adopted according to the site conditions.

3.3.2. Water storage system: cistern to estimate water scarcity and satisfy the demand

Cisterns are the main storage system for the harvested rainfall water in the NWCZ. A field survey has been implemented to collect all the data related to all the cisterns, including the following data:

- ✓ name of the owner of the cisterns
- ✓ Type of the cisterns (*Nasho*) or Roman
- ✓ When it was established
- ✓ Who established it The farmer Or project Which project
- ✓ What is the total capacity of the cisterns
- ✓ It is valid or not valid to use
- ✓ The tribe of the cisterns owner
- ✓ Is it common or private cisterns
- ✓ The location of the cisterns (coordinate of the location by GPS)

446 Cisterns have been recorded in wadi Naghamish in the 3 zones; the above mentioned data were collected for each cistern.

3.3.3. Climatic scenario: quantitative evaluation of drought on the area

For the use of the rational formula to make hydrological estimation of the study area, we have considered three possible scenarios described as follows:

SPI (Standardized Precipitation Index) calculation was implemented by using Drin C software for the annual precipitation data for Matrouh metrological station in the period (1944-2011). The SPI value calculation is based on Gamma Distribution. According to (Agnew, 2000) the calculation based on the relationship between drought duration, drought frequency, and drought time scale using the:

$$\mathbf{SPI = (X_{ik} - Xi)/ó_i}$$

Where:

$ó_i$ = standardized deviation for the ith station

X_{ik} = precipitation for the ith station and kth observation

X_i = mean precipitation for the ith station

After estimation of the SPI the probability for each year was estimated using Microsoft Excel. Based on probability results the following is the three expected scenarios:

- **Average years**: which represent a probability of 50% with an amount of rainfall about 140 mm, which the normal case in the area.

- **Dry years**: which represent a probability of 70% with an amount of rainfall about 105 mm, which are clear in the duration from 1995 to 2011.

- **Wet years**: which represent a probability of 20 % with an amount of rainfall about 200 mm, which are rare years.

3.4. Land covers change and land degradation

3.4.1. GIS and Remote Sensing

Geographic Information Systems (GIS) and Remote sensing (RS) techniques were used to determine the land cover change in the study area. Many specialized GIS and RS software's were used such as Quantum GIS, GRASS, SWAT and ARC GIS for mapping and describing the study area in the NWCZ.

GRASS software was used to determine the basin, sub-basins, the main streams and the outlet points of wadi Naghamish. ERDAS imagine, RS software's were used to determine land degradation in wadi Naghamish.

The main expected outputs were to get: Land Cover GIS Layers in vector and raster format Assessment of Change throughout the period: Significant vegetation/Biomass changes-Percentage of Change - Temporal-spatial Change.

3.4.2. Materials

The following images were used.

- SPOT images Level 2A (rectified); provided by CIRAD) for 1993,2006 and 2011 date. All the scenes are multispectral images (XS1,XS2,XS3). The resolution is 2.5m ,10m and 20m. ANNEX Table 1 gives the images list summary.

- STRM 90 m Image (Strm_41_06) downloaded from http://srtm.csi.cgiar.org/S. (CGIAR.2005). As SRTM90 is known for being more accurate ASTERDEM was not used because is known for having artifacts. USGS

http://asterweb.jpl.nasa.gov/gdem.asp.

3.4.3. Methodology

A spot images multispectral sensor Xs, dated 30 may 2006 and 2011 with high spatial resolution (2.5) were used to estimate the PVIs values, which were computed from the NIR (Xs3) and the Red (Xs2) channels brightness of the image. Geometric, radiometric and atmospheric corrections are required to estimate the herbage mass using satellite imagery. These preprocessing steps of satellite images involved modeling the relationship between the image and ground coordinate systems. Data pixels were related to exact ground locations, e.g. measured in UTM coordinates (zone 35 projection, WGS 84 datum), by using six Ground Control Points (GCP), which can be easily identified (road intersections and wadi junctions). The mean slandered error of the residuals of the points (RMS error) was less than one pixel (0.3 pixels with field information). The spot sensor acquires data as a Digital Number (DN) with a range between 0 and 255. Several steps are then needed to convert these DN values to the ground reflectance of the earth's surface figure (30). For each spectral band, the DN values were converted to spectral units. The transformation is based on a calibration curve of DN values to spectral radiance with available from the operators of the satellite system (Fig. 30 step1). Spectral reflectance is a standardized measurement. It depends on the degree of illumination (irradiance) of the objects. Reflectance is unit- less and it is expressed as a decimal fraction between 0 and 1 or 0 and 100%. Converting the spectral radiance to exo-atmospheric (Top-Of-Atmosphere = TOA) reflectance (in band planetary albedo) is performed using the formula expressed in (Fig. 31 step 2).

The TOA reflectance does not take into consideration the reflectance at the earth's surface. Removing atmospheric effects from satellite an image is then an important pre-processing step of satellite remotely data (Fig. 31, step3).

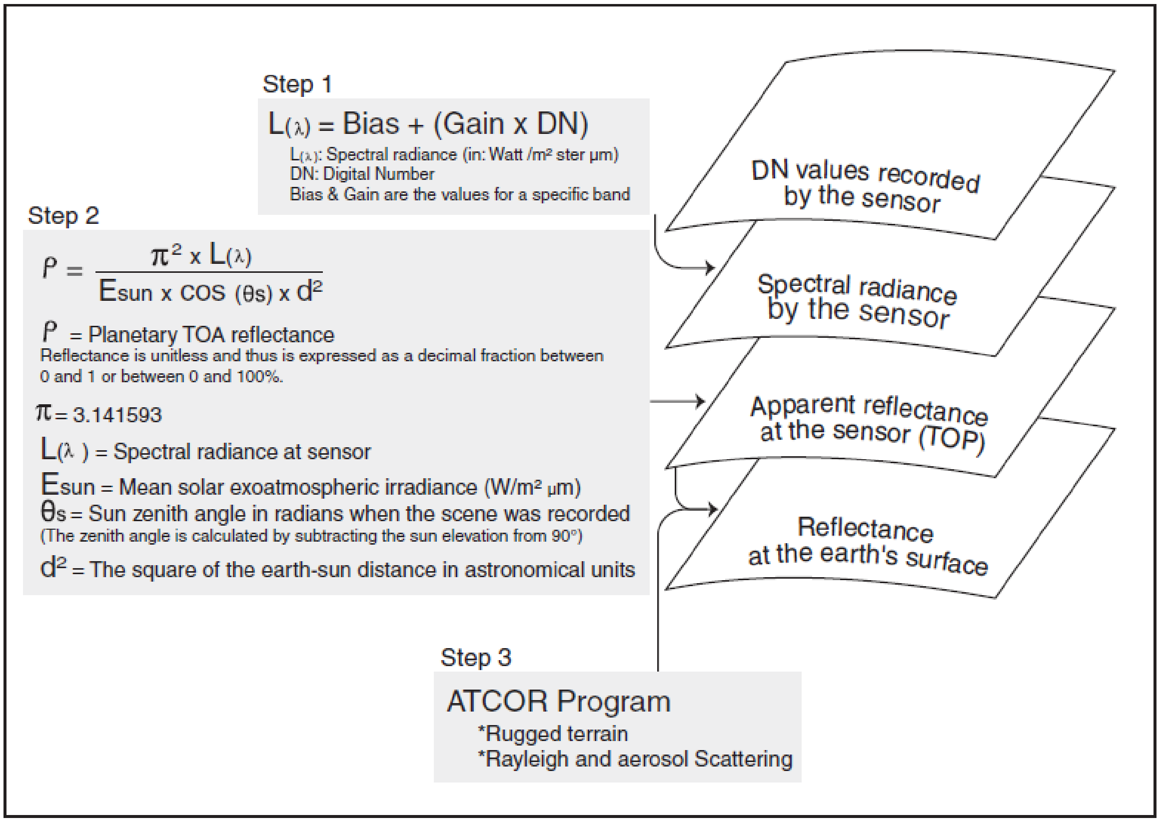


Figure 31: step-by-step process for atmospheric corrections on satellite imagery (Saïdi and Gintzburger, 2013)

It provides true surface reflectance values. This operation is especially important in cases where multi-temporal images are to be compared. For increased precision , the ATCOR (Atmospheric CORection) Program available in ERDSA imagine software, was used to determine true surface reflectance values, measured above the ground. The radiative transfer ACTOR is based on the MODTRAN4 code (Berk et al., 1998, 2003). Taking into account the soil reflectance, which was quite important in the area studied, the PVI for each field centroid was extracted to minimize the soil effect and better discriminate the vegetation cover. The PVI assumes that the perpendicular distance of the pixel from the soil line is linearly related to the vegetation cover (Richardson and Wiegnad , 1977) and herbage mass. It computed as follows:

$$PVI = (NIR - a * Red - b)/SQRT\ (a2+1)$$

Where (a) is the slope of the soil line and (b) = intercept point of the soil line. As a result the further a given pixel is distant from the soil line; the higher is its index value.

When PVI> 0, there is vegetation cover on the pixel; when PVI = 0 there is bare soil on the pixel; and when the PVI< 0, it indicates that the pixel is mostly on water or on very low mineral content or low photosynthetic activities (Richardson and Wiegnad , 1977).

3.4.4. Identification of land covers drivers

For a better understanding of the changes which were occurred in the land covers, we must analyze and understand the factors that led to these changes. For this purpose 5 Ws method has been used. According to Cook (1998), the 5Ws & H technique is a structured method that examines a problem from multiple viewpoints. It is based on who, what, when, where, why and how questions. This method used in many fields such as Business Systems Research. 5Ws&H technique is used when solving problems with multi-criteria decision-making (MCDM) methods (Čančer, 2012). The frame procedure of MCDM includes many steps. 5Ws&H technique is used in the first step which is called problem definition (Čančer, 2008). To achieve this goal, firstly we determine the factors that could control the changes, whether human or natural. Secondly, answer the 5 Ws questions. Through those answers we can understand how those factors that control such changes, whether it is negative or positive. From this perspective we can find solutions to those problems.

Materials used in this approach are mainly based on the results of family surveys and interviews and our knowledge cumulated over the last 3 years.

3.4.5. Research approach frame

Technical and socioeconomic approaches will allow assessing the collective vulnerability in wadi Naghamish. The socioeconomic approach represented by the interviews (questionnaires) with 50 household. The technical approach using the GIS and RS; based on the analysis of 3 satellite images at the wadi level to assess the main changes in the land cover affected by drought as a main factor of change. Figure (32) shows first representation of our approach in order to have analyze the interaction between the socio-economic factors and natural factors.

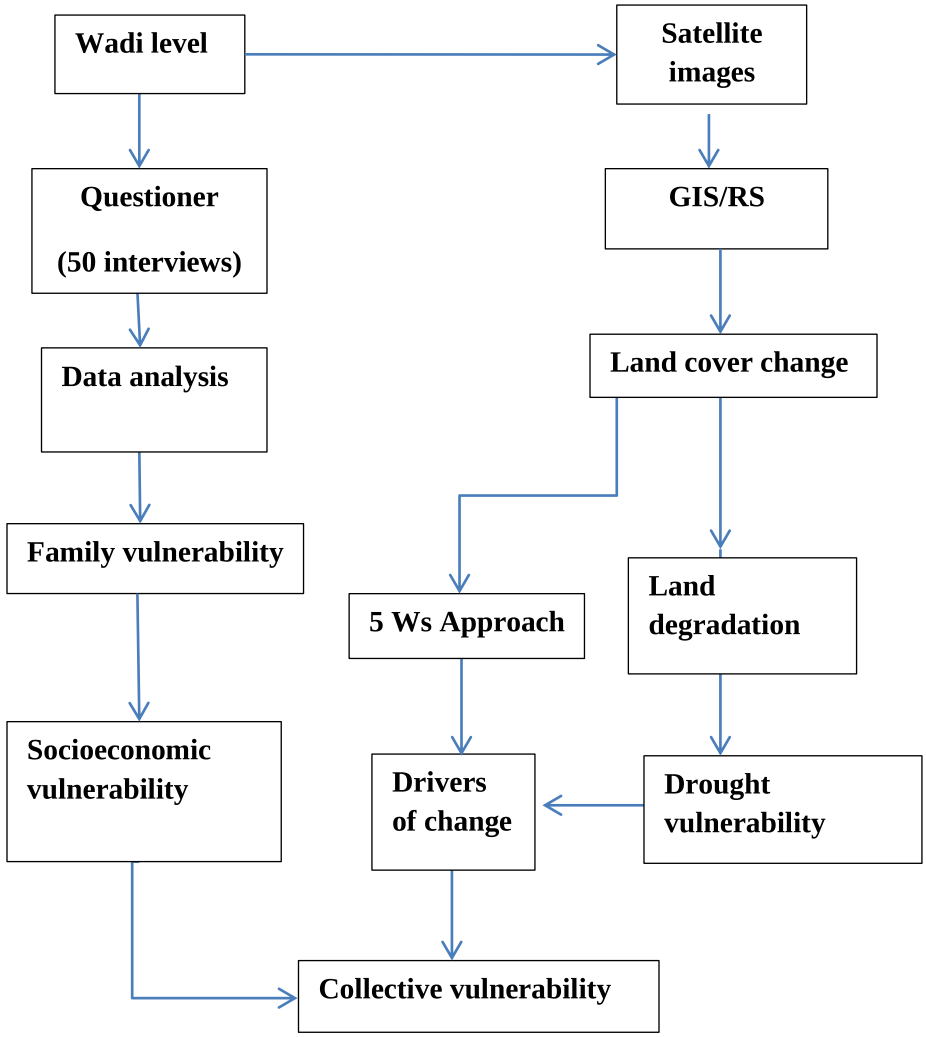


Figure 32: Research approach frame

Conclusion:

This chapter included all the material and the methods that we have used in the research including the field surveys to study the social and economic aspects as well as the methods used in the study of the impact of drought on natural resources such as water resources, vegetation cover.

Based on this, we propose in the following chapter to firstly give a detailed description of the study area at the level of the wadi in terms of social and economic aspects and the infrastructure and the description of the geography, geomorphology, topography, climate conditions and available natural resources. This description will facilitate the understating of the main results that will be presented in the following chapters (from 5 to 7).

Chapter 4:
DESCRIPTION OF THE CASE STUDY, WADI NAGHAMISH

Introduction

This chapter includes a description of the study area (Wadi Ngamish) in terms of geographical approach, natural resources, and social infrastructures in order to clarify the nature of the study area in terms of social and natural aspects.

The chapter also includes the geographical tribal distribution. For that, we have defined by field studies the borders between tribes and then estimate the available natural resources to each tribe based on their geographical location in the wadi. This information will allow understanding the ability of those tribes to adapt to drought conditions in the following chapters.

To this geographical dimension, we have added a retrospective analysis based on interviews to reconstitute the land history and its issues. In this history we point out when the settlement appeared in the study area and its relation with development. In addition to, we will detail the description of the different farming systems in the study area that we will consider in the study.

4.1. Geographical approach of wadi Naghamish

4.1.1. Physical geography

4.1.1.1. Location

Wadi Naghamish is one of the largest wadi in the North West Coastal Zone (NWCZ). It is located at around 17 km at the East of Marsa Matrouh city, with total catchment area of about 89 km2. The total length of the main stream and the branches is around 15 km. Seventeen villages are recorded in the wadi area with around 2000 persons (data source: MRMP). The area contains in total around 300 houses, 5 schools, and 2 agricultural cooperatives. The Figure (33) shows the locations of the NWCZ and wadi Naghamish.

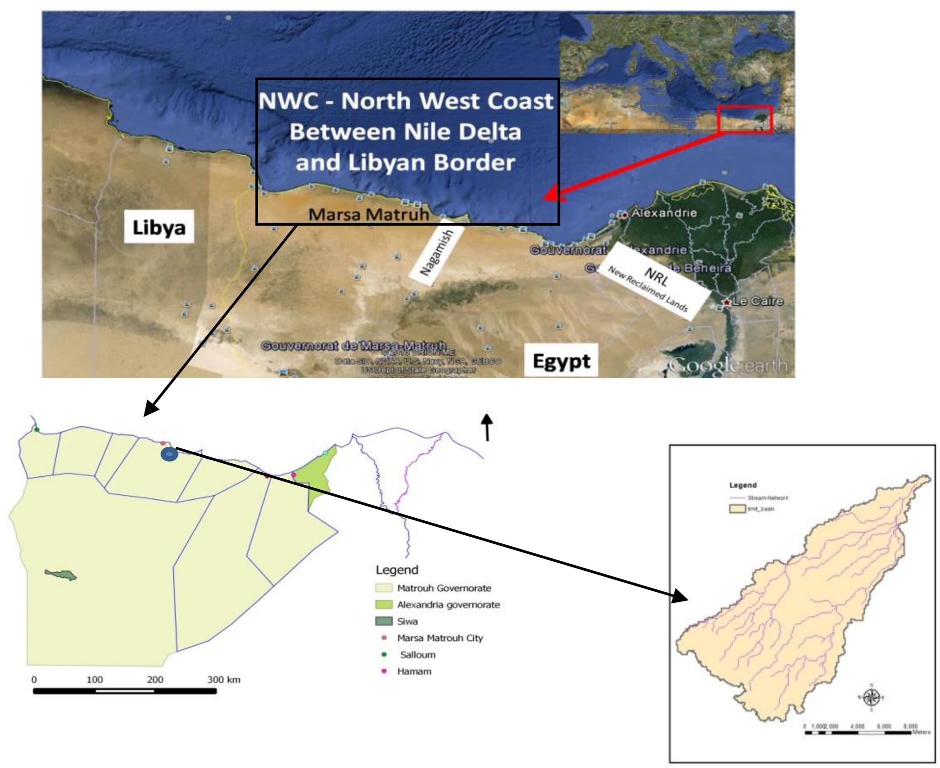


Figure 33: Locations of NWCZ of Egypt ai

4.1.1.2. Climate

Climatic conditions of the Naghamish wadi are the same climatic conditions of the NWCZ, in terms of rainfall and temperature, relative humidity, etc. Figure (34) shows the distribution of rain from north to south, where it ranges from 140 mm in the North (coastal line) to 70 mm in the South at a distance of 20 km from the coastal line in zone 3. Detailed average climate data have been discussed in detailed in chapter (1) based on the Marsa Matrouh airport station and located about 17 km at the west of Wadi Naghamish.

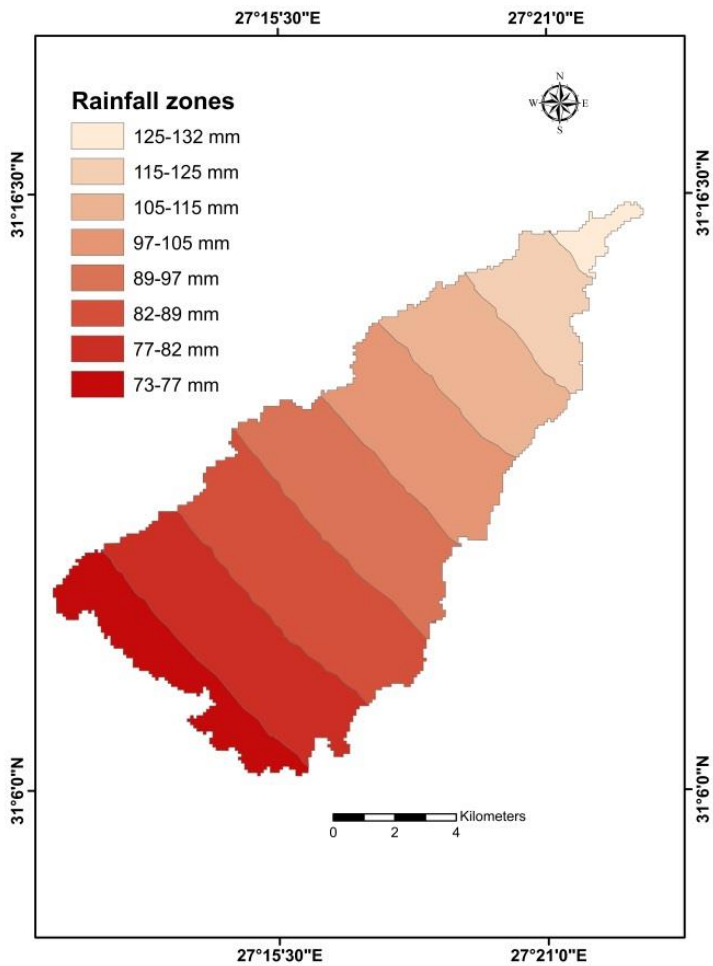


Figure 34: rainfall zones in wadi Naghamish

4.1.1.3. Topography and geomorphology

Wadi Naghamish emerges from the Southern plateau areas of the Southern borders of the wadi basin. The altitude varies from 180 m above mean sea level (msl) at the south until -2 m in the north. Figure (35) shows the DEM (digital elevation model) and contour lines of the wadi, while figure (36) shows the hill shade and the aspect in the wadi.

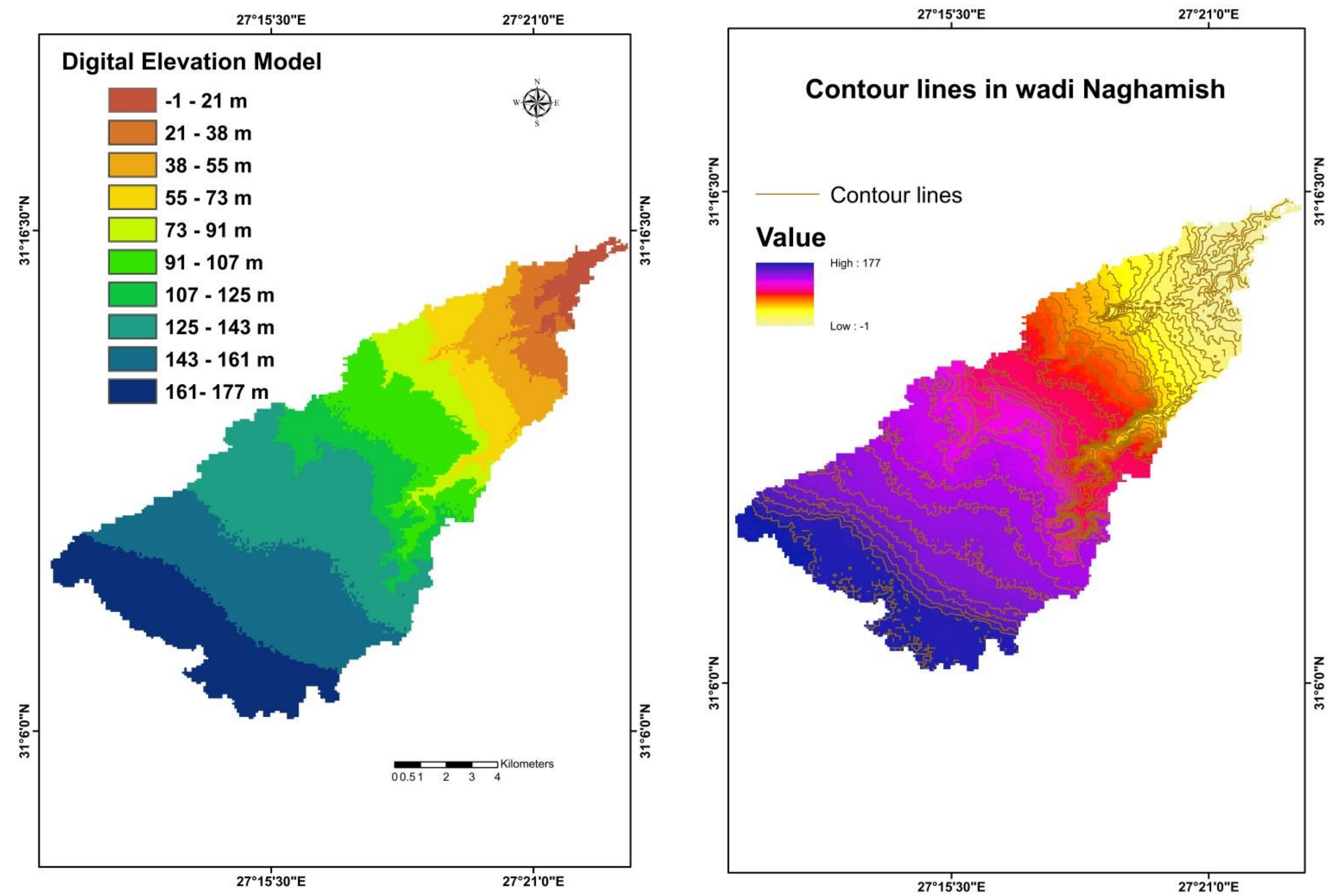


Figure 35: Digital elevation model and counter lines in Wadi Naghamish

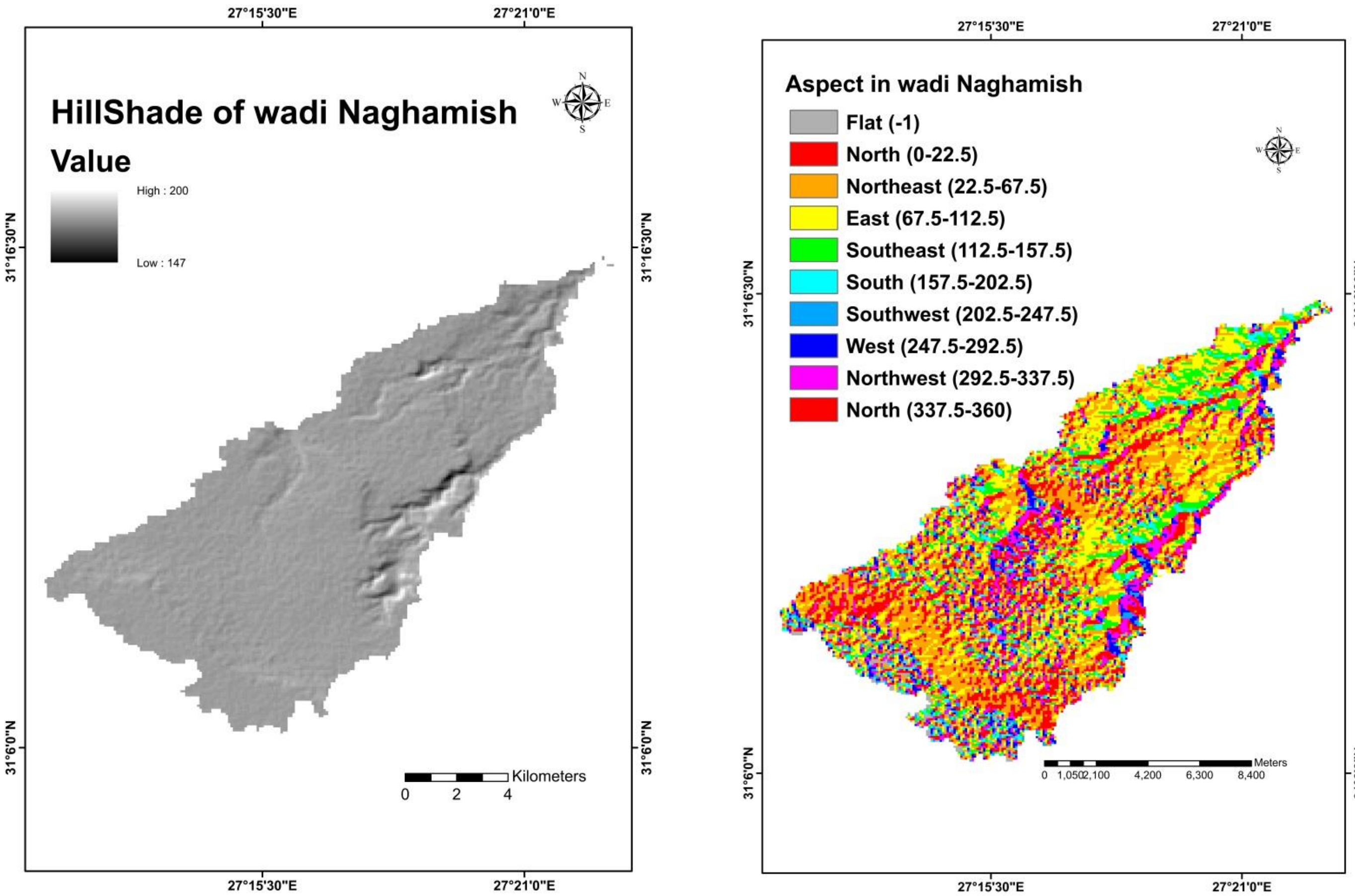


Figure 36: hills shade and aspect in wadi Naghamish

The total area of the studied area in Naghamish watershed is 141 km^2, consisting of five physiographic units which are: the wadi bed, desert delta, the northern plateau, the southern plateau, and the escarpments. Each physiographic unit has specific soil characteristics, with a large diversity among the previous units in terms of the shape of the land and the nature and density of vegetation cover. The total length of the main stream is around 20 km. Naghmish watershed includes 7 sub-basins. Each sub-basin has its own borders and several sub-streams, which at the end pour into a single outlet. Figure (37) shows streams net and sub-basins.

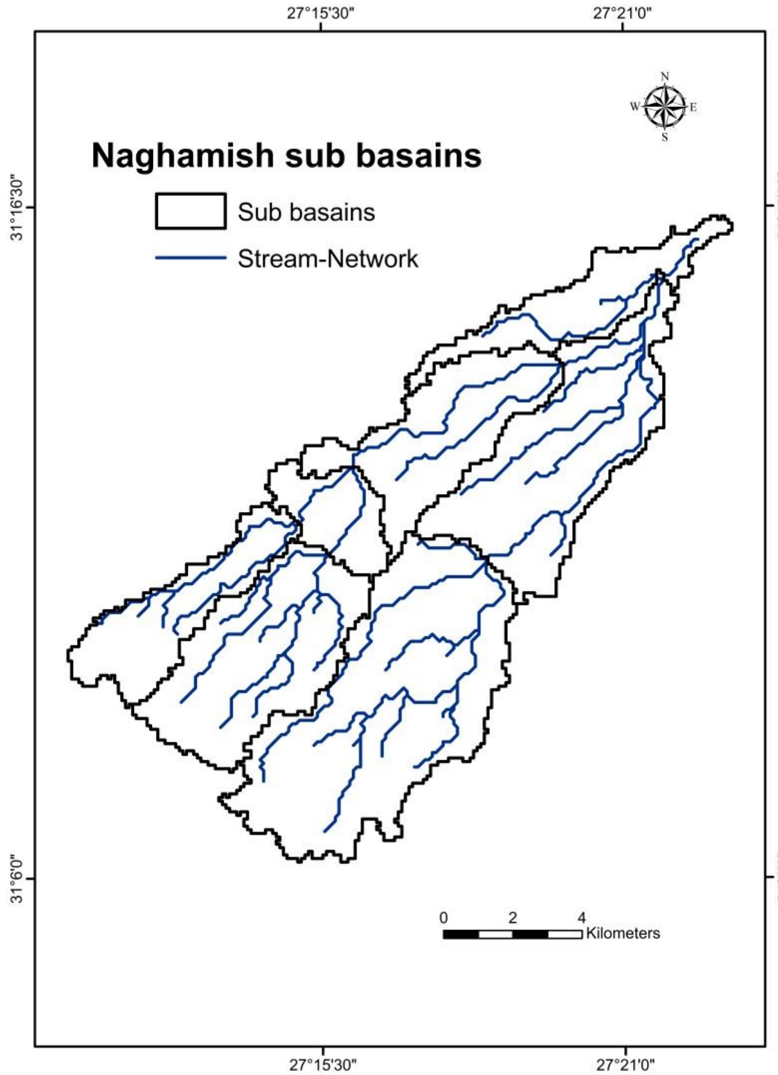


Figure 37: streams and sub-basins in wadi Naghamish

4.1.2. Natural resources

4.1.2.1. Soil of wadi Naghamish

Based on visual interpretation of SPOT PAN and XS images, DEM, as well as field and lab data, different soil polygons were digitized on screen. Twenty-eight soil sub units were identified according to soil depth, texture and salinity. It is clear that the very shallow, sandy loam, slightly saline soils occupy about 47% of the study area, followed by the shallow, loamy sand, slightly saline soils with an area of about 15% of the total acreage. Eight main soil mapping units were identified based on the original 28 soil sub-units and their taxonomic units table (10). Figure (38) shows the spatial layout of the main soil mapping unit. The physical and chemical of representative soil profiles are given in tables 2 and 3.

Parametric land evaluation procedure in the Arc View database was applied. The method takes into consideration three land uses, namely, tree plantation, cereal plantation, and grazing. Four soil qualities were used in the land evaluation procedure comprising soil depth, texture, salinity, and stoniness. It is clear that the area is dominated by class IV, which is suitable for grazing with 93.99% of the total area, followed by class III which is suitable for barley and wheat. Classes I and II, which are suitable for orchards represent only 1.21% of the total acreage and is located mainly in the wadi system and deep depressions (Abdel-Kader et al., 2004).

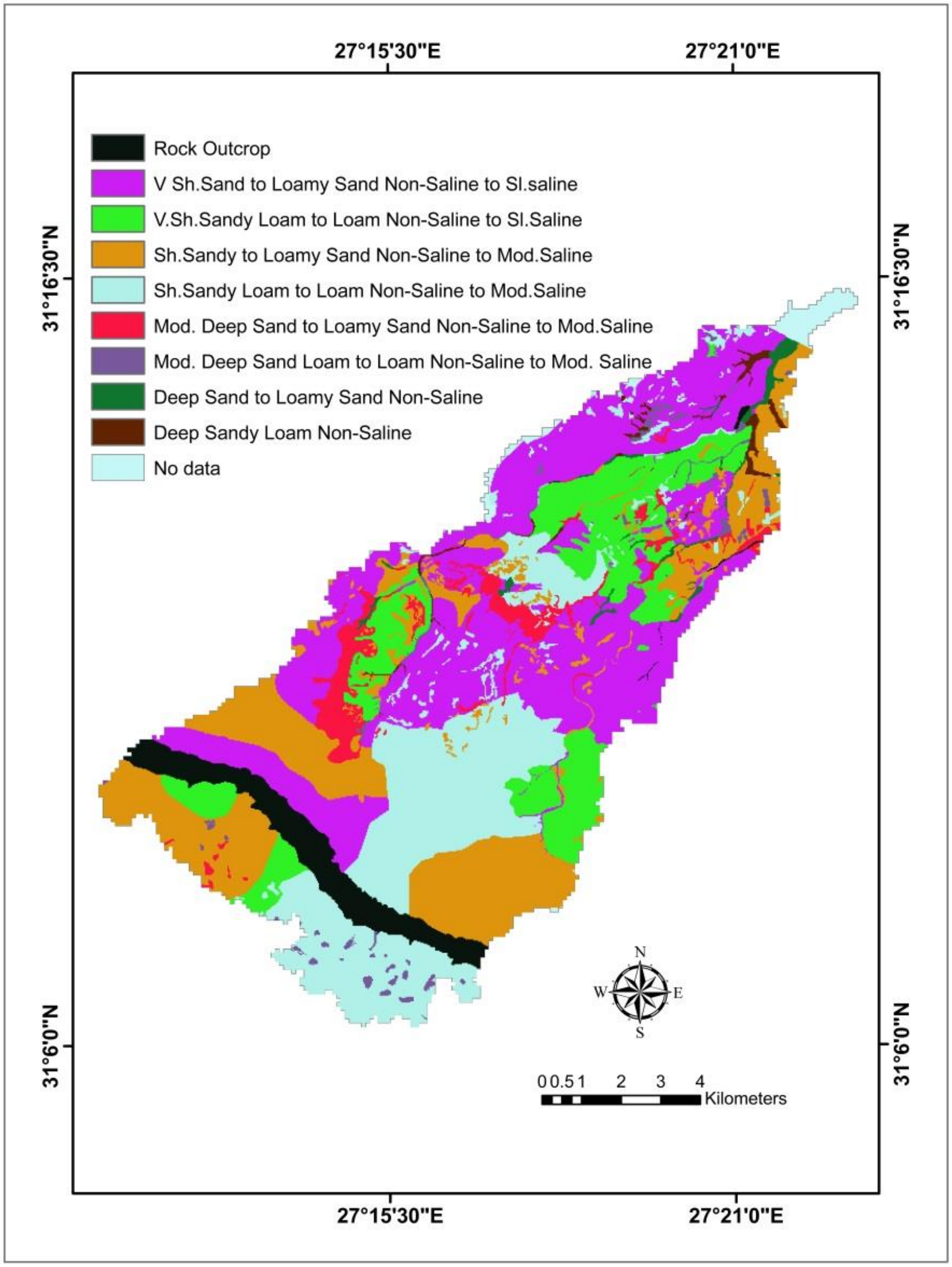


Figure 38: soil mapping units of Wadi Naghamish

Table 10: soil mapping units of Wadi Naghamish

code	Mapping Units Description	Area (ha)	%
1	Rock Outcrop	704.37	5.0
2	V Sh.Sand to Loamy Sand Non-Saline to Sl.saline (Lithic Torripsamments	3634.47	26
3	V.Sh.Sandy Loam to Loam Non-Saline to Sl.Saline (Lithic Torriorthents)	1476.59	10
4	Sh.Sandy to Loamy Sand Non-Saline to Mod.Saline (Lithic Torripsamments)	2002.76	14
5	Sh.Sandy Loam to Loam Non-Saline to Mod.Saline (Lithic Torriorthents)	1510.94	11
6	Mod. Deep Sand to Loamy Sand Non-Saline to Mod.Saline (Typic Torripsamments)	524.5	4
7	Mod. Deep Sand Loam to Loam Non-Saline to Mod. Saline (Typic Torriothents)	214.69	2
8	Deep Sand to Loamy Sand Non-Saline (Typic Torripsamments)	110.49	0.8
9	Deep Sandy Loam Non-Saline (Typic Torriorthents)	100.37	0.8
10	No data	3820.62	27
	total	**14100**	

4.1.2.2. Natural vegetation

According to (Abdel-Kader et al., 2004) in their study of Wadi Nagamish, they found that eighty nine percent of the land cover of the study area were composed of rangeland with varying quality and species composition. The various individual species identified by key informants, together with their Bedouin names and their palatability for sheep, goats and camels were identified. On the basis of a year-round species, 26 individual range types were aggregated into five main groups: Group 1 with Thymelia hirsuta dominant; Group 2 with Lycium sp. dominant; Group 3 with Atriplex dominant; Group 4 with Salsola vermiculata dominant; and Group 5 with Anabasis sp. dominant.

In terms of overall cover in the study area, Group 4 is the dominant range cover (58%), followed by Group 5 (18%) and Group 1 (11%). On a zonal level, this pattern is present in zones 1 and 3. Group 1, however, is predominant in zone 2. As a general pattern, grazing quality, both summer and winter, improves with distance from the Coast. However, ninety-nine percent of rangeland is classified poor in winter in north zone 1 compared to less than five percent in south zone 3 in the same season. In summer, ninety-nine percent of range in zone 1 cannot be grazed compared with less than ten percent in zone 3.

The vegetative cover has been exposed to a severe degradation process as a result of erratic rainfall patterns and wind erosion, combined with overgrazing and demographic pressure linked to the settlement process, which occurred without technical support to adapt to new production systems (MRMP II, 2000). Figure (39) shows vegetation in wadi Nagamesh (Southern plateau) in March 2013.

Figure 39: vegetation in wadi Nagamesh (Southern plateau), March 2013

4.1.2.3. Water resources

In Nagahmish area, cisterns remain the main source of drinking water for human consumption, in addition to the water supply from the main pipe of fresh water coming from Alexandria governorate. This last source of water concerns only the northern area of Nagamish wadi, closed to the pipe location along the costal line.

Five farmers have built wells to capture groundwater. But this experience has failed due to the low water resources and supply. And this water was very saline.

4.1.3. Social infrastructures

4.1.3.1. Roads

Two West-East main roads cross the Wadi Nagamish: (i) the international road Alexandria – Matrouh – Sallum in the North, along the coastal line and (ii) the army road in the South, at 20-25 km from the coastal line. Another North-South main road links the two roads with a total length of around 15 km. Two other small roads cross the area with length about 4 km. The following map of Figure (40) shows these roads.

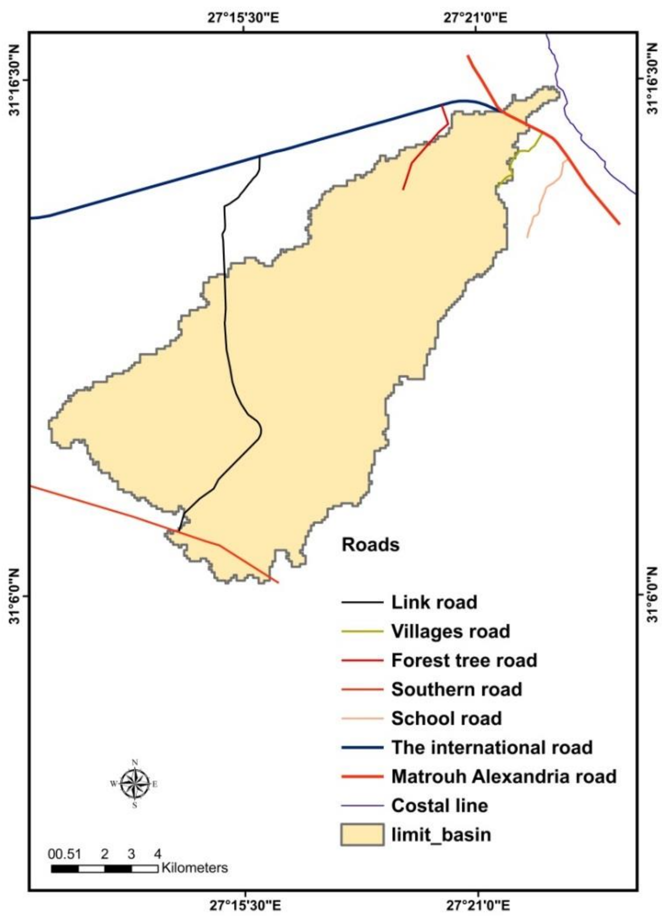


Figure 40: Roads in Wadi Naghamish

4.1.3.2. Education

In the study area, the school system stops at the primary level. There are five primary schools in the study area. While there are no preparatory or secondary schools, students are forced to go to the city of Marsa Matrouh, about 20 km in order to complete their education in the advanced stages. This raises a difficulty on families leading to “leakage” of a large number of them from education. This is one of the major factors that explain the low educational level in the zone.

4.1.3.3. Health

In the NWCZ, except Marsa Matrouh, the rural zones are only equipped with small health units. In the study area of Naghamish, this health unit is located at Garaoula village, closed to the international road. This health unit has a general practitioner doctor for the simple cases of emergency. For advanced health service care, local people need to move to the city of Marsa Matrouh.

The number of inhabitants in the study area around 2600 persons, covered by 1 doctor comparing with 1 doctor for 1070 persons at the level of Matrouh governorate and 1 doctor per 1472 at the level of Egypt.

4.1.3.4. Touristic infrastructure

Like other areas of NWCZ, tourism development in Naghamesh began in the eighties with the implementation of two touristic coastal villages covering a total area of about 125 feddans in the wadi. Before their installation, these lands were basically agricultural land, planted with figs and olive. This touristic development has had a direct impact on land access and land cultivation in this zone. Figure (41) shows the distribution of tourist villages in the study area

Tourism in Matrouh is seasonal, in summer season. It's the darling of the large sector, especially the young people who work in the tourism sector in the summer, but it represents a significant burden on water supply and transportation in the governorate. Where the number of tourists is very large compared to the number of population of the province.

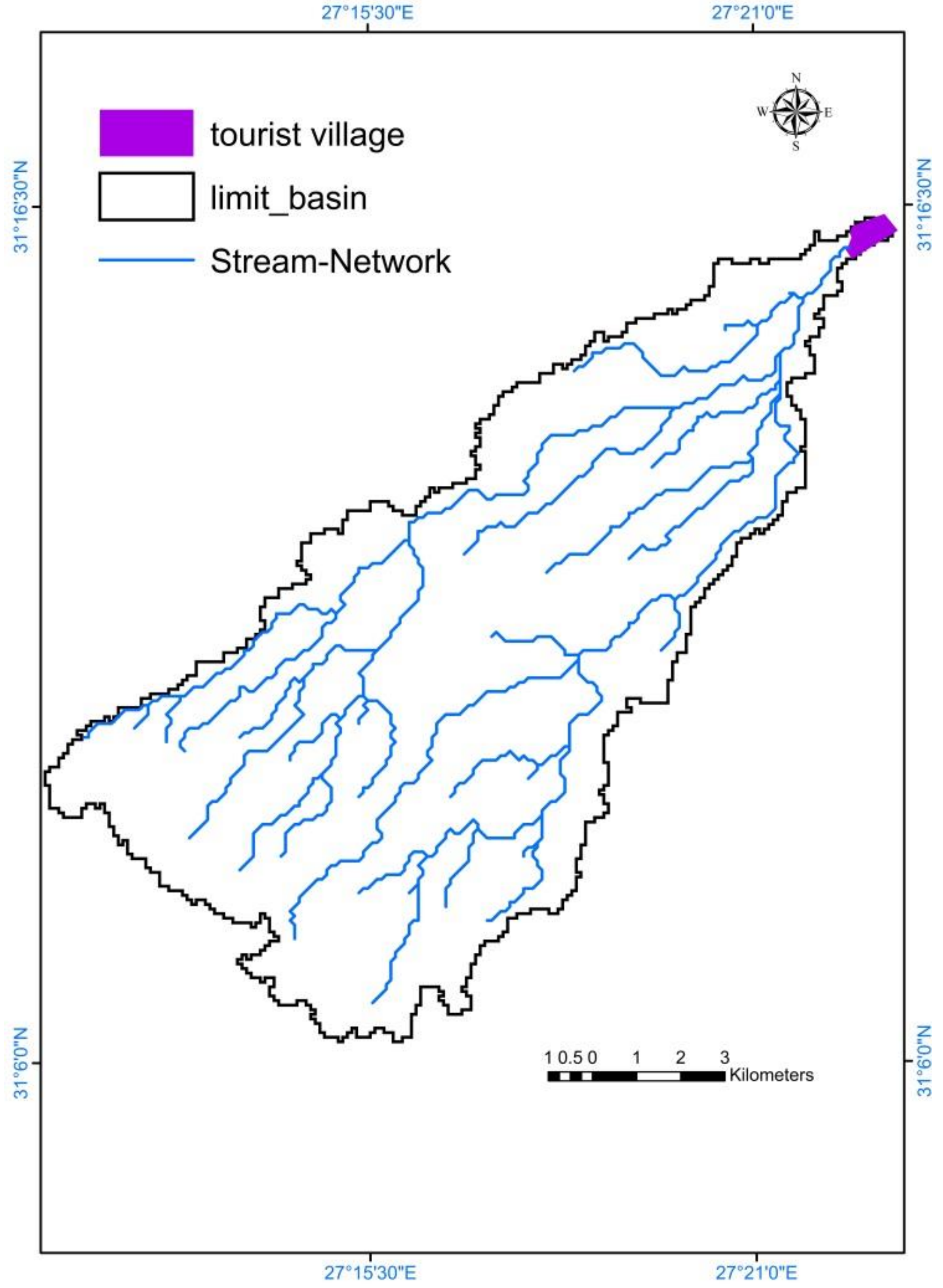


Figure 41: Tourism in Naghamish

4.2. Tribal and land history in Naghamish

According to the interviews we had with the local population to trace the history of the settlement of the land in the study area, the settlement started in the mid-nineteenth century with the arrival of the first tribes.

4.2.1. Tribal distribution

According to MRMP data, the study area is inhabited by five tribes distributed from the South to the North along the Wadi Naghamish. Those tribes are: ***Menfa, Gbihat, Hafian, Mawalek***, and ***Gnashat***. Each tribe is represented by clan "*bayts*" in Bedouin local language. The Figure (42) shows geographical distribution of the tribes along the wadi. And table (11) and figure (43) gives the composition of each tribe.

Menfa tribe is represented in the wadi area with only one clan "*bayt*", named Sebak who is composed with 43 families. This Bayt is located in the South (zone 3), upstream of the catchment area, at around 20 km from the coastal line. This zone represents very specific livestock systems with camels.

Gbihat tribe is represented in the wadi area with three clans "bayts" (*Al Borma* with 25 families, Maiof with 43 families, and Bokhatrah with 7 families). This tribe is mainly located in the middle area (called Zone 2) and the families are concentrated along the wadi bed and the wadi branches. Their main systems are mixed crop-livestock systems based on livestock (small ruminants), barley, figs and olives.

Gnashat tribe is represented in the wadi area with 3 clans "*bayts*" (Abu Baker comprising 45 families, Abd Allah with 45 families, and Msarna with 62 families). This tribe is located in the Northern area (Zone 1) closed to the coastal line.

Mawalek tribe is represented by one clan "*bayt*" and 9 families and is located in the south of the zone 1. And,

Hafian tribe is located in west area of the watershed area (Zones 2) and is represented by one clan "*bayt*" and 25 families.

In total, around 374 families belonging of these five tribes are living in the Wadi Nagahmish. Each family consists of around seven persons (husband, wife and five children).

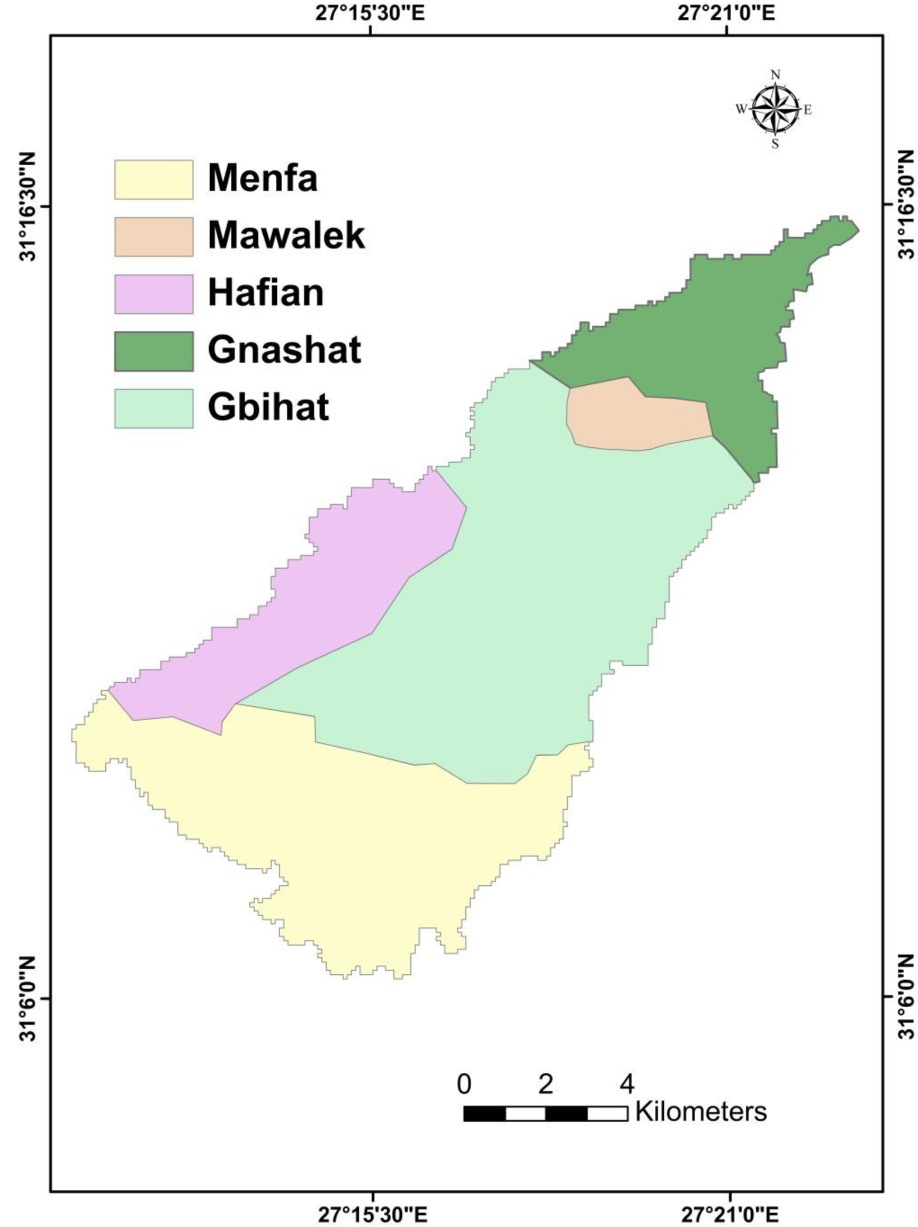


Figure 42: Geographical distribution of tribes in Naghamish

Table 11: Numbers of clan's bayts and families for each tribe in Wadi Naghamish

Name of tribe	No. of bayts represented in the study area	No. of families
Gnashat	3	152
Gbihat	3	145
Menfa	1	43
Mawalek	1	9
Hafian	1	25
Total	9	374

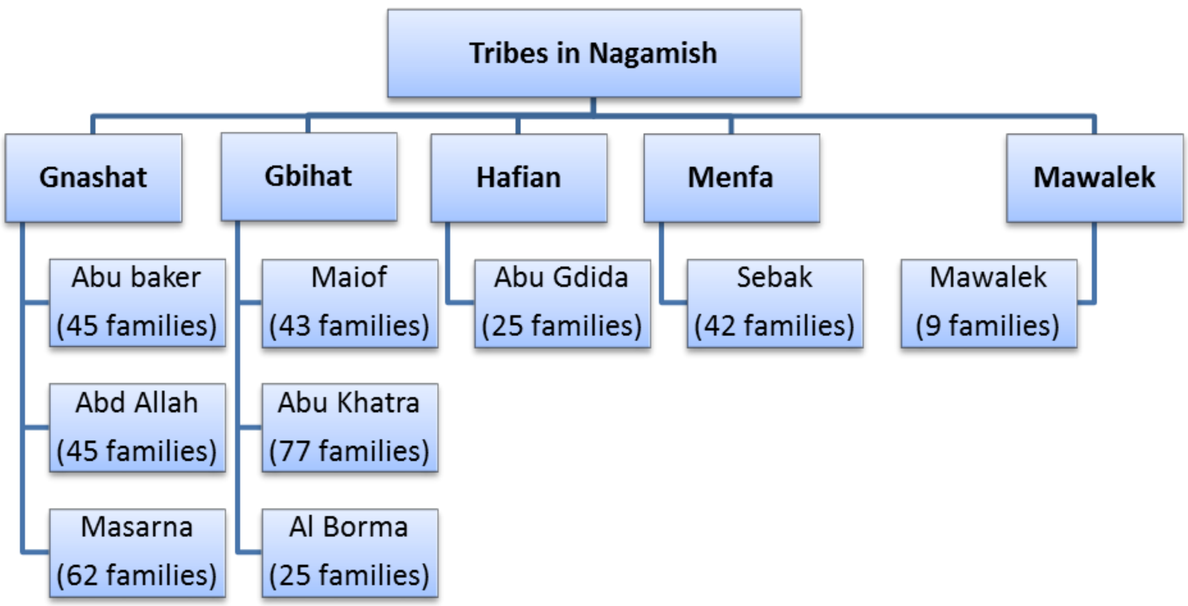


Figure 43: Trubes and clan in wadi Naghamish

This tribal geographical distribution induces very specific farming systems (crop and livestock systems) for each tribe. This induced also some conflicts at the border line of the tribe territory. Moreover, along the wadi, tribes used the dykes as personal dykes without considering farmers down and up-stream. This raises some regular tensions between tribes as if nowadays these tensions are less violent due to a type of consensus in the geographical distribution of resources. However this inequity in link with resources access constitutes a major challenge in the zone.

In summer, the south tribe, mainly Menfa, continues to practice herd mobility from south to north for grazing. Due to the change in land use, majority of them rent the land.

4.2.2. History of settlement in Wadi Naghamish

The history of the area in zone 1,2

Gnashat tribe settlement in Naghamish has started in 1925. The Omda Mahmoud from the tribe *Gneshat*, decided to rent the wadi area land from the Egyptian Kingdom. The rent was based on the payment of a quarter of the production to the Egyptian kingdom. At this time, the wadi was cultivated with figs, some cereals (barley and wheat) and breeding of pigeon. There were some conflicts between the Gneshat tribe and their neighbors. And, in 1972, these conflicts led to the first land distribution at the tribal level between three tribes Gnashat, Mawalek, and Gbihat.

In 1977, the NWCZ reconstruction organization started to develop the wadi through constructing the cemented, dry stone and earthen dikes and cisterns in the wadi. This project was implemented in cooperation with international development programs such as FAO and WFP (see chapter 1).

Before this project, there were only 5 cisterns in the area for drinking purpose for human and livestock. Only 2 sub-ground wells, called Ead, and 3 Roman cisterns were present and dated from the roman age. At this time, each family used only two gerba (unit based on the capacity of animal skin), which equaled to 3 German jerricans or 75 liters per day for the family.

The first people who cultivated figs in the area were al *Shtor* tribe in Al Dakhla area in Ras El Hekma in 1948. The first time to see the research and development projects was in 1947, in Fuka area. Its name was (*Al Nokta Al Rabaa*) what is meant the fourth point. They used the ground water to cultivate a new plant which was called by the Bedouin *kataf*, and the researchers call it Barsim Hegazy.

The concentrate appeared in the area in 1984. Before this time there was no supplementary feeding to the animals. The spring period was ranged between two and four months. In summer, they were depended on the dry grass. During drought year, they can go to another area to graze if there were no houses. Or they can go to Behaira governorate. Generally, during drought year, the lambing was one time per year compared to two lambs in good climatic year.

History of zone 3 (History of the *Bayt Sebak*)

Sebak is one of the bayts who leave in the south of wadi Naghamish area in Zone 3. This bayt is one branch of Menfa tribe. The grandfather of Sebak bayt, called Shahin, came from Libya to the area in 1840 with his son, Hamed. Shahin was graduated from Jaghbub Islamic Center of Sunosia in Libya. At that time, the land was common with the right to move to any place for searching water and rangeland. Shahin decided to stay in this place and his son, Hamed, has been married and got 11 boys. Generally, the family stayed in the area during the winter and spring periods and move the rest of the year to Tamira Oasis, which is located between Matrouh city and Siwa oasis at about 150 km at the south of Matrouh.

In 1920, the land ownerships called *Al Houz*, started. Sebak family got their land after a hard effort with their neighbors from the other tribes. Up to now the land is remained common at the level of the family. The main reasons declared during the interviews are: ‘in general most of the land in the south is common’, ‘most of the land was rocky land’, and also “oil hasn’t been found there”.

From 1840 to 1984, Sebak family lived in tents. In 1984, the Egyptian government in cooperation with the World Food Program (WFP 2270) started to settle the Bedouin society through constructing houses. The last tent in the area of Sebak family disappeared in 1989. All of the members of the Sebak live in houses after this date.

The main activities of the inhabitants in Sebak area was breeding sheep, goats and camels, and in addition cultivating barley in the depressions. Until the year 1995, the area was very rich with a dense natural vegetation cover. The livestock population was estimated at several thousands. After 1995, the drought has severely affected the area with rapid desertification and land degradation. The interviewers mentioned a completely stop of rain at this date. But the southern dry wind continued to crack in the area. The vegetation cover began to disappear in some places and the soil became very easy to be eroded. This bad situation has persisted for about 15 years. The results are dramatic. Nowadays the soil is only bare rock.

This event has completely changed the landscape and human activities, compared to zones 1 and 2. Most of the inhabitants of this part have migrated to Matrouh city.

4.3. Description of the main farming systems

4.3.1. Farming zones in the NWCZ

Shalabi in (2000) reported that, for purpose of agricultural classification, all the development projects in the zone (e.g. FAO 1970, ILACO 1976, Pacer 1986) used to classify the production systems according to 3 strips that correspond to 3 areas according to their distance from the sea:

a) Coastal cultivation strip: This strip extends from the seashore to 5 km inland, including the beach and the coastal plain. Annual rainfall is about 150 mm. Cultivation of orchards and vegetables predominate especially in the deltas of wadis. The inhabitants are settled. It constitutes 5% of total land.

b) Inland mixed production or grazing-cropping (barley) strip: This strip is located between 5-15 Km from the coast. Annual rainfall is 100-140 mm. Soils are mainly poor calcareous soils. Grazing (especially sheep and goats) and cropping are the main activities. Inhabitants are sedentary. This zone constitutes 22% of total land. With the development of dykes, we can see the extension of orchard plantation in this zone. Some authors speak about tree-crop-livestock system in this strip (MRMP II, 2000).

c) Inland grazing (Rangeland) strip: This strip lies between 15 and 50 km from the seashore. Annual rainfall is from 50-100 mm. Grazing predominates with some barley cultivation. In the wadi Naghamish, due to the last drought and erosion, this zone is completely devoted to grazing now. This strip constitutes 73% of total land in the NWCZ.

Based on the previous division of the area based on the distance from the sea coast line, wadi Naghamish basin can also be distributed into these 3 zones, figure (44).

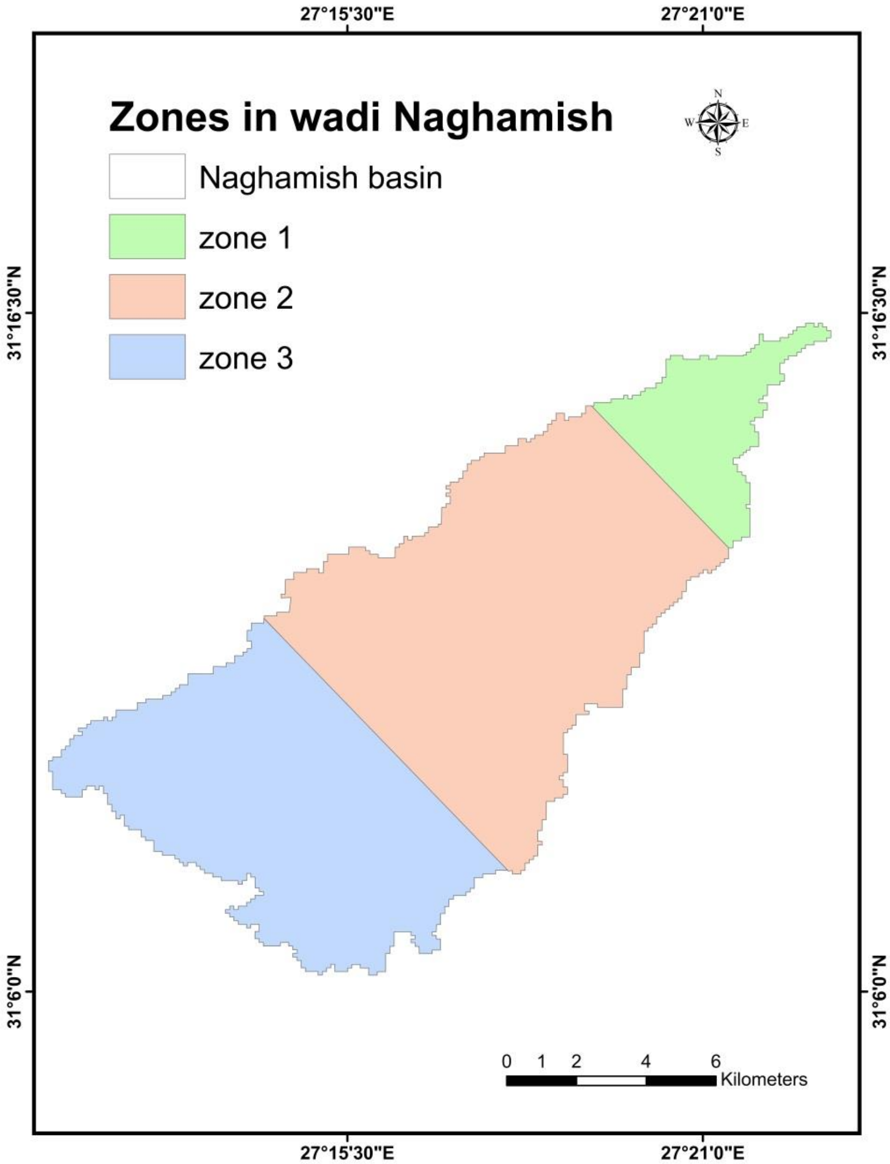


Figure 44: Zones in wadi Naghamish

Each strip has their own distinctive characteristics in terms of farming systems and demographics that explain the local diversity of strategy faced to drought.

4.3.2. Farming systems in wadi Nagamish

4.3.2.1. Farming systems in the coastal agricultural zone (Zone 1)

In wadi Naghamish, the area that extends from the coastal line to about 5 km to the south is characterized as follows:

Tribes: In the area, the main tribe is Gnashat belonging to Ali Ahmar as a 'main tribe'. And we can find also some families from Mawalek tribe.

Wadi development: The wadi bed area is well developed with several types of water harvesting techniques, such as cemented stone, earthen, and dry stone dikes. All these water infrastructures have been constructed in the eighties and nineties in the last century, during the different programs such as "reconstruction of desert organizations" -which are now called reconstructions of North west coast area with cooperation of the FAO and World Food Program. These developed projects such as FAO, WFP and MRMP focused on the increase of the potentialities of natural resources (soil and water).

The farming system is mainly composed of orchard, livestock, and crops. And the orchard cultivation, especially figs, is predominant in the economic activities of these farms. This area has a big potential of soil and water. The soil represented in the wadi bed is wide in the north (closed to the sea) and it is composed of the sediments transported by water from the upstream to downstream. This soil presents a suitable depth (more than 2 or 3 meters) for orchard trees. And, due to the proximity to the sea, the rainfall amount is relatively high in this area. However the livestock is very limited due to the orchads' orientation and the risk of divagation. Sheep and goats may cause damage to those plantations and also create tensions between farmers. The barley area is also limited due to the landscape of the area which consists of wadi area surrounded by rocky lands of the wadi sides or escarpment which cannot be cultivated with barley. The people prefer to cultivate the figs in the wadi bed and barley only in some areas which cannot be cultivated with fig trees in the wadi bed.

Family activity and live conditions: Majority of these farmers in the zone has also a civil job in the governmental organizations at the central level due to the localization of all the governmental services in this zone. This is allowed thanks also to the higher level of education than in the zones 2 and 3. The housing conditions are also more comfortable with modern materials (concrete), facilities (washing machines, refrigerator, television) and modern design.

Drinking water: The main source of drinking water is the cisterns, in addition to water from the fresh pipe water coming from Alexandria city. This last source of water comes by trucks from the main pipe station located on the international coastal road. The transportation cost increases too much for zones 2 and 3. However, due to the high use of chlorine in the water transported by truck, mainly due to infection, this water is mainly used for all cleaning purposes and families prefer to use the water of cisterns for drinking purposes.

4.3.2.2. Farming systems in the mixed production zone (Zone 2)

Tribes: This zone is constituted by a low plateau that extends from about 5 to 15 km. This zone is inhabited with two main tribes: Gbihat tribe belonging to Sengor tribe (as main tribe or mother tribe) and Al Hafian tribe belonging to Awlad Kharouf as a main tribe.

Wadi development : some of the wadi land is well developed with dikes especially in the land belong to Gbihat tribe, while the area owned by Al Hafian tribe is poorly cultivated with low agricultural development. This is explained mainly because of the status of land that remains common property of the tribe. This situation becomes more difficult due to the high cost of reclamation of the soil particularly in this zone.

The farming system type: the FS is mainly mixed farming systems with livestock, crops, poultry and orchard. The main activities are livestock and barley cultivation. Due to the drought, we have observed a rapid increase of the poultry farming in this zone as if this activity requires a significant capital. This activity has started since the last 6-years. Despite the high degree of risk in this activity, it is considered as a successful activity for local farmers who had the chance to start it. However, small ruminants remain one of the sources of income especially in the drought period.

Living conditions: The quality of the live condition is less than zone 1. This appears mainly in the material of the roof that can be with wood. In this zone, the main cereal crop is barley for grain and residues for animals.

Drinking water: The main source of drinking water is also the cisterns. Rainfall is the main source of the cisterns, while it can be transported by truck from the Alexandria pipe line with higher cost more than zone 1.

4.3.2.3. Farming system in the pastoral zone (Zone 3)

The area which covers the upper plateau of the wadi extends from more than 15 km to 20 km in the south. This area is completely different.

Tribe: *Menfa* tribe which belongs to Awlad Kharouf as a main tribe is the only tribe in the area.

Farming system: This area was significantly affected by drought during the last 15-years and has known a high degradation of his vegetation cover and soil. The vegetation cover disappeared completely. In this zone, according to interviews, the last good rainfall was in 1995. After this year, the rainfall has not fallen. Due to the disappearance of vegetation cover, the wind started to erode the soil. Currently, the zone is mainly bare rock. In the past, this zone was famous with livestock breeding and barley cultivation, and with seasonal cultivation of watermelon in the depressions. Livestock was the main activity with large flock. With the drought, the flock has known consequent reduction.

Wadi development: the zone located in the southern part of the wadi. The wadi streams and branches do not reach to it.

Living conditions: The live conditions in this zone are very difficult due to the lack of electricity and the low level of rainfall to fill the cisterns for drinking water. The inhabitants are obliged to buy the water for the human and animal consumption from Matrouh or from the pipe.

Drinking water: the cisterns are the main source of drinking water. Rainfall is the main source of the cisterns, but, it is rare to fall in the last 15 years due to the drought. The zone depends completely on the transported water from Matrouh city or the Alexandria water pipe.

Diversification: In this zone, people have been obliged to find new alternative such as jobs in Petroleum Company or periodical migration to Libya to work as shepherds. Very small number of them works also in Gulf countries as a camel shepherds.

This zone has not yet known the return of rainfall after 2010-2011 as in the other zones.

Conclusion:

This chapter gives the detailed description of the wadi in terms of location, climate, demographics, and history of settlement and farming systems. We can observe a high diversity of farming conditions in the study area in terms of social composition, natural environment and infrastructure development from a gradient North-South. This gradient has affected the ability of these communities to adapt to the different risks, especially the drought that has affected the whole zone during the 15 years. Different adaptive strategies can be observed according to the available natural resources and they are mainly based on diversification of sources of income in case of a lack of resources and lack of flexibility in their natural environment.

Based on this social and natural context, we will try to understand the adaptive strategies of each social group along the gradient North-South in the chapter 5.

CHAPTER 5: ADAPTATION PROCESS AT THE FAMILY AND COMMUNITY LEVEL: SOCIO-ECONOMIC APPROACH

Introduction

In this chapter, we propose to discuss the most important changes that have affected the Bedouin society and now that explained the newly Bedouin community functioning. In the past, this Bedouin community used to be a nomadic society with strong identical characteristics due to their tribal organization and resource management. Over the last 50 years, this nomadic live-style has completely disappeared due to the complex social changes generated firstly by the tribal land distribution in the beginning of the 1920ies and secondly by the successive development projects and policies that have encouraged Bedouin settlement since the 1950ies.

Nowadays, the newly Bedouin community use to live in houses; livestock is mainly raised around the house with only some seasonal transhumance (2-3 months). In the region, the development of orchards has induced significant changes in the relationships with land that is now the main support of their economic activity.

All these factors have induced deep changes at the family and community level in terms of traditions, habits, and more generally social live. We propose to analyze these changes at the family unit and the activity system to see how the last drought has accelerated or no these changes during the last 15 years. For the interpretation of changes, we propose to combine factual information (i.e. the activity management such as livestock or crop management) and representations declared by the people. So, in this part, all the data come from the 50 family surveys conducted in 2012 and the interviews conducted near key resource persons at the governorate level.

5.1. Bedouin family unit: new identity or only adaptation to new context

In this first sub-chapter, the objective is to explain the different changes that have been occurred in the current life of Bedouin families related to habits and tradition (inheritance rule, marriage, etc.), housing and consumption pattern, and family relationships (decision making or responsibility within the family). The analysis of the multiple changes in different domains of the Bedouin live will allow distinguishing short term changes due to punctual adaptation to the drought and long term changes that will have definitive impact on the social functioning of Bedouin society and their relationships with the resources (water and land).

5.1.1. Bedouin family identity: culture heritage (habits, tradition and marriage) and inheritance

Bedouin community is commonly described with strong and deep customs and traditions, that make their own identity and by consequence their main differences from the other communities such as Nile communities in Egypt. However the rapid changes observed during the last 50-years had some consequences on the tradition and social rules of Bedouin. These changes can be considered long term changes as soon as they induced deeply changes in the traditions. In this part attention will be paid to the drivers of changes, in particular the role of urbanization.

5.1.1.1. Bedouin Culture Heritage

Bedouin community has its own heritage well represented by specific clothes, the traditional use of tent, and local hand making as carpet. The traditional dress in the Bedouin society as shown in figure (45) is still used by the Bedouin community who live in the desert. However, near the main cities, notably Marsa Matrouh, Bedouin community has adopted the occidental dress style. This adoption is mainly conditioned by the new positions in the local administrations or it is also an obligation in schools. This dressing difference is the same in wadi Naghamish when we observe the way of dressing between the Northern cities compared to the south.

There is also a change of dressing style between generations. The youth adopt easily the modern clothes, more fashion; this also reflects a certain level of education. This facilitates also contacts with other Egyptian communities. These rapid changes in the dressing show a long term change in link with the new young generation habits even if it can be considered as an act unworthy of their age for oldest generations.

Figure 45: traditional Bedouin dress

In the same idea, for traditional Bedouin, tent remains the traditional housing of the Bedouin community even if, now, tents are only used for occasions or temporary residences when the family moves place to place for agricultural purposes: to raise barley, figs or olives. In Naghamish wadi, none still live in tent. And, more generally, there is no longer nomads living in tents in the whole NWCZ. The results of the survey show that there is a limited number of traditional tents which have been made earlier. And nowadays, the endogenous knowledge to manufacture these tents is quasi-absent; few old women could do it. So, this tradition is in the way of disappearing.

We can observe a similar change for textiles. In the past, women usually made their own wool and they manufactured themselves the traditional carpets. Nowadays, this hand making process is in the way of disappearing. Only few women maintain this activity for economic purpose, mainly for touristic complex. The results of the survey show that families keep the handmade carpets as a sort of family heritage from the past. This change results not only from family changes (knowledge, time) but also from the high competition of manufacturing carpets at low price in the global market (in Egypt and out of Egypt).

All these changes related to clothes, tent or carpet, are the first visible signs of a rapid change of Bedouin society in link with the globalization. The immediate consequence is an easier insertion in the Egyptian communities, but also this induces a definitive loss of a part of identity due to the loss of the traditional knowledge.

5.1.1.2. Place of women in traditional Bedouin society

We can observe three main changes for females in the traditional Bedouin society.

Preventing the inheritance of females was one of the most expanded internal laws in the traditional Bedouin society. This traditional law is in the process of extinction even if some families continue to practice it. The main reason of this practice was to limit the land access to anyone from outside the tribe with consequence on tribal resources distribution. Nowadays, a large proportion of female Bedouin can take their part of land inheritance, but with significant difference between remote desert areas and coastal zone. In Naghamish in zone 1 and 2 people are more linked to city, therefore they are more imitating the habits of the city, which give more rights for the women.

Another deep habit was to "catch cousin girl" in the tribe (*Mask Bent al Am*). The term of ‘Cousin’ in Bedouin community can be extended to any girl in the tribe. This habit was developed in order to avoid any marriages outside the tribe, except with the permission of male cousins. This problem raised strong social injustice for women. In some cases, this led to prevent her of marriage lifelong. The survey results show that this habit would have disappeared. However, the father of the girl can take the opinion of the male cousins in respect of a collective decision. And now father also consults their girls before taking any decisions. It is admitted that no one can force the girl to marry someone she does not want even her cousin reject.

Another habit was related to girl education. In the past, most of the Bedouin didn't want to educate their girls due to social habits; they did not promote the education of girls, mainly in the places where the customs and traditions warns mixing girls with boys, especially with the progress of age of the girl, in addition to the long distance between their houses and schools. At present, except in remote zones, majority of girls, achieve their primary school. However, fathers don't interest with educating of girls after the primary. For them, the level of reading and writing is satisfying. Also they are afraid to send a girl alone to city. The situation is different in urban area where Bedouin residents in cities try to educate their girls up to higher education stages.

From these different aspects of the position of female in the Bedouin society, we can observe a rapid change for females even if some inequities persist according to the zones, and mainly the distance to cities. The difference of education level of the head of families through different zones explains partly the difference in the maintenance of these habits. This change is in line with the regional trend of education expansion at the territorial level.

5.1.1.3. Increase the proportion of learners

The term of 'Learners' gathers the educated people in Egypt. In the past, the learners' rate in the Bedouin community was very low: The main reason was due the lack of schools in remote desert areas and not to any reluctance of education. This was reinforced by the difficulty to organize an education system that fitted to nomadic live conditions. So, in the past, the education was mainly based on temporary training to reach the level "read and write", which was called *Kotab*.

Since the 1950ies, the encouragement of Bedouin for settlement has helped greatly to increase the proportion of learners. The process of settlement included also the establishment of social infrastructure as schools for these stable communities. Given the difficulty of establishing schools in all villages scattered in the desert, the system of one-class schools, based on one teacher and one classroom, has been developed. This type of school has appeared in the sixties. It is called also, ‘societal’ or Ahlia in Arabic. It is under the supervision of the ministry of education. This type of education has been firstly developed for girls schools in 1994 to accept the girls over the school age (generally 6-years old). In 2006, some mixed schools have been developed to include male and female students.

Nowadays, the Matrouh Governorate counts 149 one-class schools (Matrouh Directorate of Education). The teachers are often residents of the village with medium or high qualifications. With the increase of number students, those schools are now replaced with primary schools, Prep Schools, mainly in villages with high densities of population, while secondary schools are found only in the big cities. The total number of primary school are (206), preschool (91), secondary school (14) (Matrouh Governorate)

However, the number of university graduates remained very low in Matrouh Governorate compared to the rest of Egypt. This is due to the absence of university in Matrouh Governorate. Since 2013, seven faculties depending on Alexandria University have been developed in Matrouh: Agricultural faculty, veterinary, tourism, Nursing, Kindergarten for girls, Physical Education for boys and education faculties.. However majority of the students are originated from the city.

5.1.1.4. Perception of changes of habits and traditions

Although we have observed strong changes of habits or traditions (see above), the results of our interviews in wadi Naghamish show that there is always a strong attachment to habits and traditions in the Bedouin society. For example, all interviewers (100% of our sample) mentioned that there is no change in the relations between them and their social leaders represented by Omdas and Sheykhs, and their adherence to Bedouin habits and traditions. This reflects well what we can observe in the desert. However, we can see important changes in social habits, especially in the cities such as Marsa matrouh, which now include mixed cultures from different areas all over Egypt. There is no doubt that the mixing of Bedouin with the other cultures in the city will induce long term changes in the Bedouin social habits, as we have shown before (e.g. education, female status, etc.).

However, even if we have observed important external changes in the customs and traditions in the Bedouin community, majority of interviewers remained committed to a lot of customs and traditions, such as the respect of mayors and Alawaql commitment to Bedouin uniforms, especially in remote places from the city's, commitment to habits marriage and several social events. The same habits and traditions of marriage inherited hundreds of years ago are still continuing to the present time, like preparing lunch and dinner meals for guests…

According to our interviews, these changes are not considered as profound changes, while they are related to some behaviors in the special occasions.

5.1.2. Socio-economic changes in the Bedouin society

5.1.2.1. Style of housing and living place

The field survey conducted in 1990 by the Qasr Rural Development Project (El Miniawy et al., 1990) showed that: 93% of the people in zone 1 lived in houses and the remaining 7% had both house and tent; 48% of those living in zone 2 had a house against 41% had both house and tent and 11% had tent only; and, finally, 49% of those living in zone 3 had a house, against 27% had both house and tent and 24% had a tent only. So, this survey showed that 11% in zone 2 and 24% in zone 3 were always living in tent in 1990 with a nomadic lifestyle.

In the past, according to our survey, Bedouins used the tent beside the house for different purposes, such as meeting, celebrations, living room especially for the men in summer, or even housing for migrant workers. At present, tents is only used for special occasions or when the family moves to work in other places, mainly for harvesting works for barley, fig or olive. In 2012, in our survey, one hundred percent of the population lives in a house in the three zones. So the nomadic lifestyle with tent has completely disappeared in the studied area.

In 1990 the majority of houses were built with stone blocks from Matrouh. The use of this material was influenced by the WFP project which has asked to each family to bring the stones to be qualified for housing funds. According to Bedouins, cut stone blocks were cheaper and easier to use than the irregular boulders and stone found in their land because of the difference in wall thickness and labor cost. Concrete block houses were rare at that time. The traditional method of using locally handmade mud blocks for bearing walls has been partially abandoned due to the requirement to use stone (El Miniawy et al., 1990).

At present the old style houses are found only in the southern region in zone 3. And, in zone 1 and a large proportion of the zone 2, farmers have built concrete houses.

5.1.2.2. The designs of the houses

At the beginning of the settlement and the construction of the houses in the NWCZ area until the beginning of the nineties of last century, the architecture of the houses of Bedouin was very simple design. The house consisted of two rows of rooms on both sides. The guest room called (Marboaa) had a separate door to the outside away from the house to avoid seeing women by the guests (Figure 46). The kitchen was a stand-alone outside the home. The majority of the houses were built with stone. Clay was used instead of cement. The roof consisted of wood.

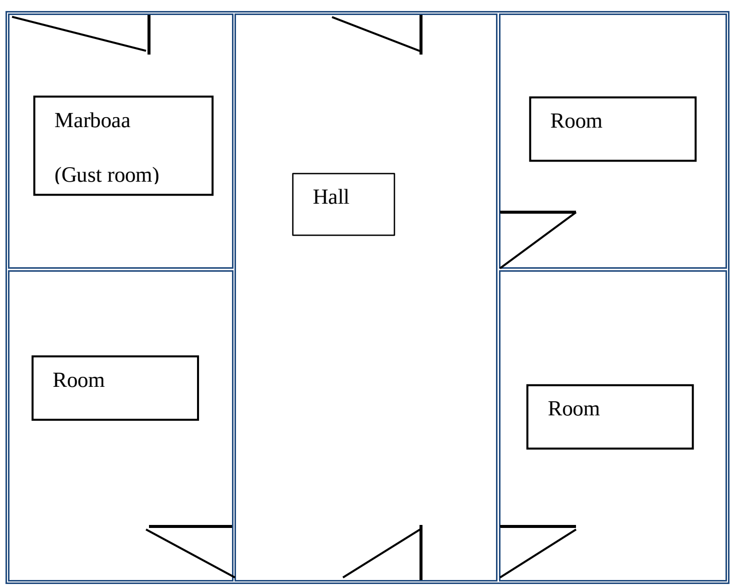


Figure 46: the old Bedouin houses design. Source: (El Miniawy et al., 1990)

Nowadays, the house design became more complex and modern (Figure 47). The main difference is that the majority of the houses are constructed with regular limestone rocks. The house is surrounded by at least one balcony. The roof is in concrete. The cement is used as a material for building. Generally, the house comprises two kitchens: a small one in the house and a big one outside the house.

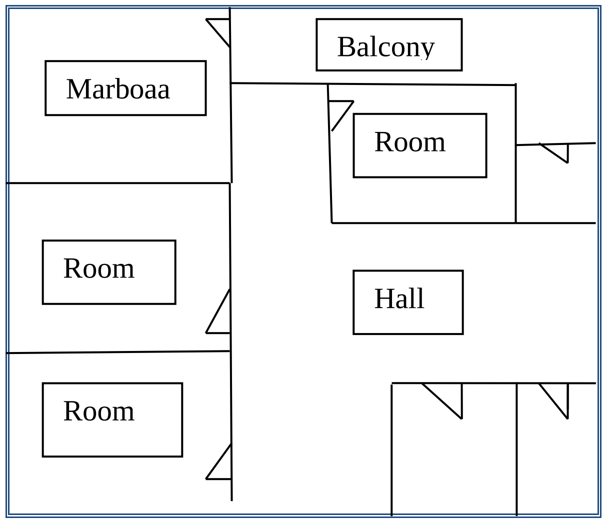


Figure 47: Modern design of Bedouin house

In Naghamish area, the old house design is still dominant in the southern area (zone 3). The main reason is due to the economic impact of the last drought that has prevented them to have the means to renew their house. This region has been the most vulnerable to drought, depriving the inhabitants from their main source of income (mainly from barley and vegetation cultivation, and livestock rising). The second reason is the feeling of the population that, this region becomes surrounded by a lot of risks, and there is no future in the area. And, in this context, investment in the establishment of modern houses becomes useless. Especially with the absence of electricity, education and health care, there is no hope for young generations. The only catalyst for the survival of the population in the region is the desire not to leave the land of their forefathers. This explains partly why they haven't left their land yet.

The modern houses in Naghamish are found in the north and middle zones (zone 1 and 2). The economic situation of the population in the northern region is much better than the southern region for a variety of reasons: the most important one is the existence of many alternatives for the population to cope with drought. Moreover, due to water infrastructure on their owned lands in the wadi bed planted with figs, olives, they can add supplementary irrigation for trees to get crops in times of drought. A variety of farming systems has also allowed them to get new opportunities to be more flexible and resistant to drought such as the opportunities to get jobs in the city, without abandoning their farm due to the proximity. Also, the access to the main facilities as electricity, roads, transportation, education and health care has encouraged them to stay with the whole family. Moreover, they expect that urban sprawl and the extension of the city will reach them in a few years and this encourages them to invest in the construction of modern houses.

So the adoption of modern house design is profoundly linked to the future of each zone and also, of course, the fund capacity of farmers to make this change.

5.1.2.3. Consumption patterns changes

According to preliminary interviews with the Bedouin along the NWCZ, one main change observed by them is the changing of consumption patterns and the water consumption. We have conducted complementary study related to water consumption in wadi Nagamish and we participated to collective work within the project ELVULMED to approach the changes of family food consumption in the region.

5.1.2.3.1. Water consumption

In the past, the water consumption in the wadi Naguamesh was very low. According to our interviews, the daily water consumption was estimated about (75 liter) for a family consisting of an average number of 7 persons. This low consumption was explained mainly by the low number of Roman Cisterns and their dispersion in the area. There were no motors to raise water from the cisterns. And they used donkeys and jerricans to transport the water with no water storage at home.

The situation has changed in mid-seventies. Our survey shows that the first cisterns established in 1979. Since this date, the number of cisterns has increased significantly due to the successive development projects in the region. Cisterns for drinking and home consumption are become close to the homes. The arrival of electricity until the zone 2 has enabled the use of water pumps;

and also the availability of vehicles for water transportation and tractors for pushing water tanks allows diversifying the sources of water. All these factors have helped to getting water and thus increase water consumption. According to (Gleick, 1996) and (Ali et al., 2009), the proposed water requirements for meeting basic human needs is estimated at 50 liters per person per day in dry areas. So according to these needs, the water consumption would be 350 liters per day and per family.

5.1.2.3.2. Food consumption

According to the case study of Martin (2013) over 2 wadis (Halazen and Anthily) in the NWCZ, he has determined the food monthly consumption using family surveys table (12). While table (13) shows QASR area monthly consumption of staples per household of 14 persons (Roushdy, 1988 & El Zein,1964). The comparison of results indicates an increase in consumption by 5% in rice; 16% in meat, 2% in sugar and decrease of consumption in wheat by 7%.

Table 12: food consumption NWCZ, 2013

(kg/month)	average (kg/month/ family)	Average ((kg/month/ capita)
Rice/macaroni	61.6	0.29
White	89.4	0.43
Meat	50.2	0.24
Legume	72.6	0.34
Fruit	25.3	0.12
Tea	4.7	0.02
Sugar	25.0	0.12

Table 13: food consumption NWCZ, 1964-1988

(kg/month)	average (kg/month/family)	Average ((kg/day/capita)
Rice	105	0.25
White	210	0.5
Meat	34	0.08
Sugar	41	0.1

5.1.3. Family structure, housing in wadi Naghamish

5.1.3.1. Family structure

Direct families members ranged between 2 and 47 members, mainly according to the age of the head of family in 2012/13. The smallest family comprises mainly the head, his wife and children; the largest families include the households of their married sons. The average size of the family is around 11 persons. This includes the head of family, his wife, and 1-2 married sons with their wife and children under 16 years old. Each family comprises around 6 children in average (with a ratio 47% female and 53% male). So there are two types of family structure in the wadi: nuclear family (husband, wife and children) and 2 generations family. The table (14) shows the ratio of the two family types at the zone level. On the contrary we don’t register extended families including 2-3 brothers with their family sons.

Table 14: family type in Naghamish

Zone	Nuclear family (husband, wife and children)	2 generations family
1	15	2
2	14	10
3	7	2
Total	36	14

In table above (14) we can see that zones 1 and 3 have the less number of 2-generations families. This can be explained by 2 major factors: the 1st one due to the departure of recent generations to the urban areas in zone 3, while the second one concerned in the strong influence of the urbanization and the generalization of the nuclear model.

In our survey, the ages of the head of the family ranged between 23 and 70 years old, with an average of 48 years old. Figure (48) shows the age pyramids of the head of family in our sample.

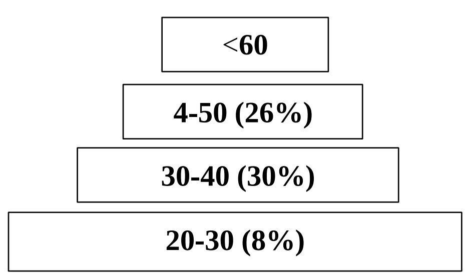


Figure 48: head family age pyramids (sample: 50)

5.1.3.2. Level of education

In wadi Naghamish, all of the young children in the age of primary school (6 to 12 years old) attended school in 2012. They represent about 74% of the children schools. The children in preparatory education (12 to 15 years old) and technical school represented, respectively, 18 % and 8% of total schooled children. We haven't students in faculty in our sample.

For the head of the family, the level of education is strongly linked to the age. In our population, 28% of the heads of family are illiterate; and there are the oldest ones with an average age of around 56 years old. Around 44 % can read and write with an average age of 47 Years old. The majority of them have received their education in what is called (Kottab). Only 18% had a certificate of primary and 10% achieved technical secondary school certificate in 2012. In summary, we can observe an increasing level of education for the young generation, mainly due to the development of education in remote areas thanks to the system of Kottab and schools in small cities in the centers.

5.1.3.3. Housing

In our sample, all families in the zone 1 live in a concrete house, compared to 74% in zone 2 and no concrete house in zone 3. All the houses in zone 3 have a roof in wood. Average house areas are around 124 m2 and 152 m2, respectively in zone 1 and 2; and 92 m2 in zone 3. The impact of the last drought has reinforced the insecurity in the zone and then the absence of any investment.

All the families in zone 1 have connected the electricity, against 90% in Zone 2; therefore they have the main facilities as refrigerator, wash machine, and also the access to information as TV or phone. In the zone 3, no one access to electricity, due to the remoteness of the region in the south.

The cisterns are the main system of water storage of rain water and transported water is the main source of drinking water for human and animal for the three zones. In zones 1 and 2, the water sources can be both the rain and transported water from Marsa Matrouh, although in the zone 3 the only source is transported water from Marsa Matrouh. This explains the high cost of water in this zone. In average, the family spends around 330 L.E/month, compared to 75 L.E/month in zones 1 and 110 L.E/month in zone 2.

Sewage system in the studied areas is the common system that we find in the North West Coastal zone. This consists of a deep well (at least 5 meters) into the lower soil layers for each house.

This results show a high contrast in living conditions between the 3 and the other zones, mainly due to the electricity access. This factor increases the remoteness of this zone and constitutes a major factor that incites people to leave.

5.1.3.4. Farm management

Our survey show different ways to manage the farm according to family structure. For nuclear family (comprising only father, mother and their young children), the farm decisions are only taken by the head of family. In the families with two generations or extended families (in which two or more brothers share the land and livestock capital), the farm decisions are distributed between the different heads of households according to their personality, their competence and the degree of diversification. Sometimes, each brother is in charge of one activity although in other types, all the brothers are involved in all activities.

Related to livestock management, the marketing decision is around 54% family decisions against 46% individual decision (by the head of family). Grazing decision is 60% family decision against 40% individual. Daily management of the flock decision is around 46% family decision against 44% individual.

Related to land management, the decisions are around 47% family decisions, against 53% individual. The decision to get a loan is 56% family decision, against 44% individual decision.

Dealing with government is 48% family decisions, against 52% individual. However, generally, if the recourse to government can be collective at the family level, the person in charge of communication with the government is the most educated member in the family.

First we can observe that the ratio of nuclear family and 2-generations family is closed to ratio observed in type of individual or collection decision.

Even if the decision is collective at the family level, only men are involved in the decisional process. Women are only involved in housing management and they depend on their husband for all external transactions outside the family.

92% of those interviewers are members in local agricultural associations; those associations are Abar Noh located in zone 2, and Garawla located in zone1. All of the interviewers decided that in the past they were getting subsidized fodder, while currently the role of agricultural cooperatives became limited and it is concerned in giving feed –term payment.

5.2. Land and cropping systems

Due to the last 15-drought years, zone 3 is become only a pastoral zone although we have observed a rapid diversification of land management and cropping systems in the zones 1 and 2. This description is based on the data collected in our family survey (50 families) in the wadi Naghamish.

5.2.1. Land access and ownerships

Firstly, all the families have their cultivated land inherited from their parents as if the land remains the property of the tribe. And there is no rent or sharecropping systems. Generally this land has been distributed by grand-parents' generation at the beginning of the twenty century.

Since the last drought, in zone 3, all the land is pastureland with no agricultural land. This is due to the strong erosion from wind and water during the last 15 years. Before the recent drought, there were agricultural lands, mainly for the cultivation of barley in the depressions (hattaya) where the soil depth was higher with a better chance to collect rain water. Canadian study project (Abd Elkader et al., 2004) in collaboration with the University of Alexandria showed that the total production of barley was around 117 tons in the mid-nineties in zone 3.

In zone 2, the only source of water for agriculture is rainfall. So this zone is totally depending on rain. In the zone 1, if the rain water remains the main source of water in normal and good climatic years, they usually use supplementary irrigation through the fresh water pipe line of drinking water (coming from Alexandria governorate) to irrigate crops. This practice is illegal. Except of the water cost for transported water, there is no investment in water equipment.

However, Zone 1 and Zone 2 have known an extension of agricultural land thanks to the water development infrastructure (Dykes, cisterns).

Table (15) and shows that the average land owned by farmers in zone 1 and 2 are respectively 15.78 feddan (6.6 ha) and 70.75 feddan (29.7 ha). The grazing land in Zone 2 is more important than in Zone 1. In fact, due to the spatial configuration of the wadi, the middle and upper plateau in zone 2 are more extended. Moreover, in zone 1, the wadi escarpments are mainly rocky land that is not valid for barley or grazing. On contrary, in zone 2, there are more wide areas that can be used for barley cultivation and grazing.

Table 15: average land area and type

Zone	Sample	average Land area	Land type
1	17	6.31 ± 4.77	Pasture
	17	3.59 ± 2.67	Barley
	17	5.88 ± 3.2	Wadi
2	24	40.29 ± 65.90	pasture
	24	24.54 ± 34.90	barley
	24	5.92 ± 4.00	wadi
3	9	0.00	pasture
	9	0.00	barley
	9	0.00	wadi

5.2.2. Cropping system

In zones 1 and 2, the main cropping system is mainly based on cereal crop (only barley) and trees such as figs, olives, and almonds. Barley is cultivated both in the depressions and in the bottom of the wadi. The main product of barley is grain for the market; during dry years, barley is only grazed by animals.

Figs, olives and almonds are cultivated only in the wadi bed, where the soil depth and water are available. However the orchards are very sensitive to drought events even if now in zone 1 farmer can mitigate the effects of drought thanks to irrigation.

Table (16) shows the crop areas in each zone. For orchards, we can see significant differences between figs and almonds between the 2 zones. This is mainly due to the wadi configuration and the irrigation supplementation in zone 1. Firstly, in zone 2, the wadi bed is more protected from wind; so almonds flower are more resistant. On contrary, in zone 1, the irrigation supplementary irrigation allows to get more fig productivity.

For olive trees, the production is irregular compared with figs or almonds and, generally, olive trees produce only every two years. Moreover, the olive price is fluctuated in the market. According to experts, there is no change for the local demand, while if the exportation of olive increases, the price will increase: the price ranges from 1 to 5 LE/kg over the last 3 years.

Table 16: crops type and crop area in feddan and in percentage of total cultivated land in wadi Naghamish in 2013

Zone	sample	crop type	average crop area (feddans)/st	% of total cultivited area
Zone1	17	Barley	4.16±3.28	35
		Fig	5.44±2.94	46
		Olive	1.17±0.64	10
		Almond	1.00±0.0	08
Zone 2	24	Barley	17.23±15.63	65
		Fig	4.56±3.33	17
		Olive	1.58±1.25	06
		Almond	3.30±3.58	12
Zone 3	9	Barley	0.00	0.0
		Fig	0.00	0.0
		Olive	0.00	0.0
		Almond	0.00	0.0

Concerning the cropping practices, the land services for ploughing or harvestingin the study area are limited. For ploughing and seedling in the wadi, the cost of service for one hour doesn’t exceed 35 LE /feddan for barley land. The price of barley seedling which is enough to one feddan is averaged 50 L.E per feddan in 2013. This was based on 1 Ardab (130 kg) of barley seed by 6 feddans with an average cost of 300 L.E.

The crop operations for orchards in the wadi bed include the following practices:

Tillage: The average plowing cost per feddan for 3-4 times was 140-145 L.E in the two zones 1 and 2. The repetition of plugging after each rainfall event allows to avoid water loss through the capillary action (tillage process closes the capillary tubes).

Labor cost: According to the results, the labor cost includes both hoeing and pruning. Average annual labor cost per feddan was around 211 L.E in zone 1, compared to 175 L.E in zone 2. This gap can be explained by the difference of expected production in the two zones.

Fertilizers: There were no fertilization practices (organic or chemical) in the whole wadi mainly due to the lack of water according to the farmers. This can give a comparative advantage for the products of this zone which are free of chemicals.

Harvesting: All harvesting operations in the study area are generally done manually. Several reasons prevent the use of mechanization harvesting operations in the region, such as, the shallowness of productivity per unit area, presence of stones heavily on the soil surface, which cause frequent damage to machines. However, there is a need for new machines due to the variable relief of the area and the irregularity of barley production. But, the recurrence of drought prevents the profitability to use costly machine in the zone.

5.2.3. Crops productivity and crop income contribution

Table (17) shows the average annual productivity at the zone level. In general the productivity in zone 1 is the highest, except for barley. The first reason is that zone 1 receives more rainfall; the second is related to the best soil quality in the downstream; and, finally, the third reason is due to the use of the supplemental irrigation from the water pipe.

Table 17: Average annual productivity (fig-olive-barley-almond)

zone	crop type	average crop yield (kg / feddan)
1	**barley**	276 ± 65
	fig	2033 ± 374
	olive	1208 ± 1527
	Almond	700 ± 0.0
2	**Barley**	281 ± 75
	Fig	1716 ± 935
	Olive	631 ± 1081
	Almond	242 ± 156

Table (18) shows the average annual gross margin by crop and by farm in the different zones of the wadi. The annual gross margin is calculated by the difference between the cost of inputs and the cost of production. Without surprise, the productivity for all crops is the highest in the zone 1. Table (19) shows average crop price in 2013.

Table 18: average crop gross margin (per feddan)

zone	Sample	Average crop gross margin (fig-olive-barley-Almond) (L.E) / ST
zone 1	17	10195 ± 12237
zone 2	24	8634 ± 12021
zone 3	0	0.0 ± 0.0

Table 19: average crop price in 2013 (in L.E. per kg)

Crop Type	Average crops prices (L.E) / ST
Barley	2.0 ± 0.62
Fig	2.4 ± 0.41
Olive	3.2 ± 1.40
Almond	5.7 ± 2.07

5.3. Livestock systems

In spite of the deterioration of vegetation as a result of the lack of rainfall and the significant reduction of livestock numbers, 46% of farmers think always that animal husbandry represents an important source of income, while 54% do not think so. However, livestock remains a security for 86% of the heads of family. And only 10% mentioned that it is only a family prestige. These first perceptions show a change of role of livestock in the family that we propose to understand through the analysis of livestock management.

5.3.1. Description of livestock systems per zone

5.3.1.1. Livestock composition over the last 15 years

The table (20) shows the change of livestock numbers and composition over the period 1995-2012. We observed a large decrease of sheep flock for all the zones. In average they have reduced their sheep flock by 52-92% over the period 1995-2012. For goats flock, the reduction in zone 3 was higher than zones 1 and 2. In zone 1 and 2 the reduction can be explained by the development of agricultural activities. However in zone 3 can be explained mainly by drought.

Table 20: livestock number in wadi Naghamish 1995-2012

zones	sample	Flock size 2012 Av./st		Flock size 1995 Av./st		Difference from 1995 (%)	
		sheep	Goats	sheep	goats	sheep	Goats
Zone 1	17	35± 96	10 ±10	73±83	19±12	**-52%**	**-0.47**
Zone 2	24	56 ± 68	11 ± 8	127±133	19±17	**-56%**	**-0.42**
Zone 3	9	51± 39	13 ±12	639±583	49±18	**-92%**	**-0.74**
Average		**47**	**11**	**280**	**29**	**-67%**	**-54%**

Compared with the results of ELVULMED project in 2011 in the rain-fed area as shown in table (21), we can find that the decrease was higher in wadi Naghamish. This can be explained by the small study area in the wadi Naghmish, which was severely affected by drought compared to the large space that was covered by ELVULMED project; where there is a disparity in the drought-affected. Moreover, we can see that the changes in the flock size in the new reclaimed lands and Siwa Oasis was positive over this period.

Table 21: flock size difference from 1995 (ELVULMED project data, 2011)

Regions	Flock size	Difference from 1995(%)
Rain-fed area	152	-37.7
New reclaimed lands	234	45.3
Siwa Oasis	65	12.1

5.3.1.2. Fattening system

Sheep lamb fattening has been considered as one of the new economic alternatives for the Bedouin faced to the drought. In our sample, only 2 farmers practice this activity: one in zone 3 and one in zone 2. This only represents about 4% of the breeders in the study area; this may be due to the presence of other alternatives in the study area.

The fattening period extends from 2 to 3 months. Generally, they start fattening at the age of 4 months, with an average weight around 30 kg. The fattened lambs' number varies between 150 and 225 lambs by farm. The average price of the lamb before fattening would be around 1000 L.E in 2012 with an average weight of 27 kg. The main costs of fattening include feed and veterinary cost (for vaccination). Average total feed costs per head were around 248 L.E in 2012. And the average veterinary cost for vaccination per head was around 30 L.E.

During the fattening period, the mortality rate is estimated around 3%. This rate of mortality is the most sensitive parameters about the profitability of fattening activity according to these 2 breeders by increasing this rate for the two case studies and without changing any costs, we can estimation that the activity would not be profitable for a rate over 8-10%.

In average, according to our data, in case 1 in zone 3, the return from one lamb fattening was 87 L.E, compared with 68 L.E in case 2 in zone 2. This can be explaining by the increase of the amount of feed provided to the animals in zone 2 compared to zone 3. Table (22) and table (23) show the fattening system calculations in zone 2 and 3.

Table 22: Fattening system in zone 3

case 1	Zone	total No. of lambs	150
cost of feeding	35500	average lamb price	1400
cost of treatment and immunization	4500	mortality rate	3%
cost of lamb purchasing	150000	Total sold animals	145
total production cost	190000	Total receipt	203000
Net Income		13000 L.E	

Table 23: Fattening system in zone 2

case 2	Zone 2	total No. of lambs	225
total cost of feeding	58200	average lamb price	1400
total cost The purchase price of the Lambs	225000	mortality rate	3%
The cost of treatment and immunization	6750	Total sold animals	218
total production cost	289950	Total Selling Price	305200
Net Income		15250 L.E	

Fattening system is not wide use in the study area for many reasons such as: the high risk which includes both of marketing and mortality rate; the high investment to purchase animals; and, also, high skills and experience that are needed.

5.3.2. Change of feeding systems

5.3.2.1. Feeding calendar according to climatic year

The feeding system in the area is based on three seasons: the grazing period generally from January-February to March-April, crop-residues grazing period (from May to June) and last no-grazing period (from July to December). The duration of each period fluctuates a lot according to the climatic year. We have tried to reconstitute the feeding system over the year for three types of years: wet years (200mm), normal year (140) and dry year (less than 105 mm) based on the calculation of rainfall probabilities in the last 60 years.

In the table (24), we don't observe significant difference between the three zones for feed calendar. The main difference of the feed calendar depends on the type of climatic year and mainly the total amount of rainfall. And in the drought years the breeders have to feed their animals for 12 months.

Table 24: animals feed calendar in three different scenarios

zone	Wet years			Average years			Dry years		
	Average supplemental period	Average hssida barley residual period	Average grazing period	Average supplemental period	Average hssida barley residual period	Average grazing period	Average supplemental period	Average hssida barley residual period	Average grazing period
	months	months	months	Months	months	months	Months	months	months
1	6.3	2.2	3.5	8.6	1.2	2.1	12	0	0
2	6.5	2.2	3.3	8.7	1.5	1.8	12	0	0
3	6.5	2.1	3.4	8.4	1.6	2.0	12	0	0
average	**6.4**	**2.2**	**3.4**	**8.6**	**1.4**	**2.0**	**12**	**0**	**0**

In summary, the duration of the period with concentrates condition the profitability of the activity.

In the year 2011/2012, the grazing period ranged from 1 to 3 months in zone 1, compared to 2 to 3 months in Zone 2, while there was no grazing period in zone 3. In our sample, 20% thought that the 2011-2012 grazing period was good, while 62% thought it was medium and 18% very weak, particularly in zone 3.

Only one large farmer in zone 2 with more than 250 ewes used a shepherd, at the rate of 1000 le monthly.

5.3.2.2. Type of supplemental after grazing period

At present, all breeders are not sending animals to the new reclaimed lands in the west Delta. Only two breeders practiced this between 2001 and 2006. However, they have given up this practice due to the fear of diseases.

Table (25) shows average feed quantity given to animals at level of zone; while table (26) shows the average different fodder prices in dry and rainy seasons. The price varies according to the zone due to transportation cost but also due to the quality. For example, the quality of wheat and barley residues is lower in the zone 3 than in zones 1 and 2. We can see also the variation of prices between the different types of climatic year. For example, according to the interviews through asking about the feed prices in wet and dry seasons, maize prices increased by 23% in dry years, compared to wet year. While concentrates' prices increased by 15%, wheat-barley' prices increased by 21%. The highest increase was for hay (estimated at 130%), that is produced locally.

Table 25: Average feed quantity given to animals at level of zone

zone	Average Concentrate quantity(kg/day/head) (sheep-goats)	Average maize quantity (kg/day/head) (sheep-goats)	Average barley wheat quantity (kg/day/head) (sheep-goats)	Average straw quantity (kg/day/head) (sheep-goats)	Average crop residual Quantity (kg/day/head) (sheep-goats)
1	0.45	0.42	0.31	0.61	0.75
2	0.46	0.46	0.31	0.53	0.78
3	0.54	0.41	0.56	0.92	1.00
average	0.48	0.43	0.39	0.37	0.84

Table 26: average fodder prices 2012 in dry and rainy seasons

zone	Dry seasons				Rainy seasons			
	Maize	Concentrates	Barley/Wheat	Hay	Maize	Concentrates	Barley/Wheat	Hay
	L.E/Kg	L.E/Kg	L.E/Kg	L.E/Kg	L.E/Kg	L.E/Kg	L.E/Kg	L.E/Kg
1	2.27	2.15	2.73	1.11	1.65	1.86	2.20	0.66
2	2.37	2.19	2.58	1.16	2.04	1.93	2.16	0.77
3	2.50	2.30	2.50	1.19	2.10	1.97	2.06	0.96
average	2.38	2.21	2.6	1.84	1.93	1.92	2.14	0.80

5.3.3. Animal performance and disease

5.3.3.1. Animal performance

Usually there are two periods of lambing: the main period in winter (especially in October and November) and the second one in summer at the end of barley grazing period (June and July).

Sheep lambing rate in the three zones was around 1.2 lamb/head/years. This rate include both of winter and summer lambing period .table (27) shows the lambing rate and the mortality rates by species and zone in wadi Naghamish. We observe an important difference of mortality rate between sheep and goat for the 3 zones. This would be due to the emergence of a new disease that have affected the kids' mortality, but also due to the non-vaccination of goat compared to sheep. We observe also a variability of mortality rate of sheep between the three zones, with a gradient North south, that can be explained by feed availability.

Table 27: lambing rate and mortality rate in sheep and goats

zone	sample	Lambs Born/ewe/year	Lamb mortality (%)	
		Sheep	Sheep	Goats
1	17	1.21	4.9	**15.2**
2	24	1.23	5.7	**15.4**
3	9	1.19	6	**14.1**

5.3.3.2. Diseases treatment

In our sample, around 90% of the breeders practice the regular vaccinations for sheep such as El Guesh, El Dolaa, El Selim, El Safar, El Zemheel, El Shalban. Table (28) shows the local and scientific name for animal diseases. Usually, breeders do not vaccine the goats.

Table 28: the local and scientific name for animal diseases

No.	Local name of diseases	The scientific name
1	El Guesh	Internal Parasites
2	El Dolaa	Foot and Mouth Disease (FMD)
3	El Selim	Sheep Box virus
4	El Safar	Jaundice
5	El Zemheel	Rift Valley Fever (RVV)
6	El Shalban	Small Ruminants Pest (PPR)

The cost of the parasite treatment increased from the zone 1 to zone 3, mainly due to the transportation cost and perhaps also to the reticence of the vets to go to zone 3. Table (29) shows the average annual coast for internal external parasite treatment at the zone level.

Table 29: average annual coast for internal external parasite treatment

zone	Av. no of animals per sheep flock	Average annual cost of external parasite treatment (LE/flock)/ST	Average annual cost of internal parasites treatment and vaccination (LE/head)/ST
1	55	123±100	22±19
2	100	154±96	28±18
3	185	200±0.0	36±12
Average	**133**	**159**	**28**

5.3.4. Livestock market and livestock income contribution

All the breeders of our studied area sold their animals in Matrouh market. In 2011-2012, the average ewe price was 552 L.E for an age of 5 years old and a weight of 27.5 Kg, while the average doe price was 288 L.E for an average age of 3.5 years old and a weight of 16.8 Kg. The table (30) shows the different prices, ages and weights in the three zones. We can observe a higher price in zone 3 compared to zones 1 and 2. The prices reflect the great interest of breeders in zone 3 for livestock compared to the other zones; where they are more specialized in sheep and goats breeding compared with breeders in zone 1 and zone 2 who are more specialist in land cultivation; animal husbandry comes second in terms of their interest.

Moreover, all the breeders have registered an increase of price per head. This increase would be due to the high demand from Libya and the good conditions of rainfall and then grazing period. Despite the absence of rains in Zone 3, the rainfall in zone 1 and 2 in season 2012 led to increased demand and thus increase prices.

Table 30: average price, age and weight for animals in 2012

zone	Ewe			Doe			Lamb			Goat kid		
	price L.E	age Year	Weight Kg	price L.E	age Year	Weight Kg	price L.E	age month	weight Kg	price L.E	Age Month	weight Kg
1	775	7.1	42.5	550	5.6	35	920	3.8	31.5	396	3.7	13.3
2	768	7.6	42.0	550	7.1	33	924	4.0	31.6	418	3.5	13.1
3	786	7.4	38.6	590	7.2	32	978	4.3	30.9	432	3.3	12.4
average	**776**	**7.4**	**41.0**	**563**	**6.6**	**33.3**	**940**	**4.0**	**31.4**	**415**	**3.5**	**12.9**

5.3.5. Contribution of sheep and goat in family consumption

In general average annual animal self-consumption was 1.37 sheep per year, while it was 1.89 sheep per year in 2012. As noted, self-consumption from goat was higher than sheep, due to the high price of sheep comparing with goat. In general sheep are prepared in Aid El-Adha. Table (31) shows self-consumption of sheep and goats at level of zone.

In general average goat milk production was about 0.5 kg/head/day and milk is only used for human consumption. The absence of milk marketing was due to several reasons, such as, the small produced quantity as a result of vegetation degradation, and the difficulty of marketing in case of milk availability.

Table 31: Sheep and goats number annual self-consumption

zone	Sample	Av. sheep self-consumption Head number/year/st	goats self-consumption Head number/year/st
1	17	1.07 ± 0.96	1.86 ± 1.30
2	24	1.65 ± 1.28	1.95 ± 1.09
3	9	1.38 ± 0.92	1.86 ± 1.57
average		1.37	1.89

Wool production in the study area ranged between 1 and 2.5 kg/head, with average price ranged between 90 to 100 L.E for the Kantar(1 kantar=45 kg). Wool is generally sold.

Skins production is exactly equal to the self-families consumption of sheep and goats number, which is used by family as a type of mats. It was the typical Bedouin carpets in the past. Nowadays Bedouin use this type of mats to revive Bedouin heritage. Skin sale is not present in the study area.

5.4. Family income

Generally, there are several aspects of economic activities in the wadi Nghamish between what is agricultural, animal husbandry or off Farm activity. Table (32) shows the income from the various activities at the level of the three zones. Firstly in zone 1 the agricultural production represented 37 % of the total income in 2012. The animal production represented around 21 % while the off farm represented 42%. In zone 2 the agricultural production represented 27% of the total income. The animal production represented around 30% while the off farm represented 43

%. In zone 3 the agricultural production represents 0% of the total income. The animal production represents around 76% while the off farm represented 23%.

The table shows that the return of agricultural activity reached its peak in zone 1, mainly due to the high yield of agricultural production. In the zone 3 where there is no agricultural production, the income from the animal production is higher than in zones 1 and 2. These results are coherent with the agro-ecological system: the zone 1 is the main agricultural production area while the zone 2 is the mixed production zone, and, finally, the zone 3 is the main pastoral zone, as well as the region has been known for a long time with the large amounts of numbers of livestock.

The off farm activities was the highest in Zone 2, followed by 1, then 3. It may be explained by the structure of family; the zone 2 is characterized by the high proportion of 2-generation family (see table 14) and this leads to increase the number of adults who are able to work and thus increase the off farm activities income. Increase of the off farm activities income in zone 1 and 2 compared with zone 3 can be explained by the near distance to the cities. In zone 1, 60% of the heads of families are government employees.

Table 32: agriculture, livestock and off farm activities average annual income

Zone	Average annual agriculture production income (L.E)/family	Average annual livestock income (L.E)/family	Average annual off farm activities (L.E)/family	Average total annual income / (L.E)/family
1	10 195 (37%)	5 706 (21%)	11 553 (42%)	27 454
2	8 634 (27%)	9 645 (30%)	13 700 (43%)	31 979
3	0.0 (0.0%)	17 487 (76%)	5 422 (24%)	22 909

It is clear that the agricultural activities continue to play a major role in the family livelihoods of all farmers, especially cereal and orchards in the two first zones (1 and 2) and livestock activity in the third zone in the south. There is also an increasing contribution of non-agricultural activities in the zones 1 and 2, mainly in link with the urban development in Marsa Matrouh and the coastal line.

In the south, livestock, especially goat, sheep, and to a lesser extent camels, remain the main source of income for inhabitants, due to the absent of agriculture land

86% for all sample considered always livestock as the main security in 2013. This security perception must be analyzed in link with the omnipresent risk of drought that will affect firstly the crops and orchads. In this sense livestock remains a sort of capital that can be mobilized to face the first negative consequence of the drought. Also livestock remains a daily capital to cover the socials needs.

However, in the same time, around 95% of the breeders in zone 1 and 2 considered that sheep and goats can cause damage to crops. This perception reflects the new trend of the two zones that have shifted from an barley-livestock system to a mixed farming systems based on tree-barley-livestock where orchard constitute one of the main income.

5.5. Perception of change

5.5.1. The most famous events in the Bedouin society

100% of the farmers and breeders thought that, the drought was the most important event that affected their livelihoods. According to the majority of the interviewers drought began in the year 1995. Also according to them, consequence of that event represented in decreasing of the livestock numbers (sheep, goats and camels), and agriculture productivity, decrease of the income of the family, water scarcity, damaging the cisterns, died of figs and olives trees, migration to the city, disappearance of many plant species. 8% of damage was due to the establishment of the forest trees in the area. Lack of percentage does not mean lack of importance of the issue. But this only reflects the proportion of those affected. According to them also consequence of that event represented in that drinking water in cisterns become invalid for drinking as a result of contamination of wastewater. As well as unpleasant odors and irrigation water became contaminated with the sewage.

In the southern area in zone 3, they think the main and the only event who has a positive effect on their live was the establishment of the southern link road, which facilitates the process of movement to and from the city.

5.5.2. Perception of change of climate change, social change and livestock management change

Table (33) shows the perception of change of climate, social links and livestock management in wadi Naghamish area. These results show and confirm the awareness of the farmers and breeders of the climate change indicators.

Table 33: Perception of the main changes

Main changes	**% of farmers who have observed a negative change**	**% of farmers who haven't observed change**
<u>Indicators of climate change</u>		
soil quality change	**72**	**28**
change of water quality	**8**	**92**
change in temperature	**76**	**24**
<u>Perception of changes in the livestock and crop management</u>	**93**	**7**
change in the mating period	**84**	**16**
change in the rate of lambing	**100**	**0.0**
change in the annual period of grazing	**68**	**32**
change in the animal production		
<u>Indicators of social change</u>		
change in the family relationships	**22**	**78**
change in the relation between poor and rich families	**68**	**32**

5.5.3. Perception of change of the environment: Soil and water management

Results show that, cisterns still remain the main source of drinking water in the area. However, in drought years people are forced to transport water to their cisterns from Matrouh city or from far unused old cisterns or from the water line pipe coming from Alexandria governorate.

Water scarcity problem was discussed in details in water resource chapter.

5.5.3.1. Water rights

Water rights mean the right to use the water. Water rights problem is fairly new and it is in link with the establishment of the dikes in the wadi bed, provided by the development projects in the purpose of cultivating orchard such as figs, olive and almond. Any farmer owns a piece of land in the wadi think that he has the right to cultivate it regardless of the extent of the impacts on water rights water balance in the wadi.

As reported by local Bedouin in Naghamish, this problem has increased with the drought waves. They think that in rainy seasons the problem is negligible, while it increases in the dry seasons, where water does not reach from upstream to downstream.

Through the discussions with the farmers, the solving of this problem can come only through discussions and mutual understanding, so that, to anyone who owns a piece of land in the wadi the right to cultivate his land with taking into consideration the right to the people who have lands in downstream, to get the runoff water which running from upstream through by not exaggerating in heights of dikes. The dikes can reserve only cultivated water requirement while allowing the water excess to flow to downstream, and through providing the earthen dikes with suitable spillways.

5.5.3.2. Desertification

All those who have been interviewed believe there is a real problem of desertification. Through discussion with them, we try to see how they see the problem how inferred its presence. What are the indicators which emphasizes the problem occurs. It was explained as follows, a massive change has already occurred in the land and the vegetation cover, where they think that the soil has lost between (5 – 10) cm only the last 15 years and this due to the emergence of small and medium stones on the surface soil ground, which means without a doubt loss of soil. In addition, they have observed the disappearance of many plant species.

Residents of the southern region who are the most affected by desertification describe how the desertification occurs. They reported that before the year 1995, a dense vegetation cover was there. The beginning was in 1996 with the absence of rain which was followed by decay of vegetation cover, which was followed by strong wind loaded with sand. With the decay of the vegetation cover, soil erosion became easier. As a result of the absence of rain it is getting worse from year to year. That we got to what we are now, no exist of vegetation, the soil has been degraded completely.

Conclusion:

This chapter focused on the socio-economic aspects the wadi such as, farming and livestock production and non-farm activities. The results showed a clear and great diversity in those activities and competence of each zone of economic pattern based on the available natural resources. As the zone 3 became out of the pattern of agricultural production as a result of drought as a main factor.

The results indicate that the areas closest to the sea and the main road is the most advantaged in terms of development opportunities and closer to public services and utilities such as water and electricity, so we can say as we get closer to the sea, the better the living conditions of the population

Clearly evident that the animal production and agricultural activities still an important sources of income for households in Zone 1 and 2, while the animal production only is a major source of income in zone 3. As how important of the off farm activity area in Zone 1 and 2, which is considered one of the community strategies to adopt with drought.

The results also point to a phenomenon of desertification in the southern region and to a lesser extent in zone 1 and 2 as well as the extent of farmers' awareness to the problem.

Rainfall is the main source of water supply for agriculture and drinking water in the wadi. Water resources management in the wadi will be focused in chapter 6 (Analysis and impact of water resource constraints under different climatic scenarios).

CHAPTER 6:
ANALYSIS AND IMPACT OF WATER RESOURCES CONSTRAINTS UNDER DIFFERENT CLIMATE SCENARIOS

Introduction

Naghamish watershed is a part of the NWCZ area which is considered as a rain-fed area. The main and only source of water is rainfall for the different purposes of use such as drinking water for human, livestock and newly poultry farms. The people use the cisterns as a very old technique for water storing. The average annual rainfall according to the collected rainfall data in the last 50 years is about 140 mm (Metrological data of Matrouh station). According to this low amount of annual rainfall, it is very difficult to cultivate orchards (like figs, olives or almonds). The water runoff harvesting system techniques, mainly dykes, have allowed to plant orchards, one of the main economic activity in the zone.

In this part, we will assess the available water resources in the wadi by taking into account the hydrological mechanisms, cisterns, and the different types of water harvesting techniques in the zone. According to the collected rainfall data in the last 50 years and the SPI method (presented in chap 3), the probability to have an average climatic year with around 140 mm is 50%, compared to 20% for a wet year (around 200 mm) and 70% for dry years (less than 105 mm). Following this, we suppose three different scenarios according to rainfall probability to assess the available water resources for each climatic year conditions. Based on these three scenarios, we will do an assessment of the extent of the impact of the fluctuation of water resources from year to another year in this dry area.

6.1. Hydrological assessment of annual runoff volume in wadi Naghamish in different climatic scenarios

6.1.1. Delimitation of hydrological basin

Based on the surface analysis of digital elevation model (DEM) in wadi Naghamish, seven sub-basins have been identified. Each sub-ends with a gathering point for several side channels are shown in Figure (49). Each sub-basin has special characteristics in terms of land cover, soil type, rainfall amount, surface roughness and slope as shown in table (34). All those factors have been taken into consideration when calculating the runoff factor.

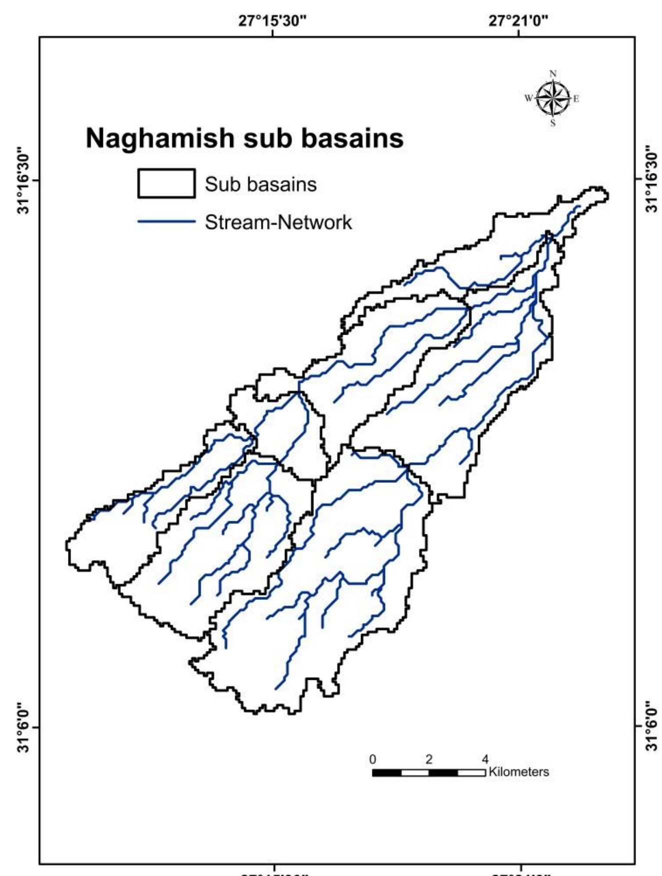


Figure 49: sub basins and streams in wadi Naghamish used (SWAT.ARCgis)

Table 34: sub basin (cells) of wadi Naghamish Statistics

Cell No.	Drainage area	cultivated area	net drainage area	distance from sea	annual rainfall	slope
	m^2	m^2	m^2	km	mm	%
1	7291002	7858	7283144	14	92	1.26
2	12861413	0	12861413	19	80	0.93
3	17496254	666815	16829439	10	102	1.9
4	23443044	39166	23403878	19	80	0.9
5	41864115	305419	41558696	16	87	1.52
6	27400402	2478465	24921937	8	108	2.23
7	11496131	1174909	10321223	5	118	1.83
total	141,852,361	4,672,632				

Before starting in the hydrological assessment process, two maps are necessary: the rainfall map to estimate the run-off coefficient and the slope map that corrects this run-off coefficient. The slope is ranged between 0.9% and 2.23% (Figure 50). The rainfalls map in figure (51) shows the distribution of rainfall along the wadi, which ranged between 140 mm in the north and 70 mm in the southern part of the wadi.

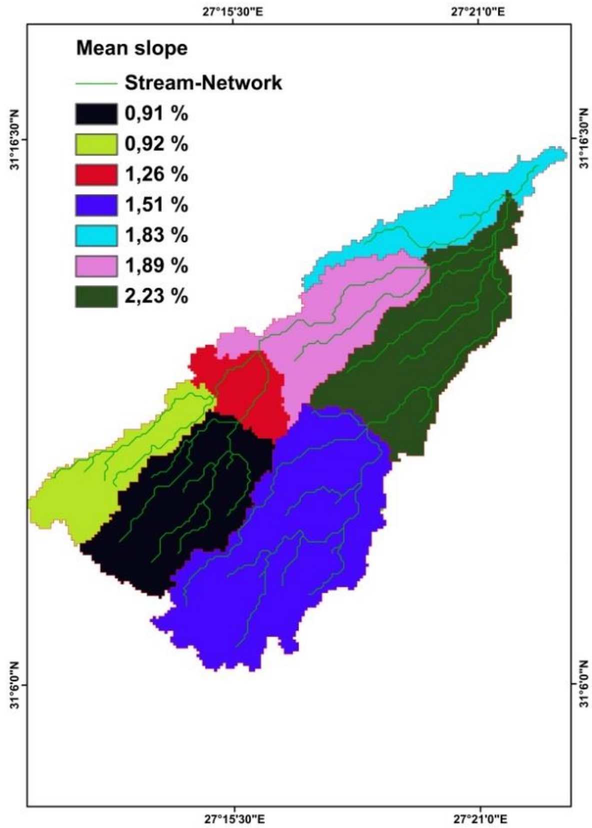


Fig. 50: slope in wadi Naghamish

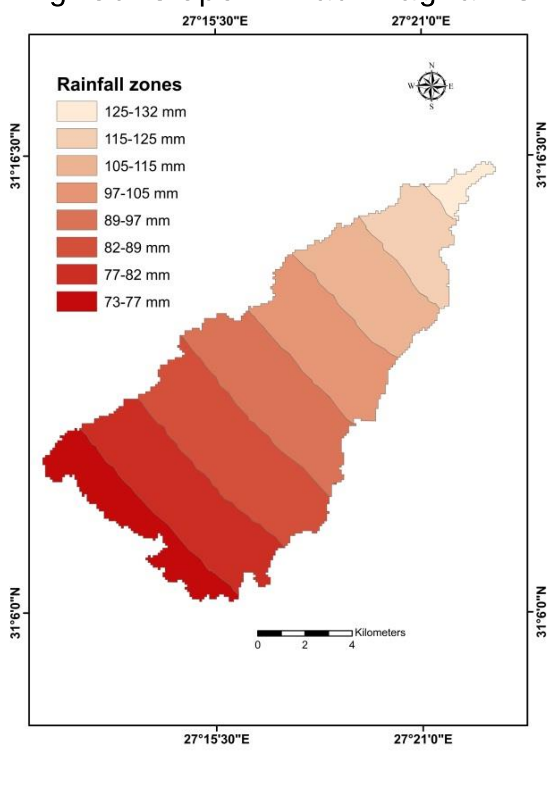


Figure 51: rainfall distribution in Naghamish

To assess the water balance, we propose to compare the total available water which includes both of the total annual runoff volume and the effective rainfall volume with the crop water requirement in the wadi bed. The water requirement has been estimated according to (Ali et al., 2000) by about 500 mm annual water per feddan for trees like figs, olives and almonds.

6.1 2. "Average" scenario: average rainy years

This section includes the total annual runoff volume and the water balance for wadi Naghamish in an "average" rainy season based on the probability of 50% and an annual rainfall of 140 mm.

6.1.2.1. Hydrological assessment of annual runoff volume

In this scenario with a probability of 50% for the average rainfall of 140 mm, the hydrological assessment in table (35) shows that the total annual runoff volume of water is around 2 million m3. The highest rate of rainfall is (118 mm) in cell number (7) adjacent to coastline, while lower values for rainfall are registered in the south: (80 mm) in cell number (2, 4). The highest runoff coefficient is recorded in the cell (7) with a value of 29.7%, which is characterized as a rocky surface with a slope of 1.83%. Figure (52) shows the runoff values in cells in wadi Naghamish and figure (53) shows the annual runoff volume in wadi Naghamish.

Table 35: Runoff volume assessment in wadi Naghamish for average years (Probability of 50% - 140 mm)

Cell No.	Drainage area	cultivated area	net drainage area	distance from sea	annual rainfall	runoff coefficient	slope	annual runoff volume	effective rainfall	effective rainfall volume	Total available water
	m2	m2	m2	km	mm	%	%	m^3	mm	m^3	m^3
1	7291002	7858	7283144	14	92	18	1.26	120609	64	506	121115
2	12861413	0	12861413	19	80	5.2	0.93	53503	56	0	53503
3	17496254	666815	16829439	10	102	20	1.9	343321	71	47611	390931
4	23443044	39166	23403878	19	80	5.2	0.9	97360	56	2193	99553
5	41864115	305419	41558696	16	87	7.2	1.52	260324	61	18600	278924
6	27400402	2478465	24921937	8	108	28.5	2.23	767097	76	187372	954469
7	11496131	1174909	10321223	5	118	29.7	1.83	361718	83	97047	458765
total	141852361	4672632						2003931		353329	2357261

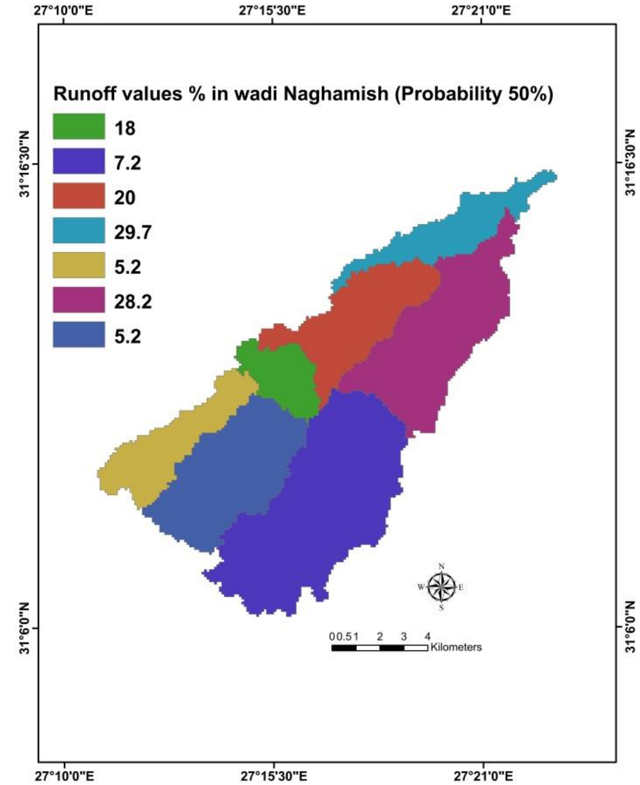


Figure 52: runoff ratio in cells in wadi Naghamish (average years)

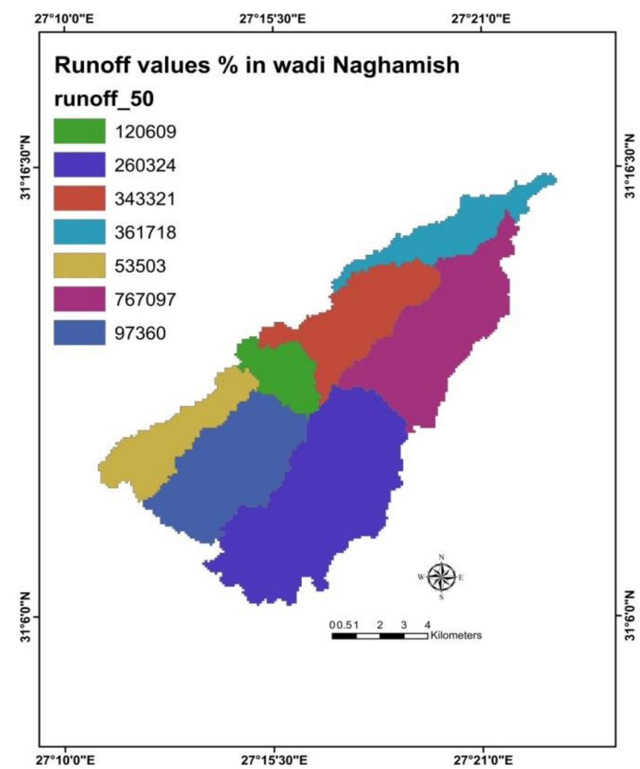


Figure 53: runoff values and volume in wadi Nghamish (average years)

6.1.2.2. Water balance (average rainy season)

Table (36) shows the water balance in wadi Naghamish in the “average” rainy years (scenario 1). The results show that the water surplus in the wadi would be about 20,945 m^3. This surplus represents around 1% of the total annual water requirement in the area.

It is also observed a water deficit at the level of some sub basins, especially the sub basins 6 and 7 in the north. This means that the catchment area is insufficient to meet the needs of the crops in these two sub basins in “average” rainfall year. However, there is an opportunity to fill the deficit through the water flowing from the south to North. But, for that, it will be important to design the dykes according to the reserve for the upstream and the need in the downstream and this according to the water rights, which mean the right to use the water. In drought period the equality requires users to share the burden of water shortages, during high water years, users have equal access to a greater quantity; in drier times, and each must use less (Westesen & bryan, 1997).

Table 36: water balance in Naghamish in average years

cell No.	cultivated area	Total available Water	water requirement	balance
	m^2	m^3	m^3	m^3
1	7858	121115	3,929	117186
2	0	53503	0	53503
3	666815	390931	333,407	57524
4	39166	99553	19,583	79970
5	305419	278923	152,710	126214
6	2478465	954469	1239,233	-284764
7	1174908	458765	587,454	-128689
total	**4,672,632**	**2,357,261**	**2,336,316**	**20945**

As shown in this scenario, theoretically, there is no gap for water resources if the dykes are designed according to water requirement by sub basins. In fact, we observe some water deficits in the downstream sub basins mainly due to the dyke infrastructure in the upstream.

6.1.3. "Drought" scenario: "drought" years

This scenario has been the most common in the area during the last 20 years (at least from 1995 to 2011). In this scenario the estimated probability is 70% for an annual rainfall amount around 105 mm.

6.1.3.1. Hydrological assessment of annual runoff volume

Based on 105 mm annual rainfall value, the hydrological assessment in table (37) shows that the total annual runoff volume of water would be around (1.09 million m^3). The highest average level of rainfall is (88.5 mm) in cell number (7) adjacent to coastline, while the weakest value for rainfall (about 60 mm) is observed in cell numbers (2) and (4), two sub basins located in the South. The highest rate of runoff is also in the cell (7) with 20%; this sub basin is characterized as a rocky surface with the highest surface slope.

Table 37: annual runoff volume assessment for Drought probability (105 mm rainfall)

Cell No.	drainage area	cultivated area	net drainage area	distance from sea	annual rainfall	runoff coefficient	slope	annual runoff volume	effective rainfall	effective rainfall volume	Total available water
	m2	m2	m2	Km	Mm	%	%	m3	mm	m3	m3
1	7291002	7858	7283144	14	69	13.5	1.26	67842	48	380	68222
2	12861413	0	12861413	19	60	4.55	0.93	35112	42	0	35112
3	17496254	666815	16829439	10	76.5	15.3	1.9	196980	54	35708	232688
4	23443044	39166	23403878	19	60	4.55	0.9	63893	42	1645	65538
5	41864115	305419	41558696	16	65.25	6.4	1.52	173549	46	13950	187499
6	27400402	2478465	24921937	8	81	18	2.23	363362	57	140529	503891
7	11496131	1174909	10321223	5	88.5	20.4	1.83	186339	62	72786	259125
total	**141852361**	**4672632**						**1087077**		**264997**	**1352074**

In this "drought" scenario, the total annual runoff volume is less than 50% of the "average" scenario. This gap raises clearly the problem of water rights.

6.1.3.2. Water balance in drought years

Table (38) shows the water balance in wadi Naghamish in the "drought" scenario. The average rainfall amount is established at (105 mm). There is a deficit of water in the wadi estimated to about 1.6 million m3.

It is also observed that this deficit affects 5 sub basins of the wadi or around 98% of the cultivated area in the wadi. In this case, the water scarcity is critical for agricultural activities, crops and livestock, in all the zones. Due to the water infrastructure, the problem is more acute in the downstream without dykes. This case shows again the critical challenge of water rights in link with water infrastructure.

Table 38: water balance in Naghamish in dry years

cell No.	cultivated area	Total available	water requirement	balance
	m2	m3	m3	m3
1	7858	68222	3929	64293
2	0	35112	0	35112
3	666815	232688	333407	-100719
4	39166	65538	19583	45955
5	305419	187499	152710	34790
6	2478465	503891	1239233	-735342
7	1174909	259125	587454	-328329
total	**4672631**	**1352074**	**2336316**	**-984242**

This scenario shows clearly that during drought year, the entire wadi is affected and there is few agricultural opportunities.

6.1.4. The "wet" scenario: wet years

This "wet" scenario has a low probability of occurrence, around 20%. And the level of annual rainfall would be about 200 mm.

6.1.4.1. Hydrological assessment of annual runoff volume (wet rainy season)

Based on an annual rainfall value of 200 mm, the hydrological assessment in table (39) shows that the total annual runoff volume of water is around (4.3 million m^3). The highest rate of rainfall is (168 mm) in cell number (7) adjacent to coastline, while the less value is (114 mm) in cell number (2) and (4) located in the south. The highest rate of runoff of about 44% is in the cell (7), which is characterized as a rocky surface with the highest surface slope.

Table 39: annual runoff volume assessment for wet season probability (200 mm rainfall)

cell No.	Drainage area	Cultivated area	Net drainage area	distance from sea	annual rainfall	runoff coefficient	slope	Annual runoff volume	effective rainfall	Effective rainfall volume	Total available water
	m^2	m^2	m^2	Km	mm	%	%	m^3	mm	m^3	m^3
1	7291002	7858	7283144	14	131.56	27	1.26	258706	92	724	259430
2	12861413	0	12861413	19	114.4	6.5	0.93	95637	80	0	95637
3	17496254	666815	16829439	10	145.86	40	1.9	981897	102	68083	1049980
4	23443044	39166	23403878	19	114.4	6.5	0.9	174031	80	3136	177168
5	41864115	305419	41558696	16	124.41	8.8	1.52	454988	87	26598	481586
6	27400402	2478465	24921937	8	154.44	41.4	2.23	1593463	108	267942	1861405
7	11496131	1174909	10321223	5	168.74	44.2	1.83	769789	118	138778	908566
total	**141852361**	**4672632**	**137179730**					**4328511**		**505261**	**4833772**

6.1.4.2. Water balance in wet years

Table (40) shows the water balance in wadi Naghamish in a wet year, where the average rainfall amount is (200 mm). We can see that there is no deficit of water for all sub-basins of the wadi. At the contrary, there is a surplus in link with traditional agricultural systems in this zone. This scenario was found before the year 1995 especially in zone 3. Maybe that can happen again in the future; in this case maybe depressions only can recover and permits the cultivation of barley, but on the condition rains continuing for several years and build soil profile again which call in this case transported soil profile by wind and water erosion.

Table 40: water balance in wadi Naghamish in wet seasons

Cell No.	Cultivated area	Total available water	Water requirement	balance
	m^2	m^3	m^3	m^3
1	7858	259430	3929	255501
2	0	95637	0	95637
3	666815	1049980	333407	716573
4	39166	177168	19583	157585
5	305419	481586	152710	328876
6	2478465	1861405	1239233	622172
7	1174909	908566	587454	321112
total	**4,672,632**	**4,833,772**	**2,336,316**	**2,497,456**

6.1.5. Global results of the 3 scenarios

Figure (54) shows the water balance in the 3 different scenarios of probability of the annual rainfall season in wadi Naghamish basin. We can see that the agricultural systems established in the zone fit well to the “average” scenario with no surplus. This means that in 50% of case, it is not possible to increase the agricultural area. During extreme years, “wet” or “drought”, the deficit or surplus are quite similar in terms of volume. In “wet” year, the surplus is waste in the sea; during “drought” year, the only way to adapt is to find another source of water, mainly transported water which increases consequently the production costs. Figures (55, 56) show the deficit or surplus in the 3 scenarios. While the deficit or surplus at the level of orchard farms scale in the wadi bed; in relation with soil type is shown in figure (57); where the orchard in the wadi bed is the final destination of water.

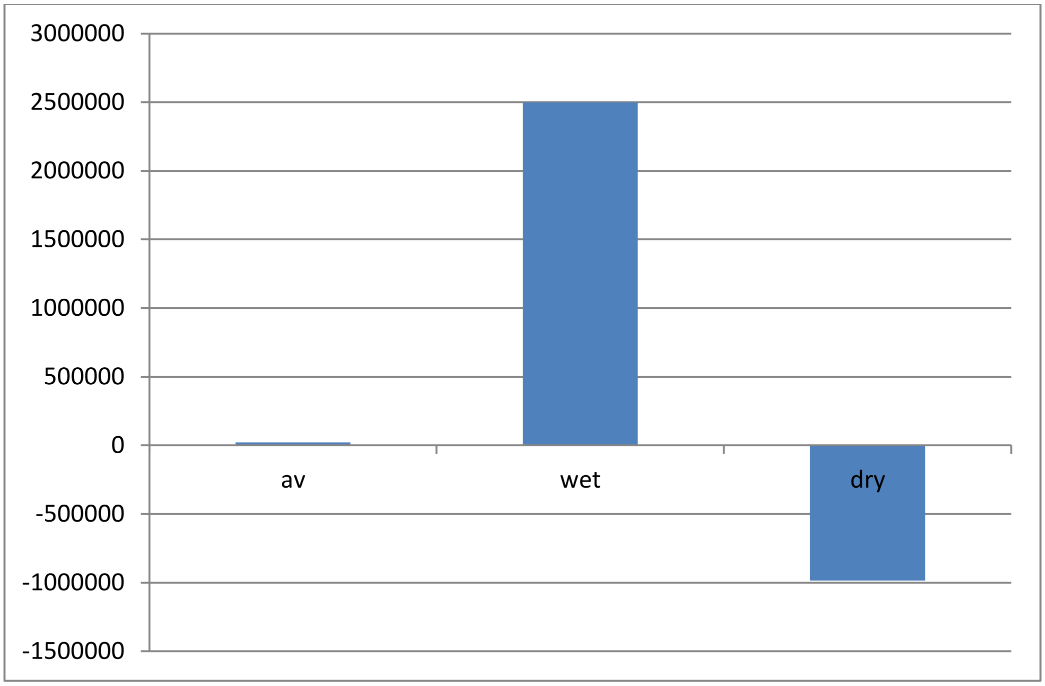


Figure 54: the deficit or surplus in the 3 scenarios (m^3)

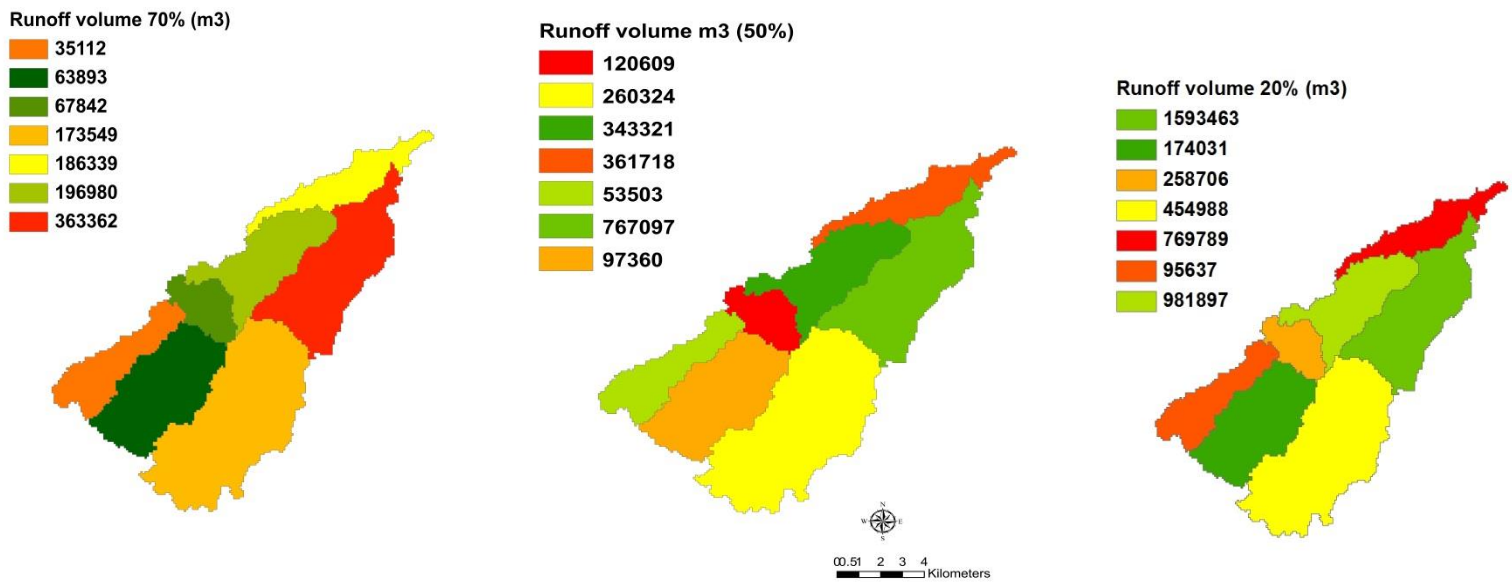


Figure 55: Annual runoff volume for wadi Naghamish for three probabilities: dry (70%), wet (20%) and average seasons (50%)

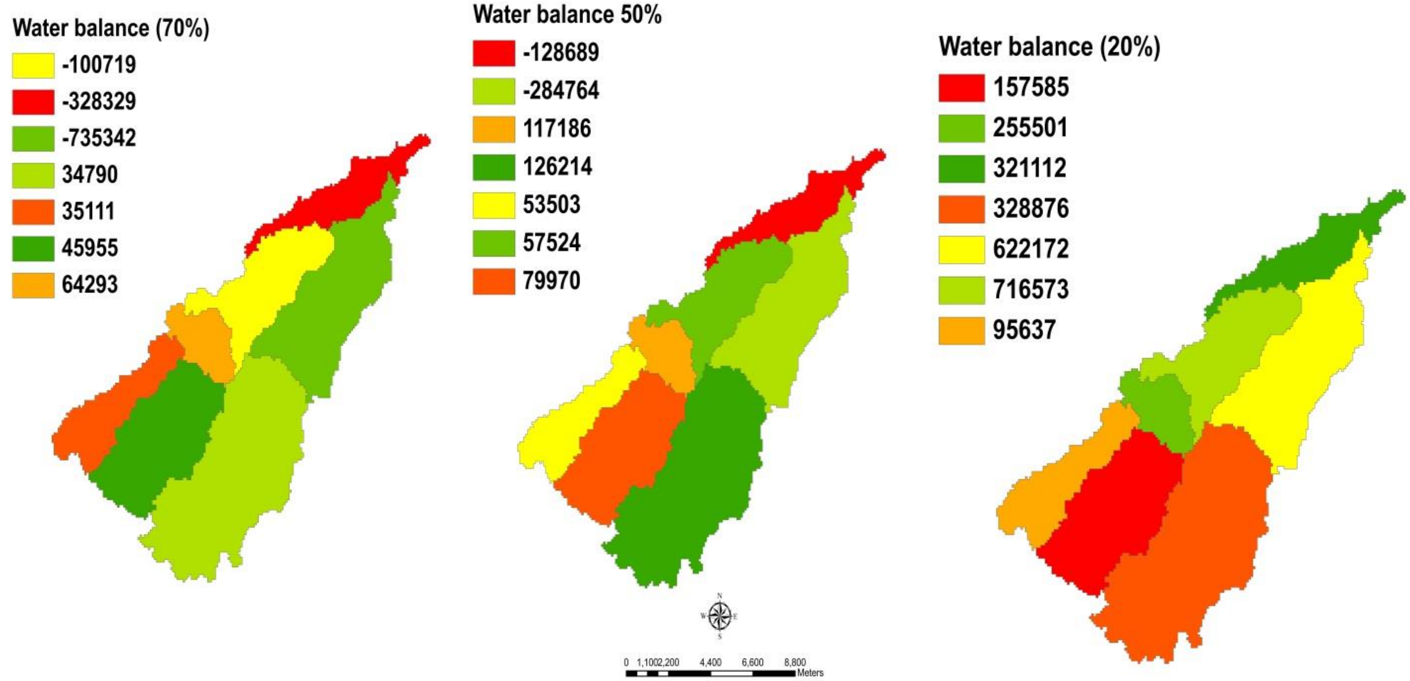


Figure 56: Water balance in wadi Naghamish for three probability dry(70%),wet(20%) and average seasons (50%)

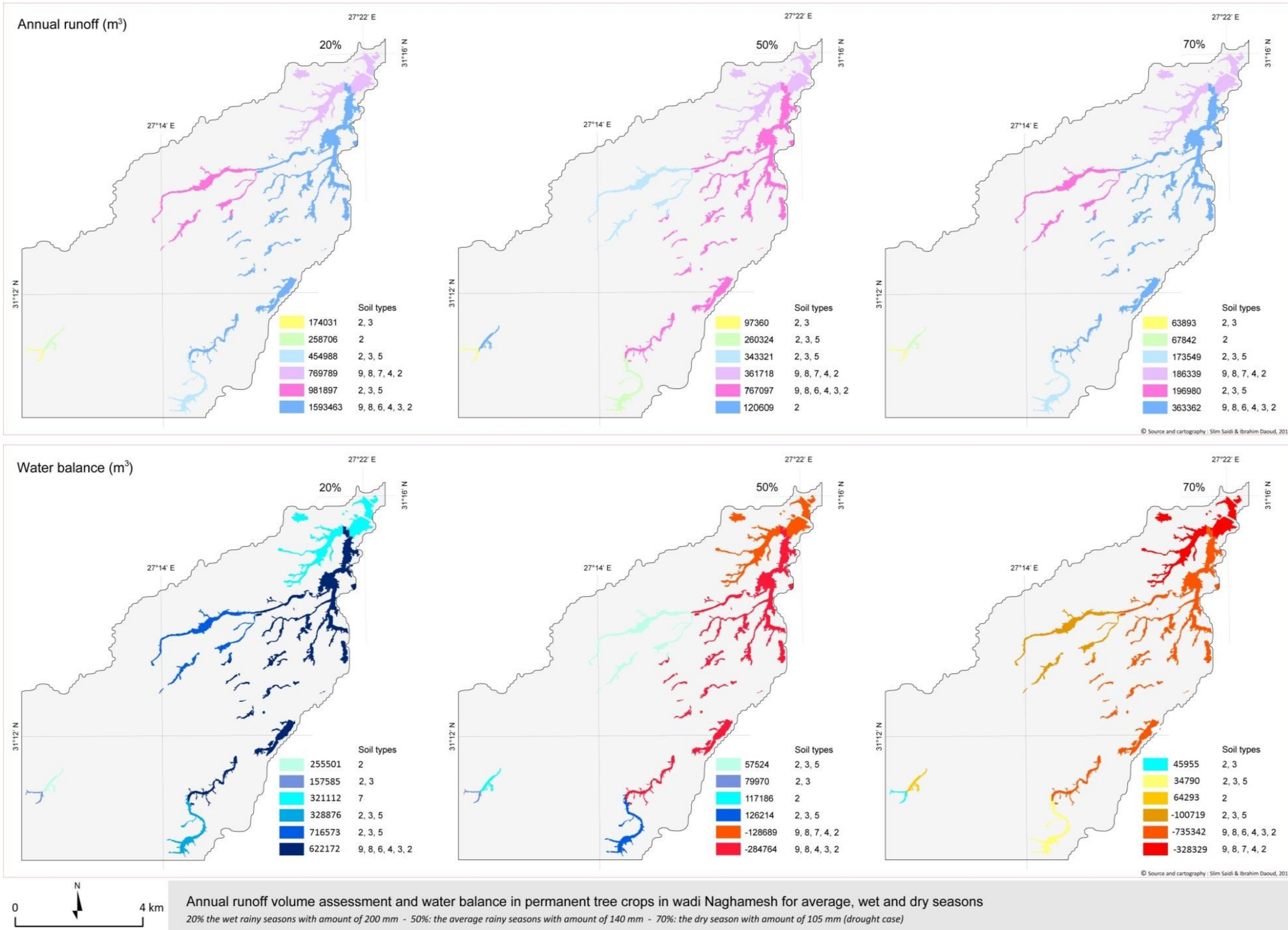


Figure 57: runoff assessment and water balance in permanent cropland in wadi Naghamish in zone 1 and 2.

6.1.6. Future of orchards

In accordance with the expected scenarios which are based on the fluctuation of rainfall, the future expansion of planting trees in the wadi need for the search of alternative sources of water. One of those alternatives can be based on improved land operations with a supplementary irrigation in drought years; this can improve the physical properties related to retain rain water for as long as possible.

6.2. Role of cisterns

6.2.1. The diversity of cisterns in the wadi

A cistern is a sub-surface water collection and storage structure, generally dug at the lowest level of a small catchment. Each cistern should have an adequate catchment to generate runoff under whatever rainfall conditions are expected, a suitable underlying geological formation, and it should make efficient use of stored water (Ali et al., 2009).

A cistern has three main components: an inlet including a settling basin, a shaft (mouth and neck), and a storage chamber. The inlet allows runoff to enter the storage chamber, while the outlet allows excess water to flow out. The mouth opening (50-75 cm in diameter) facilitates withdrawal of water from the cistern. A wooden or steel grate covers the opening to prevent the contamination. The chamber is excavated in soft to medium soils underneath a layer of hard sedimentary rock, 50 cm to 2 meters thick, which forms a natural ceiling to the chamber. The inner sides of the chamber are plastered to minimize leakage. The chamber requires cleaning every four to five years if proper sediment traps are not provided. Generally, water is extracted from the cistern using buckets; windmills, hand pumps and diesel pumps are also used. A typical cistern is shown in (Fig. 58) The shape and size of cisterns vary from one place to another. Old Roman cisterns have a capacity of 1500 m3 (the larger ones were multiple cell cisterns with sub-surface side trenches shown in fig. (59). Cisterns built in recent years have a capacity of 100-300 m3. The common chamber shapes are circular, elliptical and rectangular (Fig.59) (Ali et al 2009). Figure (60) shows the cistern during filling during rainfall storm.

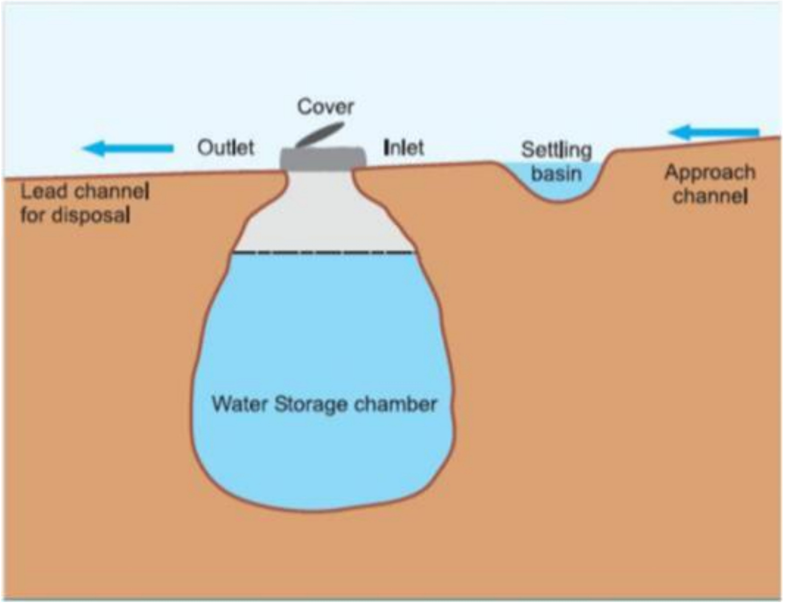


Figure 58 citernes design

(Source :Ali et al, 2009)

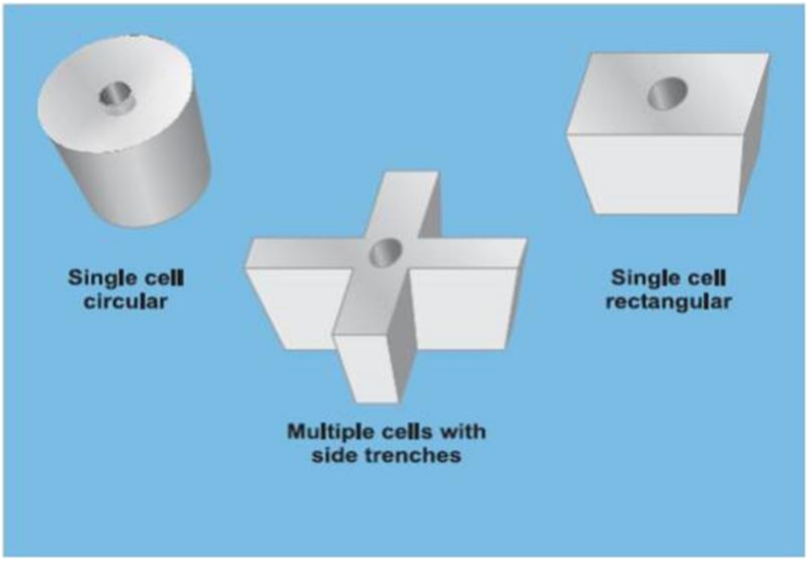


Figure 59: Cistern shape

Source: Ali et al, 2009

Figure 60: cisterns during filling in heavy storm

Source: Ali et al, 2009

6.2.2. Cisterns in Wadi Naghamish

Rainfall is the main sources of water in the study area, for rain-fed agriculture irrigation and water consumption and drinking for human and livestock. This water is harvested by two water harvesting techniques. One is the several types of dikes in wadi bed (earthen, dry stone and cemented dikes) for cultivation irrigation in the wadi bed (fig, olive and almond). The second water harvesting technique is the cisterns.

6.2.2.1. Cisterns at the zone level

According to the field survey which has been carried out in wadi Naghamish, the total number of the cisterns in the wadi were (446) cisterns in 2013. Field survey results show that we counted 129 cisterns in zone 1, 279 cisterns in zone 2, and 40 cisterns in zone 3. Figure (61) shows the spatial distribution of those cisterns along the wadi. The first establishment of cisterns, called in the local Bedouin language (Nashw) in the area, started in 1979. The total annual runoff volume in wadi Naghamish based on 140 mm average annual rainfall is around 2 million m3 in. The total annual stored water in cisterns is about 64 450 m3, that represents about 3% of the total available annual runoff water.

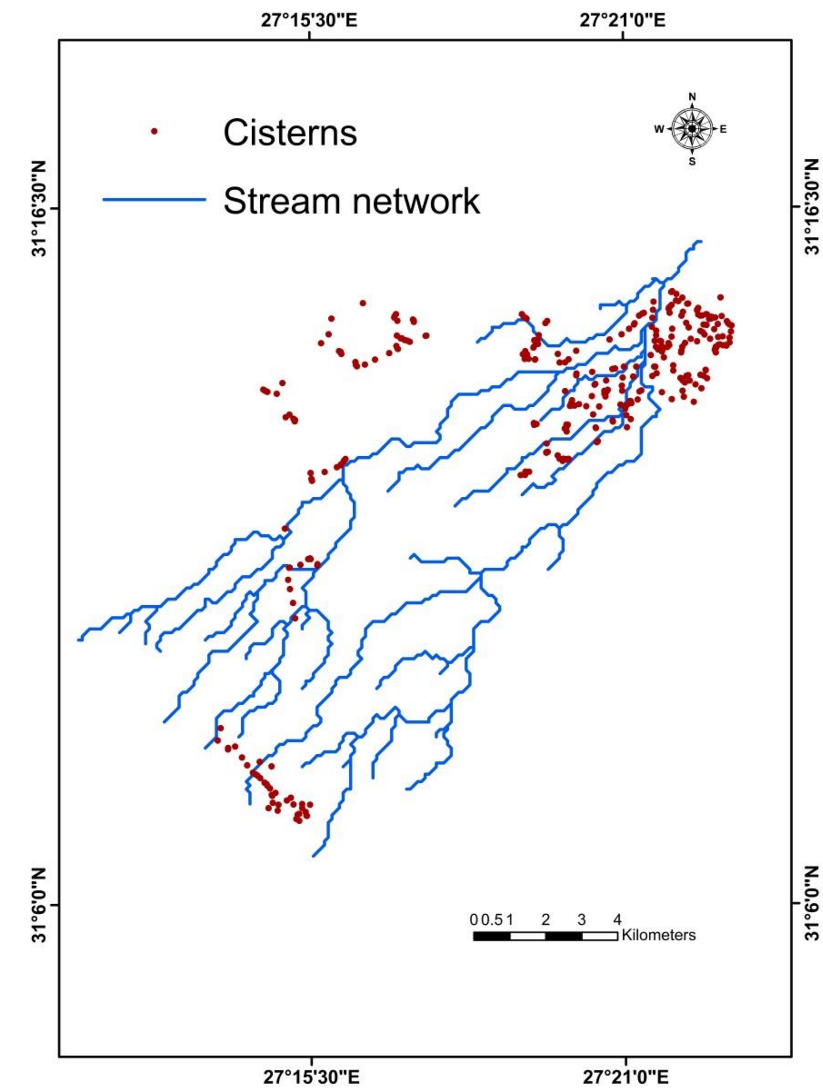


Figure 61: Cisterns distribution in wadi Naghamish (survey results by GPS)

Cisterns can be divided in terms of use into common and private cisterns; the first type, the common cistern, can be used by any member of the tribe while the second is private ownership established by the farmer. The survey result shows that 438 cisterns i.e. 98% of the total number of cisterns are private ownership owned by the farmers while only 8 cisterns (representing less than 2% of total number of cisterns) are still public ownership. Those common cisterns are Roman cisterns that dated from the Roman age and still for common use for all the tribe members. Figure (62) shows cisterns numbers in zones and figure (63) cisterns ownership.

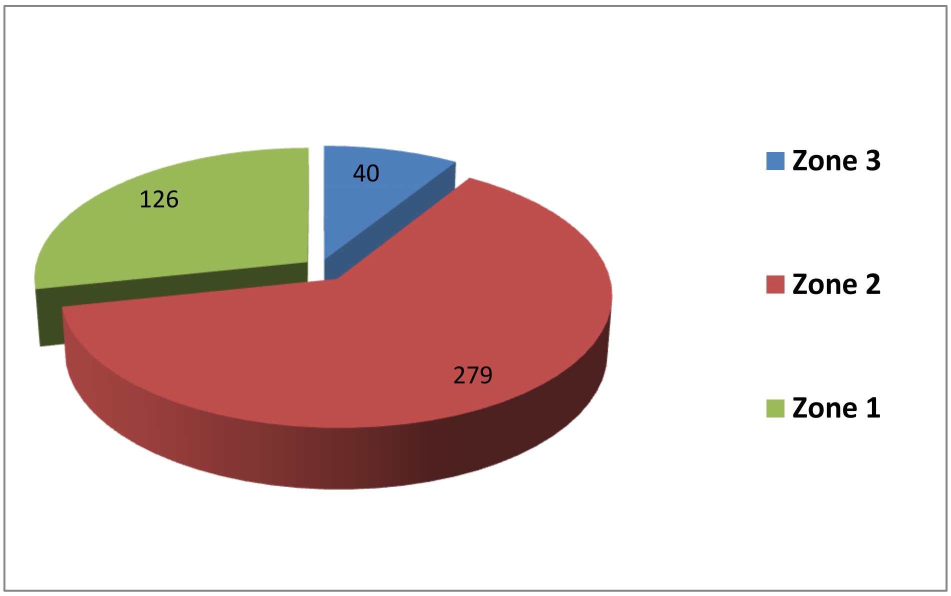


Figure 62: Cisterns numbers in zones in wadi Naghamish

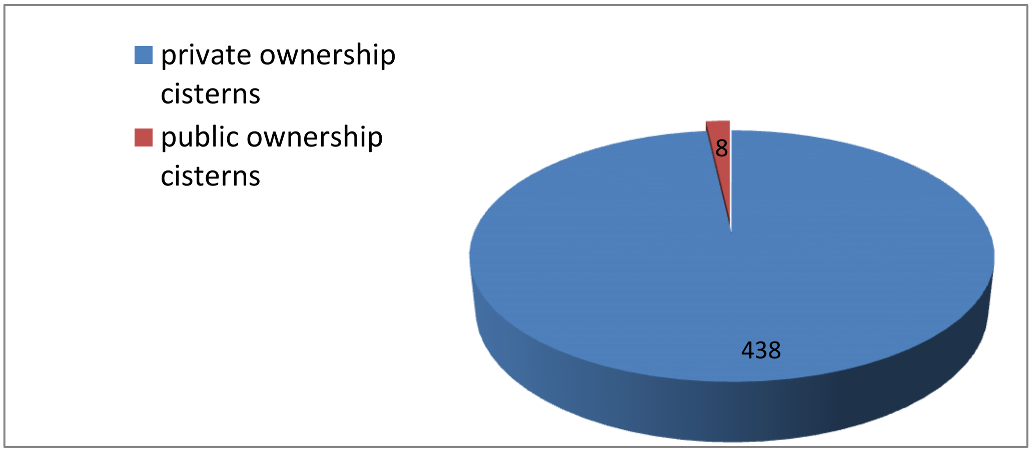


Figure 63: cisterns ownership in wadi Naghamish.

6.2.2.2. Cisterns establishment organization

265 cisterns (or 59% of cisterns) have been established by MRMP (Matrouh resources Management Project) during the last 2 decades, although 166 cisterns (37%) have been established by *GIHAZ* (the reconstruction of deserts Organization with cooperation with FAO, WFP) in the eighties. 8 cisterns (2%) are Roman cisterns established in the Roman age and 3 new cisterns (less than 1%) were established by farmers without any support from government or any other international development organizations. Besides, 2 reservoirs have been established by the water resources department and they represent less than 0.05%. Figure (60) shows Cisterns establishment organization.

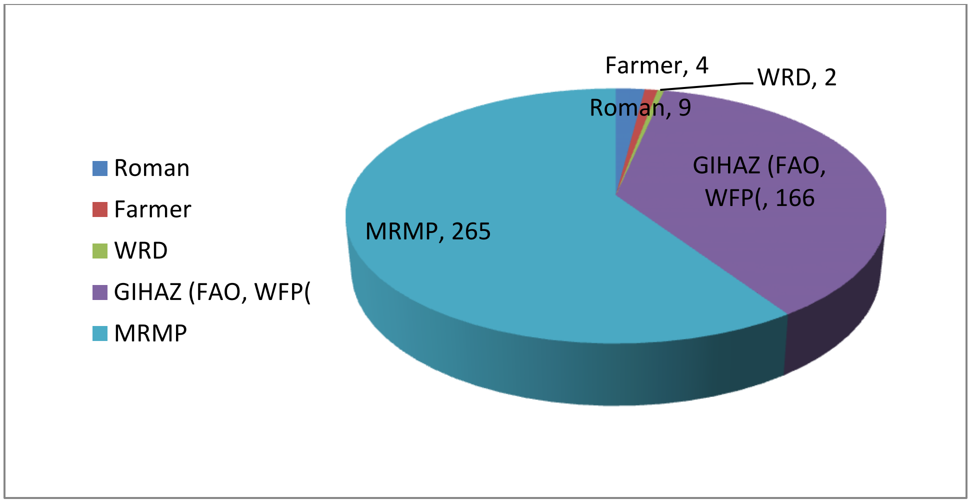


Figure 64: Cisterns establishment organization.

The field survey shows that the first establishment of the cisterns in the area started in 1979. The rate of the establishment of the cisterns has increased in the early eighties with the start-up of international development projects in the region, such as FAO, WFP in cooperation with the Desert Reconstructed Organization until the beginning of the nineties. Then, this rate decreased in the nineties. This rate re-increased at the end of the nineties with the MRMP project (Matrouh Resource Management Project) and to decline again with the end of the MRMP in 2004. Figure (65) shows the rhythm of the establishment of the cisterns in Wadi Naghamish and figure (66) shows the cumulative storage capacity from 1979 to 2012.

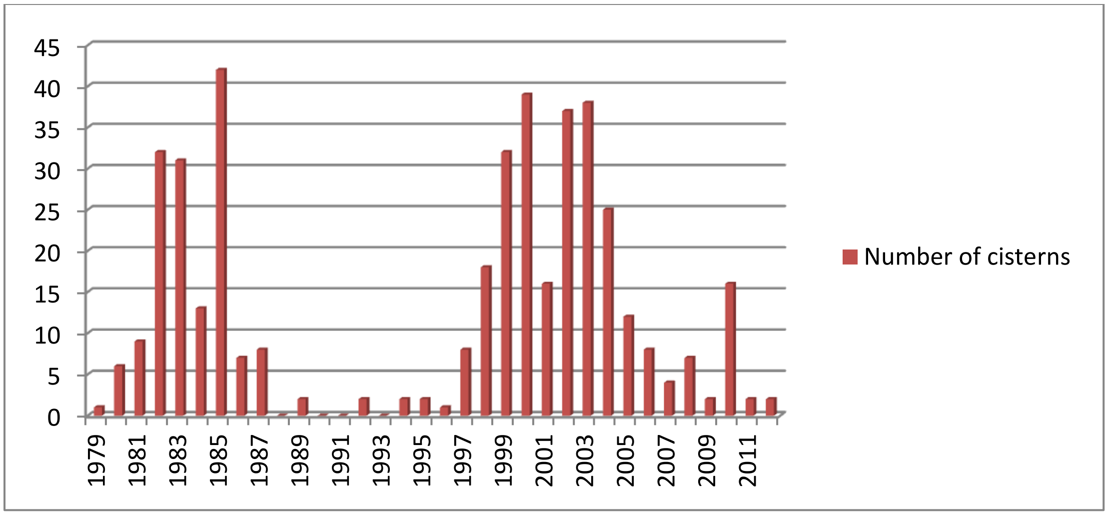


Figure 65: Establishment rates of cisterns in wadi Naghamish

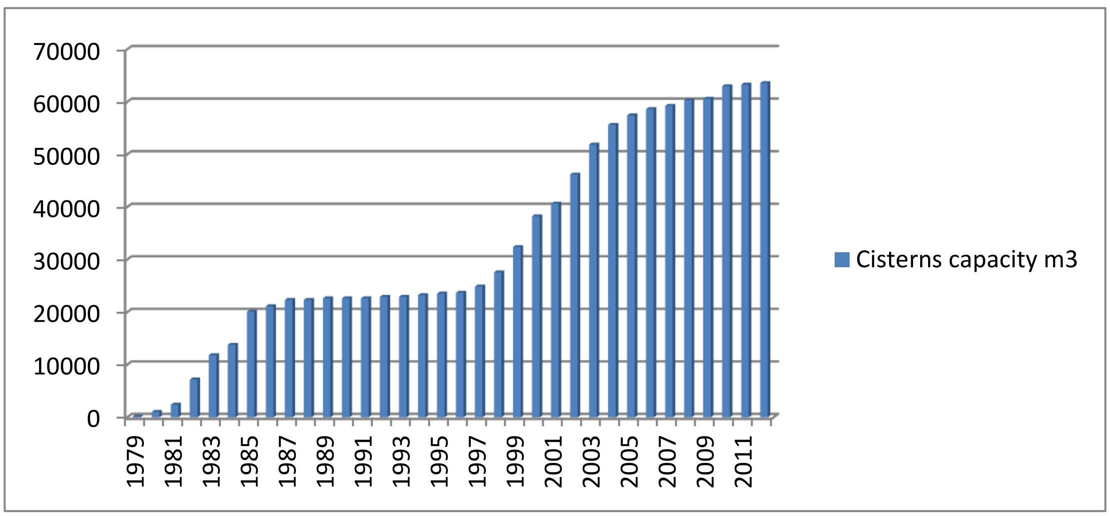


Figure 66: Cisterns cumulative storage capacity m3

6.2.2.3. Cisterns validity

Despite the large number of cisterns in the study area, these cisterns are not working with their full capacity. According to average capacity of each type of cisterns according to the date of establishment, the total capacity was 63 000 m^3 in 2012.

However, the individual survey shows that only 352 cisterns (or 79% of the total number) are valid. 94 cisterns (21%) don't work. According to the discussions with the farmers in the area, one of the main reasons to explain this lack of functioning of the cisterns is the drought event that impedes the filling of the cisterns. The drought also causes cracks in the cement that covers the cisterns walls. Also, in zone 3, they mentioned that, the giant machines of oil prospecting companies with their big vibrations caused damage for the cisterns. Figure (67) shows cisterns validity in wadi Naghamish.

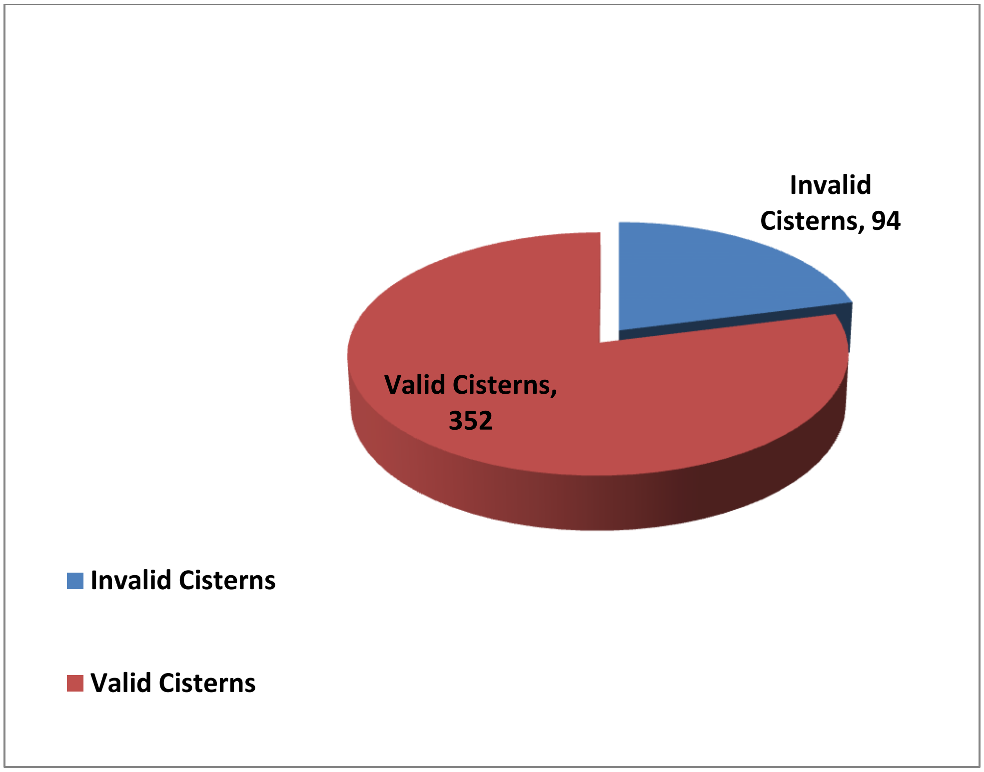


Figure 67: cisterns validity in wadi Naghamish

So according to this data, over the capacity of 63 000 m^3 only around 50 000 m^3 can be stocked in 2012. In the same time, over the last 15 years, the human needs have increased due to the activity diversification at the family level.

6.2.3. Livestock management in relation with available water resources

Water scarcity appeared in the area due the high demand of water from both human and livestock consumption and recently the situation is become more critical with the increase of establishment of the poultry farms. Here we propose to discuss the available water resources in the wadi Nagamish in relationship with human and livestock consumption estimated in terms of minimum requirements. The objective is to see the impact of water scarcity and the consequent increasing cost of transporting water on the economic viability of the livestock and family livelihood.

Sheep, goats and camels breeding, the main species in the zone, have been severely affected by drought in the period from 1995 to 2011 (see chapter 5).

This strong reduction of flock is directly due to the scarcity of water resources which affect directly the pasture and increase cost of animal breeding due to transportation of drinking water. This was in addition to the lower level of water stored and the competition with human consumption but also the newly water requirement of poultry farm systems in the zone. According to our interviews with the breeders, 50% of the cisterns have not been filled completely, while the lower runoff coefficient linked to the rainfall amount increases the scarcity of water and thus the need to bring more water from other places outside the wadi area. And the cost of transported water was too high.

Based on experience in marginal dry land environments in the region, the demand for cistern water per day for human consumption including drinking, sanitary and other uses is established at 50 liters per person (Ali et al., 2009). According to (Gleick, 1996), the proposed water requirement for satisfying basic human needs gives a total demand of 50 liters per person per day.

The minimum water requirement is 5 liters per head for sheep and goats and 15 liters per head for camels (Ali et al., 2009).

Based on the values of the water consumption for human and livestock (sheep, goat and camel) and according to statistics of human population obtained from MRMP data in 2012 and the field survey for animal population estimation in Naghamish in 2012, Fig (68) shows the change in the water consumption for the human and livestock in the area in average season between 1979 and 2012 and the link between the available water in the cisterns can be divided into 4 stages.

The first stage began at the eighties until middle of eighties (beginning of international development projects). In this period, the number of the cisterns have increased very fast and covered the human consumption requirements, but still there was a gap in the water requirement for livestock. According to our interviews, this gap was covered by a less human consumption due to the absence of electricity that limited the water pumped but also the distance to the cisterns. There were also 8 old Roman cisterns with a total capacity of 3500 m3 of water which contributed to fill that gap. Finally, the grazing period was more important; this reduced the livestock consumption in the zone for one consequent period of the year.

The second stage extends from the mid-eighties to mid-nineties. That period was characterized by almost the non-existence of any significant increase in the number of the cisterns. With the increase in population, all the present cisterns covered human consumption of water and the gap was covered mainly by the line coming from Alexandria for drinking water of human and animals.

The third stage of the mid-nineties until 2007 was the period of the MRMP (Matrouh Resources Management Project). This period was marked by a big jump in the number of establishment of cisterns which increased the water availability in order to cover both the human and animal consumption requirement.

The fourth and last stage since 2007 until now has seen the emergence of a new activity, poultry farming, which were not present before 2007. The number of poultry unit increased from 1 farm in 2007 up to 56 farms in 2013 with a consumption of 70 m3 of water per cycle lasting 40 days, as shown in Figure (69). With a rhythm of five cycles per year, this poultry farm consumes about 19,600 m^3 of water, representing almost 32% of the total water stored in the cisterns. In 2013, this gap was covered by transferring water from the city of Matrouh or line of drinking water. According to the local population, the transportation cost of water per cubic meter was about 10 E.P or 200 000 E.P. per annum for the total zone in 2012.

These results show the high competition for water between human, traditional animals and new poultry farms that affect significantly the cost of production for livestock and therefore reduce the economic return, forcing some local population to abandon their traditional system.

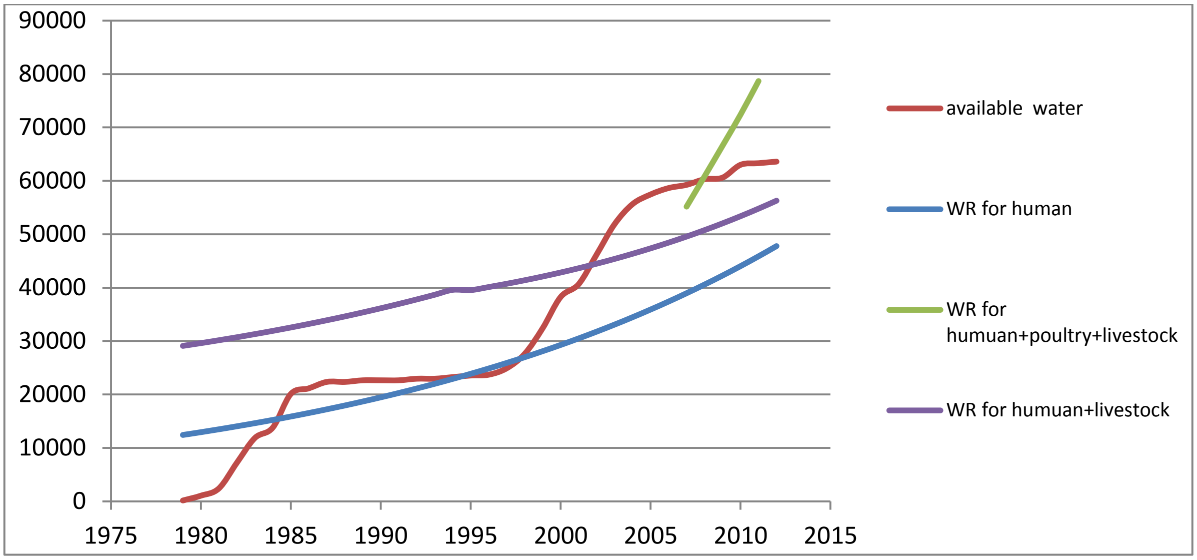


Figure 68: available stored water in cisterns in wadi Naghamish in relation with water requirements in average year

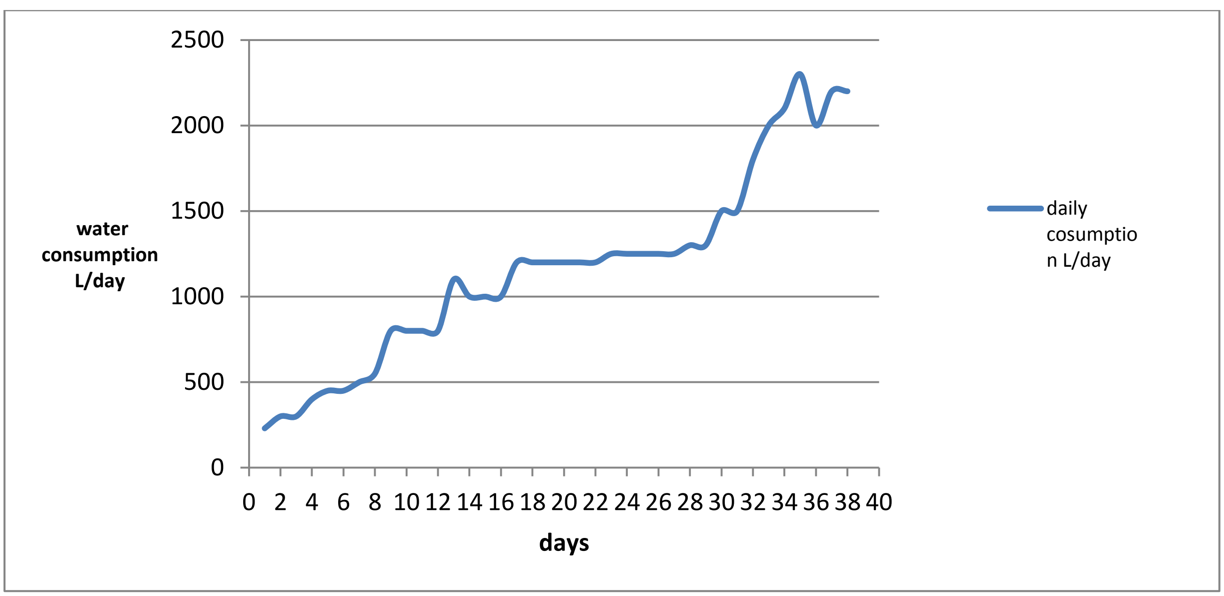


Figure 69: poultry water consumption in Naghamish (one cycle 40 days)

6.2.4. Role of cistern in Crop-Livestock orientation under different climatic scenarios

Consequently to the new water requirement, in zone 1, people depend more and more on the water pipe line coming from Alexandria to cover the gap of the water requirement. For them, the only solution is to use the vehicles or tractors with tanks to transfer the water to the cisterns closed to their houses. In zone 2, they also transfer water from the same pipe line, but, the transport cost is higher due to the distance and the difficulty of the topography in the wadi. In zone 3, the situation is the most critical since the beginning of the drought in 1995 and the complete disappearance of water. During this period, people depended completely on the transfer of water for their all requirements (human and livestock consumption). According to the available data of the numbers of people and their livestock numbers in each zone and based on the basic water daily consumption, the annual demand of water is estimated about 5,500 m3 for human consumption and about 2,100 m^3 for sheep and goats drinking. Then, the total water requirement is 7600 m^3 with a total cost about 76,000 E.P. This cost must be covered by the new adaptive activities in the zone.

According to the three different scenarios of rainfall (proposed in part 6.1) and the water capacity storage in the zone, we propose to describe the water availability and distribution for the 3 scenarios.

6.2.4.1. "Average" scenario: the average years

In the case of "average" scenario" as shown in figure (70), the total annual runoff volume of water is about 2 million representing about 15.6% from the total rainfall volume in Naghamish basin. 3.2% of the annual runoff water volume is stored in the cisterns. According to the field survey and available data for the study area and based on the daily water requirements for humans and livestock, the cisterns water is distributed as: 61% human consumption, 28% for poultry consumption and 11% only for livestock consumption based on estimated livestock population.

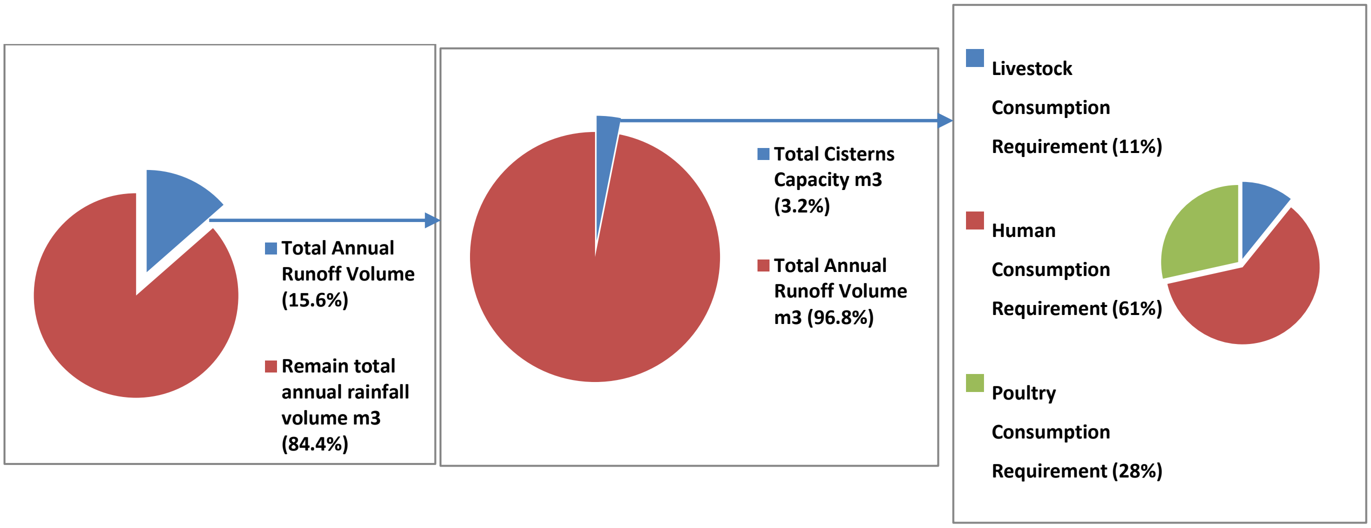
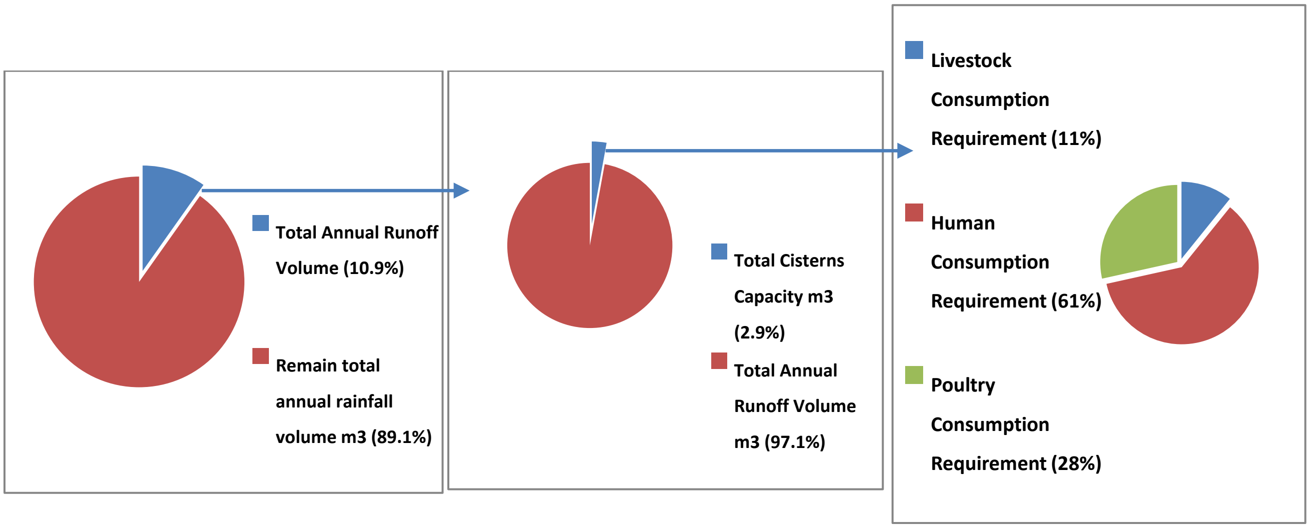


Figure 70: water resources management in Naghamish in average seasons

6.2.4.2. "Drought" Scenario: the dry years

In the 'drought" scenario, as shown in figure (71), the total annual runoff volume of water is about 1.08 million representing about 10.9% from the total rainfall volume in Naghamish basin. 2.9% of the runoff water volume is stored in cisterns that are filled only at 50% of their capacity. In this case, the water distribution between both humans and livestock and poultry remains similar to the "average" scenario. But the gap needs to be covered by water transfer from outside



.

Figure 71: Water resources management in Naghamish in dry seasons

6.2.4.3. “Wet” scenarios: the wet years

In the “wet” scenario, as shown in figure (72), the total annual runoff volume of water is about 4.3 million m^3 representing about 23.3% from the total rainfall volume in Naghamish basin. Only 1.4% of this water is stored in cisterns. The water distribution between humans, livestock and poultry remains constant but the water needs are covered.

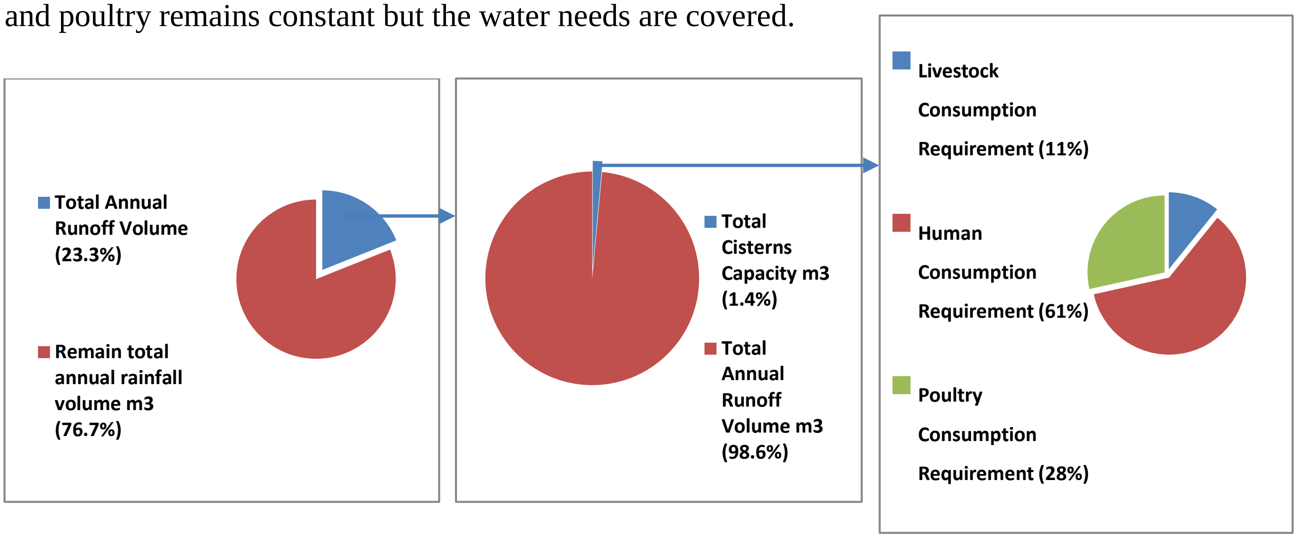


Figure 72: Water resources management in Naghamish in wet seasons

As is evident results show that in rainy years to some extent in the average years, the region does not suffer from water scarcity, while in drought season the water gab increase. With the continuous increase in the number of people it is expected that this gap will increase, especially with the increase of expansion of establishment of poultry farms. This situation led to the need to counter this increase in demand for water through establishment of more cisterns or searching for another source of water.

Conclusion:

These results based on water resources and demand show how farmers have adapted to the water constraints in each zone .If the water scarcity is a constraint to raise traditional livestock like sheep and goat due mainly to the reduction of grazing resources, farmers have developed new activities like poultry unit that require more water that is mainly transported from the pipeline. The economic profitability of this activity allows covering the transportation cost of water. However this development raises questions in terms of sustainability for the zone in link with the water resource.

There is a close link between water resources and land and vegetation in the sense that the scarcity of water resources has a significant negative impact on land resources and thus degradation of vegetation. This scenario has already happened in the Valley Naghamish and will be discussed in detail in chapter 7 (Human and natural factors of land degradation and land cover changes).

CHAPTER 7:
HUMAN AND NATURAL FACTORS OF LAND DEGRADATION AND LAND COVER CHANGES IN WADI NAGHAMISH

Introduction

NWCZ was strongly affected by drought during the last 15 years. The most important effects of drought were its direct effects on the vegetation covers in collaboration with several other factors. This chapter will focus on the most significant changes that have occurred, whether positive or negative changes, through the use of GIS and RS techniques to compare between 2 satellite images of the study area (Wadi Naghamish) in different time periods in 2006 (at the middle drought period) and 2011 (at the end of the drought period). As well as discuss the causes and factors that led to these changes, we will discuss whether human factors or natural factors. Land covers changed should followed by land degradation, where it can be consider as a step or introduction for of the land degradation.

7.1. Description of changes of land covers between 2006 and 2011 in wadi Naghamish

Before starting the comparison process between the vegetation cover between 2006 and 20011 and discussing the most important changes and their causes; should be noted out that satellite image of the study area in 1993 was analyzed before the occurrence of the drought. Due to the incompatibility Date of taking of satellite image with the satellite image in 2006 and 2011, it has been excluded from the comparison process. Figure (73) shows the land cover in 1993.

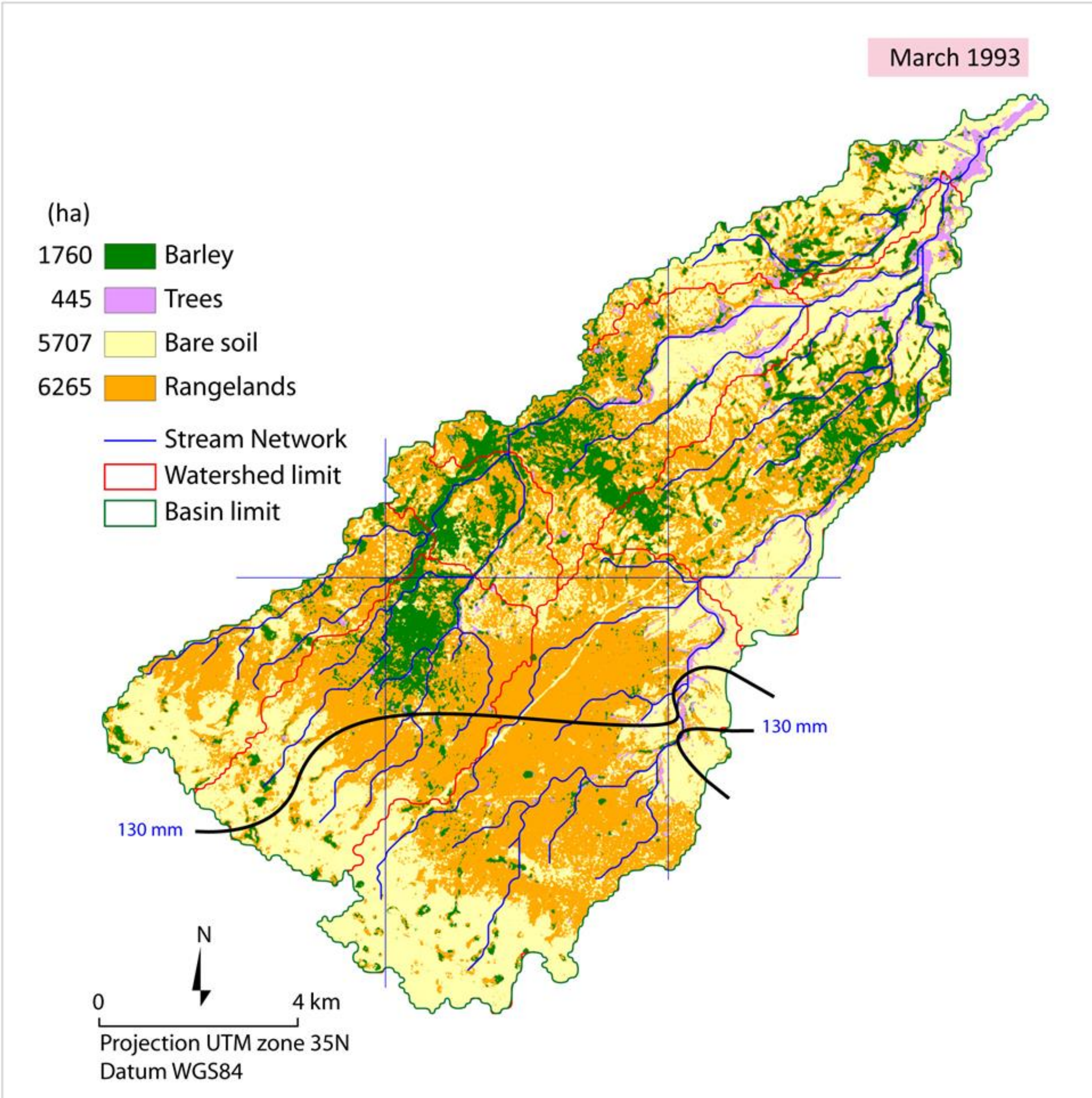


Figure 73: land cover in Naghamish in 1993

Based on the interviews of farmers and resource persons and the analysis of the satellite images in two different dates (2006 and 2011), noticeable changes occurred in the land cover of the study area. These changes will be discussed in details in this chapter and the objective is to identify, through quantitative analysis, the main drivers or factors which led at the end to the land degradation.

Figure (74) is the analyzed satellite images in 2006 and the satellite images in 2011. The two maps clearly show the magnitude of changes in the area in term of low and high vegetation, bare land and agriculture which include both of barley and trees (fig, olive and almond).

Barley cultivations area were decreased by 43%, trees were increased by 18%, range land (low and dense cover) decreased by 20%.

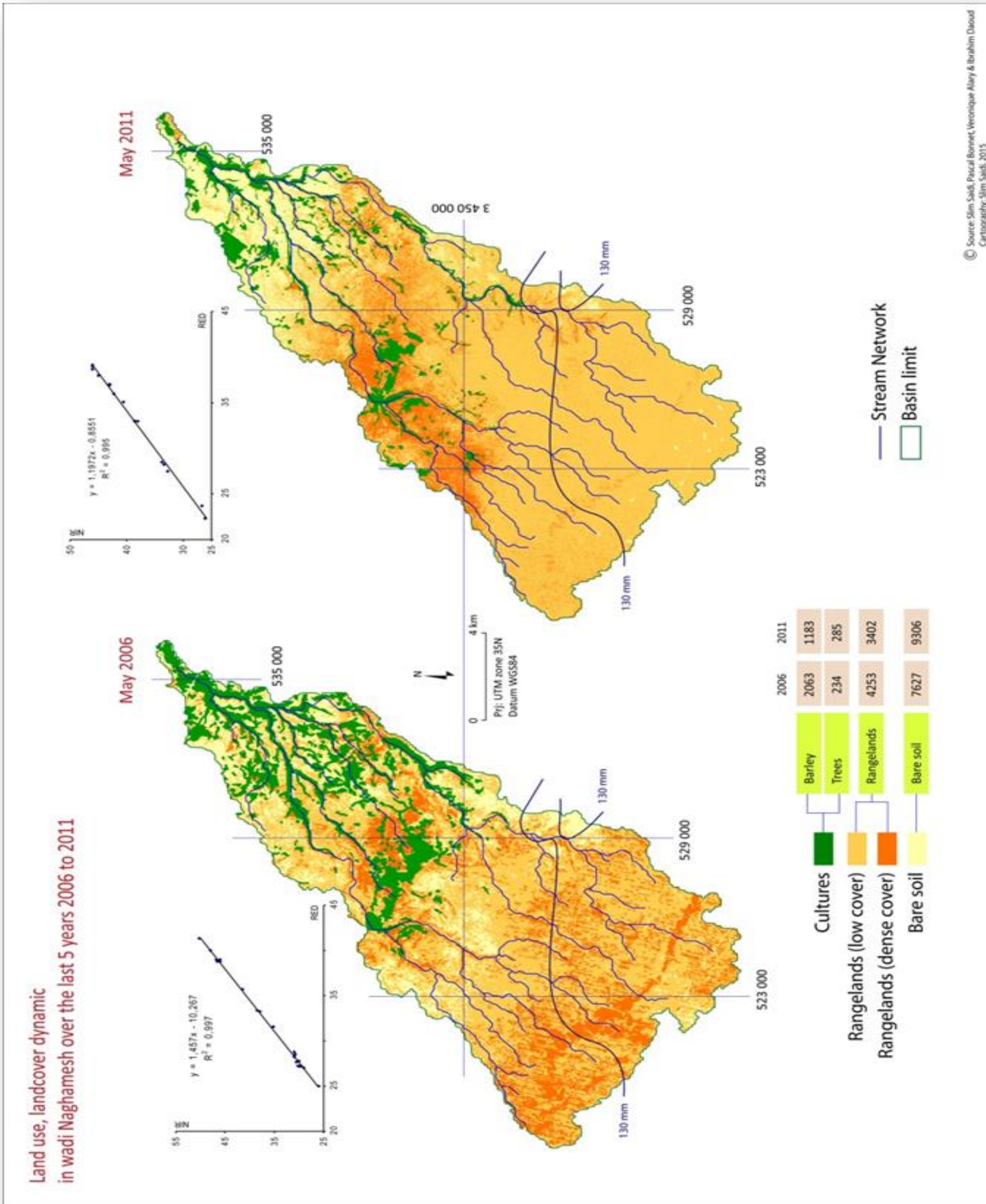


Figure 74: land use, land cover dynamic in wadi Naghamish over the last 5 years 2006 to 2011

7.2. Quantitative approach of the drivers of change of land cover

To identify the factors or drivers which led to land covers change, a root analysis approach through five W analyses has been followed. According to Cook (1998), the 5Ws & H technique is a structured method that examines a problem from multiple viewpoints. It is based on Who is it about? What happened? When did it take place? Where did it take place? Why did it happen? And how it takes place?

This section includes the most important drivers that influence and control the most important changes that have occurred during the drought period for dense and low vegetation agriculture (which includes trees and barley), and bare land.

According to the changes that have been observed in the land cover, table (41) summarizes the changes that have occurred in the wadi Naghamish based on results of the analysis and comparison of satellite images for 2006 and 2011. Changes that have occurred not necessarily be negative as some positive changes.

Table 41: change classes used in the Model

Zone	From	To	Change type
1	Agriculture	Bare	Degrading
	Dense vegetation	Bare	
	Low vegetation	Bare	
2	Dense vegetation	Low vegetation	Degrading
	Agriculture	Low Vegetation	
	Agriculture	Dense vegetation	
	Bare	Low vegetation	Improvement
	Bare	Dense vegetation	
3	Dense vegetation	Low vegetation	Degrading

7.2.1. Main changes in land cover in zone 1

Many changes have been occurred in zone 1 affected by drought and other factors. The main changes were (i) change from agriculture (barley-trees) to bare land; (ii) change from range (dense and low vegetation) to bare. The following is the discussion of the main factors and drivers which led to those changes:

7.2.1.1 Change from agriculture to bare

Change from agriculture to bare was one of the most obvious in zone 1 as shown in figure (75). Agriculture in wadi Naghamish includes both of orchard trees (figs, olive, and almond). Zone 1 is the agriculture productivity zone. Logically be agriculture are the most affected by drought. It is unfair to consider that the drought is the only factor causing this change. But it cooperate with many other factors which led at the end to this change such as lake of labor, increase of education level, increase of production cost, poultry production, market change and migration to city. Those factors were determined based on the field survey and interviews with the farmers.

For a deeper understanding of the factors that led to this change; 5 Ws approach was used as shown in table (42).

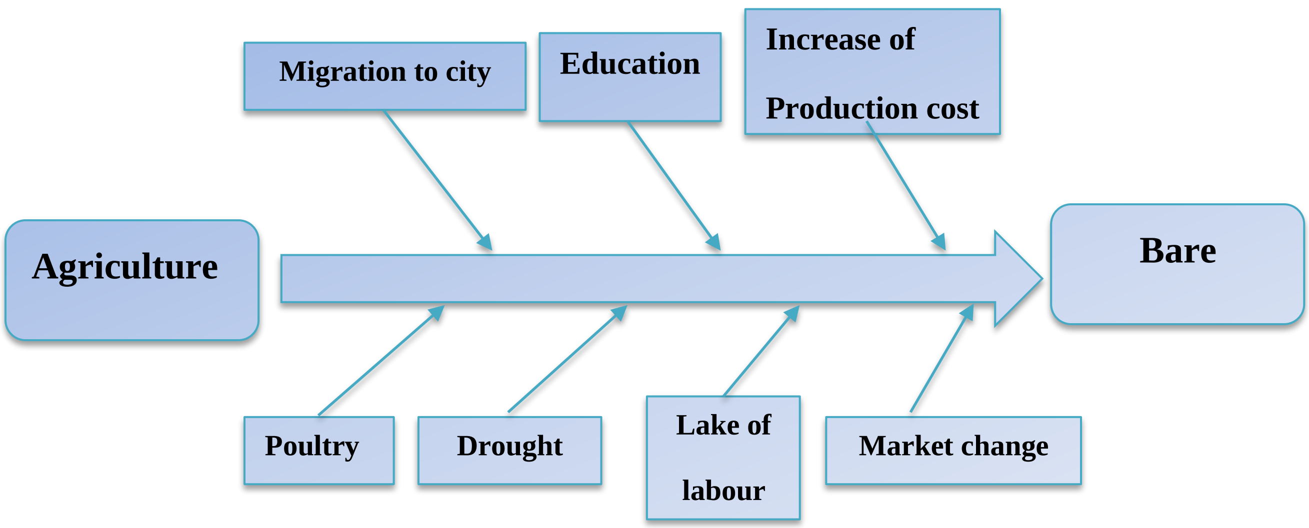


Figure 75: factors of change agriculture to bare

Table 42: Factors of change from agriculture to Bare

No.	Factors or drivers	Five Ws Answers
1	**Lake of labor** .	**What**: Agricultural labor has become unavailable **Who**: global change **Where**: everywhere in the study area **When**: after 1995 **Why**: work in Libya, low income from work in agricultural sector, migration to city, youth do not prefer the agriculture, labor work in poultry farms higher income
2	**Education**	**What**: The spread of education, especially young people, thus left agriculture. **Who**: young people **Where**: zone 1 and 2. **When**: after 1995 **Why**: global change, prefer to have better jobs and live condition
3	**Increase of production cost**	**What**: production cost increased such as, labor, seeds, machinery and thus the negligence of agriculture **Who**: global change **Where**: everywhere in the study area **When**: after 1995 **Why**: global change
4	**Poultry**	**What**: poultry farm increased in the area, many farmers left agriculture and Turned to poultry **Who**: global change **Where**: in zone and 2 **When**: began in 2007 **Why**: as strategy to face the drought.
5	**Drought**	**What**: drought event, affected the agriculture especially tress. **Who** : climate change **Where**: everywhere in the study area **When**: in 1995 **Why**: global change
6	**Migration to city**	**What**: Bedouin migrated to city, and thus left agriculture **Who** : drought (climate change) **Where**: everywhere in the study area **When**: after 1995 **Why**: to get better live condition, live became difficult with drought, for education for children.
7	**Market change**	**What**: market prices fluctuated from year to year and cannot be predicted **Who** : the local and national market **Where**: everywhere in the study area **When**: after 1995 **Why**: supply and demand

Based on the Five Ws analysis approach and our field survey results the following can explain how this factors can led to this change:

1- Drought

A drought is one of the most important drivers faced by the Bedouin community over the last 15 years. According to our survey results in chapter 5, 100% of the interviewers think that the drought was the most effected event in the last 15 years. It had a direct impact on agriculture. That's where the lack of rain for several years frequently led to declining of crop yields significantly and death of trees, and thus some areas cultivated area shifted to bare land. Results show that farmers in zone agree that the drought decreased the agricultural productivity. For example barley was around (260) kg/feddan in 2012 compared with about (500) kg/feddan in the wet seasons before the drought.

2. Education level

In link with the development of schools in the region, the spread of education, especially for young people, has encouraged the young generation to leave the agriculture and to try to get new jobs in city. This change is part of the global change. And this corresponds to the new aspirations of young generation in terms of living conditions. Thus, leaving agriculture led to its transformation into a land of bare. However, this change has been accelerated to the low productivity and then family income during the last 15 years. Results enhance this believing, where the level of education for the head of the family in zone 1 was higher comparing with zone 1 and 2. The closeness to the main road and therefore easy access to the city is considered a key factor to increase the proportion of education in zone 1.

3. Migration and work in the City

As consequence of low agricultural production and the higher educational level in the young generation, many farmers or members of families have migrated to the city for seeking a better life and also to provide education for their children or work in the city. This has reinforced the abandon of land and consequently the transformation of agricultural lands in bare lands. Result show that in zone 60% of the head of the family is governmental employers compared with 25%

and 10% in zone 2 and 3 respectively.

4. Lack of labor

Lack of labor is one of the most important factors resulting from drought, the migration or rural exodus, or even the diversification out of agriculture. This lack of labor led to the abandonment of agricultural land and its conversion into bare land. After the discussion with the farmers, it appears that the reasons are multiple, including: weakness of returns of agricultural work comparing with the work in the city or in Libya, for example daily wage in 2012 was 50 L.E/day comparing with about 200 L.E he can get it from the work in Libya. In zone 1 just 23% from the family have members work as agriculture labor comparing with 41% and 44% in zone 2 and 3 respectively. This result can be considered as an indicator for the reluctance of young people for work in agricultural sector in zone 1. In addition to the more frequent effect of drought that led to a lack of continuity and then sustainability in the work.

5. Market change

Another factor is the liberalization of prices and then their fluctuations. This has affected the agricultural work remuneration. Crop prices fluctuate from year to year and the farmer cannot control; moreover, the absence of collective action for the farmers and the lack of a joint marketing cooperative contributed to the instability of crop prices. Our results indicate that there is significant fluctuation in crop prices such as olive prices, which ranged between 1 and 5 LE/Kg in the last 3 years. Moreover, it becomes difficult for small farmers to expect the productions price with the absence of system information on market prices. These changes severely affected the continuity of work in the agricultural sector and then shifted agricultural land into bare land.

6. Increase of production cost

In the recent period, agricultural production costs significantly increased, especially those related to labor, such as hoeing, pruning and harvesting. It is known that the system of harvesting in the region is through the participation of people from the community or from other community and this people received one third of the production. Due to the new opportunities in the zone and also the lack of agricultural workers (family or occasional laborers), people have required one half of the production. This led to the reduction of benefit and then sometimes the abandon of the agriculture. In zone 1 annual tillage cost for feddan reached to around 140 L.E; labor cost around 211 L.E.

7. Poultry production

Emergence of poultry activities encouraged breeders to sell their flocks, thus mitigate the pressure on vegetation. This new activity was one of the strategies to cope with drought. It started in the study area in 2007. Despite the high proportion of risk in this activity, many breeders decided to return from sheep and goats breeding to poultry farming. Results of the ELVULMED project indicate that the farmer can get from 15 000 to 20 000 L.E, but maybe he will lose the amount or more in bad conditions.

7.2.1.2. Change from range (low and dense range) to bare land

As shown in figure (76) many factors led to change from range to bare land. Those factors were determined based on the field survey and the interviews with the farmers. For a deeper understanding of the factors that led to this change, 5 Ws approach was used as shown in table (43).

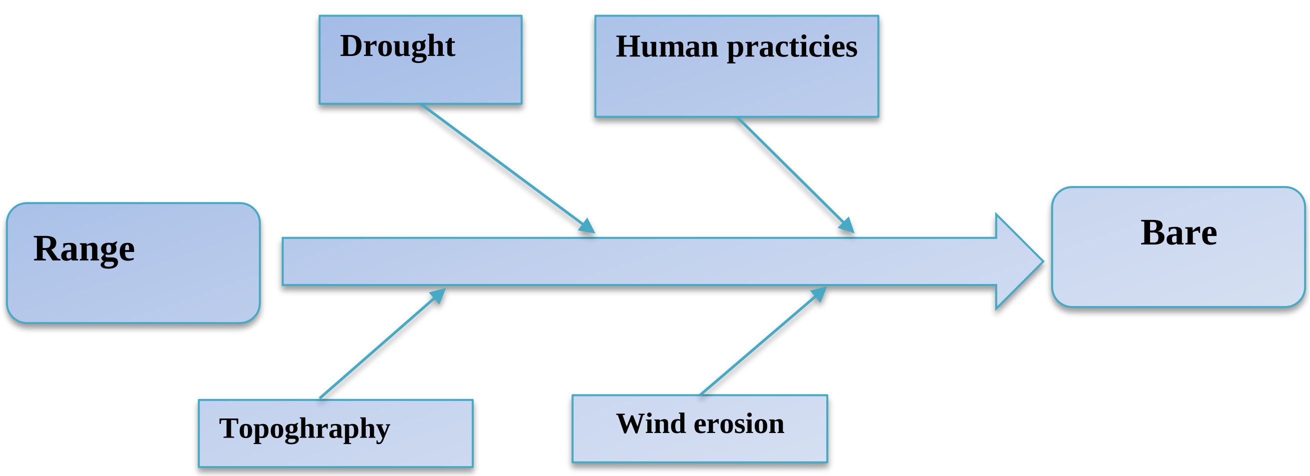


Figure 76: factors of change from range to bare

Table 43: change from range (low and dense vegetation) to bare land

No.	Factors or drivers	Five Ws Answers
1	Humane practices	**What:** cutting firewood, stone crusher, over grazing, soil removal, tourist villages and urbanization **Who** : human **Where**: everywhere in the study area **When**: with Bedouin settlement **Why**: By necessity
2	Drought (rainfall)	**What**: lack of rainfall effected the vegetation cover Consequently vegetation has been degraded **Who** : climate change **Where**: everywhere in the study area **When**: since 1995 to 2010 **Why**: naturally
3	topography (slope)	**What**: high land slope make the soil Easier to erosion, thus no soil depth to plants to grow **Who** : geology and geomorphology **Where**: in wadi sides and the edge of southern plateau **When**: unknown **Why**: naturally
4	**wind erosion**	**What**: Wind Gusts has increased significantly, with absent of vegetation, soil be easier to be eroded **Who** : climate change **Where**: everywhere in the study area **When**: with the drought 1995 **Why**: climate change

Based on the Five Ws analysis approach (table 43), we are going to describe the process of land degradation from vegetation (high and low) by considering each driver. However, firstly, we can observe that many drivers contributed to the process of land degradation; we can distinguish normal drivers, such as drought, water and wind erosion, and human drivers which result from erroneous practices of human. If we cannot attribute a degree of influence for each driver and its contribution to land degradation, we propose to describe the specific effects of each one according to our field surveys and interviews.

1. Drought

A drought is one of the most important challenges faced by the Bedouin community over the last 15 years. Drought had a direct impact on land degradation. Usually the lack of rain for several years frequently led to the decay of vegetation gradually and then the soil became more susceptible to erosion through erosion factors such as water, wind.

Drought cannot be the only factor for the occurrence of land degradation, but it is considered as the most important of these factors; other factors led to the rapid occurrence of deterioration. 100% of the population in zone 1 confirms the occurrence of drought in the zone.

2. Human practices

In wadi Naghamish many agricultural practices carried out by human led to land degradation, either directly or indirectly, such as: (i) cutting of firewood to be used as fuel for cooking, (ii) over grazing process which mean lack of prudent management of the pasture (this is shown clearly in zone1 and 2), and (iii) soil removal for the purpose of road construction. This is shown clearly in the southern region in zone 3. These processes are often mentioned in this type of environment. We can note that in Zone 1 emergence of barren land was clearer than in Zone 2 and 3; this can be attributed to the existence of high population density in this zone that had a clear role in the transition to the land of barren.

3. Topography

Topography is one of those factors that aggravated the degree of land degradation. With important surface ground slope, the processes of soil erosion by water erosion become stronger. This is shown clearly in the wadi bed sides in zone 1 and 2 and on the edges of the southern plateau where the greater degree of surface slope explains the severity of erosion. Those areas are the most eroded areas where the soil mostly washed out completely and turned into bare rock. In figure (67) we can note appearance of barren land clearly on the sides of the wadi.

4. Wind Erosion

Wind erosion is one of the natural factors that have also contributed significantly to the degree of the process of land degradation. in zone 1 as a result of bad human practices the vegetation has been removed and hence the soil has become more vulnerable to wind erosion. This did not happen with the presence of vegetation; so when drought reduces the vegetation, this phenomenon of wind erosion is reinforced.

7.2.2. Land cover change in zone 2

Many changes in the land cover have been occurred in zone 2. The most important changes were (i) Change from agriculture to range (dense and low vegetation), (ii) Change from bare to range and (iii) Change from dense vegetation to low vegetation.

7.2.2.1. change from agriculture to range (dense and low vegetation)

Figure (77) shows the most important factors which led to change from agriculture to range. For a deeper understanding of the factors that led to this change table (44) shows the 5Ws analysis approach.

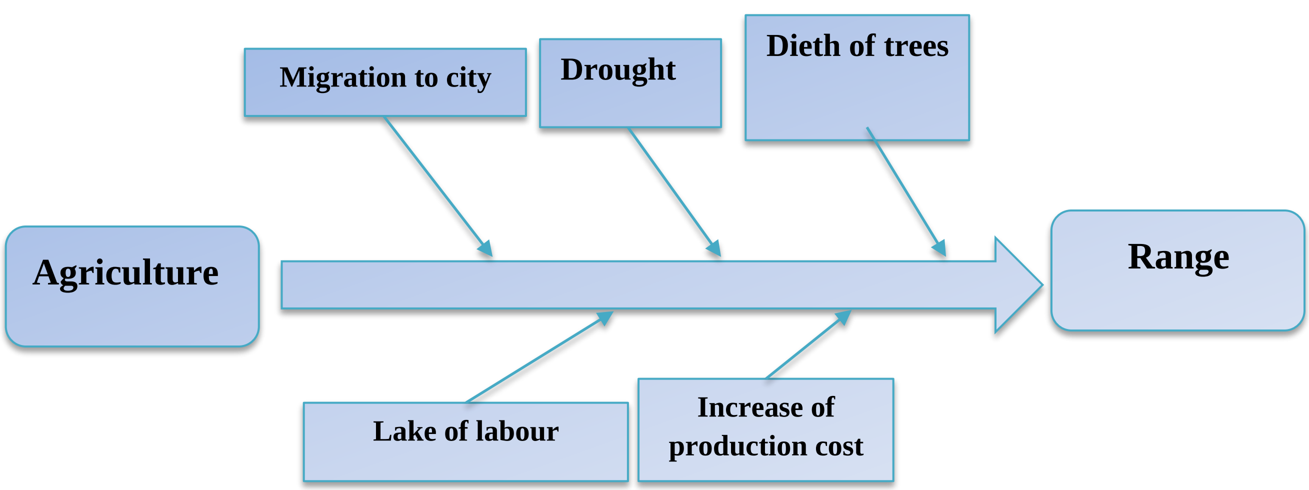


Figure 77: change from bar, agriculture and dense range to low range.

Table 44: change from agriculture to range

No.	Factors or drivers	Five Ws Answers
1	Migration to city	**What**: mitigate the pressure on vegetation and thus allows re-growing **Who**: Bedouin **Where**: everywhere in the study area **When**: after 1995 **Why**: one of the strategies to cope with drought
2	Drought	**What**: drought event, affected the livelihood, some stop to cultivate land. **Who** : climate change **Where**: everywhere in the study area **When**: in 1995 **Why**: global change
3	Lack of labor	**What**: lack of labor led to neglect of agriculture sector. **Who** : human behavior **Where**: everywhere in the study area **When**: after 1995 **Why**: global change
4	Death of trees	**What**: death of trees affected by water scarcity led to disappear of trees. Thus with rainfall it can turn into vegetation **Who** : climate change **Where**: in zone, 1 and 2. **When**: after 1995 **Why**: Global change
5	Increase of production cost	**What**: increase of production cost led to neglect of agriculture sector. **Who** : market change **Where**: in zone1,2 **When**: after 1995 **Why**: market change

1- Migration to city

Migration to the city contributes to the natural vegetation due to abandon of cultivated land. With no tillage the land is recovered by its natural vegetation. Off-farm income in zone 2 represents about 43% of the total income in the region as a result of temporary or permanent migration to work in the city. This high percentage confirms that a large proportion of the population left the agriculture sector and turned to other off-farm activities.

2- Drought

Due to recurring drought in the region; the farmers are more and more afraid of planting barley due to the frequent losses. This explains again the opportunity to see natural vegetation in this zone. Results of the satellite image and the answer of 100% of the interviewers confirm the occurrence of drought in the zone 2.

3. Lack of labor

Lack of labor is one of the most important factors that lead to the abandonment of agricultural land that can be converted into vegetation. Results of data analysis show that 54% of the labor works outside the agriculture sector in zone 2 against 46% working in agriculture and livestock sector in the zone or outside the zone such as Libya.

4. Death of trees

The death of the trees is one of the important factors that work on the conversion of cultivations to the vegetation where that after the death of the trees farmers stop tilling the land and thus grass can again grow. There are many causes of the trees death. The most important is the drought that causes the death of the trees as a result of the absence of water for several years. In addition to diseases of trees may cause its death, as well as to stop plowing the land for several years, leading to the death of trees. In addition to this, the absence of the supplemental irrigation in drought seasons led to tree death in zone 2. Figure (78) shows the death of trees as result of drought in zone 2

Figure 78: Death of trees as result of drought in zone 2, wadi Naghamish 2012

5. Increase of production cost

In the recent period agricultural production costs significantly increased, especially those related to labor, such as hoeing, pruning and harvesting. As mention before it is known that the system of harvest in the region is through participation so that it is based on the proportion of the harvest of the crop whether it is figs, olive or barley. It was in the past one-third of the crop production, currently as a result of the lack of labor, it has increased and it is established now to half of the crop production, which inevitably can lead to the abandonment of the agricultural sector. In zone 2 annual tillage cost for 1 feddan reached to around 145 L.E, while labor coast for 1 feddan was around 175 L.E in 2012.

7.2.2.2. Change from dense to low range

Change from dense range to weak range of vegetation was one of the most significant changes that can be observed in Zone 2. It is mainly a negative change due to drought with cooperation with other factors. Figure (79) shows the most important factors that can lead to this change. Table (45) shows the 5Ws approach

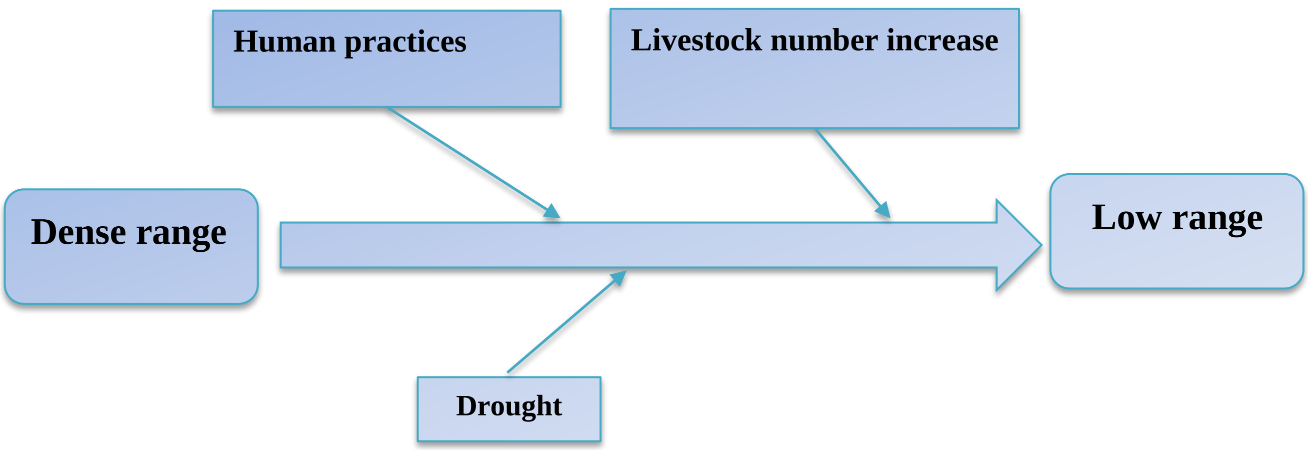


Figure 79: change from agriculture, bare and dense range to low rang

Table 45: change from high to low vegetation

No.	Factors or drivers	Five Ws Answers
1	Drought	**What**: drought event, affected the vegetation grow **Who** : climate change **Where**: everywhere in the study area **When**: after 1995 **Why**: global change
2	Livestock number increase	**What**: increase of livestock number increase the pressure on the vegetation, thus, decrease of density of the vegetation **Who** : climate change **Where**: everywhere in the study area **When**: before 1995 **Why**: global change
3	Human practices	**What**: some bad behaviors such as cutting wood decrease the density of the vegetation **Who** : human behavior **Where**: everywhere in the study area **When**: all the time **Why**: need for a source of fuel for cooking

Based on the Five Ws analysis approach, the following can explain how this change as shown in table (45) can occur

1. Drought

During the drought period the rainfall amount is decreasing, thus it has direct effect on the vegetation growing. With continuous of the drought waves from 1995 to 2011, clearly decay of vegetation appeared. This led at the end to change from high dense vegetation to low vegetation. In zone 2, 100% of farmers said that change from dense range to low was mainly the result of drought effect.

2. Livestock number increase

The increase of the number of animals leads generally to the increase of pressure on vegetation and then the process of overgrazing, which will ultimately lead to the decay of vegetation.. Results show sometimes an increase of livestock number in zone 2 at the level of breeders; but it can be decrease at general at the level of the zone.

3. Human practices

Human practices such as, cut firewood in order to obtain the source of fuel for cooking is considered one of the most common behaviors in the area. Although, the use of gas for cooking, but the population may be forced to cut firewood due to the far distance from the city and the lack of availability of gas. This behavior is common in the three zones. In addition of overgrazing; this is one of the bad human practices which led to from dense to low range.

7.2.2.3. change from bare to range (dense and low)

Change from bare to range in zone 2 is one of the important positive noticed changes. Many factors lead to this change as shown in figure (80). Table (46) shows those factors using the 5 Ws questions approach.

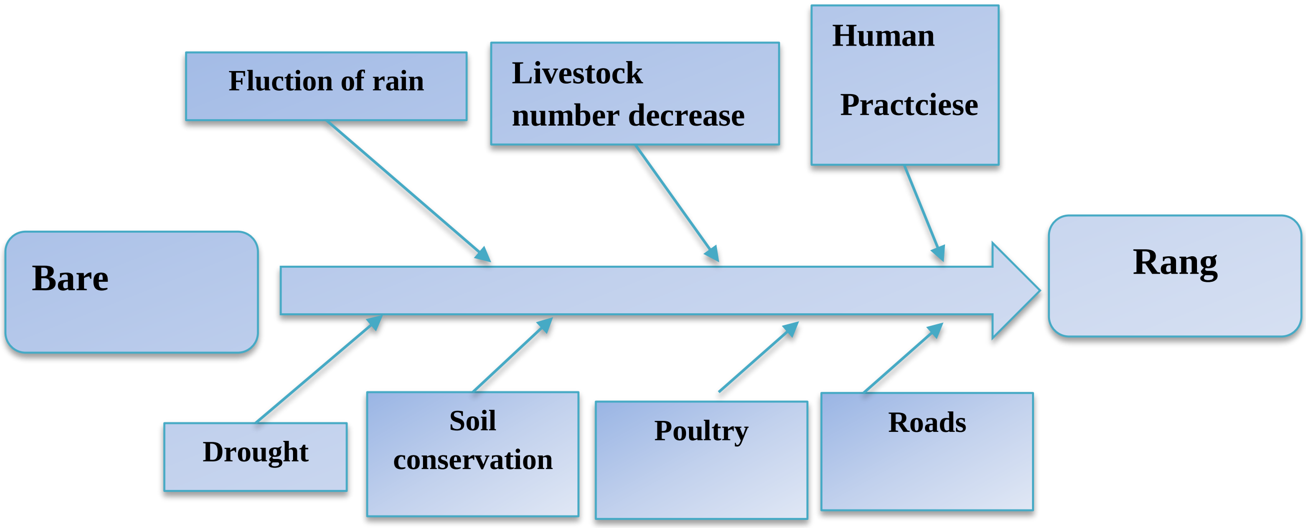


Figure 80: factors of change from bare to range

Table 46: Bare to range (high and low)

.

No.	Factors or drivers	Five Ws Answers
1	Fluctuation of rain	**What**: Despite the presence of the drought sometimes rains fall and permit the growth of vegetation **Who**: climate change **Where**: everywhere in the study area **When**: after 1995 **Why**: global change
2	Livestock number decrease	**What**: mitigate the pressure on vegetation and thus allows re-growing **Who**: climate change **Where**: everywhere in the study area **When**: after 1995 **Why**: one of the strategies to cope with drought through reducing flock number
3	soil conservation	**What**: establishment of soil conservation structures allow to the vegetation to grow around dikes. **Who** : development projects **Where**: in wadi bed and depreciations in the wadi **When**: after 1995 **Why**: governmental policy for development and Bedouin settlement.
4	human practices	**What**: establishment of forest trees on bare lands **Who** : Matrouh Governorate **Where**: in the western border of Naghamish basin **When**: 2006 **Why**: Disposal of sewage of Matrouh City
5	Poultry Farm	**What**: emergence of poultry activities encouraged breeders to sell their flocks, thus mitigate the pressure on vegetation and thus allows to re-grow **Who** : breeders **Where**: in zone1,2 **When**: after 1995 **Why**: one of the strategies to cope with drought through reducing flock number
6	livestock number decrease	**What**: mitigate the pressure on vegetation and thus allows to re-grow **Who** : climate change **Where**: everywhere in the study area **When**: after 1995 **Why**: one of the strategies to cope with drought through reducing flock number
7	Roads	**What**: establishment of roads in the area make it work as soil conservation structures, thus allow to the vegetation to grow around it. **Who** : development projects **Where**: in everywhere in the study area. **When**: after 1995 **Why**: governmental policy for development and Bedouin settlement.

Based on the Five Ws analysis approach, the following can explain how this change as shown in table (46) can occur:

1. Soil conservation

Soil conservation techniques such as dykes led to provide a suitable environment in terms of water and soil depth and this gives a proper environment for seed conservation and plant growth. Most of the branches of wadi Naghamish streams are located in zone 2 and thus the chance of having different types of dikes are high and in addition to the dry stone dikes in the flat lands.

2. Livestock number decrease

The over-grazing as a result of the increase of animal numbers in the same area is one of the major factors of the deterioration of pasture land that turns into a bare land. At opposite, the reduction of animal stock can allow the vegetation to recover the land. Most probably, this is what actually happened in wadi Ngamish as a consequence of the last drought that has induced a reduction by neat 69% of the flock in zone 2. The less pressure on the pasture allowed the vegetation to recover and then, now, there is a chance for the bare land to turn again into vegetation with the availability of a reasonable amount of rain.

3. Human practices

Human's practices have also contributed in the transformation of bare land into vegetation through the establishment of forest trees in the eastern border of Naghamish basin in 2006, despite this negative effect.

4. Migration to city

Migration to the city has contributed to the re-vegetation through the sale of the flock and then the reduction of animal pressure on land. The results confirm that idea, where the off-farm activities which depending on work in city represent about 43% of the total annual income against 30% from agriculture activities and 27% from livestock activities in zone2.

5- Fluctuation of rainfall

The fluctuation of rainfall could play an entirely different role to drought, by allowing the vegetation to grow again in the bare land where amount of rain could fall in an appropriate time for the growth of shrubs. Therefore there is an opportunity for the vegetation to recovering. Rainfall data enhances this idea; where according to the available rainfall data in the period from 1995 to 2011, the data indicate that the occurrence of drought in that period. Also the data indicate that, during that period, 12 years was dry less than 140 mm, while 4 years was wet years more than the average.

6. Poultry

Emergence of poultry activities encouraged breeders to sell their flocks, thus mitigate the pressure on vegetation. This new activity was one of the strategies to cope with drought in zone 2. It started in the study area in 2007. Despite the high proportion of risk in this activity, many breeders decided to return from sheep and goats breeding to poultry farming. Most of the poultry farms are located in zone 2 as shown in figure (81).

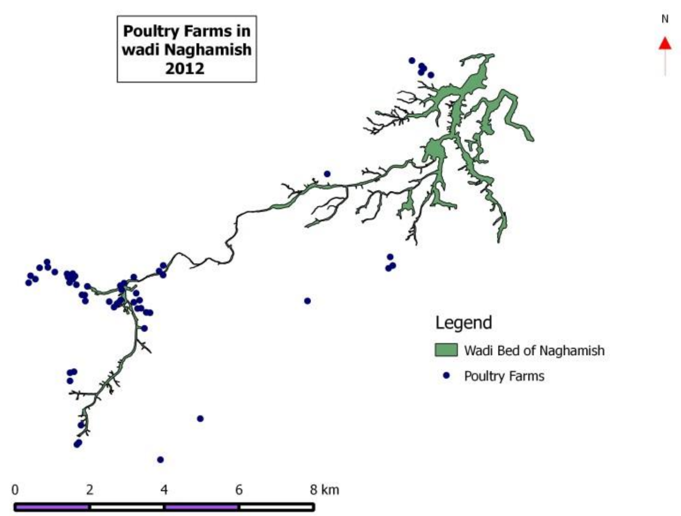


Figure 81: poultry farms in wadi Nghamish 2012

7. Roads

Establishment of roads in the area makes it works as soil conservation structures, thus allowto the vegetation to grow around it. The development projects have established many roads between the southern roads and the northern roads. Most of those roads have been constructed in in the mid ninetieth in the last century. They cross the three zones. Zone 2 includes also 2 local roads as shown in figure (82).

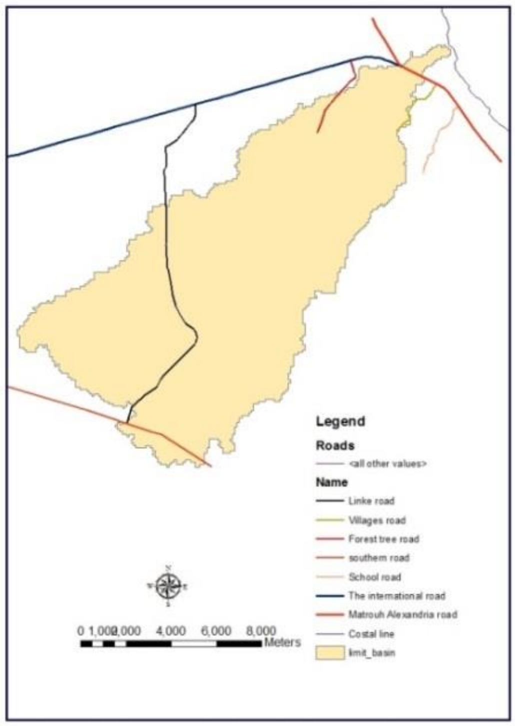


Figure 82: Roads in wadi Naghamish

7.2.3. Land cover change in zone 3

In fact, most of land cover changes have occurred in zone 3 before 2006 as shown in figure (73) above. The satellite image in 2006 shows just the change from dense to low range. Results indicate the existence of agricultural activities represented in the barley crop before 1995 in zone 3. The main change in the land cover between 2006 and 2011 was the change from dense to low range. The following are more details of this change.

Change from dense range to weak range or vegetation was one of the most significant changes that can be observed in Zone 3. It was negative change affected by drought with cooperation with other factors. Figure (83) shows the most important factors that can lead to this change. Table (47) shows the 5Ws approach

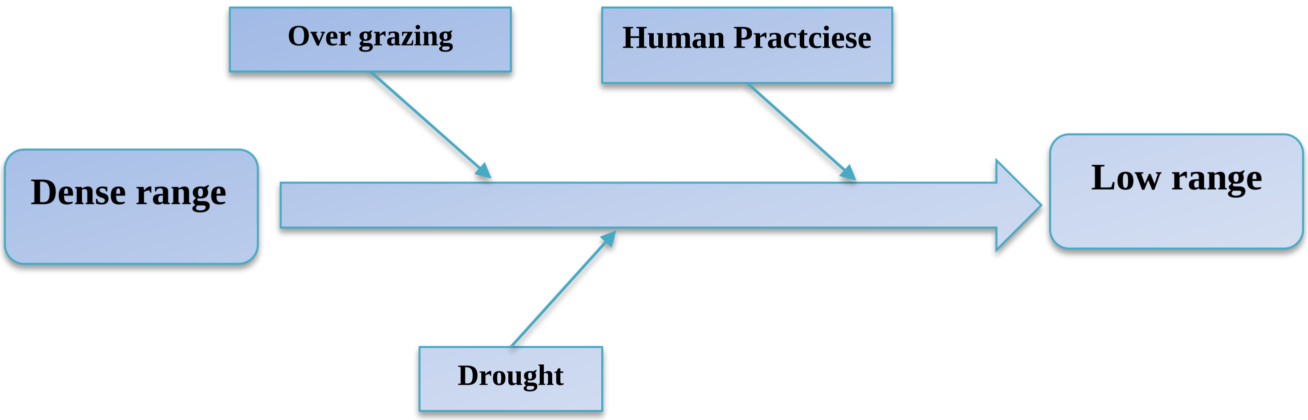


Figure 83: change from dense range to low range

Table 47: change from high to low vegetation

No.	Factors or drivers	Five Ws Answers
1	Drought	**What**: drought event, affected the vegetation grow **Who** : climate change **Where**: everywhere in the study area **When**: after 1995 **Why**: global change
2	Over grazing	**What**: increase of animal's number on the same area unit. **Who** : breeders **Where**: everywhere in the study area **When**: all the time **Why**: need to feed animals
3	Human practices	**What**: some bad behaviors such as cutting wood decrease the density of the vegetation **Who** : human behavior **Where**: everywhere in the study area **When**: all the time **Why**: need for a source of fuel for cooking

Based on the Five Ws analysis approach, the following can explain how this change as shown in table (47) can occur

1. Drought

Results and field survey show how the drought affected the zone 3. Most of these changes have been occurred in the period from 1995 to 2006 represented in the disappearance of the agricultural activities.

2. Over grazing

The increase of the number of animals leads to an increase of pressure on vegetation and over grazing. Although the decrease of the number of livestock in zone 3, the vegetation cover area comparing to the livestock number does not fit with grazing needs of herds.

3. Human practices

The population in zone 3 is often forced to cut firewood due to the far distance from the city and the lack of availability of gas as shown in figure (84).

Figure 84: Fire Wooding in NWCZ. Source: MRMP

In summary we can observe that, in general that the changes that have occurred in vegetation in Zone 1, 2 and 3 were the result of the participation of both natural factors such as rainfall and erosion, water, wind, topography and human factors represented in human practices.

7.3. Land degradation

7.3.1. Quantitative approach of land degradation

Land degradation is a process in which the value of the biophysical environment is affected by one or more combination of human-induced processes acting upon the land (Conacher & Conacher, 1995). Also environmental degradation is the gradual destruction or reduction of the quality and quantity of both of human activities and natural resources caused by soil erosion, wind, etc. It is viewed as any change or disturbance to the land perceived to be deleterious or undesirable (Johnson, et al., 1997).

Land degradation percentage is approached by map analysis and checking by random interviews in the different zones. A first classification is implanted based on the soil depth and density of the vegetation. Figure (85) and table (48) show the land degradation in wadi Naghamish. The reasons approached through random interviews and personal observations. We can classify the degraded soils in 7 categories :(1) Non degraded soil protected by dikes represents about 3%; from the total area (2) Degraded soil effected by topography represents about 14%; (3) High Degraded soil affected by topography and drought represents about 5%; (4) High degraded soil affected by drought and wind erosion represented about 41%; (5) Degraded soil effected by drought and human practices represented about 4%; (6) Moderate degraded protected by vegetation cover represented about 26%; (7) Moderate degraded protected by barley cultivations represent about 7% from the total area. Figure (86) shows average soil depth in wadi Naghamish basin.

Table 48: land degradation in wadi Naghamish

No.	Zone	Description	Area (ha)	%
1	1,2	Non degraded soil protected by dikes	342	3%
2	1,2	Degraded soil effected by topography	2013	14
3	3	High Degraded soil affected by topography and drought	748	5
4	3	High degraded soil affected by drought and wind erosion	5884	41
5	1,2	Degraded soil effected by drought and human practices	603	4
6	1,2	Moderate degraded protected by vegetation cover	3621	26
7	1.2	Moderate degraded protected by barley cultivations	975	7

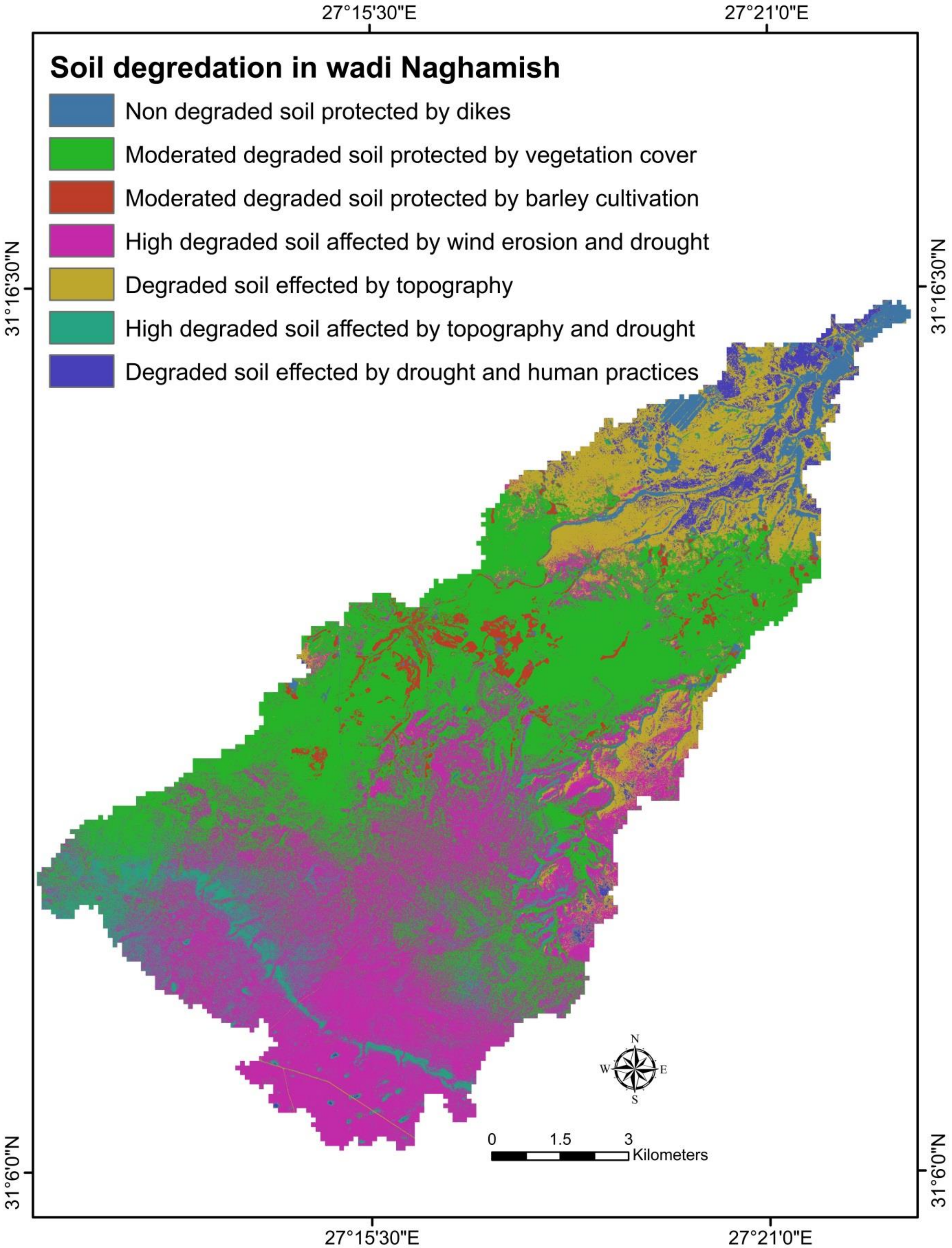


Figure 85: land degradation in wadi Naghamish

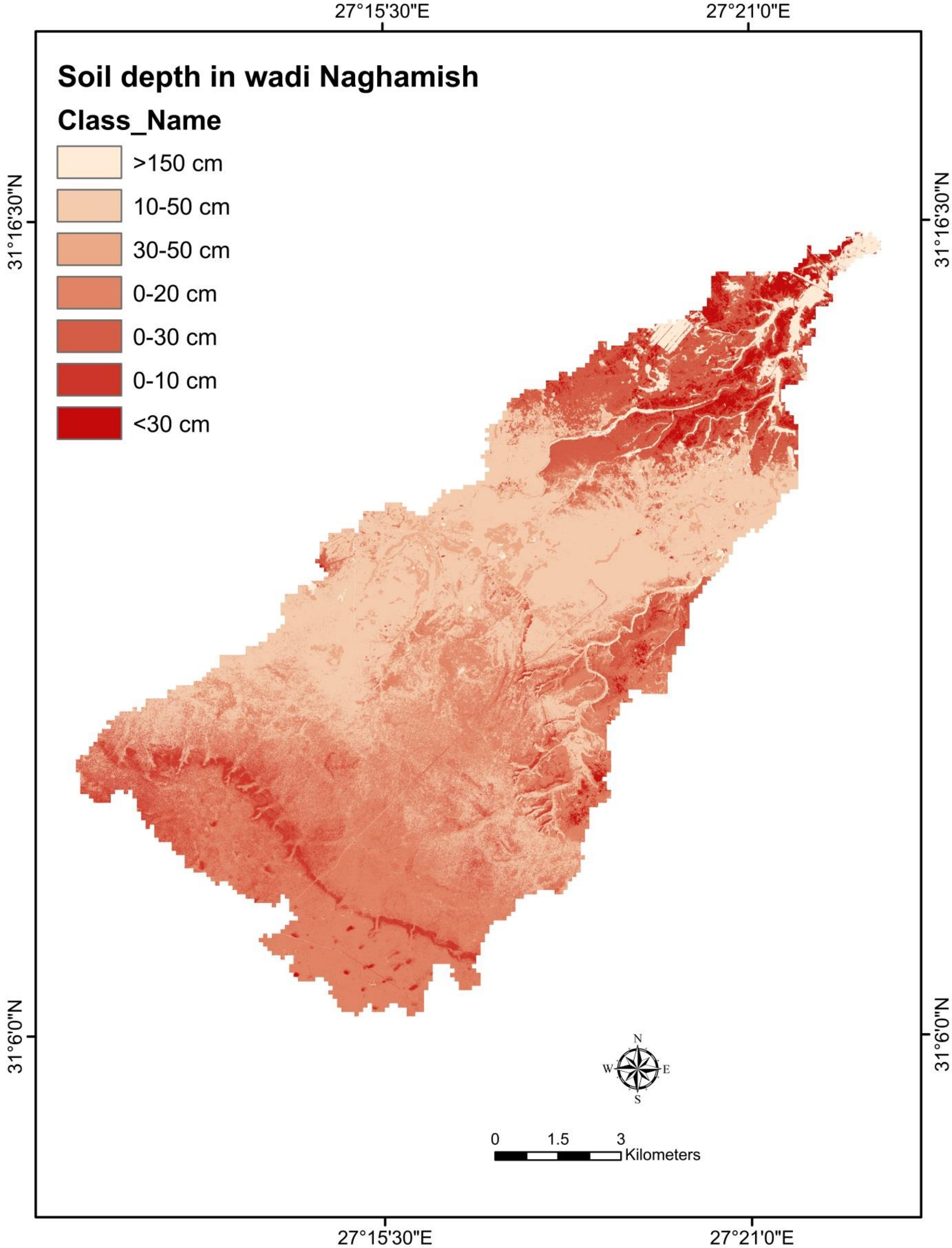


Figure 86: soil depth of wadi Naghamish

The radar figure (87) shows clear the strong contribution of drought and wind erosion in the total land degradation process at the wadi scale, in addation to to the role of vegetation and barley to protect the soil.

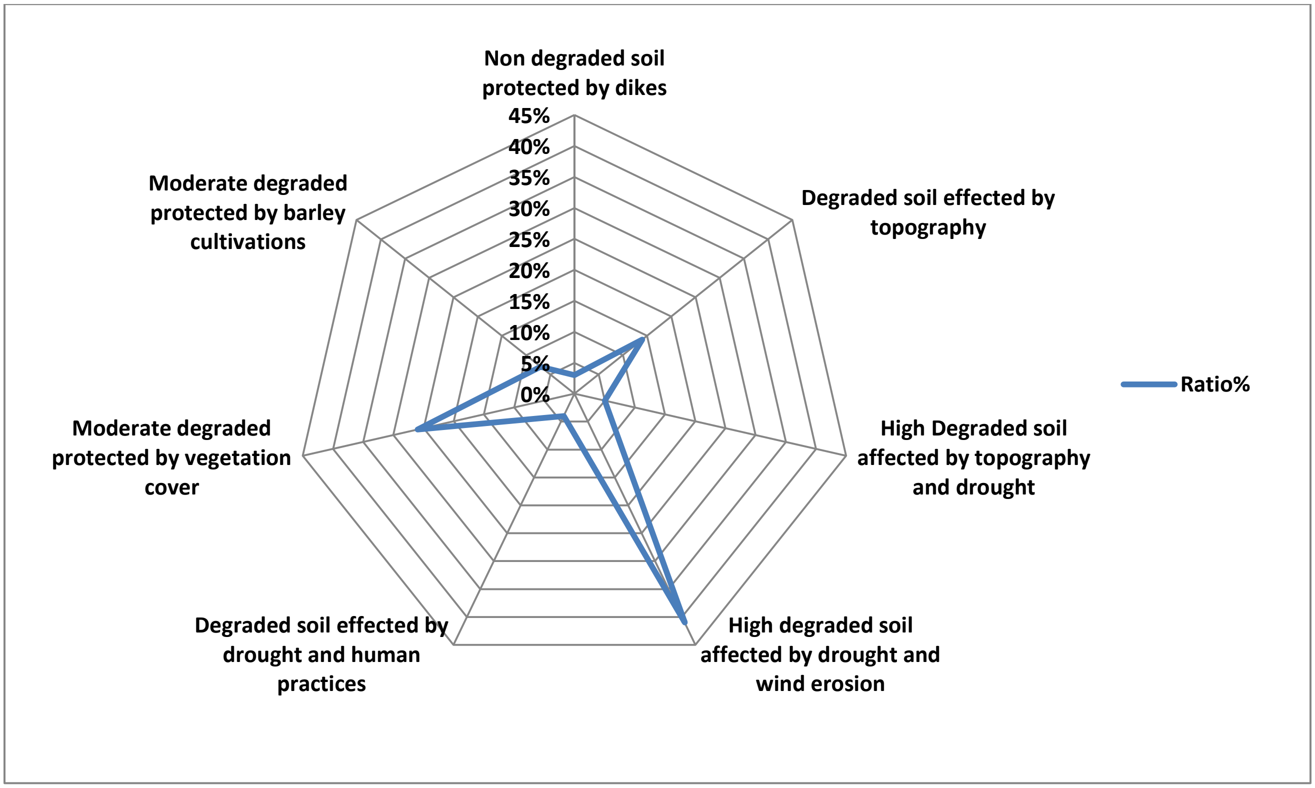


Figure 87: land degradation factors in wadi Naghamish

Land degradation takes many forms in the study area and the most important of these shapes are such as the following:

7.3.2. From degradation to desertification

Desertification is a type of land degradation in which a relatively dry land region becomes increasingly arid, typically losing its bodies of water as well as vegetation and wildlife. It is caused by a variety of factors, such as climate change and human activities. Desertification is a significant global ecological and environmental problem (Geist, 2005)

Problems of desertification are evident in Naghamish watershed and have many factors of occurrence. The field study and the results of the questionnaire show that desertification has been occurred in all the study area of wadi Naghamish, but this phenomenon is more acute in the south of the study area (zone 3) where the vegetation completely disappeared. The main reason is of course the drought. From our interviews, the population explained that, before 1995, the rain annually fell in the area and then the area was covered with dense vegetation, the barley cultivation covered high ration of the land area especially in the depressions. After 1995, the situation changed completely. With the stop of rainfall, the wind loaded with dust and fine sand become blowing strongly on land and vegetation have been strongly deteriorated before disappearing.

The erosion is the process by which soil and rock are removed from the Earth's surface by exogenesis processes such as wind or water flow, and then transported and deposited in other locations. While erosion is a natural process, human activities have increased by 10-40 times the rate at which erosion is occurring globally (Blanco, et al., 2010). Excessive erosion causes problems such as desertification, decreases in agricultural productivity due to land degradation, sedimentation of waterways, and collapse due to loss of the nutrient rich upper soil layers. Water and wind erosion are now the two primary causes of land degradation; combined, they are responsible for 84% of degraded acreage, making excessive erosion one of the most significant global environmental problems (Blanco et al., 2010).

The soil erosion in Naghamish watershed takes many forms according to causes and the location in the wadi, and occurs mainly by water and wind.

7.3.2.1. Sheet erosion

Sheet erosion is a process caused by surface runoff, where “runoff actually is concentrated in many small rivulets of water” (Toy et al., 2002, p. 338). This area is also called the inter-rill area and erosion occurring here is defined as inter-rill erosion (Toy et al., 2002).

In wadi Naghamish area, sheet erosion occurred in the northern and southern plateau in the gentle slope areas. The indicator of the occurrence of this type of erosion is the emergence of stones on the soil surface which were not present in this way on the soil surface a few years ago. Figure (88) shows the sheet esosion

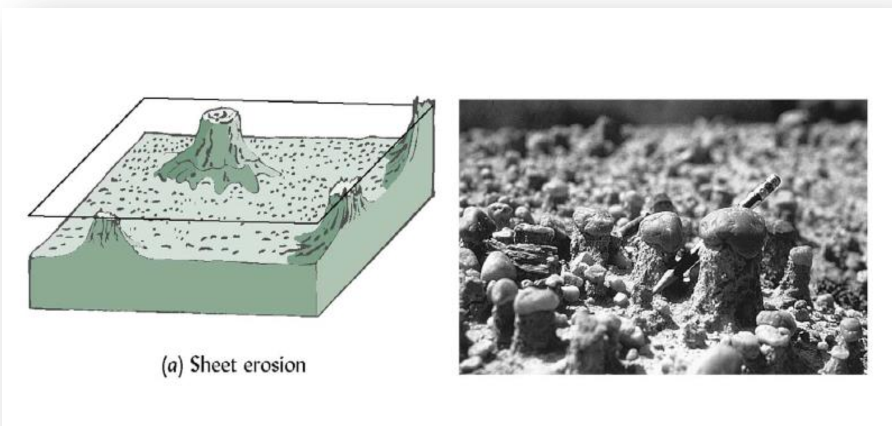


Figure 88: Sheet erosion

7.3.2.2. Rill Erosion

Rill erosion is a process caused by the concentration of surface runoff. ”Rills are channels that are so small [that] they can be obliterated by normal tillage operations. Rill erosion is of lesser frequency but higher magnitude than sheet erosion. Areas of both, rill erosion and inter-rill erosion ‘make up the overland flow areas of land scapes’ ”(Toy et al., 2002, p.338).

In wadi Naghamish this kind of erosion is commonly found in sub-branches of the wadi, especially at the beginning, which is characterized by the presence of a large slope degree to some extent, but with the absence of a major flood. Figure (89) shows the rill esrosion.

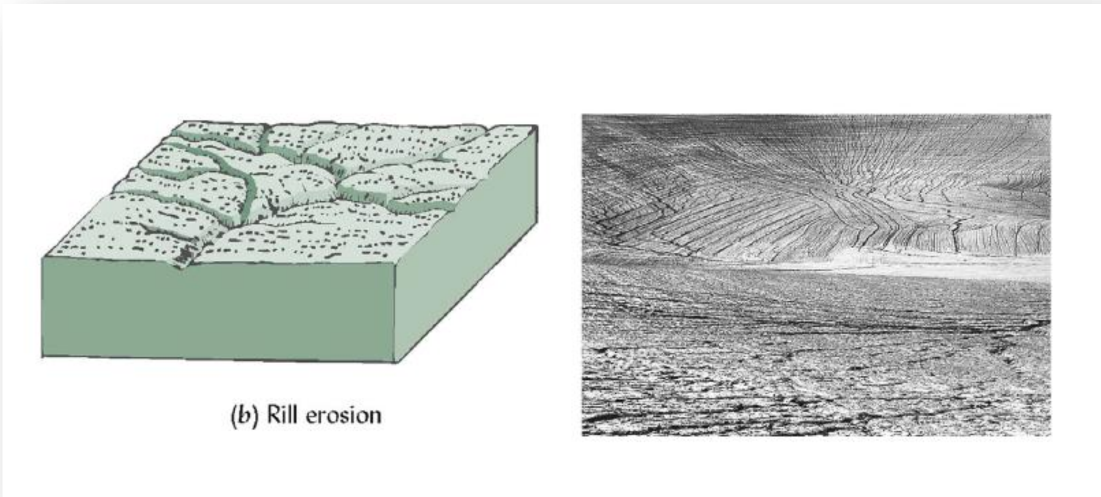


Figure 89: Rill erosion

7.3.2.3. Gully erosion

Gullies are predominately associated with water-converging geomorphological forms (e.g. valley bottoms), eventually on straight, steep slopes with strong kinetic energy of flowing water. The inception of gully erosion and incision of gullies was determined by human activity via land use change that exposed the soil and substratum to flowing water. In many cases, this land use change is associated with deforestation and subsequent agricultural use of the land (Valentin, 2005)

This kind of erosion exists in Wadi Naghamish in the main streams which is characterized by a strong slope to land surface as well as the presence of a major flood with a great depth of soil in the bottom of the wadi, especially those land of the wadi bed have not been reclaimed yet. Figure (90) shows the gully erosion.

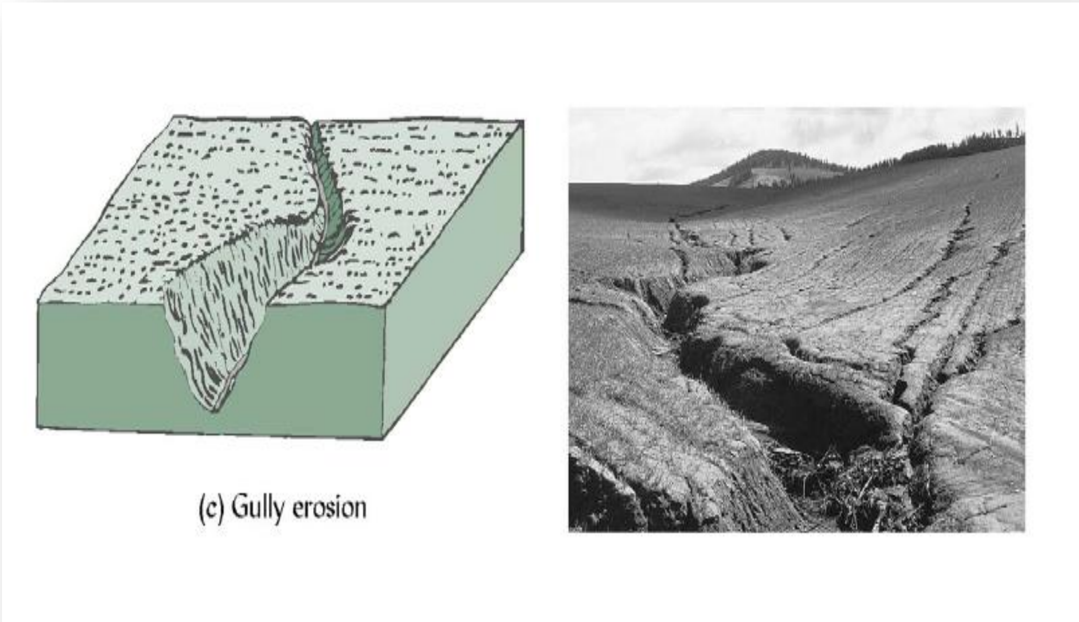


Figure 90: Gully erosion

7.4. Discussion about the aggravating or reducing factors of degradation

7.4.1. Causes and Factors of Land Degradation in Wadi Naghamish

Many factors contributed to the process of land degradation. These factors, including what is natural, such as drought and water erosion, wind, some of which is as a result of the erroneous practices of human. Also it cannot say that one factor is causing the deterioration or that those factors are equal in severity influence, but all of these factors have participated with certain degree, that we propose to discuss in detail.

1. Drought

A drought is one of the most important challenges faced by the Bedouin community over the last 15 years. It had a direct impact on land degradation, that's where the lack of rain for several years frequently led to the decay of vegetation gradually and then the soil became more susceptible to erosion through factors such as water, wind. Drought cannot be the only factor for the occurrence of land degradation, but it is considered as the most important of these factors, other factors led to the rapid occurrence of deterioration.

2. Human practices

In wadi Naghamish many agricultural practices carried out by human led to land degradation, either directly or indirectly, such as cutting of firewood to be used as fuel for cooking, over grazing process, and increase of the loading rate on pasture. This is shown clearly in zone1 and 2. Soil removal for the purpose of road construction is shown clearly in the southern region in zone 3.

3. Topography

Topography is one of those factors that helped in the occurrence of land degradation. We mean here the surface ground slope that contributes to the processes of soil erosion by water erosion. This is shown clearly in the wadi bed sides in zone 1 and 2 and on the edges of the southern plateau. here we find the greatest degree of surface slope that explains the severity of erosion. In this zone, the soil is mostly washed out completely and turned into bare rock.

4. Wind Erosion

It is one of the natural factors that have contributed significantly to the occurrence of the process of land degradation. This is demonstrated clearly in the southern region in zone 3, where the soil washed out completely as a result of wind erosion, which did not happen with the presence of vegetation.

5. Water Erosion

Despite the frequent occurrence of drought in the study area, the zone knows sever flood events leading to an erosion of the soil, according to the severity of the slope and the absence of vegetation. Water erosion takes several forms depending on the location for instance if it occurred in the main streams gully erosion will occur, in secondary streams rill erosion will occur, in the plateau in the flat area sheet erosion will occur.

6. Urbanization

The urbanization is also one of the factors that have contributed significantly to land degradation processes; this factor plays with the increase of the population and its horizontal expansion through the creation of new housing. This expansion occurred at the expense of pasture land. This factor cannot be underestimated if we know that the area of the 17 villages in wadi Naghamish, which have only about 300 houses with a total area of about 500 feddan (1feddan=4200m^2), which means that almost every house is surrounded by nearly 1.7 feddan, about 0.7 hectares per household.

7. Availability of Machines

Availability of machines led significantly indirectly to land degradation. In fact, the development of plowing machines in the wadi has favored the extension of barley crops at the expense of pasture land, which led to the disappearance of large areas of natural vegetation.

7.4.2. Practices to combat soil erosion, reducing vulnerability to flood in Naghamish

"Northwestern Coast region is one of the dry areas, which no more than average rainfall of about 140 mm, but relying on water harvesting techniques can improve these conditions, where it is by those techniques can be cultivated fruit trees that characterize the region Such as figs, olives and almonds. Rainwater harvesting also is defined as a method for inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions " (Boers & Ben-Asher, 1982). In Egypt, the North-West coast and the Northern Sinai areas have a long tradition in runoff farming water harvesting. Remnants from Roman times are frequently found (El-Shafei 1994).

Whenever rain falls over an area, part of it is intercepted and infiltrated into the soil. Excess rainfall flows away downwards, from higher to lower elevations, in the form of a 'sheet' or as a concentrated flow. Collection, storage and utilization of this running water is known as rainwater harvesting. The term 'rainwater harvesting' is derived from the more general 'water harvesting' (Pacey and Cullis, 1999) which has a number of definitions.

(Critchley & Siegert, 1991) defined water harvesting as 'collection of runoff for its productive use'. (Oweis et al., 1999) defined the water harvesting as 'the process of concentrating rainfall runoff from a larger drainage area to a smaller productive area'.

Rainwater harvesting also is defined as a method for inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions (Boers and Ben-Asher, 1982)

According to Critchley and Siegert (1991), generally, two runoff farming water harvesting groups are generally recognized, rainwater harvesting and floodwater harvesting. Rainwater harvesting can be further divided into micro catchment, and macro catchment runoff farming types. Floodwater harvesting can also be divided into within streambed and through diversion runoff farming types.

Micro-catchment runoff farming water harvesting is a method of collecting surface runoff from a small catchment area and storing it in the root zone of an adjacent infiltration area/basin. This infiltration area/basin may be planted with annual crops, or with a single tree or bush (Boers and Ben-Asher 1982)

Macro-catchment runoff farming (catchment area being 1,000 m2 - 200 ha) system is referred to by some authors as "runoff farming water harvesting from long slopes", as “medium-sized catchments water harvesting" or as "harvesting from external catchment systems" (Pacey and Cullis 1986, Reij et al., 1988). Figure (91) shows Examples of Rainwater Harvesting techniques with general features. Microcatchment: Meskat system from Tunisia.

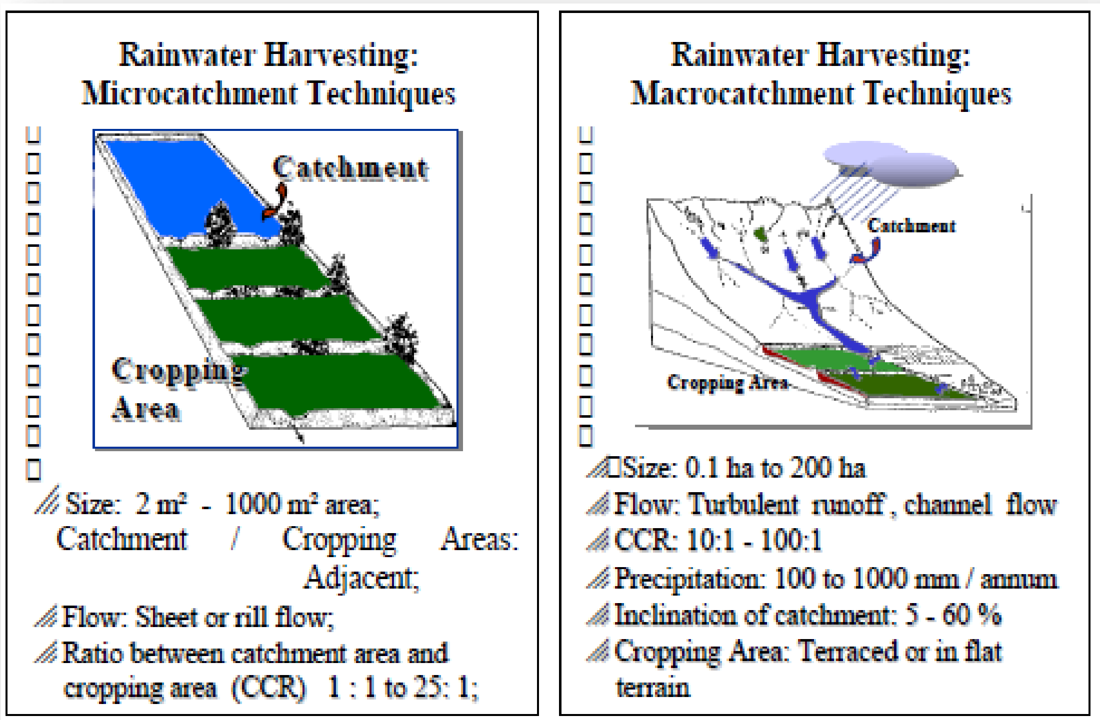


Figure 91: Examples of Rainwater Harvesting techniques with general features. Microcatchment: Meskat system from Tunisia (Source: El Amami, 1983); Macrocatchment technique: Hillside Conduit technique (Source: Prinz 1996); Source of text: Prinz 1996, Prinz 2002)

Different techniques related to water management that have been established in the wadi area are considered among the Bedouins as different ways to reduce the vulnerability of their system to flooding. These techniques constitute also one of the available alternative and strategies to the Bedouin to facing drought through the extension of the orchard cultivation which can be cultivated.

The type which is commonly used in the area of the northwestern coast of Egypt is the macro, while micro is not used in the region. There are several forms of the macro rain water harvesting techniques in the region such as: (i) dry stone dikes to resist sheet erosion in the flat land outside the wadi bed with low surface slope or in the wadi bed to resist the rill erosion especially in the territories characterized by a simple surface slope with wide section of stream and main, (ii) cemented stone dikes that are established to reduce vulnerability to flood and water harvesting purpose; they have shown high efficiency, especially in the area of the wadi bed, which is characterized by a strong surface slope; it especially designed to resist the gully erosion, and (iii) earthen dikes that have the same role especially in the wadi delta territories. Figure (92) shows the runoff in wadi stream.

Figure 92: runoff in wadi stream

1. Establishment of the Dry Stone Dikes

This type of dikes is one of the simplest types of dikes in terms of cost and ease of implementation, established in the flat land which is characterized by slope around 1%. The primary purpose of the establishment of the kind of dikes is to stop the sheet erosion and rill erosion, and reduce the velocity of the runoff and to allow to more water infiltration in the soil profile to serve the tree cultivation during the summer season. It can be said that the main purpose of construction of the dry stone dikes to conserve the soil more than conserve the water, while it can allow to the water to flow through the dike body. Figure (93) shows the dry stone dike.

Figure 93: Dry stone dike

2. Establishment of The Cemented stone dikes

This type of dam is considered as the most expensive and it is created in the wadis beds. The main purpose of this type is to stop the gully erosion and to harvest the water to serve the cultivation, and also, to construct where the other types of dikes did not success against the high amount of water flood. It consists of the dike body and spillway to allow to the extra water follow Safely without damage to the body of the dikes and to soil, with a good foundation not less than one meter under the soil surface. Figure (94) shows the cemented stone dike.

Figure 94: Cemented stone dikes

3. Establishment of The earthen dikes

"*Earth bunds are formed on lands above and within the wadi bed to collect water from local, usually small, catchments. The bunds are similar to the so-called tabia in Tunisia. Several basins are sometimes connected to each other and to the catchment in a system similar to the saylada system in Baluchistan. Improper spillways and drop structures are common and can cause the collapse of the system*" (Gray, 2005, p.21).

This type of dikes is established in the delta of the wadis or in the wadi bed which has less land slope. It is less expensive than the cemented dikes, and it can resist to the flood in the area which is characterized by high slope. It must be constructed with a cemented spillway to avoid the damage of the body of the dike. It must be well compacted by machines with the addition of water. Figure (95) shows the earthen dike.

Figure 95: earthen dikes

Conclusion

These results show the diversity of changes that have occurred in vegetation cover during the last 2 decades; some are positive but the majority is negative. Drought is not the only cause in these changes, but it is mainly the computation of drought with other factors that has the main cause of the degradation.. We can say that natural factors such as climate change represented by the drought, topography, and wind erosion caused the greater impact compared to the human activities. Degradation of vegetation was followed by degradation of the land. Land degradation took many forms in the wadi such as, soil erosion and desertification.

The main human factors that have contributed to the aggravation of land degradation are over grazing, wooding, tillage urbanization and touristic activities.

In the same time, we can note the development of new techniques in the wadi that have greatly contributed to reduce soil erosion such as the creation of various types of dikes.

So this pluridisciplinary approach crossing geographical tools and opened interviews his allowed to have a global approach of the land degradation phenomena.

CHAPTER 8: BEDOUIN STRATEGIES TO COPE WITH DROUGHT

8.1. Strategies cope with drought

People are always vulnerable to climate-drought, flood and other extremes events such as wind, temperatures that have always forced people to act in order to cope with adverse weather conditions (Tideman & Khatana, 2004). And adaptive capacity can be considered as an indicator; how and how well a system can adjust to realize or even anticipate environmental changes (Hurd et al, 2006). A comprehensive risk management framework for dealing with drought include both the development of longer term strategies to manage the risks associated with drought, and short term response strategies to mitigate the impacts when a drought actually occurs (Neal & Moran, 2009).

Drought is not as instantaneous killer and generally people have time to take the necessary measures to cope with the changing conditions. In this type of event, short-term measures to cope can be taken such as the supply of drinking water by tanker, but also more long-term measures like migration or change of livelihood activities can be used as adaptation (Tideman & Khatana, 2004). The last drought in the NWCZ began in the last two decades; the length of the drought period gave the opportunity for people to adapt to drought conditions.

Drought mitigation and response like drought mitigation actions can be implemented in advance of drought to reduce the degree of risk to human life, property and productive capacity. Drought effect can be mitigated by two factors: (i) the modification of drought hazard by using suitable and drought resistant breeds and cultivars, the preparation of food security programs and the limitation of water wastage and losses; and (ii) the diversification of crops and animals and the use of good farming practices (Karrou & El Mourid, 2008)

Previously pastoralists traditionally relied on herd mobility to cope with drought; nowadays this strategy is threatened by increased individual land ownership (Mworia & Kinyamario, 2008). In the way, herd mobility was one of the previous strategies to cope with drought in the NWCZ; this strategy is not followed now because of the division of the land to the tribes and people level.

Karrou & El Mourid in 2008 reported that; the most direct impact of a rainfall shortage on pastoralists' livelihoods is the drying up of water resources and declining forage resources for livestock. To cope with recurrent drought, pastoralists developed traditionally strategies that enabled them to survive and produce under these harsh environments. These strategies were well adapted. The strategies that were developed by agro-pastoralist societies of MENA (Medial East and North Africa) region were summarized by Hazell et al. (2001). Some of these strategies were: herd mobility, grazing arrangements, adjustment of flock sizes, keeping extra animals that can be easily liquidated in a drought, investment in digging of wells, cisterns and water harvesting systems, diversification of crops and feed storage; diversification among animal species and finally income diversification into non-agricultural occupations.

Metawi in 2012 reported that an understanding of the socio-economic impacts of drought and of farmers' coping mechanisms is essential in designing technological and policy interventions for more effective drought mitigation in the NWCZ. In the past, three Bedouins coping strategies were relied to reduce the negative impact of drought, namely; 1- decreasing flock size, 2-selling their lambs and kids after weaning directly and 3 - move with their flocks searching for feed.

According to (Osman et al., 2012) through their study in ELVULMED project in the rain-fed region, breeders have developed different adaptive mechanisms such as, decreasing flock size, raising more goats, relying more on concentrate feeding and early marketing of their lambs/kids. Migration of family members to agro-pastoral and urban areas was another social coping mechanism to the long drought. Long drought duration has induced detectable diversification of farming activities in the area.

8.2. Different capability to cope with drought in wadi Naghamish

The results show that the more natural resources available is the condition of the greater adaptability and resistance to drought. Weakness of resistance in the southern region, which is located in the far south with fewer natural resources, is proof of that. As well as the diversity of sources of income lead to increased ability to cope with drought. Also increase the proportion of education reduces the vulnerability toward drought.

Bedouin community showed an important flexibility to adapt to drought conditions through various strategies to reduce the vulnerability to drought. We can summarize it in two main options. The first is to leave the land completely, to migrate to city or another country. This alternative means they will not be considered as a Bedouin after this date and they will leave their land for ever. The other alternative is to try to stay in their land through different strategies to cope with drought. Those strategies are different from farmer to other according to their locations, available natural and human resources. So, the Bedouin society tried to be more flexible to deal with drought pressure along the last 15 drought.

8.2.1. Wadi Development and land reclamation

These strategies are considered very important in the study area and all of the people in the zone 1 and 2 have a part of land in the wadi. In zone 1 the average wadi land owned by farmer is 7.6 Feddan (fig 5.44, olive 1.17, almond 1.00). In zone 2 average wadi land owned by farmer is 9.44 feddan (fig 4.56, olive 1.58, almond 3.3). In zone 3 there is no exist for agriculture activities.

The important development of the wadi land is due to the better chance to harvest water due to its place and location in lower area, even in some years which can be considered as drought especially for barley and vegetation. The orchard need that the runoff takes place for minimum 2 or 3 times per year, runoff water can be easy store in the soil profile, even if the rain came at very late time. It will have the same importance for the trees in the wadi not the case of the barley, with low amount of rainfall the farmer can harvest fig, although the productivity is not as require but at least there is production.

Wadi land reclamation and cultivation cannot be happened without the establishment of the water harvesting and soil conservation structure, such as cemented stone dike, dry stone dikes, or earthen dikes, which can do the both jobs, harvesting the water and conserving the soil and prevent the erosion in the wadi bed. Without this technique it is no possible to control the runoff water or control the water erosion in the wadi bed.

Establishment of the different types of dikes started with beginning of eightieth in the last century, through the international development programs like FAO, WFP, WB (MRMP) which established those activities in order to settle the Bedouin, and encourage them to use the available natural resource to increase their income, and to control the soil erosion occurred by water in the wadi bed (gully and real erosion). The cost of establishment of the dikes and reclaim the land is high. It is very difficult to the farmers to establish it without development projects support.

In 2012 season, the average annual income from the agricultural land was 10195 L.E in zone 1 for an average land size of 7.6 feddan in the wadi (it represent about 37% from the total income in zone 1), 8634 L.E in zone 2 for 9.44 feddan in wadi (it represented about 27% from the total income). This amount of income in 2012 can be increased in wet years, and decreased in the dry years. . This shows that these ‘wadi land’ improvements allow getting a minimum wage for the family.

8.2.2. Fattening for the young lambs

One of the succeeded strategies followed by farmers was also the fattening of young lambs. We can observe two types of fattening: the first is through fattening of the lambs of breeders flock, by starting the fattening after the weaning period at age about 3 and 4 months, with an average weight from 25 to 30 kg. The second type is through replacement the flock with male lambs bought in the market, with an average of 4 months age (average 30 Kg weight). The fattening period is about 3 months. The lambs can be sold of weight about 50 kg, with average price of 1500.

In average, according to our data, in case 1 in zone 3 the return from one lamb fattening was around 87 L.E - compared with 68 L.E in case 2 in zone 2.

8.2.3. The breeders became traders

This is also one of the succeeded practices during the drought period. This type of strategy means that the breeder decides that he will not keep the flock forever. He will change his flock each year, the breeder will sell his flock at the period of supplemental and buy it again with the return of rainfall. Generally, when the breeder notices the spring season and the grass appears on the land, he start to reconstitute his flock, which consists of ewes and lambs with young age. The breeders will keep the flock all along the grazing period. In this strategy, the breeder depends about the grazing of the grass at spring period and then barley grazing end of spring; after he will sell the ewes, and start to fatten the lambs for 3 months, and selling the lambs. He will not pay for feeding in summer. This strategy became very famous in the area. It allows more flexibility to the breeder to cope with the drought.

8.2.4. Establishment of a poultry farm

It is one of the late strategies which appeared widely in the last 5 years in the area. It appeared the first time in the study area in 2007 with the establishment of one barn. Then many breeders noticed the high income generated from this activity; some of them decide to sell their flocks to establish a new poultry farms in the area. The expansion was very rapid. In 2012, it reached 54 farms in the study area. Selling of flocks was not the only source of funding; the other sources can be the income-return from working in Libya or collaboration of the farmers with another person's in the city who have the capability to fund this activity.

The risk is high in this activity, but in case of success the income is very high. In one cycle, which is about 40 days, the farmer can get from 15 000 to 20 000 L.E (table 49), but maybe he will lose the amount or more in bad conditions.

Many reasons make the risk very high in the poultry sector, such as the unexpected change of the feeding price for both feeding cost and poultry prices. The farmer cannot control this change.

The best he can do is to show more care in his farm, by more care of vaccine and all of the factors control of product.

Beyond these risks, the farmers still establish more and more poultry farms. The new poultry farmer has only to invest in the building. All buildings have the same conception and approximate size. Typically they are simple barns of 10-12m width by 50-60m length (i.e. ≈600m²) hosting approximately 5000 birds. They are built with blocks and bricks, windows to ventilate, and with the required equipment (manual feeders and bell drinkers). The investment cost of the building was around 10-15.000 US$ in 2012. The workforce is another strategic point. A poultry farm needs at least two workers, usually the farmer and one of his young brothers or cousins. One of the two workers generally has been trained to apply the basic rules of poultry production (Bastianelli et al., 2013)

Table 49: Technic-economic parameters of poultry production unit developed in Coastal zone of western desert in Egypt

Source (Bastianelli et al, 2013)

TECHNICAL PARAMETERS		Average value
Number of broilers	Nb	5 000
Feed consumption ratio	kg/kg	1,90
Feed consumption	kg/cycle	19 950
Water consumption	m3/cycle	80
Mortality rate	%	5,0
ECONOMICAL PARAMETERS		
Day-old chick price	EGP/chick	2,5
Feed Price	EGP/kg	3,80
Variable costs	EGP/cycle	1 500
Manpower	EGP/cycle	2 000
Building and equipment	EGP/building	80 000
Broiler price at sale	EGP/kg	11,00
INCOME		
Income from sale	EGP/cycle	109 725
Margin on chicks and feeds	EGP/cycle	21 415
Margin on total costs	EGP/cycle	14 715

8.2.5. Travelling and Working in Libya

Working in Libya is one of the important and old alternatives which are very widespread in the NWCZ and the study area. At the beginning of the sixtieth, migration becomes very famous for the Bedouin people to work in Libya, to get more income. This income helped the people in the area to do a lot of types of development in the area such as construction of houses which settle the Bedouin, development of the wadi land and increase of the flock's number. Nowadays at the period of drought; Libya has played a different role, to help the people to facing the drought through sending their young members who are able to work to get more income resource.

In the other side, working in Libya causes another problem for the agriculture sector while most of the young people prefer to work in Libya instead of work in agriculture sector. This situation make causes the limitation of labor in the area. This is appeared very clear in season 2011. It was good year, the production of barley and orchads like figs was very high. In this year the price of Libyan Dinar (currency of Libya) jumped from 3 to 5.5 L.E approximately the double. In the same time the labor in Libya decreased and caused increase of labor salaries; and in parallel it was not expected this amount of barley production and fig especially in west area of Matrouh. This situation showed an important change in the area, where a large number of the Bedouin society left the work in livestock and agriculture sector. Before this year, it was very famous that the labor harvests the barley and fig by taking a ration of the production equal to 1/3 of the total production. In 2011 this ratio increased to be 1/2 of the total production and it was also very difficult to find labor.

According to these results, the benefit of migration to Libya was not clear in the area. Moreover the work is generally not for a long period and mixed with the work as labor in the agriculture sector. Results show that work in Libya and agriculture sector as a labor represent about 21% from the annual off farm activities and about 9% from the total annual family income in zone 1, while it represented about 39% from the annual off farm activities income and 17% from the total annual family income in zone 2. In zone 3, it represented about 55% from the annual off farm activities income and about 13% from the total annual family income in zone 3.

The opposite situation took place in the period from 1979 to 1989 corresponding to a special period where the border of Libya and Egypt has been closed completely. Most of the agriculture development in the area was in this period. All of the labor came back to the area, to concentrate on development in the agriculture and livestock. This period had seen the increase of the livestock number, the development of the wadis and the increase of the area of orchard especially after the beginning of development of the wadi by support of WFP and FAO projects.

8.2.6. Work in city

This strategy was followed by the people of zone 1 in the study area, even with the people who do not have private cars. The study area is far about 17 km from Matrouh city. It is very easy for the people in zone 1 to work in the city and come back home in the same day using the public transport and on a lesser extend in the Zone 2. This alternative was very difficult to be followed in zone 3 due to far distance to the main road. The daily trip will cost them more than their salaries. The people of zone 1 have many types of work in city; the most important ones are the governmental jobs. Among the 53% of farmers which have been interviewed in zone 1, at least one member of their family works in governmental jobs such as teaching in school, working in electricity and Water Company, while the ratio of the governmental employers was 25% in zone 2 and 11% in zone 3. About 6%, 29%, and 11% of families respectively in zone 1, 2 and 3 have at least one member who works in city as taxi drivers (representing about 10%, 33% and 22% in zone1, 2 and 3 respectively from the family annual off farm activities income and representing 5%, 14% and 5% in zone 1, 2 and 3 respectively of the total annual family income). Jobs as traders or technical jobs in city represents 8%, 15% and 0% of in zone 1,2 and 3, respectively from the family annual off farm activities income and 4%,6% and 0% from the total annual family income in zone 1,2 and 3 respectively.

People in zone 2 and 3 prefer to work in Libya or as laborers in agriculture sector. This behavior is not the same in zone 1 who have better chance to be near from their families. Another reason is the high education ratio and level in zone 1 compared with the people of zone 2 and 3.

8.2.7. Selling the flock in order to investigate in small projects

One of the available alternatives for the Bedouin society was selling the flock to investigate the money in small projects such as, purchasing a small truck for transportation of agricultural products and animals, purchasing a taxi to work in city and trading in animal market. This alternative was widely spread in the study area especially in zone 2 and 3.

8.2.8. Working as laborers in agriculture sector

This alternative was widespread in zone 2, and 3; in zone 1 it was not widespread because they had other alternatives. In zone 3 the people do not have any type of wadi land, so they only have the chance to work as a laborer in the wadi land owned by people in zone 1. Most of the time, people in zone 3 make the same where the productivity of the land is less. The main agricultural works in the wadi land are: hoeing the soil, harvesting the crops and trimming of the trees. Agriculture laborers are paid on a daily basis about 40 to 50 L.E, and the work is mainly a seasonal work.

8.2.9. Decreasing of flock size

Decreasing flock size has been one of the major adaptive processes taken by the Bedouin to cope with the incidence of long drought and deterioration of range conditions during the last drought (Aboul-Naga et al., 2014). This has been the same in the wadi Naghamish as shown in table (50). We cannot say for sure that the decline in the number of animals was voluntarily but it was more or less as a result of the drought. Due to the duration of the drought in the NWCZ, all the families have been led to reduce drastically their reproductive flock to cover the costs of feed and food (Alary et al., 2012).

Table 50: livestock number in wadi Naghamish 1995-2012

zones	sample	Flock size 2012		Flock size 1995		Difference from 1995 (%)	
		sheep	Goats	sheep	goats	sheep	**goats**
Zone 1	17	35	10	73	19	-52%	**-0.47**
Zone 2	24	56	11	127	19	-56%	**-0.42**
Zone 3	9	51	13	639	49	-92%	**-0.74**
Average		**47**	**11**	**280**	**29**	**-67%**	**-54%**

8.2.10. Increase of cisterns number

According to (AMEC Earth & Environmental, 2010) through saving water, long-term conservation can also reduce the water saving potential for short-term demand management strategies during water shortages. In wadi Naghamish increase of cisterns number was one of the strategies followed by the development program in the zone. According to the interview results, breeders and farmers think that those cisterns establishments were the only support that they received to face the drought. Also according to (Matawi, 2012) cistern establishment was one of the governmental policies to support farmers during the drought period to cope with drought.

Conclusion

The main reason which makes the Bedouin society try all the time searching the different adaptive alternative to face the drought appears to be strongly linked to a special relation between the Bedouin and the land; this led to a question, what does land mean to the Bedouin society? To reply this question just we can say that most of the problems between tribes in the Bedouin society are generally relate to the land borders. The land means the social prestige for the Bedouin society. It means the most important asset he can own. In the NWCZ and the study area, a lot of examples of this relation can be observed and which cannot be logically explained; for example, we can see Bedouin people who prefer to stay in a bare land. The soil has been degraded completely, there is no source of water, just transporting the water from the city with high cost, there is no vegetation cover for animal grazing, the feed are used for 12 months, the transport is very difficult, and with all of these difficulties the people decide to stay in their land.

The second relevant result from these different alternatives is the role of city proximity for education and, consequently, off-farm job opportunities. This explains the contrast between zone 1 in the coastal line compared to zones 2 and 3 in the southern part of the wadi.

Finally we can say that livestock is remained an important factor of adaptation to drought through the market (selling and buying), the practices (from extensive to intensive practices) or the diversity (shifting from small ruminants to poultry). All these alternatives or the combination of these alternatives have played an important role during the last two decades to face the drought. However, we can note that in zones 2 and 3 sheep and goat remains a continuous activity in the sense that farmers have reinvested after the drought.

CHAPTER 9: CONCLUSION AND DISSECTION

Introduction

This chapter provides dissection of the main hypothesis and summary of major findings of the study as per the objectives set out and draws general conclusions. It is also include further makes general recommendation based of the study findings and also recommendation on issues that require further investigation or future research as they are important but fell outside the study objectives and could not be adequately addressed by the study; in addition to the research limitation.

9.1. Strong Drought

Both of available climate data and results of farmers' questionnaires confirm the occurrence of a strong wave of drought in the NWCZ during the last 2 decades (from 1995 to 2011).

On the other side, the results of SPI (Standardized Prepetition Index) indicate that in the period from (1995) to (2011): five years were mild drought, one year was moderate drought and two years were severe drought and eight years were often closed to the average. So why the breeders and farmers think that it is strong drought?

To reply this question, we can refer to many reasons such as the region has suffered from two types of drought: climatically drought and hydrological drought. Also, we can observe medium or wet climatic years (with a total annual rainfall above the average rate in the region) although this year is considered as drought by breeder. This is mainly due to the time of rain compared to the water need of the plants during the year. Rainfall falls early or late period for the crop needs. Also the location of the rainfall station at the airport station is at about only 4 km from the coastal line, this means that this rainfall amount represents only the coastal area; while according the responds of the breeders in the south in zone 3, the rainfall approximately disappeared. This results lead to the need for a deeper study to determine climate change in the region, particularly in the southern region.

So, in this context of perception of drought by farmers over a long period -15-years-, the objective of our thesis was to understand the different adaptive strategies of farmers and the role of livestock faced to water shortage and land degradation.

9.2. Discussion of the main hypothesis

At the first beginning, the main hypotheses to address the various impacts of the drought were:

- The farmers are not equal facing the drought due to different natural and social capital. And social and economic resources are the main determining factors of the range and scope of adaptive responses.
- Drought is not only the causative factor of land degradation, but it is shared with other factors to ultimately lead to the deterioration of land.
- Small ruminant flock in this traditional agro-pastoral society had played a contrasting role according to the location of farmers along the wadi;
- "Simple" technical practices can improve the adaptation process but they are confronted to complex social changes;

Following is the detail dissection of each hypothesis based on the results of the study:

First hypothesis

'The farmers are not equal facing the drought due to different natural and social capital. And social and economic resources are the main determining factors of the range and scope of adaptive responses'

"Pastoralist groups in Somali-Oromyia areas of Ethiopia who have greater freedom of movement and access to natural resources are less likely to have to rely on distressful coping mechanisms in response to extreme drought and more likely to be able to employ adaptive capacities, compared to groups without such access.” (Kurtz & Scarborough, 2012).

Farmers in wadi Naghamish had not the same degree of ability to adapt to climate conditions. Many of the factors that become available the greater flexibility and ability to adapt to drought conditions, including the following:

- **Geographic location**

The closer to the coastal line increases the flexibility : the proximity of the coastal line means proximity to transportation, electricity, utilities, water, and there are opportunities to go to work in the city and return daily, as well as this zone benefits of more water and pasture;

- **Availability of natural resources**

  Wherever the natural resources are available and varied, the greater ability to adapt to climate conditions: for example in Zone 1 and 2, farmers were more fortunate than those in zone 3 where they had only available land suitable for the cultivation of barley. In the zones 1 and 2 the wadi lands allows orchard cultivation. Moreover, the lands in these two are more attractive for development projects, mainly for the establishment of the dikes that allow reclaiming more land and increasing farmer income.

- **Diversity of income sources**

  The diversity of sources of income increases the ability to adapt with drought: where the alternatives increasing due to off-farm jobs, this creates more flexibility, unlike the animal and agricultural activities which are more sensitive and affected by drought.

- **Increase of labor number in the family**

  Whenever the number of people who are able to work in the family increased; whenever the family was more flexible to adapt to drought; where it can be for those who are able to work to move, especially younger ones, to distant regions in the city or out of the country to search for alternative sources of income.

- **The second hypothesis**

‘***Drought is not only the causative “agent” of land degradation, but it shares with other factors to ultimately lead to the deterioration of land’***

Land degradation in the arid, semi-arid and dry sub-humid areas is resulting from various factors, including both climatic variations and human activities (WMO, 2005). The vulnerability of land to desertification is mainly due to climate, state of the soil, water, and natural vegetation, and the ways to use those resources. Vulnerability varies widely depending on the way in which the natural resources are used by human communities and their livestock (Abahussain et al., 2002).

Actually drought was not the only causative agent of land degradation. Based on the interviews with farmers in the study area, drought was an important and critical factor to accelerate the process. Where it shared with another factors, those factors were not at the same degree of impact strength according to the location in the wadi and in addition to the presence or absence of another factors to support it. For example the effect of drought reaches to its maximum in the southern area where it cooperated with another factors such as wind erosion and topography.

- **The third hypothesis**

‘Small ruminant flock in this traditional agro-pastoral society had played a contrasting role according to the location of farmers along the wadi’

Rearing of small ruminants plays a very important role in the lives of households in developing countries through providing the easiest and most readily accessible source of credit available to meet immediate social and financial obligations (Oluwatayo & Oluwatayo, 2012).

The agro-pastoral production system in the NWCZ of Egypt is characterized by varied agricultural activities including raising small ruminant's flocks, beside the rain-fed cultivation represented in barley and some fruits such as olives and figs in the wadis bed. This system has been fragilized by drought that has become more frequent and worsened by human activities (Metawi, 2012).

The results in our studied area support this hypothesis. And it is mainly confirmed by the different roles of small ruminants in the different zones: (i) where it was a major source of income, livestock remains the only source of income like in zone 3; (ii) where it represented a lesser extent a source of income like in both zone 1 and 2 and this in addition to its role as a source of security and as a source of milk for the family; the average numbers of livestock is much lower than in the zone.

Goats had a major role in adaptation to climate conditions. According to breeders it is more adapted to the climate conditions than in the case of sheep. Nothing is more indicative this such as lack of decline in the goats number. Results indicate that livestock contributed and continues to contribute to the family income despite the drought conditions in the region.

It is also at the worst case; the sale of the herd and replace it with another activity, such as poultry also clarifies the role of the small ruminant in the area. It is provide source of funding for other projects in the drought period. Farmer can buy the herd again with improved weather conditions and rainfall, and thus the growth of herds.

- **The fourth hypothesis**

Simple technical practices can improve the adaptation process but they are confronted to complex social changes

This hypothesis is confirmed through the use by farmers of some simple techniques which help to a significant degree of reducing the effects of drought, water scarcity and land degradation. Cisterns are one of the main techniques to reduce water scarcity in these dry areas and the higher the number of cisterns the greater the flexibility to reduce vulnerability of water resources. Increase of cisterns number in the area reduces the size of the expenditure of water transfer. Also, the establishment of dikes in the wadi bed has had significant impacts in order to achieve more than one goal such as; reduce the soil erosion as well as minimizing the vulnerability to flood and water harvesting. Role of dikes appears clearly in drought seasons, where the vegetation fails in the absence of early rain, as well as barley crop that needs to irregular rainfall to help it to grow in different phases of growth. In case of the delayed rains in the stage of the growth the effect become high. In the case of trees, dikes can benefit any amount of rain come any time, whether early or late and stores to serve the farming in the summer period. The land should be plowing after each rain to reduce water loss; where the plowing breaks capillaries tubes.

9.3. Vulnerability analysis scale

9.3.1. At the wadi level

Results indicate that the vulnerability at the wadi level in general is a result of the drought that hit the region. The degrees of flexibility and ability to reduce the effects of drought have varied at the level of the farmers in the wadi according to the availability of natural resources and the diversity of the sources income. And the diversity of sources of incomes is strongly linked to the geographical location such as the proximity to the sea and the proximity to the city that increase the access to facilities like infrastructure, electricity and water.

9.3.2. At the regional level

If we compare the study area, wadi Naghamish, with the NWCZ region and this based on the main outcomes of the ELVULMED project, we find that the study area can represent a model of watershed basins deployed in the region (that counts around 218 watersheds (wadis) in the NWCZ).

Wadi Naghamish is one of the 218 that were mentioned in the FAO report in 1970. It is considered one of the largest wadis in the region. In this watershed, two effects are intertwined, one is positive and the other is negative. On the positive side, the presence of the watershed provided a mean which can be used as an alternative source of income in the event of a lack of income from livestock production in times of drought, mainly through the cultivation of barley or fruit trees. The downside in that it sometimes the wadi represents the only source of income and therefore if the drought continued for a considerable period, it will be strongly affected while there are not another alternative that can be resorted to.

The wadi located near from the city and the coastal line; it gave it a special status which may not be available for the other desert areas which locate at fare distance in the south in addition to the multiplicity of sources of income in the wadi; which include farm, off-farm activities and the presence of tourism as well as the presence of water drinking source represented in the fresh water pipe coming from Alexandria governorate. Also the development projects concentrated on this wadi in terms of development in this wadi due to the high development potential in terms of soil and water.

9.4. Research limitations

As with most survey research, the study is embedded with several noticeable limitations. The limitations include the following:

Results of socio-economic approach were mainly based on the questionnaire and interviews; all those who participated were volunteers and they may have some bias in their answers that may be affected, for example, they may have a sense that there is no genuine interest in the development of the region, which generates them feeling of frustrated; which maybe affect their answers.

Moreover, talking about the income making them concerned about taxes, so they tend to reduce the size of the income; as the nature of the answers based on the belief of return this questionnaire is it for submission to the decision-maker in order to help the community ? In this case they tend to exaggerate of the problems as well as participants may not have felt comfortable expressing their sincere opinions.

The questioners were carried out in the season 2011/2012 which were vary from average to good rainy season, thus the results did not represent a drought case, especially for livestock and agricultural production.

The study results may not be applicable outside the Naghamish area, since drought coping strategies may be area specific. As well as strategies are not fixed and are subject to change from time to time.

In term of water resources and the hydrological study, we have collected all the available data of Matrouh station in the period (1944-2011), but we faced a lack of rainfall data. The available data was just for Matrouh station. We were not able to get the rainfall data for the other stations that cover the NWCZ such as Dabaa, Barrani and El-Sallum to ensure the occurrence of drought in the entire zone as well as the absence of some monthly rainfall data led to the difficulty to determine intra-annual water deficit that explain some agriculture droughts in the study area. In addition, we were not able to inform about what really happened in the south in terms of rainfall data. Also, we used the Rational formula based on the available data instead of the Curve Number (CN) due to the absence of some require data for estimation.

To determine the land cover change in the study area in the period (1995-2011) we used 3 satellite images in 1993-2006-2011; unfortunately the date of the satellite images taken in 1993 was different from the dates of the satellite images taken in in 2006 and in 2011. So we were not able to compare between the three images, and we need to limit the interpretation of images between 2006 and 2011. However, this image analysis allowed us to have an idea about the dense vegetation in the wadi especially in the south.

9.5 Summary and dissection of main results

This part will include a discussion of the most important results of the study in terms of changes in the Bedouin society, agricultural and livestock production, the various sources of income, water resources management, main changes in the land cover and the most strategies which were followed by the Bedouin society to cope with drought.

9.5.1. Main changes in the Bedouin society

In general in terms of socio-economic changes, results indicate some positive changes in the Bedouin society represented by an improvement of the place of women in the traditional Bedouin society. This change is due to increase the proportion of awareness in the Bedouin community of the important of the role of women in addition to decreasing the illiteracy rate. Also a significant increase of the proportion of learners over the last two decades due to increase of the schools number in addition to the increase the awareness of important of the education; which was one of the factors to reduce the vulnerability to drought. There is also noticeable change in food and water consumption with an increase of the per-capita consumption; those changes can be considered as an indicator of improvement of live condition in the NWCZ. However, the improvements of living conditions (modern houses design, water and food consumption, education, etc.) are strongly linked to the availability of infrastructures such as roads, electricity, health care and education which vary with the geographical location. So we observe important differences of living conditions according to a gradient North-South, from the coastal zone which have benefited of important infrastructure to the south zone which is remained without basic infrastructures.

9.5.2. Agricultural production

Agricultural production in wadi Naghamish represented in trees (fig, olive and almond) which cultivated in the wadi bed and delta and barley cultivation wadi bed and depressions.

Agricultural production was one of the most important sources of income for the population in zone 1 and 2. In zone one it represented 37 % of the total income in 2012, while it was 27% in zone 2 and 0% in zone 3. Based on the result of analysis of the satellite images in 2006 and 2011; barley cultivations area were decreased by 43% while trees were increased by 18%. This confirms the hypothesis that the development of the wadi was one of the most important strategies used to cope with drought.

In zone 3, where the branches of the wadi do not reach to it, based on the reply of the population and the available data reported by projects before the drought (before 1995) there was a barley production which was cultivated in depressions. Currently there is no presence of the barley crops as a result of the impact of drought and land degradation.

9.5.3. Animal production

Results indicate that animal production is still an important part of income before and during the drought, as it represents around 21 % from the total annual family income in zone 1, 30% in zone 2 and around 76% in zone 3. As well as results reflect the importance of Animal Production for the population as we head south; where Zone 1 is heavily dependent on agricultural production; while the Zone 2 represents a mixed agricultural production and livestock area and; while in Zone 3 animal production is still main source of income for the population where the wadi branches not reach them for the cultivation of fruit, in addition to the absent of barley cultivation as a result of drought and desertification.

Over the period 1995-2011, due to the drought, a noticeable change in livestock number in wadi Naghamish, with respectively a decrease of the sheep flock by 52%, 65% and 92% in zones 1, 2 and 3. The effect of drought on livestock was the highest in zone 3. This reduction was mainly as a result of drought.

Drought represented a major challenge for animal production in terms of lack of grazing land, which is reflected heavily on the high cost of production due to the adoption of breeders heavily on the purchase of fodder basically; thus the consequent lack of return.

9.5.4. Farm and off-farm income

As a result of drought in the region, the off-farm activity was one of the strategies used to reduce the impact of drought in the region, as well as with the increase in the number of families members who are able to work, limited production of livestock and agricultural; most of young people are resorting to work in off-Farm activities; near of the study area from the city encouraged this behaviors; especially zone 1 and 2, where it is possible that these young people do the work in the city and back again to their homes daily.

the off-farm activities represented 42% from total family annual income compering to 43 % in zone 2 and 23% in zone 3. Results indicate convergence of dependence ratio of the off-Farm activities in Zone 1 and 2 because of the proximity of the city and easily accessible; While it's less than in Zone 3; because of the remoteness of the area from residential areas and the difficulty of access, which requires a full transition to the city and return at intervals that is, in short, the distance factor seen as a major factor..

9.5.5. Water resources management under different scenarios.

Rainfall is the main source of water in the study area and the NWCZ for both irrigation and drinking purpose for human and livestock and other human uses. Naturally scarcity of water happens in drought period. Three climatic scenarios have been tested: dry (105 mm), average (140 mm) and wet (200 mm) seasons with a probability of occurring of 70%, 50% and 20%. The results show that an annual deficit of around 100,000 m^3 of water is found in the wadi in the drought seasons while, in average seasons, water surplus amount of around 20,000 m^3. In the rare wet season, the surplus water volume can reach to around 2.5 million m^3.

Results indicate that there is water gab about 20 000 m^3 in the drinking water due to the non-harmonization of cisterns newly created with the increased need for water; in addition to the expansion of poultry establishment. This gap is covered by water transfer from the city and the water line adjacent to the coast. With average transport coast of about 10 L.E; to total coast reach to around 200 000 L.E annually, which represents a significant burden on the population.

With the increase in population as well as the expansion of poultry farms is expected to increase water scarcity especially in dry seasons, this requires harmonization of cisterns establishment with the future water needs.

9.5.6. Land cover changes

Based on the analysis of satellite images in 2006 and in 2011, we can approach the magnitude of changes in the area in term of low and high vegetation, bare land and agriculture which include both of barley and trees (fig, olive and almond). Barley cultivations area were decreased by 43%, trees were increased by 18%, range land (low and dense cover) decreased by 20%.

Drought was a main factor of land cover change and thus land degradation, but it's not the only factor; it joint with other factors such as, human practices, topography and wind erosion. Results indicate that drought with wind erosion were the major factors responsible about land degradation in the wadi Naghamish; it represented about 41% from the total area, while the topography was responsible about 14% from the total area, drought and topography were responsible about 5% from the total area, drought and human practices were responsible about 4% from the total area. In the same time moderate degraded protected by vegetation cover represented about 26%; moderate degraded protected by barley cultivations represented about 7% and non-degraded soil protected by dikes represented about just about 3%.

9.5.7. Main strategies to cope with drought

Bedouin community strategies to cope with drought reflect the flexibility of that community to cope with hazards. Many strategies in wadi Naghamish were followed such as wadi development and land reclamation in the zones 1 and 2 through establishment of different type of dikes. Some breeders have also started new activities like semi-intensive poultry farms and fattening of lambs. In addition, the other alternatives were to work in city and Libya, to increase the cisterns number to be more tolerant to drought. However, in the entire zone, the decreasing of flock size was a main strategy to be more resilience to drought.

It is noticeable the absence of collective strategy and appear of only just individual attempts to cope with drought conditions. The absence of effective collective action organizations such as associations and agricultural cooperatives helped to prevalence of individual strategies.

9.6. Summary of drought impact on wadi Naghamish

According to Joshua et al., (2011) Drought is measured not only by precipitation levels, but also by its resulting impact, There is no universal way of categorizing or measuring the impacts of drought; but it can be through understanding the effects of drought based on the research question at hand such as reduction in crop productivity, increased food insecurity and migration.

We can summary the impact of drought on wadi Naghamish in Figure (96), where the drought had impact on human represented in migration of 2 villages in the zone 3; we were not able to interview them; already they migrated to city. On livestock numbers the average reduction of sheep was about 67% and about 54% in goats. On vegetation lost of around 20% in the period (2006-2011) and barley lost of around 20%. On land resources highly degraded of about 41% of the total area. On water resources around 100 000 m^3 deficit of annual runoff water and around 20 000 m3 gab of driking water water

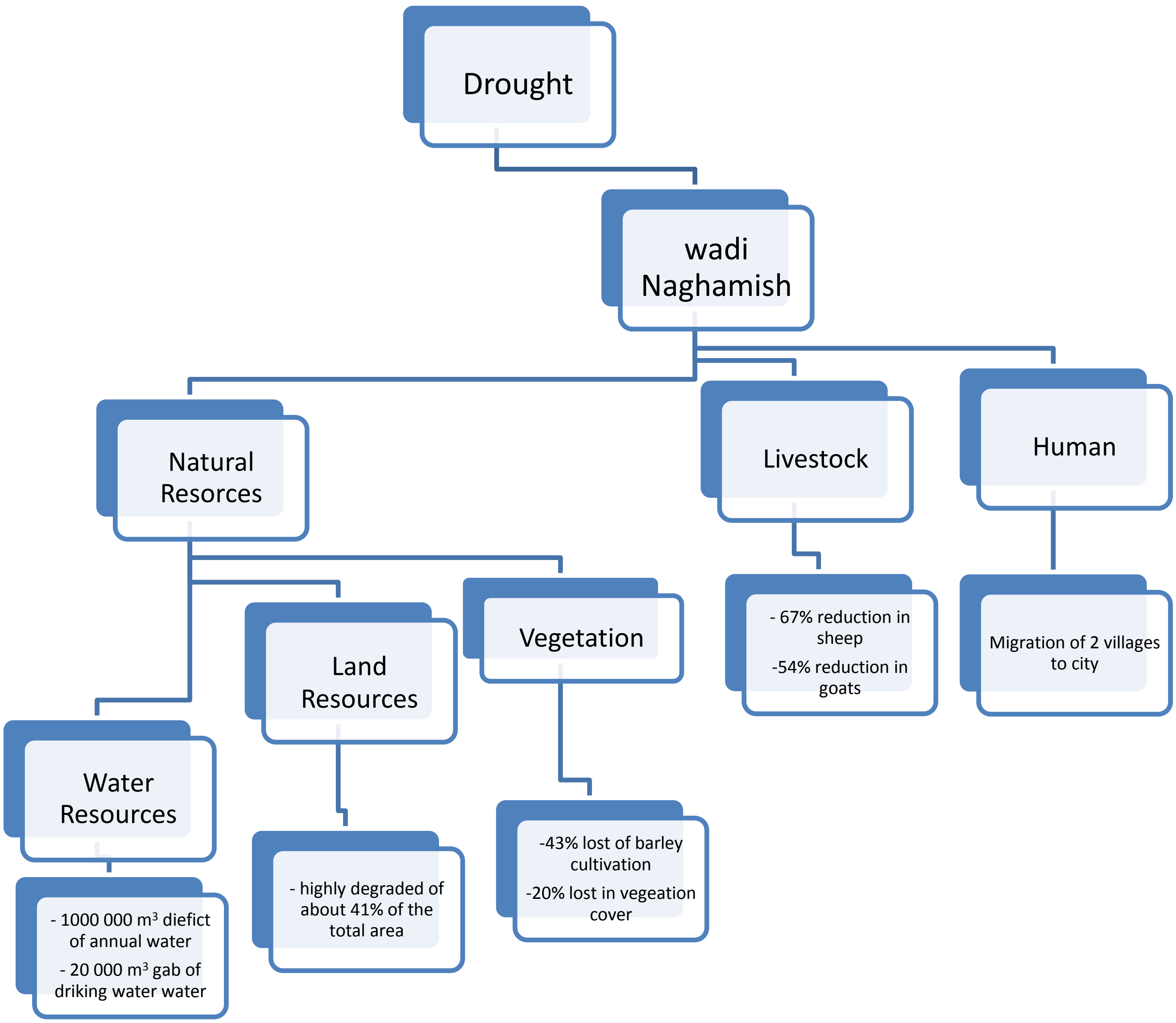


Figure 96: Drought impact on wadi Naghamish

9.7. Further research

Future research should focus on re-analysis of satellite images to show and analyze the most important changes in the region after a period of drought and try to answer the following question is vegetation can recover again with some rainy seasons or it needs a longer period ? As well as the biomass maps is require to be done; where it will be useful for the recommendations of the pasture management.

Due to a lack of available rainfall data in the southern region any future research must take into account to put a Rain gauges; even simple and manual gauges. These measurements will help us to know the truth about the distribution of rain from north to south in the region as well as based on it the drought can be classified.

It is expected that strategies to cope with drought can change with time; therefore it is important to re-study those strategies again to confirm it's persistence or change and the Bedouin community develop a new strategies or not.

9.8. Recommendations

Based on the results of the study, many recommendations and practical applications can be suggested which can be implemented easily. Those recommendations aim mainly to reduce the effects of drought on the study area and also they can be used as a model for the development of NWCZ as well as recommendations for reducing the vulnerability of water resources and ways to combat desertification and soil erosion in the region. In general those recommendations can be summarized as follows

1. Recommendations to reduce of vulnerability to drought

A drought is the main problem in the study area in recent years. The limitation of its impact on the region must be dealt with in a scientific way. The following are some recommendations that could be implemented to reduce the drought risks:

Determine a certain level of rain and a drought index

Results of the study indicate the absence of studies that focusing on the drought eventswhich hit the area from time to time. Therefore, it is important to identify a certain level of rain, with that amount the region can be considered as drought-affected area. The strength and the degree of drought should be determined based on the drought indicators such as SPI (Standrized preceptation index) or other index.

Based on the clasfication of the drought strength, whether it mild, moderate, severe or extreame drought; the decision-maker can set how to deal with that threat.

Install a mechanism to intervene during drought years

This action can be considering the second step to detrmine the occour of drought in the region. Many interventions can be achive to reduce the risk of drought on the population and livestock such as; support the supply of the Bedouin by drinking water through transportation by trucks and feed through payment on credit. In the same time a drought management policy for pastoral areas must have three components: early warning, drought contingency planning and policies to support drought resilience.

Diversification of income sources in the region

Results of the study indicate that the more sources of income for the population, the less the impact of drought; where the agricultural and the animal production are fragile and sensitive to drought. Supporting of poultry and the other off-farm activities can be one of the alternatives.

Collective action

It is noted the absence of collective action in the study area and this weakens the Bedouin and local people's ability to cope with drought and minimize its effects. So it is very important to encourage this kind of work through the creation of clusters in the form of associations or cooperatives. The activities of the associations and cooperatives can include, for example, purchasing of feed from the source in large quantities to take advantage of the price difference. Also it can include marketing purposes of agricultural products to get the best marketing opportunities; in addation to encourage the ability to communicate and common thinking between members of the community in order to formulate the best solutions to reduce the effects of drought and reducing the vulnerability to drogugth.

Resistant varieties

Expansion in the cultivation of drought-resistant varieties can be one of the important alternatives such as, barley varieties resistant to drought; which has already been tested under the conditions of the region and has achieved the effectiveness and success. From this perspective it is necessary to expansion in research that aims to develop resistant varieties to drought.

2. Recommendations to reduce vulnerability related to water resources

The lack of water was one of the most important effects of the drought in the study area. As shown before (see chapter 6: analysis and impact of water resources constraints), drinking water shortage in drought period was a high concern and around 20% of the cisterns were invalid to use. Some recommendations could be implemented:

Periodic maintenance of the cisterns

Around 20% of the cisterns in the study area were invalid cisterns in the study area; mainly due the drought and the absence of the water in the cisterns for many seasons and this number increasable in case of drought conteneous. This amount reflects the important of the maintaince for those cisterns. Around 5 million m^3 are stored in the cisterns in the NWCZ; so we can imagine about one million m^3 are lost.

Increase of cisterns numbers

It is necessary to increase the number of cisterns to fit with the increase in population. Dissection maker should take into account that the amount of water which is stored in the cisterns owned by farmer should be increase so as to increase the need for farmers or actual annual jam in order to use the surplus in the drought seasons.

Poultry cisterns

Most of the projects which worked in the region establish the cisterns in purpose of drinking for human and livestock and rarly for suplemental irrigation, with the expantion of the poultry farms in the region; a competation for water has been appeaered in the region. So, a new tape of cisterns should be established for poultry purpose.

Alternative water sources

Come up with alternative or complementary sources of water such as groundwater or desalination of sea water, taking into account to achieve sustainable development without having side effects on the soil in terms of salting.

Unconventional solutions

Some non-traditional solutions that are tested now through new techniques to purify the wash water for reuse again and is now in the process of experimentation in the NWCZ has been applied in similar areas, such as Jordan.

3. Recommendations to reduce land degradation and desertification

Recommendations for reduction of desertification and land degradation in the study area can be summarized in the following points:

Establishment of different types of dikes

Establishment of the of the different types of dikes, such as (earthen – stone – cement) is one of the best alternative to reduce the soil erosion, where the dry stone dikes can be effiecnet to stope the sheet erosion in the falt areas and the the rill erosion in the the wadi branches; while the cmented stone dikes can be effeicient to stope the gully erosion in the main streams of the wadi.

Reduction of collecting firewood

Collecting of the firewood for the cooking purpose still commn in the Bedouin society; it is necessary to sensitize the population to the seriousness of the problem; especially with the availability of the gas ovens.

Grazing management refernces

Grazing management is one of the crtical issues in the Bedouin society; which can reduce the desertification and the the land degredation in the region if it followed. Many factors restrict the grazing mangment such as lack of awareness among many educators as well as the lack of authority can control the process. It is nessaary to have a collective action between the bedouin society members to thinking how they can manage the grazing processes. Refernces

Re-seeding of indigenous species

Dissapering of many shrubes and plants species was one the cretical problems mainly due to the drought. Many attempts have been achived in the region to re-seed or planting new pastoral in the region. Most of those attempts failed due to the introduction of new varieties not adapted to local conditions in the region; so, it is nessary to take into account reseeding of the indigenous species which dissapeared from the region. With taking the opinion of the local population in those plant varieties before planting and convince them of the importance of protection to complement their life cycl.

CHAPTER 10: REFERNCES

Abahussain, et al. (2002), Desertification in the Arab Region: Analys is of Current Status and Trends, Journal of Arid Environments, 51:521-545, available at http://www.yemenwater.org/wp-content/uploads/2013/04/D2.-Desertification-in-the-Arab-Region-Analysis-of-current-status-and-trends.pdf.

Abbas M.S., El Morsy M.H., Shahba M.A., Moursy F.I. Ecological studies in coastal sand dune rangelandsin the north-west of Egypt. In: Porqueddu C. (ed.), Tavares de Sousa M.M. (ed.).Sustainable Mediterranean grasslands and their multi-functions. Zaragoza: CIHEAM / FAO / ENMP /SPPF, 2008. p. 389-393 (Options Méditerranéennes: Série A. Séminaires Méditerranéens; n. 79).

Abboudy I. M., (1968) The land and the social life of ancient Egypt as described in the classical authors of Greece and Rome between 70 B.C and A.D. 69, Durham theses, Durham University. Available at Durham E-Theses Online: http://etheses.dur.ac.uk/8023/.

Abdel-Kader, Fawzy H.; Jonh. Fitzsimons; Mohamed Bahnassy and Ashraf Moustafa . 2004. Challenges in Resource Management in Rainfed Agriculture in Wadi Maghamish, North Western Coastal Region, Egypt. Egyptian J. Desert Res., 54,No.2, 237-258 (2004) .

Aboul-Naga, A., et al., Raising goats as adaptation process to long drought incidence at the Coastal Zone of Western Desert in Egypt. Small Ruminant Res. (2014), http://dx.doi.org/10.1016/j.smallrumres.2014.02.009.

Abu Swaireh L., (2009). “Disaster Risk Reduction Global and Regional Context”, Regional Workshop on Climate Change and Disaster Risk Reduction in the Arab Region “Challenges and Future Actions”, organized by ISDR, WB, GFDRR, LAS, AASTM, Cairo, Egypt, 21 - 23 November, 21-23Nuvember

Adamson P, and Bird J. 2010. The Mekong: A Drought-prone Tropical Environment?. International Journal of Water Resources Development. http://www.informaworld.com/smpp/title~content=t713426247 .[Accessed on 25 January, 2011].

Adger, W.N. and M. Kelly. 1999. Social Vulnerability to Climate Change and the Architecture of Entitlements: Mitigation and Adaptation Strategies for Global Change 4.

Adger, W.N.: 2006, 'Vulnerability', Global Environmental Change 16, 268-281.

Agnew, C. T., "Using the SPI to Identify Drought" (2000). Drought Network News (1994-2001). Paper 1.http://digitalcommons.unl.edu/droughtnetnews/1.

Alary V., Daoud I., Salama O., Aboul Naga A.D., Merveille N., Tourrand J.F., 2012. Adaptation des sociétés bédouines de la côte Nord – O uest de l'Egypte au changement global. Autrepart, 62: 183 – 200.

Alary V., Messad S., Aboul-Naga A. et al (2014a) Livelihood strategies and the role of livestock in the processes of adaptation to drought in the coastal Zone of Western Desert (Egypt). Agric Syst 128:44–54.doi:10.1016/j.agsy.2014.03.008.

Ali A, Oweis T, Salkini AB and El-Naggar S. 2009. Rainwater cisterns: traditional technologies for dry areas. ICARDA, Aleppo, Syria. iv + 20 pp.

Ali A., Daoud I., Mansour A., Abd EL-Kader Kh., Ramzy M., (2000) Hadrological Assessment of Wadi Zainab. Matrouh Resources Management Project. Marsa Matrouh, Egypt. (Unpublished report)

Ali W., (2013), Climate Change and Livelihoods: The Vulnerability Context. UNDP. Available at: http://www.ye.undp.org/content/dam/yemen/E&E/Docs/UNDP-YEM Climate%20Change%20and%20Livelihoods-The%20Vulnerability%20Context.pdf

Altorki, S. and D. Cole. 2006. 'Land and Identity among Awlad 'Ali Bedouin: Egypt's Northwest Coast'. In Nomadic Societies in the Middle East and North Africa Entering the 21st Century, ed. D. Chatty. E.J. Brill, Leiden, pp. 634–53.

Aly, Ziad, (2000). Assessment of land Resources in Matrouh Region using RS/GIS Techniques, Master thesis, Faculty of Agriculture, Alexandria University.

AMEC Earth & Environmental (2010) Municipal Drought Management Plan Guidance Document.http://cwcb.state.co.us/technical-resources/drought-planning-toolbox/documents/droughtplanningresources/municipaldroughtmgmtplanguidancedocfull.pdf

APFM (2007) Guidance on flash flood management: Recent experiences from Central and Eastern Europe. Geneva: Associated Program on Flood Management (APFM).

Attia, A., (1999), Planning for sustainable tourism development: an Investigation into Implementing Tourism Policy In the North West Coast Region of Egypt, Ph D Thesis, Development Planing Unit, The Bartlett School of Architecture and Planning, University College London, University of London.

Aurora S. Jose (2010) Vulnerability Assessment to Environmental Changes of a Watershed Area in Sta. Maria, Laguna, Philippines. 4th Asian Rural Sociology Association (ARSA) International Conference .September 2010. Legazpi City, Philippine.

Bai ZG, Dent DL, Olsson L and Schaepman ME 2008. Global assessment of land degradation and improvement. 1. Identification by remote sensing. Report 2008/01, ISRIC – World Soil Information, Wageningen.

Baker S. M., James W. Gentry, and Terri L. Rittenburg, Building Understanding of the Domain of Consumer Vulnerability, Journal of Macromarketing, Vol. 25 No. 2, December 2005 1-12.

Bankoff, G. R., G. Freks and D. Hilhorst. 2004. Mapping Vulnerability, Sterling: EarthscanBrooks, N. 2003. Vulnerability, Risk and Adaptation: A Conceptual Framework. Working Paper38, Tyndall Centre for Climate Change Research, Norwich, United Kingdom.

Barrett, C.B., Bezuneh, M., Clay, D.C., Reardon, T., 2000. Heterogeneous constraints, incentives and income diversification strategies in rural Africa, mimeo.

Barton, D., Morton J., and Hendy C., (2001) Drought Contingency Planning for Pastoral Livelihoods. Policy Series 15. Chatham,UK: Natural Resources Institute.

Bastianelli D., Daoud I., Lescoat P., Alary V., Tourrand JF., 2013. From Sheep to Broilers: Development of Poultry Production around Marsa Matruh. International Congress on Advancements in Poultry Production in the Middle East and African Countries. Antalya (Turkey), 21-25 october 2013.

Bedient, P. B. and W. C. Huber, 1988. Hydrology and Floodplain Analysis. Addison-Wesley Publishing Company, pp. 360-364.

Berk, A., Anderson, G. P., Acharya, P. K., Hoke, M. L., Chetwynd, J. H., Bernstein, L. S., Shettle, E. P., Matthew, M. W., and Adler-Golden,S. M. (2003). ‘MODTRAN4 Version 3 Revision 1 User’s Manual.’ (Air Force Research Laboratory: Hanscom, MA.)

Berk, A., Bernstein, L. S., Anderson, G. P., Acharya, P. K., Robertson, D. C., Chetwynd, J. H., and Adler-Golden, S. M. (1998). MODTRAN cloud and multiple scattering upgrades with application to AVIRIS. Remote Sensing of Environment 65, 367–375. doi:10.1016/S0034-4257(98) 00045-5

Bezdan A , P. Benka, J. Grabić, A.Salvai., 2012, Estimation of Agricultural Drought Vulnerability Using GIS Tools: a Case Study of Vojvodina Region (Serbia). BALWOIS 2012 - Ohrid, Republic of Macedonia - 28 May, 2 June 2012.

Biggs, D., N. Abel, A. T. Knight, A. Leitch, A. Langston, and N.C. Ban. 2011. The implementation crisis in conservation planning: could “mental models” help? Conservation Letters 4:169-183. http://dx.doi.org/10.1111/j.1755-263X.2011.00170.x

Blaikie, P., T. Cannon, Davis, L. and Wisner, B. (1994) At Risk: Natural Hazards, People’s Vulnerability, and Disasters, Routledge, London.

Blanco, Humberto & , Rattan (2010). "Soil and water conservation". Principles of Soil Conservation and Management. Springer. p. 2. ISBN 978-90-481-8529-0.

Bonnet P., Alary V., Aboulnaga A. (eds.), 2014, Atlas of changes in Livestock Farming Systems, Livelihoods and Landscapes of the North West Coast of Egypt. Montpellier CIRAD, ARC-APRI 64 p.

Bores T.M., Ben-Asher J., 1982, A review of rainwater harvesting, Agric. Water Management.

Brant S. (2007) ASSESSING VULNERABILITY TO DROUGHT IN CEARÁ, NORTHEAST BRAZIL. Master thesis.University of Michigan

Brooks, N.: 2003, 'Vulnerability, Risk and Adaptation: A Conceptual Framework', Working Paper 38, Tyndall Centre for Climate Change Research, Norwich.

Čančer V., Criteria weighting by using the 5Ws & H technique Business Systems Research Vol. 3 No.2. / September 2012.

Čančer, V. (2008), “A Frame Procedure for Multi-criteria Decision-making: Formulation and Applications”, in Boljunčić, V, Neralić, L, Šorić, K. (Eds.), Proceedings of the 12th International Conference on Operational Research KOI 2008, Pula, 24-26 September 2008, Croatian Operational Research Society, Pula, Zagreb, pp. 1-10.

CAPMAS (2013) ,Central Agency for Public Mobilization and Statistics. Indicators of Social Statistics.

Cardona O. D. The Need for Rethinking the Concepts of Vulnerability and Risk from a Holistic Perspective: A N ecessary Review and Criticism for Effective Risk Management. In G. Bankoff, G. Frerks, and D. Hilhorst, editors, Mapping Vulnerability: Disasters, Development and People, chapter 3. London, 2003.

Cheong, S.-M., D. G. Brown, K. Kok, and D. Lopez-Carr. 2012. Mixed methods in land change research: towards integration. Transactions of the Institute of British Geographers 37:8-12. http:// dx.doi.org/10.1111/j.1475-5661.2011.00482.x

Christensen JH, Hewitson B, Busuioc A et al (eds.) (2007) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the

Intergovernmental Panel on Climate Change, Cambridge University Press, United Kingdom and New York.

Ciurean, R.L., Schröter, D. and Glade, T. (2013), Conceptual Frameworks of Vulnerability Assessments for Natural Disasters Reduction, In Approaches to Disaster Management - Examining the Implications of Hazards, Emergencies and Disasters[Tiefenbacher, J. (ed)], ISBN: 978-953-51-1093-4, InTech, DOI: 10.5772/55538. Available from: http://www.intechopen.com/books/approaches-to-disaster-management-examining-the-implications-of-hazards-emergencies-and-disasters/conceptual-frameworks-of-vulnerability-assessments-for-natural-disasters-reductio.

Claval P., 1995, Les méthodes de régionalisation, In: Initiation à la géographie régionale, (PITTE J.R., ed.), Nathan, Paris, 45-66.

Cole D. P., Al Torkey S., (1998) Bedouin, Settlers, and Holiday-makers: Egypt's Changing Northwest Coast.

Conacher, A and Conacher, J (1995). Rural Land Degradation in Australia. South Melbourne, Victoria: Oxford University Press Australia. p. 2. ISBN 0-19-553436-0.

Conoco (1986) Geological map of Egypt, scale 1:500,000 GPC, sheets No. NH35NE. In Yousif M., El Sayed El Abd , Ahmed Baraka, Assessment of water resources in some drainage basins, northwestern coast, Egypt. Appl Water Sci (2013) 3:439–452.

Cook BI, Miller RL, Seager R. Amplification of the North American (2009). ‘‘Dust Bowl’’ drought through human-induced land degradation. Proc Natl Acad Sci, 106:4997–5001.

Cook, P. (1998). Best Practice Creativity, Aldershot, Gower Publishing Limited.

Craik, Kenneth. 1967. The Nature of Explanation. Cambridge: Cambridge University Press DePaul, Michael & Ramsey, William (eds.). 1998. Rethinking Intuition.

Critchley W and Siegert K. 1991. Water harvesting – a manual for the design and construction of water harvesting schemes for plant production. FAO, Rome, Italy.

Cutter S. L.(1996) Vulnerability to Environmental Hazards. Progress in Human Geography 20(4):529–39.

Cutter, S. et al. (2003) “Social Vulnerability to Environmental Hazards.” Social Science Quarterly, 84(2): 242-261.

D’ercole, R., Gluski, P., Hardy, S. & Sierra, A., 2009 – Vulnérabilités urbaines dans les pays du Sud. Présentation du dossier. Cybergeo : European Journal of Geography. [In lign], Dossiers, Vulnérabilités urbaines au sud, URL : http://www.cybergeo.eu/index22151.htm

Davy, E.G., F. Marrei, and S.I. Solomon. 1976. An evaluation of climate and water resources for development of agriculture in the Sudano- Sahelian zone of West Africa. Spec. Environ. Rep. 9, W-459. World Meteorological Organization, Geneva.

De Steiguer, J.E., Jennifer Duberstein and Vicente Lopes. 2003. The Analytic Hierarchy Process as a Means for Integrated Watershed Management. Pp. 736-740

Diniz, F. H., K. Kok, M. C. Hott, M. A. Hoogstra-Klein, and B. Arts. 2013a. From space and from the ground: determining forest dynamics in settlement projects in the Brazilian Amazon. International Forestry Review 15(4):442-455. http://dx.doi.org/10.1505/146554813809025658

Dixon, J. and A. Gulliver with D. Gibbon. (2001) Farming Systems and Poverty: Improving Farmers' Livelihoods in a Changing World. FAO & World Bank, Rome, Italy & Washington, DC, USA.

Dougill, A. J., E. D. G. Fraser, and M. S. Reed. 2010. Anticipating vulnerability to climate change in dryland pastoral systems: using dynamic systems models for the Kalahari. *Ecology and Society* **15**(2): 17. [online] URL: http://www.ecologyandsociety.org/vol15/iss2/art17/

Dow, K., 1992. Exploring differences in our common future(s): the meaning of vulnerability to global environmental change. Geoforum 23, 417–436.

DRC, 2003. The development of the northern coast, land resources of Sedi Abd El Rahman, western Desert , Egypt, Internal report, Arabic ed. Agricultural and ReclamationMinistry. Desert Research center, Water Resources and Desert Soils Dept, cairo.

Dregne H.E (1987). "Soil Erosion Causes and effects: land use policy" Vol 6 pp412-418. Thapa G B and Weber K.E (1991). "Soil Erosion in Developing countries: A political economic explanation" Environment management Vol 15 No 4 pp 461-473.

Dregne, H.E. 2002. Land Degradation in the Drylands. Arid Land Research and Management, vol. 16, 99 – 132.

Du Toit, D. R., H. Biggs, and S. Pollard. 2011. The potential role of mental model methodologies in multistakeholder negotiations: integrated water resources management in South Africa. Ecology and Society 16(3): 21. http://dx.doi.org/10.5751/ES-04237-160321

Duncan, O. D. and Duncan, B. (1955). 'A methodological analysis of segregation indexes'. American Sociological Review 20: 210-217.

Edwards, D. C.; and T. B. McKee. 1997. “Characteristics of 20th century drought in the United States at multiple time scales.” Climatology Rep. 97–2, Department of Atmo- spheric Science, Colorado State University, Fort Collins, Colorado.

Ehiorobo OJ, Izinyon OC (2011). Measurement and Documentation for Flood and Erosion Monitoring and Control in Niger Delta Region of Nigeria. J. Emerg.Trends Eng. Appl. Sci.3:2.

El Amami, S. 1983, Les amenagements hydrauliques traditionels en Tunisie. Centre de Recherche du Genie Rural, Tunis, Tunisia.

El Kharraz J, El-Sadek A, Ghaffour N, Mino E (2012) Water scarcity and drought in WANA countries. Procedia Eng 33:14–29.

El Miniawy H., FRIDEL M., SANAA T., 1990, QRDP Qasr Rural development Project, Development Plan Phase II, Draft report and Development strategy, Egyptian Environmental Affairs Agency EEAA, German Agency for Technical Cooperation GTZ, Governorate of Governorate of Marsa Matrouh, Cairo.

El Zein , 1964. In: El Miniawy H., FRIDEL M., SANAA T., 1990, QRDP Qasr Rural development Project, Development Plan Phase II, Draft report and Development strategy, Egyptian Environmental Affairs Agency EEAA, German Agency for Technical Cooperation GTZ, Governorate of Governorate of Marsa Matrouh, Cairo.

El-Asmar H. M., Wood P., Quaternary shoreline development: the northwestern coast of Egypt. Quaternary Science Reviews 19 (2000) 1137-1149

El-Bastwasy, M.A., 2008. The Use of Remote Sensing and GIS for Catchments Delination in Northwestern Coast of Egypt: An Assessment of water Resources and Soil Potential., Egypt J Remote Sensing Space Sci, pp. 3-16. In Sayed A.,(2013) EVALUATION OF THE LAND RESOURCES FOR AGRICULTURAL DEVELOPMENT -CASE STUDY: EL-HAMMAM CANAL AND ITSEXTENSION, NW COAST OF EGYPT.PhD Thesis.Hamburg university.

El-Hariry, M.F.(1997). Soil variability at hillslopes at the east Matrouh arid region, NWCR, Egypt. M.Sc. Thesis, university of Alexandria, Egypt.

Eliasson J., The rational formula as a linear element in computer runoff models. Paper accepted for presentation at the European Geophysical Conference, April 22 – 26, 2002, Nice, France. Avilable at: http://english.hi.is/files/skjol/verkfraedi_og_natturuvisindasvid_deildir/umhv_og_byggv/vatnaverkfrstofa/eurogeo02cia.pdf

Ellis, F. (2000) Rural Livelihoods and Diversity in Developing Countries. Oxford University Press, Oxford, UK.

El-Naggar, S. &E.R.Perrier, (1989) .A Soil Characterization Study for Agronomic Development in the Northwest Coast of Egypt. ICARDA, Aleppo, Syria.

El-Naggar, S; (2008).Pedological Aspects of Some Calcareous Soils of Egypt. Egyptian Journal of Applied Sciences, Vol: 23, No (2A), February 2008. ISSN – 1571. P. 259 – 276. Zagazig, Egypt.

EL-SHAFEI S., 1994, Agricultural Development in the North-West Coastal Zone, Egypt. Report on Water Harvesting. , Expert Consultation, FAO, Rome, Cairo, Egypt.

Erian W., Katlan B., Babah O., 2011, Drought vulernability in arab region : special case study : Syria. The Arab Center for the Studies of Arid Zones and Dry Lands – ACSAD. http://www.unisdr.org/files/23905_droughtsyriasmall.pdf

Erian, W.F., F.S. Fares, T. Udelhoven and B. Katlan, (2006). "Coupling Long-term NDVI for Monitoring Drought in Syrian Rangelands", The Arab Journal for Arid Environments, volume (1), pp 77-87, Published by ACSAD.

Ezeaku, P. I. and A. Davidson, 2008. Analytical situations of land degradation and sustainable mana gement strategies in Africa. J. Agri. Soc. Sci.,4: 42–52 .

FAO (2002). Twenty –sixth FAO regional conferences for the near east. Tehran, Islamic Republic of Iran, 9-13 March 2002. (http://www.fao.org/DOCREP/MEETING/005/Y6067E.htm). In:ICARD (2007). Drought in the Arab World. http://css.escwa.org.lb/sdpd/30-10_1-11/D6.pdf.

FAO, 1970, Preinvestment survey of the North west coastal region, Physical conditions of water resources United Nations Development Programme Food And Agriculture Organization Of The United Nations, Roma.

Fehlberg, H. and Stahr, K., 1985. Development of sustained land use by understanding soil and landscape formation in the desert fringe area of nw-Egypt. CATENA, 12(1): 307-328. In Sayed A.,(2013) Evaalution of the Land Resources for AgricultureDevelopment – Case Study : El Hammam Canal extension NW Coast of Egypt. PhD Thesis.Hamburg University.

Ford, David N., Sterman, John D. "Expert Knowledge Elicitation to Improve Mental and Formal Models" (PDF). Cambridge, Massachusetts, US - Massachusetts Institute of Technology. pp. 18–23. Retrieved 2009-01-11.

Fraser, E. (2007) Travelling in antique lands: Studying past famines to understand present vulnerabilities to climate change. Climate Change 83, 495-514.

Gabriels D. and Cornelis W.M. (2009),Human-Induced Land Degradation. Land Use, Land Cover and Soil -Volume 3. ISBN: 978-1-84826-237-9;

Gallopín, G.C.: 2006, 'Linkages between vulnerability, resilience and adaptive capacity', Global Environmental Change 16, 293-303.

GAR (2009). “Risk and Poverty in a Changing Climate” Global Assessment Report on Disaster Risk Reduction.

Geist, H. J. 2005. The causes and progression of desertification. Ashgate Studies in Environmental Policy and Practice. Aldershot, U.K.: Ashgate.

Ghabour S. I.,(1999) The Omayed Biosphere Reserve, Egypt. In Fahmy, Ahmed. Gamal-Eldin. (ed.). 1999. Proceedings of the Workshop on Biosphere Reserves for Sustainable Management of Natural Resources and the Implementation of the Biodiversity Convention in the Arab Region. UNESCO CairoOffice, Egypt.

Gleick, P.H. 1996. “Basic water requirements for human activities: Meeting basic needs.” Water International Vol. 21, No. 2, pp. 83-92.

Goodall, D. W. and Perry, R. A. (1979). Arid-Land Ecosystems: Structure, Functioning, and Management (Cambridge Univ. Press, Cambridge).

Gray F., (2005) Water Management in Northwestern Egypt, Society for Range Management (SRM) available at: https://journals.uair.arizona.edu/index.php/rangelands/article/viewFile/13033/12276.

Hamadallah, G. 2001. Drought prepardness and mitigation plans in the Near East: an overview. Expert consultation and workshop on drought mitigation for the Near East and the Mediterranean. 27–31 May 2001, ICARDA, Aleppo, Syria. In:ICARD (2007). Drought in the Arab World. http://css.escwa.org.lb/sdpd/30-10_1-11/D6.pdf.

Hammad FA (1972) The geology of soils and water resources in the area between Ras El Hekma and Ras El Rum (Western Mediterranean Littoral Zone, Egypt). Ph.D. Thesis, Fac. Sci.Cairo Univ.

Hayes MJ (2012) Drought indices, National Drought Mitigation Cen-ter (http://www.drought.unl.edu/whatis/indices.htm) . With modifi-cations by Dev Niyogi and Umarporn Charusambot, IndianaState Climate Office, Purdue University (http://iclimate.org/ 2.2.2012).

Hazell, P., Oram, P. and Chaherli, N. (2001). Managing droughts in the low-rainfall areas of the Middle East and North Africa, EPTD Discussion Paper No. 78. Environment and Production Technology Division, International Food Policy Research Institute, Washnigton, D.C., USA. http://www.ifpri.org/divs/eptd/dp/papers/eptdp78.pdf.

Heathcote, Isobel W. 1998. Integrated Watershed Management: Principles and Practices. John Wiley& Sons, Inc. New York.

Hebb A., Mortsch L., (2007), ‘Floods: Mapping Vulnerability in the Upper Thames Watershed under a Changing Climate’, Project Report XI, University of Waterloo, 1-53.

Hegazi A.M., M.Y.Afifi, M.A.EL Shorbagy, A.A. Elwan , S. El- Demerdashe (2005), Egyptian National Action Program To Combat Desertification. Available at: http://www.unccd.int/ActionProgrammes/egypt-eng2005.pdf.

Hisdal H, L. M. Tallaksen., (2000) Drought Event Definition, Technical Report to the ARIDE project No.6: Supplement to Work Package 2 Hydro-meteorological Drought Activity 2.1 Event Definition.

Hoffet, N., Daoud,I., Alary,V., Tourrand, J.F., Moselhy,N., 2012. Participation, Power and Sustainable Water Resource Management, A Case Study of The Rainfed Desert Region of Matruh, Egypt. Communication IFSA / International Farming Systems Association, Denmark, July 2012. Link: http://ifsa2012.dk/?page_id=755.

Hua, J., Liang, Z. & Yu, Z. (2003). A MODIFIED RATIONAL FORMUI,A FOR FLOOD DESIGN IN SMALL BASINS. THE AMERICAN WATER RESOURCES ASSOCIATION, 1017-1025.

Hurd B., Brown C., Greenlee J., (2006) Granados A., Hendrie M., Assessing Water Resource Vulnerability for Arid Watersheds: GIS -based Research in the Paso del Norte Region. New Mexico Journal of Science, Vol. 44, August 2006.

ICZM, Integrated Coastal Zone Management Plan for the coastal areas between Marsa Matruh and El Sallum, 2009., Volume 1,. Egypt.

ILACO, Consultants. 1976 Ministry of Housing and Reconstruction, Regional plan for the coastal zone of the western desert: Final report.

IPBES., Scoping report for a thematic assessment of land degradation and restoration – Deliverable 3bi, the third session of the plenary meeting held from 12 – 17 January 2015 in Bonn, Germany. 3/1 Annex VIII (advance version) Available at : http://www.ipbes.net/images/decisions/ipbes3/Decision_IPBES_3_1_Annex_VIII_Advance.pdf.

IPCC, (2007) Summary for Policymakers. In: Climate Change 2007: The Physical Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996pp.

IPCC: 2001, 'Climate Change 2001: Impacts, Adaptation, and Vulnerability', in McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J. and White, K.S. (eds.), Cambridge University Press, Cambridge.

ISDR (International Strategy for Disaster Reduction) (2002) Living with Risk: A Global Review of Disaster Reduction Initiatives, United Nations, Geneva.

ISO. 1996. Requirements for characterization of excavated soil and other soil materials for re-use. CD 15176 ISO/TC 190/SC 7/ Soil and Site Assessment/ WG1/N 2. rev.3.

Jakubs, John F. 1981. "A Distance-Based Segregation Index." Journal of Socio-Economic Planning Sciences 15:129-36.

Jobbins J., Megalli M., 2006, Alexandria and the Egyptian Mediterranean, second edition., collection A traveler's guide, American University of Cairo Press, Cairo Egypt.

Johnson, D.L., S.H. Ambrose, T.J. Bassett, M.L. Bowen, D.E. Crummey, J.S. Isaacson, D.N. Johnson, P. Lamb, M. Saul, and A.E. Winter-Nelson. 1997. Meanings of environmental terms. Journal of Environmental Quality 26: 581-589.

Jones, N. A., H. Ross, T. Lynam, P. Perez, and A. Leitch. 2011. Mental models: an interdisciplinary synthesis of theory and methods. Ecology and Society 16(1): 46. [online] URL: http:// www.ecologyandsociety.org/vol16/iss1/art46/

Joshua W. Busby, Jennifer M. Hazen (2011), Mapping and Modeling Climate Security Vulnerability: Workshop Report. Program on Climate Change and African Political Stability Principal Investigator: Dr. Francis J. Gavin Robert S. Strauss Center for International Security and Law The University of Texas at Austin.

Karrou M., El Mourid M. Drought management and planning strategies in semi- arid and arid agro-pastoral systems of West Asia and North Africa: a review.In : López-Francos A. (ed.). Drought management: scientific and technological innovations. Zaragoza : CIHEAM, 2008. p. 179-184 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 80.

Kassas M.(2008). Aridity, Drought and Desertification. In: Arab environment future challenge. Technical publications and environment & Development Magazin, Lebanon, pp.96-110.

Khalequzzaman, M. 1999. “Flood Control in Bangladesh Through Best Management Practices.” Expatriate Bangladeshi 2000. http://www.eb2000.org/short_note_17.htm.

Khoshnodifar Z., M. Sookhtanlo, H. Gholami (2012) Identification and measurement of indicators of drought vulnerability among wheat farmers in Mashhad County, Iran Annals of Biological Research, 2012, 3 (9):4593-4600.

Komuscu, A. U. 1999. “Using the SPI to analyze spatial andtemporal patterns of drought in Turkey.” Drought Network News 11(1):7–13.

Kongthong O., Drought in Mekong River and Vulnerability of Livelihood: In Chiang Khan District Lower Mekong Basin Thailand (2011). Master thesis. Lund university, Thiland.

Krantz L.(2001) The Sustainable Livelihood Approach to Poverty Reduction: An Introduction. Stockholm: Swedish International Development Cooperation Agency.

Krol, M.S. and Bronstert, A. 2007. Regional integrated modelling of climate change impacts on natural resources and resource usage in semi arid Northeast Brazil, Environmental Modelling & Software, 22: 259-268.

Kuichling, E. (1889). The relation between the rainfall and the discharge of sewers in populous districts. Transactions, American Society of Civil Engineers 20, 1–56.

Kulshreshtha S.N., (1993) World Water Resources And Regional Vulnerability: Impact Of Future Changes. University Of Saskatchew.International Institute For Applied Systems Analysis .Laxenburg, Austria.

Kurtz, J,Scarborough, G (2012). From conflict to coping: Evidence from southern Ethiopia on the contributions of peace -building to drought resilience among pastoralist groups. Addis Ababa: Mercy crops.

La Mareaux, P.E. and L.W Hyde 1966. Areas recommended for immediate investigation by experts of the pre-investment survey of the North Western Coastal Region of the U.AR. A preliminary report. Administrative Report. Rome, Italy: FAO, 12 pp.

Lal, R. and Miller, F.P. (1990). Sustainable farming for tropics. In: Singh, R.P. (Ed.) Sustainable agriculture: Issues and Prospective. Vol.1 , pp. 69-89, Indian Society of Agronomy, IARI, New Delhi.

LWBC (2004) Dealing with Drought A Handbook for Water Suppliers in British Columbia. https://www.for.gov.bc.ca/hfd/library/documents/bib94583.pdf.

Lynam, T., R. Mathevet, M. Etienne, S. Stone-Jovicich, A. Leitch, N. Jones, H. Ross, D. Du Toit, S. Pollard, H. Biggs, and P. Perez. 2012. Waypoints on a journey of discovery: mental models in human-environment interactions. Ecology and Society 17(3): 23. http://dx.doi.org/10.5751/ES-05118-170323

Malagnoux, M., Sène, E.H., Atzmon, N., 2007. Forests, trees and water in arid lands: a delicate balance. Unasylva 58, 24-29.

MARTIN V., 2013, Analyse des processus d’adaptations des communautés bédouines au changement global. Etude approfondie des processus, basée sur neuf familles bédouines dans la region de Matrouh, sur la côte Nord Ouest de l'Egypte, MSc, Esitpa, école d'ingénieurs en agriculture, Montpellier, 49 p., http://www.esitpa.org.

Massey, Douglas S., Michael J. White, and Voon-Chin Phua. 1996. "The Dimensions of Segregation Revisited." Sociological Methods and Research 25:172-206.

Matrouh Development Plan 2002 – 2022. Matrouh Governorate. Egypt.

McKee, T. B.; N. J. Doesken; and J. Kleist. 1995. "Drought monitoring with multiple time scales." Proceedings of the Ninth Conference on Applied Climatology ; pp. 233–236. American Meteorological Society, Boston.

McKee, T.B., Doesken, N.J., Kleist, J. (1993). The relationship of drought frequency and duration to time scales. 8th Conference on Applied Climatology, 17-22 January, Anaheim, CA, pp 179-184.

Meadows, D. H., Meadows, D. L., & Randers, J.1992. Beyond the limits: Global collapse or a sustainable future. London: Earthscan.

Metawi H.R.M. Agro-pastoral production system of Egypt. Climate change, vulnerability and opportunities for poverty alleviation.In : Acar Z. (ed.), López-Francos A. (ed.), Porqueddu C. (ed.). New approaches for grassland research in a context of climate and socio-economic changes. Zaragoza :CIHEAM, 2012. p. 113-116 (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 102)

Metwally, M. & Abdalla, S. (Mar. 2005). "An Approach To Sustainable Tourism Dvelopment In Costal Area-Egypt", International Conference on Tourism and Development in Coastal Areas, Sharm El-Sheikh, Egypt.

Mohamed A.G.M., 2002. Corporation of remote sensing and information systems in water management geographic and land use planning in El-Hammam area, Northern coast of Egypt., Crete, Greece.

Morris, William, ed. 1976. The American Heritage Dictionary of the English Language. Houghton-Mifflin Company, Boston.

Moustafa A. T. A., EL-Mowelhi. N. M., In : VanDuivenbooden N., M. Pala, C. Studer and c.L. Bielders (eds.). 1999.Efficient soil water use: the key to sustainable crop production in the dry areas of West Asia, and Northand Sub-Saharan Africa. Proceedings of the 1998 (Niger) and 1999 (Jordan) workshops of the Optimizing Soil Water Use (OSWU) Consortium. Aleppo, Syria: ICARDA; and Patancheru, India: ICRISAT. 496 pp. ISBN 92-9066- 400-3. CPE122. http://pdf.usaid.gov/pdf_docs/pnach628.pdf.

MRMP II (second Matrouh Resources Manangmnt Project) project(2000) Project Brief.

Mworia, J. K. and J. I. Kinyamario (2008) Traditional strategies used by pastoralists to cope with la nina induced drought in Kajiado, Kenya. African Journal of Environmental Science and Technology Vol. 2 (1), pp. 010-014, January, 2008 Available online at http://www.academicjournals.org/AJest.

National Research Council. 1999. New Strategies for America's Watersheds. National Academy Press, Washington, DC.

Neal B., Moran R (2009) Droughts and drought mitigation in water resources planning. Australian Journal of Water Resources;2009, Vol. 13 Issue 2.

Nelson D., W. N. Adger, K. Brown. Annual Review of Environment and Resources. 2007, 32, 395-419.

Oluwatayo I. B., Oluwatayo T.B.(2012), Small Ruminants as a Source of Financial Security: A Case Study of Women in Rural Southwest Nigeria.Avilable at http://www.imtfi.uci.edu/files/blog_working_papers/2012-2_oluwatayo.pdf

Osman M. A., Alary V., A. Aboul-Naga, Ferial Hassan, E.S. Abdel-Aal, H.R. Metawi and J.F. Tourrand, 2012. Adaptation process of farming systems in response to 14 successive years of drought in North West Coastal Zone (Egypt)- Communication IFSA / International Farming Systems Association, Denmark, July 2012.

Oweis T, Hachum A and Kijne J. 1999. Water harvesting and supplemental irrigation for improved water use efficiency in dry areas. SWIM Paper No. 7. System-wide Initiative on Water Management, ICARDA and IWMI. International Water Management Institute, Colombo, Sri Lanka.

Pacer/Egyptian Consultants. 1986 Development Plan of Northwest coast. Ministry of Development, New Communities and Land Reclamation. Final Report.

Pacey A and Cullis A. 1999. Rainwater harvesting: The collection of rainfall and runoff in rural areas. Intermediate Technology Publications, London, UK. In : Ali A, Oweis T, Salkini AB and El-Naggar S. 2009. Rainwater cisterns: traditional technologies for dry areas. ICARDA, Aleppo, Syria. iv + 20 pp.

Pacey A. and Cullis A. 1986, Rainwater Harvesting. The collection of rainfall and runoff in rural areas. Intermediate Technology Publ., London.

Paver, G.L., Pretorius, D.A. 1954. Report on reconnaissance hydrogeological investigations in the Western Desert coastal zone. Publi. Inst. Desert d'Egypt 5:145.

Pavlov, M.1. 1962. Groundwater of Egypt. UNESCO, 183 pp.

Picheral H., 2001, Dictionnaire raisonné de géographie de la santé, GEOS , Atelier Géographie de la santé, Université Montpellier 3 - Paul Valery, Montpellier, 307 p.

Prince, S.D. 2002. Spatial and Temporal Scales for Detection of Desertification. In: Global Desertification: Do Humans Cause Deserts?, ed. Reynolds, J.F. and Stafford Smith D.M. pp 23-40, Dahlem University Press.

Prinz, D. 1996, Water Harvesting: Past and Future. In: Pereira, L. S. (ed.), Sustainability of Irrigated Agriculture. Proceedings, NATO Advanced Research Workshop, Vimeiro, 21-26.03.1994, Balkema, Rotterdam, 135-144

Prinz, D. 2002, The Role of Water Harvesting in Alleviating Water Scarcity in Arid Areas. Keynote Lecture, Proceedings, International Conference on Water Resources Management in Arid Regions. 23-27 March, 2002, Kuwait Institute for Scientific Research, Kuwait, (Vol. III, 107-122).

Ragab R., (2005). “Water Management Strategies to Combat Drought in the Semi-Arid Regions”. Expert Meeting on Drought in the Arab Region, Organized by ACSAD, UNEP/ROWA and UNESCO, 28-30 March.

Reardon, T., 1997. Using evidence of household income diversi fication to inform study of the rural non-farm labor market in Africa. World Development 25 (5), 735–748.

Regner, H.J., 1995. Rainfall distribution in the north-south extention. Project report, Qasr Rural Development Project (QRDP) north-west coast of Egypt.

Reij, C.; Mulder, P. and L. Begemann 1988, Water Harvesting for Plant Production. World Bank Techn. Paper. Washington DC.

Richardson, A. J., and Wiegand, C. L. (1977). Distinguishing vegetation from soil background information. Photogrammetric Engineering and Remote Sensing 43, 1541–1552.

Rodier, J. and Ribstein, P.: Estimation des caracteristiques de la crue decennale pour les petits basins versants du Sahel couvrant de 1 a 10 km2 , Tech. rep., ORSTOM, Laboratoire d’hydrologie, Montpellier, 1988.

Roushdy, 1988. In : El Miniawy H., FRIDEL M., SANAA T., 1990, QRDP Qasr Rural development Project, Development Plan Phase II, Draft report and Development strategy, Egyptian Environmental Affairs Agency EEAA, German Agency for Technical Cooperation GTZ, Governorate of Governorate of Marsa Matrouh, Cairo, 292 p.

Rowe, A., 'A Contribution to the Archaeology of the Western Desert: ll- lll, Bulletin of John drylands Library 36 (1953).

Said, R., 1962. Geology of Egypt Elsevier Science Ltd; First edition (December 1962).

Said, R., 1990. The Geology of Egypt., Balkema , Rotterdam.

Saïdi S., Gintzburger G., 2013. A spatial desertification indicator for Mediterranean arid rangelands: a case study in Algeria. The Rangeland Journal, 35 (1): 47-62.

Sayed A.,(2013) Evaalution of the Land Resources for AgricultureDevelopment – Case Study : El Hammam Canal extensionNW Coast of Egypt. PhD Thesis.Hamburg University.

Scherr S. J., Yadav S.,1996. Land Degradation in the Developing World: Implications for Food, Agriculture, and the Environment to 2020 Food, Agriculture and the Environment, Discussion Paper 14. Avilable at : http://pdf.usaid.gov/pdf_docs/PNABY622.pdf.

Scoones, I. (2009). Livelihoods perspectives and rural development. The Journal of Peasant Studies, 36(1),171–196.

Scoones, I. (1998) Sustainable Rural Livelihoods: A Framework for Analysis, Institute of Develo pment Studies, Brighton, UK.

Seelye I. M., Gary L. Johnson, Jonathan G. Price, and Jordan T. Hastings (2013) Updated Assessment of Risks and Vulnerability to Flood Hazards in Nevada, Nevada Bureau of Mines and Geology Open-File Report 13-3, University of Nevada, Reno.

Shalabi A. (2000) Land Development on the North Western Coastal Zone of Egypt. Available at: http://www.hdm.lth.se/fileadmin/hdm/alumni/papers/ad2000/ad2000-05.pdf

Shata, A., 1971. The geomorphology, pedology and hydrogeology of the Mediterranean coastal desert of U.A.R. Symposium Geology of Libya. In: Faculty of Science. University of Libya, Tripoli, pp.431-446.

Sivakumar, M.V.K.(2005). "Natural Disasters and Extreme Events in Agriculture, Chapter 1of the Book titled: Impacts of Natural Disasters in Agriculture, Rangeland and Forestry: an Overview". Published by Springer Berlin Heidelberg New York.

Smit, B., Wandel, J.: 2006, 'Adaptation, adaptive capacity and vulnerability', Global Environmental Change 16, 282-292.

Sogreah, (1961). Land development of the western desert coastal zone, reconnaissance surveys. Internal Report of the Desert Development Organization, Cairo, Egypt.

Stone-Jovicich, S. S., T. Lynam, A. Leitch, and N. A. Jones. 2011. Using consensus analysis to assess mental models about water use and management in the Crocodile River Catchment, South Africa. Ecology and Society 16(1): 45. [online] URL: http://www. ecologyandsociety.org/vol16/iss1/art45/

Sun Y, Solomon S, Dai A, Portmann R. 2006. " How often does it rain?". J Clim, 19:916–934

Swain M., Swain M., (2011) Vulnerability to Agricultural Drought in Western Orissa: A Case Study of Representative Blocks. Agricultural Economics Research Review Vol. 24 January-June 2011 pp 47-56.

Syresh R (2006). "Soil and water conservation Engineering" Standard publisher, Delhi India.

Tallaksen, L. M. and van Lanen, H. A. J. (editors) (2003): Hydrological Drought. Processes andEstimation Methods for Stream flow and Groundwater, Development in Water Science 48, Elsevier.

Thapa G B and Weber K.E (1991). "Soil Erosion in Developing countries: A political economic explanation" Environment management Vol 15 No 4 pp 461-473.

Thompson D. B.,(2006) The Rational Method Civil Engineering Department. Texas Tech University Kuichling, E. (1889). The relation between the rainfall and the discharge of sewers in populous districts. Transactions, American Society of Civil Engineers 20, 1–56.

Tideman E., Khatana V.(2004) Drought coping stratigies in Semi-arid india, IGBP-GTZ report.

Tigkas D., Vanghelis H., Pangalou D., 2013, DrinC, Drought Indices Calculator - Getting Started Guide, version 1.5., National Technical University of Athens, Centre for the Assessment of Natural Hazards & Proactive Planning & Lab. of Reclamation Works and Water Resources Management; (http://drinc.ewra.net/DrinC%20-%20GSG.pdf;)

Toy TJ, Foster GR, and Renard KG. 2002. Soil erosion: processes, prediction, measurement and control. New York, NY: John Wiley & Sons.

Turner II, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J.J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J.X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., Schiller, A., 2003. A framework for vulnerability analysis in sustainability science. Proceedings of the National Academy of Sciences of the United States of America 100, 8074–8079.

UN General Assembly, 2012. High-level meeting on addressing desertification, land degradation and drought in the context of sustainable development and poverty eradication. A/65/861.

UN/ISDR, 2007. Drought Risk Reduction Framework and Practices: Contributing to the Implementation of the Hyogo Framework for Action. United Nations secretariat of the International Strategy for Disaster Reduction (UN/ISDR), Geneva, Switzerland, 98+vi pp. http://www.preventionweb.net/files/3608_droughtriskreduction.pdf.

UNDHA (United Nations Department of Humanitarian Affairs) (1992) Internationally Agreed Glossary of Basic Terms Related to Disaster Management, Geneva.

UNEP (2002), Assessing Human Vulnerability due to Environmental Change: Concepts, Issues, Methods and Case Studies.

UNEP. 1977. World Map of Desertification, at a scale of 1:25 000 000. FAO/UNEP/WMO/, Nairobi.

UNEP. 1992b. Desertification, land degradation [definitions]. Desertification Control Bulletin 21.

Valentin, C., Poesen, J. & Yong, Li, 2005: Gully erosion: Impacts, factors and control. Catena 63: 132–153.

Verheye W., de la Rosa D., Mediterranean Soils, in Land Use and Land Cover, from Encyclopedia of Life Support Systems (EOLSS), Developed under the Auspices of the UNESCO, Eolss Publishers, Oxford ,UK. [http://www.eolss.net] [Retrieved December 21, 2005].

Vetter, T. (2006): Runoff pathways, disconnected contributing areas and adapted ancient watershed management in the semi-arid Northern Marmarica (NW-Egypt). Geophysical Research Abstracts, 8, EGU-A-02490.

Veyret Y**.,** 2004, La vulnérabilité, définition, In: Géographie des risques naturels en France. Del'aléa à la gestion, (A. CIATTONI, ed.), Initial, Hatier, Paris, 42-46.

Wahab M. A., G.W.Ageeb, M.M. Kotb, E.I.E. Gaber, A.M. Sharaky and E.F.Essa (2014) Sensitivity to Desertification at Sidi Barrani Area, the North-Western Coast of Egypt. Middle East Journal of Applied Sciences, 4(3): 733-739, 2014 ISSN: 2077-4613

Wakil M., Abass M., Mansour A., Daoud I, Abd El Kader k., Ramzy M., (1999) hydrological assessment of wadi El Kabsh. World Bank/ MRMP, Project document, Matrouh, Egypt.

Westesen, G.L., and M. Bryan. 1997. Wading into Montana Water Rights. Bozeman and Helena: Montana State University and Montana University System Water Center. Available at: http://www.montana.edu/wwwwdr/manuals/rights.pdf.

White C., (2012) Understanding water scarcity: Definitions and measurements. at:, http://www.iwmi.cgiar.org/News_Room/pdf/Understanding_water_scarcity.pdf.

Wiley, J., Sons, WIREs Clim Change(2011) 2 45–65 DOI: 10.1002/wcc.81.

Wilhelmi O. V., Wilhite D. A., Assessing Vulnerability to agricultural drought: A Nebraska case study, Natural Hazards, Netherland, 2002, 25, 37-58.

Wilhite D. A., M.D. Svoboda, MJ. Hayes., J. Water Resources Management, 2007, 21, 763-74.

Wilhite DA, and Glantz MH. 1985. Understanding the drought phenomenon: The role of definitions. Water International. 10:111-120.

Wilhite, D.A. (2002) Reducing Drought Vulnerability through Mitigation and Preparedness, Report to the Inter-Agency Task Force for Disaster Reduction Sixth Meeting, Geneva.

Winpenny, J.T. 1997. "Managing Water Scarcity for Water Security." A discussion paper prepared for the First FAO E-mail Conference on Managing Water Scarcity, 4 March to 9 April 1997.

Wisner. B, Blaikie, P., Cannon, T. and Davis, I..: "At risk, second edition: natural hazards, people"s vulnerability and disasters", 2003.

WMO-No. 989 (World Meteorological Organization), (2005). Climate and Land Degradation. Available At https://www.wmo.int/pages/themes/wmoprod/documents/WMO989E.pdf.

Worrell Lisa M (2007)." GIS Analysis of Gully Head Erosion Rates on High Ridge Tree farm in Winona County Minnesota" Vol 10 papers in Resource Analysis 6pp st maps university. http://www.gis.smumn.edu.

Xiaomeng Ren, Agriculture Vulnerability To Drought in Southern Alberta : A Quantitative Assessment , 2007, Master thesis, University of Lethbridge , Lethbridge, Alberta, Canada. Tallaksen, L. M. and van Lanen, H. A. J. (editors) (2003): Hydrological Drought. Processes andEstimation Methods for Stream flow and Groundwater, Development in Water Science 48, Elsevier.

Yohe, G. and R.S. Tol. 2002. Indicators for Social and Economic Coping Capacity Movin Towards a Working Definition of Adaptive Capacity on Global Environmental Change.

Young, A. 1985**.** *An environmental data base for agroforestry*. ICRAF Working Paper 5, revised edition.

Yousif M., El Sayed El Abd , Ahmed Baraka, Assessment of water resources in some drainage basins, northwestern coast, Egypt. Appl Water Sci (2013) 3:439–452.