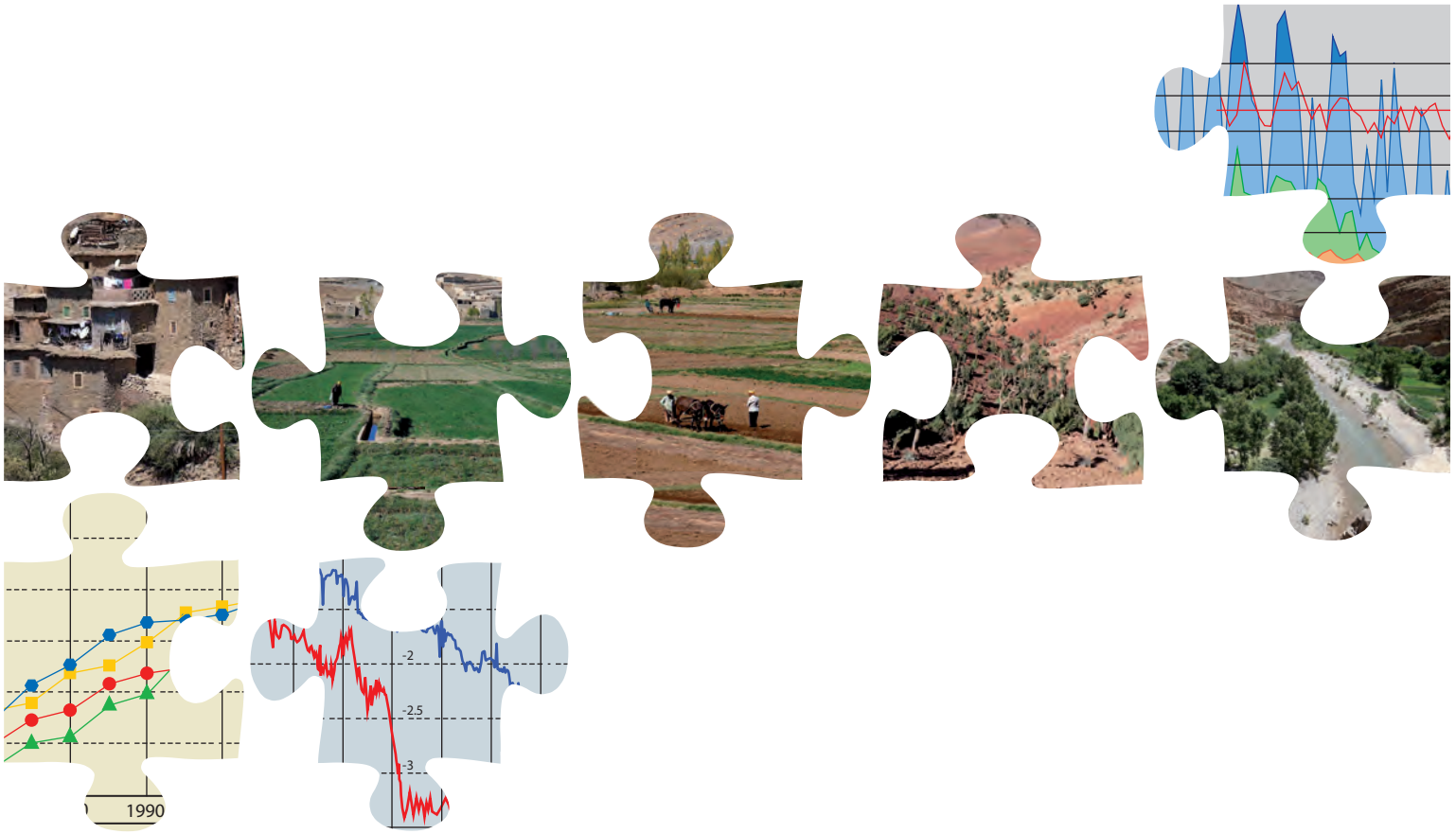
INITIATIVE FOR A BALANCED WATER RESOURCE MANAGEMENT
INITIATIVE POUR UNE GESTION INTÉGRÉE DES RESSOURCES EN EAU
INICIATIVA PARA UNA GESTIÓN EQUILIBRADA DE LOS RECURSOS HÍDRICOS

water 4 future

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

Project description



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zh aw
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November 2016

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:	17th 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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Abstract

Water is life, a gateway to the future. This is just as true for the economic, social, and cultural life of human beings as for animals and plants. Where water is scarce, we experience competition, stress, anxiety about the future, and we see the emergence of crises, pauperisation, and migration. In many regions of the world, this has come to be a daily reality. Although water abundance as such does not yet guarantee sustainable development, water shortage is likely to make sustainable development harder or impossible to achieve.

For the rural population in dry areas, especially for people living in the mountains, water is the central resource, whether for their modest agriculture or for tourism. Their local water resources are very limited and their substitution would require enormous technical efforts. In many valleys, the pressure on water, vegetation, and soil is very high today and it will increase even further in the future. But how much water can be used over time without jeopardizing the natural resources? Which activities consume or require how much water? What sort of development scenarios are compatible with existing water resources, and what impacts are to be expected on the condition of soils and vegetation? Rural communities, in particular communities in the Global South, often lack the means to elaborate answers to these questions that are, however, crucial for planning and sound decision-making.

It is thus our aim to support the population of dry rural mountain areas in using their environmental resources in a sustainable manner, and in improving the quality of their local habitats. To achieve this, we intend to develop a high-resolution decision support system (DSS) for the local resource management in the form of a free online application, which will be provided to the general public, to non-governmental organisations, to educational institutions, and of course to authorities on all administrative levels. It will enable users to disclose, analyse and evaluate the causal relations between water supply, the environmental condition, and activities related to water, as in agriculture, household or tourism, in qualitative and quantitative terms. Thus, the DSS allows users to assess the ecological and economical consequences of their current and future use of resources as well as to evaluate development options and the resulting water and environmental situation on a transparent, well-informed basis.

The scientific foundations of our decision support system will be established through a series of case studies on local water usage systems in the Atlas Mountains in Morocco, where we have found a working environment optimal in many respects. We will thoroughly examine the natural, human-altered and artificial flows of water, their interaction with soil and vegetation, the use and regulation of local environmental resources, as well as the demographic, economic, and political implications. In a first step, these interrelations will be modelled individually for each case study. For this purpose all variables relevant for the use of environmental resources such as precipitation, evapotranspiration, surface and ground water discharge, water consumption through human activity etc. will be measured in the field. Subsequently, estimates will be made concerning their development under altered climatic, demographic, and economic conditions in the future. Finally, these case-related models will be merged into a user-friendly DSS for general application in dry mountain areas anywhere in the world. The envisaged DSS will ideally be web-based, linked to a database, and suitable for interactive use on PCs, tablet computers, and perhaps also on smartphones.

Cooperation with the local population is crucial for the success of the project. Through integration of natural and social scientific analyses with the knowledge of the local population, we pursue a truly transdisciplinary approach. This allows to tailor our water usage model optimally to the local conditions and needs, and to bridge the gap between research and development cooperation. With a high-resolution DSS for the local resource management we pursue a completely new approach in decision-making support, as well as with a low-threshold, free access and with interlinking via a user platform. 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.

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

2 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[1]. 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. It has thus become a serious reason for migration that has barely been perceived or recognized so far by the wider public in the Northern hemisphere.

A sustainable[3] 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.

3 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.

4 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.

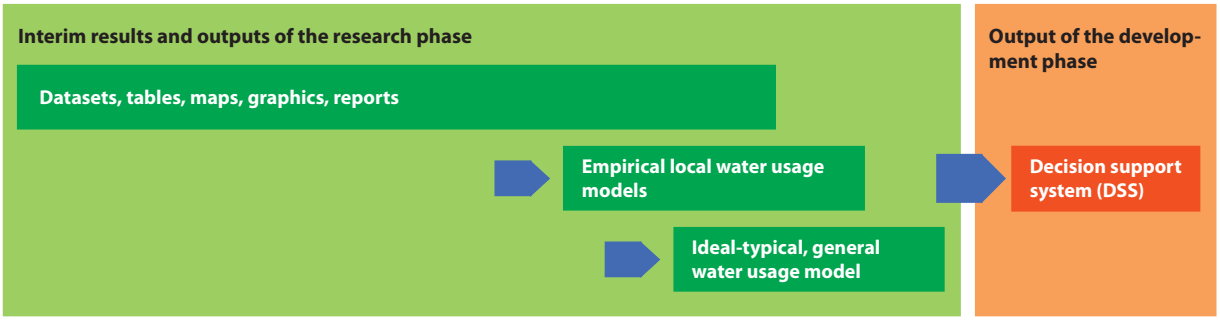
[1] Desertification: The transformation of arable and habitable land into semi-desert or desert areas.

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

[3] Sustainable development: 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.

[4] Transdisciplinary research: Interdisciplinary, natural and social scientific investigations in cooperation with the local population.

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*.



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 2015. After finishing the preliminary phase, it is now in the phase of organising fieldwork and raissing funds for the research phase. For a detailed project plan see fig. 7 on p. 10 in the enclosed project documentation.

5 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. 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.

6 The project in the light of global initiatives

The UN Sustainable Development Goals laid down in September 2015 (2030 Agenda) and the Paris Agreement to Combat Climate Change 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[5]. 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 them to partake in the devising and implementation of measures in many ways, also informally. In addition, both agree-

[5] A carbon sink (or CO_2 sink) is a reservoir that absorbs and stores carbon temporarily or durably, e.g. forests or the ocean.

Impact model

Target area / target groups

Initial situation

- Dry mountain areas worldwide, particulary in the Global South
- People affected by a scarcity of environmental resources
- Unsustainable use of environmental resources
- Degradation of soil and vegetation, desertification
- Risk of socio-economic crises, lack of perspective, out-migration and social tensions
- Lack of sound knowledge about environmental resources
- Lack of reliable and broadly accessible information

Input: Objectives / Resources

- Ecologically compatible and sustainable local management of using water, soil and vegetation
- Open access to information for everyone
- Increased partizipation of the civil society in planning and decision-making processes
- 6 years of research and development (240 % by position), volunteer work, measuring devices
- Cooperation with the population and with Universities in Morocco

Implementation / activities

- Case studies on the usage of the local environmental resources and on the local development in the Atlas Mountains in Morocco
- Multiannual transdisciplinary fieldwork: physical and chemical measurements, surveys, interviews, utilising expert knowledge of the local population
- Development of a model for the local usage of environmental resources that will help civil societies and authorities to assess their current resource usage and to simulate development scenarios

Output: services rendered

- Web-based, user-friendly decision support system (DSS) for the local management of environmental resources that will be provided to the civil society and to authorities on all administrative levels for free
- Platform for the collection, processing, and exchange of data and experiences among the users of the DSS
- Web-based application aids
- Data concerning environmental resources and their usage in the Atlas Mts. of Morocco

Outcome: effects on the target groups

- Target groups know that a sustainable use of the natural environment may improve their living conditions and are able to act accordingly
- Target groups are able to assess development scenarios with regard to their sustainability
- Target groups dispose of realistic future prospects and are able to meet future challenges
- The usage of environmental resources becomes more sustainable
- Decision-making processes become transparent and democratic participation increases

Impact: effects beyond the target groups

- Protection and preservation of water, soil and vegetation
- Deceleration of desertification, preservation of biodiversity
- Prevention of ecological and social crises
- Increase of prosperity and security, maintenance of social peace
- Reduction of out-migration
- Increased integration of research results in the political decision-making processes

ments 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, 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.

7 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:

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. In addition, the related research work mainly contributes to understanding large-scale interrelationships[6]. 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. 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.

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.

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

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.

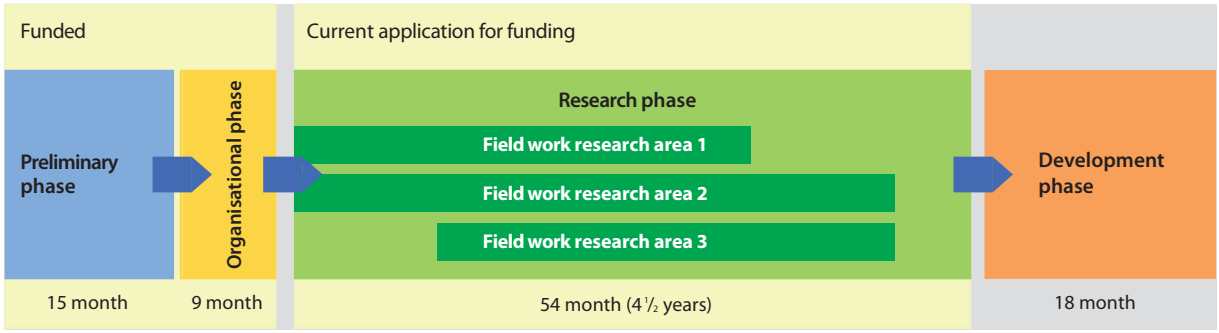
5 – Bridging the gap between scientific research and development cooperation: It has often been criticised by politicians and developmental organisations alike that there were hardly any planning and decision-making tools as a basis for a sustainable use of environmental resources. Seen the other way round, scientists were often disappointed that their research results were not sufficiently integrated in the political decision-making processes[7]. 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.

8 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. Morocco enables us to conduct case studies in areas with different climates, morphologies, vegetation and soil types, which represent typical natural environments and economic systems of dry mountain areas, and which due to the overuse of resources throughout the decades have demonstrated the need for sustainable management of environmental resources. In addition, Morocco lies within reasonable distance from Switzerland, which makes it possible to conduct field research with responsible environmental strain.

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. For a detailed time schedule with preset milestones see fig. 27 on p. 36 in the enclosed project documentation. 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 DSS and to implement it as a user-friendly IT solution. This project application serves to finance the research phase.



10 Methodology

10. 1 Preliminary phase

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). The bulk of the research work will be conducted in three research areas that are different from one another primarily in terms of climate and water stress, and secondarily in terms of morphology, geology and vegetation. For specific problems, additional areas may be included in the

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

	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

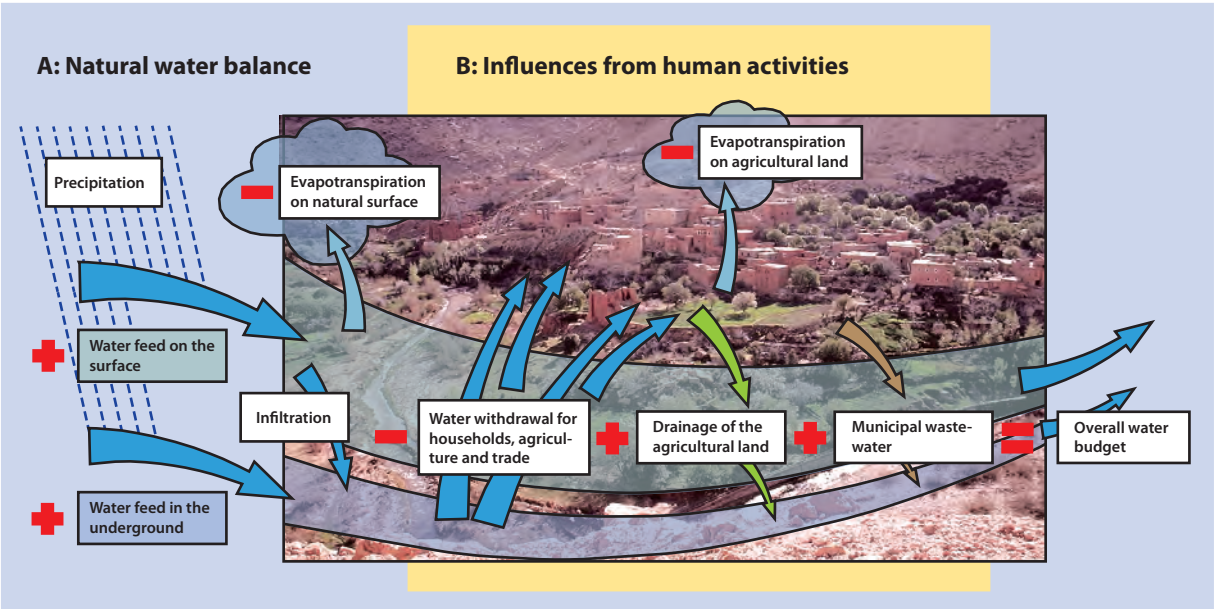
course of the project. For more detailed information about the research areas, for maps, satellite pictures and various images see chapter 10.1 on pages 9-20 in the enclosed project documentation.

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.

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. 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. 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, trade and 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[8].



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

[8] There are numerous scientific publications of Moroccan and international origin about natural and social scientific questions relating to dry and mountainous areas as well as to 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.

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 (for details, see chapters 10.3 and 10.4 on pages 21-30 in the enclosed project documentation).

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 outflow (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, Sq, 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.

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 and 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.

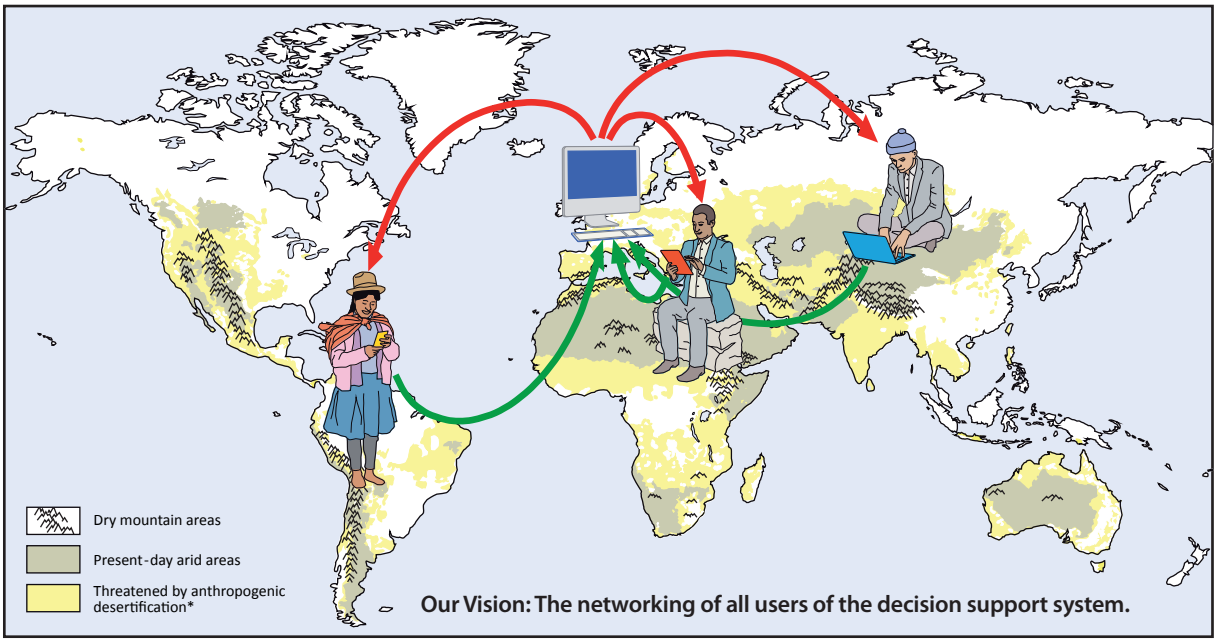
The DSS intended by this project is meant to be used by professionals as well as by interested lay people from the civil society. Operating with widely understandable pictograms, it should thus be easy to use and understand, and it will be provided in different languages. It should be accessible through a website that serves at the same time as a platform for collecting and exchanging data and case examples provided by users, in turn helping 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 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 the table below:

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 m^3 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.



Graphics: Martin Wyss

*Data according to U.S. Department of Agriculture, Natural Resources Conservation Service, Soil Survey Division, World Soil Resources.

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 project-promoting 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 association *Initiative for a Balanced Water Resource Management* 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. They have to take action, they may compete or cooperate, and they may establish scenarios. The game may be designed as a strategy-game or as a quiz. It 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

Project responsibility and project partners: Total project responsibility will be in the hands of the project team of the association *Initiative for a Balanced Water Resource Management*. We are striving to implement a good institutional network by cooperating with local partners, as well as to anchor the project in the local population. Within the research areas, we will first and foremost seek cooperation with local development organisations that are supported

by the local community. Our local university partner still needs to be designated. A number of contacts are already in place. The central project partner in Switzerland is the *Institute of Natural Resource Sciences* at the *ZHAW – Zurich University of Applied Sciences*.

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. Interviews in connection with socio-geographical research will rely on local people of both genders, who master the local languages (Berber dialects) and have at least some understanding of scientific procedures 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.

Participation of people immediately concerned: People immediately affected by the scarcity of resources will directly influence the surveyed data due to their local expertise, i.e. in interviews. They will also have the opportunity to discuss project results at events to be held in the villages involved, and they will thus be able to influence the main thrust of the research project (transdisciplinary approach).

Synergies: The cooperation with local partners will yield synergies in the fields of expertise, problem solving, infrastructure, organisation, data sharing, and personnel resources. 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 who can be involved in the project, if necessary.

Subcontracting to local service providers: The intention is to carry out part of the water analyses in laboratories of Moroccan universities or government agencies. Therefore, there are plans for the beginning of the research phase to test diverse laboratories for a potential collaboration.

Data handling and results: Public access to data and project results will be made transparent and will be ensured 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.

Publicly-effective measures: The *Initiative for a Balanced Water Resource Management* 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 *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.

Project management and evaluation: A central instrument for project management and evaluation is an impact model that guides users through the project and contains information about inputs, outputs, outcomes, and impacts including indicators, target figures, and sampling methods (see fig. 3 and annex 1 in the enclosed project documentation). 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.

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

Risks and measures to minimize risk: All risks that are currently visible and the measures to be taken in order to minimize such risks are listed in the enclosed project documentation (chapter 13 on page 37 and table 4 on page 38).

Regular project exit, transition to post-project activities: 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 organisation 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, 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.

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.

Beneficiaries: Groups of people in the target areas that are currently affected by the scarcity of water and resources, but equally all those who might or will be concerned by such circumstances in the future.

Number of users/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 villages, towns or 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 pupils, students and people from professional practice, who will raise their environmental awareness through training with the DSS.

13 Project financing

The preliminary phase and the organisational phase have been – and still are – funded by substantial contributions of the NOMIS Foundation, by smaller contributions of several other foundations, by membership fees of the project-promoting association *Initiative for a Balanced Water Resource Management* and by voluntary work. In a next step, the research phase is to be financed. The subsequent development phase can not be planned yet, the search for funding for this last phase will thus start at a later time.

The budget for the research phase was established on the basis of experience gained from the preliminary phase in 2015 that also included two trips of nine weeks altogether to Morocco. We plan with 240 per cent by position (160 per cent by position for the project team and 80 per cent by position for local employees). Since all members of the project team will work in almost all functions, and in order to keep the administrational costs as low as possible altogether (3.5% of the project costs), all functions have been calculated on the basis of the same net average hourly rate. The budget is available on request.

The research phase can start as soon as substancial financing of the first year is provided. Until the end of 2017, funding of the whole research phase should ideally be secured.

With this project, we start from the well-founded assumption that somewhere between several tens of thousands and several million people will be the beneficiaries of the intended decision support system. The investment per person amounts to approx. 50 Swiss francs given a scale of several tens of thousands beneficiaries, and less than one Swiss franc per person with several million beneficiaries.