INITIATIVE FOR A BALANCED WATER RESOURCE MANAGEMENT
INITIATIVE POUR UNE GESTION INTÉGRÉE DES RESSOURCES EN EAU
INICIATIVA PARA UNA GESTIÓN EQUILIBRADA DE LOS RECURSOS HÍDRICOS

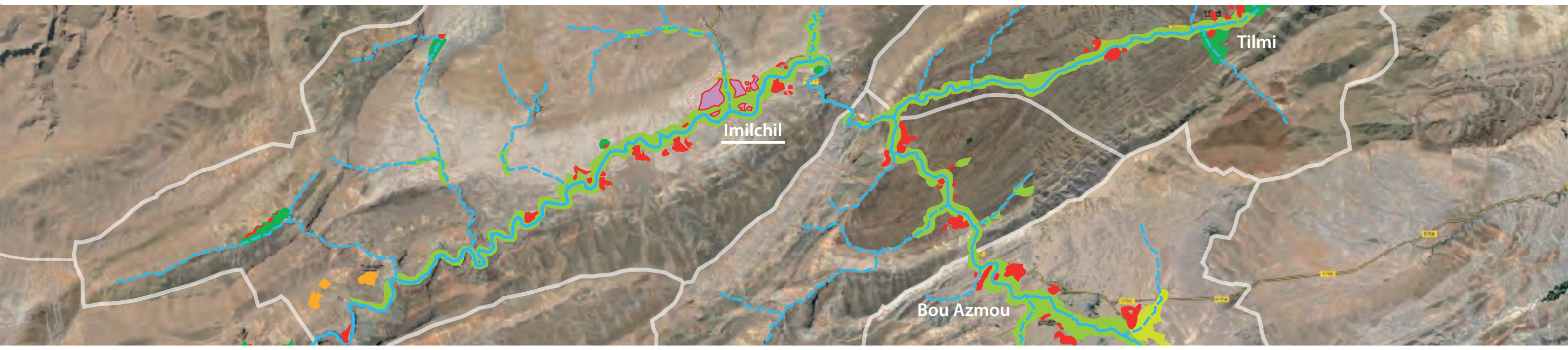
water 4 future

Scientific decision support on the sustainable use of environmental resources in dry mountain areas

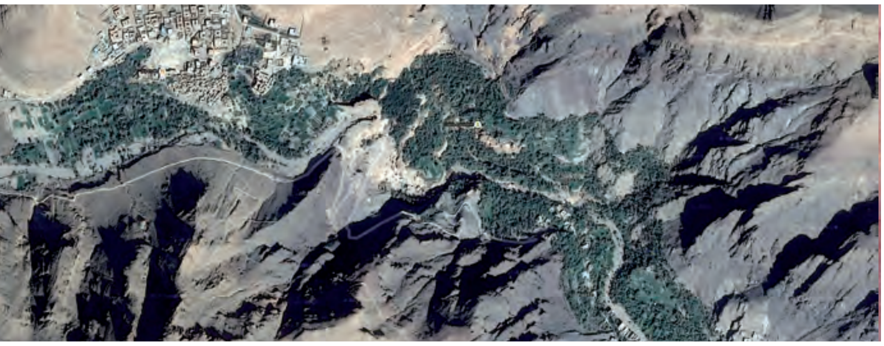
Project documentation








Initiative for a Balanced Water Resource Management

November 2016

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Project partner: Zürcher Hochschule für Angewandte Wissenschaften
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A brief overview of the project

Organisation

Name:	Initiative for a Balanced Water Resource Management
Legal form:	Association within the meaning of Article 60 et seq. of the Swiss Civil Code
Domicile:	Berneggweg 3, CH-8055 Zürich, Switzerland
Office:	Oesterliwaldweg 4, CH-5400 Baden, Switzerland Phone: +41 (0)56 222 07 10; mobile: +41 (0)79 534 46 36
Founding date:	17^{th} June 2014
Non-profit status:	Tax exemption
Website:	www.i-brm.ch
Purpose:	Conservation, sustainable utilisation and regeneration of the environmental resources water, soil and vegetation in consideration of the needs of both the population and the economy. Promotion of research, teaching, consulting, evaluation, public relations as well as attending the implementation of measures in the field of sustainable resource use.

Project

Project title:	**water4future** **Scientific decision support on the sustainable use of environmental resources in dry mountain areas**
Keywords:	Water, environment, security of resources, sustainability, empowerment, open access to information, development cooperation, system improvement, decision support, participation in decision-making, scenario development
Approach, disciplines:	Transdisciplinary research, hydrogeology, ecology, human ecology, social geography
Target regions:	Results for dry mountain areas worldwide, case studies in the Atlas Mountains in Morocco
Beneficiaries:	People concerned by a scarcity of water and resources in the target regions
Project start:	Preparatory works since April 2015; start of the research phase in the second half of 2017
Duration:	Total duration: 6 years (research phase: 4½ years; development phase: 1½ years)
Project mgmt:	Dr. Martin Wyss, +41 (0)56 222 07 10 / +41 (0)79 534 46 36, martin.wyss@i-brm.ch
Project partners:	Institute of Natural Resource Sciences, Zurich University of Applied Sciences (ZHAW) Moroccan university, yet to be designated
Brief description:	**Initial situation and background:** In many regions of the world, excessive use of water, soil, and vegetation has led to groundwater depletion, the drying up of rivers and lakes, soil erosion, and degradation of the natural vegetation. The global climate change additionally accentuates and accelerates these processes. The rural population in dry mountain areas of the Global South is particularly vulnerable in this respect, since their economic success immediately depends on the availability of local water resources and on the integrity of soil and vegetation. A scarcity of these resources puts their livelihood at risk and leads to pauperisation and emigration. Taking up the challenge of envisioning the future and subsequent realistic and reliable planning, science-based decision-making tools are invaluable. **Objective:** Providing the scientific basis for assessing a) the current and future availability of local water resources and b) the consequences of different water usage scenarios for the human development and for the natural environment in dry mountain areas worldwide. The local communities are to be supported in using their water, soil, and vegetation in an ecologically

sound and sustainable manner, in preserving them for the future, and in improving the quality of their local habitats.

Goal achievement: Development of a web-based high-resolution decision support system (DSS) for the local resource management in areas the size of villages or valley sections, which will be made available for free to all potential users such as the civil society and government agencies. To achieve this, a model of local, natural and man-induced water flows and their interactions with the soil and vegetation will be developed. The DSS is intended to enable users to assess the ecological and economical consequences of their current and future use of resources and thus evaluate development options and the resulting water and environmental situation on a transparent, well-informed basis. The scientific foundations for the envisaged DSS will be established through transdisciplinary research (that is natural and social scientific investigations in cooperation with the local population) to be carried out in three representative study areas in the Atlas Mountains of Morocco, where we have found a working environment optimal in many respects.

Innovation: Together with free, low-threshold access and interconnectedness through its user platform, the intended high-resolution DSS enables a completely new, local approach to decision-making support. It ensures an increased information flow and increased transparency of planning and decision-making processes, and encourages participation of a wider public in these processes, which is of crucial importance for the development in developing and emerging nations. The DSS allows for the protection and regeneration of water, soil and vegetation directly at those locations, where people are affected by the shortage of resources. Our project will also contribute to achieving the UN Sustainable Development Goals (2030 Agenda) and the objectives of the Paris Agreement to Combat Climate Change.

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I Introduction

Water, environmental resources and desertification

It was water that made possible the first forms of life on earth, and it was along rivers and streams that humans first settled and that human culture originated and, more than that: water still is the basis of all life to this very day; there is nothing that could possibly replace it.

Soil and vegetation are both indispensably linked to water. Water makes land arable and allows the vegetation to grow. If we look at it the other way round, an intact soil and vegetation are crucial prerequisites for an intact water balance. And because of this close interdependence, only a joint – or as we say 'integrated' overall view makes sense here at all. Since water, soil and vegetation together with the air constitute what we call our environment, which is at our direct disposal without the use of any technical aids being required, we designate them the 'environmental resources'. These environmental resources are to be differentiated from mineral resources, such as ores, coal or mineral oil. Although these latter are also of a natural origin, they can only be exploited with the help of technical means.

There is, in fact, an abundance of water on earth, this being due to the 'eternal cycle of water' starting from the oceans, its subsequent humidification, the formation of clouds, precipitation, rivers and back again to the ocean. It is practically impossible for a water molecule not to be part of this cycle one way or another. Nevertheless, a multitude of people are confronted with an extreme water shortage. Indeed, only the fortieth part of all water is fresh water, and of the entire fresh water contingent, two thirds are trapped in the form of ice. Of this remaining third, only the hundredth part is found on the surface of the earth while the rest is groundwater. However, the main reason for a shortage in water is not its insufficient quantities, but rather the unequal distribution of precipitation locally and timewise, as well as the growing human demand for and consumption of water.

While the seasonal differences in precipitation over the years have proved to be rather minor in moderate climate zones, such as in Central Europe, where even the difference between wet areas and areas deprived of rain are minimal, the subtropics and tropics are characterised by clearly distinguishable rainy and dry periods and fluctuations in precipitation of several hundred per cent between years abundant in rain and years lacking in rain.

In many areas of the world, decades of over-exploitation of the natural resources triggered by the demographic and economic growth on the one hand, and the increasing demands that go hand in hand with a modern lifestyle on the other hand, have led to distinct scenarios of deficiency, such as a lowering of groundwater tables, erosion of the soil, and degradation of vegetation. For some time now, these destructive processes have been further accelerated and aggravated by the effects of climate change. In this way, the regeneration of natural resources and the functioning

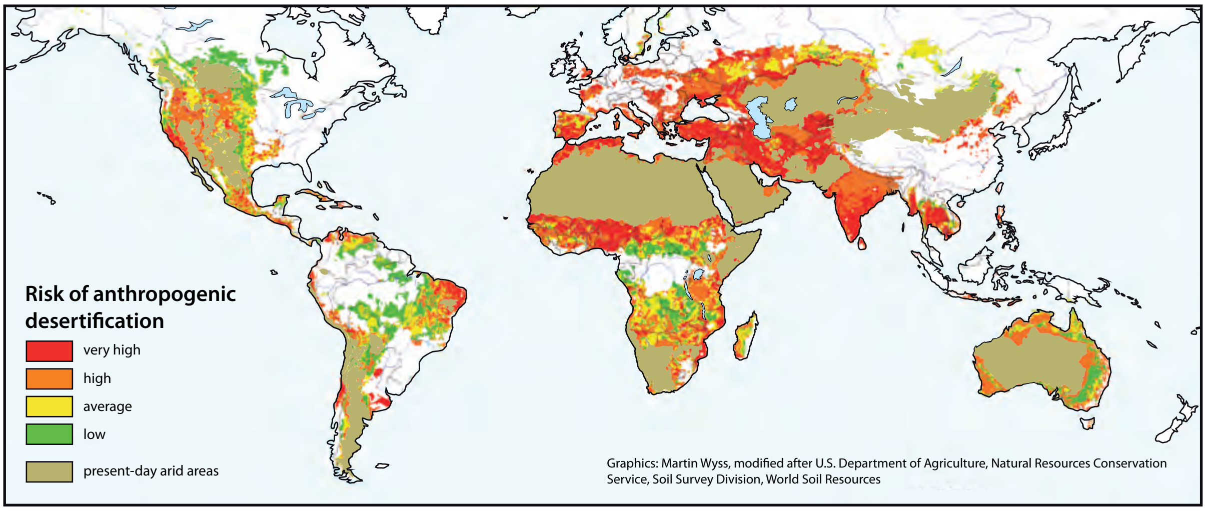


Fig. 1: Areas of risk for anthropogenic desertification [1].

[1] Explanations of technical terms and additional remarks are to be found at the end of the project documentation (p. 40, 41).

of ecosystems has been dramatically reduced in many places, manifesting in desertification, utter infertility of the soil, and disappearance of the vegetation altogether. All this leads to an impoverishment of the local population, compelling people to emigrate, with far-reaching consequences globally.

Arid environments meanwhile cover almost a third of the surface of the earth. An additional 70‘000 km^2, roughly, of arable land are lost every year to desertification – an area corresponding to the size of the Republic of Ireland. Approximately two billion people in over 100 countries are at one and the same time the originators and the victims of this creeping destruction of their natural resources.

It is therefore adamant that the management of water, soil and vegetation be urgently changed into a more sustainable and future-oriented one. The needs of the people and the requirements of the environment must both be considered. The quantity and quality of the water resources, their development under changed situations of utilization and changed environmental conditions, the water demands of the natural vegetation and demands in resources from all branches of industry and parts of the population must equally be made part of planning procedures.

The association *Initiative for a Balanced Water Resource Management*

The association *Initiative for a Balanced Water Resource Management* was founded in June 2014 by two natural scientists and one social geographer with the intention of establishing a platform for the realisation of integrated and transdisciplinary research projects in the field of sustainable use of the environmental resources water, soil and vegetation. The association is dedicated to conservation, sustainable use and regeneration of environmental resources while at the same time considering the needs of the population and the economy. In doing so, we have in mind a utilisation of resources that meets the demands of the present generation without jeopardizing the possibilities of future generations to satisfy their own needs. We emphasize that our research results will culminate in the implementation of measures directly at those locations, where people are affected by the shortage of resources. In this way, the association has a bridgehead function between scientific research on the one hand, and developmental cooperation on the other hand.

The project team mainly consists of the founders of the association, all who have doctoral degrees and working experience in the Global South.

The project *water 4 future*

The project started in early 2015 and after finishing the preparation phase, is now in the phase of organizing fieldwork. However, the idea to launch a project that would focus on supporting the sustainable use of environmental resources in arid mountain areas on a local scale, goes back to 2012 and has been continuously developed ever since. In particular, the rapid development of web-based, geographic information systems (GIS) will offer new possibilities in the future that still seemed far away a few years ago.

The UN Sustainable Development Goals laid down in September 2015 (2030 Agenda) and the Paris Agreement to Combat Climate Change from April 2016 give us an added sense of affirmation and motivation to bring the project forward. Both agreements have acknowledged the considerate use of environmental resources such as water, soil, and vegetation, as well as effective measures against global warming as urgent challenges of global relevance. Both agreements also underline the joint responsibility of the scientific community and of the civil society and have repeatedly called upon them to partake in the devising and implementation of measures in many ways, also informally, and both agreements underline the necessity to support the Global South in its efforts for more sustainability and in the fight against the consequences of global climate change.

Picture credits for the project documentation:

Graphics: Martin Wyss
Photos: Martin Wyss, Luzi Matile

II Project description

1 Initial situation and project background

The sustainable and socially compatible use of environmental resources such as water, soil, and vegetation is the basis for any successful development. Water, in particular, plays a key role for a wide range of human needs. However, in many regions of the world, environmental resources are being overused. This has led to significant, if not life-threatening, scarcity such as ground water depletion, the drying up of rivers and lakes, to soil erosion and degraded vegetation, in brief, to desertification. This development was triggered by demographic and economic growth, an increased demand due to the spreading of a modern lifestyle, unfavourable ways of resource use, and ecologically harmful policies in general. The global climate change additionally accentuates and accelerates these processes.

Rural populations in dry mountain areas of the Global South[2] are particularly vulnerable in this respect, since the success of their mostly modest subsistence economy directly depends on the availability of locally limited water resources, as well as on the integrity of soil and vegetation. They have, as a rule, neither access to external resources in a situation of crisis nor the means to invest in technical improvement. Due to their mostly low political and economic weight, dry mountain areas rarely benefit from any substantial national, or international, development efforts. The consequences are far-reaching and include not only ecological damage but also social and economic crises. The shortage of vital environmental resources puts the very existence of the people in developing and emerging societies at risk, leads to pauperisation, to the loss of local cultural heritage and to social tensions, and it may force people to leave their homes[3]. It has thus become a serious reason for migration[4] that has barely been perceived or recognized so far by the wider public in the Northern hemisphere.

A sustainable[5] future-oriented development in rural areas is only possible on the basis of locally available environmental resources. It must thus be our supreme goal to reduce the overuse of water, soil and vegetation and to adjust the allocation of resources to the local circumstances. In addition to human needs, environmental requirements such as the conservation of biodiversity must be taken into account. This can only be achieved by enabling actors to adjust their needs to the resources available on site, to detect the risks associated with the use of these resources, to act accordingly, and to react adequately to global change processes.

2 Project goals

The purpose of the project is to provide the scientific fundamentals for an ecologically viable local management of using water, soil and vegetation in dry rural mountain areas worldwide, particularly in the Global South. Local populations will be supported in using their resources in a sustainable manner, in preserving them for the future and in improving the quality of their local habitats.

Local authorities, NGOs, and the general public will be provided with a basis for planning and decision-making, thereby enabling them to assess the current availability and quality of local resources as well as to simulate different scenarios of future development under different conditions of usage and in different environmental settings. A major concern of this project is to provide sound and transparent information, not only to decision makers but also, and especially, to those directly affected by the scarcity of resources.

3 Achieving the goals: approach, interim results, output and outcome

The output of the project will be a high-resolution, integrated and web-based decision support system (DSS) for the management of local environmental resources. This DSS operates with research-based data and models, and it will be made available to local authorities, NGOs and interested individuals free of charge.

The scientific basis for the development of the intended DSS will be established through transdisciplinary research[4] to be done in three representative research areas in the Atlas Mountain Range in Morocco, where we find ideal working conditions. We will start the research phase with case studies, i.e. with extensive investigations into availability, interrelations, use, and ways of regulating the use of local environmental resources, whereby the practical knowledge of the local population is specifically taken into account.

Variables that are relevant for the usage of environmental resources, such as precipitation, surface and groundwater discharge, vegetation, soil characteristics, evapotranspiration, water consumption through human activity, as well as present demographic and economic growth will be recorded in the field. In addition, estimates will be made concerning the development of usage under altered climatic, demographic, and economic conditions in the future. The surveyed data will be used to model the relationships between natural, human altered and artificial water flows, soil characteristics and vegetation within local water usage systems the size of villages or valley sections. This will be the core of the intended decision support system (DSS). The recorded data as well as interim and final results of this research will be continuously published on the website of the project-promoting association at *www.i-brm.ch*.

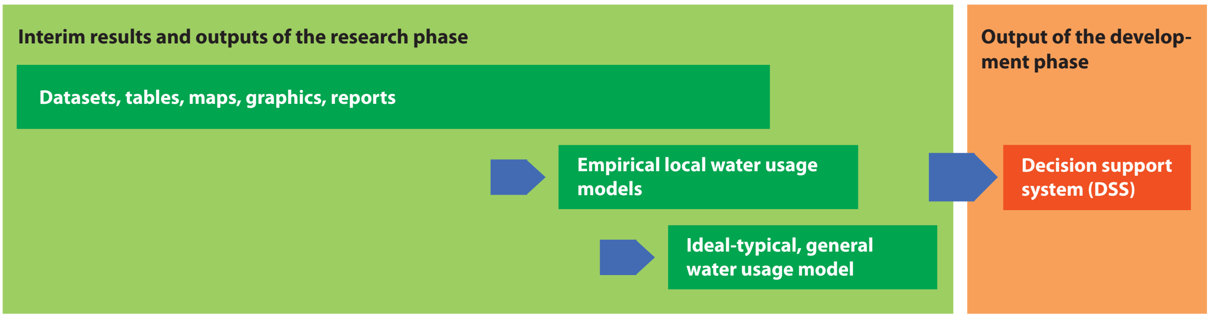


Fig. 2: Results and outputs of the project.

The decision support system will be developed in the subsequent development phase. DSS are mostly software-supported procedures capable of sourcing, processing, representing, and analysing relevant information for operative and strategic tasks. Their purpose is to elaborate scenarios and prognoses. Users of the intended DSS will be able

a) to assess whether their current use of environmental resources is economically viable and sustainable, and

b) to simulate plausible or hypothetical future trends by modifying relevant variables themselves.

This will enable users to assess the consequences of their own decisions as well as the impact of relevant environmental changes, from local to global scale, whether it concerns global warming or economic policies. Considering this information in their planning and their decisions on local development will enable them to systematically evaluate opportunities and risks of various resource use scenarios. In material terms, the DSS will be a user-friendly, interactive application for PCs or tablets, perhaps even smartphones, ideally web-based and linked to a database.

The project started in early 2015. After finishing the preliminary phase, it is now in the phase of organising fieldwork and raising funds for the research phase.

4 Project impact and leverage effect

The project will generate knowledge for the future with relevant results concerning the handling of water, soil, and vegetation in dry rural mountain areas anywhere in the world. By providing populations that are affected by the shortage of resources, and in particular of water, with reliable data for planning and decision-making, we support them in shaping and influencing their own future. Water, soil, and vegetation should be handled sparingly and carefully, and if possible regenerated, thereby increasing the ecological and economic potential of landscapes, and enabling an autonomous life for rural populations in their traditional habitat on the basis of existing resources. Rural poverty, vulnerability due to scarcity and underdevelopment will be reduced, the health of populations improved, and poverty-induced migration, with all its serious social, economic, and political implications, will be diminished (see also figs. 3 and 4). The implementation of the proposed DSS will also have a leverage effect on the increased development and application of decision-making tools, both on a local and regional level, and particularly in the Global South. Finally, the project will also make visible and tangible the concept of sustainability in the context of a scarcity of resources in the countries of the Global South. It will oblige players, thus building up pressure to act accordingly.

5 The project in the light of global initiatives

The UN Sustainable Development Goals laid down in September 2015 (2030 Agenda)[7] and the Paris Agreement to Combat Climate Change[8] from April 2016 have acknowledged the considerate use of environmental resources such as water, soil, and vegetation, as well as effective measures against global warming as urgent challenges of global relevance. One central goal is the preservation of the natural vegetation as a significant carbon sink[9]. Due to its orientation, our project is inscribed in these global initiatives for promoting sustainable development: both agreements underline the joint responsibility of the scientific community and of the civil society and have repeatedly called upon

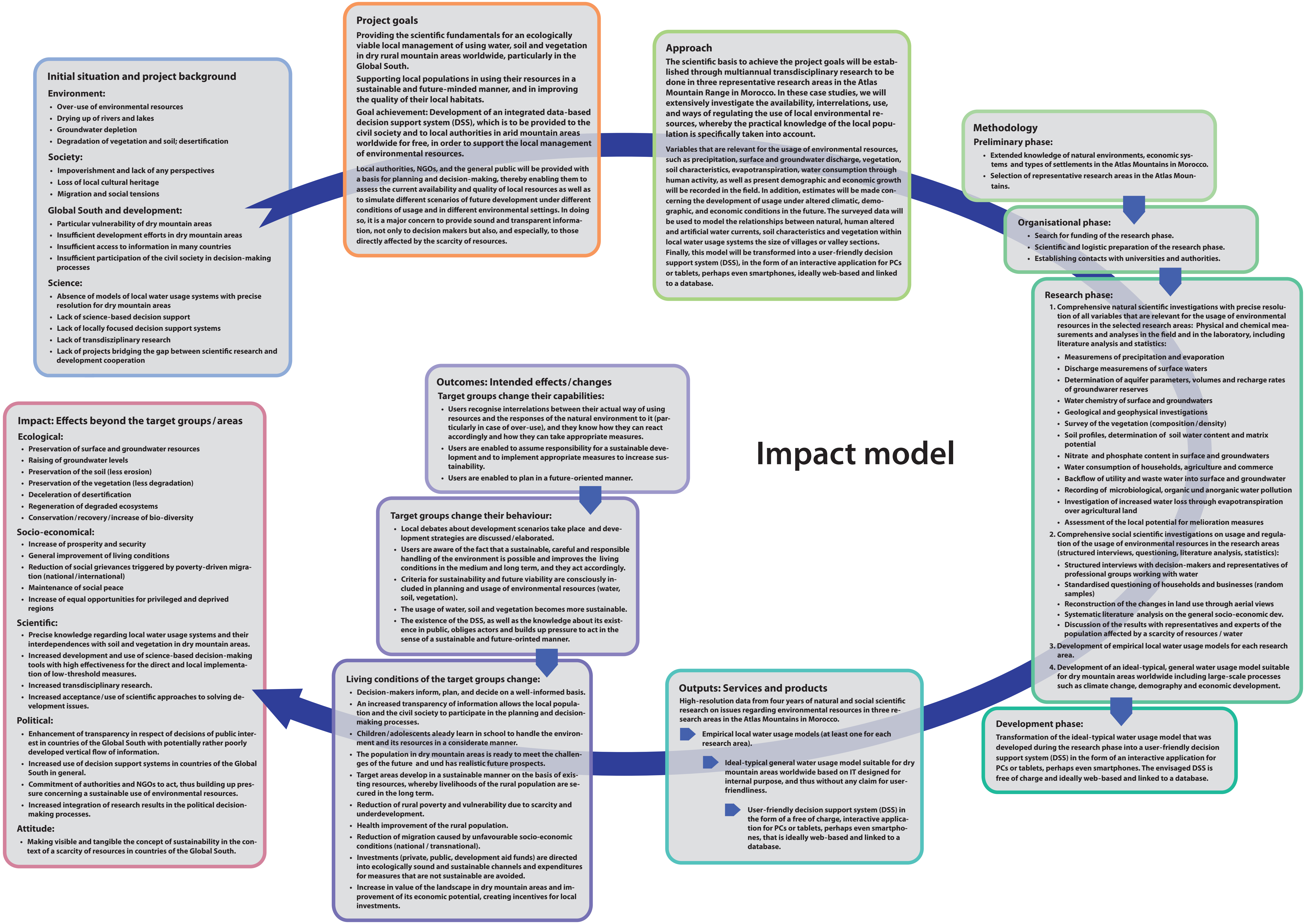


Fig. 3: Scheme showing initial situation and project background, project goals, approach and methodology, as well as outputs, outcomes and impacts of the project. The basis of the scheme is a comprehensive impact model in tabular form (log frame), that ist to be found in annex 1 (only in German).

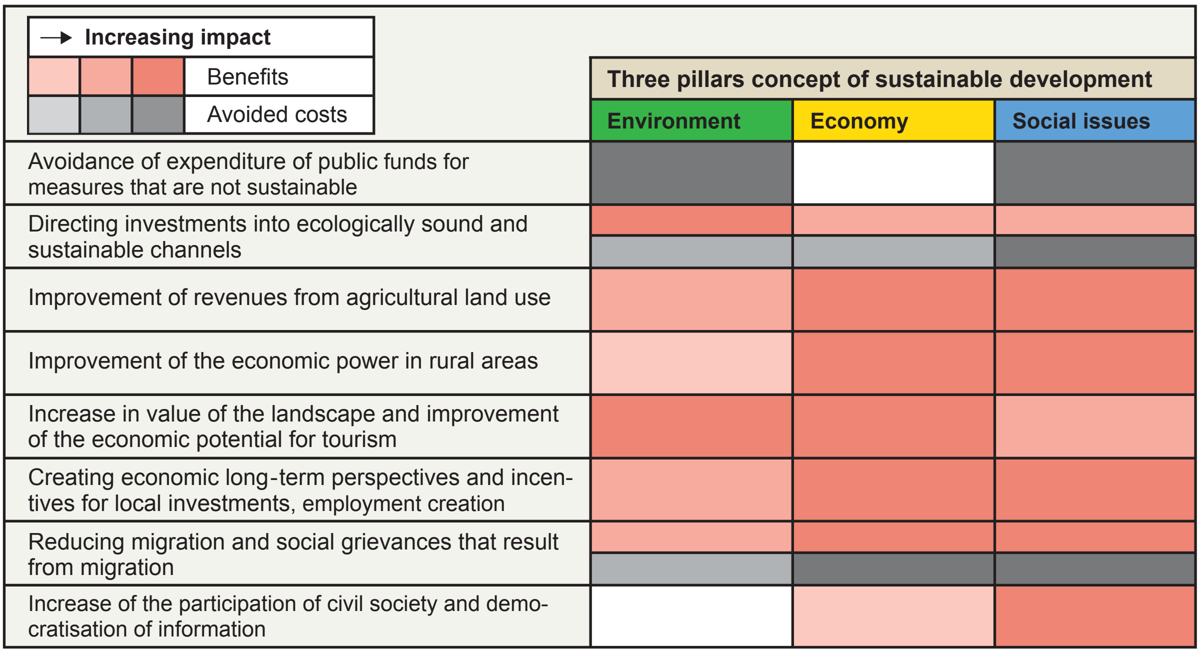


Fig. 4: Benefits and avoided costs on a qualitative level in the three pillars concept of sustainable development. The representation is based neither on calculations nor on statistics, it is purely illustrative.

them to partake in the devising and implementation of measures in many ways, also informally. In addition, both agreements underline the necessity to support the Global South in its efforts for more sustainability and in the fight against the consequences of global climate change. As a co-initiator of the Nansen Initiative[10], Switzerland has officially recognised the problematics of environmental migration and is thus particularly challenged to reduce environmentally harmful processes and their devastating consequences on a global scale.

6 Research gaps, originality, and innovation

Neither our commitment to sustainability goals, nor the involved research methods are exceptional. What makes our project unique, though, is our local approach and our way of combining different research methods in order to pursue these goals:

6.1 Local focus – global use

Usually decision support systems (DSS) for the use of water and related resources, such as soil and vegetation, are developed for large-scale, interrelated river basins (such as the Danube river) or water usage systems (such as large settlement areas or water storage reservoirs etc.). Their focus being on large-scale scenarios and their resolution remaining coarse, they would not be suitable for use by local policy-makers, planners and stakeholders[11]. In addition, the related research work mainly contributes to understanding large-scale interrelationships[12]. It is, however, at the local level that people are immediately confronted every day with existential consequences due to dwindling resources. Our intention, therefore, is to develop a DSS for a low-threshold usage in small catchment areas and in small-scale water usage systems, on the scale of villages or valley sections, which is applicable in dry mountain regions worldwide. This approach is characterised by four innovative features:

- The DSS enables local planning and decision-making directly in areas affected by a scarcity of resources, beyond the mostly large-scale approaches of supraregional or national authorities.
- A low-threshold access enables its use by the civil society at any time and in any place (local NGOs, interested groups, and individuals etc.). Their participation contributes to the transparency of planning and decision-making processes as well as to a more open access to information[13]. The DSS will be easy to use and its usage will be facilitated through tutorials (e.g. in the form of a training video).
- A web-based DSS on a joint platform will enable users to build up a global database and a collection of case studies themselves. These user data and user experiences will in turn help improve the DSS and increase its significance.

- A user platform will enable the direct linking of users and thus of individuals, groups, local authorities, and institutions worldwide that are faced with similar challenges in sometimes very remote regions.

6.2 Research with precise resolution and focus on dry mountain areas

We intend to develop a high-resolution hydrological-socio-economical water usage model for local, and at best, regional use that in addition to the natural environment includes all human activities related to water and also considers their impact on water resources, soil, and vegetation. To achieve this, we intend to investigate small-scale water usage systems in dry mountain areas the size of villages or valley sections in all detail, by “following the drop of water from its natural environment to human habitats and back again to nature” – to put it simply – whilst analysing what happens during the journey. No comparable studies have been conducted so far in dry mountain areas, in particular studies with similarly precise resolution are lacking.

6.3 Transdisciplinary approach

So far, research activities aiming at the development of DSS in the environmental field have mostly taken a multidisciplinary, rarely an interdisciplinary, and virtually never a transdisciplinary approach. While the multidisciplinary approach considers even complex systems as the sum of individual functions only, and no significant exchange between the involved disciplines takes place, interdisciplinary research follows an integrated approach. This approach considers a system as a functioning entity and seeks strategies for solution by integrating ways of thinking or methods of various disciplines. Both approaches, however, do not use the potential of the populations in the target areas of their research.

In order to optimally tailor our water usage model to the local conditions and needs, we will follow a strictly transdisciplinary approach[14]: In addition to integrating natural scientific and social scientific disciplines, we involve the local population in both the generation of knowledge and the development and evaluation of problem-solving approaches. Since our research objectives meet the interests of the local population, we confidently assume their benevolent cooperation in the field.

6.4 Educational benefit

In addition to the civil society and to institutional users, the DSS also benefits schools in the Global South, that wish to practice the sustainable handling of environmental resources with their students directly and locally, as well as higher educational institutions wishing to train students and professionals in the field of resource management.

6.5 Bridging the gap between scientific research and development cooperation

It has often been criticised by politicians and developmental organisations alike that there were hardly any planning and decision-making tools as a basis for a sustainable use of environmental resources. Seen the other way round, scientists were often disappointed that their research results were not sufficiently integrated in the political decision-making processes[15]. Our project plays a model role in how we apply scientific procedures to find solutions to developmental problems. It is located right at the interface between research and developmental cooperation, thus bringing together two fields which, by tradition, are far from being close.

7 Place of work

Preliminary research on which to base the development of the intended decision support system, will be carried out in several research areas of the Atlas Mountain Range in Morocco, an ideal working environment both from a scientific, eco-political, institutional, and logistic point of view.

Scientific arguments in favour of Morocco:

- In Morocco we are able to conduct case studies in areas with different climatic, morphological, ecological, hydrological, and geological conditions at various sea levels, that represent typical natural environments and economic systems in dry mountain terrains. We therefore expect highly representative project results that can be widely used also in other dry areas in the future.
- Morocco has been dealt with from a natural-scientific and social-scientific angle in countless detailed papers from both national and international sources, containing exploitable data. There is also a wide array of geographical maps, photos, and less recent aerial views available. These are especially important for analysing changes in population density or in the use of vegetation, land, and water.

Crippled evergreen oaks due to repetitive cutting off the branches as cattle feed, Aït Bou Oulli Valley, High Atlas.

Remnants of an at once dense cedar forest with soil erosion on a marly slope, near Amelgou, High Atlas.

“Bonsai” - thorn shrubs due to overgrazing by goats. Tizi Tirherhouzine, south of Agoudal, High Atlas. Image width is about 50 cm.

Clearing of the natural juniper forest on steep slopes to reclaim new agricultural land near Ouaouizarth, Middle Atlas. This procedure contributes to soil erosion through the formation of deep erosion gullies.

Dead cedar tress due to repeated cutting off the branches to feed animals in wintertime, whereas evergreenn oaks are less affected by this treatment. Near Amelgou, High Atlas.

Remnants of a conifer forest on land frequently used by nomads. Tizi N‘Talrhemt, southeast of Midelt, High Atlas.

Fig. 5: Degradation of the natural vegetation through overusing and logging of forests, and through overgrazing of the undergrowth by goat and sheep. Thus, soil is poorly protected from erosion by water and wind.

- The country is home to a relatively high number of universities that are active in the field of environmental sciences and avail of well-equipped laboratories.
- The Moroccan water authorities run a large-scale hydrological measurement network that serves especially to control the larger rivers and their catchment areas.

Arguments in favour of Morocco from a developmental and eco-political point of view:

- Due to a situation of overuse in the past decades, there is a demonstrable need for a sustainable management of the country's natural resources today.
- Morocco has become subject to severe environmental changes. Unless sustainable measures are taken in the foreseeable future, these changes will be further aggravated.
  - Less precipitation and distinct and longer dry periods
  - A more frequent drying up of surface waters and a lowering of the groundwater levels
  - More droughts with severe crop failures
  - Contamination of groundwater and surface water
  - Hazards to the water supply of households, agricultural land, trade and industry
  - Increasing degradation of the vegetation and acceleration of the desertification (fig. 5 on p. 7)
  - Soil erosion as a result of over-exploitation, degradation and desertification (fig. 5 on p. 7).
- The responsible ministries, regional authorities and communes as well as many NGOs in the domains of water and environmental issues are well aware of this highly complex situation. Therefore, there is a great demand in planning and decision-making foundations for a sustainable management of water and the environment. This has been repeatedly argued by various critical reports from governmental and non-governmental organisations and by various national water, environmental, and sustainability strategies[16] (see annex 2). It has raised awareness among authorities and national NGOs wishing to enter into partnerships with relevant projects in the field, as well as their readiness to support such projects on an institutional and logistical level.

Arguments in favour of Morocco from an institutional, political, and logistics point of view:

- Morocco is a politically stable country. It is currently the safest country in North Western Africa, if not in Western Africa on either side of the Sahara.
- Morocco lies within reasonable distance from Switzerland, which makes it possible to conduct field research with responsible environmental strain.
- Morocco has moderate consumer prices so that longer sojourns for research work there will not over duly strain the project budget.
- Corruption is relatively low.

8 Research, and data context

The results of the large-scale interdisciplinary project IMPETUS that was carried out partially in the Drâa river catchment in Morocco (Speth et al., 2010), of the interdisciplinary project GLOWA, including data from the Alps (http://www.glowa.org/; Mauser & Prasch, 2015) and of the WOCAT-Initiative, that identifies options for a sustainable land management in dry areas (Schwilch et al., 2012) are important for our project. For large-scale information on meteorology, hydrology, vegetation, land use, scenario simulation etc. data from the *IMPETUS open source Geonetwork* and from various publications of the *IMPETUS Atlas Morocco* can be used. For our procedure and modelling, both the GLOWA and IMPETUS projects can give valuable impulses. The modelling approaches of the partial project 'Danube', in particular, which tackled, among others, the issue of water management in the Alps, are certainly of considerable interest to us, although GLOWA did not investigate small-scale, but only regional and supraregional catchment areas. It has to be said, though, from a climate point of view that the Alps and the Atlas Mountains are only comparable in a very limited way. Of interest to us are also the results from the partial project 'Jordan', dealing with a sustainable utilisation of fresh water in dry areas, and from the partial project 'Volta', which – though located in the seasonally humid tropics – partly proved to reveal similar situations of water shortage as we found in Morocco. A list of the relevant literature can be found under http://www.i-brm.ch/docs/38_lit.pdf.

On top of that, there are numerous physio-geographical and human-geographical detailed scientific studies from Moroccan and international sources independent of IMPETUS or GLOWA which all may provide data. Partial aspects of these studies can be used for the topics of climate, geology, soil, vegetation, society, and the economy (for a list of the relevant literature, see http://www.i-brm.ch/docs/38_lit.pdf).

The Moroccan water authorities operate a large-scale hydrological measuring network which mainly serves the monitoring of the large rivers and their catchment areas while focusing in particular on the big dams in the densely populated and economically important areas in north and north-west Morocco and in the basin between the high Atlas mountains and the Anti Atlas. The runoff data of all larger rivers are published annually. However, no direct data is obtainable from the many small-scale water systems in these mountain ranges. Therefore, it will be an aim of ours to check the availability of relevant data at small-scale levels.

9 Project phases

The project includes four phases. A preliminary phase of 15 months from April 2015 to June 2016 was used to select appropriate areas for conducting the case studies. It is followed by the current organisational phase, used for the provision of further financial means, for building institutional contacts, and for the preparation of the research phase. The research phase, scheduled to last four and a half years, will start in the second half of 2017 with natural scientific and social scientific field research and the modelling of the water usage systems investigated. The last phase is the development phase that is scheduled to take one and a half years and that will be used for developing the decision support system (DSS) and to implement it as a user-friendly IT solution. Fig. 6 shows the four phases of the project and fig. 7 shows the project plan in detail. The methodology is explained in the following chapter 10.

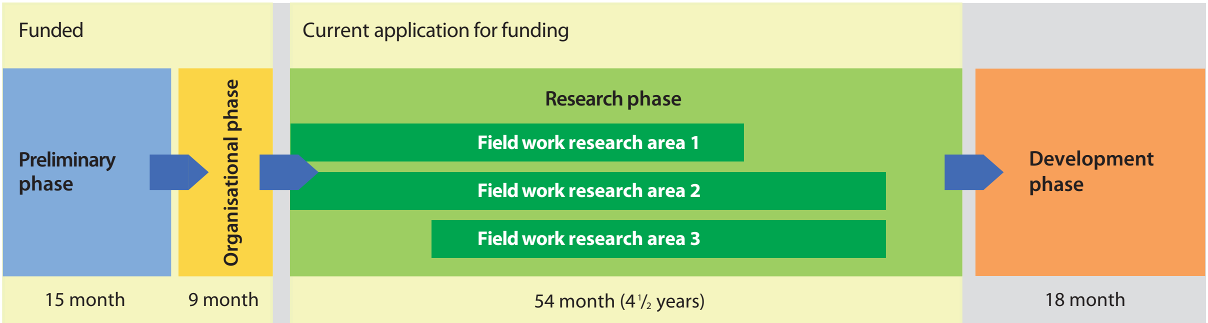


Fig. 6: Project phases

10 Methodology

10.1 Preliminary phase: Selection of research areas

The preliminary phase was used to select appropriate areas in the size of villages or valley sections, for conducting the case studies. To do this, we travelled to the High Atlas and the Anti Atlas Mountains in Morocco in spring and autumn 2015 for a total duration of nine weeks, documenting and classifying the cultural landscapes there in full detail (see the *Compendium of cultural landscapes in the High Atlas Mountains and the Anti Atlas Mountains of Morocco; results of the first year of the project 2015/16* with included CD).

During the preliminary phase, 63 areas in the High Atlas, the Anti Atlas and the Jebel Saghro region made it to the shortlist of potential research areas. Among these, 3 main research areas were selected based on criteria such as water stress, morphology, natural vegetation cover, agricultural and touristic exploitation (tab. 1 on p. 11). Other important criteria for selection were the possibility to widen the research radius step by step in each area (the phase model is explained in fig. 9 on p. 11), the presence of local disseminators that would support the project idea, as well as the availability of housing for the project team during the fieldwork phases. Should any questions come up during the project, which cannot be answered in the 3 main research areas, there will be a possibility to extend the study to other areas as well.

The fold-out map (fig. 8) shows the three main research areas plus a number of other areas that are eligible for additional studies. In the High Atlas, the research areas are marked with the introductory letters of the catchment area in

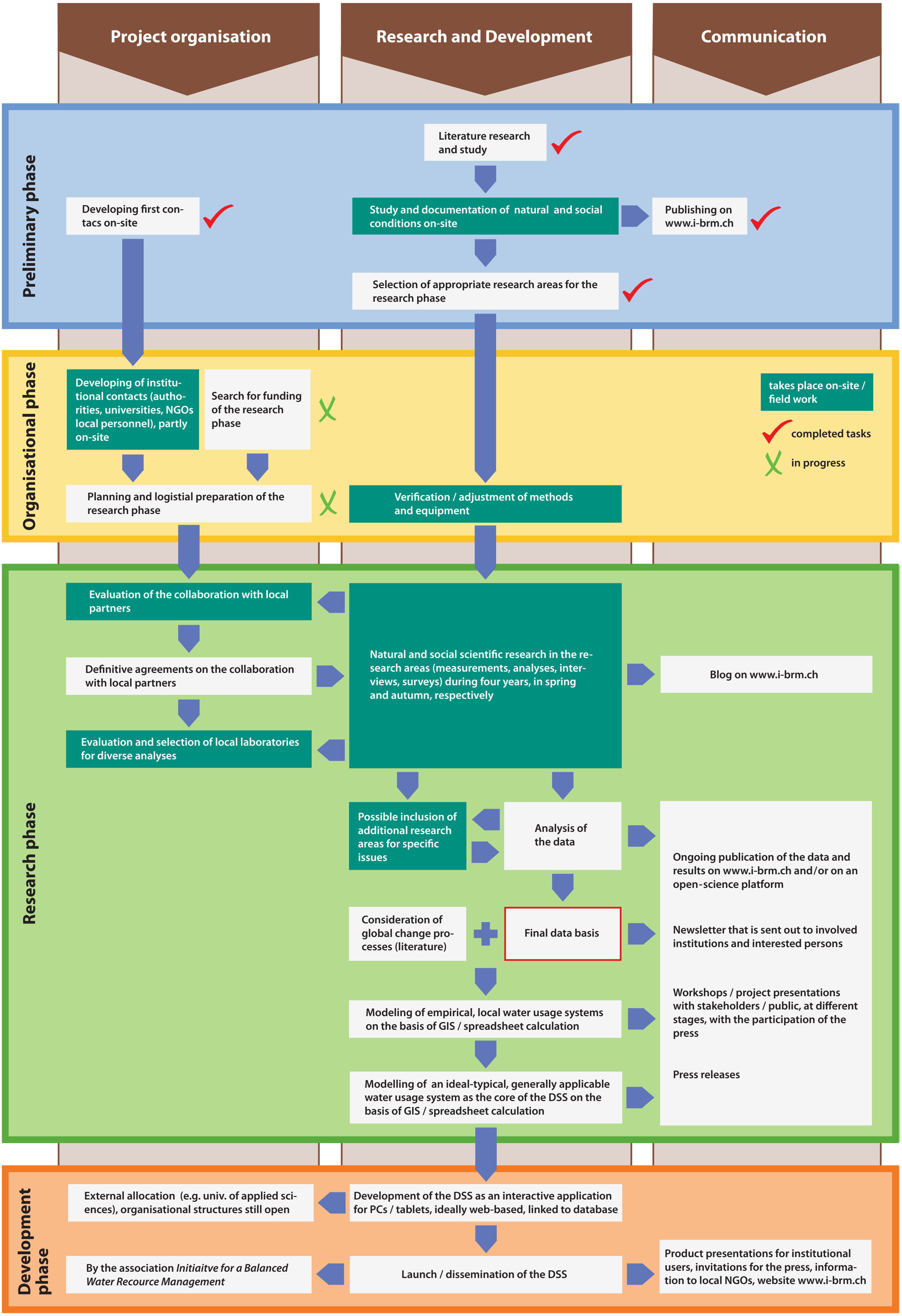


Fig. 7: Project structure plan showing the four phases and the three tracks *organisation, research and development, and communication*.

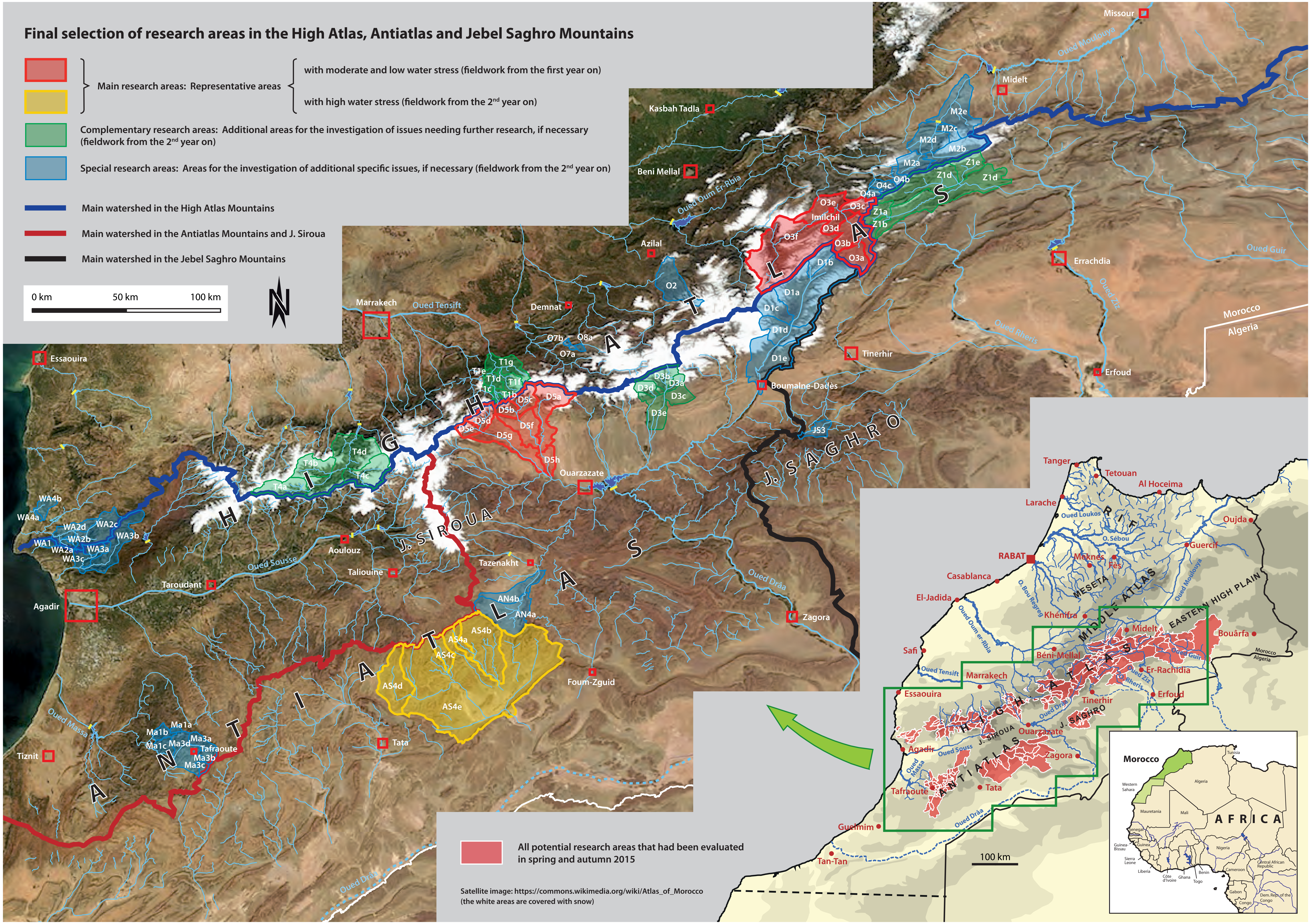


Fig. 8: Overview map of all research areas in the Moroccan Atlas Mountains. The three main research areas are red and yellow. The green and blue areas are complementary areas for special issues possibly coming up in the course of the work.

Table 1: The three main reasearch areas in the Atlas Mountains.

	Main research areas	Mountain range	Climate	Water stress
1	Upper course of Asif Melloul / valley of Imilchil-Agoudal	High Atlas	Temperate to summer-dry (mountain/steppe-climate)	Small to medium
2	Asifs Ounila, Mellah and Tamstin/N'Tamnat	High Atlas	Hot, summer-dry (steppe/desert climate)	Medium to large
3	Canyons and alluvial plains of Akka Ighane-Tissint	Anti Atlas	Hot, arid (desert climate)	Large to very large

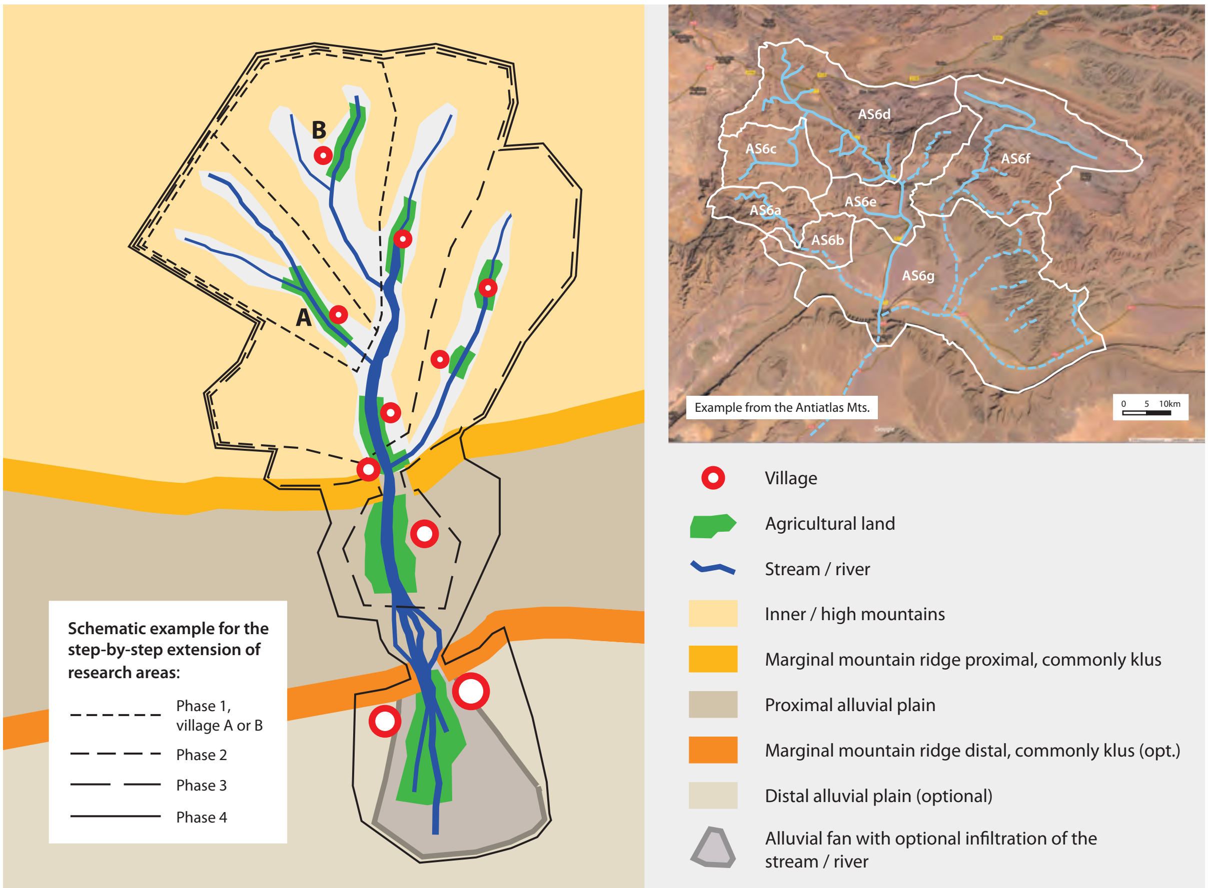


Fig. 9: Phase model showing the possibility to widen the research radius step by step.

question, followed by a serial number. The letters in lower case represent partial areas as shown on the phase model in fig. 9. Due to the absence of permanent river systems in the Anti Atlas, the research areas there have been subdivided into a North flank (AN) and a South flank (AS). The Jebel Saghro areas are shown under the abbreviation 'JS'.

The following pages 12 - 20 show the 3 main research areas, each on a map based on a large-scale satellite image, (© Google Earth 2016, Astrium, Cnes/Spot Image, DigitalGlobe, Landsat), two detailed maps based on small-scale satellite images, and various photos (figs. 10-18).

10.2 Organisational phase

Based on the research demands in the research areas, we will make contact during the organisational phase with the corresponding local universities as project partners, and the scientific and logistic preparation of the research phase will be advanced.

Documentation of research area 1: Upper course of Asif Melloul in the valley of Imilchil-Agoudal.

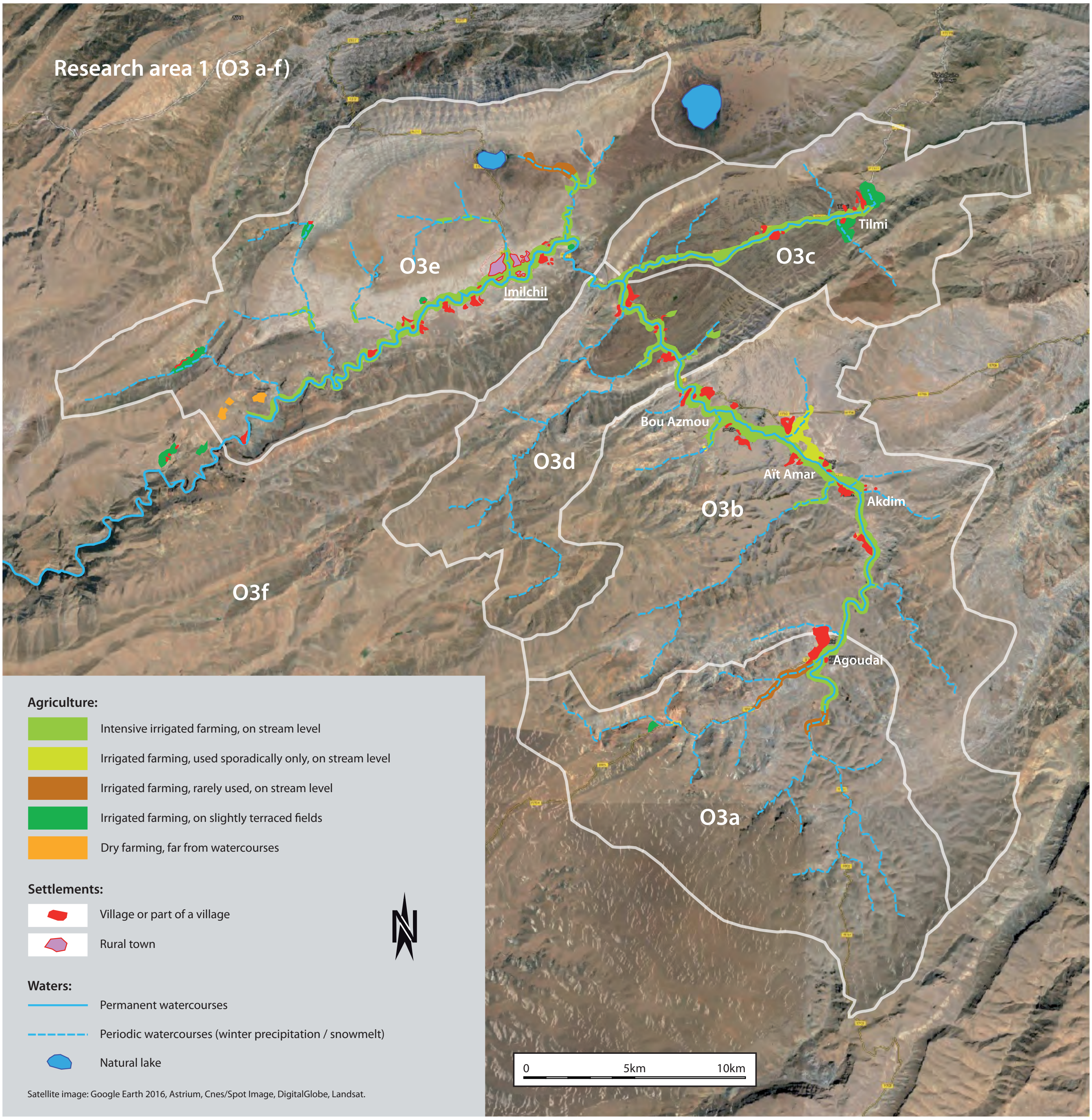
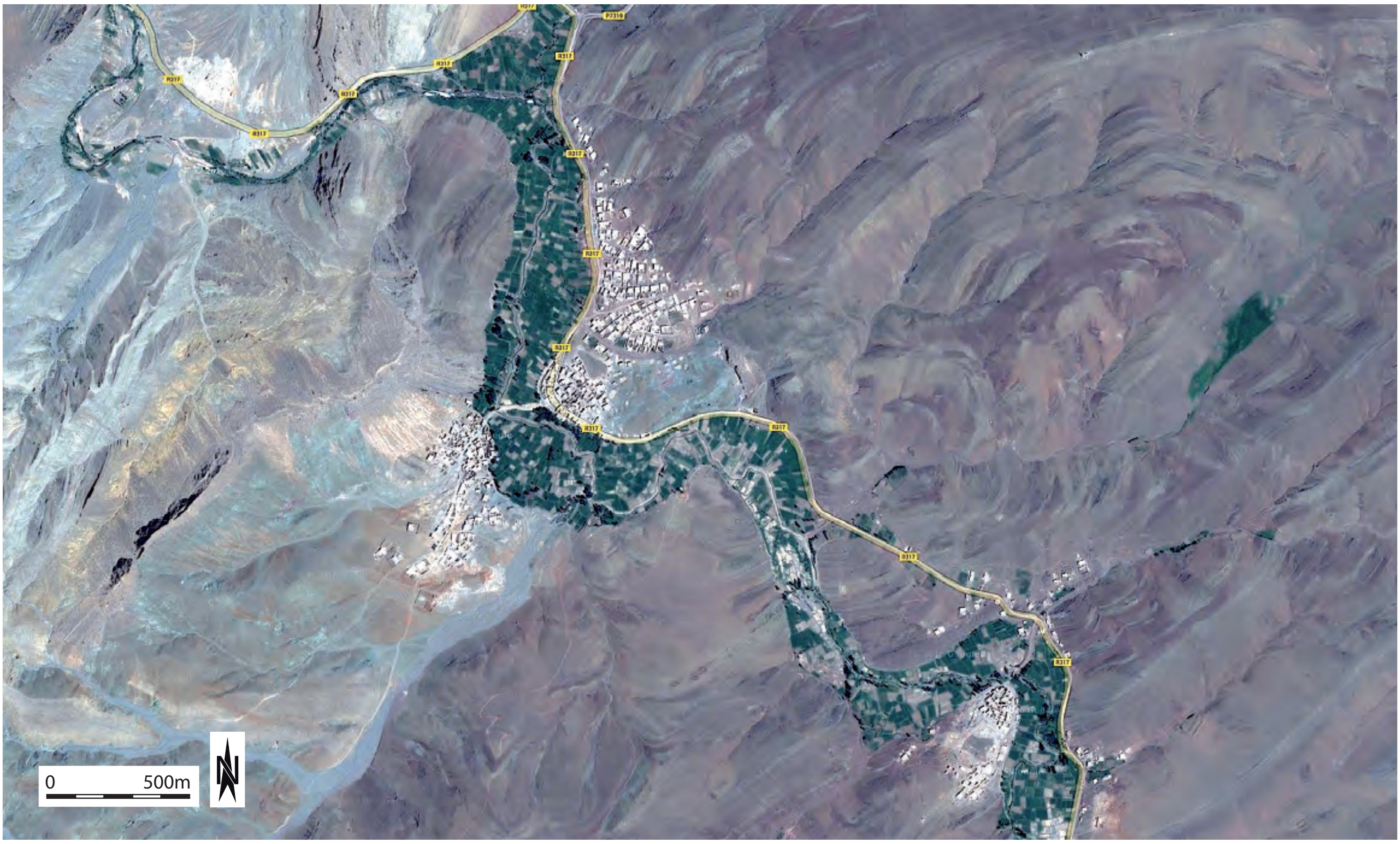
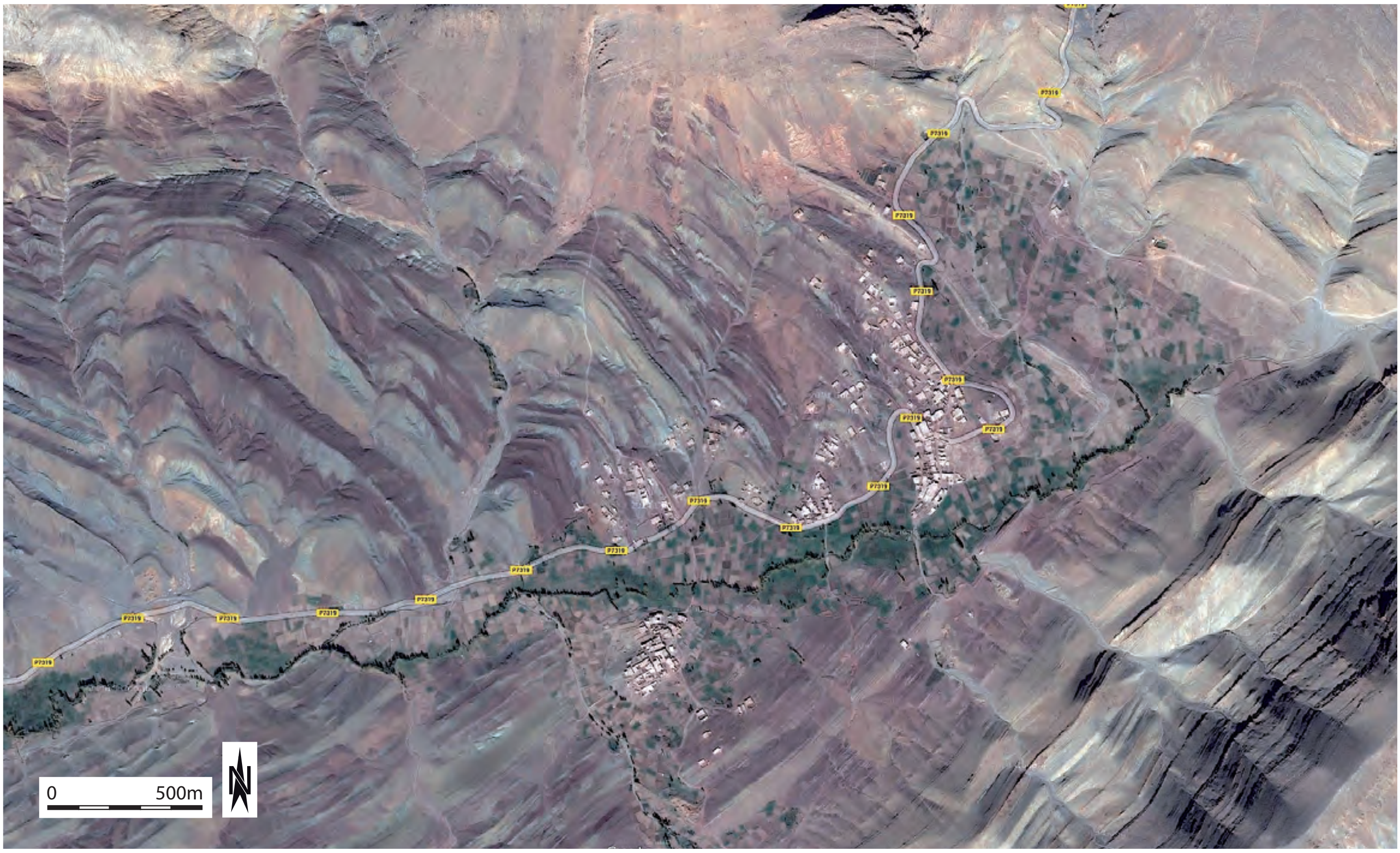


Fig. 10: Map of research area 1 based on a satellite image (Google Earth 2016, Astrium, Cnes/Spot Image, DigitalGlobe, Landsat). "O3" is the name used for the purposes of the project: 'O' stands for the catchment area of the Oued Oum Er-Rbia. Although some of the regions in the vicinity of water bodies are densely populated, only a few villages have been marked for better clarity.



Satellite image of the villages Aït Ali ou Ikkou N‘Imi N‘Tilmi and Tighramt Nihoudine, situated southeast of Imilchil. The irrigated fields are located on alluvial land on both sides of the Asif Melloul. They are mostly used to grow cereals and fruit. Grey rocks are limestones and marls of Jurassic age, reddish rocks are marls and clays of Jurassic age.



Satellite image of the villages Tilmi und Tabanast in a lateral valley of Asif Melloul. The irrigated fields are located on alluvial land on both sides of the brook. They are mostly used to grow cereals and fruit. Grey-brown rocks are limestones and marls of Jurassic age, reddish rocks are marls and clays of Jurassic age.

Fig. 11: Research area 1: Detailed satellite images of two selected areas (Google Earth 2016, Astrium, Cnes/Spot Image, DigitalGlobe, Landsat).

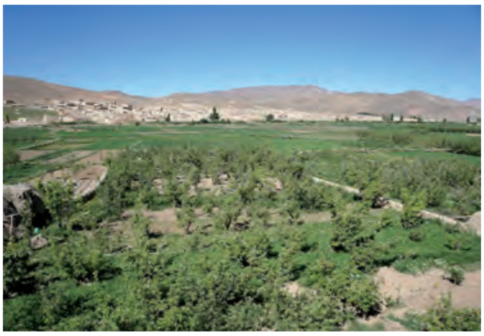
Agoudal with its irrigated fields (Asif Melloul valley).

Uprooting of shrubs for use as combustibles, Agoudal (Asif Melloul valley).

Ploughing by mules with a wooden plough, near Agoudal (Asif Melloul valley).

Asif Melloul with an irrigation channel on the left hand side.

Irrigated fields near Timarrhyine (Asif Melloul valley).



Fruit plantation near Akdim (Asif Melloul valley).

Irrigated fields and ploughman near Sountate (Asif Melloul valley).

Irrigated fields near Taghighachte (lateral valey of Asif Melloul).

Irrigated fields near Aït Yekko (lateral valey of Asif Melloul).

Mountain town of Imilchil (Asif Melloul valley).

Fig. 12: Research area 1: Upper course of Asif Melloul in the valley of Imilchil - Agoudal.

Documentation of research area 2: Asifs Ounila, Mellah and Tamstin / N‘Tamnat

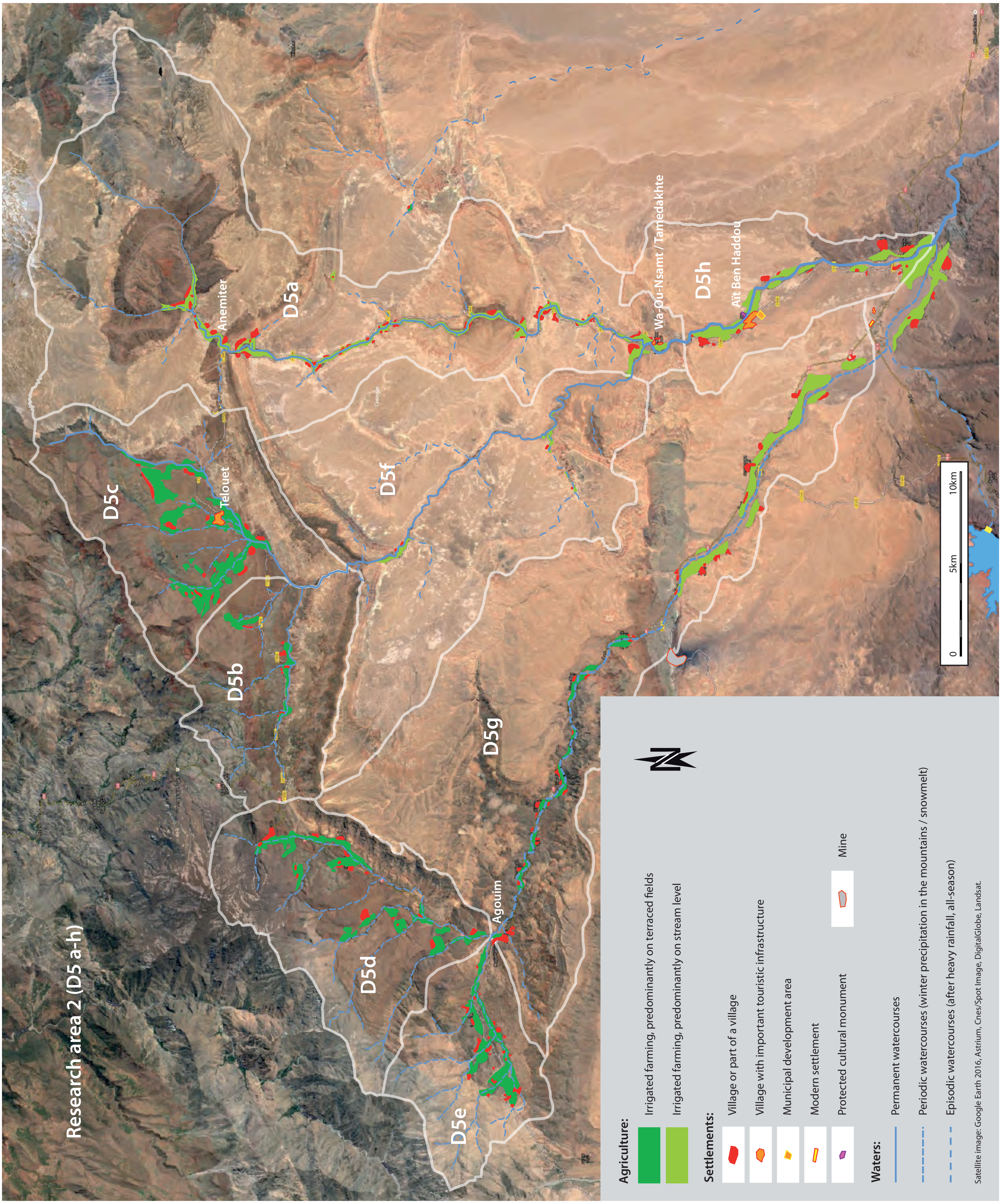
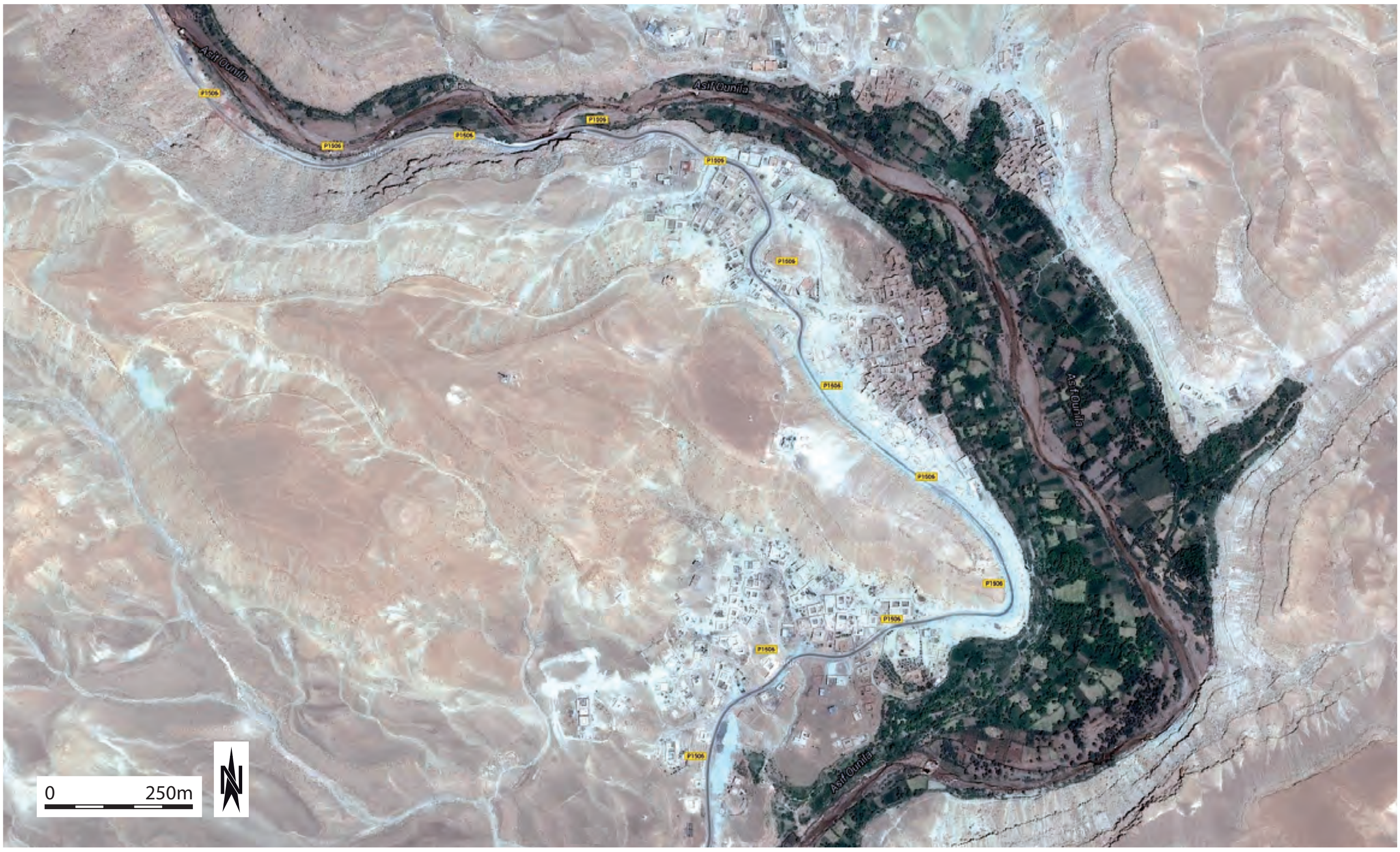


Fig. 13: Map of research area 2 based on a satellite image (Google Earth 2016, Astrium, Cnes/Spot Image, DigitalGlobe, Landsat). “D5” is the name used for the purposes of the project: ‘D‘ stands for the catchment area of the Oued D̲râa. Although some of the regions in the vicinity of water bodies are densely populated, only a few villages have been marked for better clarity.

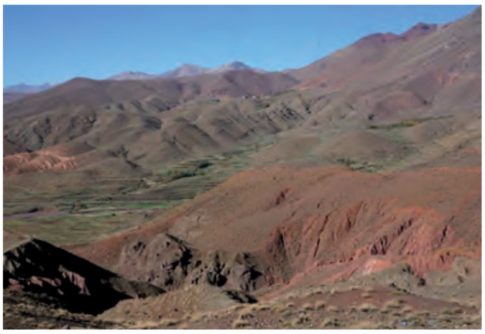
Satellite image of the villages north of Telouet with irrigated, terraced fields used to grow cereals (light green) and olives (dark green). The reddish fields are not irrigated, they are used to grow additional cereals in case of sufficient precipitation and soil humidity (dry farming). The reddish soil is the result of weathering of red clays of Triassic age with intercalations of melaphyrs (volcanic rocks).



Satellite image of the villages Tiggrte and Aït Farse. The irrigated fields are located on alluvial land at the bottom of the Asif Ounila canyon. They are used to grow cereals, olives and walnuts. The beige rocks are imestones of Cretaceous and Tertiary age.

Fig. 14: Research area 2: Detailed satellite images of two selected areas (Google Earth 2016, Astrium, Cnes/Spot Image, DigitalGlobe, Landsat).


Upper section of the Asif Mellah valley, seen from the Tizi N‘Tichka mountain pass road.


Irrigated, terraced fields in the Asif N‘Tamnat valley.


Irrigated, terraced fields near Argue (Asif Mellah valley).


Irrigated, terraced fields near Telouet (Asif Mellah valley).


Anemiter (Asif Ounila valley).


Irrigated fields and olive / walnut trees near Anguelez (Asif Ounila valley).


Tiourassine with irrigated fields (Asif Ounila valley).


Taguendouchte with irrigated fields (Asif Ounila valley).


Tajeguite (Asif Ounila valley).


Assaka with irrigated fields (Asif Ounila valley).


Asif Ounila with irrigated fields.


Aït Farse with irrigated fields (Asif Ounila valley).


Wa-Ou-Nsamt with irrigated fields (Asif Ounila valley).


Oasis gardens of Wa-Ou-Nsamt (Asif Ounila valley).


Ksar Aït Ben Haddou at the lower course of Asif Ounila, a UNESCO-world heritage site.

Fig. 15: Research area 2: Asifs Ounila, Mellah und Tamstin / N’Tamnat.

Documentation of research area 3: Canyons and alluvial plain of Akka Ighane-Tissint

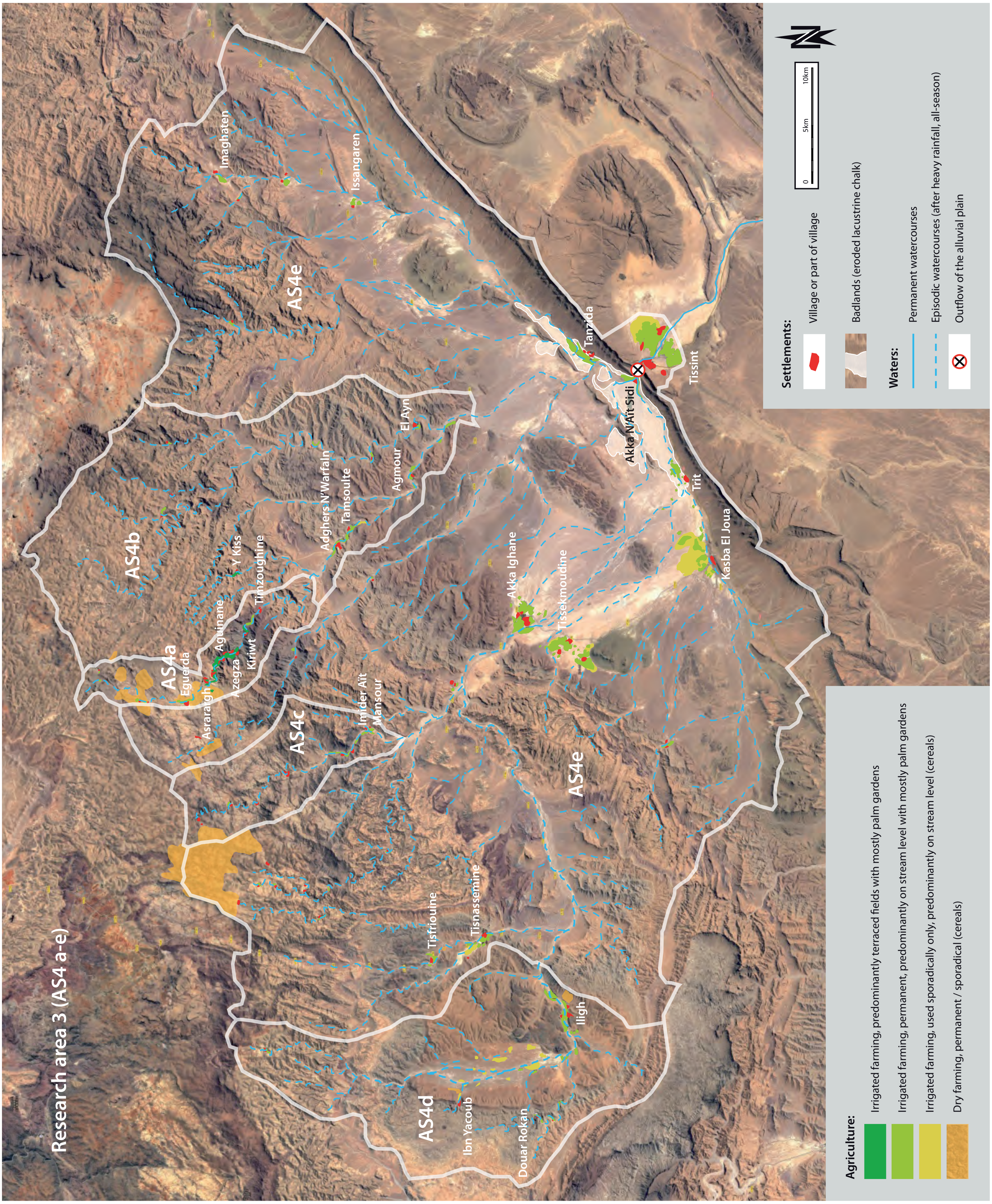
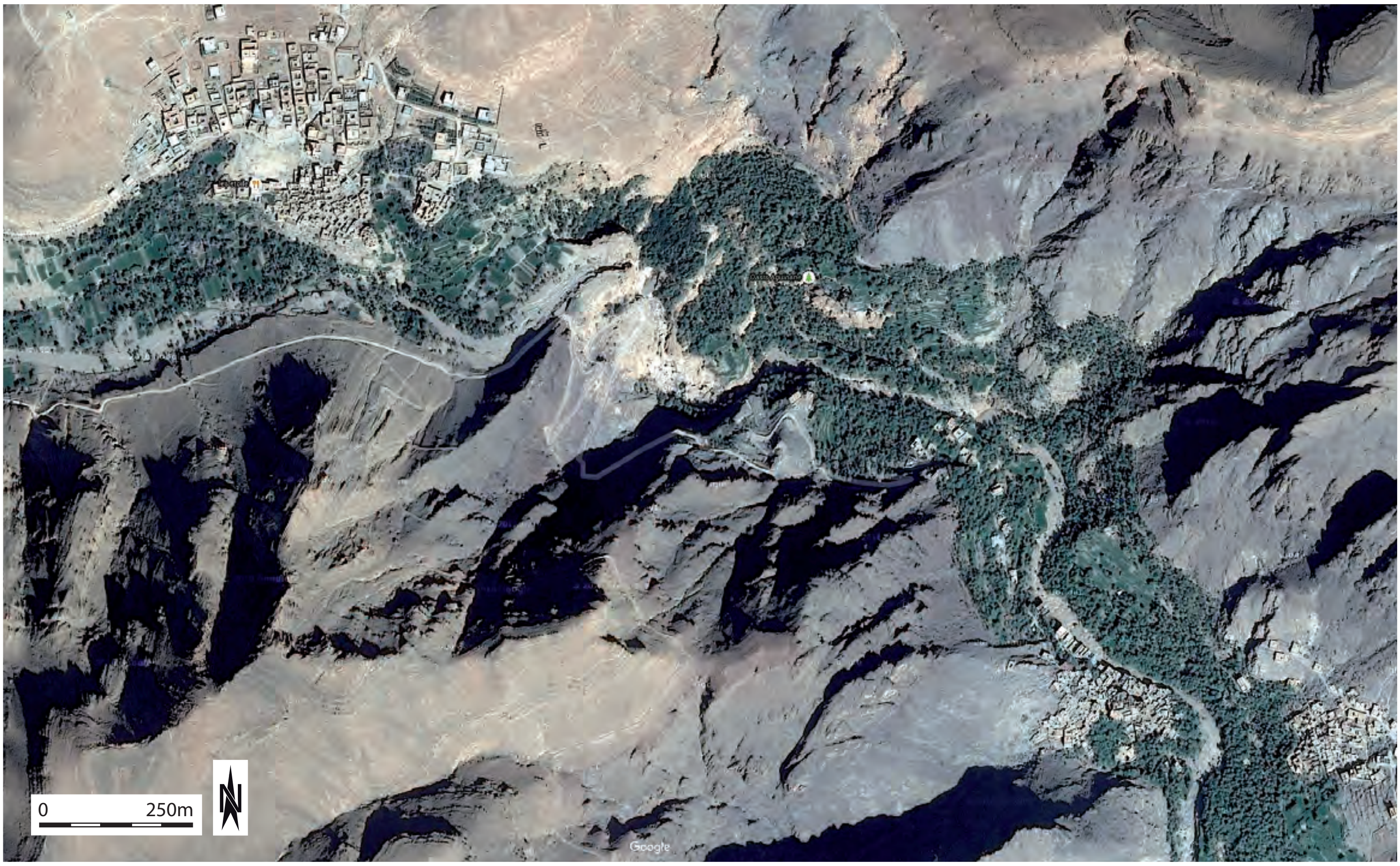


Fig. 16: Map of research area 3 based on a satellite image (Google Earth 2016, Astrium, Cnes/Spot Image, DigitalGlobe, Landsat). "AS4" is the name used for the purposes of the project: AS stands for the South flank of the Anti Atlas. All villages inside the research area have been marked.



Satellite image of the village Aguinane with irrigated, terraced fields and palm gardens in the uppermost part of a narrow ravine. The reddish grey rocks are Precambrian volcanic and volcanoclastic rocks, the beige rocks are Precambrian dolomites and sandstones.

Satellite image of the village Tanzida with irrigated palm gardens at the southeastern margin of the Akka Ighane-Tissint alluvial plain. The strikingly bright parts are badlands made up of limnic sediments, suggesting that the alluvial plain was permanently flooded in the course of recent earth history.

Satellite image of the village Adghers N'Warfaln with irrigated and partly terraced fields and palm gardens. The beige rocks are Lower Cambrian dolomites and sandstones.

Fig. 17: Research area 3: Detailed satellite images of three selected areas (Google Earth 2016, Astrium, Cnes/Spot Image, DigitalGlobe, Landsat).

Palm gardens and village Adghers N'Warfaln.

Irrigated, terraced fields and palm gardens north of Adghers N'Warfaln.

Palm gardens of Aguinane.

Irrigated, terraced fields in the palm gardens of Aguinane.

Terraced palm gardens of Aguinane.

Irrigated, terraced fields and village Azegza.

Draw well of Timzoughine.

Dry riverbed at the northern edge of the Akka Ighane-Tissint alluvial plain.

Village Trit at the southern edge of the Akka Ighane-Tissint alluvial plain.

Confluence of the two rivers draining the Akka Ighane-Tissint alluvial plain below village Akka N'Aït Sidi (northwest of Tissint).

Akka Ighane-Tissint alluvial plain with acacias, indicating the existence of groundwater.

Dry riverbed crossing the badlands of the Akka Ighane-Tissint alluvial plain along its southern edge.

Village Ibn Yacoub.

Fig. 18: Research area 3: Canyons and alluvial plain of Akka Ighane-Tissint.

10.3 Research phase

Detailed qualitative and quantitative modelling of the total local water balance of ground and surface water systems in the selected research areas will form the core of the case studies. In fig. 19 the most important components of a water balance are depicted. We will record all relevant natural, human altered and artificial water inflows and outflows and examine the various influences on them, while steadily expanding the research radius within each research area (see also the phase model in fig. 9 on p. 11). We will, in particular, focus on the relationships between the natural water budget and the conditions of soil and vegetation on the one hand, and on the impact of human activities (agriculture, households, commerce, tourism) on the availability and quality of water, on soil, and on vegetation on the other hand. In addition, we will examine the impact of large-scale processes, such as economic and demographic trends, global climate change, and national water policies on local water balances, and integrate data from existing studies[17].

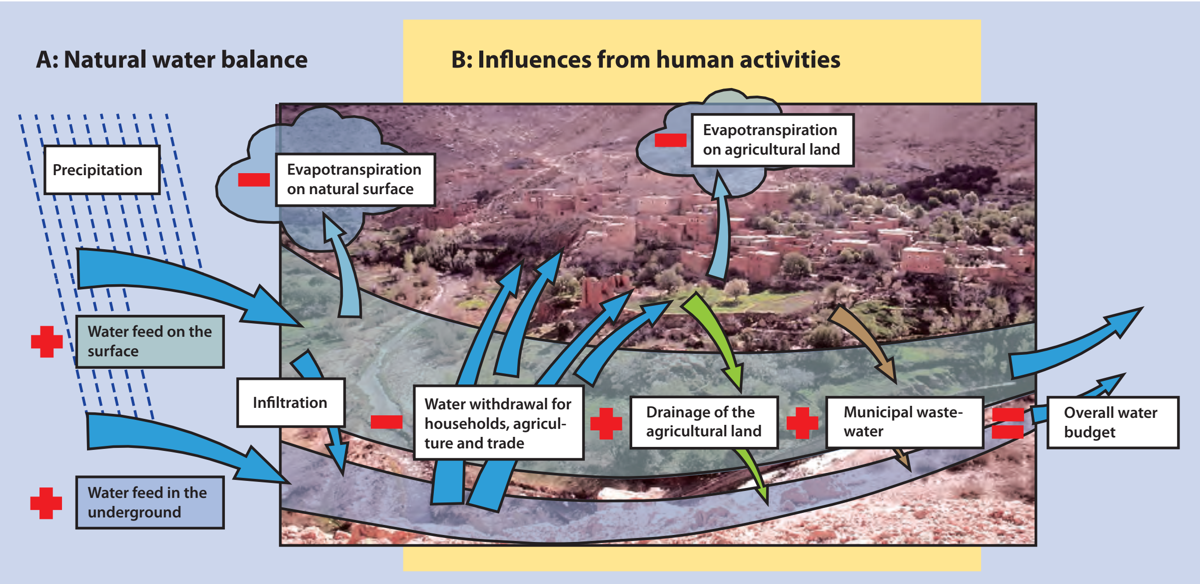


Fig. 19: Overall water budget in a system with variables, that are influenced partly by the natural water balance and partly by human activities. Components with red „+“ and „-“ are part of the local water balance equation.

10.4 Research methods

In all investigated systems, natural scientific fieldwork includes hydrogeological, pedological, ecological, and climatological investigations that are able to manage with as little logistic effort as possible. In doing so, we shall use above all physical and chemical techniques of measurement and/or analysis. Measurements will be conducted in different seasons and repeated over several years in order to obtain significant results and exclude extreme weather conditions. Social scientific fieldwork will include systematic interviews to be conducted with the resident population regarding their water-related activities in agriculture, at home, in trade, commerce and tourism.

Table 2 on page 22 shows a list of the major natural and social scientific investigations to be conducted in each case study. The research scheme shown on the folded plate in fig. 20 describes the interaction of the different scientific methods on the way to calculte a total water balance, with additional explanations on pages 21 to 30.

Physical and chemical measurements and analyses

A: Natural water balance, soil, and vegetation

Natural variables of the water balance

The major natural variables of the water balance are precipitation, evaporation (from open water surfaces, evapotranspiration from soil and through vegetation), as well as groundwater drainage and surface water runoff.

Precipitation

Precipitation in the hydrological catchment area of the water usage systems under research will be measured using simple pluviometers or more sophisticated pluviographs. The disturbing effects of wind and evaporation leading to measurement errors will be reduced using simple weather stations that supply data about wind force and tempera-

Table 2: Scientific investigations that will be carried out in every research area. Measurements will be conducted in different seasons and repeated over several years in order to determine seasonal variations, to obtain significant results and exclude extreme weather conditions. Interviews will be repeated at longer intervals.

Physical and chemical measurements and analyses include:

A – Natural water balance, soil, and vegetation

- Measurement of precipitation and evapotranspiration
- Measurement of surface water inflow and runoff (discharge measurements)
- Determination of aquifer parameters
- Determination of groundwater volumes and recharge rates
- Water chemistry of surface water and groundwater
- Geological and, if necessary, geophysical examination
- Registration of vegetation in terms of density and composition in representative places
- Soil profiles and determination of volumetric soil water contents and of matrix potentials

B – Influences from human activities

- Water consumption and water reflux from agriculture, households, trade and tourism from / in surface water and groundwater
- Organic and inorganic pollution of surface waters and groundwater
- Impact of waste water on ecosystems
- Investigation of land use
- Local potential of improvement measures (e.g. water storage, anti-soil erosion and anti-desertification measures, regeneration of natural vegetation)

Socio-economic investigations include:

- General handling of water in households, agriculture, trade and tourism (Si, Ss, Ob)*
- Regulative aspects of water use, e.g. distribution of water within communities and between communities sharing the same waters (Si, Sq, Ob)
- Conflict-solving strategies concerning water end environmental resources in general (Si, Sq)
- Traditional and modern techniques for collecting, storing, and transporting water (Si, Sq, Ob)
- Development and change in settlement and land use (Si, Sq, La, Hm, Ap, Ob)
- Economic and social development (Si, Sq, La, Ap, Ob)
- Statistical assessment of data representativeness
- Systematic analysis of literature on general socio-economic trends
- Discussion of results with representatives of the affected population

* Si = Structured interviews with decision-makers and representatives of professional groups working with water (e.g. farmers, owners of tourist accommodations etc.)

Sq = Standardised questioning of households and businesses (random samples)

Ob = Observations

La = Systematic literature analysis

Ap = Analysis of aerial photographs (if possible also historical)

Hm = Analysis of historical maps

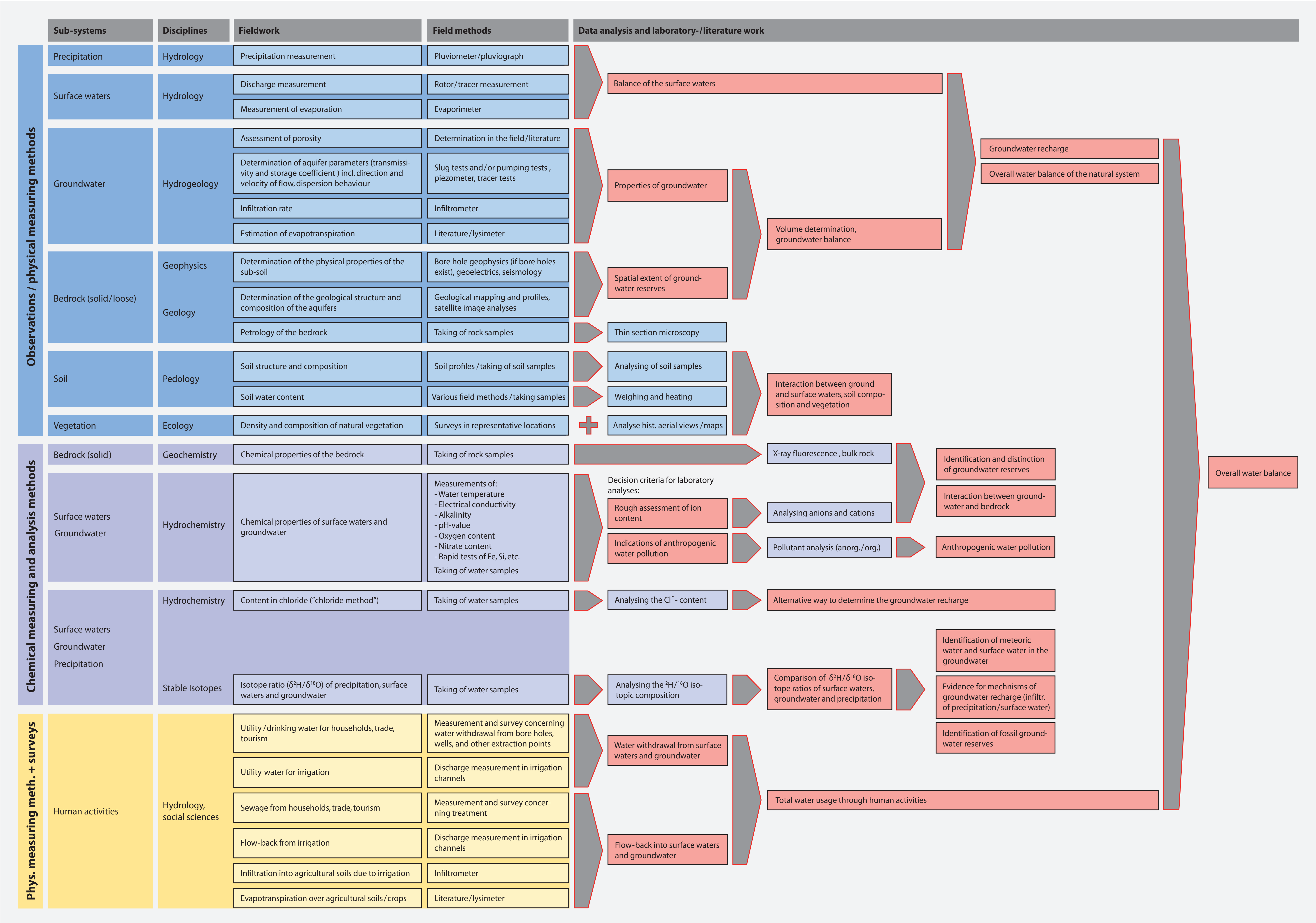


Fig. 20: Methodology: The path to the overall warer balance (including some interactions between the sub-systems).

ture. In addition, we can rely on large-scale weather and climate data from Moroccan environmental agencies and universities and on existing literature.

Surface waters

Surface waters (brooks and small rivers, see fig. 21, p. 24) will be surveyed through discharge measurements taken at the "inlet" and "outlet" of the research areas. Discharge of running waters with a simple profile and rather laminar runoff will be determined through cross-sectional measurements and flow velocity (or rotor) measurements, in case of turbulent runoff using environmental tracers (showing the thinning of a marker liquid after a certain distance). Open waters in dry terrains show a marked water loss due to evaporation from the water surface. This water loss is measured using an evaporimeter. The results will be compared with data from the literature.

Groundwater

Properties of groundwater resources

The main physical properties of a groundwater resource, or aquifer parameters, include transmissivity and storage coefficient of the loose or solid rock of the aquifer. Other valuable data to be gathered include the porosity and infiltration rate of the aquifer, the direction and velocity of flow, as well as the dispersion behaviour of the groundwater, in a scale appropriate to the size of the respective groundwater resource. Porosity – or pore space in soil – will be assessed based on the solid or loose rock present, either using values from the literature or identifying it in the rock itself. Transmissivity, storage coefficient, flow direction and flow velocity as well as dispersion behaviour can, in case of small-scale flow systems and opting for a simple method, be determined through slug tests in existing wells or bore holes, or in a more time-consuming process, through pumping tests to be carried out in one or several bore holes, with or without the use of tracers. In addition, groundwater levels will be measured and modelled over extended periods using an electric contact meter. Since the exact altitudes of wells and bore holes will only be known in exceptional cases, it will be necessary to measure the difference in altitude levels between their relative locations. The infiltration rate depends on soil structure and will be measured using an infiltrometer.

Volume calculation

To assess the groundwater resources of a certain area, it will be necessary to estimate their volume. The volume of a groundwater resource depends on the porosity (see chapter *Properties of groundwater resources*) and on the horizontal and vertical extension of the aquiferous rock formations, which are either determined – with the simpler method – by assessing the geological situation through detailed geological surface mapping or – in a more time-consuming approach – using geophysical methods (geoelectrics, seismology). Where drilling was necessary to capture the groundwater resources, the contractors or competent authorities might have access to drilling profiles, which would provide additional insight into the sub-soil. The groundwater level and / or volume fluctuations may be determined based on the water levels found in existing boreholes and wells using an electric contact meter.

Groundwater recharge

A volume calculation is no more than a snapshot in time and defines the maximum quantity of water theoretically available. If it is depleted, which should definitely be avoided, the area will risk the total exhaustion of its groundwater reserves. Therefore, in order to assess the availability of a groundwater reserve, the groundwater recharge is of great concern; it defines the quantity of groundwater regenerated per time unit, either by direct infiltration of precipitation into the subsoil or of water from rivers, brooks and lakes, and thus defines the amount of water available without risking a long-term drawdown of the groundwater table. In principle, the groundwater recharge can be determined via the general water balance equation *precipitation = surface runoff + subsurface drainage + evaporation*, however, a number of influencing factors that are difficult to verify need to be taken into consideration, too. To this end, we should know the sum of inflows (or precipitation), the amount of surface runoff, and the amount of evaporation. While precipitation and surface runoff in small-scale flow systems can be monitored with sufficient accuracy, evaporation from the soil or through vegetation (evapotranspiration) is very hard to determine.

Therefore, there is another option to determine the groundwater recharge with natural tracers that occur in precipitation. The chloride method yields good results especially in arid terrains near the sea. It measures and compares the contents of natural chloride occurring in precipitation and in groundwater, by means of chemical analysis. Another method is based on the comparison of stable isotope ratios ($\delta^{2}H / \delta^{18}O$); it is used for determining groundwater recharge by comparing the isotope contents in precipitation and in the groundwater resource. These methods are, however, limited by diverse local factors and their outcome can only be assessed once the first results are

Lower course of Oued Ziz, south flank of the High Atlas, north of Er-Rachidia.

Upper course of Oued Rheris with irrigated fields, south flank of the High Atlas, southeast of Assoul.

Oued Tata, infiltrating into the riverbed a few kilometers north of the town of Tata; south flank of the Anti Atlas.

Dry riverbed of Oued Akka, south flank of the Anti Atlas. In the dry season the water flows in the subsoil only in the form of a groundwater stream.

Fig. 21: Brooks, rivers and dry riverbeds in the Atlas Mountains.

available. In case of large-scale systems, the stable isotopes method can also provide information about mechanisms of recharge, i.e. it allows to determine whether a groundwater resource is mainly fed by precipitation or by surface water. Another method is based on the age of the groundwater resource; it also helps to find out about mechanisms of recharge (for procedures see chapter *Chemical and micro-biological investigation*).

Evapotranspiration

To determine water loss over either natural or agricultural areas, evaporation from soil (evaporation) and through plants (transpiration) play a decisive role. Evaporationtranspiration depends on the type and water saturation of the soil, the type of vegetation (plants with strong or weak transpiration through stomata), irradiation and thus the warming of air and soil/plants, air humidity and wind situation. These parameters are difficult to measure and are highly variable regionally and seasonally.

We will thus rely on values from the literature wherever possible. On-site measurements could be done using a lysimeter. Although small-scale lysimeter units can already provide good results, such measurements demand significant effort in terms of logistics, time and additinal funding, and will only be conducted with the help of local partners (e.g. national authorities or universities) to be won over during the course of the project for assistance with funding and operation.

Chemical and micro-biological investigation

A water balance first and foremost describes the quantity of water available. However, water quality is at least equally important. To appraise water quality, the surface and groundwater resources will be analysed in chemical tests several times a year. The following routine tasks will be carried out for each sampling campaign, in order to obtain a data base with constant data volumes across all research areas:

- Measuring water temperature, alkalinity, pH, electrical conductivity, oxygen and nitrate content directly after sampling, using simple analysis methods (titration) and measuring probes.

In addition, water samples will be taken where necessary for chemical/isotope-chemical analysis in the laboratory:

- Anions and cations in order to determine the natural salt content and anthropogenic contamination, e.g. by nitrates and phosphates from agricultural land use, as well as for the chloride method (see chapter *Groundwater recharge*).
- Oxygen and hydrogen isotopes (relationship of stable isotopes ($\delta^2H/\delta^{18}O$) in order to determine groundwater recharge (see chapter *Groundwater recharge*).
- Pollutant analysis in case of suspected heavy man-induced pollution (heavy metals, volatile and semi-volatile organic compounds etc.)

In case of suspected bacterial pollution due to household, industrial, or agricultural sewage, we will also take samples for micro-biological testing.

Geological and geophysical surveys

Understanding the hydrogeological situation requires seamless, or almost seamless, knowledge of regional geology. This applies just as much to the physical properties of the rocks, such as susceptibility to crevasse formation, the level of cracking or of pore space in soil, as to their chemical properties that determine their complex chemical interactions with the groundwater and thus its natural quality.

In addition to geophysical testing, geological mapping is the most significant basis for surveying a groundwater resource. For Morocco, only a few detailed recent geological maps are available, in addition to a large-scale geological map (scale = 1:1‘000‘000). It is thus to be expected that detailed geological investigation will be required during the course of the project. This is why we will try to gather as much geological information as possible, as a “by-product” of the actual fieldwork. If necessary, additional specific geological problems will be dealt with on site and/or in the laboratory (e.g. thin section analyses and bulk rock chemistry).

Where geological mapping should not suffice to survey the dimension of aquiferous rock formations, we will use geophysical methods, such as geoelectrics or seismology. As these measurements require a high amount of logistics and additional funding, they will have to be carried out in cooperation with local universities.

Vegetation

Vegetation plays a significant part in the infiltration of rainwater and snowmelt into the groundwater, and for evaporation as well as degradation and desertification processes. It will thus be surveyed in locations representative in terms of density and composition, in order to improve our understanding of the relationship between vegetation growth, soil composition, erosion risk, and infiltration.

Soil

Soils play a key role in water infiltration and groundwater recharge, for vegetation, evaporation, as well as for degradation and desertification processes. We thus intend to analyse soil profiles for the upper soil layers. To achieve this, we will excavate ditches with a depth ranging from several decimetres to approx. 1 meter, depending on soil types. This will help us to find out about the relationships between soil composition, infiltration, vegetation, soil erosion and evaporation, as well as to assess whether conditions are favourable for regenerating the vegetation cover, if the need arises.

Vegetation and infiltration of rainwater into the groundwater both depend, among other things, on the soil water content, which is subject to strong seasonal variations. The layer above the groundwater table, or unsaturated zone, usually contains adhesive water that is retained in the pores against the effect of gravity. This water may either stem from precipitation or, in arid terrains, pass through capillaries in the soil and, migrating from the groundwater to the surface, evaporate from there (generally referred to as *evaporative pumping*). The water content of the soil will be determined at representative locations on a seasonal basis, either by weighing and heating the samples or by calculating the volumetric water content using the TDR method (Time-domain reflectometry). In order to investigate the water balance in the soil, it will be necessary to measure soil water matrix potentials with a tensiometer.

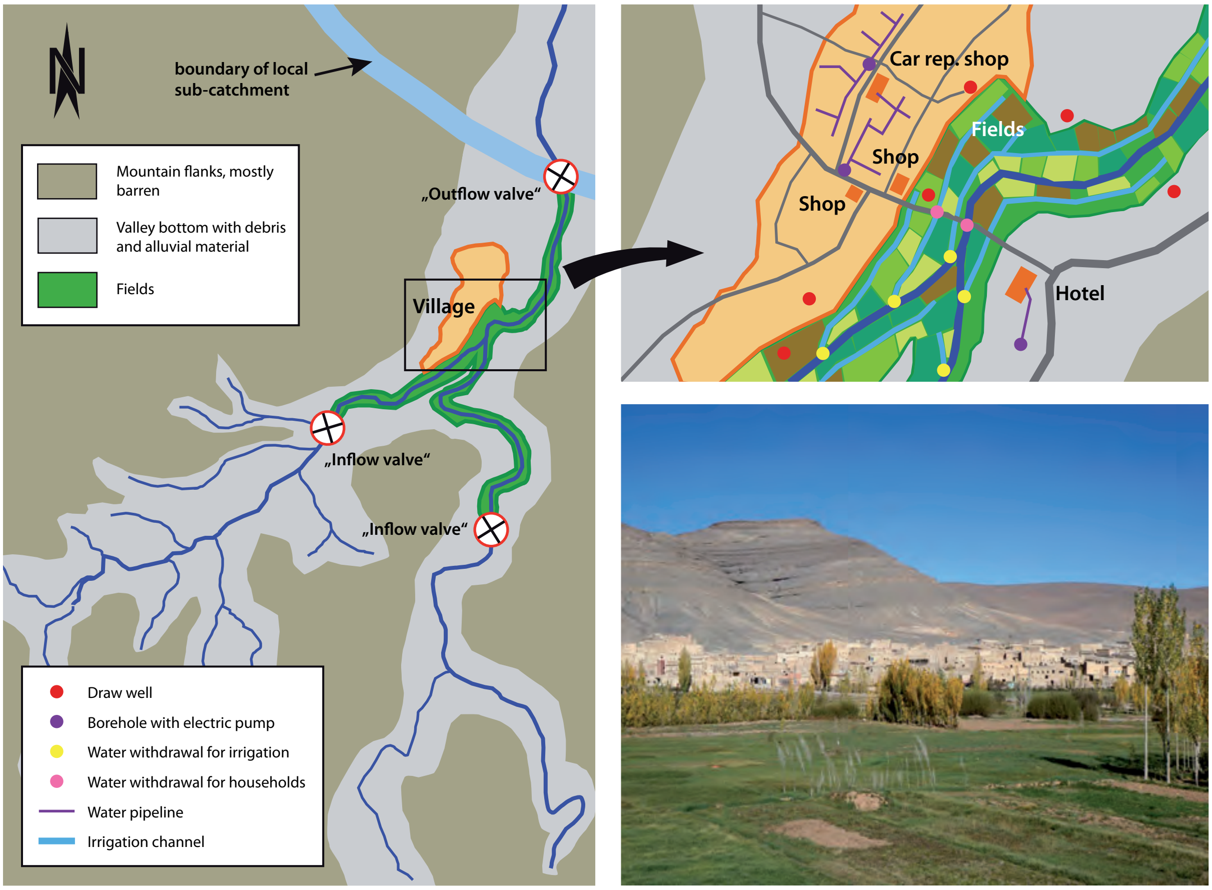


Fig. 22: Example of a small-scale water usage system: the village of Agoudal is located on a low-traffic but locally important pass road in the eastern part of the High Atlas. The main income for the population is agriculture, and the services sector is gaining in importance. The village is located in the remotest corner of a narrow valley and avails of a controllable, homogenous hydrological catchment area. Both the inlet and outlet of the flow system as well as the agricultural areas are well defined along the brooks. The village possesses several wells and boreholes.

B: Direct and indirect impact of human activity

In addition to the natural variables of the water balance, it is also necessary to measure anthropogenic variables, i.e. variables that either directly or indirectly influence the water balance due to human activity. (see also fig. 19 on p. 21). The focus in this case is on the influence of human activity on vegetation, soil conditions, water flow and water quality. For this purpose, natural and social scientific methods will be combined with each other (details on the social scientific methods are to be found on the pages 29 and 30)

Local water usage systems, mostly small catchment areas or defined stretches of rivers/brooks, may for the purpose of modelling be considered as “conduit systems” in which human activity functions as valves that direct the water to various areas of the flow system. Some of these “ducts” are natural (e.g. brooks, groundwater), while the remainder is generated through human activity (e.g. boreholes, wells, irrigation channels to fields, or piping leading to houses). Thereby the water stream comes in contact with other material flows (e.g. fertilizers, faeces, waste water etc.). A section of such a “conduit system” is shown in fig. 22, with the example of Agoudal in research area 1.

Measurements, interviews, observations, and mapping will be carried out in order to analyse the local economic activities and their qualitative and quantitative consequences for the water flows, both in terms of space and time. On the other hand, it will also be possible in this way to assess the consequences of potential changes of the availability and quality of water for various activities, such as drinking and utility water consumption or irrigation (along the lines of “what would you do if…”). In this case, utility waters and waste waters from households, agriculture, trade, commerce and tourism enterprises, as well as land use and water evaporation from agricultural surfaces (which is higher than that through natural vegetation) play a key role.

Utility water

In the research areas, we will survey the need for utility water in households, agriculture, trade, commerce and tourism enterprises, as well as the daily and seasonal variations. This will be done using different methods:

- Water meters in case of a public piping system with payable water consumption.
- Interviews and observations regarding the consumption of water taken directly from wells (fig. 23 on p. 28) or from surface runoff (e.g. counting the water containers filled from a well per day).
- Runoff measurement in agricultural irrigation channels. (fig. 24 on p. 29; for procedures see chapter *Natural variables of the water balance / Surface waters*).

Utility and waste water backflow

Utility and waste water returning to the same groundwater and surface water system from where it was taken is part of the total water balance of the ground and surface flow systems under research, and of major significance both in terms of quantity and quality. This water comes in contact with human activity in various ways: as domestic water, it can be polluted e.g. by faeces or cleaning products, or it can, if used for agricultural irrigation, be contaminated with residues of fertilizers or toxic substances. Our research will in particular:

- Assess the quantity and type of wastewater flows returning from households, trade, commerce and tourism enterprises to the natural hydrologic cycle.
- Assess the quantity and type of drainage in case of submersion irrigation and / or of seepage water returning from agriculture to the natural hydrologic cycle.
- Conduct chemical and / or microbiological analyses of waste and irrigation waters returning to the natural hydrologic cycle, where necessary.
- Study the influence of wastewaters on eco-systems (e.g. eutrophication of waters).
- Identify particular sources of pollution (agriculture, trade, commerce and tourism enterprises).

For procedures see chapter *Natural variables of the water balance / Surface waters* and *Chemical and micro-biological investigation.*

Land use

Utilized agricultural land may be split into grassland and cultivated surfaces (fields, orchards etc.). A comparison between grazed pastures and lightly or ungrazed pastures allows us to assess the influence of cattle grazing on the composition of species and stand density of natural vegetation and / or what is left of it. Changes to land use over the last decades may be reconstructed by analysing aerial views and historical maps. Cultivated surfaces are mostly irrigated and thus show higher water loss by evapotranspiration than unused surfaces.

Increased water loss through irrigation and evapotranspiration in agriculture

In dry areas, agricultural cultivation increases the percentage of soil covered in vegetation that has been unable to adapt its water balance to environmental conditions. The result is an additional need for irrigation. This leads to an increased water loss through the surface of plants (transpiration). Traditional agriculture mostly uses submersion irrigation, less frequently spraying irrigation. Both methods are relatively cheap, but they are also associated with high water consumption, and comparatively high direct water evaporation. Thus water evaporating and transpiring from irrigated surfaces represents a decisive water loss in the flow systems under research, and this has to be assessed.

Excessive irrigation leads to a correspondingly increased surface runoff and subsurface drainage. It redirects the water flow back to the groundwater table and constitutes a type of artificial infiltration; however, for establishing the water balance, it is important to distinguish between surface water and ground water use for irrigation.

The methodology of evaporation and infiltration measurements are explained in the chapter *Natural variables of the water balance / Properties of groundwater resources* and *Evapotranspiration*.

Potential for melioration measures

Micro-dams

We will assess the degree to which it is possible to capture surface water from precipitation and / or snowmelt for bridging dry periods through micro-dams (1000 - 2000 m^3) . This is, among other things, contingent upon whether this causes a down-valley shift of the water shortage, which might lead to conflicts over the use of water within a valley.

Measures against soil erosion, degradation and desertification, reforestation

Among the long-term sustainable measures to be taken against the erosion and degradation of soils are not only mechanical barriers, such as terraces to avoid the washing away, and wind fences to avoid the blowing away of soil particles with the wind, but also, and above all, the densification of extant vegetation or establishing of a new vegetation cover, in order to protect the soil against the erosive effects of wind and water. The construction of a new vegetation cover is another very effective measure when it comes to intensifying groundwater recharge, since it increases humidity in the soil and slows down surface runoff, whilst facilitating infiltration. Any new vegetation cover in arid terrain will require artificial irrigation over an extended period of time, in order to ensure that it will be able to sustain itself at a later stage. Scenario design thus also includes assessing the extent to which this is feasible, based on the available water resources, without causing damage due to the additional use of water.

Draw well for the water supply of nomads, high plateau in the southern Anti Atlas.

Cistern with a piping system in Argue, High Atlas.

Well with a mobile motor pump, used for irrigation of apple trees near Outerbate, High Atlas.

Former draw well recently equipped with a motor pump at Wa-Ou-Nsamt, High Atlas.

Rural households without water connection rely on water transportation with donkeys, Wa-Ou-Nsamt, High Atlas.

Fig. 23: Traditional and modern water supply in the Atlas Mountains.

Asif Ounila with a small dam made of stones and sandbags to branch off an irrigation channel (arrow); Tiourassine, south flank of the High Atlas.

Irrigation channel made of concrete near village Akdim, Asif Melloul valley between Imilchil und Agoudal, High Atlas.

Irrigation channel in the gardens of Wa-Ou-Nsamt, Asif Ounila valley, south flank of the High Atlas.

Open cistern and groundwater pump in the upper section of the Handour valley, Jebel Saghro.

Fig. 24: Water transportation and storage for irrigation in the Atlas Mountains.

Socio-economic research

Local water budgets cannot be reduced to water balances alone, whether natural or of anthropogenic origin, that are analysable and measurable by physical and chemical analysis. They are imbedded in a wide range of activities, behaviours, and developments that bear an influence on the water regimes beyond the mere consumption of water.

- General handling of water in households, agriculture, trade and tourism (Si, Sq, Ob)*
- Regulatory aspects of water usage, e.g. the distribution of water within communities and between communities sharing the same water bodies (Si, Sq, Ob)
- Conflict-solving strategies for water and natural resources in general (Si, Sq)
- Traditional and modern methods for collecting, storing, and transporting water (Si, Sq, Ob)
- Development and changes to settlements and land use (Si, Sq, La, Ap, Hm, Ob)
- Economic and societal development (Si, Sq, La, Ap, Ob)

* Methods involved:

Si = Structured interviews with decision-makers and representatives of professional groups that carry out work related to water or that control water flows: Staff of public authorities, farmers, owners or leaders of certain businesses, household members.

Sq = Standardized questioning of households and businesses (random samples)

Ob = Observations

La = Systematic literature analysis concerning the development of Morocco in general

Ap = Analysis of aerial photographs (if possible, also historical)

Hm = Analysis of historical maps

Representativeness of the surveyed data will be assessed using statistical methods. In order to guarantee the response accuracy required, interviews must be conducted in the local Berber language. To achieve this, local staff such as trekking guides, village teachers, students or phD students will be hired, introduced to and accompanied in their work. Results will be discussed with experts and representatives of the local population as part of workshops organized on site.

Water usage model

Based on the collected data, we will develop a model of interdependencies between natural and human-dominated water flows, and their dependence on soil characteristics and vegetation within local water usage systems, on the scale of villages or valley sections. Figuratively speaking, this is a water-network model composed of intakes, pipes, nodes, valves, and outlets, in which the variables most relevant for the use of environmental resources can be modified:

- Precipitation and evapotranspiration
- Surface water and groundwater flows
- Chemical and biological water pollution of natural and anthropogenic origin
- Soil characteristics
- Vegetation (composition, density)
- Water used and consumed by human activities (agriculture, households, trade and tourism)
- Activities and processes indirectly impacting water budgets (e.g. deforestation, degradation of soil and vegetation)

We will first create empirical local models in order to depict the situation in the research areas as realistically as possible; in first instance, though, these models will be valid exclusively for these areas. On this basis we will subsequently develop an ideal-typical model for general use in dry mountain areas, which is to form the core of the intended DSS. This model will then be supplemented with information about the economic, social, cultural, and ecological trends (e.g. temperature and precipitation trends due to global climate change) on the regional, national, and global level, as well as with information on possible forms of cooperation, regulations or rules for the use of resources. This water usage model is the output of the research phase. Initially, it will be based on IT that was designed for our own purpose and thus may in general not yet be as user-friendly as desired.

10.5 Development phase

The development phase will serve to transform the water usage model from the research phase into a user-friendly decision support system (DSS), perhaps involving the support of external experts for the development of the IT tool. The final tool should then allow to be applied in dry mountain areas anywhere in the world.

DSS are mostly software-supported procedures capable of sourcing, processing, representing, and analysing relevant information for operative and strategic tasks. Their purpose is to elaborate scenarios and prognoses. The DSS intended by this project is meant to be used by professionals as well as by interested lay people from the civil society. Operating with widely understandable pictograms, it should thus be easy to use and understand, and it will be provided in different languages. It should be accessible through a website that serves at the same time as a platform for collecting and exchanging data and case examples provided by users, which in turn will serve to improve the DSS.

The proposed DSS will enable users to create their own model of the local usage of environmental resources, in order to assess the degree of sustainability of their current resource usage and to simulate trends and scenarios: The DSS will guide users to input their own data concerning the local conditions or to agree to data automatically provided by the DSS, based on geographic location, thereby enabling them in a first step to assess the general availability of water resources. Further steps will allow them to modify different environmental variables in order to create trends and scenarios, and to assess the consequences for the availability and/or conditions of water resources, soil, and

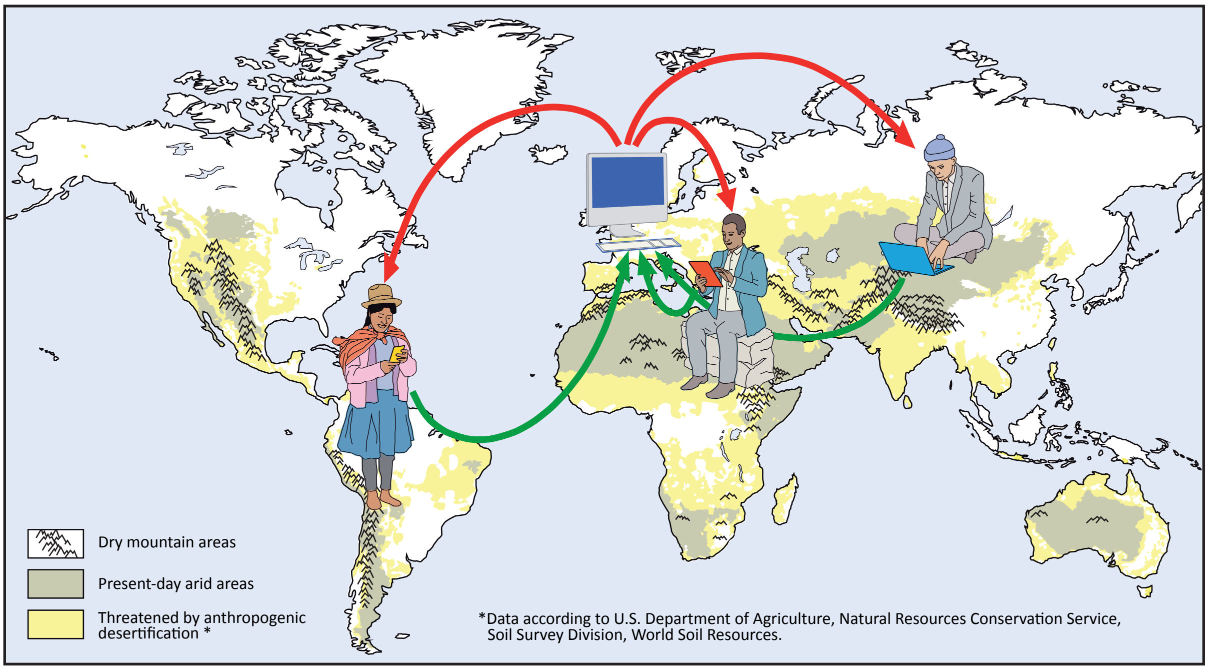


Fig. 25: Our vision: Networking among the users of the intended decision support system (DSS) through a common platform.

vegetation in the future, and thus also the feasibility of different activities (e.g. cultivation of certain products, growth of settlement, tourism offer etc.).

In doing so, the requirements on the user for creating a local database should be kept as low as possible on the one hand. Data, e.g. on climate, geology, vegetation cover and demographics that cannot easily be collected locally by the user him/herself should be obtained alternatively from public databases, using coordinates or references to geographical or place names of municipalities. On the other hand the tool should offer experienced users the opportunity of integrating comprehensive, user-generated empirical data and perhaps even adjust aspects of the model structure. The more local empirical data can be considered, the more precise the model and the more reliable and plausible the scenarios will be. The achievable quality level, the extent to which analogies between different geographical areas and natural environments can be reasonably determined, and the degree of variability of the model structure can only be assessed adequately after completion of the case studies. Our approach is the first of its kind and there are no previous projects or experience values that we could rely on. The intended functionality for users is illustrated by a number of examples in tab. 3 and in fig. 26 on page 33.

Table 3: Examples of questions on a general and a practice-related level that can be answered by the DSS.

Output: Illustration of	**Examples for general issues**	**Examples for practice-related questions ("what people in the villages are interested in")**
Data or as-is state	Current availability and quality of the water, potential hazards	Can the short-term water supply of households, agriculture and trade/commerce etc. be guaranteed?
Data evaluation	Degree of sustainability	How many m³ of water must be saved per year in order to achieve sustainability; or how much excess water is there?
Trends and forecasts	Natural and anthropogenic environmental aspects and their future development	How are water reserves developing – and with them the possible maximum amount of cultivable land – under specific demographic, economic and climate conditions?
Scenarios and their further consequences	Long-term water availability for the regeneration of the natural vegetation	Is it possible, given the existing water resources, to carry out the long-term irrigation of a reforestation area (with predefined dimensions, species of trees, etc.) without jeopardizing the water supply of the nearby villages?

Materially speaking, the DSS will be a user-friendly, interactive application for PCs or tablets, perhaps even for smartphones. Ideally these would be self-explaining, web-based, free-of-charge applications to be accessed through common web browsers without having to install extra software. In order to continuously improve the DSS, it is desirable to collect user-surveyed data and case examples in a global database. Users of the DSS, even in very remote areas, will have the possibility to network among themselves and to establish communication beyond a mere data exchange (see fig. 25 on p. 31).

10.6 Dissemination of the DSS

The DSS will first be used in the research areas in Morocco where the project idea is anchored in the local population and authorities due to a long-standing cooperation. Thereafter it will be disseminated on a global scale by the association *Initiative for a Balanced Water Resource Management*. In a first step, international conferences on environmental topics, workshops, water and environmental agencies as well as international and national NGOs will be used as dissemination channels. Once a certain level of awareness has been reached, and since the DSS will be available free of charge and in the form of a low-threshold service, we guess that it will start to spread on its own. During the project work, the promoting association will evolve into a centre of expertise and ensure the dissemination of the DSS as well as its further development and the upkeep of the related user platform and database.

10.7 A game as an optional project supplement (board game, computer game, app for smartphones)

A game that focuses on relations between society, nature and resource use in the Global South will increase the awareness and the comprehension of these relations. Being based upon our models and data, it will also ease the access to our DSS and thus supplement the tutorials in an attractive way. While adolescents will likely be interested in a computer game or an app, a board game may reach people with little affinity for IT. The players, e.g. representing fictitious villages, may have to arrange the water usage in their valley under the conditions of variable precipitation, population growth, economic constraints, climate change and other realistic factors. The game might be developed as a competition for graduate projects at universities or upper secondary schools. For the realisation we could seek collaboration with a game publisher or a software company, also including sponsoring.

11 Project organisation, cooperation, communications, and networking

11.1 Partner organisations

Local project partners: We are striving to implement a good institutional network by cooperating with local partners, as well as to anchor the project in the local community. Our primary university partner still needs to be designated. A number of contacts are already in place.

In the research areas, we will first and foremost seek cooperation with local development organisations built up by the population, most of which are organized under the umbrella of the *Initiative Nationale pour le Développement Humain*. Some of them also work on their own account, as e.g. the *Association AKHIAM*[18] that is active in the valley of Asif Melloul in research area 1. If and how government authorities will be involved will be decided during the course of the works on a case-by-case basis.

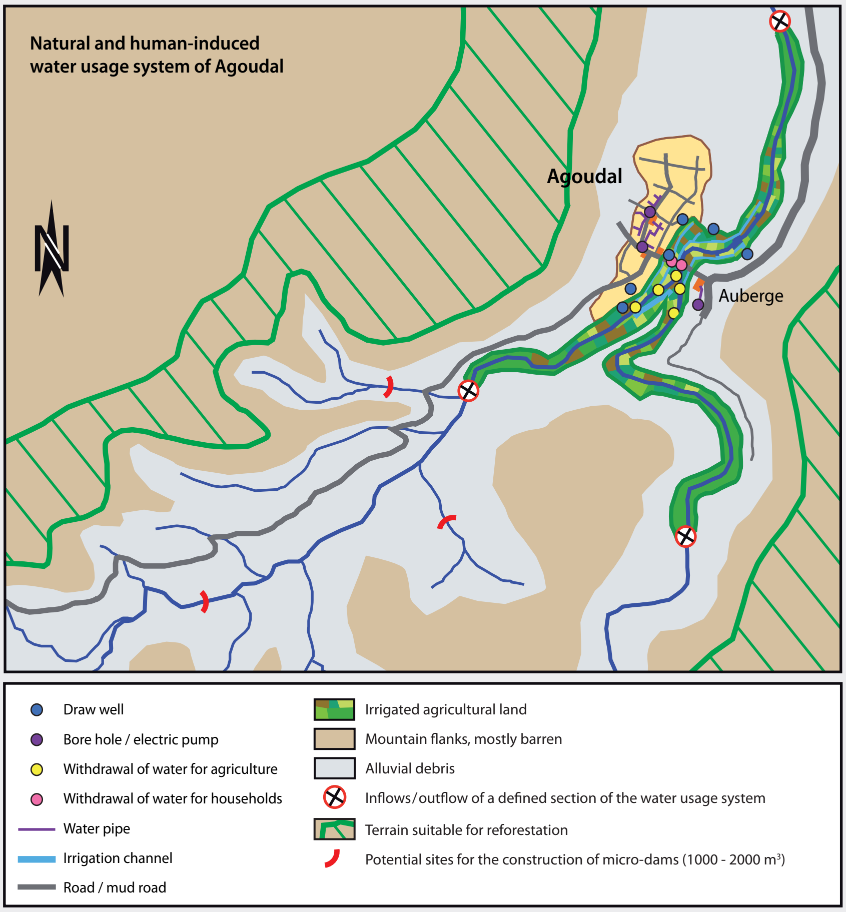
We will first of all be looking mainly for informal cooperations. Once these partnerships prove to be satisfactory, we can then go more in-depth together in the course of the project and, if necessary or desirable, we will then formalise our collaboration. When setting up our network, we know we can count on the Swiss Agency for Development and Cooperation (SDC) in Rabat.

Project partners in Switzerland: The central project partner in Switzerland is the *Institute of Natural Resource Sciences, Zurich University of Applied Sciences, Switzerland (ZHAW)*, which is at the same time the working place of the deputy project manager, Dr. Luzi Matile. The institute has its own highly suitable laboratories, and has gained a lot of experience in all sorts of technical questions concerning environmental management in the past. For very specific questions that might evolve in the course of the project, furher university institutes can be addressed and involved.

11.2 Project responsibility

Total project responsibility will be in the hands of the project team of the association *Initiative for a Balanced Water Resource Management*. The responsibility for selected parts of the project may be given siuationally, and in function of their resources, to local partners.

Potential functions of the decision support system (DSS), presented by the example of the village Agoudal (research area 1) with fictitious values.



Function: Current state of the resources

Example: Sustainability of current water usage

Function: Trends and forecasts

Example: Drinking and utility water supply with and without the construction of micro-dams

2025 / 2030 / 2035

2040	Drinking and utility water provided per capita per day in liters: January to May		Drinking and utility water provided per capita per day in liters: June to December	
Growth of the population	Without water storage	With water storage	Without water storage	With water storage
1 %	230	256	77	320
1,5 %	213	236	71	296
2 %	196	218	67	273
2,5 %	182	202	62	253
3 %	168	187	56	234

Funktion: Scenario creation

Example: Long-term effects of a reforestation on the water resources

2090	Drinking water available per capita per year in m^3	
Growth of the population	Without reforestation	With reforestation
1 %	84	141
1,5 %	58	97
2 %	40	67
2,5 %	28	46
3 %	19	32

Fig. 26: Potential functions of the decision support System (DSS), presented by the example of the village Agoudal (research area 1) with fictitious values.

11.3 Organisation of field work

Scientific field work will be coordinated and carried out mainly by the project team and by collaborators of local partner organisations. Partners will include universities and local development organisations. For long-term measurement series with short measuring intervals that cannot be automated, such as water level measurements or precipitation measurements, local people will be commissioned, e.g. the staff of local water authorities, or local village teachers.

Interviews as part of socio-geographic research will rely on local collaborators of both genders, since men usually do not have access to women in order to interview them. A prerequisite for taking part is a good working knowledge of at least one local language (Berber dialect) and a minimal understanding of scientific approaches and precision. This will be ensured by locally anchored teachers or trekking guides, perhaps also students or post-graduate students. A number of contacts are already in place.

11.4 Participation of directly concerned persons

All research work will be carried out in regions where people struck by drought and / or a scarcity of resources live. Through their local expert knowledge, these people are on the one hand directly involved with the collection of data, e.g. when surveys are carried out. On the other hand they have the opportunity to discuss project results on the occasion of special events to be held in the villages involved. In this way, they can influence the focus of the questions to be asked and help to set the direction of the solution-finding process. Proceeding in this way will combine the 'development from below' approach with our transdisciplinary research approach. Directly concerned people will also participate in the project work as paid local staff (see above); for instance in the long-term measurements or interviews / questioning to be carried out.

11.5 Subcontracting to local service providers

In the course of the scientific investigations, a great number of water analyses are planned to be carried out in laboratories of Moroccan universities or authorities. Therefore, there are plans for the beginning of the research phase to test diverse laboratories for a potential collaboration.

11.6 Synergies

The cooperation with local partners will yield synergies in the fields of expertise, problem solving, infrastructure, organisation, data sharing, and personnel resources. For the project team, in addition, institutional anchoring of the project goals as well as acceptance and dissemination of the outputs of the project through the participating actors are crucial. Universities in Morocco are always in search for research opportunities and training vacancies for both the professional and scientific practice of master and phD students. Therefore, it is highly desirable that students of master's courses and phD students in Morocco be attracted to the project so that additional detailed issues can be worked on.

11.7 Data handling and results

Public access to data and project results will be made transparent at any time due to our principle of open-science. Each measurement, analysis, and interviewing campaign and / or each modelling step will yield interim results (data sets, tables, diagrams, maps, reports etc.) that will continuously be made accessible on the project-promoting associations' website at *www.i-brm.ch* and / or on one of the recently launched platforms dedicated to open-science. All involved institutions as well as an ever-increasing circle of interested people will be informed via newsletter. The DSS as final product will be accessible free of charge. Results of greater relevance will additionally be published in scientific journals. This ensures that even in case of an early project end due to unforeseeable reasons the results will be accessible to the public at any time. Being a non-profit organisation, the association *Initiative for a Balanced Water Resource Management* will make sure that neither any interim results nor any final results will be used by third parties for commercial purposes.

11.8 Activities to enhance public awareness and project visibility

In addition to the regular publishing of data and results on the web page of the association *Initiative for a Balanced Water Resource Management* and / or on one of the open-science platforms, the latter will organise workshops about project-related topics. Representatives of NGOs, the scientific community, environmental agencies, and media representatives will be invited to participate. The purpose of the workshops is to strengthen the function of the association *Initiative for a Balanced Water Resource Management* as a competence centre and to raise awareness for the project. The project results will also be presented at international conferences held about environmental issues. (see also the track *Communication* in fig. 7 on p. 10). In addition, we try to place press articles.

The engagement of funding institutions will be mentioned on the website of the association, upon request. In addition, funding institutions will be given the opportunity to place their logos on the project vehicle, and reports about the project can be written for publications of funding institutions.

11.9 Project management and evaluation

Impact model (log frame): A central instrument for project management and evaluation is a impact model (log frame) that guides users through the project and contains information about inputs, outputs, outcomes, and impacts including indicators, target values, and sampling methods. A summary of the impact model is given in fig 3, the complete impact model in tabular form is enclosed in annex 1 (only in German). Each project step is a prerequisite for the success of the next step, which automatically ensures ongoing internal evaluation and check of the previous steps, thus triggering corrections, if necessary. Additionally, an external evaluation is informally done by our local project partners who, in their turn, will make their collaboration with us dependent on the quality of the project processes and results.

Controlling: Approx. 80% of the project work will be carried out by the project team itself. Project progress will thus mainly be monitored in the form of self-control. A time schedule with preset milestones and divided into quarterly periods will be used as a major monitoring tool (fig. 27 on p. 36). The quality and progress of outsourced work will be monitored through performance agreements and performance checks.

Auditability of the results, documentation of progress: All structural and organisational progress achieved by the project will be visible in that the scientific work is carried out within good time as scheduled. All progress made in the scientific work will manifest continuously in the ever new project results. These results will, depending on the phase of the project, consist of tables, theme maps, diagrams, explanatory reports or models of water utilization systems. All results obtained will continuously be published on the project-promoting associations' website at *www.i-brm.ch* and/or on an open-science platform. Of course, the results will also be contained in the annual accountability reports to be passed on to the donors. Any results of a far-reaching scientific interest will additionally be published in scientific journals. The field research work will be documented by photographs and, if moving images allow for a surplus in information, certain situations and sequences might even be filmed. Experience reports covering the work on site will be publically accessible in the form of blogs with pictures or short film clips on the associations' website.

11.10 Project exit, transition to post-project activities

Regular project exit: Parallel to the project, the association *Initiative for a Balanced Water Resource Management* will develop into a competence centre with the intention to initiate other projects in the environmental and sustainability fields and will thus remain active beyond the end of the project period. The association will accompany and actively promote the worldwide dissemination of the DSS. In addition, it will be responsible for the operation of the user platform and for regular updates.

Forced project exit before the agreed project end: Should an early project end be inevitable (see chapter 13, *Risks*), the project funds will not be lost. Each measurement, analysis or interview campaign and/or each modelling step will generate results that can also be used independently from the project and that will be continuously published on the associations' website at *www.i-brm.ch*, and/or on an open-science platform, and that, where appropriate, will also be published in scientific journals. Results are thus put at the disposal of users in research, education, and professional practice. Last but not least, the field work undertaken and internships made by students from Moroccan universities will help to create a permanent value as well.

12 Target areas and target groups: users and beneficiaries

Target areas: Rural areas in dry mountain regions worldwide, but primarily in the Global South.

Users: Regional and communal authorities, the civil society including local corporations and non-governmental organisations, research institutes and interested individuals will all be able to use the DSS as a planning and decision-making tool. At the same time, it will serve in the tuition of students and training of professionals in the field of resource management.

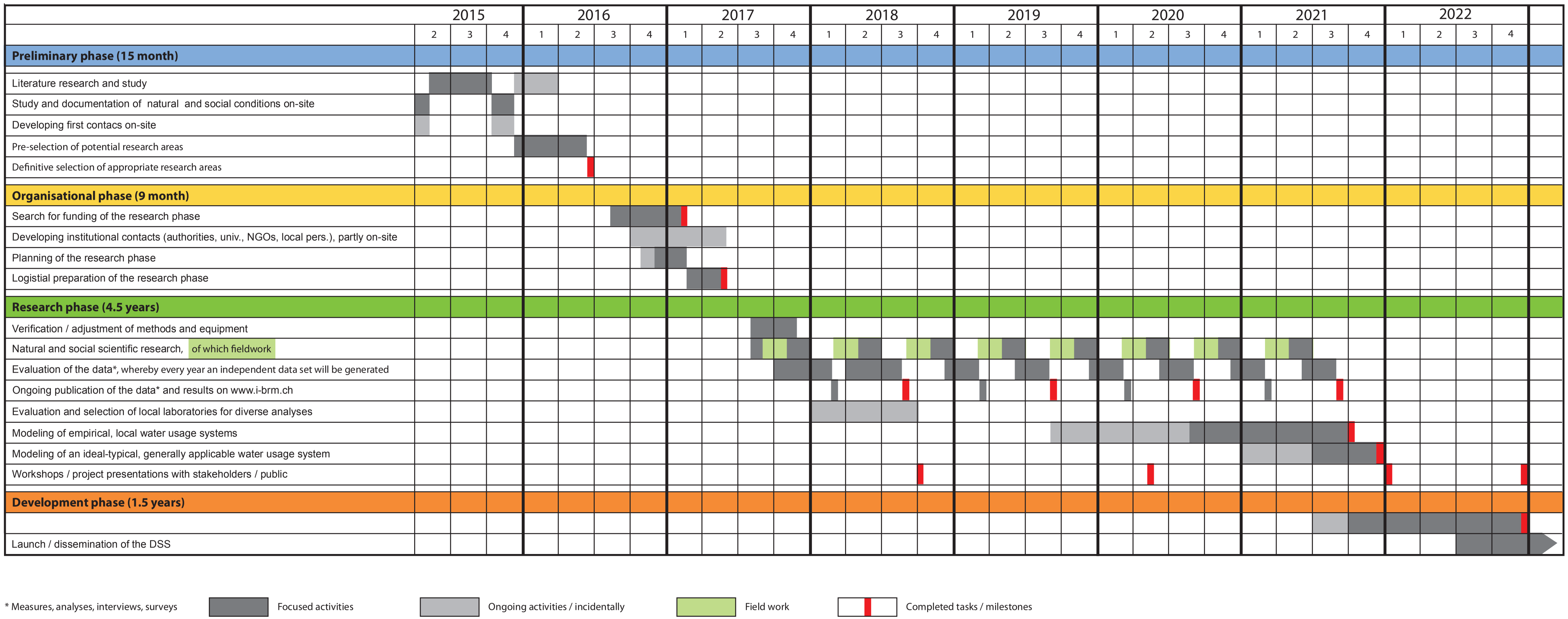


Fig. 27: Project schedule with milestones.

Beneficiaries: The beneficiaries of a future-oriented and ecologically sound environmental management are, first and foremost, all those struck by a scarcity in water supplies and environmental resources in dry mountain areas worldwide, but equally all those who might or will be concerned by such circumstances in the future.

Number of users and beneficiaries: The number of users will level off in the range of several thousands. The number of potential beneficiaries, in contrast, is very high. Today, an estimated 150 million people live in dry mountain areas, and this figure is increasing annually by tens of thousands more, due to the rapid expansion of arid zones. With several thousand users, of which everyone may represent an average of 500 beneficiaries (from individuals to representatives of entire valleys with several thousand inhabitants), we would be talking here of several million beneficiaries that will benefit from a sustainable and ecologically compatible environmental management through the intended DSS. In addition, there is a significant number of students and people from professional practice, who will raise their environmental awareness through training with the DSS.

13 Risks and measures to minimise risk

This Projekt will take advantage of a wide-ranging experience from the *Projet hydrogéologique pour une gestion durable et efficace des eaux souterraines du Mali* that was carried out by part of the the project team in Mali in the Sahel from 2002 to 2008. All risks that are currently visible and the measures to be taken in order to minimize such risks are listed in tab. 4 on page 38.

14 Requirement analysis

14.1 General

The need for scientifically substantiated decision support for a sustainable local management of environmental resources in dry mountain areas results, first and foremost, from the generally extremely alarming state of the natural environment in many areas in the world. This is particularly serious in those areas where deficiencies prevail due to unfavourable climate, topography, altitude, and related over-use of environmental resources (see also chapter 1, *Initial situation and project background*). Moreover, dry mountain areas are often situated in remote regions, they are structurally neglected with low economic and financiel power, and rarely targeted by any substantial national, or international, development efforts.

14.2 Reports from national environmental authorities and NGOs in Morocco and North Africa

The water resources, soil and vegetation of Morocco, as well as of other Southern Mediterranean and North African countries are, with a few exceptions, in an extremely poor condition. Since approx. 1995 and, even more so, in the course of the last 10 years, lots of reports written by the authorities and various NGOs have been published which criticise an unsatisfied demand in planning and decision-making foundations in the field of water and environmental management in Morocco and its neighbouring countries (for a selection of reports, please see annex 2; for a comprehensive literature list go to http://www.i-brm.ch/docs/38_lit.pdf).

14.3 Development organisations

Development organisations, in their mission to fight underdevelopment, frequently forget that their environmental activities are not sustainable in many cases and may lead to collateral problems or even cause severe consequential damage. The enhancement of water infrastructure is particularly delicate in this respect: although an increased pumping capacity of groundwater through new wells and bore holes may make life easier for the population, it seems only natural that water consumption will multiply and the groundwater tables may fall as a result. It is, therefore, important for development organisations to base the assessment of the medium- and long-term consequences of their work on scientifically sound information.

14.4 Government authorities

Government authorities are frequently under pressure from the population, the government itself, and the international community to remedy water shortage situations within the shortest time possible, either by increasing the pumping capacity of extant installations or by constructing new wells and bore holes. Since they tend to do this the cheapest way without any preliminary hydrogeological clarification, government authorities in the same way as development organisations also run the risk of creating consequential problems. It is thus also important for authorities to be able to rely on scientifically sound support for their decisions.

Table 4: Risks and measures to minimize risks.

Internal risks (influenceable)	Reduction / prevention
Difficulties in communicating the project goals locally since they are not immediately obvious, and unusual for the rural population.	Sufficient time to establish contacts, and thorough explanations, and repeated reinsuring. Active involvement of the local population into the solution-finding process.
Technical/functional problems in implementing the project.	Relying on external expert support (universities etc.).
Imponderabilities connected to the openness of scientific work that may cause deviations from the original research plan, requiring the appropriate acceptance from the project partners and funding institutions.	Optimum preparation of the research work in order to avoid deviations as much as possible; if they occur nevertheless, give a well-founded reasoning and appeal for flexibility on the part of project partners.
Technical difficulties with measuring equipment or the project vehicle due to difficult operating conditions.	Long-term experience of the project management in countries of the global South; applying only simple measuring devices, avoiding electronic equipment, and sufficient spare parts and tools on site.
Lacking interest/acceptance of the users and target groups in relation to the project results.	Ensure strong institutional and local anchoring of the project, communication and active promoting of the project results.

External risks (not influenceable)	Mitigation / Compensation
Complications in data acquisition in Morocco due to external influences (e.g. extraordinary weather conditions that might corrupt the data) as the relevant period of four years to carry out all surveys in the field is tight.	Flexible adaptation of the measuring campaigns to the relevant situations encountered there and appropriate appreciation of the conditions on the occasion of data interpretation.
Lacking reliability on the part of the major project partners in Morocco (authorities, universities, and local stakeholders), creating the impression of a 'lopsided' partnership.	Establishing a broad basis for the project, integrating sufficient partners so as not to be reliant on one specific partner; close collaboration with the Swiss Agency for Development and Cooperation (SDC) in Rabat.
Intransparent situations concerning competencies and power structures nationally, regionally, or locally. Risk of instrumentalization of the project for individual interests.	Establishing a broad basis for the project, gathering information from various sides, close collaboration with SDC in Rabat, only entering into partnerships after verifying that conditions to do so are favourable.
Changed security situation (political/religious) in Morocco.	It can be assumed that, in a country where 50% of the population lives in cities, rural and remote areas without previously recognizable conflict potential are hardly the first to be affected by political and religious unrest. This allows enough reaction time to weigh risks. If the research areas are not insecure, carrying on working while paying extra attention; wherever research areas are considered to be insecure, moving to other regions; if not possible, suspending work for the time being. Close collaboration with the Swiss Agency for Development and Cooperation (SDC) in Rabat.
Changed working conditions on site (e.g. project team is no longer welcome in Morocco).	Generally, to keep a low profile; asking for help and support from the Swiss Agency for Development and Cooperation (SDC) in Rabat.
Corruption	Avoiding or refusing any working together with corrupt persons and/or institutions; establishing a broad basis for the project in order to be flexible with partnerships; asking for help and support from SDC in Rabat.

In the year 1995, a programme for the improvement of the drinking water supply in rural areas was initiated in Morocco (*Programme d'approvisionnement groupé en eau potable des populations rurales, PAGER*). Its declared aim was to raise the degree of supply of a mere 14 per cent of the rural households in 1990 to 80 per cent by the year 2010. The intention was to equip 27'500 villages with water distribution systems, thus benefitting a total of approx. 12 million people. The *PAGER* programme succeeded in bringing about a short-term improvement of the social situation in rural areas, and thus a significant short-term amelioration for people living in the mountains and in the dry south and south-east of Morocco, respectively. However, talking with residents of the Atlas Mountains as part of the preparatory work in 2015 showed that the improved water supply led to an increase in the basic water consumption by five to ten times within a few years, thus lowering groundwater levels locally to the extent that old wells dried out. From this, it can easily be seen how important a scientific accompaniment is in these areas for a sustainable and future-oriented handling of the tightly limited resources: it is a matter of survival indeed.

14.5 Groups affected by a scarcity of water and other natural resources

After government authorities or development organizations have finished setting up water infrastructures, the installations, local authorities and users are often left to themselves. This means that they will have to face any consequential problems or damage without any external support. However, the traditional rural knowledge will not always suffice to grasp the extent of environmental issues in order to take reasonable counter-measures. Representatives of the civil society as well as committed private persons and politicians would thus welcome the possibility of getting a clear and independent picture regarding the use of their environmental resources and their perspectives for the future.

Explanation of technical terms and additional remarks

[1] Anthropogenic desertification: the direct or indirect transformation of arable and habitable land to a desert due to human-induced activities.

[2] Global South: Group of developing and emerging contries in Africa, Latin Amerika, the Middle East and Asia.

[3] There is a widespread tendency today to consider migration as an opportunity, rather than a problem. This perspective focuses on migrants with good chances for success at their final destination. The prerequisite for this is, as a rule, a good basic education or at least the opportunity to train at a later stage in life. The vast majority of migrants from rural areas, however, have neither nor, and thus perceive migration as a risk. From an ecological standpoint, there are hardly any arguments for considering emigration – whether domestic or cross-border – from the rural areas of the Global South as an opportunity, since it leads to the loss of ecologically valuable cultural landscapes at the place of origin, which might become of economical interest in the future, through the use of technologies that are not even conceivable today. For a shake-out of unprofitable regions in the sense of an ‘orderly retreat‘, as frequently discussed in Europe, developing and emerging countries lack the required financial means, legal basis, and political will.

[4] These are frequently subsumed under the terms ‘climate migrants‘ or ‘environmental refugees‘. Both terms may be suitable to denote people fleeing from unexpected natural disasters or people expected to become homeless due to the rising sea level. They do, however, fall short when it comes to hidden change processes, since eco-unfriendly action on a local scale mostly has a greater bearing on problematic environmental changes than the global climate change or the not anthropogenically influenced natural environment itself. More suitable, if less media-conform, would thus be to speak of ‘migration due to the scarcity of resources‘ or ‘migration due to the loss of resources‘.

[5] The term *sustainable development* is used here in its wider meaning, in terms of “a principle according to which one should not consume more than can regrow, regenerate, or be recovered in the future.” (translation of a quote taken from the German Duden). See also: Gro Harlem Brundtland: Our Common Future, 1987 and http://www.i-brm.ch/docs/42_sust_dev.pdf.

[6] Transdisciplinary research: Natural and social scientific investigations in cooperation with the local population (see also explanation 14).

[7] UN Sustainable Development Goals (2030 Agenda): The protection and sustainable use of environmental resources such as water, soil, and vegetation as well as a global partnership for sustainable development are central goals of the 2030 Agenda. For example, Goal 6 demands a sustainable, integrated management and use of water resources, the general improvement of water quality, the reduction of the number of people affected by the scarcity of water, and clean, accessible water for all. Rivers, lakes and groundwater resources are to be protected and recovered, wherever necessary. Goal 15 aims at the recovery and sustainable use of ecosystems, in particular of forests and especially of mountain areas. It calls for the end of worldwide deforestation, for the recovery of damaged forests, and for serious efforts to increase surfaces for reforestation. In addition, we should combat desertification, halt land degradation, clean up polluted land, and halt the loss of biodiversity. Goal 17 calls for a global multi-actor partnership for sustainable development, which is to improve access by emerging countries to science, technology, and innovation while strengthening the exchange of knowledge. In particular, the development, North-South transfer, and the dissemination of eco-compatible technologies should be promoted in cooperation with emerging societies, and the creation of high-grade up-to-date datasets about society, economy, and environment in emerging countries should be forced. In addition, the project also contributes to reaching Goal 1 (End poverty), Goal 2 (End hunger), Goal 8 (Decent work and economic growth), Goal 13 (Combat climate change) and Goal 16 (Peaceful and inclusive societies for sustainable development). See also http://www.un.org/sustainabledevelopment/sustainable-development-goals/.

[8] Paris agreement to Combat Climate Change: to limit the progression of global warming to clearly less than 2°C, the Paris Climate Convention targets a worldwide balance between the emission and absorption of greenhouse gases. This can be achieved by promoting not only the drastic reduction of global emissions but also local mechanisms that absorb greenhouse gases from the atmosphere. The Climate Convention explicitly proposes to halt deforestation, to improve the health of existing forests, and to improve forest surfaces as natural and efficient CO_2 sinks (Art. 4,5). By improving the capacity of adjustment, strengthening resistance, and reducing susceptibility to climate changes as well as by combating its harmful effects, an additional contribution to the protection of mankind, of their existential basis, and of ecosystems can be ensured. This by especially taking account of particularly vulnerable communities and ecosystems and of emerging countries that are generally more prone to crisis (Art. 7). The convention underlines that the scientific knowledge gain concerning the implementation of these climate goals should also include the collaboration of the affected people as well as the traditional knowledge of indigenous populations (transdisciplinary approach). See also http://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf.

[9] A CO_2 sink (or carbon sink) is a reservoir that temporarily or durably absorbs and stores carbon, as for example forests or the ocean.

[10] https://www.nanseninitiative.org/; and http://disasterdisplacement.org/.

[11] Generally, the moderate interest shown by developing and emerging countries for the use of decision support systems (DSS) is explained by the lack of appropriate structures in these countries (Giupponi & Sgobbi 2013). Another central reason is that there is no direct benefit to be drawn so far from decision support systems for the implementation of local development measures.

[12] Examples of this are: GLOWA (http://www.glowa.org/; Mauser & Prasch, 2015), IMPETUS (Speth et al., 2010), WATERMAN (Manos et al. 2004), mDSS / MULINO (http://siti.feem.it/mulino, Giupponi 2007), WaterWare (http://www.ess.co.at/WATERWARE), AQUATOOL (Pedro-Monzonís 2016), SimBaT (Pierleoni et al. 2014).

[13] Democracy of information is the democratic principle taken further, according to which the participation of citizens in political processes is based on the democratic distribution of information.

[14] Transdisciplinarity as a principle of integrative research is a methodical process that combines scientific knowledge and practical knowledge, in this case the knowledge of people on site. Problems within the world of everyday-life increasingly call for transdisciplinary consideration. This is especially true if the existing knowledge is vague and issues are highly controversial. The challenge consists in first identifying the relevant problem situations, to comprehend them in their complexity, and to formulate adequate research questions.

[15] Liu et al, 2008; Giupponi & Sgobbi, 2013.

[16] National sustainability goals in Morocco: In response to the ratification of international treaties and agreements, Morocco has elaborated various reports and action plans in the fields of sustainability as well as environmental, water, and climate policies; among these are a national environmental and sustainability charter, the national strategy for sustainable development, the national action plan for the environment, a national report on water resources, the national water debate, the national report on the implementation of measures to combat desertification, and a report about the UN Framework Convention on Climate Change (for the original titles, see the list of literature under http://www.i-brm.ch/docs/38_lit.pdf). The core of the debate is mostly congruent with the long-term objectives of this project. The sustainability goals of Morocco are all linked, directly or indirectly, to the availability of water:

- Improvement of the water supply of households, agriculture and industry
- Fight against degradation and desertification
- Mitigation of the effects of climate change
- Conservation of biodiversity
- Acceleration of reforestation
- Promotion of renewable energies
- Reduction of poverty
- Empowerment of the rural population
- Promotion of social development

[17] There are numerous scientific publications of Moroccan and international origin about natural and social scientific questions relating to arid and mountainous areas as well as to country-specific issues concerning Morocco. In addition Morocco publishes yearly run-off and climate data from its measurement network in a hydrological Year Book. A list of selected references is to be found under: http://www.i-brm.ch/docs/38_lit.pdf.

[18] http://www.akhiam.org/

References:

For reasons of space, only directly quoted literature is listed here. A comprehensive list of selected references is to be found on the website of the promoting association: http://www.i-brm.ch/docs/38_lit.pdf.

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Annexes

1 **Logframe (impact model or ‚Wirkungsmodell', only in German)**

2 **Selected reports of Moroccan water authorities and international organisations**

Annex 1: Logframe (impact model or ‚Wirkungsmodell', only in German)

Ausgangs-lage	**Welche übergeordneten gesellschaftlichen Probleme werden durch das Projekt angegangen?**
	Übernutzung von Umweltressourcen, Desertifikation: In vielen Gebieten der Erde führt jahrzehntelanger Raubbau an den Umweltressourcen Wasser, Boden und Vegetation zu ausgeprägten Mangelsituationen wie Grundwasserabsenkung, Bodenerosion und Degradation der Vegetation. Die Erneuerungsfähigkeit der Umweltressourcen und die Tragfähigkeit von Ökosystemen sind dadurch vielerorts derart reduziert, dass die Desertifikation einstmals bewohnbarer und landwirtschaftlich nutzbarer Gebiete kaum mehr aufzuhalten ist. Ausgelöst werden diese Prozesse durch Bevölkerungs- und Wirtschaftswachstum, durch die steigenden Ansprüche des modernen Lebensstils, oftmals ungünstige Nutzungsweisen und teilweise auch bewusst umweltschädigendes Handeln. Seit einiger Zeit werden sie zusätzlich durch die Auswirkungen des Klimawandels akzentuiert und beschleunigt.
	Besondere Verwundbarkeit von trockenen Gebirgsregionen mit globalen Folgen: Die ländliche Bevölkerung in trockenen Gebirgsregionen ist durch diese Prozesse besonders verwundbar, da der Erfolg ihrer meist bescheidenen Landwirtschaft unmittelbar von der Verfügbarkeit lokal begrenzter Wasserressourcen, sowie von der Unversehrtheit von Boden und Vegetation abhängt. Deren Verknappung oder sogar Zerstörung führt zu Verarmung, zum Verlust lokaler Kultur, zu sozialen Spannungen und zur Abwanderung. Die Folgen dieser Entwicklung bleiben dadurch nicht lokal beschränkt, sie sind im Gegenteil global und weitreichend.
	Mangelnde Entwicklungsbemühungen in Gebirgsregionen: Gebirgsregionen ausserhalb Europas werden aufgrund ihres geringen ökonomischen und politischen Gewichts strukturell und finanziell vernachlässigt. Sie sind dort meist Teil von Entwicklungs- und Schwellenländern, wodurch sie sowohl im internationalen Vergleich wie auch innerhalb dieser Länder selbst zu den unterentwickelten Regionen gehören. Sie werden bei der Umsetzung von Massnahmen zur Erhaltung ihres Lebensraumes auch zu wenig durch internationale Entwicklungsprogramme unterstützt.
	Mangel an Brückenprojekten zwischen wissenschaftlicher Forschung und Entwicklungszusammenarbeit: Es besteht ein Mangel an Projekten an der Schnittstelle zwischen Forschung und Entwicklungszusammenarbeit, welche Brücken zwischen diesen zwei Bereichen schlagen, die sich traditionell nicht nur nicht nahe stehen, sondern sich oft sogar mit Misstrauen begegnen.
	Mangel an Informationsdemokratie in Ländern des globalen Südens: Gut fundierte, transparente Information soll nicht nur Entscheidungsträgern, sondern – und vor allem – auch der Zivilgesellschaft und direkt Betroffenen ohne Umwege über träge agierende Behörden oder nationale / internationale NGOs zugänglich sein.
	Welche Forschungslücken werden durch das Projekt angegangen?
	Zu wenig wissenschaftlich fundierte Entscheidungsunterstützung: In den vergangenen Jahren wurde von Seiten der Politik und von Entwicklungsorganisationen vermehrt bemängelt, dass kaum wissenschaftlich fundierte Planungs- und Entscheidungswerkzeuge als Basis einer gezielten, nachhaltigen und zukunftsfähigen Nutzung natürlicher Ressourcen vorhanden seien. Umgekehrt wird von Seiten der Wissenschaft bedauert, dass Forschungsresultate zu wenig in politische Entscheide und in die Lösung von Entwicklungsfragen einbezogen würden.
	Mangelnder lokaler Fokus bei der Entwicklung von Entscheidungsunterstützungssystemen (EUS): EUS im Bereich der Nutzung von Wasser und damit verbundener Ressourcen, wie Boden und Vegetation, werden in der Regel für grossräumige Wassernutzungssysteme wie zusammenhängende Flusseinzugsgebiete, grosse Siedlungsräume oder Stauseen entwickelt. Da ihre räumliche Auflösung dadurch gering ist, eignen sie sich nicht als Planungs- und Entscheidungsgrundlagen auf lokaler Ebene. Es ist jedoch die lokale Ebene, auf der die Menschen jeden Tag unmittelbar mit den existentiellen Folgen von Ressourcenknappheit konfrontiert sind.
	Mangel an transdisziplinärer Forschung: Forschungsaktivitäten zur Entwicklung von EUS im Umweltbereich sind meist multidisziplinär, selten hingegen interdisziplinär und so gut wie nie transdisziplinär. Beim transdisziplinären Ansatz wird neben der Integration unterschiedlicher Disziplinen auch die lokale Bevölkerung sowohl in die Wissensgenerierung wie auch in die Entwicklung von Lösungsansätzen und deren Evaluation eingebunden.
	Fehlende lokale Wassernutzungsmodelle mit präziser Auflösung: Bisher wurden für trockene Gebirgsregionen keine hochauflösenden hydrologisch-sozioökonomischen Wassernutzungsmodelle für die lokale Nutzung entwickelt, die neben der natürlichen Umwelt alle menschlichen Aktivitäten und deren Auswirkungen auf Wasserressourcen, Boden und Vegetation einschliessen (die „dem Wassertropfen von seiner natürlichen Umgebung zum Menschen und wieder zurück in die Natur folgen").

Input	**Konzept und Ziele: Mit welchen Massnahmen sollen welche Veränderungen bei wem, wo und bis wann erreicht werden?**
	Massnahmen: Bereitstellung wissenschaftlicher Grundlagen für ein ökologisch verträgliches, lokales Nutzungsmanagement von Wasser, Boden und Vegetation durch die Entwicklung eines daten- / webbasierten, integrierten Entscheidungsunterstützungssystems (EUS) für die lokale Ressourcennutzung mit niederschwelligem, kostenlosem Zugang. Öffentlichkeit, Zivilgesellschaft und Behörden werden damit verlässliche Planungs- und Entscheidungsgrundlagen zur Verfügung gestellt, die es erlauben, sowohl die aktuelle Verfügbarkeit und die Qualität der lokal vorhandenen Umweltressourcen abzuschätzen, als auch Entwicklungsszenarien unter verschiedenen Nutzungs- und Umweltbedingungen in der Zukunft durchzuspielen. Die wissenschaftliche Basis dafür wird durch mehrjährige, transdisziplinäre Forschungsarbeit in drei repräsentativen Studiengebieten im Atlasgebirge in Marokko gelegt. In Fallstudien werden umfangreiche und hochauflösende, natur- und sozialwissenschaftliche Untersuchungen zu Verfügbarkeit, Interaktion, Nutzung und Regulation lokaler Umweltressourcen durchgeführt, wobei das praxisrelevante Wissen der lokalen Bevölkerung mitberücksichtigt wird. Für die Ressourcennutzung relevante Variablen wie Niederschlag, ober- und unterirdischer Wasserabfluss, Vegetationsbewuchs, Bodenbeschaffenheit, Verdunstung, Wasserverbrauch durch menschliche Aktivitäten, sowie Bevölkerungs- und Wirtschaftswachstum werden für die Gegenwart empirisch erfasst, zusätzlich wird ihre Entwicklung unter veränderten klimatischen, demographischen und ökonomischen Bedingungen in der Zukunft abgeschätzt. Aus den dabei erhobenen Daten wird ein Modell der Zusammenhänge zwischen natürlichen und anthropogen beeinflussten Wasserströmen, der Bodenbeschaffenheit und der Vegetation innerhalb lokaler Wassernutzungssysteme in der Grösse von Dörfern oder Talabschnitten entwickelt. Dieses Modell wird zuletzt in ein nutzerfreundliches EUS überführt, das idealerweise webbasiert und mit einer Datenbank verknüpft, und interaktiv auf PCs, Tablets, und allenfalls auch Smartphones verwendet werden kann**.**
	Wo: In trockenen Gebirgsregionen weltweit, insbesondere jedoch im globalen Süden.
	Wer: Nutzer: Zivilgesellschaft inkl. NGOs, interessierte Einzelpersonen, Behörden (lokal bis national), Bildungsinstitutionen. **Begünstigte:** Zehntausende bis Millionen von Menschen, die heute von Wasser- und Ressourcenknappheit betroffen sind und es in der Zukunft sein werden.
	Kurz-/mittelfristige Veränderungen auf gesellschaftlicher Ebene: • Kriterien der Nachhaltigkeit werden in die lokale Entwicklung, insbesondere in die Ressourcennutzung (Wasser, Boden, Vegetation) einbezogen. • Die Nutzungsregimes von Umweltressourcen auf lokaler und allenfalls regionaler Ebene werden zur Diskussion gestellt und im Sinne einer nachhaltigen / zukunftsfähigen Nutzung angepasst. • Es findet lokal eine Auseinandersetzung mit Entwicklungsszenarien statt und es werden Entwicklungsstrategien diskutiert und ausgearbeitet. • Die Existenz des EUS, und das Wissen um diese in der Öffentlichkeit, nimmt die Akteure in die Pflicht, im Sinne einer nachhaltigen / zukunftsfähigen Ressourcennutzung zu handeln.

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Die Bevölkerung kann sich auf die Herausforderungen der Zukunft einstellen und hat realistische Zukunftsperspektiven.
Planung und Entscheidungsfindung ist vermehrt auf gut informierter Basis möglich, an Stelle des sich-verlassen-müssens auf Vermutungen, Halbwahrheiten und überholte Vorstellungen.
Informationstransparenz und -demokratie und dadurch die Möglichkeit für Partizipation der lokalen Bevölkerung / Zivilgesellschaft. Dadurch Förderung von ‚development from below upwards', ‚empowerment' und Steigerung der ‚capabilities' der lokalen Bevölkerung/ Zivilgesellschaft.
Vermehrter Einbezug von Nachhaltigkeits- und Umweltaspekten in die schulische Ausbildung / Berufsausbildung auf verschiedenen Stufen.

Langfristige Veränderungen auf gesellschaftlicher Ebene:

Den Akteuren wird bewusst, dass ein nachhaltiger und eigenverantwortlicher Umgang mit der Umwelt möglich ist und mittel- / langfristig die Lebensumstände verbessert, sie handeln entsprechend, pure Schicksalsergebenheit nimmt ab.
Die ökologische und sozioökonomische Verwundbarkeit („vulnerability“) der Bevölkerung sowie Armuts- und Migrationsrisiko werden reduziert, Wohlstand und Sicherheit wachsen.
Nachhaltige Entwicklung auf der Basis vorhandener Ressourcen und langfristige Sicherung der Lebensgrundlage der Bevölkerung.
Die Landschaft erfährt eine Steigerung ihres ökologischen und ökonomischen Potentials, wodurch Anreize für lokale Investitionen geschaffen werden.
Ressourcenübernutzung nimmt ab, bestenfalls können sich degradierte Ökosysteme regenerieren.
Zunehmende Akzeptanz / Vermehrte Nutzung wissenschaftlicher Vorgehensweisen / Forschungsresultate zur Lösungsfindung in Entwicklungsfragen.
Vermehrter Einbezug von Forschungsresultaten in die politischen Entscheidungsprozesse.
Vermehrte Investitionen (privat, öffentlich, Entwicklungsgelder) in umweltfreundliche, nachhaltige Projekte und Vermeidung von umweltschädigendem Vorgehen wie z.B. der „blinden“ Neuerschliessung neuer Ressourcen.
Hebelwirkung zur vermehrten Entwicklung von EUS zur lokalen Nutzung.
Hebelwirkung zur vermehrten Nutzung von EUS in Ländern des globalen Südens generell.

Schliessung von Forschungslücken:

Bereitstellung umfangreicher und hochauflösender Daten zur Verfügbarkeit, zur Interaktion, zur Nutzung und zur Regulation der Nutzung lokaler Umweltressourcen in trockenen Gebirgsregionen.
Entwicklung hochauflösender hydrologisch-sozioökonomischer Wassernutzungsmodelle für Nutzungssysteme in der Grösse von Dörfern oder Talschaften in trockenen Gebirgsregionen.
Entwicklung eines Entscheidungsunterstützungssystems für die weltweite Nutzung auf lokaler Ebene in trockenen Gebirgsregionen.
Förderung transdisziplinärer Forschung.

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<tr><td>Bis wann: Projektdauer: 6 Jahre; Einsetzen der Wirkung: ab 6 bis maximal 8 Jahre.</td></tr>
<tr><td>Ressourcen, die zur Durchführung von Aktivitäten notwendig sind:</td></tr>
<tr><td>Vorbereitungsphase, 14 Monate: Abgeschlossen, finanziert.</td></tr>
<tr><td>Organisationsphase, 7 Monate: Am laufen, finanziert.</td></tr>
<tr><td>Organisationsphase, 4 ½ Jahre:
<u>Personalkosten:</u> 150 Stellenprozente für das Projektteam (wissenschaftliche Arbeiten),10 Stellenprozente Administration, 80 Stellenprozente lokale Mitarbeiter; lokale, regionale, nationale Behörden / Entscheidungsträger und / oder Universitäten als Projektpartner; Flüge; Übernachtungen und Verpflegung vor Ort für jährlich 2 mehrwöchige und zwei kurze Aufenthalte von Teilen des Projektteams vor Ort.
<u>Materialkosten:</u> Diverse Messgeräte (Piezometersonde, Leitfähigkeitsmessgerät, Tensiometer, Pluviometer, Infiltrometer, Flügelmessgerät mit Datenlogger, Theodolith, Verdunstungskessel, GPS, Konzentrationsmessgerät für Tracermessungen, Inkubator für Bakterienkulturen); Software für Messgräte; diverse Chemikalien, Labormaterial und Verbrauchsmaterial; mobiles Stromaggregat; Büromaterial und Fachliteratur.
<u>Reisekosten Feldarbeit:</u> Mobilität im Feld (Allradfahrzeug), Flüge
<u>Externe Laborarbeiten:</u> (Wasser: An- / Kationenanalysen, O / H-Isotopenanalysen, organische und mikrobiologische Verunreinigungen; Boden- und Gesteinsanalysen)
<u>Diverses:</u> Besuch und Organisation von Workshops, Konferenzen.
Freiwilligenarbeit des Trägervereins ‚Initiative for a Balanced Water Resource Management'
Budget 1. Jahr: Fr. 334'860 (inkl. einmalige Anschaffungen)
Budget 2. bis 5. Jahr gesamt: Fr. 961'810, auf 3½ Jahre verteilt: ca. Fr. 275'000 pro Jahr
Gesamtbudget: Fr. 1'296'670</td></tr>
<tr><td>Entwicklungsphase, 1 ½ Jahre: Nicht Teil dieses Projektantrags, geschätzte Kosten ca. Fr. 200'000</td></tr>
</table>

Aktivitäten und Umsetzung

	Handlungen, welche zur Erreichung der angestrebten Leistungen und Ziele durchgeführt werden.	Indikator	Welche Aktivitäten, in welcher Menge, bis wann?	Überprüfung der Umsetzung
	Vorbereitungsphase (14 Monate, ABGESCHLOSSEN):			
1	Das Projektteam macht sich mit den Verhältnissen in den Gebirgsregionen Marokkos im Detail durch Literaturstudium und durch Aufenthalte vor Ort vertraut (Topographie, Geologie, Hydrologie, Klima, Morphologie, Vegetation, Landwirtschaft, Besiedelung, kultureller Hintergrund etc.) und beginnt mit dem Aufbau eines Archivs. Dies auch hinsichtlich der Absicht, den Trägerverein zu einem Kompetenzzentrum zu entwickeln.	• Umfang und Qualität des Archivs (Literatur, Karten, Luftaufnahmen etc.). • Umfang und Qualität der Dokumentation von Naturräumen, Bewirtschaftung etc. durch das Projektteam vor Ort. • Umfang und Qualität der Daten / Dokumentation für Bericht und Auswahl der Studiengebiete.	• Literaturstudium (möglichst umfangreich). • Suche nach geographischen Karten mit untersch. Massstäben und Luft- / Satellitenbildern mit maximaler Abdeckung des Atlasgebirges und seines Umfeldes bis Ende 2015. • 2 Feldaufenthalte von insgesamt 9 Wochen im Hohen Atlas und Antiatlas bis Ende 2015. • Fotografische Dokumentation von Naturräumen, Bewirtschaftung und Kultur im Atlasgebirge während der Feldaufenthalte. • Beschreibung und Dokumentation der vorgefundenen Verhältnisse in einem umfassenden Bericht bis Ende Mai 2016.	• Hochauflösende Satellitenaufnahme des Atlasgebirges mit über tausend Beobachtungen und dazugehörendes Fotoarchiv liegt vor. • Bericht *Compendium of cultural landscapes in the High Atlas Mountains and in the Antiatlas Mountains of Morocco - Results of the first year of the project 2015 / 16* (275 S., siehe www.i-brm.ch) liegt vor. • Literaturliste / Literaturarchiv liegen vor. • Archiv mit Karten / Luftbildern liegt vor.
2	Auswahl von Studiengebieten im Atlasgebirge in Marokko, welche folgende Voraussetzungen erfüllen müssen: • Repräsentativität für unterschiedliche Naturräume und Bewirtschaftungsformen in trockenen Berggebieten. • Radius der Forschungsarbeiten muss schrittweise ausdehnbar sein. • Vorhandensein lokaler Multiplikatoren und Unterkünfte.		• Festlegung definitiver Auswahlkriterien bis Ende Mai 2016. • Festlegung der Anzahl Studiengebiete bis Ende Mai 2016.	• Internes Dokument zu Auswahlkriterien und Auswahlprozedere liegt vor. • Auswahl und Dokumentation der Arbeitsgebiete liegt vor (siehe Kap. 10.1, ab S. 9 der Projektdokumentation).
	Organisationsphase (7 Monate, AM LAUFEN):			
3	Suche nach finanziellen Ressourcen für die Forschungsphase.	• Qualität von Projektbeschrieb und -dokumentation. • Qualität und Anzahl von Kontakten zu potentiellen Geldgebern.	• Fertigstellung Projektbeschrieb (ca. 10 Seiten, Dt./Engl.) und -Dokumentation (ca. 50 Seiten, Dt./Engl.) bis Ende August 2016. • Versand Projektbeschrieb / -Dokumentation an pot. Geldgeber bis Ende September 2016.	• Selbstkontrolle • Reaktionen potentieller Geldgeber.
4	Wissenschaftliche und logistische Vorbereitung der Forschungsphase.	Reduktion der Anzahl offener Fragen.	Vorbereitungsarbeiten bis Ende Dezember 2016 abgeschlossen.	Planmässiger Start Forschungsphase im Januar 2017.
5	Herstellung institutioneller Kontakte (Universitäten, Behörden).	Anzahl und Qualität der Kontakte.	Bis Mitte Dezember 2016 mindestens ein qualitativ hochstehender, ausbaufähiger Kontakt.	Provisorische Vereinbarung zur Zusammenarbeit.
	Forschungsphase (ab Januar 2017, 4 ½ Jahre, Gegenstand dieses Finanzierungsgesuchs): Handlungen laufen z.T. parallel zueinander, z.T. als Folgen vorhergehender Handlungen ab.			
6	Umfangreiche naturwissenschaftliche Untersuchungen in den Studiengebieten (Feld- und Laborarbeit, Analytik, Auswertung des ist-Zustandes): • Niederschlags und Verdunstungsmessungen. • Abflussmessungen bei Oberflächengewässern. • Bestimmung der Aquiferparameter, Volumen und Neubildungsrate von Grundwasservorkommen. • Wasserchemie von Oberflächengewässern / Grundwasservorkommen. • Geologische/geophysikalische Untersuchungen. • Erfassung der Vegetation. • Bodenprofile, Bestimmung Bodenwassergehalt und Matrixpotential. • Nitrat- und Phosphatgehalte im Oberflächen- und Grundwasser. • Wasserverbrauch von Haushalten, Landwirtschaft und Gewerbe. • Rückfluss von Nutzwasser in Oberflächen- und Grundwasser. • Erfassung mikrobiologischer, organischer und anorganischer Wasserverschmutzung. • Untersuchung erhöhter Evapotranspiration über Kulturland. • Abschätzung des lokalen Potentials für Meliorationsmassnahmen.	• Anzahl plan- und termingemäss durchgeführter Messkampagnen. • Menge und Qualität der Daten, die nach jeder Messkampagne vorliegen bzw. auf www.i-brm.ch veröffentlicht werden. • Anzahl und Qualität allfälliger Publikationen in wissenschaftlichen Zeitschriften.	Während 4 Jahren werden in jedem Studiengebiet zwei Mal jährlich die wichtigsten Grunddaten erfasst, um räumliche und zeitliche Vergleichbarkeit zu gewährleisten. Komplette Datenerhebungen und Analysen werden so geplant, dass jedes Untersuchungsgebiet mindestens 2 Mal vollständig bearbeitet wird. Dadurch können statistisch relevante Daten erhoben werden. Dafür sind pro Jahr ca. 170 Personen-Arbeitstage im Feld vorgesehen (Projektteam + lok. Mitarb.) Mess –und Analysedaten (Tabellen, thematische Karten, Diagramme etc.) werden bis spätestens 2 Monate nach jeder Messkampagne auf der Webseite www.i-brm.ch veröffentlicht. Falls Ergebnisse von übergeordnetem Interesse vorliegen, werden diese in wissenschaftlichen Zeitschriften publiziert (nicht terminierbar).	Wo die Arbeiten vom Projektteam selbst ausgeführt werden, gilt der Zeitplan mit Meilensteinen. Extern durchgeführte Analysen oder durch lokale Mitarbeiter ausgeführte Arbeiten werden nach jeder Mess-/Analysenkampagne anhand der Plausibilität der Daten und Resultate beurteilt. Der Fortschritt ist von extern durch Menge und Qualität der Daten überprüfbar, die auf www.i-brm.ch veröffentlicht werden.

Aktivitäten und Umsetzung	7	Umfangreiche sozialwissenschaftliche Untersuchungen in den Studiengebieten: • Strukturierte Interviews mit Entscheidungsträgern oder Repräsentanten von Berufsgruppen, welche Arbeiten mit Wasser ausführen (z.B. Bauern, Besitzer von Touristenunterkünften etc.). • Standardisierte Haushalts- und Betriebsbefragungen (Stichproben). • Abschätzung der Repräsentativität durch Statistik. • Rekonstruktion der Veränderung der Landnutzung durch Luftbilder. • Systematische Literaturanalyse zur allgemeinen sozioökonomischen Entwicklung. • Diskussion der Resultate mit Repräsentanten und Experten der betroffenen Bevölkerung.	• Anzahl plan- und termingemäss durchgeführter Interviews / Befragungen. • Menge und Qualität der Daten, die nach jeder Kampagne vorliegen bzw. auf www.i-brm.ch veröffentlicht werden. • Anzahl und Qualität allfälliger Publikationen in wissenschaftlichen Zeitschriften.	Während 4 Jahren werden Interviews und Befragungen in jedem Untersuchungsgebiet zwei Mal im Abstand von mindestens 2 Jahren durchgeführt. Dabei wird eine statistisch relevante Menge von Personen/Institutionen befragt, die von der Grösse der Untersuchungsgebiete abhängt. Dafür sind pro Jahr ca. 20 Arbeitstage im Feld für 1 Person vorgesehen, der ein/e Übersetzer/in für lokale Berbersprachen zur Seite steht. Daten (Tabellen, thematische Karten, Diagramme etc.) werden bis spätestens 2 Monate nach jeder Kampagne auf der Website www.i-brm.ch veröffentlicht.	Wo die Arbeiten vom Projektteam selbst ausgeführt werden, gilt der Zeitplan mit Meilensteinen. Durch lokale Mitarbeiter ausgeführte Arbeiten werden nach jeder Kampagne anhand der Plausibilität der Daten und Resultate beurteilt. Der Fortschritt ist von extern durch Menge und Qualität der Daten überprüfbar, die auf www.i-brm.ch veröffentlicht werden.
	8	Entwicklung empirischer, lokaler Wassernutzungsmodelle für jedes Studiengebiet.	• Qualität der vorliegenden Modellierungsansätze bzw. fertigen Modelle. • Anzahl veränderbarer Variablen.	Ab 3. Jahr Start erster Modellierungsversuche parallel zur Datenerhebung, laufende Verbesserung der Modelle bis Ende 4. Jahr.	Selbstkontrolle, es gilt der Zeitplan mit Meilensteinen. Der Fortschritt ist von extern durch die Qualität der Modellierungsansätze überprüfbar, die auf www.i-brm.ch veröffentlicht werden.
	9	Entwicklung eines generell in trockenen Gebirgsregionen nutzbaren, idealtypischen Wassernutzungsmodells.	• Qualität der vorliegenden Modellierungsansätze bzw. fertigen Modelle. • Grad der generellen Einsetzbarkeit. • Anzahl veränderbarer Variablen.	Zusammenzug der empirischen Einzelmodelle in ein generelles, idealtypisches Modell im letzten halben Jahr der Forschungsphase, in welchem alle für die Nutzung lokaler Umweltressourcen relevanten Variablen veränderbar sind.	
	10	Erweiterung des idealtypischen Wassernutzungsmodells mit Informationen zur wirtschaftlichen, sozialen, kulturellen und ökologischen Entwicklung auf nationaler und globaler Ebene, sowie zu möglichen Formen von Kooperationen, Verordnungen oder Richtlinien zur Nutzung von Ressourcen. Das Endprodukt erlaubt Aussagen zum aktuellen Zustand der Ressourcen in lokalen Nutzungssystemen, sowie die Erstellung von Szenarien, hat jedoch noch nicht den Anspruch von Nutzerfreundlichkeit.	Qualität und Variabilität der integrierten Informationen.	Erweiterung im letzten halben Jahr der Forschungsphase.	
	Entwicklungsphase (1 ½ Jahre, nicht Teil dieses Finanzierungsgesuchs):				
	11	Überführung des idealtypischen Wassernutzungsmodells aus der Forschungsphase in ein nutzerfreundliches Entscheidungsunterstützungssystem in Form einer kostenlosen, interaktiven Anwendung für PCs oder Tablets, allenfalls sogar Smartphones, die idealerweise webbasiert und mit einer Datenbank verknüpft ist.	• Grad der generellen Anwendungsfreundlichkeit für Fachleute und Laien. • Grad der Verknüpfung mit adäquaten, bestehenden Datenbanken. • Grad der Niederschwelligkeit im Zugang. • Grad der Mehrsprachigkeit.	Programmierarbeit unter Einbezug externer Fachleute während ca. 1 Jahr. Testphase während ca. ½ Jahr.	Wo die Arbeiten vom Projektteam selbst ausgeführt werden, gilt ein Zeitplan mit Meilensteinen (bisher nur in groben Zügen skizziert). Leistungsvereinbarungen mit externen Fachkräften.
	Übergreifende Begleitarbeiten (hauptsächlich während der Forschungsphase)				
	12	Einbindung der betroffenen Bevölkerung in Wissensgenerierung, Entwicklung von Lösungsansätzen und deren Evaluation (Transdisziplinarität).	• Generelles Interesse der lokalen Bevölkerung am Projekt. • Grad der lokalen Projektverankerung. • Anzahl Teilnehmer an Veranstaltungen.	Organisation von Diskussionen / Evaluationen mit der lokalen Bevölkerung gruppenweise oder in Form grösserer Veranstaltungen.	Selbstkontrolle
	13	Capacity Building bei Projektpartnern und Mitarbeitern vor Ort.	Anzahl Teilnehmer an Veranstaltungen.	Gezielte Ausbildung „On - the – job“. Organisation / Besuch von Veranstaltungen.	Selbstkontrolle
	14	Stakeholderdialog	Interesse der Stakeholder an Projekt / Dialog.	Informelles „Im Gepräch bleiben“ mit offiziellen Projektpartnern und „inoffiziellen“ / potentiellen Stakeholdern.	Selbstkontrolle
	15	Projektmanagement und Qualitätssicherung	Korrekturen am Projektverlauf.	Selbstkontrolle, Einhaltung des Zeitplans und der Meilensteine.	Korrekturen zeigen Wirkung.

	Nr.	Zählbare Leistungen und Produkte des Projekts	Indikator	Welche Leistungen und Produkte in welcher Menge bis wann?	Erhebung der Daten
Outputs		**Stufe 1: Erbrachte Leistungen und Produkte**			
	1	**Vorbereitungsphase, Dokumentation der Naturräume in Marokko:** • Hochauflösende Satellitenaufnahme des Atlasgebirges mit über tausend Beobachtungen und dazugehörendes Fotoarchiv. • Bericht *Compendium of cultural landscapes in the High Atlas Mountains and in the Antiatlas Mountains of Morocco - Results of the first year of the project 2015 / 16* (275 S., siehe www. i-brm.ch). • Literaturliste / Literaturarchiv • Archiv mit Karten / Luftbildern	Qualität der Dokumentation	Alles bis spätestens Ende Mai 2016.	Selbstkontrolle
			ERLEDIGT		
	2	**Vorbereitungsphase, Auswahl der Studiengebiete:** • Internes Dokument zu Auswahlkriterien und Auswahlprozedere. • Auswahl und Dokumentation der Arbeitsgebiete (Kap. 10 der Projektdokumentation).	Repräsentativität und Praxistauglichkeit der Studiengebiete.	Alles bis spätestens Ende Mai 2016.	Selbstkontrolle
			ERLEDIGT		
	3	**Organisationsphase:** Finanzierung der Forschungsphase. – Teilfinanziert, so dass der Start Anfang 2017 gesichert ist.	Zugesicherte Finanzmittel	Mindestens Fr. 100'000 bis Ende 1. Quartal 2017.	Selbstkontrolle
		Vollständig finanziert	Zugesicherte Finanzmittel	Ca. Fr. 500'000 bis Ende 2017.	Selbstkontrolle
	4	**Forschungsphase:** Hochauflösende Daten / Resultate aus vier Jahren natur- und sozialwissenschaftlicher Forschungsarbeit in drei Arbeitsgebieten im marokkanischen Atlasgebirge zu den, in Kapitel 10.4. ab S. 21 in der Projektdokumentation aufgezählten Untersuchungen.	Menge und Qualität (Relevanz, Genauigkeit, Zuverlässigkeit) der vorliegenden Daten.	Mehrere Tausend Messungen, 500-600 Analysen und 100-150 Interviews/Befragungen bis Ende 2020 (jedes Semester ca. ⅛ der Gesamtmenge). Veröffentlichung der Daten auf www.i-brm.ch und / oder als Publikationen in wiss. Zeitschriften. Newsletters, Pressemitteilungen, Organisation von Workshops bei Bedarf.	Selbstkontrolle, Zeitplan mit Meilensteinen, fortlaufende Projektdokumentation auf www.i-brm.ch.
	5	**Forschungsphase:** Modelle empirischer, lokaler Wassernutzungssysteme (mindestens eines für jedes Studiengebiet).	Qualität (Zweckmässigkeit, Anzahl und Relevanz veränderbarer Variablen, Genauigkeit, Zuverlässigkeit) der Modelle.	Teilmodellierungsschritte frühestens ab 2019, alle Modelle fertig bis Ende 2020.	Selbstkontrolle, Zeitplan mit Meilensteinen, fortlaufende Projektdokumentation auf www.i-brm.ch.
	6	**Forschungsphase:** Generell in trockenen Gebirgsregionen nutzbares, idealtypisches Wassernutzungsmodell.	Qualität (Grad der Generalisierbarkeit, Anzahl und Relevanz veränderbarer Variablen, Genauigkeit, Zuverlässigkeit) des Modells.	Teilmodellierungsschritte frühestens ab 2020, Fertig bis Ende Juli 2021.	Selbstkontrolle, Zeitplan mit Meilensteinen, fortlaufende Projektdokumentation auf www.i-brm.ch..
	7	**Entwicklungsphase:** Nutzerfreundliches Entscheidungsunterstützungssystem (EUS) in Form einer kostenlosen, interaktiven Anwendung für PCs oder Tablets, allenfalls sogar Smartphones, die idealerweise webbasiert und mit einer Datenbank verknüpft ist.	• Qualität (Grad der Generalisierbarkeit, Anzahl und Relevanz veränderbarer Variablen, Genauigkeit, Zuverlässigkeit). • Anwendungsfreundlichkeit	Vollständiges EUS ungetestet bis 1 Jahr nach Beginn Entwicklungsphase (externe Programmierung), danach ½ Jahr Testphase + Beginn Verbreitung.	Wo die Arbeiten vom Projektteam selbst ausgeführt werden: Selbstkontrolle. Externe Aufträge: Leistungsvereinbarung mit Meilensteinen, Überprüfung.
	8	Pressemitteilungen, Besuch / Organisation von Workshops / Konferenzen zur Präsentation / Diskussion von Resultaten / Bekanntmachung des EUS.	Anzahl Interessenten, ev. neue Mitglieder des Trägervereins.	Organisation / Besuch von mindestens 4 Workshops / Konferenzen, Festlegung Zeitpunkt flexibel nach Bedarf.	Selbstkontrolle, im Zeitplan provisorisch eingetragen.
		Stufe 2: Nutzung der Leistungen und Produkte durch die Zielgruppen			
	9	Zivilgesellschaft inkl. NGOs, interessierte Einzelpersonen, Behörden sind fähig: • Die aktuelle Verfügbarkeit ihrer lokalen Wasserressourcen und den Grad der Nachhaltigkeit von deren Nutzung in Bezug auf die Bedürfnisse von Mensch und Umwelt abzuschätzen. • Entwicklungsszenarien für die Zukunft zu kreieren, um die Konsequenzen für Verfügbarkeit bzw. Zustand von Wasser, Boden und Vegetation, und damit die Realisierbarkeit verschiedenster Tätigkeiten (z.B. Anbau bestimmter Produkte, Siedlungswachstum, touristische Angebote usw.) abzuschätzen.	Anzahl Nutzer	1000 Nutzer im ersten Jahr nach Abschluss der Entwicklungsphase sind realistisch. Findet das EUS Anklang, wird es sich durch den niederschwelligen, kostenlosen Zugang schnell von selbst ausbreiten.	Über die Nutzerplattform des Trägervereins werden Nutzer automatisch registriert.

Outputs	10	Bildungs- und Forschungsinstitutionen nutzen das EUS zur Ausbildung von Studierenden und Berufsleuten im Bereich des Ressourcenmanagements.	Anzahl Nutzer	50 Nutzer im ersten Jahr nach Abschluss der Entwicklungsphase sind realistisch.	Über die Nutzerplattform des Trägervereins werden Nutzer automatisch registriert.
		Stufe 3: Zufriedenheit der Nutzer mit den Leistungen und Produkten			
	11	Zielgruppen sehen einen messbaren Nutzen durch die Anwendung des EUS: • Verbesserte Planung • Besser abgestützte Entscheidungen. • Mehr Transparenz (horizontal und vertikal). • Positive Entwicklungen bei Ressourcennutzung / Umweltzustand. • Verbesserung der (Umwelt-)Ausbildung auf verschiedenen Stufen.	• Verbreitungsgeschwindigkeit des EUS • Nutzer beteiligen sich über die Nutzerplattform an der Verbesserung des EUS.	Mindestens eine Verdoppelung der Nutzerzahl pro Jahr bis zum Sättigungspunkt (4-5 Jahre?), danach vermutlich Abflachung. Wenn jeder Nutzer (ausser Bildungsbereich) im Schnitt 500 Begünstigte hinter sich hat, ergibt das 7-15 Millionen Begünstigte.	Über die Nutzerplattform des Trägervereins werden Nutzer automatisch registriert und können periodisch zu ihren Erfahrungen, Zufriedenheit, Verbesserungsvorschlägen etc. befragt werden (bzw. tragen durch ihre Daten zur Verbesserung des EUS bei).

		Erwünschte Wirkungen / Veränderungen bei der/den Zielgruppe(n)	Indikator	Welche Veränderungen in welcher Menge bis wann?	Erhebung der Daten
Outcomes		**Stufe 4: Nutzer verändern ihre Fähigkeiten**			
	12	• Nutzer erkennen Zusammenhänge zwischen ihrer aktuellen Art der Ressourcennutzung und den Reaktionen der natürlichen Umwelt darauf (besonders im Fall von Übernutzung), und wissen, wie sie entsprechend reagieren und Massnahmen ergreifen können. • Nutzer sind befähigt, Verantwortung für nachhaltige Entwicklung zu übernehmen und Massnahmen zur Steigerung der Nachhaltigkeit umzusetzen. • Nutzer sind fähig, zukunftsorientiert zu planen	Verbessertes Ressourcenmanagement.	Die Festlegung von konkreten Zielgrössen ist bei langfristigen Entwicklungen (5-10 Jahre) nicht sinnvoll. Der erhoffte Effekt kann am ehesten mit „spürbare Veränderung" umschrieben werden.	Direkt: • Kommentare / Befragung von Nutzern auf der Nutzerplattform. • Monitoring ausgewählter Gebiete durch den Trägerverein. Indirekt: • Berichte von Behörden und NGOs zum Zustand der Umwelt im Rahmen diverser Programme / Abkommen (MDGs, Klimaabkommen etc.). • Projektunabhängige Monitorings von Umweltorganisationen. • Medienberichte
		Stufe 5: Nutzer ändern ihr Verhalten			
	13	• Es findet lokal eine Auseinandersetzung mit Entwicklungsszenarien statt und es werden Entwicklungsstrategien diskutiert / ausgearbeitet. • Den Nutzern ist bewusst, dass ein nachhaltiger und eigenverantwortlicher Umgang mit der Umwelt möglich ist und mittel-/langfristig die Lebensumstände verbessert, und handeln entsprechend. • Kriterien der Nachhaltigkeit/Zukunftsfähigkeit werden bewusst in die Ressourcenplanung und -nutzung (Wasser, Boden, Vegetation) einbezogen. • Wasser-/Ressourcennutzung verändert sich hin zu einem nachhaltigen Level. • Die Existenz des EUS, und das Wissen um dieses in der Öffentlichkeit, nimmt die Akteure in die Pflicht, im Sinne einer nachhaltigen/zukunftsfähigen Ressourcennutzung zu handeln.	Steigende Anzahl beabsichtigter und realisierter Planungen bzw. Entscheide zur Umsetzung konkreter Massnahmen.		
	14	Erwünscht, aber nicht explizit erwartet: Transfer des neu erworbenen Bewusstseins auf andere Lebensbereiche (z.B. Familienplanung, Bildung etc.).	Sinkende Geburtenrate, steigende Alphabetisierungsrate.	Die Festlegung von Zielgrössen ist hier nicht sinnvoll (siehe Begründung unten).	Demografische Statistiken, Berichte von Behörden und NGOs.
		Stufe 6: Lebenslage der Zielgruppen ändert sich			
	15	• Die Entscheidungsträger informieren, planen und entscheiden auf gut informierter Basis. • Durch Informationstransparenz kann die lokale Bevölkerung / Zivilgesellschaft vermehrt an Planungs- und Entscheidungsprozessen partizipieren. • Kinder / Jugendliche lernen bereits in der Schule, sorgsam mit Ressourcen und Umwelt umzugehen. • Die Bevölkerung in Gebirgs- und Trockengebieten kann sich auf die Herausforderungen der Zukunft einstellen und hat realistische Zukunftsperspektiven. • Die Zielgebiete entwickeln sich wirtschaftlich nachhaltig auf der Basis vorhandener Ressourcen, wodurch die Lebensgrundlagen der Bevölkerung langfristig gesichert sind.	• Allgemeinzustand der Siedlungen verbessert sich (weniger verfallene Häuser, mehr neue Häuser). • Allgemeinzustand der Anbauflächen verbessert sich (weniger Erosion). • Es wird weniger Abfall in der freien Natur entsorgt. • Reduktion direkter Anzeichen negativer Einwirkung auf die Umwelt (Erosion, Degradation, Desertifikation, Eutrophierung etc.). • Binnenangebot auf den lokalen Märkten verbessert sich. • Infrastruktur verbessert sich.	Die Festlegung von Zielgrössen ist hier nicht sinnvoll, da diese auf grossmassstäblicher Ebene von Faktoren mitbestimmt werden, die weder von den Projektinitianten noch von den Zielgruppen genügend beeinflusst werden können. Der Zeitrahmen ist langfristig bis sehr langfristig (> Jahrzehnt).	Direkt: • Kommentare / Befragung von Nutzern auf der Nutzerplattform. • Monitoring ausgewählter Gebiete durch den Trägerverein. Indirekt: • Berichte von Behörden und NGOs. • Projektunabhängige Monitorings von Umweltorganisationen. • Medienberichte • Sozioökonomische und demografische Statistiken, z.B. zur Migration. • Fernerkundung

Outcomes	• Die ökologische und sozioökonomische Verwundbarkeit (vulnerability) der Bevölkerung, Unterentwicklung und Armutsrisiko werden reduziert. • Die Gesundheit in ländlichen Gebieten verbessert sich. • Migration aufgrund ungünstiger sozioökonomischer Voraussetzungen verringert sich (national / transnational). • Investitionen (privat, öffentlich, Entwicklungsgelder) werden in umweltfreundliche, nachhaltige Bahnen gelenkt und Ausgaben für umweltschädigende Projekte können vermieden werden. • Die Landschaft in Gebirgs- und Trockengebieten erfährt eine Wertsteigerung und damit eine Steigerung ihres wirtschaftlichen Potentials, was Anreize für lokale Investitionen schafft.	• Zunahme lokaler Investitionen in Gewerbe und Dienstleistung (z.B. neue Läden, touristische Infrastruktur).	Siehe oben.	Siehe oben.
Impact	**Wirkungen über Zielgruppen hinaus**			
	Beabsichtigte positive Veränderungen	**Indikator**	**Welche Veränderungen in welcher Menge bis wann?**	**Erhebung der Daten**
	Ökologisch: • Schonung der Wasserressourcen, Hebung von Grundwasserspiegeln. • Schonung des Bodens (weniger Erosion). • Schonung der Vegetation (weniger Degradation). • Reduktion der Desertifikation. • Regeneration degradierter Ökosysteme. • Erhaltung / Erholung / Vergrösserung der Artenvielfalt.	• Weniger Wasserarmut. • Seltener und weniger ausgeprägte Mangelsituationen. • Erhöhte Bodenfruchtbarkeit. • Weniger Abholzung. • Dichterer Vegetationsbewuchs.	Die Festlegung von Zielgrössen ist hier nicht sinnvoll, da diese auf grossmassstäblicher Ebene von Faktoren mitbestimmt werden, die weder von den Projektinitianten noch von den Zielgruppen genügend beeinflusst werden können. Der Zeitrahmen ist langfristig bis sehr langfristig (> Jahrzehnt)	Umweltstatistiken, Berichte von Behörden und NGOs, Fernerkundung, Pressemitteilungen.
	Sozioökonomisch: • Vergrösserung von Wohlstand und Sicherheit. • Generelle Verbesserung der Lebensbedingungen. • Reduktion sozialer Missstände durch Armutsmigration (national / international). • Erhaltung des sozialen Friedens. • Vergrösserung der Chancengleichheit zwischen privilegierten und weniger privilegierten Regionen.	• Generell steigender Lebensstandard. • Sinkende Geburtenrate. • Weniger Abwanderung vom Land in städtische Gebiete. • Steigende Alphabetisierungsrate. • Steigende Lebenserwartung. • Reduzierte Slumbildung.		Demografische Statistiken, Berichte von Behörden und NGOs, steigender HDI (Human Development Index), Pressemitteilungen.
	Wissenschaftlich: • Präzise Kenntnis der Nutzung lokaler Wasserhaushalte und deren Interaktionen mit Umweltressourcen in trockenen Gebirgsregionen. • Vermehrte Entwicklung wissenschaftsbasierter EUS zur lokalen Nutzung mit hoher Wirkung für lokal, direkt und niederschwellig umsetzbare Massnahmen. • Vermehrte transdisziplinäre Forschung. • Vermehrte Akzeptanz / Nutzung wissenschaftlicher Vorgehensweise zur Lösung von Entwicklungsfragen.	• Anzahl neuer Projekte in diesem Bereich. • Menge an Fördermitteln für entsprechende Projekte.		Fachliteratur, wiss. Konferenzen, Pressemitteilungen.
	Politisch: • Vergrösserung der Transparenz bei Entscheiden von öffentlichem Interesse in Ländern mit potentiell schwach entwickeltem vertikalen Informationsfluss. • Vermehrte Nutzung von EUS im globalen Süden generell. • In-die-Pflicht-Nahme bzw. Aufbau von Handlungsdruck für Behörden und NGOs im Bereich der nachhaltigen Nutzung natürlicher Ressourcen. • Vermehrter Einbezug von Forschungsresultaten in politische Entscheidungsprozesse.	• Grad der Partizipation der lokalen Bevölkerung / Zivilgesellschaft an Entscheidungsprozessen. • Grad der Umsetzung von ‚development from below upwards'- Prozessen. • Zufriedenheit der Zivilgesellschaft / einzelner kritischer Bürger/innen / der Presse mit den Behörden, und / oder mit NGOs.		Berichte von Behörden und NGOs, Pressemitteilungen.
	Haltung: Greif- und Nutzbarmachung des Konzeptes der Nachhaltigkeit für knappe Ressourcen in Ländern des Südens.	• Nachhaltigkeit ist nachweislich vermehrt Basis des Handelns. • Grad des Transfers der Erkenntnisse in die Öffentlichkeit durch Nutzer, Presse.		

<table>
<tr><td rowspan="4">Risiken und Chancen</td><td>Risiken und Chancen, die das Projekt positiv oder negativ beeinflussen könnten.</td></tr>
<tr><td><u>Chancen:</u>
Bei Behörden und NGOs in Marokko und in vielen anderen, von Trockenheit / Mangel an Umweltressourcen betroffenen Ländern weltweit besteht ein gut verankertes Bewusstsein um die “fünf-vor-12-Situation” im Wasser- und Umweltsektor und ein grosses Bedürfnis nach Planungs- und Entscheidungsgrundlagen für einen nachhaltigen Umgang mit Wasser und Umwelt. Dies ist eine optimale Basis für die Durchführung des Projektes, sowie Interesse an / Akzeptanz der Resultate und des Endprodukts.
In vielen Ländern des globalen Südens besteht ein Mangel an Informationsdemokratie. Niederschwellige, webbasierte Informationsangebote sind in der Zivilgesellschaft sehr willkommen.
Die Finanzkraft in Ländern des globalen Südens ist gering, so dass kostenlose Informationsangebote gerne genutzt werden.
Die abwechslungsreichen geologischen, hydrologischen, klimatologischen und sozioökonomischen Voraussetzungen in Marokko ergeben vielfältige, optimale Untersuchungsräume und bieten damit beste Voraussetzungen für weiträumig anwendbare Ergebnisse.
Das Projekt liegt in der Stossrichtung der nationalen Umweltpolitik Marokkos, welche auf die Erhöhung der Nachhaltigkeit ausgerichtet ist, so dass Marokko grosses Interesse an Kooperation bei der Ausführung der Forschungsphase hat.
Das Projekt liegt in der direkten Stossrichtung der Agenda 21, der UN-Nachhaltigkeitsziele (Agenda 2030) und des Pariser Klimaabkommens und ist damit (wenn auch nur informell) breit abgestützt.
Das Projekt bildet eine Brücke zwischen Forschung und Entwicklungszusammenarbeit, kann also vom Know-How zweier sehr unterschiedlicher Bereiche profitieren.</td></tr>
<tr><td><u>Kritische Erfolgsfaktoren (Risiken, die durch uns positiv beeinflusst werden können):</u> (Massnahmen zur Minderung sind in Tab. 4, S. 38 aufgeführt.)
Schwierigkeiten bei der Kommunikation der Projektziele lokal, da langfristige Effekte anstelle kurzfristig und unmittelbar spürbarer Resultate (z.B. Bau neuer Brunnen) angestrebt werden, was für die Bevölkerung ungewohnt ist.
Fachliche Probleme bei der Umsetzung des Vorhabens (z.B. Auftauchen von Fragestellungen, die vom Projektteam selbst nicht abgedeckt werden können).
Unwägbarkeiten, die in der Natur und Offenheit der Forschungsarbeit liegen (z.B. mangelndes Verständnis von Stakeholdern für Abweichungen vom Forschungsplan, um nicht eingeplante, aber neu als projektrelevant erkannte Fragestellungen zusätzlich zu bearbeiten und ev. andere Inhalte zurückzustellen).
Technische Schwierigkeiten mit Messgräten oder Projektfahrzeug aufgrund schwieriger Einsatzbedingungen.
Mangelndes Interesse / Akzeptanz der Nutzer und Zielgruppen gegenüber den Projektresultaten.</td></tr>
<tr><td><u>Externe Einflussfaktoren (Risiken, die vom Projektteam nicht oder nur mir Schwierigkeiten positiv beeinflusst werden können):</u> (Massnahmen zur Abfederung / Kompensation sind in Tab. 4, S. 38 aufgeführt.)
Erschwerung der Datenakquisition vor Ort durch äussere Einflüsse (z.B. ungewöhnliche Wetterlagen, die Daten verfälschen), da mit 4 Jahren knapp bemessene Zeitspanne.
Mangelnde Zuverlässigkeit seitens der zentralen Projektpartner vor Ort (lokale Organisationen, Universitäten, Behörden), Eindruck des “ausgenutzt werdens”.
Intransparente Kompetenz- und Machtverhältnisse national, regional und lokal, dadurch Gefahr der Instrumentalisierung des Projektes für Partikulärinteressen.
Die Projektpositionierung zwischen wissenschaftlicher Forschung und Entwicklungszusammenarbeit kann auch ein Risiko sein, da das Projekt als keinem Bereich klar zugeordnet wahrgenommen werden könnte.
Veränderung der Sicherheitslage in Marokko.
Veränderung der Voraussetzungen vor Ort (z.B. nicht mehr willkommen sein aufgrund einer Änderung der Kompetenz / Machtverhältnisse).
Korruption</td></tr>
</table>

Annex 2: Selection of reports of Moroccan water authorities and international organisations on the conditions of water and environment in Morocco

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