

Chapter 4

Conceptual model and hypotheses

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4.1. Objectives of the research project

As was indicated in chapter 2, little is known about the mechanisms that determine geographically differentiated agricultural transformations in the oases of the Maghreb, and the extent to which these transformations are linked to migration. The IMAROM research project aims at gaining a more systematic insight into the interaction between migration and the concomitant socio-economic changes and agricultural transformations within oases of the Maghreb. This reflects the first general objective, as formulated in the project's research proposal.

The second general objective is to examine the ecological impact of these changes in land, water management and resource exploitation. This includes the important question whether the latter contribute to desertification processes, undermining the sustainability of agriculture. The third objective is the elaboration of a conceptual model, reflecting and improving the insights into the enabling conditions for investment in agriculture and an improved allocation of migrant remittances for local agricultural development. These general objectives, elaborated in five specific objectives guiding empirical research, were formulated as follows:

1. To determine the socio-economic characteristics of oasis households and their livelihood strategies, in particular concerning migration and agriculture.
2. To determine actual cropping patterns and land and water management practices at a plot level, related to the socio-economic characteristics and livelihood strategies of households.
3. To identify the main obstacles and enabling conditions for sustainable land and water management:
 - (a) physical (i) existing agricultural and hydrological infrastructure on oasis level (land distribution; water rights) (ii) ecological constraints (water availability; soil and water quality; climate)
 - (b) socio-economic and political (i) traditional local decision-making structures concerning land and water management (ii) access to credit and legal structures.
4. To determine which measures adapted to local socio-economic, political and ecological conditions are most appropriate for preventing desertification and to improve the efficiency of resource exploitation.
5. To determine under which enabling conditions migration remittances can be invested in the development of oasis agriculture and sustainable resource exploitation (positive feedback between migration and agricultural development).

The initiators of the project recognised a clear need for more generalised knowledge regarding the allocation of remittances, the impact of migration on decision-making concerning resource exploitation and finally the consequences of changing resource exploitation for desertification in the oases of the Maghreb. Although there is a growing

consensus on the differentiated impact of migration as such, systematic insight into the main obstacles and enabling conditions for increased investments in oasis agriculture is largely absent. It is only recently that this theme has become the subject of serious scientific debate and systematic study.

As has been demonstrated in chapter 2, the vast majority of existing studies on the interaction between migration and agricultural development in the Maghreb are descriptive in nature, lack an analytical focus and are hardly guided by theory. They concentrate either on the biophysical environment, or on socio-economic characteristics (mainly migration). One of the exceptions is Bencherifa (1991, 1993), who was among the first to generalise about agricultural development responses to migration in rural areas of the Maghreb, while recognising the heterogeneity of actual developments. He stressed the importance of considering local variations in land and water resources, including specific socio-economic circumstances, in order to comprehend differentiations in migration-development responses.

Based on Bencherifa's synthesis, we could explain actual agricultural patterns and land and prevailing water management on a local level by (1) socio-economic characteristics of households (notably household size, migration and income-remittances) on the one hand and (2) on the other, local bio-physical circumstances (notably water availability, water and soil quality, agricultural infrastructure).

These two dimensions form the specific local investment environment, which differs from place to place, and partially explains differences in agricultural development. This notion – integrating socio-economic and biophysical factors in explaining the different levels of intensity of land and water use and resource exploitation – was used as starting point for IMAROM research aimed at further elaborating a conceptual model focusing on the identification of enabling conditions for remittances being invested in agricultural transformations.

In order to achieve increased insight into the interactions between migration, oasis agriculture and the environment, a comparative and interdisciplinary approach seemed indispensable. First, the physical environment (e.g. local land and water resources) partly determines the possibilities for agricultural development. Second, changes in land and water management will have their impact on the environment. Third, as oases are typical man-made agricultural systems, changes in the socio-economic and political realm are likely to have a direct impact on oasis agriculture and ecology. To be adequately comprehended, the study of interactions between physical and social environments requires an interdisciplinary approach.

4.2. Objectives of modelling

In order to integrate the large amount of data gathered by IMAROM project partners, a conceptual model was needed to guide our analysis and to come to a focused set of conclusions based on fieldwork providing tests for the theoretical model. In order to materialise the abstract general research questions, a number of hypotheses were formulated in the course of the second year of the project, based on literature research and preliminary research results. The hypotheses explicitly address the primary IMAROM research questions, which can be inferred from the main objectives of the project. These hypotheses, establishing relationships between a limited set of key variables, should be derived from a conceptual model.

It is important to stress that the goal of the conceptual model is *not* to analyse all possible relationships between all variables that might play a role in oasis systems and which

may explain agricultural change. It is not an IMAROM goal to develop a comprehensive model of oasis systems. The research project has a clear analytical focus, and this should be confined to the analysis, which implies that we have to limit our analysis to mechanisms only within a subset of relations in the oasis system. The very framework of the IMAROM project already guides us in a certain direction, as it focuses on migration-related impacts on resource exploitation and the interaction of this impact with the environment. IMAROM seeks to ‘push the frontiers forward’, that is, to gain more insight into these specific mechanisms.

As stated in the project’s Technical Annex, the main objectives of the project were the following: (1) to study the interaction between migration and changing land/water management with resource exploitation in the oases of the Maghreb; (2) to examine the ecological impact of changes in land/water management and resource exploitation, particularly their contribution to desertification processes; and (3) to design a model for increased investments and improved spin-off of the allocation of remittances in sustainable agriculture.

As the partners concluded during the first project meeting in Amsterdam (9-11 March 1998), the study focuses primarily on the relation between (1) *migration* on the one hand and (2) *land and water management* (which includes *resource exploitation*) on the other, as well as the impact of the latter changes on the (3) *environment* (such as depletion of water resources and land degradation). This reflects the first two main objectives of the IMAROM project. The third objective, the development of a conceptual model, focuses on a sub-analysis of migration-related changes in oases, namely *migration-driven, remittance-related investments*.

The analysis of the IMAROM project, thus, only focuses on some particular variables, in particular the role that migration plays in explaining increased investments within agriculture, and the interaction of such a development with (the durability of) natural resource exploitation. The number of variables to be included in the model is severely limited, and the model lacks any ambition to achieve comprehensiveness. Only variables directly related to the main objectives are used.

Migration impact is the central axis of the research. We estimate that migration plays an important role in the agricultural dynamics of oasis areas in Morocco and Tunisia. Its impact seems to be diverse: income effects, available investment capital (for example in agriculture), labour prices, socio-cultural changes and impact on agricultural as well as entrepreneurial knowledge and attitudes.

Moreover, apart from migration, there are many other factors that are supposed to have an impact on oasis agriculture. It would seem artificial to completely isolate migration from other factors. After all, agricultural change is also taking place in oases where international migration does not play an important role. Agricultural change is the result of the interplay of many factors, such as integration in the national political system, integration of regions in nation-wide or world-wide capitalist economic systems and the disintegration of ancient collective institutions. Migration, therefore, is only one element among others that play a role and that have a supposed impact on soil and water use and agricultural development in general.

However, the analysis of IMAROM is specifically directed at the study of migration impacts. This is not without reason, as there is growing evidence from the literature that migration, in particular international migration, has a high development potential for regions of origin, since, under certain circumstances, migrants may inject their externally earned incomes into the local economy. In addition to constructing houses, commercial enterprises, and transport businesses, money is invested in the development of agriculture in several

migrant-sending areas. By systematically comparing non-migrants with migrants, we have as much as possible attempted to isolate the impact of migration from other variables¹.

The IMAROM project studied the conditions under which these migration-induced investment are made, and, secondly, the effects of agricultural transformations on land and water resources. The latter analysis is fundamental as well, as the availability and quality of land and water resources are not only dependent variables influenced by agricultural practice, but also shape the future conditions for agricultural development (i.e., they may undermine the sustainability of agricultural developments).

The choice of what kind of conceptual model to develop mainly depends on both the input-side of the model, the kind of data that is available, and on the desired outcome, in other words the purpose of the model. Although the IMAROM partners collected a large amount of data, the input side posed restrictions on the type of analyses performed, as data from different oases and countries were not always comparable, not always quantitative, and lacked a time-series dimension. The goal behind the elaboration of a conceptual model was the integration of diverse socio-economic and biophysical data collected by different field teams on different sites in Tunisia and Morocco. In order to keep the conceptual model as realistic as possible, it was of the utmost importance that the assumed primary relations between dependent and independent variables be reflected in a number of clear hypotheses. Bearing these considerations in mind, the project co-ordinator elaborated a first conceptual model addressing the main IMAROM questions. After discussions between project partners, it was slightly adapted, resulting in the final conceptual model.

Concerning the scale of analysis for the conceptual model and the level of data aggregation, there were three options: household level, oasis level and regional-national level. For several reasons it was decided to perform the project-wide analysis on an oasis level. First, some variables, notably those on land and water resources and environmental factors, can only be gathered at the level of the entire oasis, or at the level of certain geomorphologic units which do not coincide with socio-economic categories, such as households or individuals.

Work Packages III and IV mainly concern such analyses and generalisations on an oasis level. In many cases they simply cannot be analysed on a household level. The household survey (work package I) occurred on a household level. The analyses on Work Package I can be found in subsequent chapters and will provide important insights into the interaction between migration, demography, consumption and investment behaviour, including investments in agriculture. Plot level research (Work Package II) deepens insights into the agricultural behaviour of migrants versus non-migrants, as well as the influence spatial biophysical factors have on land and water management. These will provide the project with important qualitative insights into the spatial behaviour and motives of households and individual peasants.

However, so as to achieve a useful integration of data from the first four empirical work packages (I through IV) in the final chapters, it was obligatory to bring all data on the same level. For this purpose, the data from work packages I and II has been aggregated on an *oasis (village) level*. The oasis, and not the regional level, is chosen since biophysical

¹ We are aware that the complete 'isolation' of one variable is not possible, as spurious correlations can never be theoretically excluded, particularly in such a complex field as 'agricultural change', in which numerous variables play a role. Moreover, variables such as migration may be endogenous, as they may in fact reflect other independent variables, such as personal characteristics. The analysis will be conducted as carefully as possible, each time considering the role of other factors, so as to avoid erroneous conclusions regarding migration impacts based on a purely 'blind' comparison between migrants and non-migrants.

conditions show important variations between different oases. This will enable us to study the influence of environmental context-variables (notably availability and quality of soil and water) on agricultural intensity and investment levels per oasis.

The analysis by oasis level will also facilitate the comparison between Moroccan and Tunisian field sites, which is after all the ultimate goal of IMAROM. This final ‘upscaling’ of the study will enable us to introduce supposedly important national context variables, such as ‘government intervention and policies’ or ‘general economic-juridical-fiscal investment conditions’, which might partly explain differences between Moroccan and Tunisian field sites that cannot be directly attributed to variations in local environment or migration patterns.

Although the main focus of the project-wide analysis will take place at the oasis level, analysis at a household level is equally important, as they constitute important production and decision-making units. A close examination of the behaviour of different types of households (migrant, non-migrant, re-migrant) will contribute to the comprehension of phenomenon observed at oasis level. Household level analysis has been performed by all socio-economic research partners based on the specific data collected. They have extensively documented their analyses in several IMAROM working papers². Chapters 6, 7, 9, 10, and 11 of this report constitute summaries of those analyses, applying the same hypotheses developed for project-wide modelling to household-level analysis. Chapters 5 and 8 are detailed analyses of the biophysical characteristics of the research oases. Although one should be extremely careful to automatically translate relations between variables to another scale level, the results of these analyses will be used as an important input for the concluding section.

4.3 Problem statement and delimitation of hypothesis

This paragraph discusses the key variables included in the conceptual model. We aimed at selecting a limited number of variables on the basis of three criteria. First, only variables are to be selected that figure prominently in the main objectives of the project. Secondly, variables to be selected should be measurable. Third, data should actually be available from fieldwork.

The assumed nature of the relationship between variables has been formulated into a set of hypotheses. Of course, this does not imply that there is general agreement on the nature of the relationships between variables in the scientific literature. The formulation of hypotheses has a strict analytical purpose. Subsequent data analysis will give an indication of their validity. To paraphrase Popper (1959), it is better to formulate wrong hypotheses than no hypotheses at all.

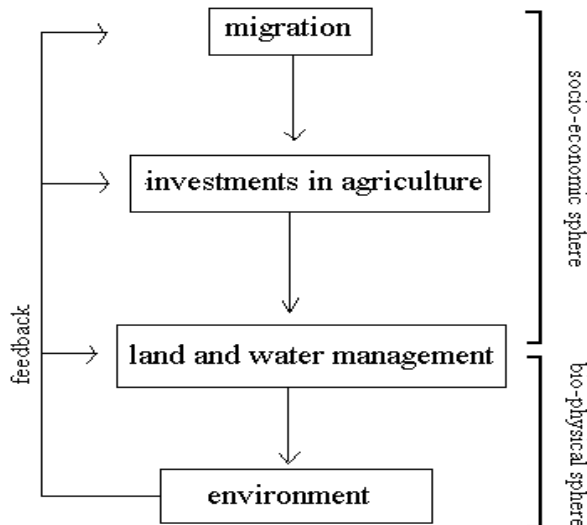
Above all, the conceptual model should respond to the objectives of the IMAROM project. The three main objectives, as mentioned in paragraph 4.2, can probably be best summarised in the following problem statement.

- (1) What is the impact of migration on changing land and water management?
- (2) Under which enabling conditions can migration contribute to increased investments in agriculture?
- (3) What are the ecological consequences of these changes in land and water management, and
- (4) To what extent do ecological changes constitute a danger for the durability of agriculture?

² For an overview of all IMAROM working papers, please see the annex.

In order to organise our thoughts, figure 4.1 represents the basic general model, which includes the key variables mentioned in the above-mentioned main objectives as well as in the problem statement. On this basis, we will gradually build the eventual model.

Figure 4.1 ‘Most basic general model’



This basic model serves to focus our thinking, but is too general for practical purposes. It needs further elaboration, as it denies the existence of other factors in addition to migration that may play an important role as independent variables. Some variables mentioned in the basic model are rather ‘dimensions’ or ‘aspects’ (i.e., they group the different variables of which they are made up). This applies particularly to ‘land and water management’ and ‘environment’. In order to operationalise them, they need to be split into tangible variables. In the following section, each of the main variables and the relationships between them will be discussed, so as to produce a more elaborate model.

The analysis centres around two main axes: (A) The first analytical axis treats the impact of migration on investments in agriculture and, hence, on land and water management. This is the socio-economic component of analysis, although biophysical factors play a prominent role as ‘enabling’ variables. (B) The second analytical axis focuses on the impact of changes in land and water management on land and water resources (e.g., the impact of water pumping on water resources). These biophysical variables, in turn, partly form the above-mentioned ‘enabling conditions for agriculture’, that is to say feedback mechanisms supposedly exist between the environment (land and water resources), agricultural investment-induced investments, changes in resource exploitation and investment conditions. For example, man-induced degradation of land and water resources may negatively influence the conditions for new investments in agriculture. According to the same logic, positive feedback mechanisms are possible.

As has already been argued, the IMAROM conceptual model is deliberately limited in its framework. This in no way suggests that migration is the only factor playing a role in agricultural change in oases. One of the major problems for the IMAROM project has been how to interpret the effects of migration in relation to other determining socio-economic factors.

Reflecting this awareness, and to delimit our analysis, the following three hypotheses have been formulated.

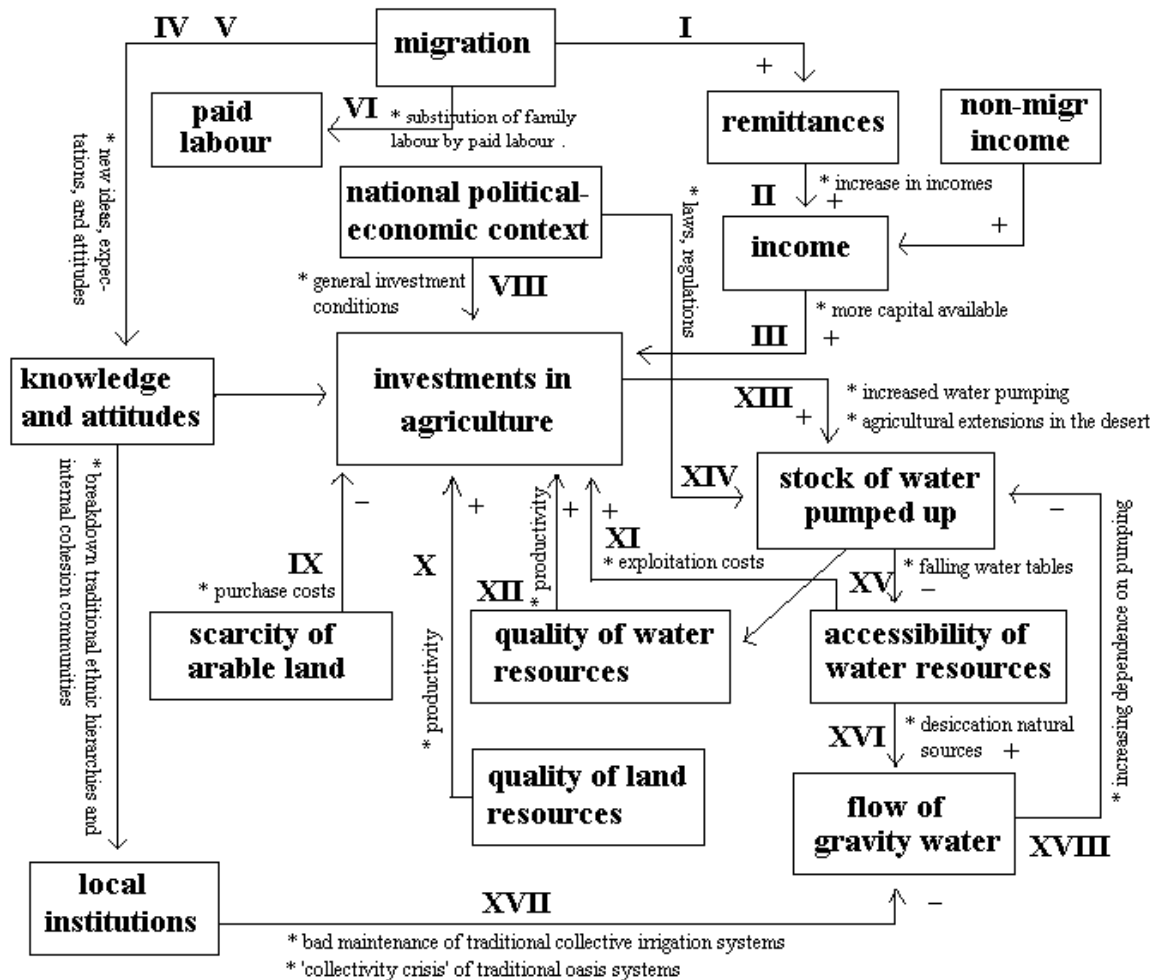
- A. **Investments in agriculture do not uniquely originate from migration remittances, but from other sources of income as well.**
- B. **Migration-related investments are not uniquely made in agriculture, but also in non-agricultural sectors.**
- C. **Investments in agriculture can originate directly from migration remittances, but also indirectly via the investment of migrant remittances in other economic sectors (local income multiplier effects)**

In order to measure the specific impact of migration on agricultural investments (hypothesis A), general income effects should be included in the model. Non-agricultural investments (hypothesis B) seem not of direct interest for the model as such, but may deepen insight into the circumstances wherein people do not invest in agriculture and prefer to allocate their investments in other economic sectors, and illuminate the conditions for high-level investments in general. In another vein, it will be interesting to analyse whether migrants tend to invest in specific sectors as compared to non-migrants. Indirect impacts (hypothesis C) are important to consider, but seem beyond the limited scope of the project as such an analysis requires rather sophisticated econometric analysis and better comparable data on a project level. Nevertheless, whenever circumstantial evidence is available concerning the economy-wide effects of migration, it will be mentioned.

4.4. Variables and hypotheses of the conceptual model

This paragraph addresses the variables to be included in the conceptual model. A graphic representation of the conceptual model (figure 4.2) includes all the variables that are mentioned, and their supposed relationships. Each link (arrow) is related to a specific hypothesis. Roman numerals correspond to the hypotheses developed for each of the links between variables. The plus and minus marks next to arrows indicate the supposed ‘direction’ of the relationships.

Figure 4.2 Conceptual model on the interactions between migration, agricultural investments, land and resource management³



Axis A: Impact of migration on investments and other conditions that shape agricultural investments.

i. Migration impact

Migration (variable 1) is assumed to have a large influence on migrant sending areas. This impact is very diverse, but we can distinguish two primary domains: material impact (e.g. remittances) and non-material (e.g. cultural effects). We should not study the whole array of possible migration impacts, but only those that seem the most relevant to the impact on agriculture and land/water management. The material impact seems to materialise itself primarily through *migration remittances* (variable 2). Migration remittances are supposed to lead to an increase in *total household cash income* (variable 3), which enable *investments in agriculture* (variable 4). This is the direct income effect of migration. All values for variables 1 - 4 can be derived directly from the household questionnaires (work package I). The following hypotheses can be formulated.

³ Plus and minus marks indicate the supposed 'direction' of the hypotheses as formulated in the text. So, they are subject to change. Text fragments following '*' signs are descriptions of the supposed relationships between variables.

- I. More migration⁴ coincides with higher migration remittances
- II. More migration remittances coincide with higher cash incomes
- III. Higher cash income leads to higher capital investments in agriculture

Migration remittances are not the only source of cash income for oasis households, and other sources of cash income can enable investments in the same way through income effects. If the investment effect of migration is purely an income effect, there should be no correlation between migration and investments, if we control for income. In oases where migration is the most important source of cash income, migration households should have a higher propensity to invest compared to non-migrant households than in oases where the income differential between both groups is relatively small.

The non-material impact of migration includes the broad field of socio-cultural and political impacts of migration on a local level. Migration can lead to a change in *knowledge and attitudes* (variable 5). As some argue, migration can lead to the ‘import’ and dissemination of new ideas, expectations and attitudes, which may in turn stimulate or, by contrast, diminish local investments in specific sectors. If it concerns the knowledge of modern agricultural techniques, marketing and modern business practices, it is assumed to stimulate investments in agriculture.

Many researchers also observe an opposite trend, where migration leads to an attitude, particularly among younger generations, which can be characterised as disaffection towards agriculture, increasingly perceived as an inferior activity. In practice, as we have seen in chapter 2, both phenomena seem possible and might even occur simultaneously.

This non-material migration impact might explain the situation whereby migrants tend to invest more than non-migrants, if we control for income. In that case, the migration effect would be more than only an income effect. The following closely related hypotheses are meant to test ideas about the ‘extra-income’ impact of agriculture on investments:

- IV. Migration leads to higher investments than predicted on the basis of income only,
- V. High migration coincides with positive attitudes towards agriculture, which encourage capital investments in agriculture

A frequently discussed issue is the impact of migration on agricultural labour allocation within the household. Migration in a way re-allocates labour towards foreign countries, and according to some studies it may deprive households of important agricultural labour resources. Consequently, according to a common hypothesis in the literature, this phenomenon would lead to a shortage of agricultural labour on a household and oasis level. Nevertheless, other studies suggest labour shortages do not always exist, or that at least they cannot explain the neglect of agriculture, which would be more related to a shift in the economic preferences of households and the decreasing need to maintain subsistence agriculture.

There are indications that labour is becoming increasingly monetarised in oasis areas, and ancient forms of sharecropping are rapidly losing ground. If a migration household intends to continue or even intensify agriculture in the absence of some its members, and a real labour shortage exists, we might expect that in addition to ‘free’ family labour, one is increasingly dependent on hiring *paid labour* (variable 6), particularly during ploughing and harvest seasons. This leads us to the following hypothesis.

⁴ This research specifically considers *international* migration. Unless it is mentioned otherwise, ‘migration’ should be interpreted as ‘international migration’, and ‘migrants’ as ‘international migrants’.

VI. Migration leads to the partial substitution of family labour by paid labourers.

The central variable of the conceptual model could be called ‘investments in agriculture’, as it is mainly through the investment of migration remittances that the impact of migration on agriculture is materialised. The conceptual model focuses on explaining variations within this specific variable.

We assume that more migration remittances and more income do not automatically lead to more investments in agriculture or other sectors. After all, in the same way as remittances enable investments in local activities, the availability of high external income may likewise also lead to a termination of local economic activities, reflected for example in a partial or complete retreat from agriculture. Whether and to what extent agricultural investments occur, depends on a set of enabling conditions for agricultural investments, to be discussed in subsequent paragraphs. The question is: what independent variables determine the spatially diverging development responses to migration?

ii. Enabling conditions: contextual variables

In the socio-economic ‘sphere’ (axis A), the focus will be on migration and its impact on investments in agriculture (via migration remittances as well as ‘knowledge and attitudes’). Several factors play a role in determining to what extent migration remittances will be invested in agriculture. Together, they form the ensemble of enabling conditions for investments in agriculture. They constitute the ‘field’ on which the ‘seeds’ of migration (remittances) might be sown. If this field is not fertile enough in the eyes of the peasants, the seeds might not be sown at all. The goal of the research is the identification of the circumstances which create such ‘fertility’. As the IMAROM partners concluded at their first meeting in Amsterdam (February 1998), “The impact of migration on oasis systems is not uniform. It is characterised by a diversity that has to be comprehended”. In other words, migration impact is highly contextual, depending on specific local circumstances. From this, the next *general* hypothesis will be derived, which needs to be disaggregated in order to analyse its different components.

VII. The extent to which higher incomes lead to higher investments in agriculture depends on enabling biophysical and political-economic conditions.

First, we have to mention what can be called the *political-economic context* (variable 7). This includes all the political-economic and legal factors at the national level which determine the general investment conditions in a country and a region. In the case of oasis agriculture, we could think about including determinants such as ‘effectiveness of national agricultural policies in oasis areas’, ‘access to credit for small peasants’, ‘level of corruption’, ‘legal security’ and ‘political stability’. Another strong argument to include this variable is that it enables us to study the influence of ‘national’ factors in the comparison between Tunisian and Moroccan oases. The following hypothesis has thus been derived.

VIII. Effective agricultural support by governments, access to credit, low levels of corruption, legal security, and political stability lead to higher investments in agriculture

It goes without saying that the national political-economic context also influences migration movements. However, this subject lies outside the scope of our study, and will not be considered for that reason.

Another important factor seems to be the *scarcity of arable ('irrigable') land* (variable 8). In some oases, arable land is scarce. This is a factor of importance, as plot sizes are often extremely small and many peasants willing to invest desire to purchase agricultural land, in particular in plains outside the old oases, where new, relatively large-scale agricultural enterprises can be established. Particularly in mountainous or hilly areas, the local relief of the landscape can be an obstacle for the extension of agricultural land if oases are hemmed in by mountains or hills. Other physical obstacles may be that the immediate surroundings of the oasis are already occupied by either peasants from other oases or by urban areas. Another obstacle may be the low agricultural quality of surrounding land, marked by salinisation, stoniness, or the existence of sand dunes, which make agricultural extensions difficult.

Many factors play a role in determining the 'scarcity of land', but the best proxy for it seems to be 'land prices', since of all the indicators it best reflects factual land scarcity. It also reflects the costs involved in land investments. Other parameters, such as 'mean plot size', are less reliable as they do not directly consider questions of supply and demand. Moreover, land prices seem to be generally higher in areas where plots are smaller, since this division already indicates a small total surface in relation to demand. Land price also seems a rough indicator of such factors.

A problem to be solved is that low land prices may also reflect poor soil quality, which may even make agriculture difficult or next to impossible (ie., due to prevalence of salt, sodification, sand dunes, etc). Therefore, it seems wise to consider land prices in the old, traditional oasis as an indicator, and not land prices in the surrounding, barren areas. The assumption is that land prices in old oases will be relatively low if good, irrigable new agricultural land is available in the immediate surroundings. Prices will be the highest in areas without any possibility for extension. The analytical problem remains, however, if land in the old oasis *itself* is of poor quality. Therefore, the variable *quality of land resources* (variable 9) has been included.

IX. Low local land prices lead to higher investments in agriculture

X. Good land quality lead to higher investments in agriculture

In addition to land, availability of good quality water for irrigation seems the most important enabling condition for oasis agriculture. As in the case of land, this has both a quantitative and a qualitative dimension. First, we mention the quantitative aspect: the availability of water resources on a village level. The question is how we can best measure this entity. The underlying idea is that the more easily water is available, the fewer investments are necessary to obtain this water. So, the easier the access to water, the more likely investments are to be. This variable could be called *accessibility of water resources* (variable 10).

Water is supposed to be easily accessible (at low cost and low risk) in the case of abundant surface water resources, such as is the case in some upstream river oases, in the case of functioning *khettaras*, or in the case of state-led central drillings which provide water at relatively low costs to peasants without taking any significant risks. In the case where peasants have to pump water themselves, risks and costs are higher, but vary with the depth

of water tables and the recharge capacity of aquifers. The following hypothesis can therefore be formulated:

XI. Easily accessible water resources lead to higher investments in agriculture

In several oases, especially in Morocco and Algeria, gravity irrigation (irrigation directly from rivers and *khettaras/foggaras*) still plays a role. However, most oases included in the IMAROM research suffer from absolute lacks of gravity water. Furthermore, due to increased pumping and socio-political processes at the local level (see the following paragraphs on variable 13), maintenance of collective gravity-oriented irrigation systems is less and less assured. There seems to be a general tendency towards the increased use of non-gravity water (i.e., motor pumping by individuals or by the state). Particularly in the agricultural extension zones, this is the only option.

Investments and agricultural extension movements in the desert, therefore, seem to be strongly linked to water pumping. Motor pumping is necessary mostly in quantitative terms, in order to dispose of enough water to irrigate which cannot be provided by 'gravity sources' alone. There is also another reason to use motor pumps, as it gives the peasant complete individual freedom to irrigate at times chosen by him. In collective 'gravity' arrangements, this freedom and flexibility generally does not exist. The trend towards 'modern' agriculture raises the need for individual irrigation planning. Although this is not always the case, investments in agriculture seem to be strongly associated with the rise of motor pumping. As costs of pumping can be very high, accessibility of water resources (i.e., the price and risks that have to be taken to get access to this natural resource) seems a relevant factor in determining investments.

The last variable in the set of 'context variables' is the *quality of water resources* (variable 11). This is important, as low water quality may render water of very low or no use to agriculture. The quality of the water (salinity, pH, etc.) is therefore supposed to be an important determinant for investment potentials. The hypotheses is:

XII. Good quality water resources lead to higher investments in agriculture

Axis B: Impact of investments in agriculture on land/water management and the environment

Investments in agriculture have many dimensions. To follow the categories defined in the household survey questionnaire employed, the following categories of long-term investments can be distinguished: (1) Purchase of motor pump, including digging of the well (2) purchase of tractor and other agricultural machinery (such as harvesters, combines), (4) purchase or rent of land and water.

Furthermore, there is a range of purchases and expenses (requiring capital input), which can be seen as 'capital intensity indicators of agriculture': (1) purchase of fodder, (2) purchase of fertilisers, (3) purchase of pesticides, (4) purchase of HYV seeds or tree offshoots, (5) cash expenses on agricultural labourers.

For the purpose of the study we could interpret higher investments in agriculture as an increase in the capital intensity levels of agriculture. To some extent we could also see this as an indicator of 'modernisation', although this is at the risk of triggering a heated debate on what is 'modern'. Other important aspects of modernisation include changes in cultivation

and irrigation methods, a larger plot size and ‘scale of production, heightened market-orientation, and an increase in the use of paid labourers.

All these investments are supposed to have an impact on land and water management practices. Besides capital inputs, land and water management practices comprise cropping patterns, cultivation techniques, water extraction and irrigation techniques, ploughing methods, etc. All these aspects will be studied in detail in the individual chapters on the research oases in Tunisia and Morocco.

The question now is what ‘impact on land and water management’ variables should be included in the conceptual model. Keeping an eye on the main objectives of IMAROM, we are specifically looking for the environmental impact of changing land and water management. For the purpose of modelling, therefore, the focus should specifically be on possible impacts on natural resources (i.e., land and water).

Oasis systems are highly sensitive agricultural systems, as land and water resources are scarce, and as the same natural resources easily fall prey to degradation. The main environmental dangers can be summarised as follows: falling water tables and desiccation of natural water resources, salinisation and sodification of water and land resources, soil erosion and sand encroachment⁵. We could analyse the impact of changing land and water management on all these aspects of degradation. Yet, the problem with this is that this impact seems to be very indirect and complex.

In order to be useful for direct application in the conceptual model, it is better to take out the most relevant aspects of ‘(changing) land & water management’, with supposed migration links and which have a clear environmental impact with possible (future) drawbacks for oasis agriculture. We particularly focused on one aspect of this environmental impact, namely the availability of water resources. This appears to be both one of the most important and threatening consequences of changing land and water management, which over the long term could undermine the sustainability of oasis agriculture.

An increase in the *amount of pumped water* (variable 12) may have, over the long term, a negative effect on the availability of water resources, that is, they become scarcer. The increase in motor pumping can, depending on specific hydro-geological circumstances, lead to falling water tables. This, in turn, may cause the diminution of the flow of natural sources. This may even cause the total desiccation of former natural sources for gravity irrigation, which further undermines traditional oasis systems. Moreover, it makes water more difficult to access, and will generally increase the costs of pumping and decrease profits. To measure this impact, we should include the variable *flow of gravity water* (variable 13). As measuring these variables in terms of relative flow (‘per household or per hectare’) became highly complicated, a rough qualitative measure was used indicating whether there is an ‘increase’, ‘constant’ or ‘decrease’ in flows over the past decades. This data was obtained through inquiries conducted in the field.

The stock of pumped water is expected to increase with total investments in agriculture (i.e., the purchase of motor pumps would be an important component of these investments). Another assumption is that the national political-economic context (variable 6) – in the form of regulations, laws and controls in the field – also influences the total amount of water pumped. Effective government policies should control and regulate the amount of water pumped. State-led, collective pumping is meant to decrease the costs and risks of access to water for individual peasants, thereby stimulating agricultural activity. This leads to the following hypotheses:

⁵ We can summarise these degradation processes, typical for arid and semi-arid environments, as ‘desertification’.

XIII. Higher investments in agriculture coincide with increased pumping of water compared to flows of gravity water

XIV. More government involvement leads to decreased individual pumping

It is important to recognize that a decrease in the flow of gravity water can also be due to changes in local socio-political organisation, namely a crisis in the management of collective irrigation systems. This can also be the case for non-gravity water if it concerns collective pumps. Better knowledge, general education and changes in attitudes (variable 5), often accelerated by migration (variable 1), can contribute to the rapid breakdown of traditional local authorities and community organisations (i.e., *local institutions*) (variable 14).

The most important local institution used to be the village community, which organised and maintained irrigation and land infrastructure. The highly labour-intensive maintenance of agricultural infrastructure such as dams, *khattaras/foggaras*, irrigation channels, terraces as well as the allocation of scarce water resources to individual peasants and the settling of disputes over land and water, was pre-eminently a collective affair. With the penetration of the central state in the past decades (variable 5), the traditional community no longer has any effective legal status, and has been replaced by official state institutions. Moreover, economic and legal changes have eroded the traditional socio-ethnic hierarchies within oases. In this last development, migration seems to have played at least an accelerating role.

The breakdown of the power and effectiveness of these traditional, collective communities, has in many cases contributed to the poor maintenance of labour-intensive land and irrigation infrastructure, with direct repercussions on agriculture. The poor maintenance of irrigation infrastructure has contributed to a decreased water intake in irrigation channels and *khattaras/foggaras*. In this way, the loss of power and effectiveness of local institutions may also contribute to a lower flow of gravity water (variable 12). Fieldwork and literature demonstrate that this factor can explain much of the ‘desiccation’ of natural sources, often too easily and incorrectly attributed to poorly defined factors, such as ‘drought’ or ‘climate change’.

In the conceptual model, both local institutions (variable 13) and water pumping (variable 11) are supposed to influence the total flow of gravity water. Qualitative analysis stemming from Work Package IV should result in a measure of the ‘effectiveness of collective water management’. The goal of this analysis is to analyse to what extent changes in gravity water flows can be explained by both variables. The final link in the model represents the assumption that falling water tables and a reduced flow of gravity water increases the dependency on motor pumping. These feedback mechanisms could finally result in a vicious circle, whereby underground water resources are gradually depleted. At this point, the sustainability of oasis agriculture comes into question⁶.

⁶ The process by which overexploitation of water resources may lead to a change in water quality has not been included in the analysis.

- XV. More motor pumping leads to a reduced accessibility of water resources and higher costs and risks associated with pumping**
- XVI. Reduced accessibility of water resources leads to a reduced flow of gravity water and the further breakdown of traditional oasis systems**
- XVII. The breakdown of local institutions managing the traditional irrigation system leads to a reduced flow of gravity water**
- XVIII. Reduced or absent flows of gravity water lead to a higher stock of water pumped up**

4.5. Discussion

In the conceptual model, we presume the existence of a number of feedback mechanisms. However, for data analysis it is necessary to maintain a clear distinction between exogenous and endogenous variables. In the case of feedback, initially endogenous variables become exogenous at a later point. This may complicate or render impossible analysis of feedback mechanisms concerning land and water management and for context variables as availability of water.

It was a difficult dilemma deciding what to do with people who invest in land far away from the immediate surroundings of the oasis (i.e., in other regions of the country). This category will not be excluded beforehand, since an analysis of the reasons why certain persons are investing elsewhere may provide us with interesting insights into certain investment obstacles in the oases under study.

The conceptual model does exclude the village-wide economic impact of migration remittances. As has been argued, theoretically, agricultural or non-agricultural investments do lead to employment generation in the oases and generate revenues which may sustain economic growth through multiplier effects. This village and region-wide impact of migration has recently gained much attention in the field of migration impact studies, which has led to a re-evaluation and a subsequent re-appreciation of what in an older migration literature was wrongly downgraded as ‘non productive investments’. For example, important investments in the habitat often have in practice an important stimulating effect on local employment and economies (cf. Taylor et al. 1996).

Although the village-wide economic impact of migration lies beyond the central scope of IMAROM research – which is specifically focused on the direct agricultural impact of migration – the activity and income patterns of non-migrant households were also assessed, enabling us to provide limited descriptive insights into the impact of migration on non-migrant households.

The conceptual model is strongly oriented towards (the rise) of the modern agricultural sector and capital investments in motor pumping. This is also the weakness of the conceptual model. Animal husbandry does not receive specific attention, and no distinction has been made between traditional and modern agricultural systems. As stated before, it has been a deliberate choice not to set up a comprehensive model analysing the whole oasis system. In this study, we only wish to highlight a subset of relationships within a whole complex of variables.

Since the conceptual model is focused on investments in agriculture, it does not differentiate between modern and traditional oasis systems. Nevertheless, these aspects are too important to neglect, as developments in modern and traditional sectors are dissimilar and often contradictory. Therefore, these aspects are treated in the analysis of individual oases.

The conceptual model itself is not explicit concerning the geographic and time scale, but seems to concentrate on the short to medium term local context in which most investment decisions by households seem to be made. Generally, the socio-economic processes under study operate on the short to middle-long term (i.e., most migration and investment decisions we were able to document took place in the last 25 years). Nevertheless, processes such as the depletion of water resources and land degradation operate over longer periods, and the effects of changing resource management on the environment may only be felt after several decades. Moreover, local agricultural investments may have a significant impact outside the place in which the investments are originally made. For example, water pumping or increased irrigation may significantly affect relatively distant oases located downstream in the same watershed. In the final analysis, this kind of effect over the longer term and at a larger scale will be distinguished from effects occurring over the short term and at a local scale.