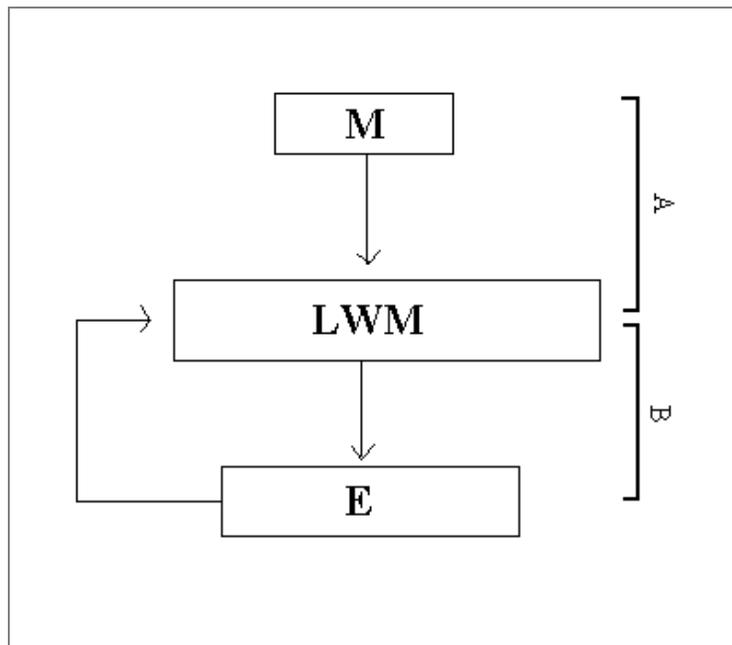




Interaction between Migration,
Land & Water Management and Resource
Exploitation in the Oases of the Maghreb

Modelling for the IMAROM project Basic ideas and proposals



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1. Introduction

This note on modelling for the IMAROM project is meant to start discussion between the project partners on the elaboration of Work Package V. This will be the final and stage of the IMAROM project and also the most important, as the data gathered for the other work packages will be integrated and analysed in the very modelling exercise. A large amount of data has currently been gathered by the different field teams. In order to come to a useful and, hence, focused analysis of these data on collective project level, a sound theoretical model is needed to guide and confine our analysis.

Although discussions on modelling already started in 1998, they gained more momentum with the initiative of dr. Mongi Sghaier (IRA Medenine) in spring 1999. At the meeting on 16 July 1999 in Tinghir, the subject of modelling was discussed again (see the report on this meeting). Project partners who were present at this meeting concluded that the best way to materialise the rather abstract idea of modelling, is the formulation of a number of hypotheses, based on preliminary research results and first comparisons between the Moroccan and Tunisian oases. These hypotheses should explicitly treat the main IMAROM research questions, which can be inferred from the main objectives in the Technical Annex. These hypotheses about supposed relationships between a limited set of key variables, should serve as basis for the conceptual model, treating the main research questions of the IMAROM project. At the Tinghir meeting, IRA Medenine and the University of Amsterdam agreed to take the lead in further modelling.

Photo 1 Collective thoughts on modelling, 16 July 1999 in Tinghir, Morocco



photo by Youssef Moumni

At 1 December 1999, dr. Mongi Sghaier, dr. Leo de Haan, drs. Hein de Haas, and drs. Laurens Nijzink (a temporarily appointed IMAROM researcher) met in the Netherlands to discuss modelling for the IMAROM project. They agreed on the main issues and agreed to work out a concrete proposal. Subsequently, drs. Laurens Nijzink and drs. Hein de Haas worked out the first conceptual model in December 1999. It was on the

basis of these fruitful discussions, and thanks to the input of the contributors, that this note was prepared in December 1999 and January 2000.

The following text is largely meant to trigger discussions at the next IMAROM meeting in Medenine, Tunisia (February 9th-14th 2000). It merely serves as a first proposal, and has by no means a definitive status. We would hereby strongly urge all project partners to participate in the discussions, to criticise and propose alternatives. The discussions at the next meeting should result in a final proposal for a model, to be described in a second working paper dedicated to this issue. Depending on the type of model chosen, we will be able to identify the type of variables that are needed, and on which level they should be calculated. Data on these variables should subsequently be delivered by the different researchers to the project coordinator.

2. Goals of modelling

It should be clear that the goal of our model is *not* to analyse all possible variables and relationships between them, that play a role in oasis systems and which may explain agricultural change. This might result in a highly complex conceptual model, highlighting all the main factors that play a role in (changing) oasis agriculture. Such a ‘comprehensive’ or ‘exhaustive’ model does say ‘little about many’, and will be limited to merely descriptive use. In order to test the supposed relationships within an analytical model, the total number of variables should be limited. This implies that we have to limit our analysis to mechanisms only within a subset of relations in the oasis system.

The very set-up of the IMAROM project already guides us in a certain direction. It is not IMAROM goal to develop a comprehensive model at all. The IMAROM project focuses on the migration-related impact on resource exploitation and the interaction of this impact with the environment. IMAROM wants to ‘push the frontiers forward’, that is to gain more insight in these mechanisms. This automatically implies the choice for an analytical model, which enables to really test relationships between variables. The choice for a comprehensive, ‘all-including’, descriptive model of oasis systems would be justifiable, if our goal would be to gain insight in oasis systems in its globality as such. However, this is not the goal of the IMAROM project. It specifically focuses on the analysis of the relationships between a specific set of variables. Hence, the goal of our model is limited and will focus on the main research questions of the IMAROM project. It would therefore be useful to repeat the main objectives of the project, as cited in the technical annex.

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 the changes in land & water management and resource exploitation, especially their contribution to desertification processes.
3. To design a model for increased investments and improved spin-off of allocation of remittances in sustainable agriculture.

As we all concluded at 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, though to be interpreted in a broader sense, *resource exploitation*¹) on the other hand, as well as on 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, that is modelling, further seems to focus the analysis on some particular sub-analysis within the whole of migration-related changes in oases, namely *remittance-related investments*. The Technical Annex states “Through systematic data input and the development of index variables, the research aims to contribute to the further elaboration of a quantitative theoretical model, focusing on the identification of enabling conditions for sustainable agricultural development.”

The analysis of the IMAROM project, thus, only focuses on some particular variables, in particular the role that migration plays in explaining increased investments in agriculture, and the interaction of such a development with (the durability of) natural resource exploitation. It is may be in this way, that the overall objective of the project can the best be summarised. The number of variables to be included in the model will be severely limited, and the model will lack any ambition of being comprehensive. Only variables directly relating to the main objectives should be used.

3. Looking for a compromise

Migration impact is the central axis of the research. First and foremost, the model should serve to test hypotheses concerning the interaction between migration, land and water management and the environment. Yet it would seem artificial to completely isolate migration from other factors. We, that is to say the IMAROM group, suppose 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 entrepreneurial knowledge.

Moreover, apart from migration, it goes without saying that there are many other factors that have an impact on oasis agriculture. Migration, therefore, is one element among others that play a role and that have an impact on soil and water use. Should we then study the role of migration within the whole of variables, which form together agricultural oasis systems? Yet we cannot pretend to analyse all possible relations. ‘Explaining everything with everything’ would almost certainly end up in an interesting descriptive study, but which lacks an analytical focus. We need a clear-cut model, with a limited number of variables that we can operationalise. It should focus on the main variables migration-soil and water use-environment, but without isolating these factors from others that play a role. Consequently, we should look for a compromise between the twin aims to be comprehensive and to focus on the key variables, emanating from the main objectives of the IMAROM project.

¹ In literature, controversy exists on the definition of concepts as land & water management, resource exploitation and desertification. Although we should certainly define these concepts, it is not the purpose of this note to do so.

Photo 2 Modernising agriculture (Tunisia)?



photo by Albert Solé-Benet

4. Existing models found in literature

** General overview of frequently used models (by Mongi Sghaier)*

Models for multi-objective and multi-criteria programming are models that support decision making (decision making tools). These models are able to integrate multiple objectives which may even be contradictory. The advantage of these models is that they permit to build predictive tools supporting decision making, which link social and economic variables with bio-physical variables, as well as economic and environmental objectives. The models can test the impact of an arbitrary change of variables on the behaviour of objectives, such as the effect of a rise in water or land prices on a household's revenues. An inconvenient is that these models demand exact data on socio-economic and physical level, and that they depend on rather restrictive hypotheses (such as the linearity of relations, etc.).

Models for cost benefit analysis can be used for an evaluation of the impact of investments originating from migration on the households' revenue and on the level of natural (water and land) resource exploitation. They can, by combining socio-economic variables (agricultural work, prices of inputs and products) and bio-physical variables (use of inputs, yields, water use, etc.), evaluate the long-term proceeds (*rentabilité*) of agricultural investments or migration-related investments. They have the advantage of combining three levels: farm level, oasis level and national level. Their major inconvenient is that they demand supplementary data not produced by IMAROM.

The FORCES-MOD model, which was developed by the World Bank and the FAO can be very useful, since it is able to integrate different environmental aspects and could give an operational interpretation, for example, figure 1.

** Specific models for modelling on village level (by Laurens Nijzink)*

It was the intention was to search for existing models on village level in order to learn from other examples and to prevent ‘inventing the wheel once more’. However, whereas the number of models on farm/household level are numerous (including combined socio-economic and bio-physical data), village-level models are hardly existent. The two most important sources found are Barbier (1996) and Taylor and Adelman (1996).

Barbier has developed a mathematical model on village-level in which socio-economic and bio-physical data is combined. In this model, decision making at the village level is simulated from year to year by means of linear programming over a period of more than 40 years. Thus, the model can be classified as a predictive model. This implies that the model works with a set of assumptions about decision making (e.g. yield maximisation) and about general conditions (e.g. functioning of markets) that seem not very appropriate in our modelling attempt. The most interesting element of Barbier’s model in relation to the IMAROM model is that the village is seen as one ‘superfarm’. He works with aggregate variables (yields, inputs, etc) implying that every member of the village is a member of the production unit and makes the same decisions at the same time as everyone else in the village.

The other example found is by Taylor and Adelman (1996). They work with SAM’s (Social Accounting Matrix) on village level which form the basis of general equilibrium modelling. Within a SAM, transactions within villages, and between the village and the ‘outside world’, become clear. Thus, this approach seems very appropriate to analyse migrant remittances coming into the village economy but less appropriate to compare villages with each other. Besides, there is no example in which bio-physical variables are taken into account. Concluding it can be said that none of the examples are directly applicable on the IMAROM case. First, both examples are far to elaborate to follow in some detail (it would take more time and more skills) and second it can be stated that none of the existing models serves the purpose as stated by the IMAROM project.

5. Model type and level of analysis

by Hein de Haas, Laurens Nijzink & Mongi Sghaier

The choice what kind of model to develop, depends mainly on both the input-side of the model, the kind of data that is available, and on the desired outcome, the purpose of the model. Since there seems to be an overwhelming variety of data, the input side seems to pose hardly any restrictions on the type of model, except maybe that there are no elaborate time-series available. Thus, apart from some practical limitations such as time and capabilities constraints, the leading question seems to be on the kind of outcomes desired, that is the purpose of the model.

As stated above, one of the most important goals of the modelling effort seems to be an integration of various elements present within the IMAROM research project. Therefore, it was decided that the model should be in the first place of an analytical-

explicative character. Relations and magnitudes of relations between variables on the present moment are sought. This implies that variables are quantified as much as possible. ‘Quantitative’ does not mean that we exclude on beforehand variables that are difficult or impossible to quantify, such as policies or ‘attitudes’. It only means that we will strive to quantify variables wherever possible. Although we will firstly construct on analytical-explicative model, and we will test the relationships it embodies, in a second stage, insight in certain aspects which appear interesting may be deepened by constructing specific statistical models (such as regression model, etc.).

In order to keep the model as simple as possible, at least in a technical sense, it is of the utmost importance that, on the basis of qualitative analysis and ‘expert knowledge’, the main supposed relations between dependent and independent variables are indicated on beforehand, which should be reflected in specific hypotheses. ‘Data mining’ seems no option. Therefore, the present workshop should yield a conceptual model (like the one is indicated in this proposal) or an elaborate framework indicating possibilities and constraints, on the basis of input and comments from the experts, that would make the actual modelling a ‘piece of cake’. During the meeting in December (De Haan, De Haas, Sghaier, Nijzink) in Nijmegen it was decided that some sort of statistical/econometric modelling should be applied if possible.

We also should make a clear choice for the scale level of the model and, from there, the variables to be used. Following the overall design of IMAROM data collection, there are three options: household level, oasis level and regional-national level. We propose to focus the analysis on oasis level, for the following reasons. First, some variables, notably those on land and water resources and environmental factors, can only be gathered on oasis level. Work Packages III and IV mainly concern analysis and generalisations on oasis level. In many cases, they cannot be analysed on household level. The household survey (Work Package I) took place on household level. The analyses on WP I itself will provide important insights in the interaction between migration, demography, consumption and investment behaviour, including investments in agriculture. The plot level research (Work Package II) deepens insight in agricultural behaviour of migrants versus non-migrants, and the influence that spatial bio-physical factors have on land and water management. These will provide the project with important qualitative insights in spatial behaviour and motives of households and individual peasants.

However, in order to come to a useful integration of data from the first four empirical work packages (I through IV), it is obligatory to bring all data on the same level, i.e. the data from Work Packages I and II should be aggregated on *oasis (village) level*. The oasis, and not the regional level, is chosen since bio-physical 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.

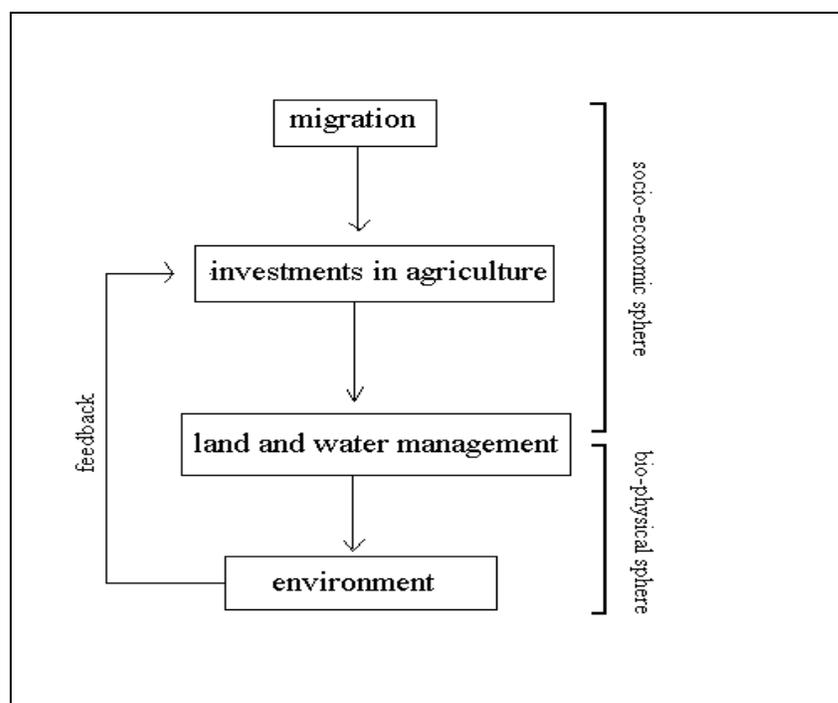
The analysis on oasis level will also facilitate the comparison between Moroccan and Tunisian field sites, which is after all the ultimate goal of IMAROM. This final ‘upscaling’ of the study will enable us to introduce national context variables, which

are supposed to be important, 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 directly be attributed to variations in local environment or migration patterns.

Although the main focus of the analysis will be on the oasis level, analysis on household level is certainly important, since they constitute important production and decision making units. A close examination of behaviour of the different types of households (migrant, non-migrant, re-migrant) will contribute to the in-depth comprehension of phenomenon observed on oasis level. Household level analysis will primarily be the job of the individual researchers’ analyses, to be published in their working papers and their subsequent PhD theses. In principle, they could apply the same hypotheses applied for overall modelling to their household-level analysis. Although conclusions on relations between variables cannot automatically be applied to another scale level (the ‘ecological fallacy’ trap), the result of this analyses should be used as an important input for modelling, and to provide ideas for the development of hypotheses.

The modelling on oasis level (executed on IMAROM coordination level), the household analysis ‘underneath’ this modelling (by the individual researchers, i.e. final reports on WP I and II) and the regional analysis (by the individual researchers, i.e. bio-physical and socio-economic ‘cadres générales’) will together provide the main ingredients for the final report.

Figure 1 ‘Most basic general model’ with IMAROM’s key variables



6. Building the model

This paragraph aims to discuss the key variables that should be included in the model for analysis on oasis (village) level. As stated above, many variables can be included. Yet we aim at selecting only a limited number of variables on the basis of two main criteria. Firstly, only variables will be selected that figure prominently in the main objectives of the project. Secondly, variables to be selected should be measurable², so that they can be used for testing of the model. Thirdly, data should actually be available.

For each variable that is proposed to be included, suggestions will be done how to operationalise them, i.e. how to measure them in practice. In discussing the variables, also the nature of their supposed relationships will be discussed. This discussion will be based on elements found in existing literature on migration impact, oasis agriculture and oasis ecology. For each of the relations, a hypothesis will be formulated. Of course, this does not imply that there is general agreement on the nature of the relationships between variables in scientific literature.³ The formulation of hypotheses has a strict analytical purpose. The actual testing will give indication about its validity. To paraphrase Popper, it is better to formulate wrong hypotheses than no hypotheses at all. Finally, we have to develop a concrete set of parameters, i.e. variables should be operationalised. This directly relates to the concrete data input that all research partners have to deliver.

Above all, the model should respond to the objectives of the IMAROM project. The three main objectives as mentioned in paragraph 2 can possibly best be summarised in the following problem statement.

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

In order to organise our thoughts, figure 1 represents the most basic general model which includes the key variables mentioned in the above-mentioned main objectives as well as in the problem statement. From this basis, we will gradually build the eventual model.

The proposed analysis centres around two main axes of analysis. (A) The first analytical axis focuses on the impact of migration on investments in agriculture and, hence, on land and water management. This is the largely socio-economic component of the analysis, though bio-physical factors play a prominent role as ‘enabling’ variables. (B) The second analytical axis focuses on the impact of the main variable ‘investments in agriculture’ on land and water management (resource exploitation), especially on the impact of water pumping on water resources. These bio-physical

² This does not automatically imply ‘quantitative’, as qualitative variables can be included as well, either quantified (coded), either in a qualitative form.

³ For example, see the old debate between ‘positive’ and ‘negative’ schools concerning the impact of migration on oasis agriculture.

variables, in their turn, partly form the above-mentioned ‘enabling conditions for agriculture’, that is to say that *feedback mechanisms* supposedly exist between 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.

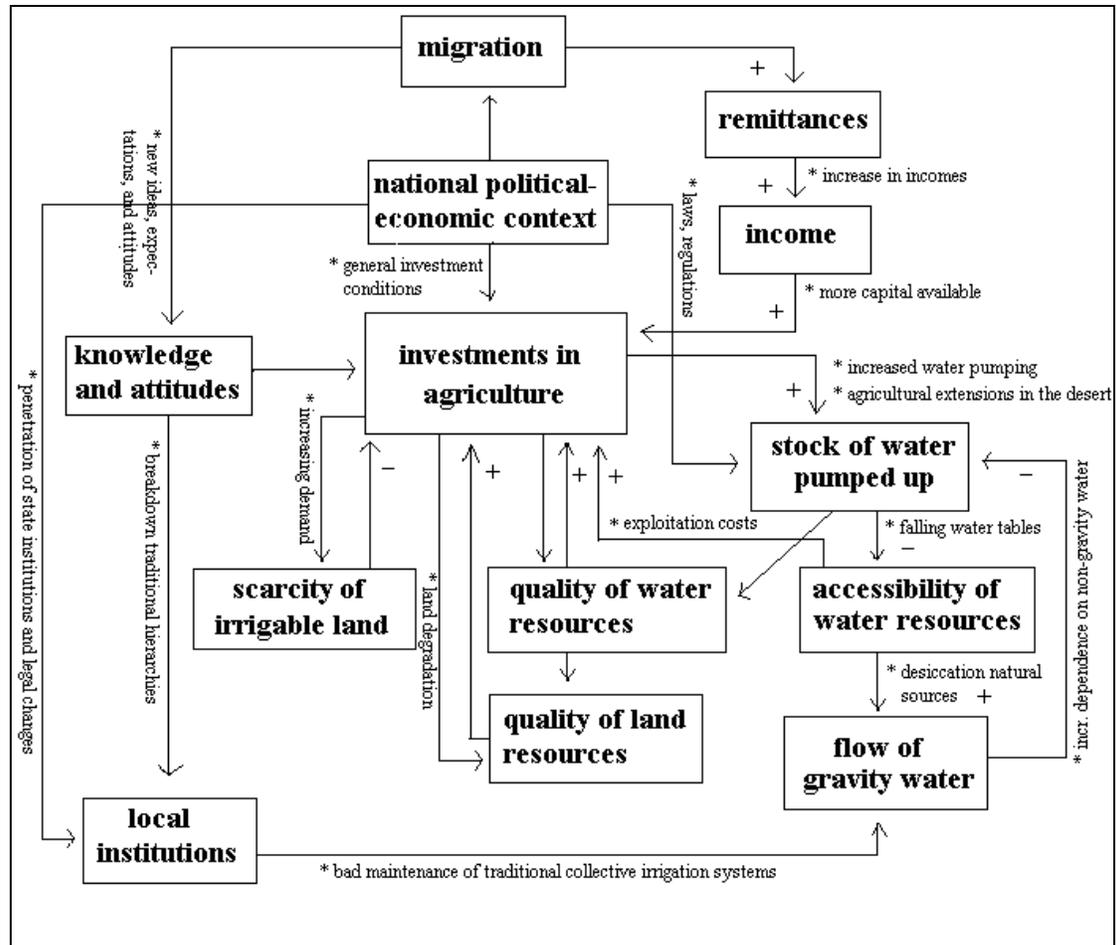
It should be explicitly mentioned that this model is deliberately limited in its set-up and that it is not a way to suggest that migration is the only factor that is playing a role in agricultural change in oases. One of the major problems for the IMAROM project has been how to interpret the effects of migration in relation to other determining socio-economic factors. In this context, three important general hypotheses should be 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 done in agriculture, but also in non-agricultural sectors.**
- C. Investments in agriculture can directly originate from migration remittances, but also indirectly via investment of migrant remittances in other economic sectors (local income multiplier effects)**

As was already stated in chapter 2, the modelling exercise for the IMAROM project aims at specifically analyse the direct impact of migration. In other to measure the specific impact of migration remittances on agricultural investments (hypothesis A), general income effects should be included in the model (see chapter 7, variable 3). Non-agricultural investments (hypothesis B) seem not of direct interest for the model as such, but may deepen insight in the circumstances wherein people do not invest in agriculture, or whether there are circumstances which are stimulating for investments in general. It is therefore an option to include a variable ‘non-agricultural investments’. Indirect impacts (hypothesis C) three are important to notify, but seem beyond the limited scope of this analysis.

The basic model, serves only to conceptualise thinking and to agree on the fundamentals of the modelling exercise, but is too simple and general for practical purposes. It needs further elaboration since it denies the existence of other factors, which might play an important role as context variables. Furthermore, important feedback mechanisms are not mentioned. Finally, some key variables rather ‘dimensions’ or ‘aspects’, i.e. they group the different variables of which they are made up. This particularly goes for ‘land and water management’ and ‘environment’. In order to operationalise them, they need to be split up into tangible parameters, In the following section, each of the main variables and the relationships between them will be discussed, to result in a more elaborate model.

Figure 2 Extended model for analysis⁴



7. Variables and hypotheses to be included in the model

The structure of the following paragraph is as follows. Following the main structure of the two analysis axes (as mentioned in paragraph 6), it will be discussed which variables should be included. Figure 2 includes all the variables that are mentioned, and all their possible relationships. However, to focus our analysis more on the exact goals of the IMAROM project, it will be proposed not to analyse some of the possible relationships. This in order to develop an as clear-cut model as possible. Each link (arrow) will be represented by hypotheses.⁵ This will result in a third, ‘stripped’ model.

⁴ Plus and minus marks indicate the ‘direction’ of the hypotheses as formulated in the text. So, they are subject to change. Texts fragments following the ‘*’ signs are examples and illustrations of possible relationships between variables.

⁵ In the text, variables will be indicated in Arabic numerals, hypotheses in Roman numerals.

Axis A: Impact of migration on investments in agriculture and on land and water management.

i. Migration impact

Migration (variable 1 MIG) is often supposed to have a distinct influence on the area of origin of migrants. This is also strongly implicit in the IMAROM project set-up. This impact is very diverse, but we can distinguish two main domains: material impact and non-material. We should not study the whole array of possible migration impacts, but only those which seem the most relevant to the impact on agriculture and land and water management. The material impact seems to materialise itself primarily through migration remittances (variable 2 REM). Migration remittances are supposed to lead to an increase in income, which enable investments in agriculture (variable 4 IIA, see for its calculation the paragraph on ‘axis B’). However, as one may assume, more migration remittances and more income do not automatically lead to more investments in agriculture. That is dependent on a set of enabling conditions to be discussed in the next paragraphs.

Migration remittances are not the only source of cash income. This implies that in the analysis, total income should be held constant for migration income. In order to measure the impact of migration on investments, the variable cash income (variable 3 INC) should be introduced. All values for variables 1-4 can directly be derived from the household questionnaires (WP I). The values should be made relative, that is calculated per household in ECU values, to ensure comparability. The following hypotheses can be formulated.

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

The non-material impact of migration includes the broad field of socio-cultural and political impacts of migration on local level. Migration can lead to a change in knowledge and attitudes (variable 5 KNW). As some argue, migration can lead to the ‘import’ and dissemination of new ideas, expectations, and attitudes. If it concerns knowledge of modern agricultural techniques, marketing and modern business practice, it is supposed to stimulate investments in agriculture. It is important to notify that the very non-material migration impact may explain the hypothetical case in which migrant-dominated villages do more invest than other villages that has, *ceteris paribus*, the same total income but no migrants. Many researchers also observe opposite trends, in which migration leads to an attitude, especially among younger generations, which can be characterised as disaffection towards agriculture, which would increasingly be seen as an inferior activity. In practice, both phenomena seem possible and might even occur simultaneously. The following hypotheses are meant to test ideas about the ‘extra-income’ impact of agriculture on investments:

- IV. More remittances lead to higher investments in agriculture than expected on the basis of cash income only**
- V. High migration coincides with positive attitudes towards agriculture**
- VI. Positive attitudes towards agriculture coincide with more investments in agriculture**

Following the above-mentioned objectives, the central variable of the model could be called ‘investments in agriculture’, as it is mainly through investment of migration remittances that the impact of migration on agriculture materialises. Moreover, it is a tangible variable, that can be derived from the questionnaires of WPI. The IMAROM theoretical model will be centred on explaining variation of this variable. The objectives of the IMAROM research focus even more on the analysis of the interaction of a specific subset of variables with ‘investments in agriculture’.

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’). However, besides migration, other main 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) could be sown. If this field is not fertile enough in the eyes of the peasants, the seeds might not be sown at all! As we concluded at the meeting in Amsterdam in February 1998 (hypothesis 5): “La réaction du système oasien vis-à-vis de la migration n'est pas la même. Elle se caractérise par une diversité qu'il faut appréhender.” From this, next general hypothesis will be derived, which needs to be split up in order to analyse its different components.

VII. The extent to which higher income leads to higher investments in agriculture depends on enabling bio-physical and political-economic conditions

Resuming, it is highly important to consider the other main variables explaining variation in migration impact on investments, though with a constant focus on migration. Which minimum of these context variables should be included in the model? What variables make up the main enabling conditions for investments in agriculture?

First of all we have to mention what can be called the national political-economic context (variable 6 PEC). This includes all the political-economic (and legal) factors on national level, which determine together the general investment conditions in a country and its different regions. 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 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 than expected on the basis of cash income only

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

Another factor of high importance, is the scarcity of irrigable land (variable 7 ALND). In some oases, irrigable land is scarce. In the upper parts of the Todgha valley (Morocco), for instance, the local relief can form an obstacle for extension of agricultural land, since the oasis is hemmed in by steep mountain chains. Other physical obstacles may be that the immediate surroundings of the oasis are already occupied by peasants of other oases or by urban structures. Another obstacle may be the low agricultural quality of surrounding land, such as salinisation, stoniness, or the existence of sand dunes.

Photo 3 Modelling on the spot, 14 July 1999, oasis of Aït el Meskine, Tinghir, Morocco



photo by Youssef Moumni

Many factors play a role in determining ‘availability of land’, but the best proxy for it seems to be ‘land prices’, since of all indicators it best reflects factual land scarcity. It reflects also the costs involved in land investments. Other parameters such as ‘mean plot size’ are more shaky because they do not directly consider supply and demand questions. Moreover, land prices seem to be generally higher in areas where plots smaller, since this division already indicates the small total surface in relation to demand. Land price is, therefore, also a rough indicator for such factors, although it should be noted that the ‘emotional value’ of land also plays a role in determining actual land prices.

A problem that has to be resolved is the fact that low land prices also may reflect a bad soil quality, which may even agriculture difficult or even impossible (salt, sodification, sand dunes etc). Therefore, it seems wise to take land prices in the old, traditional oasis as indicator, and not land prices in the surrounding, barren areas. The assumption is that land prices in the old oasis will be relatively low if good, irrigable new agricultural land is available in the immediate surroundings. The prices will be the highest in areas without any extension possibilities. This analytical problem remains, however, if the land in the old oasis *itself* is of bad quality. Therefore, and for many other reasons the variable quality of land resources (variable 8 QLAND) has been included. A classification has to be developed, based on several parameters (see

table 1). A dichotomous, bipolar classification ('good' or 'bad') based on threshold values (structure, texture, physical and biological degradation, salinisation, and erosion), has several statistical advantages, but it remains to be discussed whether it is desirable to develop a scale of several values

IX. Low local land prices lead to higher investments in agriculture than expected on the basis of cash income only

X. Good land quality lead to higher investments in agriculture than expected on the basis of cash income only

Besides land, availability of good quality water for irrigation is the most important 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 village level. The question is how can we best measure this entity. The underlying idea is that the more easily water is available, the fewer investments are necessary to win this water. So, the easier the access to water, the more likely investments are. Therefore, the variable could be called accessibility of water resources (variable 9 AWAT). The most objective parameter to measure this is possibly 'depth of ground water tables'. It should be discussed whether to include other aspects of water availability, such as the (the rate of) renewal of water resources. The following hypothesis can be formulated:

XI. Easily accessible water resources lead to higher investments in agriculture than expected on the basis of cash income only

It should be mentioned that in many oasis areas, especially in Morocco, gravity irrigation (irrigation directly from rivers and *khettaras*) does still exist, often in combination of pumping. In taking depth of ground water tables as measure, this source of irrigation is excluded in the set of context variables determining investments in agriculture. Except for some oases in the upper Todgha valley (where there is no water scarcity but an acute land scarcity), all other oases included in the IMAROM research suffer absolute lacks of gravity water. Furthermore, due to increased pumping and socio-political processes on local level (see the following paragraphs on variable 13), the maintenance of the collective gravity-oriented irrigation systems is less and less ensured. There seems to be a general tendency to the increased use of non-gravity water (i.e. motor pumping). This is already almost uniquely the case for the Tunisian sites and for some of the sites in the lower Todgha valley. Especially in the extension zones, motor pumping is the only option.

Investments and agricultural extension movements in the desert, therefore, seem to be strongly linked with water pumping. Motor pumping is mostly necessary in quantitative terms, to have disposal of enough water to irrigate which mostly cannot be provided by 'gravity sources'. There is also another reason to use motor pump, as it gives the peasant a complete individual freedom to irrigate at times chosen by him. In the collective 'gravity' arrangements, this freedom and flexibility does generally not exist. So, the tendency to a more 'modern' agriculture raises the need for individual irrigation planning. Although it this is not always the case, investments in agriculture seem to be strongly associated with the rise of motor pumping. These seem to be sufficient arguments to use the depth of water tables as general indicator for water accessibility, and to leave out 'total flow of gravity' out as determinant of

investments in agriculture. However, this variable will be used in analysis of axis B; the impact of investments in agriculture on land and water management and natural resources.

The last variable in this set of 'context variables' is the quality of water resources (variable 10 QWAT). It is important, since low quality may render water of very low or no use to agriculture. The quality of the water, is therefore supposed to be an important determinant for investment potentials. As in the case of quality of land resources (variable 7), a classification has to be developed. A dichotomous, bipolar classification ('good' or 'bad') based on threshold values (EC, pH, cations, anions, others), has several statistical advantages, but it remains to be discussed whether it is desirable and possible to develop a scale of several values. The hypotheses will be:

XII. Good quality water resources lead to higher investments in agriculture than expected on the basis of cash income only

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

Investments in agriculture (variable 4) have many dimensions. To follow the categories defined in the household questionnaire of WP I, the following categories of long-term investments can be distinguished:

1. purchase motor pump including the digging of the well
2. purchase tractor
3. purchase other agricultural machinery (harvester, threshing machine etc)
4. purchase or rent of land
5. purchase or rent of water (rights)

Total investments should be calculated over the same period, both for Morocco as Tunisia. In the Moroccan questionnaires, only investments as of 1975 are included. In the Tunisian questionnaires, all investments are calculated, but the year in which the investment has been done, has been mentioned. Therefore, investments per household as of 1975 can be calculated for both countries. Furthermore, there is a range of purchases and expenses (which require capital input), for which we have to discuss whether we can mark them as 'short-term investments', or should they rather be seen as indicators of 'capital intensity levels 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 capital intensity levels of agriculture. To some extent, we could also see this as an indicator of 'modernisation', though this is at the risk of triggering a heated debate on what is 'modern'. But in this case, we could agree to see relative high capital inputs as one aspect of 'modern'. Other important aspects are of course other ('modern') cultivation methods, plot size, market-orientedness, etc.

All these investments are supposed to have an impact on land and water management practices. Besides the capital inputs, the actual land and water management practices can be extended with data on cultivated crops, crop associations, cultivation methods, ploughing methods, etc. All these aspects will be studied in detail in the individual reports on the research oases in Tunisia and Morocco.

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

Photo 4 Ségua, Tunisia



photo by Albert Solé-Benet

Oasis systems are highly sensitive agricultural systems, as water resources are scarce, and land and water resources fall easily a prey to degradation. The main environmental dangers can be summarised as follows: falling water tables and desiccation of natural water resources, salinisation of water and/or soil, soil erosion, and sand encroachment. We could analyse the impact of changing land & water management on all these degradation aspects. The problem with this is, yet, that this impact seems to be very indirect and complex. Moreover, besides migrations, many other factors play a role. A direct link with migration is often difficult to make. Therefore, they are probably better to be studied in the qualitative analyses of the different work packages. Especially Work Package II, the plot level research,

provides interesting insights in changing land and water management in response to migration, as both categories of migrant and non-migrants are included in this research.

In order to be useful for direct use in a model, it is better to take out the most relevant aspects of '(changing) land & water management', which have clear migration links and which have a clear environmental impact with possible (future) drawbacks for oasis agriculture. I therefore propose to focus 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, and which have mostly clear links with migration (capital), and which are quantifiable to some extent.

An increase in the stock of the water pumped up (variable 11 PUMP), may have, at the long term a negative effect on the availability of water resources, i.e. they become more scarce. Variable 9, accessibility of water resources might be used to measure this scarcity. The disadvantage of this parameter, however, is that it does not include the dynamic aspects. Alternatively, we could also think about defining another variable, such as 'decrease/increase of water resources' (to be discussed). The increase in motor pumping can, depending on specific hydro-geological circumstances, lead to falling water tables. This, in turn, may cause diminution of the flow of natural sources. This may even cause the total desiccation of former natural sources for gravity irrigation. To measure this impact, we should include the variable flow of gravity water (variable 12, GRAV). An alternative to measuring these variables in terms of relative flow (per household or per hectare) is to define a dynamic measure, with classifications such as 'increase', 'constant', or 'decrease' in flows over a certain period. This data can be obtained, by doing some brief inquiries in the field. If we opt for this choice, it will not be possible to quantify the decrease or increase, since data is often not available.

The stock of water pumped up is expected to increase with total investments in agriculture, i.e. purchase of motor pumps would be an important component of these investments. Another assumption is that the national political-economic context (variable 6) also influences the total amount of water pumped up, in the form of regulations, laws, and controls in the field. Effective government policies should control and regulate the amount of water pumped up. This leads to the following hypotheses:

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

XIV. More government involvement leads to decreased individual pumping

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

The most important local institution used to be the village community (or *jemaâ*) coincides with the organisation and maintenance of the irrigation and land infrastructure. The highly labour-intensive maintenance of agricultural infrastructure such as dams, *khettaras*, irrigation channels, terraces as well as the allocation of the 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 has no effective legal status anymore, 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 bad maintenance of the labour-intensive land and irrigation infrastructure, which has direct repercussions on agriculture. Bad maintenance of the irrigation infrastructure has contributed a decreased water intake in the irrigation channels and *khettaras*. In this way, 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, that are often too easily and incorrectly attributed to mostly rather poorly defined phenomena as ‘drought’ or ‘climate change’.

In the model both local institutions (variable 13) and water pumping (variable 11) are supposed to influence on the total flow of gravity water. Qualitative analysis of work package IV should result in a measure on the ‘effectiveness of collective water management’. We can also think of introducing another variable, to be called ‘state of irrigation system’. 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 need for further motor pumping. These feedback mechanisms could finally result in a vicious circle, whereby underground water resources can be gradually depleted. At this point, the sustainability of oasis agriculture comes into question.

XV. More motor pumping lead to a reduced accessibility of water resources

XVI. Reduced accessibility of water resources lead to a reduced flow of gravity water

XVII. Breakdown of local institutions managing the traditional irrigation system lead to a reduced flow of gravity water

XVIII. Reduced or absent flows of gravity water lead to a higher stock of water pumped up than expected on the basis of income only

It should be discussed whether to include the mechanisms by which overexploitation water resources may lead to a change in water quality (for example salinisation).

Summarising, we can conclude that the model seeks to analyse under what enabling conditions higher migration remittance (income) do lead to higher investments in oasis agriculture. Secondly, it analyses the environmental consequences of higher investments in agriculture, especially concerning the scarce water resources. This exactly coincides with the third main IMAROM objective.

The choices made in the preceding discussion lead to the following, somewhat stripped model (figure 3). Some of the arrows present in the first model, have been removed. The absence of arrows between variables in the model, is not to say that there does not exist some sort of relationship between them, but that these relationships do not form subject of the analysis, that should directly respond to the IMAROM main objectives. For practical reasons, this model should only include a limited number of most important variables. The Roman numerals correspond with the hypotheses developed for each of the links between variables. The plus and minus marks next to the arrows indicate the 'direction' of the hypotheses. Table 1 gives an overview of all variables included and proposals concerning the way in which they could be calculated.

Figure 3 Provisional conceptual model

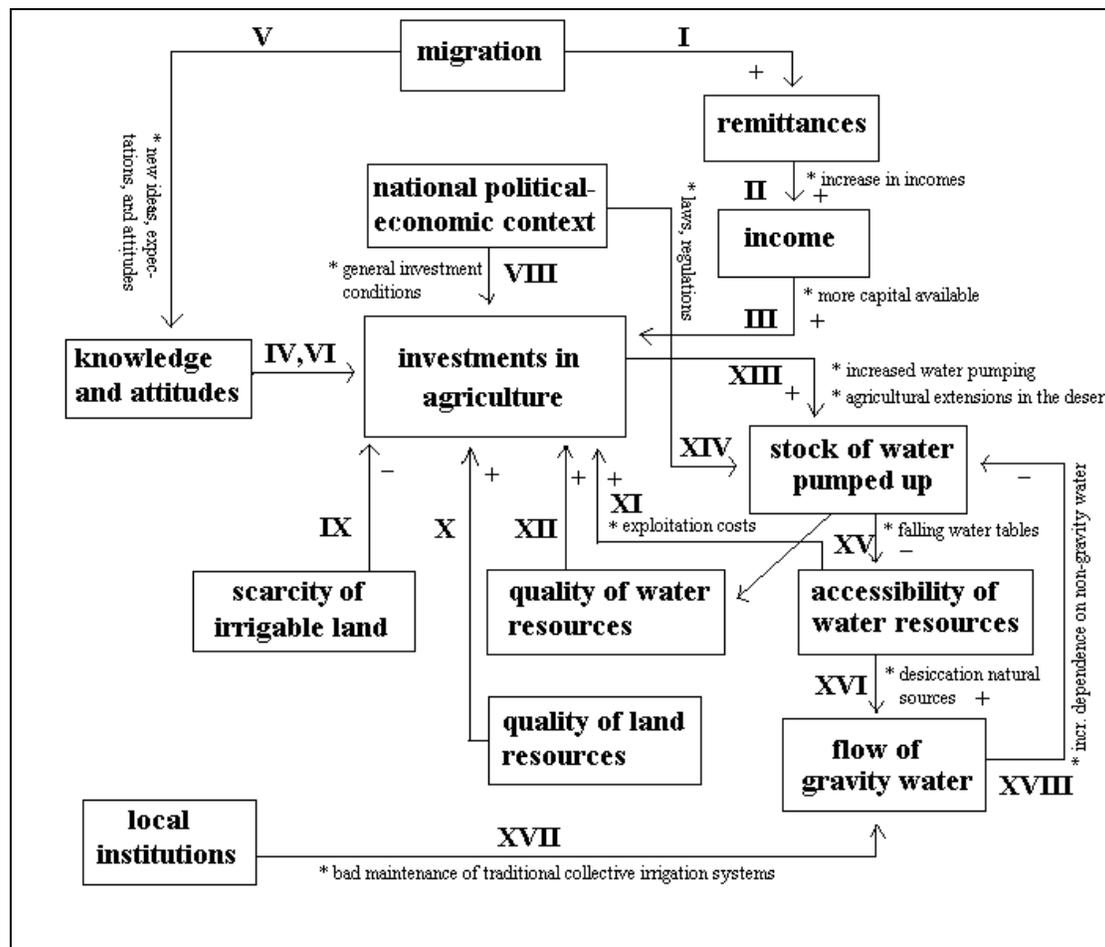


Table 1 List of variables to be included in the extended IMAROM model

<i>No</i>	<i>Variable</i>	<i>Options for parameters on village level</i>	<i>Source</i>
1	Migration	<ul style="list-style-type: none"> percentage of migrant households related to the total number of households (measures migration-orientedness of village) 	WP I
2	Remittances	<ul style="list-style-type: none"> mean volume of remittance income per household in ECU 	WP I
3	Income	<ul style="list-style-type: none"> mean total cash income per household in ECU 	WP I
4	Investments in agriculture	<ul style="list-style-type: none"> total investments in agriculture in ECU ('investments' is an aggregate variable, should be worked out) yes/no investments (dummy) qualitative scale of investments' in agriculture, e.g. five steps from 'abandonment' towards 'highly intensive agriculture' 	WP I
5	Knowledge and attitudes	<ul style="list-style-type: none"> Concerning attitudes toward agriculture. Bipolar qualitative classification ('positive' and/or 'negative') or a scale of several values (very positive, positive, negative, very negative) 	WP I (open questions)
6	National political-economic context	<ul style="list-style-type: none"> effectiveness of national agricultural policies reaching oasis areas access to credit for small peasants level of corruption legal security political stability 	Literature
7	Scarcity of irrigable land	<ul style="list-style-type: none"> land price in ECU/ha in the old oasis area 	WP I
8	Quality of land resources	<ul style="list-style-type: none"> bipolar classification (good-bad) or a scale of several values according to threshold values (structure, texture, physical and biological degradation, salinisation, and erosion).-> one parameter (to be elaborated by EEZA and UMO) 	WP III
9	Accessibility of water resources	<ul style="list-style-type: none"> mean depth of water table in meters on village level 	WP III
10	Quality of water resources	<ul style="list-style-type: none"> bipolar classification (good-bad) or a scale of several values according to threshold values (EC, pH, others) -> one parameter (to be elaborated by EEZA and UMO). 	WP III
11	Total stock of pumped up water	<ul style="list-style-type: none"> Litres per second per household on an annual basis. In case of sampling these values should be extrapolated. 	WP I&II
12	Total flow of gravity water	<ul style="list-style-type: none"> Mean annual surface flow available for village in litres per second per hectare (l/s/h). Or per household? Surface to be calculated on the basis of currently irrigated surface. 	WP III
13	Local institutions	<ul style="list-style-type: none"> Developing dichotomous classification 'good-bad' concerning effectiveness of collective water management. 	WP IV
*	Labour	<ul style="list-style-type: none"> local price agricultural labourer ECU / man hour 	WP I
*	Market	<ul style="list-style-type: none"> ? 	
*	Non-agricultural investments	<ul style="list-style-type: none"> total investments in ECU ('investments' is an aggregate variable, should be worked out. We should also define what we consider as investments, i.e. do we also include habitat, schooling etc.) yes/no investments (dummy) 	WP I

8. Suggestions for model extension

The model neglects a number of ‘context’ variables that might yet be important in determining investments in agriculture. After discussion, they might even well be included. They have been left out up to now, in order to keep the number of variables down and to focus the analysis as much as possible. The following might be added.

The model seems to neglect one important production factor, that is labour and its allocation within the household. Migration forms a way to allocate labour towards foreign countries, but they may deprive the households from important agricultural labour resources. Consequently, this phenomenon might lead to a shortage of agricultural labour on household and oasis level (this is a potential hypothesis) The reason not to include this factor in the initial model was based on the supposition that migration has only theoretically an influence on local labour costs. Recent migration impact studies have demonstrated that this influence is hardly perceptible in practice. Furthermore, recent evidence from Moroccan oases also seems to suggest that there are no real labour shortages, at least they cannot explain neglect of agriculture, which would be rather related to a shift in economic preferences of households and the decreasing need to maintain a subsistence agriculture. Moreover, as was thought, inclusion of labour would complicate the model, and would lead us too far from the IMAROM’s core analysis.

Evidence from Tunisia, however, suggests a serious impact from migration that would deprive the oases from their most active and specialised labour forces. This seems a strong argument to include a labour-related variable. If we decide so, the only question is how to operationalise this variable. Possibly the most short-cut way to do so is to approach labour from the cost side. Labour is getting increasingly monetarised in oasis areas, and ancient forms of sharecropping are rapidly losing ground. Besides ‘free’ family labour, one is increasingly dependent on hiring paid labour, especially during ploughing and harvest seasons. Labour costs (salary levels for agricultural labours reflect scarcity of labour) are therefore another potential ‘context’ factor determining investments in agriculture. If labour is less expensive, one could be further encouraged to invest.

Another potential variable to include is access to markets or local price levels for agricultural products. If local prices remain low and the access to national and international markets is difficult, this will discourage people to invest in agriculture.

9. Discussion: weaknesses and possibilities for refinement

Without any doubt, this first draft for the IMAROM model certainly still contains many weaknesses. Discussion and input of expertise from colleagues can lead to further refinement of this model. We have also to discuss whether and especially how we should extend the model with the interaction of investments in agriculture on land quality (soil degradation) and water quality. All colleagues are invited to come with ideas and concrete proposals for changes.

a. Feasibility

A general weakness of the model is the large number of ‘context variables’ determining agricultural investments. This might complicate analysis. The quantitative nature of the model has the disadvantage, that it leaves out many qualitative aspects, which might well explain differences in investment levels. Also very specific local circumstances, will not be captured.

b. Level of analysis

The analysis on village level has the advantage of a higher comparability between Morocco and Tunisia, as well as the possibility to include many variables, which only can be measured on a higher scale level. The low number of observations (12) will severely reduce statistical potentials. The model furthermore neglects intra-oasis differences between migration and non-migration households. The individual reports of the researchers on the different oases, however, will provide this intra-oasis analysis, and will provide many insights to be used in the explanation of (unexplained) variations. In other to systematise analysis, they could re-test the hypotheses on village level. The modelling on project level is focused on the comparison between oases and the two countries involved. Both analyses are complementary. It would be interesting to analyse whether hypotheses hold on both scale levels in the same way.

c. The ecological fallacy trap

The most important danger of village-level analysis is to see a village (oasis) as a kind of big household. We should therefore not project the behaviour of households on villages as such. This has consequences for the nature of the hypotheses and the analysis. For example, if we would observe that villages with many migrants, people tend to invest more in agriculture, we cannot automatically state that individual migrants tend to invest more in agriculture. We should be aware of this kind of ecological fallacy traps.

d. Feedback mechanisms

In the conceptual framework, we suppose some feedback mechanisms. However, in the case of (statistical) modelling 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 moment. This may complicate or render impossible analysis of feedback mechanisms concerning land and water management and for context variables as availability of water.

e. Agricultural investments in other regions

An important question is 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. Should we count them as investments or not? We should probably not consider land that is bought further away, as goes outside the regional scope of the research. If we judge this development interesting enough, however, we should include ‘investments in agriculture elsewhere’ as a distinct variable.

f. Exclusion of village-wide economic impact of migration

Finally, the model does exclude the village-wide economic impact of migration remittances. Theoretically, agricultural or non-agricultural investments do lead to employment generation in the oasis and generate revenues, which accelerate economic growth through multiplier effects. This village and region wide impact of migration has recently gained much attraction in the domain of migration impact studies, which had led to a re-evaluation and a subsequent re-appreciation of what was wrongly downgraded as 'non productive investments' in ancient migration literature. For example, the important investments in habitat has in practice often an important stimulating effect on local employment and economies (cf. Taylor et al. 1996). Although it is important to be aware of the village-wide economic impact of migration, this subject lies beyond the real focus of the IMAROM research, which is specifically focused on the agricultural impact of migration.

g. Orientedness on recent capital investments in the 'modern' sector

The model is strongly oriented towards (the rise) modern sector agriculture and capital investments in motor pumping. Furthermore, livestock breeding is not considered as such. Also the traditional agricultural system is not considered as such. The model only focuses on the investment potentials of agriculture and specifically highlights the modern sector. Since migration remittances also give people the freedom not to invest or even to leave agriculture, growing neglect may also lead to 'underexploitation', neglect of the agricultural infrastructure and land degradation.

The focus of this model is on enabling conditions for investments of migration remittances in agriculture, as is included in the main objectives for the project. As stated before, it is a deliberate choice not to set up a comprehensive model for analysing the whole oasis system, which would get too general and descriptive. In this study, we want to highlight a subset of relationships within this whole complex of variables. Since the modelling will be focused on new investments in agricultural and not on the traditional system as such, these aspects will not be considered in this modelling exercise, though they should be treated in the analysis of the individual oases.

h. Time scale

The IMAROM consortium should agree on whether to consider immediate effects of migration or also mid and long-term effects. This issue was brought in by Mongi Sghaier and should be discussed at the Tunisia meeting.

10. Further planning

The empirical phase of data collection should largely be finished in February 2000. The last project year will then be dedicated to analysing data, running models, testing hypotheses and report writing. After discussing modelling on the meeting in Tunisia, a final model will be developed, which, depending on the discussions, can be quite a

different model from the model proposed in this text. In April 2000 the latest, the IMAROM partners will receive the final model, including the variables to be delivered. Data on village level should be delivered to the project coordinator in May 2000 the latest, so that analysis can begin.

11. Text summary (main proposals)

- The level of analysis will be the oasis (village) level. Data should be delivered on this level.
- The individual researchers execute the analysis on household level, whereby they use the same hypotheses of the oasis-level to test them on household level (taking into account the 'ecological fallacy trap').
- The primary goal is to develop a quantitative, non-deterministic model with explicative purposes. In a second stage, insight in certain aspects which appear interesting may be deepened by constructing specific statistical models (such as regression model etc.).
- The goal of the model is not to analyse all possible variables and relationships between them that play a role in oasis systems and which may explain agricultural change.
- In order to test the supposed relationships within an analytical model, the total number of variables should be limited. This implies that we have to limit our analysis to mechanisms only within a subset of relations in the oasis system.
- The three main objectives of the IMAROM project form the basis of the development of the model.
- Selection of variables will be based on their relevance and measurability.
- The study centres basically around two main axes of analysis. (A) The first analytical axis focuses on the impact of migration on investments in agriculture and, hence, on land and water management. (B) The second analytical axis focuses on the impact of the main variable investments in agriculture on land and water management (resource exploitation), especially on availability of water resources by pumping of water.

Literature

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