

ORIGINAL ARTICLE

Open Access



Migration as one of several adaptation strategies for environmental limitations in Tunisia: evidence from El Faouar

Karolina Sobczak-Szelc^{1*}  and Naima Fekih²

* Correspondence: k.sobczak-szelc@uw.edu.pl

¹Centre of Migration Research,
University of Warsaw, Pasteura 7,
02-097 Warsaw, Poland
Full list of author information is
available at the end of the article

Abstract

Water scarcity and management of this problem are increasingly acknowledged in development policies as well as in adaptation and migration discourse. In South Mediterranean countries, insufficient water supplies in oases are the biggest limitation on yields of sufficient quantity and quality and increase in arable land, in short, the development of agriculture. Insufficient income from agriculture, when it is the main source of revenue, can push people to migrate. However, migration does not have to be the measure of last resort. Proper adaptation to this limitation, including proactive migration, can reduce forced movements from this region in the future. The main aim of this paper is to identify and analyse household strategies, including migration, to cope with and adapt to the impact of environmental changes and limitations on agricultural development in the South Mediterranean. This paper is based on field research carried out in the El Faouar oasis area in Tunisia using a mixed-method approach. The results show that the inhabitants of El Faouar must cope with unforeseen crop destruction limiting their daily expenses by selling livestock or, in years of drought, migrating to look for additional sources of income. The results also show that local households try to increase their resistance to climate change, environmental limitations, and permanent migration by developing their agricultural capacity, provided they have additional resources from such endeavours as work outside El Faouar or remittances. Moreover, migration has become part of a wider process of socio-economic transformation in which people leave in order to cope with or adapt to environmental changes.

Keywords: Adaptation strategies, Coping strategies, Water scarcity, Environmental migration, Mediterranean migration, Kebili, Tunisia

Introduction

Although it is challenging to estimate the specific scale and scope of impacts related to environmental change, water scarcity and the depletion of resources add to the already increasing levels and complexity of population mobility (Christian Aid, 2007; Ionesco, Mokhnacheva, & Gemenne, 2016). The Mediterranean region is struggling with a growing migration movement. While migrants declare financial constraints and professional goals as the most common reasons for migration (Flahaux & De Haas, 2016; Kriaa & El Elj, 2013; Zuccotti, Geddes, Bacchi, Nori, & Stojanov, 2018), studies also show that environmental changes and limitations are no less important (Afifi, 2011;

Ait Hamza, El Faskaoui, & Fermin, 2009; Freier, Bruggemann, Scheffran, Finckh, & Schneider, 2012). As North African countries lie in an area of low rainfall, the most serious problems are caused by climate change, water scarcity, and drought. The most susceptible areas to water scarcity and management of this problem are those in arid and semiarid zones. Some results of empirical studies focused on migration in drought-affected areas have already been published (Findley, 1994; Morrissey, 2013; Rain, 2000; Tegegne & Penker, 2016; Vidyattama, Cassells, Li, & Abello, 2016). Although there is a significant number of these studies (CLIMIG, 2018), there is still a need for a deeper understanding of the ongoing processes that push people to migration. Special attention should be given to those that highlight the environmental conditions of human existence because not only one-off hazardous events but also irreversible changes in the environment may push people to migrate (Renaud, Dun, Warner, & Bogardi, 2011). In the South Mediterranean, environmental changes and limitations to oases reduce income from agriculture and force people to look for additional sources of income, including from migration. However, migration does not have to be the measure of last resort. It may provide financial resources for adaptation. And yet, introducing pertinent adaptation measures that allow for long-term adjustment of economic strategies can reduce forced movements from this region in the future (Geddes, 2015, p. 4). Therefore, there is a need to present new approaches to adaptation, such as “adaptive co-management for climate change adaptation” (Plummer & Baird, 2013), measures taking into account the high level of uncertainty (Kwakkel, Haasnoot, & Walker, 2013), “patchwork household economy” (Ravnbøl, 2019) or bottom-up approaches known as “community-based adaptation” (Reid, 2009).

The main aim of this paper is to identify and analyse households’ coping and adaptation strategies, including migration, in response to the impact of environmental changes and limitations on agricultural development. In this paper, we use a multidisciplinary approach and consider the diversity of economic and social realities existing in the source territory. Additionally, this article adds a more geographical perspective to this discussion, as we can observe an over-reliance on other social sciences in migration studies.

The analysis is based on a case study of a regional situation, El Faouar (Tunisia), aggravated by global climatic problems. We have addressed the following research questions:

1. What coping and adaptation measures do households use in the context of environmental changes and limitations?
2. Do households employ the migration of their members as an adaptation strategy?

The article begins with a brief introduction of the concepts of coping and adaptation strategies. Next, we describe the geography and environment of the El Faouar region and the socio-economic conditions and migration characteristics of the investigated area. Then, a description of the methodology and analytical approach follows in section four. We continue with the results of quantitative and qualitative analyses of adaptation measures implemented by the inhabitants of the study area to cope with the demands of the environment and the diminishment of agriculture, with particular attention devoted to migration as a way to gain new resources for agricultural development. The

final section provides conclusions, focusing on the role of migration among different adaptation strategies implemented in the investigated area, and reflections regarding the role of migration in the transformation of oases in the Mediterranean region.

Migration as a coping and adaptation strategy—state of the art

Throughout history, people have adapted to and coped with their environment. The increasing interest in environmental change and its consequences is followed by actions aimed not only at mitigating climate change but also at implementing strategies to cope with or adapt to the impacts of environmental change and environmental limitation, one of which is migration (Geddes, 2015; Wamsler & Brink, 2014).

The United Nations Office for Disaster Risk Reduction (UNDRR) (formerly United Nations Office for Disaster Risk Reduction (UNISDR)) defines a “coping strategy” as “the ability of people, organisations, and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters” (UNISDR, 2009, p. 11). For this paper, however, a more suitable approach is the one taken by the Intergovernmental Panel on Climate Change, which distinguishes between coping and adaptation strategies. According to this division, a coping strategy focuses on short-term reactions to unforeseen or unplanned situations resulting from sudden-onset events, such as heavy rains, floods, or earthquakes, and involves currently available skills, such as selling household or farm assets (IPCC, 2012). On the other hand, adaptation involves actions taken for the long-term adjustment of economic strategies or protective investments (Nelson, Adger, & Brown, 2007; Schraven & Rademacher-Schulz, 2015) and are designed to prevent risks related to slow onset hazards, such as soil erosion or lowering of quality and quantity of water, or at least mitigate their course (IPCC, 2012). However, the concept of adaptation through transformation is still rather excluded in the adaptation debate (Schraven & Rademacher-Schulz, 2015).

One of the most common definitions of environmental migrants, implemented by IOM, does not directly reflect migration as an adaptation strategy. It defines environmental migrants as “persons or groups of persons who, for compelling reasons of sudden or progressive change in the environment that adversely affects their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad” (Perruchoud & Redpath-Cross, 2011, p. 33). Following this definition, migration is a last resort strategy as a reaction to a specific short- or long-term event. However, migration does not have to be the end stage of the response to environmental degradation or a measure of last resort. It is not necessarily a response to failure, but may be part of a wider process of transformation in which households, and migrants in particular, try to ensure their livelihood’s security (Jónsson, 2010, pp. 26–27 after Hampshire & Randall, 1999). Migration is the effective way to allow people to diversify income and build the resilience of those facing environmental change and limitations (e.g. Afriyie, Ganle, & Santos, 2018). If it is part of wider income diversification strategy, where each of household’s sources of income can be replaced or supplemented by another economic source, it reminds of a continuous crafting process where small squares of fabric are sewn together to form a patchwork pattern. In the case of Romanian Roma in Denmark, this kind of strategy was called a “patchwork economy” (Ravnbøl, 2019, p. 212). Migration also allows for looking for additional financial resources for

investments into agriculture. Evidence from the Philippines shows that remittances from international migrants transform productive practices within agriculture, as they increase the availability of working capital and serve an insurance purpose. Additionally, remittances influence the choice and production of more specialised and high value commercial crops (e.g. Gonzalez-Velosa, 2011).

Thus, adaptation strategies through migration do not require permanent mobility but are linked to additional income for households and for agricultural development. This makes it closer to the definition of environmentally motivated migrants, who leave a steadily deteriorating environment to pre-empt the worst and to avoid further deterioration of their livelihoods (Renaud et al., 2011, p. e15).

This situation is particularly visible in the case of South Mediterranean oases,¹ although, most research carried out in Maghreb countries focuses on the economic and social dimension of migration. For instance, Kriaa and El Elj (2013) show that drivers of migration in Tunisia, both internal and international, are mostly economic and that migration is perceived as a way to overcome migrants' and households' financial constraints. Further, single males migrate to satisfy their needs and achieve their professional goals and projects. Those economic constraints have, however, an environmental background, as agriculture, which was the main source of income for oasis inhabitants, faces many problems, mostly due to water scarcity and extreme weather events (Ait Hamza et al., 2009; Rössler, Kirscht, Rademacher, Platt, & Kemmerling, 2010). The case of the Mhamid oasis in Morocco is an example of where, due to water scarcity and its deteriorating quality, agriculture does not provide an income sufficient for survival. Therefore, the inhabitants have had to limit agriculture and either look for another source of income in the oasis area (army or tourism) or emigrate to the big cities in Morocco (Ait Hamza et al., 2009; Sobczak, 2008). However, migration also may have a positive impact on oasis transformation, including socio-economic and political changes in agriculture and the output of natural resources. Some examples of oases in Morocco and Tunisia were described by de Haas (2001). These cases of transformation, however, can hardly be generalised to all of the Maghreb.

Research area

The geography and environment of El Faouar

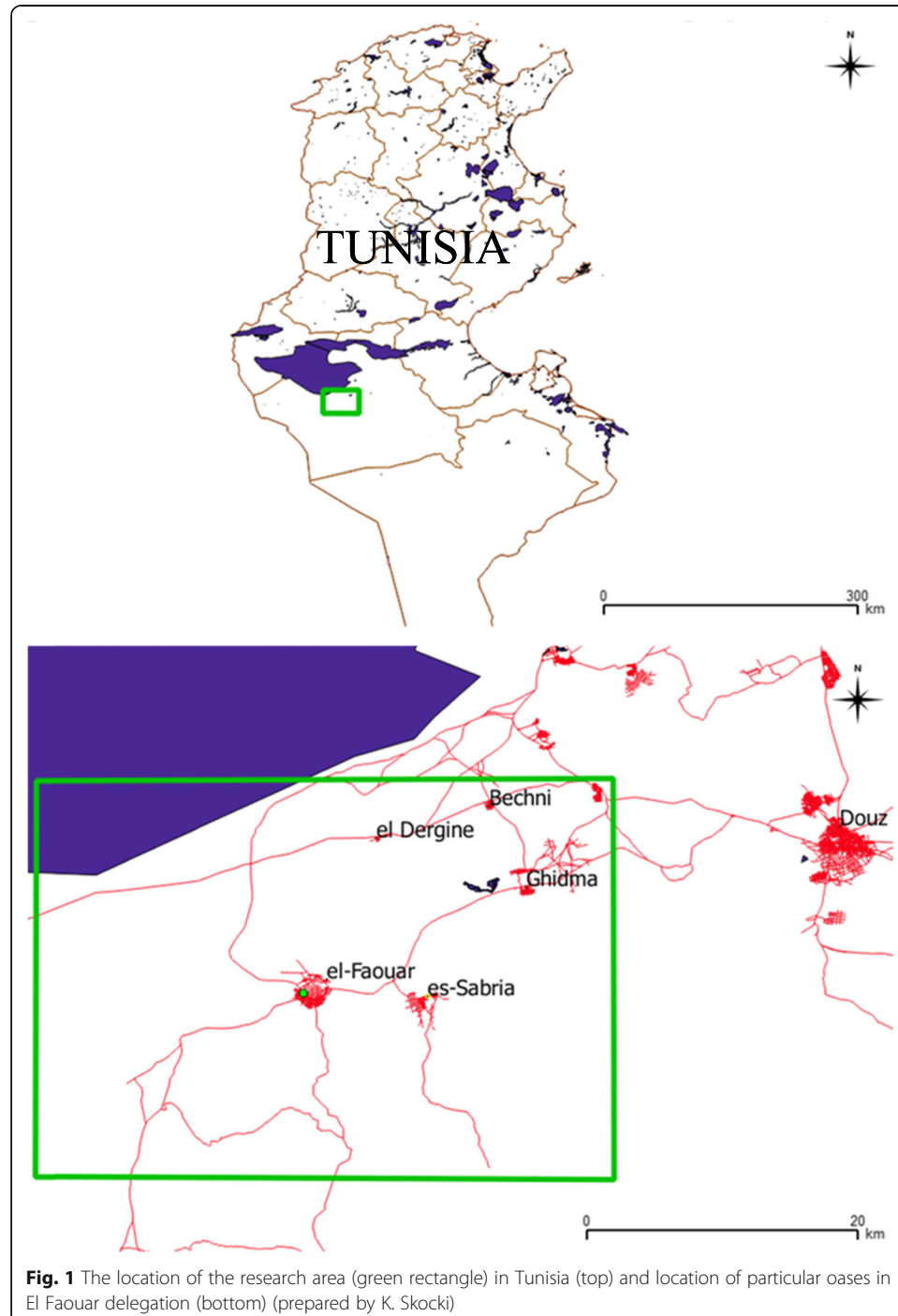
We selected the El Faouar region as a case study for our research because it has experienced several serious environmental changes and outmigration (Mekki, Jacob, Marlet, & Ghazouani, 2013). The area studied is located in central Tunisia, south of Chott el-Jerid, an episodic saltwater lake that constitutes the natural outlet for drainage water (Auclair & Zaafouri, 1996, p. 17). The El Faouar delegation² is the largest in the Kebili governorate, with an area of 9671.3 km² and consisting of eight villages (INS, 2016). The research was carried out in six of them (El Faouar, Essabria Ouest, Essabria Est, Grib, Gidma, and

¹An "oasis" is understood as a fertile area in a desert that has a supply of water that can support vegetation. Groundwater is accessible from a natural spring or reached by wells.

²Tunisia is divided into 24 governorates. Each governorate is further divided into delegations (districts); each delegation is subdivided into municipalities and sectors. The main village in a municipality is called a communal village, distinct from non-communal ones. In the text, we use El Faouar in three meanings: as a delegation, as a village within the El Faouar delegation, and the El Faouar oasis, a village area with neighbouring palm groves.

Bechni-Dergine) while in-depth interviews were conducted in four of them: El Faouar, Essabria Ouest, Essabria Est, and Ghidma (Fig. 1).

The environmental conditions of the El Faouar region are highly challenging for agriculture. The climate is classified as hot and arid. The average annual temperature is about 25 °C (Agoune, Kamel, Chkir, & Ammar, 2016), but in summer it can reach 41 °C, and in winter it can fall to 7 °C. The annual rainfall does not exceed 100 mm while evaporation reaches nearly 1300 mm (Habib, 2013; Kadri & Ranst, 2002; Marlet,



Bouksila, Mekki, & Benaissa, 2007). In this region, not only is rainfall scarce but also surface water cannot be used for farming purposes due to its salinity (Omrani, 2002). The main sources of water for agriculture are non-renewable, underground artesian and subartesian waters. However, they face overexploitation and scarcity of resources mostly due to increasing demand and a relatively rigid offer (Louhichi, Flichman, & Comeau, 2000). The overexploitation of artesian water leads to a regression in its flow and transition to subartesian, based on electrical pumping (Latos, Sobczak-Szelc, Kozłowski, Skocki, & Szczucińska, 2018). Additionally, in the El Faouar oasis, the state has funded 1500 m deep drilling to hot water (Mekki et al., 2013), which after cooling down is used for irrigation. It allows for the cultivation of plants in greenhouses and more demanding crops such as peppers, watermelons, and tomatoes. This innovation is, however, limited to one oasis and the area close to the water source. The underground artesian, subartesian, and thermal waters are distributed by an irrigation network. As irrigation is rotating between land connected to one well, the amount of water delivered and the frequency of irrigation is strictly dependant on the surface area of the connected fields. Due to the growth of arable land, in some areas it has changed from once per week in the 1970s to once per 20 days currently. The water has become increasingly more expensive and more saline that in order to satisfy the irrigation needs of existing oases, new water resources must be developed (Habib, 2013; Kadri & Ranst, 2002; Marlet et al., 2007). Pedological conditions are not less demanding than irrigation ones. The soils of the investigated area are classified as Aridisols (Habib, 2013; Soil Survey Staff, 2014). Additionally, almost constant winds help to create sequential patches of wind-blown sands and dunes. Complex systems of transverse and longitudinal sand dunes approach and endanger both cultivated and inhabited areas.

Traditionally, oases are planted with three vegetative strata: the highest being date palms, the middle one fruit trees such as olive, pomegranate, and fig, and the lowest one grains and yearly herbaceous crops (de Haas, 2001). In the El Faouar region, this diversification varies between oases, depending on water accessibility and financial resources. Most households focus on date palms, which, if managed well, bring the biggest profit.

Socioeconomic and migration characteristics of the El Faouar region in the Tunisian context

The end of the nineteenth century in Tunisia was a time of gradually establishing new urban centres in the desert area (Médénine, Tataouine, Zarzis, Ben Gardane, Douz, Kébili). This was accompanied by the creation of areas planted exclusively with “Degla” palms with the intention to ensure the allegiance and collaboration of settlers or former nomads and semi-nomads (at Bazma, El Faouar, and Douz) (Ministère de l’environnement et de développement durable, Direction générale de l’environnement et de la qualité de la vie, 2015). The El Faouar oasis and delegation was founded in 1949 with the first borehole, followed by a border crossing and a school created by the French administration. It was not until the end of the 1960s that the families of two nomadic tribes, the Ghrib and the Essabria, settled in the El Faouar region. The process of settlement was followed by demographic growth. The population of the El Faouar delegation

increased tenfold between 1970 (about 1000 inhabitants, including many transhumant pastoralists), and 1994 (about 10,000) (Auclair & Zaafour, 1996). Meanwhile, new oases such as Bechni and El Dergine appeared. In another 10 years, due to the continuing settlement of former nomads, the population almost doubled, reaching 19,613 in 2014 (INS, 2016).

Settlement was followed by a change in life habits and a shift from pastoralism (e.g., breeding of camels) to agriculture. Agriculture is based on the cultivation of the *Deglet Nour* date palm, which became the main source of income despite the small size of available areas (on average, a quarter of a hectare per household). In 1982, through additional drilling, 134 ha of new land was prepared for palm groves (Auclair & Zaafour, 1996).

State and local authorities consider the ongoing transformation of nomads into oasis farmers to be successful and advantageous because it is accompanied by a noticeable rise in most development indicators (consumption, housing, schooling, etc.) (Auclair & Zaafour, 1996). Yet, the agricultural area and the available quantities of water are insufficient to ensure a decent income for the population. The inhabitants of the new oases managed this situation by illegal drilling to expand the areas planted with *Deglet Nour* dates. However, increasing irrigation has led to the depletion and degradation of the groundwater in El Faouar, as in the whole Nafzawa region (Mekki et al., 2013). This is a classic problem extensively described by Hardin (1968) and better known as a “tragedy of common pasture”. The state seems powerless to devise regulatory mechanisms for “illegal” drilling (Talbi, Ben-Mansour, & Talbi, 2008).

The problems affecting agriculture are very serious for the inhabitants of the El Faouar region as, in 2014, more than 36% of total employment there was in agriculture. As possibilities for employment outside agriculture in the El Faouar region are limited, unemployment is no less an important challenge. The unemployment rate in the delegation increased from 7% in 2004 to 28% in 2014 while in the governorate of Kébili as a whole, it was 12% and 21% respectively (INS, 2016). The agricultural sector’s problems and unemployment have forced rural households to support their income with revenues from off-farm sources, including out-migration (Nori, El Mourid, Giorgi, & Nefzaoui, 2009). This approach is a modification of the New Economics of Labour Migration theory (Stark & Bloom, 1985), in which families act collectively to maximise expected income and minimise risks and constraints; however, here it is not due to market variability but to the changing natural environment and its limitation of agricultural development.

Methods of data collection and analysis

We used a mixed-method approach combining quantitative and qualitative components (Brannen, 2017, pp. 26–27). This method allowed to differentiate research approach and source of data. The quantitative part provided contextual information and characteristics of the sample in a generalised manner. Additionally, it allowed for choosing the most suitable households for in-depth interviews, which saved time. The main qualitative component was to identify the coping and adaptation strategies developed by inhabitants of the area.

The data collection was initiated by holding open-ended interviews with local authorities (the head of the El Faouar delegation, the heads of five villages, and a

representative of the Agricultural Extension Cell of El Faouar). The team also worked personally within the target area conducting field research, compiling photo documentation, etc. These interviews and field studies provided the background for the survey questionnaires conducted among local respondents. Three trained local interviewers helped implement PAPI (paper and pen personal interview). The questionnaire was in French; however, if the respondent was not able to understand the questions, they were translated into *darija* (spoken Arabic, which differs from one country to another).

We surveyed only households that had an income from agriculture, as these households were expected to be directly affected by the environmental problems and limitations on agricultural development. There was no list of households with incomes from agriculture. Therefore, lacking a sampling frame, we had to rely on quota sampling, asking households in different parts of the settlements to take part in the study. The quantitative research was carried out in 120 households (out of which 25 were in El Faouar itself and the rest in smaller settlements). Due to non-random sampling and the relatively low number of investigated households, the sample is not representative; therefore, this study cannot be treated as a comprehensive assessment of adaptation strategies in the El Faouar delegation. It should be seen as a case study and a basis for further research. Nonetheless, we tried to ensure that all relevant aspects of the environment, financial conditions, both internal and international migration, and absence of migration were represented among the selected households. The questionnaire was divided into three parts: A) Introductory, with general information regarding household members and links to agriculture, B) About household members, with questions regarding all persons that were members of the household since 1990³ and their migration experience (the first and the longest trip), C) Concerning households and agricultural conditions, and how those conditions have changed since 1990.

Next, to collect more details regarding the reasons for migration and/or staying put and adaptation strategies, we carried out 17 qualitative in-depth interviews (14 in households selected from each of three groups of households defined by their members' migration experience and three recruited in addition to the sample of surveyed households). The interviews were carried out among households located in the three oldest settlements of the El Faouar delegation—El Faouar, Essabria, and Ghidma—as these regions remain the most affected by environmental degradation and migration and, therefore, give deep insight into the history of the region, the experienced changes, and the mobility of the residents. We interviewed only those households affected by different environmental factors (they indicated in the questionnaire that more than 50% of their crops had been destroyed due to such factors).

We assumed that the in-depth interviews would be carried out with the heads of households, as they were best informed about the farmstead situation and responsible for family finances. Sometimes, the household head was absent or unable to participate in the research; in those cases, the interviews were carried out with another respondent (wife or son of the household head) (Table 1). The interviews were conducted in Arabic and French with an interpreter. Most of the interviewees understood questions in French; however, the responses were given in Arabic. The interviews were translated

³The research was part of the DeMiNoA project carried out in five different regions. In two of them, the year 1990 was mentioned as the moment when significant changes in the environment were observed. The timeframe was unified in all the investigated areas.

Table 1 Characteristics of in-depth interview respondents and their households

| No | Code | Oasis | Gender | Age range | Education | Occupation | Size of arable area*/ % cultivated area |
|-----|------|-----------|--------|-----------|-------------------|---------------------------|---|
| 1. | H63 | El Faouar | F | 40–49 | primary education | at home | large /25% |
| 2. | H68 | El Faouar | F | N/D | primary education | at home | medium /30% |
| 3. | H70 | El Faouar | M | 40–49 | not educated | agriculture, day labourer | large |
| 4. | H73 | El Faouar | M | over 60 | N/D | retired / agriculture | small |
| 5. | H81 | El Faouar | M | 30–39 | primary education | agriculture, day labourer | large /20% |
| 6. | H9 | Sabria | M | N/D | not educated | day labourer | N/D |
| 7. | H15 | Sabria | F | 30–39 | secondary | at home | small |
| 8. | H19 | Sabria | F | over 60 | not educated | at home | small |
| 9. | H21 | Sabria | M | 30–39 | university degree | unemployed | small |
| 10. | H33 | Sabria | M | 57 | not educated | agriculture, day labourer | small /50% |
| 11. | H121 | Sabria | M | 30–39 | N/D | agriculture | large |
| 12. | H12 | Ghidma | M | 40–49 | secondary | technician in agriculture | small |
| 13. | H39 | Ghidma | M | 50–59 | not educated | agriculture/ farmer | small |
| 14. | H43 | Ghidma | F | 30–39 | university degree | at home | large /43% |
| 15. | H45 | Ghidma | M | 30–39 | secondary | military | medium /75% |
| 16. | H122 | Ghidma | F | over 60 | not educated | at home | small |
| 17. | H123 | Ghidma | M | 30–39 | university degree | agriculture | medium |

*small (below 1 ha), medium (1–4 ha), large (over 4 ha)

and transcribed to English and subsequently analysed into themes based on the following criteria: agricultural conditions, threats to agriculture, coping actions, adaptation actions, additional sources of income, migration of interviewees, and migration of family members.

The survey data were analysed on two levels: the households, and the household members. The first level was based on the information regarding the reason for the longest movement⁴ of each person that has been a member of the household since 1990 and was more than 15 years old at the moment of the survey.⁵ We distinguished three groups of households: 1) economic migrant households (EMH), which had at least one member who had moved for economic reasons (looking for a job or because of a job contract), 2) non-economic migrant households (NEMH), which had at least one member who had moved for educational, family, or other reasons but had no economic migrant among the household members, and 3) non-migrant households (NMH), with no migrant members. Among the 120 investigated households, there were 51 EMH, 32 NEMH, and 37 NMH.

⁴As we investigated a relatively long period of time and movements of persons that had been members of the family since 1990, we decided to focus on the reason for the longest movement (absence from home due to internal or international movements). We assumed that this one would be the most important and potentially so for economic reasons. As the movements under investigation were just the most significant ones, the response error was expected to be low.

⁵This approach is in line with the Tunisian national census.

Table 2 Migrants according to their mobility motivations

| Gender | Reasons for migration | | | | Total |
|--------|-----------------------|-----------|---------------|-------|-------|
| | Labour | Education | Family reason | Other | |
| Women | 8% | 53% | 36% | 3% | 100% |
| | 6 | 41 | 28 | 2 | 77 |
| Men | 65% | 26% | 7% | 2% | 100% |
| | 67 | 29 | 7 | 2 | 105 |
| Total | 73 | 70 | 35 | 4 | 182 |

The second level of analysis was based on the members of households. In 2016, 732 people lived in the 120 households chosen for the survey. On average, the investigated households had six members. Children under 15 years old made up 24% of the total number of members of the investigated households. There were 554 adults (over 15 years old). The proportion of women to men was 51% to 49% and was similar in all age groups.

Based on the question regarding the reasons for the longest movement of each member of the household over 15 years old, we distinguished three groups of migrants according to their mobility motivations: 1) labour, migrating either due to a job contract (39 persons) or to look for a job (34); 2) education; and 3) family reasons, such as a family reunion or marriage (Table 2). Apart from the reason for the longest movement, we also asked about its year, its duration (divided into categories of 1–4 weeks, 1–12 months, 1–3 years, more than 3 years), and direction. Unfortunately, some of these data are limited. For instance, of the 202 recorded migrants, a reason for migration was given for only 182 of them. Further, of the 73 economic migrants, data on the year of the longest movement were provided for only 57 of them.

How to cope, how to adapt—the different challenges for agriculture and ways to overcome them

The second and third generation of settlers in El Faouar face three main problems: limitations on agricultural development, decrease in income from agriculture, and a high unemployment rate. The first two were spurred by high demographic growth, fragmentation of inherited arable land, and environmental conditions. The last one is the effect of environmental limitations (water scarcity and the spread of dunes), climate variability (most often mentioned were heatwaves and heavy rain), and a lack of prospects outside agriculture for those for whom work in agriculture has become too harsh. Interviewee H122 recounted this situation in the following words:

Agricultural activity has become difficult due to problems with sand and additionally the lowering water level. (...) Every 20 days, we receive water for 3 h of irrigation. This is not enough for hydration of palm trees. (...) Previously, the field was irrigated every 12 days for 4 h. (...) Once, the palm gave 100 kg, and now gives about 50 kg. In the past, there were no problems with water and there were no changes in the amount of fruit received. (H122, female, Ghidma).

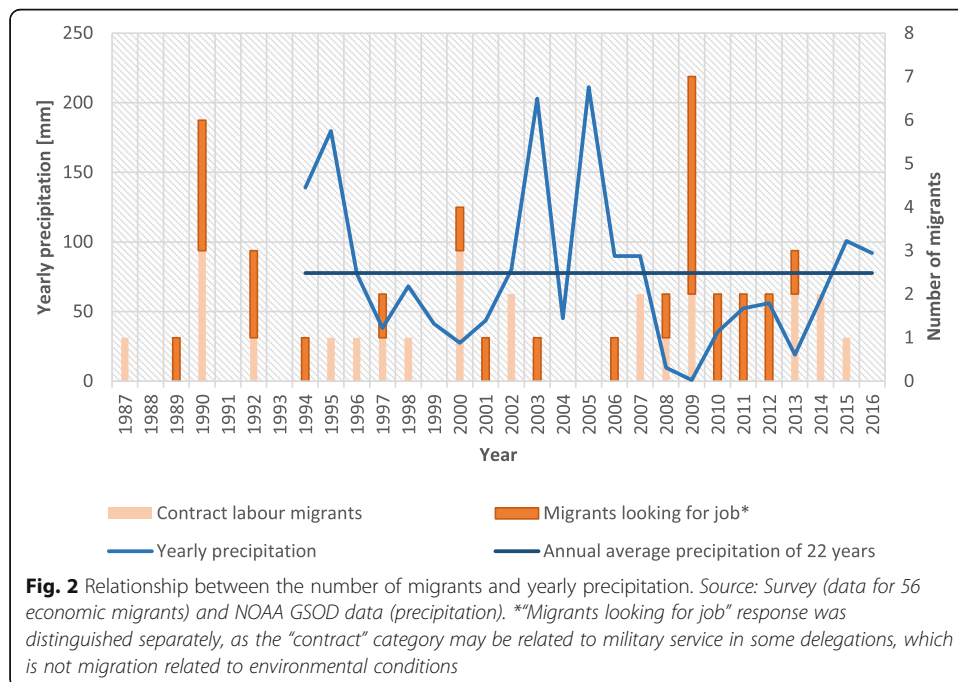
Heavy rains, heatwaves, and drought are the most common sudden events requiring a short-term reaction in El Faouar. The first strategy to cope with lowered income from agriculture is to limit consumption and/or sell livestock, as interviewee H68 explained:

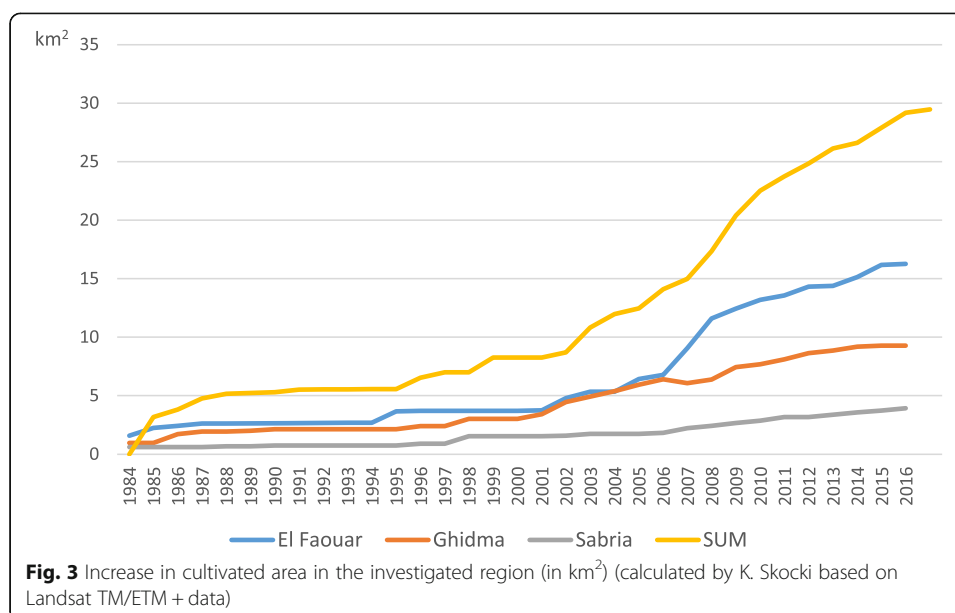
In that case (crop destruction), we limit our consumption in order to leave something for the next year for investments. (H68, female, El Faouar).

Less often mentioned during the in-depth interviews but visible when analysing the relation between the year of the longest labour migration and changes in rainfall, is the role of migration as a coping strategy. Although data for this relation are limited, comparing the number of labour migrants with yearly precipitation records, we can observe an increase in labour migration in periods with extremely low precipitation, namely in the years between 1997 and 2001 and 2008–2014. During the latter period, the number of migrants could have been even higher if the political situation in Tunisia had not stopped out-migration and in some cases, even reversed its direction. On the other hand, we can also observe little labour migration in years with extremely high precipitation—in 2003, 2005, 2015–2016 (Fig. 2). These migrations were either a coping strategy, when lasting less than 1 year (20 cases), or led to the development of an adaptive strategy, if lasting more than one (8 cases) or 3 years (22 cases). This temporal link shows that those more susceptible to climate variability and with the possibility to migrate used this opportunity as either a coping or an adaptation strategy in response to arid years.

The issue of land fragmentation for descendants and, therefore, the size of arable area, has resulted in challenges demanding long-term adjustment of economic strategies or proactive investments. Just a few trees or a quarter hectare has become insufficient to survive. Facing the lack of land, households started to cultivate new areas on the periphery of the oasis. The biggest increase in the newly cultivated area took place between 2006 and 2013 (Fig. 3).

For a long time, investments in the new areas were not followed by drilling of new wells by the state. That led to insufficient water for irrigation. To cope with this issue,





many households invested in new wells. As water resources are located at depths of 70–250 m, the expenses of drilling a new well are high. Only 21 out of all the households in the survey had access to a private well that allows for more frequent irrigation. Some of these wells are subartesian, which increases the costs related to water pumping, as the households need to afford either a motor pump and fuel or an electric pump and solar panels. One of the ways of financing a new well is to apply for favourable loans and state subventions, accessible mostly to those receiving a regular income, preferably from the public sector. Only 25% of households receive an income from the military sector, which is the main source of fixed salary. Therefore, there is a need for other sources of funds. Some households deal with the financial constraints by cooperating with their neighbours, sharing both investment expenses and access to water. Those who managed to develop their arable area and irrigation system confirmed that cooperation was an essential aspect of this, as explains interviewee H121:

There is a group of neighbours and we cooperate. We have done drilling, that has 180 m. But there is no water (it is not artesian water). There is a need for a pump with solar energy. This year, as soon as we will sell the dates we will buy the pump. It is expensive. Last year, we did the drilling; this year, we will buy the pump and solar panels. (H121, male, Sabria).

Also, in the survey, most of the households declared their willingness to cooperate with other farmers (63% of surveyed households declared more cooperation with neighbours among their plans for the future).

Long-term strategies demand not only finding new water resources but also using available resources more effectively. All interviewees claimed that drip-irrigation is the best option. Unfortunately, it is limited by the physical conditions (spring pressure) and cost of installation. If the water pressure is not high enough, a drip-irrigation system is not effective. In that case, only surface watering is possible. This results not only in a

Table 3 Households and non-agricultural sources of income

| Number of sources of income | Number of households | % |
|-----------------------------|----------------------|------|
| 0 | 38 | 32% |
| 1 | 51 | 42% |
| 2 | 16 | 13% |
| 3 | 7 | 6% |
| 4 | 8 | 7% |
| Total | 120 | 100% |

huge loss of water but also limitations on the area to be irrigated because, with limited time, water cannot reach more distant parts of fields. Some of the respondents were willing to deepen their wells to increase water supplies or, what was seen as more effective, to dig a new well. However, this solution demands more financial resources and runs the risk that no water will be found. Currently, the national and local authorities also try to take part in developing the irrigation system by financing new drilling, which started in 2017.

Investments in agriculture and its transformation seem to be the most favourable adaptation strategy. The majority of respondents said that the potential additional income would be devoted to new land, a new irrigation system, or for deepening the well. However, this is not possible for all households. Besides the environmental limitations, a lack of finances is a significant barrier. Even when sharing costs with neighbours, one needs investment capital, which more and more often is possible only outside the agricultural sector. This pushes households toward income diversification, in many cases reminding “patchwork economy”. In the survey, we investigated households’ non-agricultural sources of income. From the sample of 120 households, 82 had at least one non-agricultural source of income. The majority had just one additional income, but 31 had more than one (Table 3). Most of the additional income comes from the army (25%), construction (20%), remittances from internal and international migrants (18%), other services (18%), casual work (13%), or trade (13%).

An important additional source of income in the El Faouar region was, until recently, the tourism industry. Previously, nomads were the best-qualified tour operators for desert trips and local shops were full of regional souvenirs. The revolution in 2011 and terrorist attacks in Sousse and Tunis in 2015 stopped any tourist traffic in the region, deepening the crisis in the labour market.

This need for multiple sources of income was also highlighted during the in-depth interviews. Interviewee H73 underlined the need to have different sources of income as a way to overcome the lack of water and few crops:

It is obvious for us to develop agriculture, but the problem is with water. (...) If there is water, we don't need to have other work. But because there is a lack of water, we need to have another way to live. (H73, male, El Faouar)

However, income received outside agriculture serves not only as additional income for daily expenses or to cope with the loss of crops and ad hoc activities allowing for survival. It is also a kind of adaptation strategy and additional income that allows for the development of either agriculture or other activities, as explains interviewee H121:

I combine sources of income; I sell dates, work in France, I work with a tractor because I have it for one month, one and a half, then it goes to the neighbour. This tractor, and some money from France I mix. (...) Now, I build a garage, I prepare a place for selling agricultural materials and agricultural products. (...) You have to mix the sources of income. You have to do this way in order to live here. (H121, male, Sabria)

Also, those in the most difficult situations make an effort to develop agriculture, even if it is extended in time. An example is interviewee H122, a widow living with two daughters and one son who works as a day labourer. The family has recently bought 2 ha of land. However, due to lack of resources, they cannot afford further development.

Out-migration as part of adaptation strategies

This vicious circle of a lack of water, spread of dunes, insufficient arable land, crop destruction, insufficient income, lack of other job opportunities, and lack of money for enlargement of arable land forms a complex set of reasons pushing people to migrate. In order to answer the question of whether population movement can be considered an adaptation strategy, we looked at differences in household characteristics between the three groups of households: non-migrant (NMH), non-economic migrant (NEMH), and economic migrant (EMH).

The analysis of 120 households' characteristics shows that migration is not only a coping strategy but an adaptation strategy as well. Financial resources from emigration allow for both income diversification and better development of agriculture. According to the results of the survey, EMH rely less on agriculture in comparison with NEMH and NMH. Just 46% of investigated households declared that their income from agriculture constitutes more than 50% of household income. In comparison, in NEMH and NMH, 66% and 61%, respectively, declared the dominant role of agriculture in the household budget. In this way, EMH has become less vulnerable to climate variability and environmental changes. Although apparently EMH seem to have non-agricultural sources of income less frequently, out of the 51 investigated EMH, 47% had at least one other source of income. However, this number reaches 80% when we also include remittances. Their non-migration and non-agriculture-related incomes come from stable sources such as the army, trade, and construction activities. In the group of NEMH, 56% had sources of income other than agriculture, and just one more also received remittances. Of the 37 NMH, 62% declared that they had at least one source of income other than agriculture. Usually, these are temporary jobs in construction and day labour. In other words, for EMH, migration through remittances has become an element of their "patchwork household economy."

Moreover, the results of both the survey and in-depth interviews show that money earned during migration allowed for investment in agriculture. The willingness to develop agriculture in the El Faouar region is very strong among both EMH and NMH. Their average agricultural area has evolved since 1990 (Table 4), although their chances of doing so differ, related to the level at which they start. This willingness to develop agriculture finds its justification in the cultural background. Also, during the in-depth

Table 4 Average agricultural area per household (ha)

| Type of household | Number of households in 1990 | Average cultivated area (ha)* | | The change in average arable land (ha) |
|----------------------|------------------------------|-------------------------------|-------------|--|
| | | in 1990 | in 2017 | |
| non-migrant | 23 | 0.672 | 0.957 | 0.29 |
| non-economic migrant | 21 | 0.541 | 0.487 | -0.05 |
| economic-migrant | 31 | 0.790 | 1.069 | 0.28 |
| Total | 75 | 0.68 | 0.87 | 0.19 |

*Declaration of households that existed in both 1990 and 2017

interviews, those who came back or never left underlined their attachment to the region, land, family, culture, and work in agriculture.

However, the possibilities of adaptation through the agricultural transformation of EMH are much higher than NMH. This is visible when we look at the frequency of irrigation, access to new technologies, and innovative cultures. The best quality dates need irrigation once a week. This is possible with one’s own private well. Therefore, those who can afford developing agriculture, invest in a private well. Although the number of well owners among EMH and NMH is similar (9 and 8 respectively), typically, EMH irrigate fields more often than other households. The median frequency of watering for EMH is 2–3 times per month, where median for NMH is once a month (Fig. 4). The justification for this situation is the (co) ownership of the well. If the household can afford its own well, then irrigation is possible even 2–3 times per week. However, without money earned outside the El Faouar region, it is more difficult to have one’s own well and farmers decide to team up with neighbours. This allows for rotational irrigation with a frequency of 2–3 times per month, which is still better than the once per 20 days from the state well. Also,

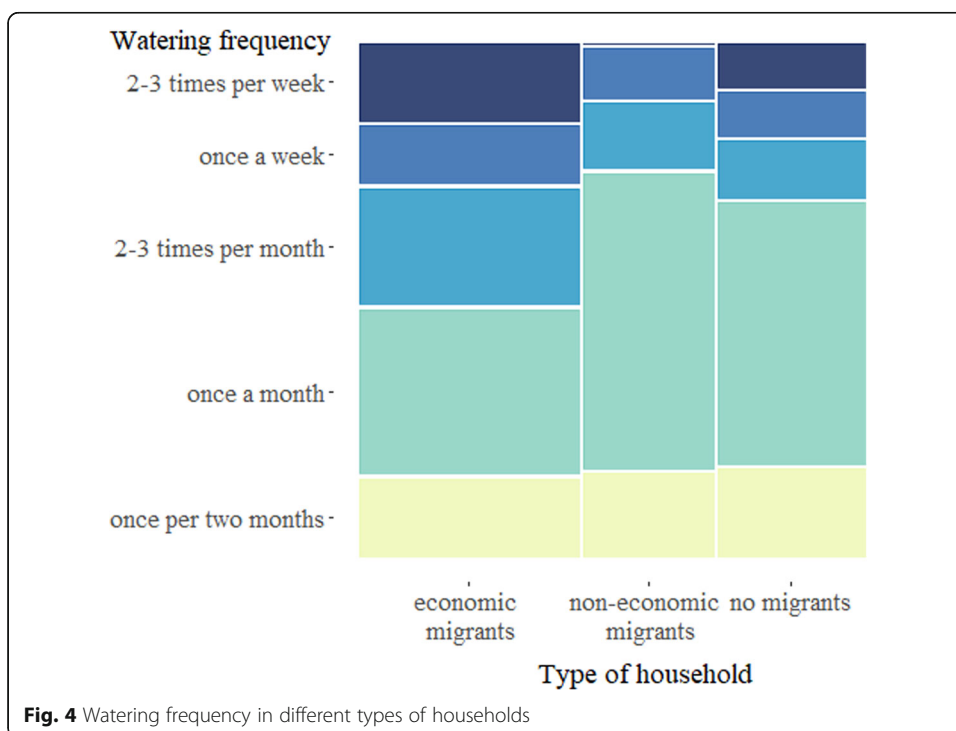


Fig. 4 Watering frequency in different types of households

Table 5 Number of households cultivating crops other than the date palm

| Crop type | Number of households | % of all households | % of EMH | % of NMH |
|--------------|----------------------|---------------------|----------|----------|
| wheat | 18 | 15% | 29% | 22% |
| barley | 17 | 14% | 32% | 17% |
| carrot | 15 | 13% | 29% | 22% |
| parsley | 15 | 13% | 19% | 13% |
| pepper | 14 | 12% | 29% | 17% |
| potatoes | 13 | 11% | 35% | 9% |
| leek | 13 | 11% | 32% | 9% |
| fig | 13 | 11% | 10% | 13% |
| grapes | 12 | 10% | 13% | 17% |
| pomegranates | 9 | 8% | 13% | 4% |

new irrigation techniques are more common among the EMH. Among all the investigated households, just six used a drip-irrigation system, five of which were EMH.

Finally, access to better and more frequent irrigation influences the choice of crops. Although all investigated households cultivate palm trees, EMH are more open to additional, new and riskier crops such as vegetables and spices (Table 5).

NEMH show a lack of interest in adaptation through agricultural development, visible in the reduction of cultivated land. The justification is complex, but two main reasons can be distinguished: the division of land among descendants and loss of family labour force after children leave, mostly due to education. Lack of labour force is a wider problem, as those who emigrate for educational reasons tend to settle in big cities because in the researched area they cannot find prospects for themselves. Also, educated children are no longer willing to work hard in agriculture as day labourers because they view it as below their qualifications. They instead want to hire someone. Interviewee H21 describes this:

After graduation, everyone is searching for a full-time job. Even in the private sector. They hate being treated as day labourers (usually related to work in agriculture). I have a degree, so it is shameful to work as a day labourer. So, we seek jobs in Douz or in Zaafran, for instance, jobs in our domain of study. (H21, male, Sabria)

The region has turned into one with problems of unemployment, especially among young graduates. With the growing number of better educated and jobless inhabitants, this situation forces a large number of citizens to leave the region to regain the chance to improve their standard of living. Migration became for them a means to assert themselves and achieve individual and social success. From the in-depth interviews, it became evident that migration, especially for young people, is perceived as a way to a better life, either through education or a job opportunity. It is no longer an adaptation strategy but a flight out of the region that has become a path to “success” for unemployed youth.

Conclusions

Since the mid-twentieth century, like all South Mediterranean countries, the El Faouar region has experienced an increase in the number of inhabitants and, consequently, growing pressure on resources, especially land and water. The increase in water needs and the reduction of available resources (overexploitation, unbalanced distribution of

water between households, mismanagement, etc.) has brought both environment and agriculture to a crisis during the last decade, forcing people to look for different coping and adaptation strategies. Those strategies depend on human, social, environmental, and financial resources.

In case of unforeseen crop destruction, the inhabitants of the El Faouar region focus on limitations of daily expenses or occasionally sell their livestock, if they have any. This is their first choice of coping strategy. Another short-term reaction is labour out-migration in years of drought (years with precipitation below the average).

Those who are willing and can afford to, try to adapt to the demanding and changing situation through a transformation of agriculture. The most common and, at the same time, most expensive ones include efforts to transform and develop agriculture, usually by enlarging the cultivated area, planting new palm trees, and digging a new well. If such development cannot be achieved from the household's own resources, other solutions are needed. Therefore, some households cooperate in order to share the expenses. Others try to implement "patchwork economy" and look for different sources of income outside agriculture. The majority of economic active men search for them locally while others move to look for work possibilities in Tunisia's big cities or, less commonly, abroad. Money earned outside the El Faouar region and remittances from migrants play an important role in economic migrant households' income, which results in their better adjustment to the environmental changes and limitations and increased resilience to unforeseen crop destruction. Moreover, income earned as an emigrant plays a crucial role in the transformation of agriculture and its development. The EMH (economic migrant households) more often than NMH (non-migrant households) have their own private well and, therefore, EMH typically water their fields more often than other types of households. Better resilience and access to water allows for riskier crops. This group of households also relies less on incomes from agriculture in comparison with NMH and NEMH (non-economic migrant households). Thus, EMH can risk the destruction of crops, cultivating more demanding vegetables and spices.

It can be concluded that migration is used by households as one of several adaptation strategies and is part of a wider process of socio-economic transformation in which people leave in order to cope with or adapt to environmental changes or to optimise their livelihood. This can be misunderstood if migration is considered purely from an economic background. The case of El Faouar is an example of adaptation through transformation, which confirms the findings of de Haas (2001, p. 29). Societies here are struggling to develop through enlargement of the cultivated area (in other words, overcoming the fragmentation of fields), where migration has become a facilitator in the transition from family-based subsistence farming to commercial production and where migration is an integral part of the strategies of looking for additional resources needed for development (described by Stark (1980)). Therefore, these results contribute to filling the gap in the adaptation debate mentioned by Schraven and Rademacher-Schulz (2015).

Acknowledgements

The authors wish to thank Dr. Krzysztof Skocki and Mr. Adel Ben Hamed for help during the field studies. Dr. Krzysztof Skocki also took part in the preparation of the first unpublished version of this paper. Although the content is solely the responsibility of the authors and does not represent the official views of CMR UW, the discussions within its Integration and Ethnic Relations Unit had crucial value for the latest shape of this article, with particular mention of Dr. Weronika Kloc-Nowak and Dr. Barbara Jancewicz who read and commented on the final draft. We also thank to the anonymous reviewers and the editors of this special issue, Ricard Zapata-Barrero and Luisa Faustini Torres for their valuable comments.

Authors' contributions

KSS is responsible for the design of the study and the methodology used for the collection, analysis, and interpretation of data and was a major contributor in writing the manuscript. Both co-authors collected data in the El Faouar region, Tunisia, and participated in data analysis and theoretical input. Both authors read and approved the final manuscript.

Authors' information

Karolina Sobczak-Szelc is an Assistant Professor in the Centre of Migration Research, University of Warsaw. Using a multidisciplinary approach, she studies the influence of the environment on human migration from North African countries.

Naima El Fekih has a PhD in demography from the Faculty of Humanities and Social Sciences, University of Tunis. Her research focuses on demographic and sociological topics.

Funding

The research was funded by the National Science Centre, Poland, in the framework of the project "Environmental determinants of migration from countries of North Africa" (grant no. 2014/13/D/HS4/03644).

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available. Where applicable, we provide the source of our data. All research participants' identities are protected and personal details removed. Original data collected for the project are stored on a password-protected computer.

Competing interests

The authors declare that they have no competing interests.

Author details

¹Centre of Migration Research, University of Warsaw, Pasteura 7, 02-097 Warsaw, Poland. ²Regional Direction of Social Affairs of Kebili, Kebili, Tunisia.

Received: 3 January 2019 Accepted: 10 October 2019

Published online: 14 February 2020

References

- Affi, T. (2011). Stealth environmental influences on economic migration in Egypt. Africa Initiative Discussion Paper Series, (1). Centre for International Governance Innovation <https://www.cigionline.org/publications/stealth-environmental-influences-economic-migration-egypt>. Accessed 21 June 2018.
- Afriyie, K., Ganle, J. K., & Santos, E. (2018). 'The floods came and we lost everything': Weather extremes and households' asset vulnerability and adaptation in rural Ghana. *Climate and Development*, 10(3), 259–274. <https://doi.org/10.1080/17565529.2017.1291403>.
- Agoune, A., Kamel, Z., Chkir, N., & Ammar, F. H. (2016). Hydrogeological characteristics of the geothermal transboundary aquifer reservoir case study of the continental intercalaire aquifer system in North Sahara Aquifer System (NSAS) in Southern Tunisian field. *International Journal of Environmental Science and Toxicology Research*, 4(4), 54–60.
- Ait Hamza, M., El Faskaoui, B., & Fermin, A. (2009). *Morocco case study migration and environmental change in Morocco: The case of rural oasis villages in the middle Drâa Valley*. Rotterdam: Erasmus University. <https://maithamza.files.wordpress.com/2010/12/migration-and-environmental-change-in-morocco-the-case-ait-hamza-mohamed.pdf>. Accessed 21 June 2018.
- Auclair, L., & Zaafour, M. S. (1996). La sédentarisation des nomades dans le sud Tunisien: comportements énergétiques et désertification. [The sedentarization of nomads in southern Tunisia: energy behaviors and desertification]. *Secheresse*, 7, 17–24.
- Brannen, J. (2017). Combining qualitative and quantitative approaches: An overview. In J. Brannen (Ed.), *Mixing Methods: Qualitative and Quantitative Research* (pp. 3–37). London: Routledge.
- Christian Aid. (2007). *Human tide: The real migration crisis (2007)*. Global: Christian Aid. <https://www.christianaid.org.uk/sites/default/files/2017-08/human-tide-the-real-migration-crisis-may-2007.pdf>. Accessed 26 June 2018.
- CLIMIG. (2018). *Bibliographic database*. https://www.unine.ch/geographie/climig_database. Accessed 3 Dec 2018.
- de Haas, H. (2001). *Migration and agricultural transformations in the oases of Morocco and Tunisia*. Utrecht: KNAG.
- Findley, S. E. (1994). Does drought increase migration? A study of migration from rural Mali during the 1983–1985 drought. *The International Migration Review*, 28(3), 539–553. <https://doi.org/10.2307/2546820>.
- Flahaux, M.-L., & De Haas, H. (2016). African migration: Trends, patterns, drivers. *Comparative Migration Studies*, 4(1), 1. <https://doi.org/10.1186/s40878-015-0015-6>.
- Freier, K. P., Bruggemann, R., Scheffran, J., Finckh, M., & Schneider, U. A. (2012). Assessing the predictability of future livelihood strategies of pastoralists in semi-arid Morocco under climate change. *Technological Forecasting and Social Change*, 79(2), 371–382. <https://doi.org/10.1016/j.techfore.2011.07.003>.
- Geddes, A. (2015). Governing migration from a distance: Interactions between climate, migration, and security in the South Mediterranean. *European Security*, 24(3), 473–490. <https://doi.org/10.1080/09662839.2015.1028191>.
- Gonzalez-Velosa, C. (2011). The effects of emigration and remittances on agriculture: Evidence from the Philippines. *Job Market Paper*. http://econweb.umd.edu/~gonzalez-velosa/JMP_Gonzalezvelosa_JAN.pdf. Accessed 2 Oct 2019.
- Habib, B. H. (2013). Effects of underground water on soil salinity and dates production in Kebili oases area (Tunisia): The case of El Bahaier oasis. *IOSR Journal of Environmental Science, Toxicology and Food Technology*, 4(4), 51–58. <https://doi.org/10.9790/2402-0445158>.
- Hampshire, K., & Randall, S. (1999). Seasonal labour migration strategies in the Sahel: Coping with poverty or optimising security? *International Journal of Population Geography*, 5, 367–385. [https://doi.org/10.1002/\(SICI\)1099-1220\(199909/10\)5:5<367::AID-IJPG154>3.0.CO;2-O](https://doi.org/10.1002/(SICI)1099-1220(199909/10)5:5<367::AID-IJPG154>3.0.CO;2-O).

- Hardin, G., (1968). The tragedy of commons. *Science*, 162(3859), 1243-1248. <https://doi.org/10.1126/science.162.3859.1243>
- INS. (2016). KÉBILI A travers le Recensement Général de la Population et de l'Habitat 2014 [KÉBILI Through the 2014 General Census of Population and Housing]. Institut National des Statistiques. <http://www.ins.nat.tn/fr/publication/k%C3%A9bili-travers-le-recensement-g%C3%A9n%C3%A9ral-de-la-population-et-de-l%E2%80%99habitat-2014>. Accessed 24 Oct 2018.
- Ionesco, D., Mokhnacheva, D., & Gemeine, F. (2016). *The atlas of environmental migration*. London: Routledge.
- IPCC. (2012). *Managing The Risks of Extreme Events and Disaster to Advance Climate Change Adaptation* (a special report of working groups I and II of the intergovernmental panel on climate change). Cambridge University Press. <https://wg1.ipcc.ch/srex/>. Accessed 24 Sept 2018.
- Jónsson, G. (2010). The environmental factor in migration dynamics – A review of African case studies. *International Migration Institute, James Martin 21st Century School, University of Oxford*, 21, 34.
- Kadri, A., & Ranst, E. V. (2002). Contraintes de la production oasienne et stratégies pour un développement durable. Cas des oasis de Nefzaoua (Sud tunisien) [Constraints of oasis production and strategies for sustainable development. Case of the oases of Nefzaoua (southern Tunisia)]. *Science et Changements Planétaires / Sécheresse*, 13(1), 5–12.
- Kriaa, M., & El Elj, M. (2013). Impact de la migration sur les familles des migrants présentes au pays. Note de synthèse [Impact of migration on the families of migrants present in the country. Executive summary]. http://citoyensdesdeuxrives.eu/index.php?option=com_content&view=article&id=4641:a-lire%2D%2Detude-de-limpact-de-la-migration-sur-les-familles-de-migrants-presentes-au-pays&catid=193:tunisien-nes-a-letranger&Itemid=163. Accessed 4 Oct 2018
- Kwakkel, J. H., Haasnoot, M., & Walker, W. E. (2013). Adapt or perish: A review of planning approaches for adaptation under deep uncertainty. *Sustainability*, 5(3), 955–979.
- Latos, B., Sobczak-Szelc, K., Kozłowski, R., Skocki, K., & Szczucińska, A. (2018). The quality of utility water in the arid climate zones on the examples of Kébili and Medenine regions (Southern Tunisia). *Prace Geograficzne*, 155, 139–156 doi: <https://doi.org/10.4467/20833113PG.18.017.9540>. Accessed 18 Feb 2019.
- Louhichi, K., Flichman, G., & Comeau, A. (2000). L'Amélioration de l'Efficiency de l'Irrigation pour une Economie d'Eau: Cas d'un Périmètre Irrigué en Tunisie [Improving the Efficiency of Irrigation for Water Saving: the Case of an Irrigated Perimeter in Tunisia]. *MEDIT*, 3, 9.
- Marlet, S., Bouksila, F., Mekki, I., & Benaissa, I. (2007). Fonctionnement et salinité de la nappe de l'oasis de Fatnassa: arguments géochimiques [Functioning and salinity of the water table of the oasis of Fatnassa: geochemical arguments]. In M. Kuper & A. Zairi (Eds.), *Economies d'eau en systèmes irrigués au Maghreb. Actes du troisième atelier régional du projet Sirma [Water savings in irrigated systems in the Maghreb. Proceedings of the third Sirma project regional workshop]*, Nabeul, Tunisie, 4–7 juin 2007. Cirad, Montpellier. <http://agritrop.cirad.fr/547474/>. Accessed 4 Oct 2018.
- Mekki, I., Jacob, F., Marlet, S., & Ghazouani, W. (2013). Management of groundwater resources in relation to oasis sustainability: The case of the Nefzawa region in Tunisia. *Journal of Environmental Management*, 121, 142–151. <https://doi.org/10.1016/j.jenvman.2013.02.041>.
- Ministère de l'environnement et de développement durable, Direction générale de l'environnement et de la qualité de la vie. (2015). *Stratégie de Développement Durable des Oasis en Tunisie [Strategy of Sustainable Development of Oasis in Tunisia]*. http://www.environnement.gov.tn/fileadmin/medias/pdfs/projet_etude/projet_GDEO/3_1.pdf. Accessed 15 Oct 2018.
- Morrissey, J. W. (2013). Understanding the relationship between environmental change and migration: The development of an effects framework based on the case of northern Ethiopia. *Global Environmental Change*, 23(6), 1501–1510. <https://doi.org/10.1016/j.gloenvcha.2013.07.021>.
- Nelson, D. R., Adger, W. N., & Brown, K. (2007). Adaptation to environmental change: Contributions of a resilience framework. *Annual Review of Environment and Resources*, 32(1), 395–419. <https://doi.org/10.1146/annurev.energy.32.051807.090348>.
- Nori, M., El Mourid, M., Giorgi, P., & Nefzaoui, A. (2009). *Herdling in a Shifting Mediterranean Changing agro-pastoral livelihoods in the Mashreq & Maghreb region*. EUI Working Paper. RSCAS 2009/52. Robert Schuman centre for advanced studies, San Domenico di Fiesole, European University Institute. <http://cadmus.eui.eu/handle/1814/12714>. Accessed 31 July 2018.
- Omrani, N. (2002). *Gestion de la salinité: Oasis Fatnassa [Salinity Management: Oasis Fatnassa]*, TEMBIB ET Tembar. Rapport de Projet de fin d'études. INAT.
- Perruchoud, R., & Redpath-Cross, J. (Eds.). (2011). *Glossary on Migration*. 2nd ed., Vol. 25. Geneva: IOM Online Bookstore. <https://publications.iom.int/books/international-migration-law-ndeg25-glossary-migration>. Accessed 4 June 2018.
- Plummer, R., & Baird, J. (2013). Adaptive co-Management for Climate Change Adaptation: Considerations for the Barents region. *Sustainability*, 5(2), 629–642. <https://doi.org/10.3390/su5020629>.
- Rain, D. (2000). *Eaters of the dry season: Circular labor migration in the west African Sahel*. Boulder, CO: Westview Press.
- Ravnbøl, C. I. (2019). Patchwork economies in Europe: Economic strategies among homeless Romanian Roma in Copenhagen. In T. Magazzini & S. Piemontese (Eds.), *Constructing Roma Migrants: European Narratives and Local Governance* (pp. 209–226). https://doi.org/10.1007/978-3-030-11373-5_12.
- Reid, H. (2009). *Community-based adaptation to climate change*. London: IIED.
- Renaud, F. G., Dun, O., Warner, K., & Bogardi, J. (2011). A decision framework for environmentally induced migration. *International Migration*, 49, e5–e29. <https://doi.org/10.1111/j.1468-2435.2010.00678.x>.
- Rössler, M., Kirscht, H., Rademacher, C., Platt, S., & Kemmerling, B. (2010). Migration and resource management in the Drâa Valley, southern Morocco. In P. Speth, M. Christoph, & B. Diekkruger (Eds.), *Impacts of Global Change on the Hydrological Cycle in West and Northwest Africa* (pp. 584–597). Berlin and Heidelberg: Springer.
- Schraven, B., & Rademacher-Schulz, C. (2015). Beyond adaptation? The changing nature of seasonal migration in northern Ghana in the context of climate change, agricultural decline and food insecurity. In F. Hillmann, M. Pahl, B. Rafflenbeul, & H. Sterly (Eds.), *Environmental change, adaptation and migration: Bringing in the region*, (pp. 267–280). London: Palgrave Macmillan UK. https://doi.org/10.1057/9781137538918_14.
- Sobczak, K. (2008). Changes in the environment and migration in southern Morocco - example of the Mhamid oasis. *Miscellanea Geographica*, 13, 239–250.
- Soil Survey Staff. (2014). *Keys To Soil Taxonomy*, 12th ed. Washington, DC: USDA-Natural Resources Conservation Service.
- Stark, O., & Bloom, D. (1985). The new economics of labor migration. *American Economic Review*, 75(2), 173–178.
- Stark, Q. (1980). On the role of urban-to-rural remittances in rural development. *The Journal of Development Studies*, 16(3), 369–374. <https://doi.org/10.1080/00220388008421764>.

- Talbi, M., Ben-Mansour, N., & Talbi, K. (2008). Changements des modes de gestion des ressources et conséquences environnementales milieu aride et saharien: Cas de la Jeffara, des oasis du Nefzaoua et du Sehib, sud de la Tunisie. http://zoumine.free.fr/tt/sahara/histoire_ethno/histo_sud_tun/nomades_nefzaoua.html. Accessed 31 July 2018.
- Tegegne, A. D., & Penker, M. (2016). Determinants of rural out-migration in Ethiopia: Who stays and who goes? *Demographic Research*, 35, 1011–1044. <https://doi.org/10.4054/DemRes.2016.35.34>.
- UNISDR. (2009). *Terminologie pour la prévention des risques de catastrophe, stratégie internationale de prévention des catastrophes [Terminology for disaster risk reduction, international strategy for disaster reduction]*. Genève, Suisse: Nations Unies. https://www.unisdr.org/files/7817_UNISDRTerminologyFrench.pdf. Accessed 22 Oct 2018.
- Vidyattama, Y., Cassells, R., Li, J., & Abello, A. (2016). Assessing the significance of internal migration in drought affected areas. *Australasian Journal of Regional Studies*, 22(2) <https://bcec.edu.au/publications/assessing-the-significance-of-internal-migration-in-drought-affected-areas-a-case-study-of-the-murray-darling-basin/>. Accessed 25 Nov 2018.
- Wamsler, C., & Brink, E. (2014). Moving beyond short-term coping and adaptation. *Environment and Urbanization*, 26(1), 86–111. <https://doi.org/10.1177/0956247813516061>.
- Zuccotti, C. V., Geddes, A., Bacchi, A., Nori, M., & Stojanov, R. (2018). *Drivers and patterns of rural youth migration and its impact on food security and rural livelihoods in Tunisia*. <http://cadmus.eui.eu/handle/1814/53724>. Accessed 1 Aug 2018.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Submit your manuscript to a SpringerOpen[®] journal and benefit from:

- ▶ Convenient online submission
- ▶ Rigorous peer review
- ▶ Open access: articles freely available online
- ▶ High visibility within the field
- ▶ Retaining the copyright to your article

Submit your next manuscript at ▶ [springeropen.com](https://www.springeropen.com)
