GLOWA JORDAN RIVER
AN INTEGRATED APPROACH TO SUSTAINABLE MANAGEMENT OF WATER RESOURCES UNDER GLOBAL CHANGE

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INTRODUCTION

OVERALL GOAL OF THE PROJECT

The GLOWA Jordan River Project (GLOWA JR) provides scientific support for improved water management in a highly water-stressed region, or as stated in the BMBF guidelines, GLOWA provides “simulation tools and instruments to develop and realize strategies for sustainable water management” under global change. As confirmed in the recent IPCC report (IPCC 2007a), the Mediterranean region is likely to suffer most dramatically from an increase in temperatures, a decrease in precipitation and an increase in the variability of climatic conditions, plus projected sea level rise. These will considerably increase water scarcity and associated problems in the study region – highlighting the importance of the GLOWA Jordan River Project.

The central question of GLOWA JR is:

How can the benefits from the region’s water be maximized for humans and ecosystems, under global change?

With that central question, GLOWA JR provides an innovative framework for assessing ‘new’ blue and green water sources (i.e. land management and reallocation options), overcoming the traditionally fragmented approach to sustainable resource management.

A multitude of scientific studies and applied projects have been conducted in the Eastern Mediterranean region, addressing the issue of water scarcity. Therefore, GLOWA JR has built upon the rich and long-standing experience in adapting to water scarcity and climate variability in the Jordan region. However, these activities either lack thorough scientific support (e.g. some of the development projects), they do not address global change impacts, they ignore predominant land use types, they are narrowly focused on the water supply side, or they are purely scientific and lack communication of findings to other scientific disciplines or to the relevant stakeholders. With this study, we aim at filling these gaps.

Compared to the many previous studies in the region and other IWRM projects, the specific niche of GLOWA Jordan River is:

a) Its focus on **global change processes**. These have become even more important with the renewed interest in climate change and its impact with the recent IPCC reports. These have confirmed that the water-stressed Eastern Mediterranean region will suffer from a further reduction in annual precipitation and an increase in frequency of extreme climatic events. Clearly, these and simultaneous land use changes need to be addressed when developing sustainable strategies for managing the scarce water resources in the region.

b) Its **integrated analysis** of strategies for sustainable water and land management under global change. Previous studies have usually narrowly focused on isolated measures to increase water supply and only few studies have addressed more than one option for water management. Also, water demand management has played a relatively minor role when compared to supply-side options including so-called 'new water' options such as desalination or irrigation with treated waste water. Here, we integrate both an entire range of water supply management options as well as water

c) Its pioneering attempt to specifically address so-called **green water management**, i.e. the management of water demand via wise land use management. Within this context, GLOWA JR is furthermore unique in systematically addressing the impact of land use on the hydrological cycle and water productivity for the entire range of land use types. IWRM analyses must remain incomplete when narrowly focusing on only a fraction of the land. Open space accounts for 80-90% of the total land cover in the study region and terrestrial ecosystems 'use' 70% of the worldwide available rainwater. Open areas and their vegetation both critically affect the hydrological cycle and water productivity through changes in water fluxes. At the same time, water productivity of these areas (estimated as ecosystem services) may be very high. Therefore, open space and its management must be an integral part of sustainable water management in the region. Though obvious, previous IWRM projects (in general and in the region) have failed to explicitly address the value of water in all important types of land use.

TOWARDS PHASE III

In phase I of the project, GLOWA JR has provided new process understanding and a wealth of new water-related data and information for specific locations. Phase II has synthesized and consolidated this information and regionalized methods and findings for the upper and the lower Jordan River catchment. Phase II was built of an integrated mosaic of 11 subprojects, each of which investigated different aspects of input scenarios (climate, land use and others), or impact modeling (water, land allocation, socio-economy, ecology).

While phase I mainly focused on experiments, data collection and on building up the necessary knowledge of the status quo, phase II has relied more strongly on modeling for improving scenarios of global change impacts on social and natural systems, for upscaling results from field measurements to a basin scale, for developing and adaptation options, and for introducing the two integration tools. Short descriptions of the models used in phase II of GLOWA JR can be found at http://www.glowa-jordan-river.de/Project/Models. Also, consistent with the GLOWA mandate, we have intensified our efforts to integrate the scientific results and communicate them to the stakeholders. Phase III will build on the existing models and, with the exception of the ecological studies, there will be no more new data collection (see JAC recommendations of mid-term evaluation 2006).

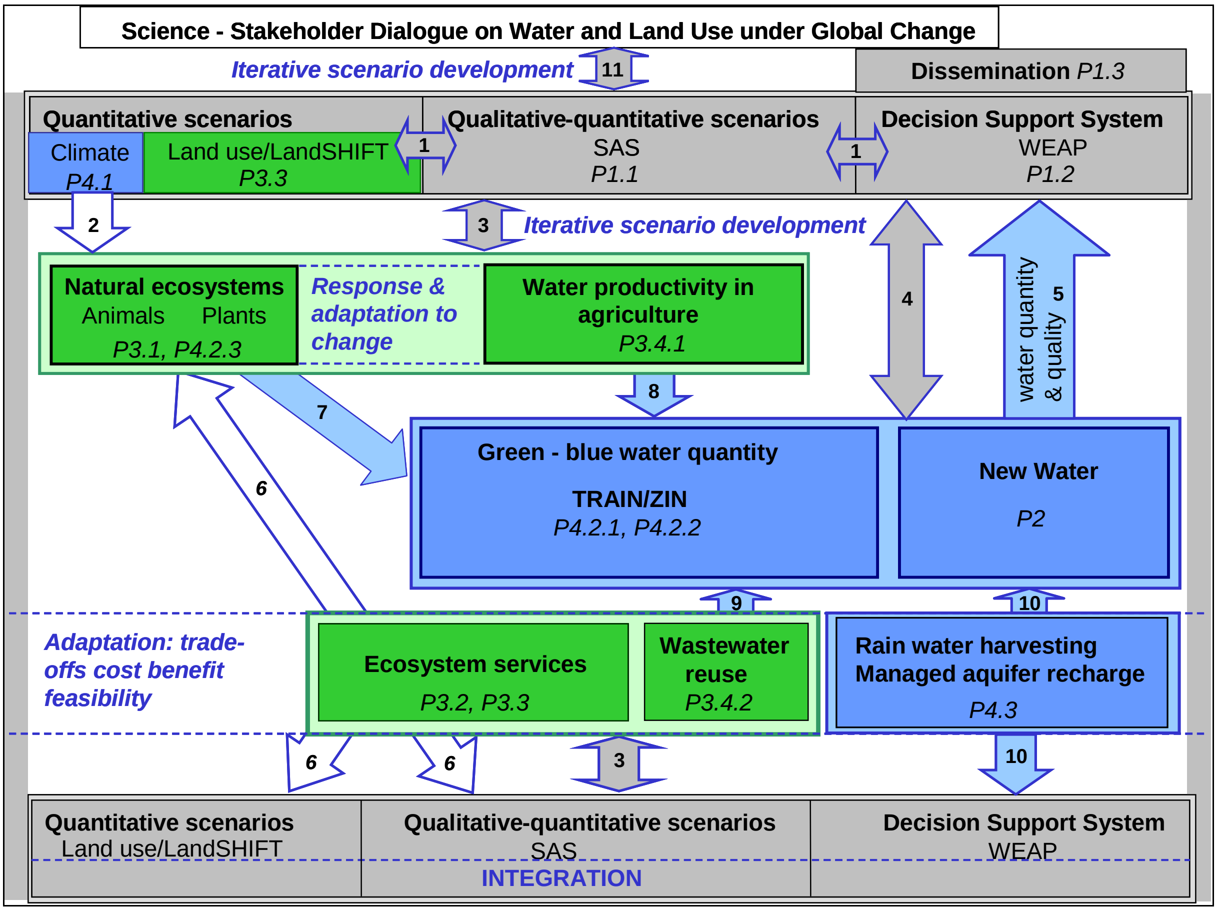

Fig. 1 Integration in phase 3 of GLOWA JR is achieved at two different levels: between subprojects and the integration tools, and among subprojects

1) An alternating exchange of information to reshape the scenarios (⇔):

This iterative process initially takes place between the integration tool SAS and the quantitative scenario model LandSHIFT with the ecological and hydrological subprojects. While P1.1 (SAS) and P3.3 (LandSHIFT) provide quantitative scenarios and land use information, the data from the ecological projects (3) include maps of biomass production, runoff vulnerability, extinction risks, maps of vegetation types, vegetation structure, erosion risk, plant productivity and changes in economic welfare under different scenarios to be processed in LandSHIFT. The output (1) will be maps of land use change and its impact on ecosystem services, water requirements for livestock and settlements provided to SAS to shape the scenarios successively.

The iterative alternating data flow with the hydrological projects (4) include amounts and spatial distribution of future surface and ground water availability, distribution, balances for green water and irrigation water requirements applying the GLOWA JR climate change simulations (2). The socio-economic projects provide data on value of landscape (ecosystem services) via 3.2 to SAS (6).

Furthermore, an iterative exchange takes place between P1.1 (SAS) and P1.2 (WEAP) with the stakeholders through an extensive science-stakeholder dialogue for scenario development as well as for implementation and dissemination of GLOWA JR results (11). Within the integration tools the data exchange is mainly characterized by providing scenario information (1) from SAS to LandSHIFT and WEAP, and vice-versa by providing water balances (current & scenarios), hydrological & economic evaluation of adaptation strategies from WEAP to SAS (1).

2) Unilateral flows of information (⇨) between the projects:

This includes data flowing into the modeling projects (LandSHIFT, TRAIN-ZIN) to be finally integrated in SAS and WEAP. The dataflow contains (7) predictive vegetation maps, vegetation parameters for modeling; (8) drainage patterns for the crop/soil combinations; (9) maps of TWW potential and (10) estimates of potentially new water surces. Most of this data will be used to compile the final output from TRAIN/ZIN into WEAP (5) which contains data on spatial representation of land use effects on water supply, green blue water fluxes, water demand by irrigation, yield distribution and effects on water demand and RWH & MAR-potential and focus areas.

For a detailed list of the flow of deliverables and time schedule within GLOWA phase III see tables A.1 and A.2.

Key tools for integration and dissemination of results, introduced in phase II have been:

1) The Water Evaluation and Planning tool (WEAP), for simulation and visualization of water availability, demand and quality for a range of global change scenarios and evaluating the consequences of various adaptation measures for the regional water system and comparing the respective costs of each of these measures. WEAP has become a generally accepted water resources planning and scenario tool across the MENA region, with several applications in and beyond the Jordan basin. A number of water managers from key institutions such as Ministry of Water and Irrigation, Jordan Valley Authority and Palestinian Water Authority, Ministry of Agriculture and Negotiation Support Unit have received initial WEAP training, in order to introduce WEAP in their respective institution. Also, the Israeli Water Authority and Mekorot have shown specific interest in applying WEAP in the Upper Jordan River Catchment. In the course of phase II, WEAP has been developed further to integrate additional data and to address specifically groundwater management (dynamic coupling of WEAP and MODFLOW). Due to the great success in disseminating sub regional and regional WEAP applications to several key stakeholders in all three countries, WEAP will continue to serve as a major comprehensive data integration, analysis and evaluation tool in phase III. In addition to the sub-regional WEAP models, phase III priority is on further developing the regional WEAP application for assessing sustainability of transboundary adaptation options.
2) The Story and Simulation (SAS) approach, which combines expert and stakeholder knowledge with the scientific methods from the other projects in GLOWA JR, to derive comprehensive and coherent scenarios on global change impacts. Phase II has yielded the first four scenarios (‘GLOWA scenarios’ in the following) which have been partly integrated with the scientific models. Phase III will focus on further developing these scenarios and – with the help of WEAP – on evaluating the sustainability of various specific management options.

These two integration tools have a) strongly supported integration among subprojects and between science and stakeholders and b) provided the required link between science and water and land management, in order to compare trade-offs between different adaptation options in water and land management for their social, economic and ecological costs and benefits. The potential to assess trade-offs between very different management options, with respect to their implications for water quality, quantity and costs will be the major scientific contribution of GLOWA Jordan River.

Phase III will be devoted to further developing and applying the two integration and dissemination tools, and to filling gaps in the scientific knowledge required to evaluate strategies of coping with water scarcity under global change. Another focus of phase III will be on regionalization of scenarios, building upon the national WEAP applications that were developed in phase II.

PROJECT STRUCTURE

In phase II, GLOWA JR Project has been successfully restructured and followed a top-down approach. Namely, all subprojects in GLOWA JR were explicitly designed to interact with the SAS (scenario) approach and to deliver data to WEAP and/or produce data in GIS format. For phase III, we have largely kept this successful structure and flow of data from phase II (Fig. 1) but we have merged several subprojects under four projects, each addressing a different aspect of water management under global change or integrating these aspects to answer three central questions (Fig. 2, see also P1 for the three questions).

The four themes are as follows:

1) **Integration, application and dissemination**, dealing with the integration of phase II and phase III scientific results, with developing integrated strategies for sustainable water and land management under global change, and with dissemination of the results to stakeholders and the scientific community.
2) **'New' (blue) water sources**, where existing information on the most important sources of blue water will be collected to be systematically analyzed for potential to alleviate water scarcity and for their side effects and sustainability, e.g. in WEAP. The data will be obtained from phase II results and from existing results of other water-related scientific and applied projects in the region.
3) **Green water management**, where we will continue our successful focus on the role of land management in sustainable water management under global change. As pointed out above, this theme is unique within the regional IWRM context in that the explicit role of open space ('nature') and other land uses in water management will be addressed systematically, and services produced by water in ecosystems and agriculture will be traded-off against each other.
4) **Regional water balance**, where we will finalize our regional climate scenarios and subsequent effects on the regional water balance by means of existing models. Consistent with the needs of the stakeholders, refinement of models will be done with a focus on extreme climatic events, in particular series of drought years.

The key questions for phase III will be:

- **Taking into account future climate and land use change scenarios, how can various "new" (blue) water sources contribute to future water resource needs of the region?**
- **How can land use planning, i.e. green water management, become integral part of water management under different scenarios?**
- **What will be the effect of climatic extremes on the regional water balance and sustainable management of water resources in the region?**

Consistent with these key questions, the main tasks will be to:

- Further establish WEAP as strategic planning and scenario tool for local and regional water managers.
- Develop strategy-based scenarios using the SAS approach.
- Systematically evaluate new blue water sources with respect to their usefulness in future water management.
- Systematically evaluate the potential of green water management, including open space as the major land cover type, with respect to its usefulness for future water management.

- Further evaluate the impact of climate change (especially extreme events) and land use change on water resources in the region.

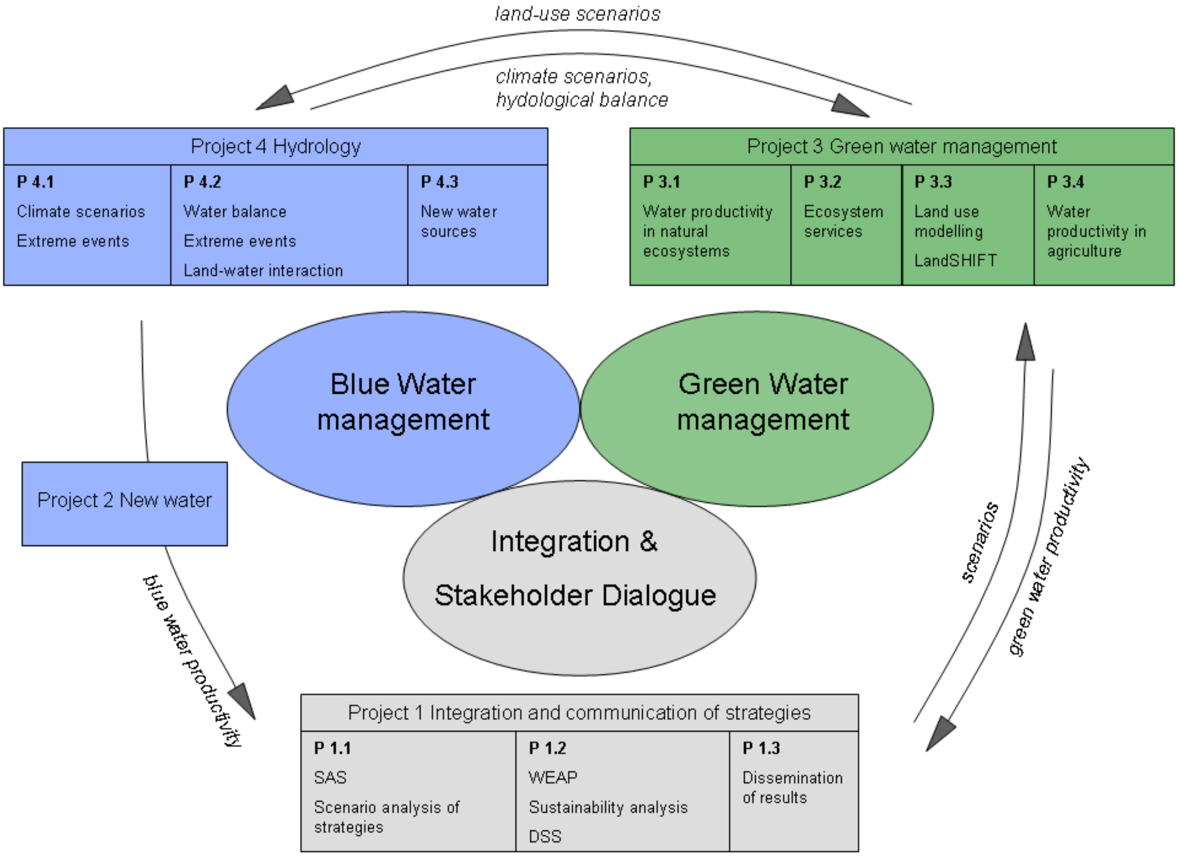

Fig. 2: Phase III project structure (only main links shown) with the four themes feeding into three central tasks. Products of separate projects and their links are explained in detail in the subproject proposals. Three core questions are addressed by the main integration tools (see project 1): The so-called New Water Question is addressed by project 2, project 4.3, and project 3.4; the Land Use Question is mainly addressed by project 3; the Climate Extreme Question is mainly addressed by project 4.1 and by project 4.2.

PROJECT 0: COORDINATION

Strong overall coordination is required to achieve the GLOWA goal of synthesizing and translating scientific results from all projects into information for decision support in sustainable water and land management. Successful and efficient routines for managing this international project have been established during the previous phases and will be maintained during phase III.

SUBPROJECT 0.1: SCIENTIFIC COORDINATION

Germany: K. Tielbörger (University of Tübingen), J. Alcamo (University of Kassel)

Israel: P. Alpert (Tel Aviv University)

Palestinian Authority: A. Jayyousi (An-Najah University)

Jordan: A. Salman (University of Jordan)

Scientific coordination will be based on the integration tools in the GLOWA Jordan River Project described in P1, i.e.

1) WEAP the Water Evaluation and Planning tool
2) SAS (story and simulation) approach for qualitative and quantitative scenario development and stakeholder dialogue

The project partners in the scientific coordination of phase III of GLOWA JR will be the two principal investigators for these tools i.e. K. Tielbörger (University of Tübingen, WEAP) and J. Alcamo (University of Kassel, SAS). For ensuring implementation within the region also beyond GLOWA, the leading scientist from each project country, P. Alpert (Tel Aviv University, Israel), A. Jayyousi (An-Najah University, PA) and A. Salman (University of Jordan, Jordan) are involved. Based on the activities in phase I and II, the scientific coordinators will be responsible for the integration of information from all projects into the integration tools, and will lead the continuous interaction with stakeholders on the regional adaptation and application of these tools and the overall project results for bridging between science and water management and policy making. Furthermore, the scientific coordinators will be responsible for building a network with other activities in the region and beyond and for working together with the other GLOWA projects, including presentation of GLOWA Jordan River at major international and national conferences.

Scientific coordination includes the following activities:

1) Decision-making regarding internal project structure and direction, and communication of decisions to project participants and, if applicable, to the BMBF, the MOST and the JAC (UT & TAU, via technical coordination).

2) Scientific organization of project meetings: This includes the coordination of the scientific program of the kick-off meeting, the annual status conference and the wrap-up conference (e.g. decision about meeting structure, invited speakers, key topics, etc. see P1.3 for details).
3) Continuous and frequent personal contact to project partners and stakeholders.
4) Regular communication of overall project results to stakeholders and scientific community (see also P1.3).
5) Scientific exchange with current and past related projects (e.g. SMART, Dead Sea project, EXACT, and others).
6) Co-editing of dissemination products (e.g. special issues, CDs, flyers, etc. see P1.3 for details)

SUBPROJECT 0.2: STEERING COMMITTEE

Germany: K. Tielbörger (University of Tübingen), J. Alcamo (University of Kassel) & J. Lange (University of Freiburg)

Israel: P. Alpert, T. Dayan (Tel Aviv University) & M. Shechter (University of Haifa)

Jordan: A. Salman & E. Karablie (ATEEC)

Others: R. Twite (IPCRI), H. Hoff (SEI)

Palestinian Authority: A. Jayyousi (An-Najah University)

A permanent steering committee has been formed in the previous project phase, the core of which consists of the key scientists in the four countries. The mandate of this committee is to take major decisions about overall direction and structure of the project. The committee members from the study region are also responsible for the flow of information within the project in their respective partner countries. The committee is formed by K. Tielbörger, J. Alcamo and J. Lange (Germany), A. Jayyousi (Authority), A. Salman and E. Karablie (Jordan), P. Alpert, T. Dayan and M. Shechter (Israel), H. Hoff (Sweden), and R. Twite as a representative of a binational NGO.

The extended steering committee consists of the above scientists and selected stakeholders from Germany (GTZ), Israel (e.g. Water Authority, Ministry of Agriculture), Palestinian Authority (PWA, PHG, Ministry of Agriculture), and Jordan (MWI, Ministry of Agriculture).

The steering committee meets twice a year. One meeting will be held at the annual status conference, the second meeting (extended committee) will be held at the annual scenario workshop. The agenda for these meetings will be defined by the scientific coordinators in collaboration with the other partners in the region. In addition to these formal meetings, there will be continuous contact via phone and email between all members of the steering committee to enable maximum transparency of decisions and complete flow of information.

SUBPROJECT 0.3: TECHNICAL COORDINATION

Germany: K. Tielbörger (University of Tübingen)

Israel: P. Alpert (Tel Aviv University)

(Note that the special funding situation requires a separate technical coordinator in Israel.)

Technical coordination includes the following activities:

1) The overall administrative coordinator (K. Tielbörger) is the contact person for the BMBF and the Joint Advisory Committee in all project-related manners. She is responsible for communicating instructions of the BMBF and decisions of the JAC to the project participants and the steering committee (see P0.1). Vice-versa, Tübingen University is the main contact for the project participants The Israeli coordinator (P. Alpert) is the main contact for the MOST and for Tübingen University in project matters related to the Israeli scientists. In charge of preparing MOST report and other technical matters in Israel is Mr. Haim Shafir.

2) Administration of funds: This includes preparation of subcontracts for all Jordanian, Palestinian, German (IMK-IFU), and other institutions (SEI, Tahal, IPCRI), distribution of annual budgets to the respective partners, annual accounting and auditing activities and supervision of appropriate use of funding. Administration of funds for Israeli scientific partners is via MOST, supported by TAU.

3) Compilation of overall annual project reports: This includes organization of timely submission of reports of all partners, control of milestones and deliverables, recommendations about release resp. freezing of funds, and compilation, formatting and submission of long and short annual report to the BMBF. Similar to phase II, Israeli partners will submit a long report to the coordination in Germany, but a separate short report to the MOST (via the Israeli coordinator).

4) Technical organization of a kick-off meeting, an annual status conference and the wrap-up conference (see P1.3) will be done by the coordination team at Tübingen University. Due to the wrap-up conference, these activities will be more extensive than in the previous project phases. The tasks include organization and reservation of conference location, invitation of project partners and other participants (e.g. BMBF, JAC, keynote speakers, stakeholders, and scientists from related projects), technical arrangements and travel arrangements for invited participants, and on-site technical organization of the conferences (e.g. printing of programs and other information, help desk, technical support etc.). We intend to hold the kick-off meeting in Germany embedded in the German-Israeli Year of Science. The status conference will probably be held in the region. The wrap-up conference is planned to be held in Cyprus, to enable a maximum number of stakeholders and scientists to attend.

5) Travel arrangements for Palestinian and Jordanian partners, such as support of visa applications with the respective embassies will be done by the coordinators at Tübingen University, similar to the previous project phases.

6) Maintenance of the GLOWA Jordan River website will be continued by Tübingen University. This includes permanent updates of ongoing project activities, publication lists and uploads of visual information, e.g. model outputs, updated fact

7) The coordinators will also be the main contact for related projects, such as the SMART project and scientists, NGOs, and stakeholders.

8) Tübingen University will be responsible for main public relation activities such as press release, brochures, fact sheets and CDs for wrap-up conference and post-GLOWA time, presentation of overall project at conferences etc.

PROJECT 1: INTEGRATION AND COMMUNICATION OF STRATEGIES

Coordination:

Germany and Sweden: J. Alcamo (University of Kassel), K. Tielbörger (University of Tübingen), H. Hoff (SEI)

INTRODUCTION

This project deals with …

- the core goals of the GLOWA Jordan River Project ("to provide scientific support for improved water management in a highly water-stressed region"), and
- the core objectives of the overall GLOWA research program as stated in the BMBF guidelines (to provide "simulation tools and instruments to develop and realize strategies for sustainable water management").

The aim of this project is to integrate results from different subprojects into coherent policy- and scientific products and to communicate the results of the project to a wide audience of stakeholders and scientists.

This project includes three subprojects and covers the following major activities:

1.1) The stakeholder-driven scenario analysis which will produce rich scenarios that examine a wide range of alternative water management strategies with respect to their sustainability.

1.2) The WEAP analysis that will generate informative and useful water balances and water quality and economic assessments, also for a wide range of alternative water strategies with respect to their sustainability and that will be implemented as a key water management support tool in the region beyond GLOWA.

1.3) The consolidation and communication of project results in the form of various policy-relevant and scientific products.

SUBPROJECT 1.1: SCENARIO ANALYSIS OF STRATEGIES

Germany: J. Alcamo (University of Kassel), K. Tielbörger (University of Tübingen)

Israel: P. Alpert & T. Dayan (Tel Aviv University), Yossi Dreizin (Water Authority)

Jordan: A. Salman (ATEEC), A. Subah (Ministry of Water and Irrigation)

Others: R. Twite (IPCRI)

Palestinian Authority: A. Jayyousi (An-Najah University), A.-R. Tamimi (Palestinian Hydrology Group), A. Jarrar (Palestinian Water Authority), I. Nofal (Ministry of Agriculture)

Background

These above two goals are fulfilled in this subproject in two ways. First, by providing stakeholders with the scientific and organizational support for developing scenarios. Second by working with stakeholders and experts to evaluate specific strategies for sustainable water management.

The new scenarios in phase III will synthesize information coming from project 1.2 (WEAP analysis), project 2 (evaluation of new water sources), project 3 (evaluation of land management) and project 4 (evaluation of extreme climate events and water availability).

The aim of the scenario analysis is to develop strategies for managing water in the region under climate change that take into consideration the uncertainties covered by the four scenarios developed under phase II (Box 2). Strategies for sustainable water development will be "overlaid" onto these four scenarios. The special value of designing strategies for four different possible futures is that it gives stakeholders and experts an appreciation of the uncertainty of how the future many unfold and provide an opportunity to design strategies that are robust to this uncertainty.

As in phase II, the SAS approach (Box 1) will be used to develop scenarios. This time the scenarios will focus on strategies for sustainable water management. The scenario analysis and development of strategies will focus on three "big questions" (see below). Information from all phase III subprojects will be needed to answer these questions.

Key results and key products from phase II

a) Results from phase II

In phase II a series of three scenario workshops were held in which stakeholders developed four storylines describing developments in society, land and water resources in the region over the next several decades. The scenario workshops and supporting quantitative analysis accmplished the following:

1) Results from a wide range of running scientific studies were synthesized in the study. Despite the fact that these scientific studies were carried out on a range of different scales and with very different goals, a substantial amount of information could be incorporated into the scenarios.

2) Stakeholders from Israel, the Palestinian Authority and Jordan came together to discuss and formulate scenarios about water management in the region. The scenario exercise provided a common ground for discussions about the future of the region that could be applied to other topics of importance in the region.

3) The stakeholders produced four storylines which are extensively documented in detail in Lübkert et al. 2007a and b. These storylines provide a valuable picture of the range of uncertainties that water managers must deal with in designing sustainable water management strategies for the region.

4) The entire procedure for the scenarios analysis is also described in detail in Lübkert et al. 2007a and b. This documentation will be very valuable for carrying out additional scenario exercises in the region.

b) Deficits of phase II

While the scenario analysis in phase II was partly successful in synthesizing disparate scientific information and in generating a view of developments in the region, it has not yet produced specific strategies for sustainable water management in the region. The deficits of the phase II scenario analysis included:

1) Lack of specific information about various water management options including water harvesting and managed aquifer recharge.

2) Incomplete information on water balances for various water development options.

3) Incomplete analysis of future occurrence of climate extremes.

4) Gaps in linkage between land and water management – While phases I & II began important studies about the land-water linkage, up to now their has not been a systematic regionwide analysis of these linkages as is planned in phase III project 3.

5) Insufficient contact with stakeholders in the region.

6) Insufficient involvement of GLOWA JR partners in the coordination of the scenario analysis itself.

Overall goal and key research questions

The aim of this subproject is to develop strategies for sustainable water management in the light of global change in the region. These strategies will be depicted in the form of scenarios (see below). It was not possible to develop these strategies in phase II because of the deficits noted above.

These deficits will be addressed by:

1) Providing information about water resource projects in the region (project 2).

2) Providing specific information about various water management options including water harvesting and managed aquifer recharge (projects 2, 3 and 4).

3) Providing detailed water balances for various water development options and their sustainability (projects 1.2 and 4).

4) Providing sufficient climate change data and information about climate extremes (project 4).

5) Providing a unified approach to evaluate the impact of land management on sustainable water management, namely, by comparing economic value – including ecosystem services of different land management options (project 3).
6) Expanding the scenario team to include partners from the region with significantly increased budget who will be responsible for intensifying contact with stakeholders in the region and who will be trained at Kassel University (project 1.1).

The sustainable water strategies to be designed in phase III will be depicted in the form of scenarios that build on the four GLOWA JR storylines developed in phase II of the project. The strategies will focus on **three big questions**, each of which deals with a critical water resource issue in the region:

Question 1: The "New Water" Question
What is the potential of "new water" sources?

How can "new water" sources be combined with conventional water resources and be utilized under the four GLOWA JR futures to provide adequate water for society and nature in the region? This question will be addressed by making use of information generated in P2, P3.4 and P4.3 and its further analysis in P1.2.

Question 2: The "Land Use" Question
How can land management contribute to sustainable water management?

What are future economic benefits, including ecosystem goods and services, provided by blue water uses in the region (e.g. for domestic sector and water sector) vs. green water uses (e.g. agriculture, tourism and other uses on open land). What actions can be taken to reduce water use (e.g. by increasing water productivity of crop production or shifting from irrigated to rainfed land uses)?

This question will be addressed with information from project 3, i.e. estimating future ecosystem goods and services and water requirements for different land uses.

Question 3: The "Climate Extreme" Question.
What kind of impacts will extreme climate events have on regional water resources and related socio-economic development?

How will the climatic extremes (in particular, extended droughts) affect water management options under the different GLOWA JR futures? Where will major vulnerabilities arise? What actions can lessen these vulnerabilities?

This question will be addressed by making use of information generated in P4 and subsequent analyses in P1.2, i.e. the impact of climate extremes on water resources in particular the changed frequency of droughts, and analyses of actions such as new water sources, adaptive land and water use, and other adaptation options.

A note on definition of "scenarios" – The scenarios to be developed in GLOWA JR Project will consist of two main parts:

1) Qualitative scenarios (storylines) – To be developed by the stakeholders.
2) Quantitative scenarios – To be developed in conjunction with the storylines by GLOWA JR subprojects.

Working plan

Task 1.1a: Organizing and Conducting the Scenario Analysis

As in phase II, the storylines of the scenarios will be developed at a series of Scenario Panel meetings. This time the storylines will depict different visions of sustainable water management in the region, with a focus on the three big questions above (regarding new water sources, land management and water, and climate extremes and water).

The Scenario Panel will consist of stakeholders from the region. The meetings will be moderated by a professional facilitator and supported by GLOWA JR scientists. At the meetings, GLOWA JR scientists will present results from the subprojects and answer requests for further analyses from the stakeholders. In between scenario panel meetings, the scenario team will organize the meetings, coordinate quantitative analyses needed for the scenarios (e.g. by preparing model inputs based on the storylines), synthesize relevant information from GLOWA JR subprojects, and meet with stakeholders and inform them about scenario results and obtain their feedback.

The scenario analysis will be organized in the following way:

1) **First Scenario Panel Meeting (Sub-Regional Meetings)** – The scenario exercise in phase III will begin with three separate “sub-regional” meetings, one for stakeholders from Israel, one for stakeholders from Jordan, and one for stakeholders from the Palestinian Authority. It is thought that a larger number of stakeholders could be reached in this way. The stakeholders will include mayors, representatives of Farmers Associations working in the Jordan valley, members of NGOs (e.g. Friends of the Earth Middle East), local officials (representatives of local water authorities) and national officials (e.g. representatives of Ministries of Agriculture & Water).

2) At these meetings stakeholders will be informed about the scenarios developed in phase II, and will be asked to begin the development of the storylines for phase III. The storylines will depict different visions of sustainable water management in the region, with focus on the three big questions above.

3) **Quantification and Elaboration of Scenarios** – After the round of sub-regional meetings, the scenario team will coordinate quantitative analyses needed for the scenarios (e.g. by preparing model inputs based on the storylines), synthesize relevant information from GLOWA JR subprojects (see below), and prepare a workshop report.

4) **Second Scenario Panel Meeting (Regional Meeting)** – This will be a joint meeting with stakeholders from Israel, Jordan and The Palestinian Authority. Results from the sub-regional Scenario Panel meetings will be summarized, first results from GLOWA JR subprojects will be presented, and the panel will develop first draft storylines. Stakeholders will also specify the analyses they wish to have conducted by GLOWA JR subprojects.

5) **Post-Meeting Stakeholder Consultation 2** – Members of the scenario team will again consult with stakeholders, as above.

6) **Quantification and Elaboration of Scenarios** – As above.

7) **Third Scenario Panel Meeting (Regional Meeting)** – This will again be a joint meeting with stakeholders from Israel, Jordan and The Palestinian Authority. The

8) **Final Quantification and Elaboration of Scenarios** – As above.

9) **Post-Meeting Stakeholder Consultation 3** – As above.

Task 1.1b: Interaction with Regional Stakeholders and Training of Local Scenario Representatives

The aim of this task is to intensify the involvement of regional stakeholders in the development and use of GLOWA Jordan River scenarios. This will be accomplished in various ways:

1) Direct one-on-one meetings. It has been argued that the most effective way to reach regional stakeholders is through one-on-one meetings with members of the scenario team. With this in mind, members of the scenario team from the region [P. Alpert (Tel Aviv University); A. Salman (ATEEC), R. Twite (IPCRI); A. Jayyousi (An-Najah University), A.-R. Tamimi (Palestinian Hydrology Group)] will meet with stakeholders and present results of the Scenario Panel meetings and other project results, and discuss with stakeholders how the scenarios can be further elaborated and improved. The scenario team will then take this stakeholder input into account in preparing for the next meeting. The team will also report on these consultations at the Scenario Panel meetings.

2) Training of local scenario representatives. As part of this project two additional experts from the region will be trained to conduct scenario analyses and to serve as intermediaries between the Scenario Project and stakeholders in the region. One will be a full-time Post-Doc researcher from Israel. The other will be a part-time junior researcher (without a doctoral degree) from the Palestinian Authority.[1] (The funding for these persons is contained in the Tel Aviv University and An-Najah University budgets, respectively, of sub-project 1.1). These researchers will spend an extended time at the Center for Environmental Systems Research at the University of Kassel working with the core GLOWA Jordan River scenario team to learn scenario analysis techniques. They will discuss the procedures for scenario analysis with experienced scenario analysts, attend classes at the university related to scenario techniques (if available in a language understood by the guests), accompany the scenario team when they visit stakeholders in the region, and gain practical experience by working with the scenario team at the GLOWA Jordan River scenario panel meetings.

After training, the two researchers will return to their home institutions where they will work further on the Jordan River scenario analysis and explain scenario techniques to colleagues at their home institutions. In particular, as mentioned above, they will become special intermediaries between stakeholders in the region and the Scenario Project. The two researchers will explain interim results of the GLOWA Jordan River scenario results to

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[1] This person has the option of studying for a doctoral degree in electrical engineering at the University of Kassel if he/she fulfills the standard requirement: a university degree in engineering with sufficient grades from the University of Kassel or another German university. Otherwise, this person has the option of spending an extended time at the University of Kassel as a junior researcher.

stakeholders, compile the comments of the stakeholders, and deliver this feedback to the Scenario Panel meetings or Scenario Team.

Task 1.1c: Elaborating Storylines

The storylines developed at the Scenario Panel meetings will be in a very incomplete form (the storylines will be in the form of tables, phrases, or key words). In this task the scenario team will elaborate the storylines into readable form, distribute them for comment to Scenario Panel members, and have them printed in a workshop report. The workshop report will also document all the procedures and decisions taken by the stakeholders at the Scenario Panel meetings.

Task 1.1d: Quantifying Scenarios

In this task the scenario team works with colleagues in the GLOWA JR subprojects to prepare the quantitative GLOWA JR scenarios that will be input to the scenario process.

Preparing Model Inputs – To make a link between the storylines developed in the Scenario Panel meetings and the analyses conducted in projects 2, 3 and 4 it is first necessary to convert the storylines to model inputs. For example, the storylines will make assertions about driving forces such as population, agriculture, and industry and these assertions must be translated into suitable assumptions for the agriculture, land use, water balance and other calculations conducted in the GLOWA JR subprojects. These translations will be carried out by the scenario team.

Coordinating Flow of Information Between Modeling Teams – Providing quantitative input to the scenario analysis will also require coordination between the modeling teams. This is because information from one model is needed as input to other models. An example is that the model in project 4 used to compute water availability under future droughts requires land use data produced by a model in project 3. The scenario team and the coordination team will coordinate the necessary flow of information between the modeling teams.

Task 1.1e: Preparing Input to Scenarios

a) Synthesizing Information and Data

One of the most challenging tasks in the entire project is to synthesize the valuable but very dissimilar information and data from various subprojects in a form usable in the GLOWA JR scenarios. In this task the scenario team works with GLOWA JR scientists to synthesize this information. By “synthesis” we mean:

1) **Selecting results to present to the Scenario Panel** – The scenario team will discuss the results of projects 1.2, 2, 3 and 4 with the responsible scientists and decide with them which results to bring into the scenario analysis. These results will then be presented either in written form or verbally at the Scenario Panel meeting. Some of these results will also be included in written documentation of the scenarios.

2) **Analyses requested by Scenario Panel** – At the Scenario Panel meeting the scenario team will note the analyses of new water, land management, etc. requested by the Panel and after the meeting will work with the responsible scientists in projects 1.2, 2, 3 and 4 to have these analyses carried out.

3) **Facilitating WEAP input to scenarios** – The scenario team will work with project 1.2 to facilitate the input of the WEAP analysis to the scenario analysis and to ensure that inputs from other projects are consistent with the WEAP analysis (or at least do not contradict them).

4) **Mapping selected geographic data** – Since the WEAP model is a point-model it cannot depict data on a geographic grid. Therefore some data from projects 2, 3 and 4 will be mapped onto a standardized geographic grid so that they can be compared and presented in a clear form at the Scenario Panel meeting and in scenario reports. These maps will provide a standardized way of visualizing and comparing data about new water sources in a geographically-explicit manner. Possible examples include: locations of potential rainwater harvesting, locations of main groundwater recharge areas, areas unsuitable/suitable for wastewater irrigation. Some of these maps (with the agreement of responsible scientists) will be made widely available as part of the GLOWA JR GIS (see P1.3).

5) **Preparing a Synthesis scenario report** – Selected quantitative results from the previous points will be presented along with the storylines in a comprehensive synthesis scenarios report. This will be a **joint** report of all contributors. Presentation of quantitative results in this report **will not hinder** the publication of these results elsewhere.

b) Type of Information and Data Input to Scenario Analysis

Below are the data that will be synthesized as described above and brought into the scenario analysis. These data will come from the GLOWA JR projects indicated in brackets.

The tasks and deliverables of other subprojects that feed into project 1.1 are further specified in Tab. 1.1 at the end of the project 1 description.

New Water Data (To address Question 1)

- Water transfers, such as the Red Sea-Dead Sea Canal and alternatives to this project such as water transfers from other parts of the region as well as the alternative sources of water listed below [project 2, and project 1.2 with WEAP].
- Desalination of seawater and brackish water [project 2, and project 1.2 with WEAP]
- Rainwater harvesting in the lower catchment (with a qualitative examination of its downstream consequences such as reduced runoff or groundwater recharge). [project 4.3 (TRAIN-ZIN based), and project 1.2 through WEAP].
- Managed aquifer recharge in the lower catchment [project 4.3, and project 1.2 through WEAP] – these data will be closely linked with data about rainwater harvesting and will be developed in cooperation with the SMART project.
- Wastewater reuse (following up on preparation of data in phase II) [projects 2 and 3.4, through project 1.2 through WEAP]
- Demand management [project 2; through project 1.2 through WEAP]
- Water productivity of different land use options using information generated in phase II [project 3.4, and project 1.2 through WEAP]
- Virtual water trade [project 2, and project 1.2 through WEAP]

Data related to land management (To address Question 2)

Information on the following land management options will be fed into the scenario analysis.

- The water requirements and ecosystem services or economic value of current and potential irrigated land (blue and green water requirements) [project 3.2]
- The water requirements and ecosystem services or economic value of current and potential rainfed land (green water requirements) [project 3.1 and 3.2]
- The water requirements and ecosystem services or economic value of current non-sustainable livestock raising & potential sustainable livestock raising (blue and green water requirements) [project 3.1 and 3.2]
- The water requirements and ecosystem services or economic value of potential multi-use open land – livestock raising plus recreational value and other ecosystem services (blue and green water requirements) [project 3.1, 3.2, and 3.3]

Data related to climate extremes and regional hydrology (To address Question 3)

- Maps of climate change scenarios [project 4.1]
- Graphs of future frequency, length, and intensity of hydrological droughts [project 4.2]
- Information about strategies for adapting to these climate extremes [project 1.2]

(Strategies to cope with extremes will consider a range of alternatives from conventional water storage, the exploitation of "new water" as above, land management (e.g. changed crops), or reallocation of water between water-using sectors.)

Task 1.1f: Preliminary Sustainability Analysis

Since the core objective of the overall GLOWA research program is to investigate *sustainable* water management, it is necessary to make some judgement in GLOWA JR about the sustainability of the various water management options discussed above. However, there is not enough capacity in the project to conduct an in-depth, quantitative analysis of the many water management options covered in GLOWA JR. As a compromise, a preliminary evaluation of the sustainability of water strategies will be conducted. This will be a **semi-quantitative analysis** based on standard sustainability criteria (ecological, economic and equity) as used in other studies. The sustainability evaluation will take into account the scope and extent of usage of management options as anticipated in the scenarios. For example, desalination could be sustainable in the region if it provides only a small fraction of domestic water needs in the future and if it is driven by solar energy, but might be unsustainable if it is envisioned to be a major source of irrigation water.

Task 1.1g: Interactive Scenario-Viewer (to communicate policy-relevant findings)

Experience in phase II has shown that the presentation of detailed scenario results can be made much more interesting for stakeholders and a wider audience if they are built into an "Interactive Scenario-Viewer". This is a simple visualization program which presents the main messages of the scenarios in the form of pictures and simple diagrams and allows the viewer to get more detailed information through a hierarchical, interactive menu. The Viewer will include short video clips, maps, photos, graphs, and audio narration of the storylines. Under this task (carried out in project 1.1) the scenario team will construct the

Scenario-Viewer and make it available to all GLOWA JR scientists (e.g. in Task 1.3a above) to assist in their presentation of GLOWA JR results.

Deliverables

1) A detailed scenario analysis, stakeholder-driven and scientist-supported, consisting of several Scenario Panel meetings together with additional stakeholder consultations.
2) Consolidation of information from all subprojects in form usable for analyzing policies for sustainable water management.
3) A set of rich scenarios that consist of stakeholder-derived storylines and scientifically-derived quantitative scenarios. The scenarios will depict:
    - The future use of different mixes of new water sources together with conventional water sources
    - The future use of different land management options to conserve water and gain ecosystem services
    - The consequences of future climate extremes on water resources in the region and strategies for coping with these extremes.

SUBPROJECT 1.2: WEAP ANALYSIS

Germany and Sweden: H. Hoff (Stockholm Environment Institute), K. Tielbörger & U. Nicklas (University of Tübingen)

Israel: Mekorot, D. Hamberg (Tahal), A. Rimmer (KLL), Y. Salingar (STAV-GIS), C. Lipchin (Arava Institute), I. Litaor (Tel-Hai College), Yossi Dreizin (Water Authority), Moshe Gophen (MIGAL)

Jordan: A. Subah (Ministry of Water and Irrigation), N. Seder (Jordan Valley Authority), A. Salman, (ATEEC)

Palestinian Authority: A. Jarrar (Palestinian Water Authority), I. Nofal (Ministry of Agriculture), A.R.. Tamimi & M. Abu Saada (Palestinian Hydrology Group), A. Jayyousi (An-Najah University)

Background

In phase II, WEAP and SAS scenarios were introduced as central integration and application tools for the scientific data and information generated in all other subprojects. Phase III will see a closer integration of these two tools, with WEAP building on the visions and scenarios and addressing the same three "big questions" (new water, land use effects, climate change and extremes) as SAS in subproject 1.1. By using WEAP's capability of integrating water quantity and quality as well as financial and (to some extent) land use information, different scenarios, development pathways and interventions can be tested for their sustainability in terms of closing the water gap, and being economically and ecologically (environmental flows) sustainable.

In Phase II preliminary water balances and water resource models for Israel (upper Jordan), Jordan (Jordan Valley) and The Palestinian Authority (West Bank) and a region-wide model were prepared, using the WEAP tool. In phase III, these models and water balances will be validated and upgraded with new information that will become available from additional partners' databases, as well as from GLOWA JR hydro-climatological and eco-hydrological model simulations, e.g. from TRAIN-ZIN, HYMKE, WADISCAPE and MODFLOW. With that, WEAP results will be improved to the point that decision makers can use them for visualizing, evaluating and comparing different water management strategies and interventions in the region under each of the GLOWA JR scenarios (see subproject 1.1). Moreover, the WEAP applications and underlying database will be completed and agreed upon by all partners, so that the WEAP applications can be handed over and used by regional water managers independently. Given that several water management institutions in all three partner countries in the region have started to use WEAP during phase II of GLOWA JR, phase III should provide the required training and technical support to enable these institutions to use WEAP operationally and beyond the lifetime of GLOWA JR.

Key results and key products from phase II

WEAP was developed in phase II of GLOWA JR in a nested approach, starting from the local community and sub-catchment scale, successively aggregating and regionalizing the information that each WEAP partner contributes, to the full Jordan River basin.

The national WEAP partners developed, calibrated and validated their respective sub-basin models (for the upper Jordan, the West Bank and the Jordan Valley) in close collaboration with key water management institutions such as the Palestinian Water Authority and Ministry of Agriculture, the Jordanian Ministry of Water and Irrigation and the Jordan Valley Authority, Israel Water Authority and Mekorot, according to the stakeholder requirements for decision support, and utilizing data from these institutions. Also the German Development Cooperation, through GTZ and BGR, has expressed strong interest in WEAP, with BGR and SEI having jointly developed a new WEAP-MODFLOW coupling for the region. These and other institutions now wish to use WEAP as a database and planning tool, in the context of ongoing activities, such as local infrastructure planning, national water planning and also transboundary management and negotiations. At transboundary level, it was acknowledged that WEAP can become a standard tool for a harmonized IWRM approach of all partners.

Consequently there is now strong support for WEAP development and application across scales in the region. In particular the need for continuous updating of the underlying data base was recognized as very important. Stakeholders have agreed to share their data for the development of sub-regional and regional WEAP applications (under the condition that they are becoming formal project partners in phase III).

After the key components of the water system were implemented in WEAP and the sub-regional applications were calibrated and validated with data from each of the partner countries, it was agreed that the resulting water balances will serve as a basis in phase III for

1) Iteratively adding water quality information, to also assess water quality constraints (e.g. restrictions in wastewater reuse, exceedance of salinity thresholds etc.) in the different GLOWA scenarios, eventually to identify adaptation options that also address water quality.
2) Iteratively adding economic information, in particular costs of different adaptation options, in order to enable cost-benefit analyses and comparisons of the costs of different interventions in terms of their overall and per-unit costs.

For improving user-friendliness, several new features were added to WEAP by SEI and partners: e.g. as requested by some stakeholders, a slider-based interface was developed, that allows defining and fine-tune key parameters such as population growth or efficiency gains very easily also by inexperienced WEAP users, individually for each country or sub-catchment. With this approach the training needs for new WEAP users are further reduced.

For improving WEAP's simulation capabilities, for evaluating future scenarios and comparing different interventions, an API interface was developed by SEI that allows linking WEAP to external models, scripts, spreadsheets etc: in particular a fully operational WEAP-MODFLOW coupling was implemented in collaboration with BGR. This provides an integration of the water management and planning approach of WEAP, with a detailed simulation of groundwater dynamics and feedbacks, to analyze different scenarios and interventions. GLOWA JR partners and stakeholders expressed a strong interest to capitalize on this development and use the coupled WEAP-MODFLOW model in several aquifers in the region, in particular for the different parts of the Mountain Aquifer. This proposed WEAP-MODFLOW application will be closely coordinated with the SMART project (which has also recently begun to apply WEAP-MODFLOW in several of its focus catchments); in order to maximize synergies in one coordinated effort vis-à-vis regional partners, donors and other beneficiaries of the WEAP (MODFLOW) results.

At a regional WEAP training workshop (in Amman) these developments were tested extensively by key stakeholders (such as the Palestinian Water Authority, Ministry of Agriculture, Negotiation Support Unit, Ministry of Water and Irrigation, Jordan Valley Authority) and proposals for further improvements and application in their respective institutions in phase III were agreed upon with all partners. In particular, it was agreed that by testing not only different new water options, but also a number of water re-allocation schemes in scenarios, WEAP is expected to be used also as a negotiation support tool for transboundary water management.

Key goals

- Refine WEAP models and current water balances for Israel, Jordan and The Palestinian Authority as well as the region-wide model, based on updated information from various GLOWA Jordan River Projects and from other data sources, for the different GLOWA JR scenarios produced in project 1.1:
    - Information on “new water” sources (from project 2, 3.4 and 4.3)
    - Information on land use and green water flows and productivities (from project 3)
    - Hydrologic information on surface and groundwater availability taking into account climate change, in particular future frequency, intensity and duration of droughts (from project 4)
    - Information on water demands and productivities in all sectors (from project 2 and project 3)
    - Information on costs of different adaptation options

  This update will result in much more realistic, informative and agreed-upon water system representations and water balances as compared to those derived in phase II. We expect that these WEAP scenarios will be very useful in the scenario analysis of strategies (Subproject 1.1) as well as other studies of water management in the region (e.g. the new AVOW consortium study on Alternative Visions of Water).
- Develop future scenarios and water balances for the Jordan River region and selected sub-basins.
- Perform WEAP analyses in response to specific requests and questions posed by stakeholders involved in scenario analysis, e.g. analyzing strategies for restoring the lower Jordan River and/or the Dead Sea, and salinity management strategies for the Upper Jordan River.
- Conduct cost-benefit analyses for different new water options at the level of WEAP scenarios, which yield comparisons of costs per unit of water produced (or saved), also in relation to revenues, for a range of different new water options.
- Establish WEAP as operational scenario planning tool beyond the duration of the project, by training and supporting local users and transferring it to national Water Authorities, Ministries and regional NGOs.

Research questions and tasks

The main task of this project will be to provide agreed upon, reliable and credible representations of the water system and water balances that can be used for scenario analyses. Specific tasks are given below.

After development of conceptual WEAP models and initial WEAP representations of the regional and sub-basin water systems in phase II, phase III will address real water management and planning questions at various aggregation levels (e.g. individual side Wadis, upper and lower Jordan and the full Jordan River basin), as defined by partners from governmental, non-governmental and research institutions in the Jordan region. The questions and tasks listed below have been derived from intensive direct stakeholder dialogues during GLOWA JR phases I and II, these tasks will be further specified throughout the WEAP development process.

Question 1:

How can green and blue water be allocated and managed sustainably and cost effectively, to meet all demands in the Jordan River region, under different GLOWA scenarios?

Task 1.1:

WEAP-based assessment of various development/management alternatives to the Red Sea-Dead Sea Canal.

A number of conventional and non-conventional water management options, such as desalination of brackish and sea water, introducing wastewater reuse in the West Bank and increasing wastewater reuse in other parts of the basin, water harvesting and managed aquifer recharge (assessed in detail in project 4.3), demand management (e.g. via land use management, project 3), reducing losses in the distribution systems, increasing water productivity in agriculture (project 4.3), re-allocating water to other sectors, virtual water trade, land use changes (project 3.3) etc. will be simulated in WEAP at different levels of aggregation up to regional scale, evaluated and compared for their costs and for their potential to cover future water demands and allow stabilization of the Dead Sea level and restoration of the lower Jordan.

Cooperative vs. non-cooperative solutions will be compared.

Future water availability for different GLOWA JR scenarios and land use and climate changes will be modeled and provided for WEAP in project 4.2 (eco-hydrological modeling using TRAIN-ZIN)

Future water demands will be specified from available projections, in particular those developed in subproject 1.1 (SAS scenario development).

Partners: An-Najah National University, Arava Institute (AIES), Arab Technologists for Economical and Environmental Consultations (ATEEC), German Technical Cooperation (GTZ), Kinneret Limnological Laboratories (KLL), Ministry of Water and Irrigation Jordan, Palestinian Water Authority, PA Negotiation Support Unit, STAV-GIS, Tahal, Stockholm Environment Institute (SEI), University of Tübingen.

Tahal will, via project 2, provide water supply, demand and quality data and economic information associated with infrastructure projects for the GLOWA Jordan River region, including trends and projections. In particular all available data on “new water” sources, i.e.

desalination, wastewater reuse, water transfers and demand management will be relevant. Tahal is bringing into the project long-standing experience, having been involved in most of the multi-lateral projects in the region that were concerned with the availability and use of water resources and potential new water resources Tahal is also participating in the Red Sea-Dead Sea Conduit feasibility study and will provide a key link to the WEAP-based assessment of development alternatives.

PWA will use WEAP for catchment-based and national water planning, including transboundary management of the Mountain Aquifer. Together with An Najah University, PHG, Environmental Quality Authority and local institutions several sub-catchment management plans will be tested in WEAP for their feasibility and sustainability. Supported by University of Tübingen and BGR, WEAP-MODFLOW will be used by PWA (Eastern Aquifer) together with An Najah University (Northeastern Aquifer) and PHG (Western Aquifer) for deriving sustainable management and allocation of Mountain Aquifer waters. In this context a close cooperation between An Najah University and PHG will in particular focus on detailed calculations on sustainable yields and assessment of groundwater dynamics for different management scenarios for the Mountain Aquifer. A PhD student will mainly work on this task using WEAP-MODFLOW locally supervised by An Najah University (Dr. Anan Jayoussi) and externally supervised by BGR and University of Göttingen (Prof. Sauter). To utilize this opportunity for maximal capacity building a nine months stay at BGR in Hannover is planned. The designated person (Muath Abu Saada) will work at PHG in close cooperation with the local supervising institution.

Key questions to be addressed include:

1) The impact of altering pumping / withdrawals at existing wells on potentiometric head / storage as well as on spring yield, also under climate and land use change scenarios.
2) The hydrological and economic impacts of new wells on the aquifer, as a basis for optimizing well locations, taking into account safe yields.
3) The impact of surface water harvesting and managed artificial recharge (espececcially in the Eastern part of the West Bank) on the local aquifer systems (mainly spring yield and potentiometric heads).
4) Integration of aquifer management into IWRM.

MWI in Jordan will test WEAP applications that can complement the National Water Master Plan, e.g. for rapid assessments of different planning alternatives before these are analyzed in more detail with the instruments of the NWMP.

As an example, a rapid assessment of development alternatives to the Red-Dead Canal is planned for phase III.

AIES, having been selected by the Israel Water Authority to participate in the forthcoming World Bank sponsored feasibility study of the Red Sea-Dead Sea Conduit (RSDSC), will provide a key link between that study and the WEAP-based assessment of development alternatives. In the World Bank study, AIES will focus on the geological, hydrological, environmental, economic and social impacts of the RSDSC in the Arava valley/Wadi Arava in both Israel and Jordan, as well as on the Dead Sea itself. AIES will contribute to the regional WEAP information and scenarios for the restoration of the Dead Sea and the lower Jordan, including restoring the flow of the Jordan to the Dead Sea. Further, AIES will contribute data and other results from previous projects on water and land management in the lower Jordan and the Dead Sea basin. These include:

- A GIS-based database that contains harmonized and comparable physical, economic and social data.
- Realistic development scenarios until about the year 2020.
- Analysis of the current water management system and its driving force.
- Criteria for essential water requirements for nature.
- Analysis of socially, economically and environmentally sound alternatives for irrigated agriculture.

AIES will also work closely during WEAP development with stakeholders and decision makers in Israel, Jordan and The Palestinian Authority.

Question 2:

How can green and blue water be allocated and managed cost effectively, to meet all demands in the Upper Jordan River (UJR), under different GLOWA scenarios?

This question also takes into account water transfers out of the Jordan River basin through Israel's National Water Carrier (NWC).

Task 2.1:

WEAP-based assessment of various development/management alternatives to secure water replenishment, water availability, and water quality (with respect to salinization) and environmental flows in the UJR catchment with focus on the upper Jordan River and Lake Tiberias.

This task will use information also from task 2.2 on Einan and Hula Valley management options as well as from project 2 on new water sources (e.g. desalination capacity) and demand management via land use (project 3) that could reduce NWC withdrawals, in order to develop UJR regional water budgets and scenarios. With that, task 2.1. will provide information to task 1.1. in the form of surplus water from the UJR catchment under different land use and climate scenarios that can be provided to the lower Jordan River.

Given that project 4 does not explicitly model green water flows in the Upper Jordan River, the WEAP Hydrology Module will be employed, by specifying catchment nodes in WEAP, that represent land use and vegetation cover in a generalized form, allowing WEAP to calculate evapotranspiration, runoff and groundwater recharge, consistently with the scenarios and assumptions developed in project 1.1, using land cover and climate as input data from projects 3 and 4.

This task will build on the WEAP model for the UJRC that was developed in phase II, which includes a full water budget model of Lake Tiberias Catchment, including an extremely detailed database on water resources and consumption in the catchment. In phase III the WEAP application will move from "system verification" to predictive modeling. The main water sources of the UCJR (the Mt. Hermon area), will be fed by an external hydrological model (HYMKE) that was developed in phase II and that will be driven by different climate scenarios as they become available from project 4.1. In the Hula Valley (and later in the Eastern Galilee Mountains and the Golan Heights) the Hydrology Module of WEAP will be used. The main local water consumption in agriculture and runoff generation will be specified through catchments nodes in WEAP, allowing it to calculate evaporation (by employing the Penman Monteith Equation) based on the specified land use. This project will be carried out by STAV-GIS (WEAP application) and KLL (hydrology, evaporation and water management of the UCJR) jointly with SEI – all data will be shared by these three partners. Data generated in phases I and II by the groups of Iggy Litaor (Agriculture and land use in the Hula Valley) and Moshe Gophen/Moshe Meron (GIS database of agricultural management) will be integrated. Supplementary data, in particular on climate scenarios and socio-economic drivers will be provided by project 4, project 3, and subproject 1.1.

In Lake Tiberias the phase II WEAP water balance will be extended to also perform solute mass balance, using knowledge and data collected in previous research, in particular GLOWA phase I and II. Increased lake salinity is a growing problem in this semi arid region. Operational management, which is based on a reliable hydrological understanding, has the potential to manage and reduce the lake salinity. This is the case of the salinity in Lake Tiberias, where saline water flows into the lake through on-shore and off-shore springs. This WEAP application possibly coupled with Qual2K will reflect the salinity of the NWC transfers, and the water quality for restoration of the lower Jordan flow (the release of water from Lake Tiberias to the south). WEAP will be applied jointly by KLL, STAV-GIS and SEI. All data will be shared between these three partners.

This proposed contribution will be conditional on sharing the WEAP UJRC model as developed in phase II and all its data with the other WEAP partners.

Partners: KLL (in close collaboration with DHV), STAV-GIS, SEI, Tel-Hai College, University of Tübingen

Task 2.2.:

WEAP-MODFLOW based assessment of various development/management alternatives for surface and groundwater in the Einan and Hula Valley sub-catchments of the UJR catchment, which will provide additional information to the UJRC WEAP and eventually to the regional WEAP.

The Einan Basin is located in the western side of the Hula Valley, as part of the groundwater catchments area of Lake Tiberias. Prior to 1960 the Einan Spring was the main source of the Eastern Galilee Mountains to the Jordan River, with an annual discharge of $\sim 25\times10^6$ m^3. Since 1962, the deployment of the aquifers in this region (Einan wells) caused a gradual decrease of the natural discharge to the Jordan River. Today the remaining natural outflows from the basin are through springs and lateral flow to the Hula Valley. Groundwater is exploited by means of wells and water is also exported from the Hula Valley for agriculture uses in the Eastern Galilee through the Zemer project. Mekorot is planning to increase the total pumping amount from that region. WEAP-MODFLOW will be employed as a supporting management tool to evaluate the current and future deployment scenarios from the Einan Basin.

Partners: KLL, Mekorot, SEI, STAV-GIS, Tel-Hai College, University of Tübingen

Question 3:
How can green and blue water be allocated and managed cost effectively, to meet all demands in the lower Jordan River and Jordan Valley, under different GLOWA scenarios

Task 3.1:

WEAP based assessment of various development/management alternatives to restore the lower Jordan River. This task will focus on securing minimum environmental flows in the lower Jordan for restoring water quality and aquatic ecosystems, and for generating new income opportunities (tourism and others) in the riparian zone of the river. This task will use external information, and also results from tasks 3.2 and 3.3 in this project, and in particular work very closely with project 4.4 through transient coupling with TRAIN-ZIN, which will provide flows and availability of green and blue water for the different scenarios.

WEAP will integrate existing information on environmental flow requirements for aquatic ecosystems and riparian vegetation, surface water inflows for a defined set of sub-catchments that contribute runoff to the lower Jordan, including contributions from “new water” sources and return flows, as well as interactions of the Jordan mainstream with the adjacent groundwater.

Criteria will have to be defined for environmental flow requirements, e.g.

- Minimum flows and their spatio-temporal distribution throughout the year and along the river.
- If requested by stakeholders, also minimum inflows to the Dead Sea (closely linked to the scenarios under Task 1.1 of this project for stabilization of the Dead Sea level.
- Water quality constraints, e.g. related to wastewater reuse and salinity.

WEAP will be used to test different scenarios of land and water management, including e.g. the effects on the lower Jordan River discharge of measures in the upper Jordan (as analyzed under Question 2 in this project) and the Yarmouk, effects of potential water harvesting structures in side wadis (modeled in detail in project 4.3 using TRAIN-ZIN), effects of changes in wastewater reuse, or effects of changes in irrigation technologies and associated return flows in the Jordan Valley.

The integrated approach of WEAP allows to assess the tradeoffs between different options and to compare the overall hydrological and economic effects of combinations of measures.

A range of stakeholders will be involved in these activities to ensure that their perspectives and preferences are realistically represented in the WEAP models, e.g. by way of setting priorities for supply sources and for meeting different demands, or by defining economically beneficially water demand sectors and activities, such as tourism, to be included in the scenarios.

No new database development is foreseen for this task, but instead existing data will be integrated, e.g. from the previous EU Lower Jordan Valley and the Dead Sea projects, from the EXACT and SMART projects and other sources.

A transient coupling of WEAP with TRAIN-ZIN is planned for the lower Jordan River, in closed cooperation with project 4.4, in which there will be bidirectional feedback between TRAIN-ZIN and WEAP at each time step. This will help to model and illuminate for the stakeholders the interplay between management decisions and changing hydrology driven by land use and climate change. Runoff and groundwater recharge results from TRAIN-ZIN will flow into WEAP as data for its allocation procedure. Scenarios developed in the consistent WEAP framework, will respond to these hydrological inputs, as well as to other political, technological, social and economic drivers, as specified by the stakeholders. The WEAP scenarios will evaluate different management decision that affect the hydrology of the lower Jordan – e.g. groundwater pumping, water harvesting and managed aquifer recharge, cropping and irrigation patterns and return flows to surface and ground water - which in return will flow into TRAIN-ZIN for its computations in the next time step. Development of this soft coupling will be based upon previous experience with coupling

WEAP to other process-oriented models and the API interface that was recently developed for WEAP.

Partners: An-Najah University, Arava Institute (AIES), ATEEC, Israel Ministry of Environment, Jordan Ministry of Water and Irrigation, Jordan Valley Authority, Palestinian Environmental Quality Authority, Palestinian Ministry of Agriculture, Palestinian Water Authority, SEI, SMART (currently implementing WEAP-MODFLOW for several side wadis in the West Bank and "East Bank" and for the alluvial fan aquifer in the Jordan Valley), University of Tübingen

AIES will contribute to Task 3.1 in assessing minimum environmental flows for the lower Jordan and the Dead Sea. This will build upon results from the previous Dead Sea project, where "water for nature" was modeled for the lower Jordan River and the side wadis entering the Dead Sea so as to determine a base flow for ecological services for these streams. These flows were linked to social and economical services such as the development of tourism in the region. AIES will provide biomonitoring information and economic analysis to determine optimal restoration strategies for the lower Jordan and the Dead Sea. In addition, the AIES will work closely with GLOWA JR stakeholders, in order to integrate GLOWA JR scientific results and other findings into IWRM and to promote the operational use of WEAP in policy making in IWRM for the lower Jordan River/Dead Sea.

Task 3.2:

WEAP-based assessment of various development/management alternatives for Wadi Faria, with focus on wastewater reuse and water harvesting in combination with managed aquifer recharge. This task will be coordinated closely with project 4.3, using data and modeling results from the detailed GLOWA JR studies for Wadi Faria. Also this task will work closely with the next phase of the EXACT project (which is working on water harvesting and managed aquifer recharge in Wadi Faria), extrapolation of the potential in Wadi Faria for these techniques to the lower Jordan will contribute to task 3.1.

Partners: An-Najah University, Palestinian Environmental Quality Authority, Palestinian Ministry of Agriculture, Palestinian Water Authority, SEI, University of Tübingen

Task 3.3: WEAP-MODFLOW based assessment of various development/management alternatives for the West Bank Aquifer System, including potential for aquifer recharge and storage

See also project 4.3

Partners: An Najah University (North-eastern aquifer), BGR, House of Water and Environment/Palestinian Hydrology Group (Western Aquifer), Palestinian Water Authority, Mekorot, SEI, SMART, University of Tübingen

Task 4.1 - WEAP Training, Capacity Building and Implementation:

This task is to provide workshops, internet and online tutorial as well as individual support to those WEAP partners and water management authorities and ministries that have expressed their interest to use WEAP now and in the future.

We foresee to hold one training workshop per country per year, plus further training and mainstreaming with other GLOWA activities and in particular SAS scenario development at the SAS meetings, as described in project 1.1

In addition to that, we will provide support to institutions when using WEAP in their day-to-day activities, such as National Water Planning, spatial planning, pre-feasibility studies of new infrastructure projects, climate adaptation projects etc.

SEI currently collaborates closely with BGR on WEAP, in particular WEAP-MODFLOW capacity building as well as with Swedish development cooperation on WEAP training in the MENA region. This will be intensified in phase III by the University of Tübingen.

Task 4.2 - WEAP Dissemination

Much like in project 1.1 (SAS), WEAP itself and WEAP results will be disseminated in the region. Besides the implementation of WEAP models at various scales in the key water management institutions (Task 4.1 of this project) we will also hold on-line WEAP sessions and tutorial / scenario exercises at various meetings in the region, e.g. international and national water conferences, inter-ministerial working groups on water (and climate), transboundary water negotiations, climate adaptation projects of German and other development cooperation.

Deliverables

- Credible current water balances for the region, integrating data and information from all other subprojects and stakeholder information and knowledge.
- Water balances for the scenarios developed in project 1.1 for the region, e.g. implementing in WEAP different adaptation measures, such as infrastructure and other supply and demand-side measures.
- Hydrological and economic evaluations and comparisons of different scenarios and adaptation strategies.
- Training and support for local and regional water managers, to establishing WEAP in their respective institutions.
- WEAP established as operational user support tool for local and regional water management institutions, to be used beyond GLOWA JR.

SUBPROJECT 1.3: COMMUNICATION OF RESULTS

Germany: K. Tielbörger (University of Tübingen), J. Alcamo (University of Kassel)

Israel: P. Alpert & T. Dayan (Tel Aviv University), Yossi Dreizin (Water Authority)

Jordan: A. Salman (ATEEC)

Others: R. Twite (IPCRI)

Palestinian Authority: A. Jayyousi (An-Najah University)

Background

Phase III will be the wrap-up phase of the project. Members of the project must ensure that the products of the project receive the widest-possible dissemination in the science and policy communities. It must be noted that dissemination of results from the GLOWA JR Project poses special problems because the disseminated information is very varied and the audiences for this information are also very dissimilar. Hence a broad strategy is needed, as outlined below to guarantee the continious dissemination of the GLOWA JR results in science, policy and civil society.

Overall goal

The goal of this subproject is to disseminate the results of the GLOWA Jordan River Project to stakeholders and the scientific community. Since the data and information from the project is very variable and since the audience for the information is also very varied we will use several different approaches:

1) Distribution of the WEAP model and its data (to provide ongoing scientific support for developing water management strategies). (Part of project 1.2)
2) Direct meetings between GLOWA JR scientists and stakeholders in the region (to continuously communicate policy-relevant findings).
3) Preparation of an interactive scenario-viewer and other visual materials to present scenario results (to communicate policy-relevant findings). (Part of project 1.1)
4) Distribution of a GIS with spatial data from the project (to provide ongoing scientific support for developing water management strategies).
5) Preparation of detailed workshop reports (to provide ongoing scientific support for developing storylines).
6) Scientific papers, journal special issues and other printed products (fact sheets) on various scientific topics from the project (to communicate important scientific findings).
7) A major wrap-up conference with experts and stakeholders (to communicate major policy-relevant and scientific findings of project).

8) Follow-up meetings in order to guarantee dissemination of results to the widest audience possible and to enable dissemination and stakeholder support beyond the project's duration.

Working plan

Task 1.3a: Distribution of the WEAP Model and its Data

(to provide ongoing scientific support for developing water management strategies)

In phase II it has been shown that the WEAP model is an effective mean of clearly depicting complicated water balances in the region at different resolutions and therefore is very useful for analysing different water management strategies for their sustainability. Several regional stakeholders in all three countries are beginning to use the model themselves and will continue to develop it further beyond GLOWA JR. Therefore, the further distribution of the WEAP model in the region (together with the new water balance data to be generated in phase III in project 1.2) will be a main tool for disseminating project information. See project 1.2 description for more details. **UT, SEI, STAV-GIS, An-Najah, ATEEC**

Task 1.3b: Direct Meetings with Stakeholders

(to communicate policy-relevant findings)

Experience of the project's experts have shown that an efficient way of disseminating detailed policy-relevant information to stakeholders is via direct dialogue between the project scientists of the region and the stakeholders. This direct contact ensures scientifically sound recommendations, and continuation of dissemination of project results and further development of information beyond the duration of the project. Under this task GLOWA JR scientists will organize a series of one-on-one meetings with key stakeholders in the region to communicate both policy-relevant and scientific findings of the project. **TAU, ATEEC, An-Najah, UT**

Task 1.3c: Presentation of a Scenario-Viewer

(to communicate policy-relevant findings)

In this task we build and distribute a simple visualization program to present the main messages of the scenarios in the form of pictures and simple diagrams. This will be one of the main ways of conveying the important messages of the scenarios (and the many analyses they contain) to stakeholders in the region. This task is carried out in project 1.1 and is described under Task 1.1g. **UK**

Task 1.3d: Distribution of GIS data (maps) produced in GLOWA JR

(to provide ongoing scientific support for developing water management strategies). **UT & UK**

While the WEAP model is very useful for distributing water balance and water strategy information for the region, it is not a GIS and cannot depict spatial data. But the project is producing a large number of spatially-explicit data sets that are very useful for further work in the region on sustainable water management. These include spatially-explicit data sets for current conditions and future conditions under the four GLOWA JR scenarios on land cover, value of open space, biodiversity and vulnerability maps, stocking densities, livestock water use, soil degradation, new water source suitability maps, climate scenarios, and groundwater recharge zones, as just a few examples. In order to make these data sets widely available in the region, the coordination teams will archive the data sets and provide access retrieving and the data in a user-friendly way via the GLOWA JR website. We note, however, that the GIS will not be able to archive all of the project's spatial data because of problems arising from data format differences. We aim at closely collaborating with the data consolidation and data management subproject of the SMART project.

Task 1.3e: Distribution of Scenario Workshop Reports

(to provide ongoing scientific support for developing storylines.) **UK**

Among the many important methods further developed during the GLOWA JR Project is the procedure for developing storylines and linking these storylines to quantitative analysis. This procedure will be carefully documented in Scenario Panel workshop reports. These reports will be made available to regional partners and others in the region to help them develop their own storylines about sustainable water management.

Task 1.3f: Scientific Papers and Other Printed Products

(to communicate important scientific findings). **all partners**

To ensure that the scientific results of the project are widely disseminated in the scientific community a wide variety of scientific products will be produced including special issues of scientific journals. Examples of expected scientific products are given in Tab. 2.1. A focus will be put as well on the production of non-scientific products as info sheets, brochures and interactive Info-CDs for the general public, stakeholders and politicians. GLOWA JR has started and will continue to produce regularly updated GLOWA JR fact sheets about important results on climate change, e.g. with respect to hydrological or ecosystem impacts and adaptation, in order to inform stakeholders and the public. Development cooperation (BGR, GTZ, KfW) are very interested in these products, in particular for mainstreaming climate adaptation into their projects. Other non-scientific publications will be continiously produced for the respective target audience within the scope of local and regional meetings, conferences and workshops of GLOWA JR. Furthermore, GLOWA JR results will be incorporated in publications of international policy networks as the NATO Mediterranean Dialogue or the IUCN Regional Water Programm in the Middle East.

Task 1.3-g Kick-Off Meeting and Major Final Conference

(to communicate major policy-relevant and scientific findings of the project) **UT, ATEEC**

To start the third phase of GLOWA JR with an highly visible event inviting officials from politics, science and civil society, a representative kick-off meeting will be organized in Germany embedded in the German-Israeli Year of Science. The event will be preceded by the first scenario meetings and a professional, transboundary excursion along the Jordan River Valley to give the participants an understanding of the changes and challenges of the GLOWA JR project. The meeting will be held at the beginning of November 2008. Holding this meeting in Israel – as initially proposed - would compromise our chances to have Palestinian and Jordanian colleagues attend the meeting

A major wrap-up conference will be organized in the region to reach a wide audience of stakeholders and experts. At this conference GLOWA JR scientists and experts will present the wide range of policy-relevant and scientifically-relevant results of the project. Various tools and outputs of the project (e.g. WEAP, Scenario-Viewer, geographic data sets) will be presented at side events to the main plenary. Presentations will be short, and the main accent will be on podium and break-out discussions of the main project results. Keynote speakers (experts on IWRM in the region) will be invited and attend the conference. In addition, leading scientists and stakeholders from the other GLOWA projects will be invited to present their products. Since GLOWA JR will be the last of the GLOWA projects to finish, we furthermore foresee a session about cross-cutting themes/lessons for the entire GLOWA programme. The location will be Cyprus in order to allow maximum attendance of key stakeholders of the region. In order to ensure full iterations with the scenario process and presentation of integrative results from SAS and WEAP, the conference is planned for February 2011.

Task 1.3-h Follow up meetings

(to further communicate major policy-relevant and scientific findings of project). **all partners**

A series of follow-up meetings with stakeholders in the region is planned until August 2011 and beyond based on the results of the conference and the need to present and hand over the final dissemination products. These meetings may, according to the needs identified, include also further training in WEAP.

Task 1.3-i GLOWA Jordan River website

(to continuously communicate major policy-relevant and scientific findings of project and store and communicate spatial and other data). **UT**

Deliverables

1) A series of direct meetings between GLOWA JR scientists and stakeholders in the region. These meetings will be very useful for directly communicating project results to key people in the region.

2) The distribution of the WEAP model and its data. This has already been a very efficient way for disseminating the water balances produced by the project to a wide audience. Furthermore, the WEAP model will be a valuable tool for developing new water balances for evaluating sustainable water management alternatives.

3) The construction and wide distribution of an Interactive Scenario-Viewer. This Viewer will provide an effective means for communicating scenario results.

4) The distribution of spatial (GIS) data (climate, hydrologic, ecological and land-related data) generated by the project for being widely available for evaluation of sustainable water management strategies.

5) The distribution of reports documenting the methodology of storyline development. These reports will provide support for ongoing development of storylines of sustainable water management.

6) The preparation of scientific papers and journal special issues on various scientific topics from the project.

7) The preparation of non-scientific publications as fact sheets, brochures, Info-CDs and policy-oriented articles for dissemination of results in policy and civil society.

8) A representative kick-off meeting.

9) A major wrap-up conference. This conference will be a major vehicle for reaching a wide audience in the region.

10) A series of follow-up meetings even beyond the duration of the project.

11) A continuously updated website.

Box 1.1: The SAS Approach to Scenario Analysis

An innovative procedure called the "SAS approach" (Story and Simulation) will be used to develop qualitative-quantitative scenarios in the GLOWA project. This is an iterative procedure that ensures the engagement of both stakeholders and experts in the scenario building process (see below). This approach has been used in international scenarios exercises (Intergovernmental Panel on Climate Change, the World Water Commission, and the Millennium Ecosystem Assessment) for combining state-of-the art complex scientific knowledge with local knowledge in a way useful for developing policies (Alcamo 2001). As part of this project we will test and further develop the SAS methodology.

The GLOWA JR scenarios will illustrate the impacts of global change on water resources in the Jordan River basin as well as provide an ideal vehicle for compiling and consolidating information from the different GLOWA JR projects such as new knowledge regarding wastewater management, agricultural water use, land use changes, climate changes, and other subjects (see Tab. 1.2).

Steps in the SAS Approach

At its core, the SAS approach involves the work of a Scenario Panel made up of stakeholders and experts from Israel, Jordan, and The Palestinian Authority already associated with the project. The main task of this Panel is to draft qualitative scenarios or "storylines". A storyline is a narrative description of future events that lead to different future conditions of land use and water resources in the Jordan basin. For example, one scenario could describe the state of land use and water resources in the basin in 2050 if current land and water policies are not modified. Another scenario could lay out a plausible path for maximizing water use, environmental quality and human welfare under global change in the basin by 2050. In addition to the Scenario Panel meetings, we will organize special "Stakeholder Meetings" to ensure broad stakeholder input to the scenarios. The SAS procedure requires three Scenario Panel meetings.

In the next step, the scenario coordinating team uses information from the storylines to derive a consistent set of quantitative driving forces for model inputs.

The quantified driving forces are then used by the GLOWA JR modeling teams from various subprojects to compute future water demand, water availability, land use, and other indicators of the Jordan River basin. Tab. 1.2 indicates the modeling and other inputs from GLOWA projects that will feed into the scenario exercise.

The GLOWA modeling teams will then report their results to the Scenario Panel. In particular the modeling teams will report inconsistencies in the storylines indicated by model calculations, as well as additional information provided by the modeling analyses that can be incorporated into the storylines. The Scenario Panel revises the storylines based on the model calculations and other new information.

Steps b, c, and d are repeated twice in order to achieve a comprehensive and consistent set of qualitative scenarios (storylines) and quantitative scenarios (model calculations). Tab. 1.3 depicts the schedule for interaction between the Scenario Panel and modeling groups, as well as the timing of input from special stakeholder meetings.

In the last step, the scenarios are sent out for wide review, final revisions are made to the scenarios, and they are published, widely distributed, and presented to policymakers, stakeholders and researchers involved with water issues in the Jordan River basin.

Box 1.2: The four GLOWA JR storylines from phase II

“Poverty & Peace”
“Willingness & Ability”
“Modest Hopes”
“Suffering of the Weak & the Environment”

Tab. 1.1: Tasks from other projects providing input to projects 1.1 (Scenario Analysis) and project 1.2 (WEAP Analysis).

Theme/Task	Responsible Organization	Deliverable	Due Date	Project No.
Question 1: The “New Water” Question				
Water transfers e.g. Red Sea-Dead Sea Canal; water transfers from Turkey; West Ghor Canal, fossil aquifers	Tahal MWI PWA MoA (PA) PHG	Estimates of annual yield (m^3/yr), lifetime of resource (yr) (e.g. of fossil groundwater), “quality level” (to be defined), spatial distribution of resource and potential distribution to demand sites, and preliminary estimates of costs ($/$m^3$) and side impacts ($/m^3).	First results: Month 6 Nearly final results: Month 15	2
Desalination	Tahal MWI HWE	Estimates of current and future annual volume of desalination (m^3/yr) (seawater and brackish); spatial distribution of resource and potential distribution to demand sites, preliminary estimates of costs and side impacts	First results: Month 6 Nearly final results: Month 15	2
Wastewater reuse	Tahal MWI HWE RUB HUJI ATEEC An-Najah	Estimates of current and future annual volume of usable wastewater (m^3/yr) (volume in different quality categories); spatial distribution of resource and potential distribution to demand sites, estimates of costs	First results: Month 6 Nearly final results: Month 15	2 3.4.2
Blue Water demand (Estimates of current situation and business-as-usual scenarios)	Tahal MWI PWA MoA (PA)	Estimates of current and future annual water withdrawals (m^3/yr), water consumption (m^3/yr); water productivity ($/$m^3$-yr); spatially and temporally (e.g. seasonal patterns) defined. For following water-use sectors: - Domestic - Irrigation - Livestock - Manufacturing - Electrical generation - Tourism	First results: Month 6 Nearly final results: Month 15	2

Theme/Task	Responsible Organization	Deliverable	Due Date	Project No.
Demand management	Tahal MWI PWA PHG	Estimation of water savings potential for above water-use sectors together with preliminary estimate of costs ($/m^3)	First results: Month 6 Nearly final results: Month 15	
Virtual water	Tahal	Annual flows of imports and exports, origin / destinations and value of imported / exported commodities, trends and future potential	First results: Month 6 Nearly final results: Month 15	2
Rainwater harvesting & Managed aquifer recharge	Uni Freiburg Uni Kassel, Ben Gurion Univ., An-Najah Univ., Mu'tah Univ., in cooperation with SMART	Estimate of potentially recoverable additional water supply (m^3/yr) and storage; spatially-defined	First results: Month 6 Nearly final results: Month 24	4.3
Question 2: The "Land Use" Question				
Water productivity in irrigated agriculture	Ben Gurion Univ.	Estimation of potential for increasing water productivity of different important crops in the region (decreasing m^3/$-yr). Preliminary estimates of costs	First results: Month 6 Nearly final results: Month 24	3.4.1 3.2 3.3
Green water fluxes – land use types	Uni Freiburg, Uni Kassel, Uni. Tübingen, TAU, HUJI, Uni Potsdam, Haifa Univ., Weizman Inst.	Estimate of green water fluxes from different land cover types in the region (m^3/ha-yr)	First results: Month 6 Nearly final results: Month 24	3.1.1 3.1.2 4.2.1
Ecosystem services – open space	Haifa Univ., Hebrew Univ., Uni Tübingen, Uni Kassel, Uni Potsdam, Uni Hannover, ATEEC, Uni Jordan, AAA/PARC, Tel Aviv Univ., BERC	Estimate of ecosystem services provided by different land use types (e.g. $ / ha-yr) under all GLOWA JR climate scenarios.	First results: Month 1 Nearly final results: Month 24	3.1 3.2

Theme/Task	**Responsible Organization**	**Deliverable**	**Due Date**	**Project No.**
Ecosystem services – (irrigated) agriculture	Uni Tübingen, Uni Kassel, Uni Potsdam, Uni Hannover, ATEEC, Uni-Jordan, AAA/PARC, Haifa Univ., Hebrew Univ., Tel Aviv Univ., BERC	Estimate of ecosystem services provided by different land use types (e.g. $ / ha-yr) under all GLOWA JR climate scenarios.	First results: Month 1 Nearly final results: Month 24	3.1 3.2 3.3
Average future irrigation water requirements	Uni-Freiburg, Uni-Kassel An Najah Uni Mutah University BGU	Monthy irrigation water requirement during future period (around 2050) under all GLOWA JR climate scenarios (m^3/month)	First results: Month 6 Nearly final results: Month 15	3.4.1 4.2
Question 3: The “Climate Extreme Question”				
Future downscaled climate simulations	IMK-IFU Tel Aviv Univ.	Evaluation of average trends and probability of climatic extremes	Final results: Month 12	4.1
Average future water availability	Uni Freiburg, Uni Kassel An Najah Univ., Hebrew Univ.	Monthy surface and ground water availability during future period (around 2050) under all GLOWA JR climate scenarios (m^3/month) In cooperation with SMART	First results: Month 1 Nearly final results: Month 15	4.2 4.3
Hydrologic conditions under future drought	Uni Freiburg, Uni Kassel An-Najah Univ.	Monthy surface and ground water availability during future drought period (m^3/month) In cooperation with SMART	First results: Month 6 Nearly final results: Month 15	4.2 4.3
Driving forces				
Driving forces of scenarios	AAA, ATEEC, Uni Kassel, Haifa Univ., Hebrew Univ., Tel Aviv Univ., HWE	Prepare data on the following driving forces in Israel: available data on demographic and economic development, national planning strategies and international food trade.	First results: Month 6 Nearly final results: Month 15	2
		Prepare data on the following driving forces in Jordan: available data on demographic and economic development international food trade national planning strategies	First results: Month 6 Nearly final results: Month 15	2

Theme/Task	Responsible Organization	Deliverable	Due Date	Project No.
Driving forces of scenarios (cont.)		Prepare data on the following driving forces in the West Bank: available data on demographic and economic development and national planning strategies.	First results: Month 6 Nearly final results: Month 15	2

Tab. 1.2: Scientific products based on synthesis and integration in the project.

Product	**Description**	**Coordination**	**Participants**
"Land-water interactions in the Jordan River Basin" Special Issue of land-oriented journal	Collection of publishable results from land-based studies in GLOWA Jordan River Project	K. Tielbörger et al.	P3, P4
The Jordan River Basin Scenarios Paper in policy-oriented journal	Description of storylines and supporting calculations from Phase II	J. Alcamo et al.	P1.1
Climate change and water availability in the Jordan River Basin Special issue of water or climate-related journal	Sum of publishable work regarding climate scenarios and hydrological calculations	H. Kunstmann Lucas Menzel Jens Lange	P4, P2, P1.2
Transboundary water management Paper in policy-oriented journal	Comparison of hydrological and economic effects of unilateral vs. cooperative water management (WEAP-based)	H. Hoff, U. Nicklas et al.	WEAP-partners
Adaptive management under climate change	Potential of individual and combined adaptation options to cope with future water scarcity (WEAP-based)	H. Hoff, U. Nicklas et al.	WEAP partners, P1 partners

Tab. 1.3: Schedule for project 1.

Year	**2008-2009**	**2009**	**2009-2010**	**2010**	**2010-2011**	**2011**
Month	**Sept-Feb**	**Mar-Aug**	**Sept-Feb**	**Mar-Aug**	**Sept-Feb**	**Mar-Aug**
Task 1.1a: Scenario Panel meetings	*X*		*X*		*X*	
Task 1.1b: Consultation with stakeholders		■	■	■	■	
Task 1.1c: Elaboration storylines		■		■		■
Task 1.1d: Quantifying storylines:	■	■	■	■	■	
• Preparation of first results from subprojects for scenario analysis	■					
• Continued analyses from subprojects in support of scenario analysis		■	■	■	■	
Task 1.1e: Preparing input for scenarios	■	■	■	■	■	
Task 1.1f: Prelim. sustainability analysis			■	■	■	
Tasks 1.2: WEAP-based scenario assessment						
• Definition of adaptation options to be evaluated in each WEAP model	■					
• Data consolidation and assimilation in the WEAP models	■	■	■			
• Testing WEAP results with stakeholders and adjustments			■	■	■	
• Presentation and discussion of WEAP results (“dissemination”) within and beyond GLOWA				■	■	■
• WEAP support for all partners and water management institutions, including implementation for operational use	■	■	■	■	■	■
• WEAP training workshops in each country		*X*		*X*		*X*
• WEAP mainstreaming with SAS scenario development	*X*		*X*		*X*	
Tasks 1.3b: Direct meetings with stakeholders	■	■	■	■	■	■
Tasks 1.3c: Presentation of a Scenario-Viewer	*X*		*X*		*XX*	
Task 1.3d: Distribution of GIS data (maps) produced in GLOWA JR	■	■	■	■	■	■
Task 1.3e: Distribution of Scenario Workshop Reports		*X*		*X*		*X*
Task 1.3f: Scientific Papers and Other Printed Products	■	■	■	■	■	■
Task 1.3g: Major Final Conference					■	
Task 1.3h: Follow up meetings						■ →
Task 1.3i: GLOWA Jordan River website	■	■	■	■	■	■

PROJECT 2: NEW WATER

Coordination:

Germany: K. Tielbörger & U. Nicklas (University of Tübingen), J. Alcamo (University of Kassel)

Israel: D. Hamberg & J. Schwarz (Tahal), Yossi Dreizin (Water Authority)

Jordan: A. Salman (ATEEC)

Others: H. Hoff (SEI)

Palestinian Authority: A. Jayyousi (An-Najah University)

INTRODUCTION

Background

Many of the questions raised by stakeholders in phase II of the GLOWA Jordan River Project had to do with the availability of water in the region from various "new sources" under development such as desalination, water transfers possibly including the Red Sea-Dead Sea Canal, wastewater reuse, demand management, water harvesting and green water management. Indeed, in order to achieve the main goal of the GLOWA Jordan River Project – to develop new ideas and strategies on "sustainable water management in the Jordan River basin" – it is important to take into account the contribution of new sources of water to future water demands. Some of these (e.g. wastewater) have been addressed in detail in the two previous project phases. This phase will be devoted to consolidating this data (in P3.4 and P4.3) and new external data.

In project 2 we compile, consolidate and analyze information about new sources of water from within the project and from external sources and make this information available directly to the SAS scenario exercise in project 1.1, and for the WEAP water balances and management scenarios in project 1.2.

The tasks and deliverables of project 2 that feed into project 1.1 and project 1.2 are described in Tab. 1.1 at the end of the project 1 description.

No new data will be generated in this project. Only existing data will be synthesized and assessed. To avoid doubling of efforts, this will be done in close collaboration with the data consolidation subproject of the SMART project.

Key goals

- Consolidate quantitative estimates of the potential contribution of 'new' water sources.
- Make preliminary estimates of the side-impacts of new water sources.
- Make preliminary estimates of the costs of new water sources.
- Make these estimates available to the GLOWA Jordan River Scenario Exercise in project 1.1.
- Make these estimates available to the WEAP Analysis in project 1.2.

Research questions and tasks

This project will deal with the basic question, “What is the potential for new (blue) sources of water to address current and future needs of people and ecosystems in the region?” This information will be integrated in the project in two ways: (i) as a part of the SAS scenarios of strategies, (ii) as part of the regional water balances and management scenarios computed and analyzed by WEAP.

The following new water options will be analyzed in this project:

1) Water Transfers – preliminary evaluation of different water transfer schemes including Red Sea-Dead Sea Canal (including side-impacts), water transfers from Turkey, and other proposals (including preliminary estimates of their side-impacts).

2) Desalination – evaluation of its potential, costs and side-effects.

3) Wastewater reuse - building on results of phase II (see P3.4), the volume and quality of usable wastewater, costs and side-effects are estimated.

4) Water demand and demand management – future water use in the domestic, irrigation, livestock and other sectors and potential water savings in all water use sectors are estimated (see also P3).

These options will be assessed country by country in order to evaluate the differences in importance of the various adaptation options. To cover the entire range of scenarios developed in phase II (e.g. cooperation vs. no cooperation in water management, as well as different economic development trajectories) a regional assessment will be made in P1.1 and P1.2, based on the country assessments. Information about wastewater will rely on the data collected in phases I and II (P3.4.2). Other relevant information will be synthesized from available sources, i.e. no new field experiments or models will be initiated in phase III of GLOWA JR. This data consolidation will be done in close cooperation with relevant stakeholders in the region (e.g. national water authorities and ministries, international NGOs).

Other “new” water sources will be estimated in project 3 (improved land /green water management, improved water productivity of crops, suitability evaluation for irrigation with treated wastewater) and project 4 (water harvesting and managed aquifer recharge and storage).

SUBPROJECT 2.1: NEW WATER - PART A

Israel: D. Hamberg & J. Schwarz (Tahal), P. Alpert (Tel Aviv University)

Introduction

a) Background

Given Tahal's role in GLOWA Jordan River as a consulting company, it will not primarily conduct new science, but rather will provide expert knowledge on new water options and associated data. Tahal was involved in the last two decades in most of the multi-lateral projects in the East Mediterranean area concerned with the availability and use of water resources and potential new water resources. Data were collected and generated on supplies, demands, quality, trends & projections of both water quantities and qualities, and costs of infrastructure measures. Tahal was particularly involved in the planning and in many cases also the design of new water resources including inter alia: sewage reclamation for agricultural and industrial uses, desalination of saline brackish water and sea water, import of water, Red Sea and Mediterranean Sea to Dead Sea transfers, demand management and water saving. These projects were financed by the World Bank (IDA), EC, GTZ, The Government of Israel, and Center for Middle East Peace and Economic cooperation.

b) Key results and key products from phase I and II

Project 2 is a new project. Therefore there are no results to report from Phases I and II. To ensure smooth integration, Tel Aviv University will function as the main contact person and coordinator of the data consolidation for Israel.

Working plan

The main tasks in this subproject will be to:

- Consolidate data on the new water sources described below.
- Prepare and present data to the Scenario Panel as part of the GLOWA Jordan River Scenario Exercise in project 1.1
- Compile further data as requested by the Scenario Panel.
- Prepare data files for input to WEAP analysis in project 1.2.
- Compile further data files as requested by the WEAP analysts.
- Upon request, prepare short (up to 5 pages) reports documenting the data and analyses prepared for the Scenario Panel (project 1.1) and WEAP and WEAP-MODFLOW analysis (project 1.2).

The new water sources to be analyzed in this subproject include:

a) Water transfers

These include water tranfer projects such as the Red Sea-Dead Sea Canal, water transfers from Turkey and other options. For these water transfer projects the following information will be compiled:

- Estimates of their annual yield (m^3/yr) and spatial availability of water.
- Estimates of the project's lifetime. For example the number of years expected before a fossil groundwater supply is exhausted or before other demands override those from the Jordan River basin.
- Estimates of the "quality level" of the water delivered by a water transfer scheme. For example, the expected salinity level of delivered water. This information is needed to determine if the low quality of transferred water will prohibit certain uses ("quality levels" to be defined).
- Preliminary estimates of water transfer costs ($/$m^3$) and costs of side impacts.

b) Desalination capacity and production

Estimates will be generated of current and future annual volume of desalination (m^3/yr) (seawater and brackish) and spatial availability of desalinated water. In addition, preliminary estimates of costs and side impacts of desalination will be described.

c) Wastewater reuse

Estimates of current and future annual volume of usable wastewater (m3/yr) will be compiled. The volume of wastewater will be described in different quality categories so the suitability of wastewater for different purposes can be analyzed, refering to the GLOWA JR land suitability maps generated in phase II and in P3.4. These data will be spatially-explicit.

d) (Blue) Water demand and demand management

Estimates of current and future blue water demand will be compiled. These data will be spatially-explicit. Future water demand will be described for business-as-usual scenarios. Water demand will be given as annual water withdrawals (m3/yr) and water consumption(m3/yr). Water productivity in the different sectors below will also be compiled ($/m3 yr). These data will be compiled for the following water-use sectors:

- Domestic
- Irrigation
- Livestock
- Manufacturing
- Electrical generation
- Tourism

Demand management data will be compiled on the potential water savings in all the above water-use sectors (m^3/yr). Preliminary estimates of costs of water conservation measures ($/$m^3$) will also be compiled. Demand management via land use management is addressed in project 3.

The spatial extent of data will be Israel and West Bank. Data will be retrieved from published reports and data bases of projects completed by TAHAL and by other planning agencies. Permission will be solicited from the Israel Water Authority and other employers of TAHAL for using unpublished reports and data of on going projects.

Schedule of work

First year: Participation in GLOWA JR meetings and conferences in an advisory role. Initial screening of available data and data requirements of other GLOWA JR projects (month 2), decision on temporal and spatial resolution, data and GIS formats where required (month 2), data collection for all groups (month 6), preliminary data made available for SAS Scenario Exercise (project 1.1) and WEAP Analysis (project 1.2) (month 6), soliciting feedback from other projects (month 10), cost estimates (month 10), first year report (month 12),

Second year: Participation in meetings and conferences in an advisory role. Nearly final results made available for Scenario Exercise (project 1.1) and WEAP Analysis (month 15), identification of remaining data gaps, collecting additional information, consultancy services on further scenario development and plausibility and feasibility of different adaptation options, with a focus on WEAP Analysis and SAS Scenarios.

Third year: Participation in meetings and conferences in an advisory role.

Deliverables

The following data will be delivered to the GLOWA Jordan River Scenario Exercise (project 1.1) and WEAP Analysis (project 1.2). These data will be delivered in the form of presentations, data files and short reports, as described above.

1) Data on the volume of **water transfer schemes** including spatial availability and quality of water, project lifetime, and preliminary estimates of their side impacts and costs.

2) Data on **desalination capacity and production**, including spatial availability of water and preliminary estimates of their side impacts and costs.

3) Data on potential volume, quality and spatial availability of **wastewater reuse**, including preliminary estimates of costs.

4) Data on **blue water demand** for all major water use sectors and estimates of water savings that can be accomplished by **demand management.**

SUBPROJECT 2.2: NEW WATER - PART B

Jordan: A. Subah (Ministry of Water and Irrigation), A. Salman (ATEEC)

Introduction

a) Background

The Ministry of Water and Irrigation (MWI) is responsible for water resource management and development, and holds all relevant water data for Jordan. MWI has developed and maintains the National Water Master Plan, a detailed planning instrument for the Jordanian water sector. Also, MWI has played a central role in the EXACT regional data bank development and is responsible for the planning of the Red-Dead Canal study in Jordan.

MWI is collaborating closely with GTZ, another important stakeholder in GLOWA JR, which will also help in phase 3 to ensure application of the scientific results in water management.

MWI itself has been a key stakeholder in phase II of the GLOWA JR Project, e.g. in the development of the regional and national WEAP models.

In phase III, MWI will be a full project partner in GLOWA JR, providing expert knowledge and taking responsibility for data delivery and scenario development in Jordan.

b) Key results and key products from phase I and II

Project 2 is a new project. Therefore, there are no results to report from phases I and II. To ensure smooth integration, ATEEC will function as the main contact person and coordinator of the data consolidation for Jordan.

Working plan

The main tasks in this subproject will be to:

- Consolidate data on the new water sources described below.
- Prepare and present data to the Scenario Panel as part of the GLOWA Jordan River Scenario Exercise in project 1.1.
- Compile further data as requested by the Scenario Panel.
- Prepare data files for input to WEAP analysis in project 1.2.
- Compile further data files as requested by the WEAP analysts.
- Upon request, prepare short (up to 5 pages) reports documenting the data and analyses prepared for the Scenario Panel (project 1.1) and WEAP and WEAP-MODFLOW analysis (project 1.2).

The new water sources to be analyzed in this subproject include:

a) Water transfers

These include water transfer projects such as the Red Sea-Dead Sea Canal, water transfers from Turkey and other options. For these water transfer projects the following information will be compiled:

- Estimates of their annual yield (m^3/yr) and spatial availability of water.
- Estimates of the project's lifetime. For example the number of years expected before a fossil groundwater supply is exhausted or before other demands override those from the Jordan River basin.
- Estimates of the "quality level" of the water delivered by a water transfer scheme. For example, the expected salinity level of delivered water. This information is needed to determine if the low quality of transferred water will prohibit certain uses ("quality levels" to be defined).
- Preliminary estimates of water transfer costs ($/$m^3$) and costs of side impacts.

b) Desalination capacity and production

Estimates will be generated of current and future annual volume of desalination (m^3/yr) (seawater and brackish) and spatial availability of desalinated water. In addition, preliminary estimates of costs and side impacts of desalination will be described.

c) Wastewater reuse

Estimates of current and future annual volume of usable wastewater (m^3/yr) will be compiled. The volume of wastewater will be described in different quality categories so the suitability of wastewater for different purposes can be analyzed, refering to the GLOWA JR land suitability maps generated in phase II. These data will be spatially-explicit.

d) (Blue) Water demand and demand management

Estimates of current and future (blue) water demand will be compiled. These data will be spatially-explicit. Future water demand will be described for business-as-usual scenarios. Water demand will be given as annual water withdrawals (m^3/yr) and water consumption(m^3/yr). Water productivity in the different sectors below will also be compiled ($/$m^3$ yr). These data will be compiled for the following water-use sectors:

- Domestic
- Irrigation
- Livestock
- Manufacturing
- Electrical generation
- Tourism

Demand management data will be compiled on the potential water savings in all the above water-use sectors (m^3/yr). Preliminary estimates of costs of water conservation measures ($/$m^3$) will also be compiled. Green water demand management is addressed in project 3.

The spatial extent of data will be Jordan. Data will be retrieved from published reports and data bases.

Schedule of work

First year: Participation in GLOWA JR meetings and conferences in an advisory role and as stakeholder. Initial screening of available data and data requirements of other GLOWA JR projects (month 2), decision on temporal and spatial resolution, data and GIS formats where required (month 2), data collection for all groups (month 6), preliminary data made available for SAS Scenario Exercise (project 1.1) and WEAP Analysis (project 1.2) (month 6), soliciting feedback from other projects (month 10), cost estimates (month 10), first year report (month 12),

Second year: Participation in GLOWA JR meetings and conferences in an advisory role and as stakeholder. Nearly final results made available for Scenario Exercise (project 1.1) and WEAP Analysis (month 15), identification of remaining data gaps, collecting additional information, consultancy services on further scenario development and plausibility and feasibility of different adaptation options, with a focus on WEAP Analysis and SAS Scenarios.

Third year: Participation in meetings and conferences in an advisory role and as stakeholder.

Deliverables

The following data will be delivered to the GLOWA Jordan River Scenario Exercise (project 1.1) and WEAP Analysis (project 1.2). These data will be delivered in the form of presentations, data files and short reports, as described above.

1) Data on the volume of **water transfer schemes** including spatial availability and quality of water, project lifetime, and preliminary estimates of their side impacts and costs.
2) Data on **desalination capacity and production**, including spatial availability of water and preliminary estimates of their side impacts and costs.
3) Data on potential volume, quality and spatial availability of **wastewater reuse**, including preliminary estimates of costs.
4) Data on **blue water demand** for all major water use sectors and estimates of water savings that can be accomplished by **demand management.**

SUBPROJECT 2.3: NEW WATER- PART C

Palestinian Authority: A. Jarrar (Palestinian Water Authority), A. Aliewi (House of Water and Environment), I. Nofal (Palestinian Ministry of Agriculture), A.R. Tamimi (Palestinian Hydrology Group), A. Jayyousi (An-Najah University)

Introduction

a) Background

Palestinian Water Authority (PWA) and Ministry of Agriculture (MoA) are responsible for water resources management and development and agriculture in PA, and hold all relevant water, irrigation and agricultural data for PA. PWA has also played a central role in the EXACT regional data bank development and is closely involved with the planning for the Red-Dead Canal study.

PWA and MoA have been key stakeholders in phase II of GLOWA JR, in particular when developing the SAS scenarios and the national and regional WEAP applications.

House of Water and Environment (HWE) and the Palestinian Hydrology Group (PHG) have been involved in several regional water studies, in particular related to the management of the Western Mountain Aquifer. HWE and PHG have also begun to use the WEAP-MODFLOW model in close cooperation with GLOWA JR in phase II.

In phase III, PWA, MoA, HWE and PHG will be full project partners in GLOWA JR, providing expert knowledge and taking responsibility for data delivery and scenario development in Jordan.

b) Key results and key products from phase I and II

Project 2 is a new project. Therefore there are no results to report from Phases I and II. To ensure smooth integration, An-Najah will function as the main contact person and coordinator of the data consolidation for the Palestinian Authority.

Working plan

The main tasks in this subproject will be to:

- Consolidate data on the new water sources described below.
- Prepare and present data to the Scenario Panel as part of the GLOWA Jordan River Scenario Exercise in project 1.1.
- Compile further data as requested by the Scenario Panel.
- Prepare data files for input to WEAP analysis in project 1.2.
- Compile further data files as requested by the WEAP analysts.
- Upon request, prepare short (up to 5 pages) reports documenting the data and analyses prepared for the Scenario Panel (project 1.1) and WEAP and WEAP-MODFLOW analysis (project 1.2).

The new water sources to be analyzed in this subproject include:

a) Water transfers

These include water transfer projects such as West Ghor canal and other water transfers. For these water transfer projects the following information will be compiled:

- Estimates of their annual yield (m^3/yr) and spatial availability of water.
- Estimates of the project's lifetime. For example the number of years expected before a fossil groundwater supply is exhausted or before other demands override those from the Jordan River basin.
- Estimates of the "quality level" of the water delivered by a water transfer scheme. For example, the expected salinity level of delivered water. This information is needed to determine if the low quality of transferred water will prohibit certain uses ("quality levels" to be defined).
- Preliminary estimates of water transfer costs ($/$m^3$) and costs of side impacts.

b) Desalination capacity and production

Estimates will be generated of current and future annual volume of desalination of brakish water (m^3/yr) and spatial availability of desalinated water. In addition, preliminary estimates of costs and side impacts of desalination will be described.

c) Wastewater reuse

Estimates of current and future wastewater treatment capacity and treatment level, as well as annual volume of usable wastewater (m^3/yr) will be compiled. The volume of wastewater will be described in different quality categories so the suitability of wastewater for different purposes can be analyzed, refering to the GLOWA JR land suitability maps generated in phase 2. These data will be spatially-explicit.

d) (Blue) Water demand and demand management

Estimates of current and future (blue) water demand will be compiled. These data will be spatially-explicit. Future water demand will be described for business-as-usual scenarios. Water demand will be given as annual water withdrawals (m^3/yr) and water consumption(m^3/yr). Water productivity in the different sectors below will also be compiled ($/$m^3$ yr). These data will be compiled for the following water-use sectors:

- Domestic
- Irrigation
- Livestock
- Manufacturing
- Electrical generation
- Tourism

Demand management data will be compiled on the potential water savings in all the above water-use sectors (m^3/yr). Preliminary estimates of costs of water conservation measures ($/$m^3$) will also be compiled. Green water management is addressed in project 3.

The spatial coverage of all data will be the West Bank. Data will be retrieved from published reports and data bases.

Schedule of work

First year: Participation in GLOWA JR meetings and conferences in an advisory role and as stakeholders. Initial screening of available data and data requirements of other GLOWA JR projects (month 2), decision on temporal and spatial resolution, data and GIS formats where required (month 2), data collection for all groups (month 6), preliminary data made available for SAS Scenario Exercise (project 1.1) and WEAP Analysis (project 1.2) (month 6), soliciting feedback from other projects (month 10), cost estimates (month 10), first year report (month 12).

Second year: Participation in meetings and conferences in an advisory role and as stakeholders. Nearly final results made available for Scenario Exercise (project 1.1) and WEAP Analysis (month 15), identification of remaining data gaps, collecting additional information, consultancy services on further scenario development and plausibility and feasibility of different adaptation options, with a focus on WEAP Analysis and SAS Scenarios.

Third year: Participation in meetings and conferences in an advisory role and as stakeholders.

Deliverables

The following data will be delivered to the GLOWA Jordan River Scenario Exercise (project 1.1) and WEAP Analysis (project 1.2). These data will be delivered in the form of presentations, data files and short reports, as described above.

1) Data on **desalination capacity and production**, including spatial availability of water and preliminary estimates of their side impacts and costs

2) Data on potential volume, quality and spatial availability of **wastewater reuse**, including preliminary estimates of costs

3) Data on **blue water demand** for all major water use sectors and estimates of water savings that can be accomplished by **demand management**

PROJECT 3: GREEN WATER MANAGEMENT: WATER AND LAND INTERACTIONS IN AGRICULTURAL AND NATURAL SYSTEMS

Coordination:

Germany: K. Tielbörger (University of Tübingen), R. Schaldach (University of Kassel)

Introduction

a) Background

Green water – the water stored in plants and soil – is an important component of the hydrological balance and accounts for the majority of 'productive' water in agriculture and natural ecosystems. It accounts to triple the amount of blue water that is involved in food production (Falkenmark 2006). However, the management of green water has been widely neglected in integrated water resources management. In particular, the value of water in open space (the dominating land use type in the study region), and the effect of natural areas on the hydrological cycle has been largely ignored. Green water can be managed by means of land use management, i.e. water productivity of a region can be considerably increased by wise land use allocation. Therefore, the importance of green water suggests that an L (for land and livelihood) must be added to Integrated Water Resources Management (Falkenmark 2006).

Here we aim at identifying optimal land allocation under different climate scenarios and GLOWA JR scenarios, and compare them with existing national planning schemes. The criteria for optimal land allocation can be roughly divided into two categories: geographical and biophysical criteria (suitability of the land) and economic criteria. Furthermore, "optimal" may have different meanings under different scenarios. For example, values and attitudes which differ among economic settings may greatly affect the relative value of nature vs. agriculture. The interdisciplinary approach of the GLOWA Jordan River Project enables us to address all these aspects in an integrated assessment of green water productivity.

The decision to allocate land to one or the other land use type will, on one hand, greatly affect the local and regional water balance via changes in runoff and evapotranspiration. Therefore, these effects must be considered when deriving land use allocation schemes under different scenarios. The effects of land management on the water balance will be investigated by applying the land use scenarios generated here within the hydrological models in project 4.

On the other hand, land use decisions will affect local and regional economic benefits, because the 'crop produced per drop' differs largely among land use types, but also among climate scenarios. Therefore, the economic evaluation of water productivity of the different land use types must form an integral part of optimizing land allocation. To that end, we need to evaluate the effect of different land use types on the hydrological cycle, their respective water demand and the value generated by the different land use types under different scenarios.

Value generated by agricultural products is relatively straightforward and is mostly determined by the yield and the current market price of the crop produced. However, next to yields there may be benefits from so-called ecosystem services. These services can be either direct (e.g. stocking capacity of rangeland) or indirect measures of the value of a certain land use type. These include recreational value, value of biodiversity, erosion control, carbon sequestration and many more. Ecosystem services are not necessarily provided only by so-called natural terrestrial areas (which use 70% of the world's available green water resources, Falkenmark 2006), but also by agriculture or by semi-natural afforestations. In total, these open areas account for more than 90% of the land cover in the study region (approx. 80% outside arid regions). The value of ecosystem services may be affected by the specific economic situation itself, i.e. the same ecosystem may have considerably different recreational values in the three societies of our focal region because they depend on how the respective society values nature. However, attitudes may change and benefits from different land use types will differ largely among the different GLOWA JR scenarios.

In order to derive sound information that can be used by stakeholders to decide about land management, the following general data must be gathered:

- Current and planned land use allocation, i.e. spatial distribution of open space, afforestation, agricultural land, urban space etc.
- Water productivity for each of the above land use types as a function of climate, land use and socio-economic situation.

A novelty of our approach is our explicit focus on the dominating land use type (open space) which will enable us to evaluate trade-offs in management decisions among entirely different sectors. For example, we will be able to evaluate the effect of allocation of land to natural or semi-natural open space vs. irrigated agriculture. Based on results from the two previous project phases, our central hypothesis is that optimal land allocation under most scenario conditions (e.g. climate change and socio-economic change) includes shifting from irrigated agriculture to natural and semi-natural terrestrial ecosystems.

b) Key results and key products from phase I and II

From phase I and II, we have obtained detailed information about water productivity of many key crops in Israel and for some climate scenarios. Furthermore, we have studied means to enhance water productivity in agriculture by specific crops or management types (e.g. intercropping, mulching). Economic evaluation of different land use allocation schemes was conducted at varying level of detail and spatial extent in the three partner countries. The effect of climate-driven water availability and of land-use decisions (stocking rates) has been evaluated for the range of natural and semi-natural ecosystems. Water productivity in terms of biomass production for livestock was evaluated for the entire region; water productivity measured in non-market value was obtained for Israel (phase I). First land use maps for the GLOWA JR scenarios were generated based on globally consistent land-cover datasets. Furthermore, coarse-scale suitability maps for wastewater irrigation are available for the entire region.

A key finding of phase I and II was the high resistance of natural ecosystems against climate change, their rapid and large response to varying land use schemes and their potentially high economic value. This combination indicates that open space (i.e. rainfed land use) may be a highly sustainable and productive land use type under climate change. Unfortunately, the economic value of open space was not evaluated for all countries and for the entire range of ecosystem services. Also, due to natural variation in climate, only long-term experiments can show whether the systems are really resistant to climate change and which useful indicators for evaluating climate change effects on natural ecosystems.

Further, not all economic evaluations were utilized in the initial land use modeling. These gaps have led to the formulation of our major goals related to "the land use question" and green water management for phase III.

c) Overall goal

The main objective of this project is to evaluate the potential of land use decisions to increase water productivity and benefits derived from the regional water resources for the different climate scenarios and the four GLOWA JR scenarios. Our central hypothesis is that optimal land allocation under various climate and land use scenarios includes shifting from irrigated agriculture to natural and semi-natural terrestrial ecosystems.

The models developed in phase I and phase II provide a sound basis for finalizing our simulations of optimal land use under climate change and under the four GLOWA JR scenarios. However, in order to systematically evaluate highly contrasting land-use decisions such as allocation to agriculture vs. allocation to open space, we need to complement the existing results by the following information:

1) Vulnerability assessment for natural ecosystems under climate change and land use change, by means of ecological models based on sound field data.
2) Systematic evaluation of associated ecosystem services under climate change and land use change by means of economic models based on simulated ecosystem response.
3) Systematic analyses of optimal land use allocation, including trade-off analyses, based on physical criteria (suitability for certain land use types) and economic criteria, by means of LandSHIFT

Specific goals include:

- Consolidation of information needed to simulate the distribution of future natural vegetation for different climate and land use scenarios, with a focus on extreme climatic events (P3.1.1).
- Reliable evaluation of response of natural vegetation and biodiversity to different scenarios, including estimates of ecosystem functional variables (e.g. biomass, species richness) and extinction risks, to be used by ecological models and scenarios (P3.1.1, P3.1.2).
- Provision of indicators of global change
- Nested set of ecological models for producing spatial representation of ecosystem structural variables (LAI, biomass, erosion risk, biodiversity, extinction risk), to be used by the hydrological models, WEAP, LandSHIFT, the economic models and the scenarios (P3.1.1).
- Development of region-wide quantitative estimates of future agricultural production and ecosystem services that take into account the following factors (P3.2, P3.3, P3.4):
    - Impact of future food trade between countries in the region and between the region and Europe and other outside markets.
    - Impact of economic situation and associated changes of attitudes towards natural areas.

  - Impact of various scenarios of water availability (under climate change and other variables, information on water availability from project.
  - The potential for increasing (physical and economic) water productivity in agriculture, including technical options, changes in crop selection etc.
  - Water prices
- Simulation of future agricultural land use in the region and the distribution of future natural ecosystems (e.g. about 5 natural land cover types or life-forms) in the face of climate scenarios (focus on extreme climatic events), physical factors, the above factors and changing food demand and trade, urbanization, and other driving forces (including water availability) (P3.3 in collaboration with P3.1 and P3.3).
- Consolidation of external and GLOWA JR information needed to evaluate the feasibility of rainfed and irrigated agricultural production in the region in the face of future availability of water and the potential for increasing agricultural water productivity with new water sources such as irrigation with treated wastewater (P3.4 and previous project phases).

Deliverables

a) Deliverables for the scenarios

- Quantitative inputs to scenario analysis of strategies about optimal land use allocation under the different scenarios, and associated environmental and economic effects.
- Tradeoff analysis for different ecosystem services (e.g. biodiversity, recreational value, rangeland value, soil protection).
- Direct quantitative information about species extinction risks and associated economic loss under different scenarios.

b) Deliverables for WEAP (mostly via TRAIN-ZIN)

- Parameters required by hydrological models to quantify changes in evapotranspiration, runoff and groundwater recharge for different scenarios (e.g. plant cover, LAI).
- Spatial representation of water demand under different climate and GLOWA JR scenarios.
- Spatial representation land use effects on water supply.
- Spatial representation of water productivity of different land use types under different scenarios.

c) Further deliverables for stakeholders

- Series of maps depicting the most important results about optimal land use, ecosystem properties (e.g. biodiversity, erosion risk), ecosystem services and agricultural production/suitability maps under different scenarios.
- A set of indicators for climate change effects on natural ecosystems, including vulnerability assessment.

Input from other projects

a) Scenarios

- Final scenario information needed for land use modeling (e.g. demographic development, technological development, and state-specific and scenario-specific attitudes)

b) WEAP

- Information about water supply from various sources including new (blue) water sources.

c) Other projects

- P4.1: Final climate scenarios and their range/uncertainties, including probabilities of extreme events.
- Information about new water sources (e.g. suitability maps for wastewater irrigation and water harvesting).

Work package structure/subprojects

Subproject 3.1: Climate change and land use change effects on natural and semi-natural ecosystems and their feedback on the hydrological system

This project deals with the impact of climate change and land use change on the dominating land use type in the region- natural ecosystems- their structure and function, their ecosystem services and feedback effects on the hydrological cycle. It addresses the recommendations of the JAC to further evaluate the effects of global change on biodiversity and to continue the basic monitoring of ecosystem response to climate and land use change.

Subproject 3.2: Assessing the Socioeconomic Benefits of Ecological System Services and Their Integration into Models of Optimal Land-Use Under Climate Change in the Jordan River Basin

This project deals with the systematic evaluation of the economic value (ecosystem services) associated with the natural and semi-natural ecosystems studied in 3.1 under different scenarios, integration of these results into the agricultural models and trade-off analyses.

Subproject 3.3: Integrated modeling of land use change and environmental impacts

This project will use the GLOWA JR scenarios and integrate socio-economic and ecological data from 3.1 and 3.2 and phase II for performing land use simulations combining economic and physical criteria for allocation of land to different land use types.

Subproject 3.4: Water productivity in agriculture

The main goal of this subproject is to provide LandSHIFT (3.3) with consolidated phase II information about boundary conditions for the different agricultural practices studied in the previous project phases. These include, for example, rainfed agriculture with drought-resistant crops, intercropping, mulching, irrigation with treated wastewater, but also standard practices (e.g. wheat, cotton, rainfed silviculture/olives and fruit trees).

SUBPROJECT 3.1: CLIMATE CHANGE AND LAND USE CHANGE EFFECTS ON NATURAL AND SEMI-NATURAL ECOSYSTEMS AND THEIR FEEDBACK ON THE HYDROLOGICAL SYSTEM

Germany: K. Tielbörger (University of Tübingen), F. Jeltsch & M. Köchy (University of Potsdam), R. Prasse (University of Hannover)

Israel: M. Sternberg & T. Dayan (Tel Aviv University) J. Kigel (Hebrew University of Jerusalem), D. Malkinson (Haifa University)

Jordan: S. Oran & S. Damhoureyeh (University of Jordan)

Palestinian Authority: M.S. Ali-Shtayeh. (Biodiversity and Environmental Research Center), A. Saleh (Al-Quds University)

Introduction

a) Background

The Eastern Mediterranean is a major biodiversity hotspot of the world. At the same time, this region of special conservation concern will be seriously affected by changes in land use and climate (IPCC 2007a, b). Since 70% of the rain water over continents is consumed by terrestrial ecosystems (Falkenmark 2006) and they have a large economic value (Fleischer & Sternberg 2005), it is mandatory to apply credible methods for evaluating ecosystem response to climate change and land use change in the GLOWA Jordan River region. Integrated water resource management under global change must remain incomplete when ignoring the land use type that consumes most of the rain water and covers the great majority of the land (70% in the center, 98% in the south).

Ongoing climate change is expected to have significant effects on the natural distribution of plant species (Walther et al. 2002). While climate is the principal determinant of current distributions and past range shifts for a large number of species, the importance of other factors in shaping predicted future species ranges has been largely underestimated. Most predictions of future species´ distributions result from bioclimatic envelope models (BEM), which deduce climatic requirements for individual species from their current geographical range, and project distributions under future climate scenarios, assuming that species will shift their geographical ranges to track their 'preferred' climate (e.g. Thomas et al. 2004, Thuiller et al. 2006; IPCC, 2007b). Although there is evidence of range shifts already occurring (e.g. Walther et al. 2005, Thuiller et al. 2006), it is now common knowledge that BEM rely on highly unrealistic assumptions (Hampe 2004). For example, many BEM assume that the current realized niche of a species corresponds only to the climatic axis of its fundamental niche, often based on very few climatic correlates (temperature, precipitation). Therefore, the approach not only disregards other abiotic factors but also the very (biotic) processes that determine the realized niche. For example, the research area has been under grazing pressure since several thousands of years, and interactions of climate and land use effects are highly likely. Also, in BEM, species are assumed to migrate freely across the landscape, regardless of species-specific dispersal ability and dispersal barriers imposed by fragmentation of landscapes. Finally, the role of adaptation to changing climatic conditions has been almost neglected, though there is ample evidence of the potential of organisms to undergo rapid evolutionary change. Due to the limited empirical evidence about the adaptive potential of species it has been erroneously concluded that adaptation of species or ecosystems may play a minor role in predicting the response of organisms to climate change (e.g., Parmesan 2006; IPCC 2007b).

However, it is highly unlikely that most species shift their ranges and reach their moving habitat in the projected future (Malcolm et al. 2002, Pitelka et al. 1997). Given that most species will not be capable of tracking their climatic niche, the only way of persisting under climate change is most likely in situ adaptation (Jump & Penuelas 2005). So, while common sense and some critical studies tell us that BEM are too simplistic, they still account for the majority of climate impact studies in ecology. This limits our capability to provide stakeholders with credible scenarios of ecosystem response to climate change and their impact on the hydrological cycle.

Here, we established a novel and integrative project focusing on changes in precipitation patterns and changes in grazing regime. We have manipulated stocking rates and climate for evaluating the potential of land use management as a means to adapt to climate change. Finally, we evaluate the potential of species to adapt to a changing climate. Experiments allow a mechanistic understanding about the impacts of changes on natural plant and animal communities and ecosystem functioning. However, it must be noted that Mediterranean ecosystems have evolved under highly variable climatic conditions and experiments manipulating precipitation or grazing must be conducted over a long time period .

b) Key results and key products from phase I and II

A main lesson from the previous phases is that on one hand, natural ecosystems are highly resistant against imposed climate change while on the other hand, they may produce a considerably larger value than alternative land use types. Finally, we could show that the main value of natural vegetation may not be in its value as rangeland but as space for recreation (Fleischer & Sternberg 2005). On the other hand, our empirical and theoretical findings from phase II indicated a considerable response to different grazing regimes, which, under increasing grazing pressure with increasing population growth, may lead to irreversible destruction of these valuable land use types.

The apparent resistance of natural ecosystems to climate change has been demonstrated on several levels. At a population level, we found a very high potential to adapt, but that there are differences between species (Lampei & Tielbörger 2007). At a community level, we have studied the response of the above- and below ground annual community to climate change and grazing manipulation (Metz et al. 2007). The main lesson from the empirical studies is a high resistance of the natural vegetation to climate change and a rapid response to land use change (grazing; Bangert et al. 2007). Similar differences have been shown by the landscape-scale models. Since the ecosystems in this region experience a high natural variation in climatic conditions it is not surprising that they are relatively resistant against short-term climate change. However, this observation calls for a continuation of the field manipulations over a longer time period for evaluating whether there would be a threshold from which there would be a drastic change in the structure and function of the systems. If these systems prove to be resistant, they may represent the ideal land-use type in the region, since our evaluation of ecosystem services from phase I (Fleischer & Sternberg 2005) has indicated that the recreational value of open space exceeds its value as rangeland by several orders of magnitude. In combination, our results suggest that open space may be both a productive and sustainable land use type under global change conditions. This has led us to the main working hypothesis of P3, i.e. optimal land allocation (i.e. highest water productivity) under any scenario condition will most likely involve a shift from agriculture to open space.

Our contribution is based on an integrative study of soil, overland-flow, vegetation, animals and landscape processes affecting the ecosystem, combined with socio-economic methodology (P3.2). Two alternatives to current bioclimatic models are applied:

1) The vegetation studies apply a mechanistic approach by means of manipulative experiments and modeling on different organizational scales for evaluating causal feedbacks between the hydrological cycle and changes in biodiversity and ecosystem structure (P3.1.1, P3.1.2).
2) The faunal studies (P3.1.3) attempt to improve the bioclimatic envelope approach by integrating realistic landscapes and projected land use scenarios (from P3.3), as well as estimates of migration probabilities into bioclimatic modeling.

Deliverables

a) Deliverables for the scenarios

A main deliverable to the scenario development will be landscape value (phase I and via P3.2) as well as ecosystem structure and function under different scenarios of climate change and land use change. We will produce maps of vegetation types, vegetation structure (cover of different life-forms), erosion risk, plant productivity, LAI, plant species extinction risk, species richness and value of landscape under different change scenarios. The field data, which is the basis for the maps, will feed into the scenarios as qualitative and quantitative information about extinction risks, and changes in economic welfare. The models will be refined through the iterative SAS approach via LandSHIFT, which will provide updated land use change scenarios throughout phase III. The most relevant in that respect are scenarios of stocking rates as a function of demographic and social development.

b) Deliverables for WEAP

The main deliverable to WEAP is directly and indirectly via TRAIN-ZIN which produces spatially-explicit data of green water fluxes through natural ecosystems and via the economic evaluations. As a basis, a set of predictive vegetation maps has been be created by means of spatially-explicit modeling of vegetation dynamics under different climate change and management scenarios. The phase II model results have been successfully applied in TRAIN-ZIN (P4). The first half of phase III will be devoted to run the existing models for the final climate scenarios (focus on extremes) and the four GLOWA JR scenarios.

c) Further deliverables for stakeholders

The deliverables to the stakeholders will be a set of predictive maps and the associated uncertainties for several key ecosystem features. Input to creating these maps are the climate scenarios, the GLOWA JR scenarios and land-use scenarios (via LandSHIFT). The outputs are maps of ecosystem productivity, landscape structure, erosion risk, plant species extinction risks and biodiversity (plants and animals). These will be evaluated for their economic value in P3.2. Our maps of water productivity in natural ecosystems will be compared with the value produced by other land use types under climate change and scenario conditions.

Other key deliverables include land management guidelines for different scenarios in the form of oral and written reports, a list of indicators of climate change and associated recommendations for monitoring programs, and an educational platform which integrates among all GLOWA results which are relevant for conservation.

d) Scientific deliverables

The main scientific deliverables are:

1) A challenge of the bioclimatic envelope approach which predicts shifts of species ranges based on their climatic niche only. At the end of phase III, we will be able to make an integrated assessment of ecosystem change with climate and land use change which are based on experimental data instead of bioclimatic models. Here, we explicitly address the role of real landscape structure, species migration potential and potential of in-situ adaptation in response to climate and land use change. These serve to validate over-simplified projections of bioclimatic envelopes.
2) Projections of ecosystem services including uncertainties based on transient dynamics and feedbacks between vegetation and soil water.
3) Evaluation of management options for open space under climate and land use change.
4) Indicators of climate change and land use change.
5) Establishment of long-term ecological research stations (LTER) in Israel.

Working titles for high-end scientific and applied manuscripts are:

1) Challenging the bioclimatic envelope approach with real data - lessons from an integrated long-term study in the Eastern Mediterranean (P3.1.1, P3.1.2).
2) High resistance and adaptive potential of Eastern Mediterranean ecosystems to climate change (P3.1.2).
3) Response of Eastern Mediterranean ecosystems to climate and land-use change: an integrated assessment based on 10 years of data and modeling (P3.1.1, P3.1.2).
4) Assessment of management options under climate change: a large scale approach for terrestrial ecosystems in the Jordan River watershed (P3.1.1, P3.1.2, P3.2).
5) Wise land use decisions can offset unwanted effects of climate change in eastern Mediterranean ecosystems (P3.1.1, P3.1.2).
6) Managing water through managing land use: the overwhelming value of open space (P3.1.1, P3.1.2, P3.2, P3.3, P1).
7) Planning for climate change: projected changes in species distributions in the eastern Mediterranean and their implications for conservation planning (P3.1.3).
8) Ecological communities and climate change: climatic envelope modeling and changes in animal community composition (P3.1.3).
9) Climate change, species range shifts, and planning: testing the case for species translocations.
10) Agriculture, silviculture, biodiversity, and climate change: the challenges ahead.

Work package structure/subprojects

Subproject 3.1.1: Simulation-based guidelines for management of uncultivated rangelands subject to climate change

This subproject will deal with regional (landscape-scale) modeling of climate change effects and land-use/management effects on key structural variables of natural ecosystems for the scenario time frame. The results feed into the scenario analyses (P1.1) and WEAP (P1.2 via hydrological models P4). The models which currently address global change effects on productivity of natural vegetation will depict erosion risk, biodiversity and effect on the water balance (via TRAIN-ZIN) and their associated ecosystem services under the GLOWA scenarios, climate change and land use change. The data for parameterizing and validating the models stems from empirical field data about plant extinction risks, productivity, diversity, as well as of vegetation effects on runoff (subproject 3.1.2).

Subproject 3.1.2: Medium-term effects of climate change and land use change on structure and function of natural ecosystems.

This subproject includes all empirical field studies performed for the two GLOWA JR gradients in Israel and Jordan. It includes the continued basic monitoring activities, as well as final evaluation (integrated data analyses) for the 10-year field data, i.e. the activities requested by the JAC. Furthermore, data and annual submodels produced in phase I and II will be applied for evaluating extinction risks of all component plant species. Finally, we aim at developing minimal requirements for routines of data collection, analyses and field manipulation that may be continued after phase III, for transforming the unique setup in Israel into Long Term Ecological Research sites (LTER).

Subproject 3.1.3: Animal biodiversity

This subproject is concerned with analyzing projected spatial patterns in faunal diversity at the biogeographic and community level, in response to different climate change scenarios and in response to different land use change scenarios, and how they will be impacted by various regional and national level planning scenarios We would like to study how projected changes in climate (climate change scenarios), development (planning scenarios), modeled changes in land use (socio-economic models, LandSHIFT model), and modeled changes in water availability (hence land use practices), are anticipated to affect patterns of animal biodiversity in the Jordan River Basin in The Palestinian Authority and Israel. Data collection in phase III will be limited to supplementary agro-biodiversity data and we will focus on analyses of existing data (generated by earlier GLOWA work as well as data produced in other projects) in cooperation and in light of other ongoing analyses, and to fine-tuning and updating our spatial models. We will focus on integration, including developing integrative input into biodiversity and ecosystem service management policies west to the Jordan River.

3.1.1: SIMULATION-BASED GUIDELINES FOR MANAGEMENT OF UNCULTIVATED RANGELANDS SUBJECT TO CLIMATE CHANGE

Germany: F. Jeltsch (University of Potsdam/ZALF), Martin Köchy (University of Potsdam), Ralf Wieland (ZALF)

Israel: D. Malkinson (Haifa University)

Introduction

a) Background

Process-based models link results of ecological field experiments and other existing knowledge allowing simulating the response of vegetation to climate change beyond the limitations of field experiments. Using simulations, the response of vegetation in field sites can be scaled up further to the extent of landscapes. In addition, the arrangement of field sites along a climatic gradient allows the interpolation of simulation results for other locations on the gradient and thus extrapolation to the extent of a greater geographical region and individual watersheds.

b) Key results and key products from phase I and II

In phase I of the GLOWA Jordan River Project we constructed dynamic, process-based models of annual plants, the dominant herbaceous growth form in the region, and shrubs (Köchy 2006, Malkinson and Jeltsch 2007). They were parameterized and validated by data obtained from field experiments. Systematic evaluation of the effects of climatic variability on annuals indicated that populations of annuals varies strongly with annual precipitation and daily distribution patterns but that the average performance of vegetation is quite resistant to projected long-term changes of annual precipitation (Köchy 2006, Köchy 2007a). Furthermore, some simulations suggested that greater environmental stochasticity may benefit the persistence of populations in stressful environments (Jeltsch et al. 2003). Evaluation of the shrub model highlighted the importance of facilitation of seedlings in stressful environments. This facilitative effect of shrubs on herbaceous seedlings was also observed in the field sites (Holzapfel et al. 2006). In phase II the annuals and shrub models were systematically evaluated to produce transition probabilities and equations. These were incorporated in a vegetation model with the extent of a landscape (1.5 km × 1.5 km) to assess the response of vegetation to climate change and land-use effects (grazing management). Using the models we derived the productivity and sustainable stocking capacity for several landscape classes under different climate change scenarios. Overall, yearly productivity was highly variable but mean productivity and stocking capacity were hardly affected by projected changes in the annual distribution of precipitation (Köchy and Jeltsch 2006, Köchy 2007b, Köchy and Jeltsch 2007). Simulations with the annuals model, however, suggest that changes to the distribution of precipitation within a year may have stronger effects. The models, which have been parameterized and validated based on the field data from only the first two growing seasons of phase I are thus in great agreement with the long-term observations at the field sites that the mean vegetation performance is quite resistant to environmental variability. Finally, we used an extended version of the landscape model (Mathaj 2007) to assess the effect of land-use (grazing) via vegetation structure on surface runoff and erosion. Surface runoff and erosion was locally highly variable but we were able to derive quantitative correlations between vegetation cover and erosion rates conditional on management scenarios.

c) Overall goals

We will link and use the dynamic, process-based models constructed in phase I and II, including the latest climate change projections, to

1) Project the mean and variance of vegetation cover and vegetation production for general and specific landscapes for a range of climate change and land-use scenarios.
2) Project the effect of changes in vegetation on generation of runoff and erosion for a range of climate change and land-use scenarios and indicate the likelihood of results.
3) Evaluate the models to test hypotheses regarding the benefit of environmental variability for populations with a seed bank.
4) Evaluate the ecohydrological models regarding feedback loops between vegetation and soil hydrology at the sub-watershed scale.
5) Assess landscape vulnerability to specific climate change and land-use scenarios and extreme events.
6) Apply the existing basin model to other basins.
7) Scale floristic diversity from plots at field sites to landscapes including effects of climate change, vegetation change, and land-use/management.
8) Present results as maps with accompanying reports for means and variance of vegetation productivity, composition, stocking capacity, runoff, and erosion.

Deliverables

a) Deliverables for the scenarios

Regional maps of biomass production for each climate change scenario × each time slice × two scenarios of grazing (0 and 0.2 LSU/ (ha · yr) showing their means and variance.

Regional maps of vulnerability of biomass production (e.g., the probability that the landscape supports 0.2 LSU/ha in 9 of 10 years) and vulnerability of runoff (e.g., the probability that the runoff of watersheds deviates by 20% from that under current conditions).

b) Deliverables for WEAP

Maps of water (rain) productivity of uncultivated land for each climate change scenario × each time slice × two scenarios of grazing.

Runoff and ground water recharge values for specific watersheds incorporating dynamic vegetation-soil feedbacks.

Via TRAIN-ZIN: spatial representation land use effects on water supply.

c) Further deliverables to other projects

TRAIN: Parameters required by hydrological models to quantify changes in evapotranspiration, runoff, and groundwater recharge for different scenarios – equations for leaf area index and mean vegetation height with mean annual precipitation as independent variable for each climate change scenario × each time slice × two scenarios of grazing).

LandSHIFT.R: Maps of biomass production and stocking capacity for each climate change scenario × each time slice; in addition, biomass production for the aforementioned grazing scenarios.

Socioeconomic models: Maps showing the projected vegetation productivity (economic value), composition (esthetic value), and biodiversity (esthetic value) and landscape vulnerability (economic value) as ecosystem services.

Biodiversity models (project 3.1.3): Maps of floristic diversity for integration in measures of overall biodiversity.

d) Further deliverables for stakeholders

Application of projected vegetation changes for specific landscapes and landscape classes

Maps (to be stored in the GLOWA JR GIS, P1.3): means and variance of vegetation composition, productivity, stocking capacity, floristic biodiversity, with explanatory reports especially regarding feed back effects between soil water and vegetation and the vulnerability of key ecosystem services

Guidelines for landscape management regarding shrub encroachment and erosion control using

1) grazing
2) prescribed fire
3) mechanic shrub removal

e) Scientific deliverables

Understanding of the processes causing feedback loops between vegetation and soil water across spatial and temporal scales. Furthermore, the implications of perturbations to the ecosystems on the relationships between vegetation and soil water will be assessed.

Understanding of the importance of environmental variability for the persistence of populations with seed banks (Higgins et al. 2000).

In addition to the collaborative papers mentioned in the project introduction, we plan the following publications (preliminary titles, underlined words represent short titles used in table of milestones):

- Scaling up from individual plants to countries using hierarchical modeling.
- Seed banks as temporal refuges in variable environments (with M. Sternberg).
- Vulnerability of ecosystem services in Middle East landscapes depends on daily rain patterns.
- Relevance of extreme events versus changes in mean values in unpredictable environments.

- Ecohydrological modeling – towards a process-based understanding of water and vegetation dynamics in landscapes.
- Interaction of climate change effects and landscape management on floristic diversity in Mediterranean landscapes
- Does land-use and management amplify climate change effects?
- Temporal and spatial mesoscale feedbacks between soil water and vegetation in small basins.
- Climate change effects on fire regimes in the Middle East

Input from other projects

a) Scenarios

Final scenario information for vegetation modeling: median small livestock density per climatic/geographic region, use of uncultivated land for other purposes than rangeland that might affect the vegetation. This information would be used to simulate more closely the SAS scenarios than just assuming a constant stocking rate of 0.2 LSU/ha.

b) WEAP

Not applicable.

c) Other projects

Final transient climate time series (scenarios A2, A1B, B2 from TAU, scenarios A2, and B2 from IMK-IFU) including probabilities for extreme events for 1961–2055 (assuming the latest projection is requested for 2050 by the stakeholders) or statistical distributions of daily and annual rain patterns.

Field sites (project 3.1.2): LAI (seasonal min/max), biodiversity (different areas, grazing), extinction risks for selected species, biomass production, density of juvenile and mature plants, seed bank density from phase I & II. Expert knowledge regarding effects of management decisions on ecosystem features not included in the models.

TRAIN: indices of evapotranspiration per climatic region.

Working plan

a) Overview

We propose seven main activities: (1) providing for the socioeconomic models, the biodiversity model, TRAIN, LandSHIFT.R, and SAS the required projections of biomass, leaf area index, vegetation height, cover, and stocking capacity based on the final climate simulations (2) linking existing dynamic process-based GLOWA JR soil, runoff, and vegetation models for examining dynamic feedbacks among the ecohydrological processes, understanding the buffering capacity of seed banks for herbaceous vegetation, and exploring management strategies to preserve ecosystem services, (3) evaluating the linked models with regard to climatic extremes and their effect on the vulnerability of ecosystem services, (4) application of the existing regional vegetation-runoff model to basins in other regions, (5) scaling floristic diversity from plots to landscapes using biogeographic principles and landscape model projections, (6) providing maps with explanatory reports, and management guidelines to stakeholders, (7) deriving landscape management guidelines based on simulated results.

1) Based on the final climate projections of the IPCC climate change scenarios A1B, A2, and B2 we will provide final projections of biomass, leaf area index, vegetation height, and stocking capacity per square kilometer to SAS, TRAIN, LandSHIFT.R, and the socioeconomical models. The final projections of vegetation on the landscape scale require a revision of input from the submodel for annual vegetation for each climate scenario to account for the latest projections of within-year rain distribution. In order to enhance further the reliability of the simulated results, we will use the long time-series of field data from two climatic gradients (Israel and Jordan) that are now available to re-parameterize and revalidate the annuals submodel. Output of the landscape model will be provided in the form of equations (functions of mean annual precipitation) and geographically interpolated as maps as required. The models will be further used to test the hypothesis that seed banks may provide temporal refuges for populations resulting in higher population persistence when environmental variability is high than when it is low (Higgins et al. 2000). The models include spatial effects of seed dispersal and interactions with shrubs and take a long-term perspective. The hypothesis will be tested by creating and systematically varying suitable climatic time series as model input, systematically varying species attributes, and statistically analyzing the simulations. Results from simulations with the annuals submodel will be transferred to the landscape model to assess the wider implications of the results. This study will be carried out by a Master's/Diploma student (SHK, 9 months). The reparameterization and validation, production of equations and maps for the other projects, and supervision of the student requires on average a ¼ position for a senior researcher (TV-L 13) for the whole funding period.
2) Separate models exist that emphasize either soil water dynamics, erosion or vegetation dynamics at the landscape scale with the other factors playing a static role. The lack of dynamic interaction among the factors in the models is due to the fact that the factors vary on very different temporal and spatial scales. The available expertise, data, and models in GLOWA JR now allow linking these models dynamically. The dynamic linkage of soil, water, and vegetation models is essential for a comprehensive, reliable assessment of simultaneous climate change and land-use impacts on several temporal and spatial scales. The results of this activity will present novel scientific knowledge and more solid ground for including feed-backs between vegetation and soil water in management guidelines based on the final climate projections. The linking of models requires a ½ position on average for the whole funding period for a senior researcher (TV-L 13) experienced in modeling of vegetation and soil water.
3) Climatic extremes are expected to become more frequent in the future (Easterling et al. 2000). We will use the linked models to assess the vulnerability of biomass production (e.g., the probability that the landscape supports 0.2 LSU/ha in 9 of 10 years) and vulnerability of runoff (e.g., the probability that the annual runoff of watersheds deviates by 20% from that under current conditions or the probability of daily runoff being greater than the current 90% quantile). For the assessment we will generate time series of precipitation and temperature for model input according to the probability of extreme events provided by the climatologists. In addition, climatic change may be expressed not only in changes in precipitation patterns, but also in changes in dry spells and temperature shifts. These changes may influence

the propagation of wildfires in the ecosystems. Although it has been demonstrated that all the wildfires in the region are a result of anthropogenic activities (Kleiot and Keidar 1992), the climatic changes may affect the overall fire regime, and hence overall vegetation community structure and dynamics. This requires a ¼ position on average for the whole funding period for a researcher (TV-L 13) experienced in modeling of vegetation and soil water.

4) Application of the existing regional vegetation-runoff model to other watersheds. This requires a full time position on average for the whole funding period for a PhD. Student experienced in modeling of vegetation and soil water.

5) The proportion of growth forms and bare ground controls the floristic and faunistic species diversity at the landscape scale. We will use biogeographic principles to combine model results of structural landscape diversity and observed plant species diversity at the ecological field sites to estimate floristic diversity at the landscape scale. This estimate will include effects of vegetation change via climate change and management. The projection of biodiversity will be conducted by a student as a Masters'/Diploma thesis for 9 months (SHK position), supervised by the senior researcher and PI. The estimates of floristic diversity will be provided as maps and used together with faunistic diversity (project 3.1.3) to assess overall changes of biodiversity due to climate change (delivered to P1.3, geodatabase).

6) We will summarize the scientific findings that we obtained from field experiments via simulations in the form of regional maps showing information like biomass production, capacity for livestock, floristic biodiversity, runoff generation, or vulnerability of ecosystem services. The maps for different climatic and land use scenarios will be accompanied by explanatory reports for a non-specialist audience in English, Hebrew, and Arabic. Maps and reports will be augmented by guidelines for landscape management to preserve or improve selected existing ecosystem services. Map production requires a research assistant (WHK) for three months; the writing of reports for a non-specialist audience will be conducted by a science writer.

7) Managers are often faced with a dilemma when they must decide between contrasting managements and not knowing the likelihood of the resulting main (e.g. productivity) and side effects (erosion, biodiversity) on ecosystem services. We will develop guidelines for landscape management by evaluating simulations of the linked models for specific management scenarios. The guidelines will be presented as a written report focusing on feedback effects between vegetation and soil water. Combination of simulations, field data that could not be included in the models and expert knowledge. Expertise for this exists within the Centre for Agricultural Landscape Research (ZALF (Mirschel et al. 2006, Wieland et al. 2006)), of which the PI is an associated scientist. We will elicit the collective knowledge and experience of the group's ecologists in interviews to rate the probability of immediate effects of management decisions. These probabilities will be linked with those produced by field experiments and simulations in a formal way using fuzzy logic or Bayesian statistics. A similar procedure is used in the SAS process to quantify attitudes of stakeholders. The guidelines will be prepared in three ways to address different audiences.

b) Milestones

Task 1

12/2008: Reparameterization and validation of 3 existing models based on data from whole phase 1–2. ECHAM4/MM5/A2&B2, ECHAM5/RegCM3/A1B: Calculation of statistical distributions of daily and annual precipitation for creation of stochastic time series. Consecutive simulations with hierarchical models for all management scenarios.

04/2009: Condensation of results as equations for TRAIN. Interpolation of results and preparation of maps with reports for LandSHIFT.R, SAS and socioeconomic models.

08/2010: Assessment of benefit of environmental variability for populations with seed banks.

04/2011: Manuscript: Seed banks

08/2011: Manuscript: Scaling up

Task 2

08/2009: ECHAM5/RegCM3/A2&B2: Calculation of statistical distributions of daily and annual precipitation for creation of stochastic time series. Consecutive simulations with hierarchical models for all management scenarios. (Data from project 4.1 available in May 2009)

12/2009: Condensation of results as equations for TRAIN. Interpolation of results and preparation of maps with reports for LandSHIFT.R, SAS and socioeconomic models.

04/2011: Manuscript: Ecohydrology

08/2011: Manuscript: Extreme events

Task 3

12/2008: Production of conceptual framework for linking of models across temporal and spatial scales.

08/2009: Simulations with linked models to assess vulnerability of specific ecosystem services (statistical assessment of phase-2 models from project 4.1 available in April 2009).

12/2009: Statistical evaluation of vulnerability simulations. Simulations with linked models to obtain likelihoods for management effects.

04/2010: Produce maps and report of vulnerability for SAS.

08/2010: Evaluation of simulations to generate management guidelines.

12/2010: Manuscript: Vulnerability, Report: Management guidelines.

Task 4

04/2009: Biogeographic upscaling of floristic diversity to landscape without climate effects.

09/2009: Accounting for climate change and landscape change effects in projections of biodiversity for the full range of climate and management scenarios.

12/2009: Produce maps of biodiversity for P3.2 and SAS.

12/2010: Validation of maps of biodiversity with community-wide evaluation of extinction risks (from P3.1.2), new maps for P3.2 and SAS.

Manuscript: Diversity.

Task 5

04/09: Processing and analysis of satellite images vegetation distribution in other representative watersheds in Israel, the PA and Jordan.

08/10: Simulation of the watersheds with respect to climatic changes and changes in fire regimes.

12/10: Report

04/11: Manuscript: Watershed

08/11: Manuscript: Fire regimes

3.1.2: MEDIUM-TERM EFFECTS OF CLIMATE CHANGE AND LAND USE CHANGE ON STRUCTURE AND FUNCTION OF NATURAL ECOSYSTEMS

Germany: K. Tielbörger & P. Stoll (University of Tübingen), R. Prasse (University of Hannover)

Israel: M. Sternberg (Tel Aviv University), J. Kigel (Hebrew University of Jerusalem)

Jordan: S. Oran (University of Jordan)

Introduction

a) Background

Open areas and their vegetation both critically affect the hydrological cycle and water productivity through changes in lateral and vertical water fluxes. Open space accounts for 80-90% of the total land cover in the study region. At the same time, water productivity of these areas may be very high. Therefore, open space must be an integral part of sustainable water management in the region. Though this seems logical, previous IWRM projects (in general and in the region) have neglected this aspect, making GLOWA Jordan River a globally unique and pioneering project within the entire IWRM context.

This subproject addresses the request of the JAC for further focusing on evaluation of global change effects on open space (mainly natural and semi-natural ecosystems) and for continuing the basic monitoring activities. It comprises of a globally unique experimental setting that was established in phase I and phase II. The project deals with the short and medium-term responses of natural vegetation to climate change and land use change and serves two purposes within GLOWA JR: first, the data is used to evaluate water productivity of open space which we assume to be by an order of magnitude larger than that of (irrigated) agricultural use. This is particularly true for climate change scenarios, due to the high resistance of natural systems to climate change, and for scenarios of economic growth. Therefore, reliably evaluating the resistance of these systems to climate and land use change is a key contribution to modeling land use allocation via LandSHIFT and the scenarios. Secondly, the data is used for validating the large-scale vegetation models (P3.1.1) which are linked to WEAP via TRAIN-ZIN and thus forms an integral part of the regional water balance evaluations.

Due to the high natural variation of the climate of the region, plant and animal species must show a high resistance to climatic variations. Namely, the large resistance shown by the herbaceous natural community at the study sites along the aridity gradient in response to medium-term climate change (i.e. climatic manipulations) most probably reflects long evolutionary adaptation to drought and rainfall unpredictability (i.e. inter-annual as well as within a season) of the dominant and sub-dominant species. Adaptation to variable and dry conditions has been studied intensively in phase II. The rationale for focusing on adaptation is that in order to persist, most species will need to adapt in situ to the changing climate or land use. **Sound estimates of biodiversity change (and associated landscape value)** need to rely on sound estimates of extinction probabilities. The first step in evaluating extinction risks is the identification of traits which maximize fitness in a given environment. The next step is to investigate whether the amount of heritable genetic variation in the adaptive traits is sufficiently large to allow adaptation to a changing climate. This can be done by means of combined population genetic studies and theoretical modeling (Rice & Emery 2003, Etterson & Shaw 2001). Regrettably, such studies are very work-intensive and can be done for only very few species. It is therefore not surprising that this limited evidence has not been reflected in the recent IPCC WG2 report (IPCC 2007b). Here, we propose to apply a combined empirical-theoretical approach that will enable us to identify proxies for extinction risks (i.e. easy-to-measure plant traits) for most of the component species. The main result will be an estimate of extinction risks and, subsequently **biodiversity change and associated change in ecosystem services** for the major ecosystems studied.

In contrast to its stability under medium-term climatic change, the vegetation shows a rapid response to cessation of grazing (i.e. land use change, Bangerter et al. 2007). In the case of the herbaceous vegetation, vegetation response is productivity-dependent: in low productivity sites species richness increases after grazing removal due to recovery of the palatable species, while in high productivity sites richness decreases due to competitive displacement of the small size species thriving under grazing, by the large size, palatable species that recover after grazing cessation (Osem et al. 2004, 2005). These changes in vegetation composition depend on seed availability in the seed bank, or seed influx from grazing refuges and neighbor ungrazed vegetation. In the more humid regions of the two rainfall gradients where shrub cover is larger (i.e. Maquis vegetation formation), grazing cessation results in shrub encroachment and gradual loss of the productive and nutritious herbaceous vegetation. This increase in shrub cover reduces plant diversity and the value of the landscape and is thus a primary variable of interest for evaluating sustainable land use strategies.

b) Key results and key products from phase I and II

The key result that highlights the urgent need for maintaining the manipulations and continuous monitoring is that there was, so far, no strong indication of change in ecosystem structure and function as a result of the climate manipulations. At the same time, the systems along the Jordanian gradient have responded rapidly to a change in grazing intensity (Bangerter et al. 2007).

Due to the delayed response of the systems to climate change, it will be a major challenge to provide the stakeholders with indicators of climate change that may serve as an ‘early-warning system’. At the same time, systematic evaluation of grazing increasers yields indicators of overgrazing. Currently, the only variable that responded to climate manipulations was plant biomass. However, the changes were much smaller than expected and not always statistically significant. A better indicator would be a systematic change in overall species composition or changes in abundance and distribution of certain key species.

Results from phase II also indicate apparent local adaptation (Petrů et al. 2006) but a high potential of three model plant species to adapt to climate change (Lampei & Tielbörger 2007). For these species, we have obtained extensive demographic and population genetic information that allowed us to investigate the degree of adaptation to the current climate. At the same time, the three species exhibited large heritable genetic variation with respect to the adaptive traits, i.e. a high adaptive potential. One must note that currently approx. 600 annual plant species coexist along the entire climatic gradient in Israel and Jordan. Since the main challenge is to evaluate extinction risks for all species in the plant community, we must find a way of extrapolating the results of the few model species to the other component species. By means of very simple population models, we could identify two key life history traits that are indicative of adaptation to certain climatic conditions or certain competitive conditions: seed dormancy, i.e. the capability of a seed to survive extended periods of drought; seedling survival, i.e. the capacity of a seedling to reproduce within a given year. The first reflects adaptation to climatic variability, the second to average climatic conditions- the two key components analyzed in the climate models of the project (P4.1). We could furthermore show that seed weight - a trait that is easy to measure for many species - correlates negatively with seed dormancy and positively with survival. Thus, it appears possible that we could measure these key traits or their correlates and their genetic variability for the entire plant community. As a result, we could, by adjusting the existing models to the new data, evaluate a proxy for extinction risks for each species in the plant community.

c) Overall goal

Based on the gaps identified above, the main goals of this subproject are:

- Providing a reliable database for resistance of natural vegetation (in terms of extinction risk, productivity change, diversity change) to climate change.
- Providing estimates of vulnerability to climate change and overgrazing on a species and community level.
- Providing baseline data for ecological and hydrological model calibration and validation (P3.1.1, P4.2).
- Providing management and monitoring recommendations under various change scenarios.
- Providing indicators of climate change for the dominant land use type in the region.
- Providing the baseline data (e.g. improved biodiversity estimates) needed for evaluating ecosystem services of the dominant land use type under scenario conditions (P3.2).
- Establishing the basis for LTER research, including minimal routines of monitoring and data analyses.

Deliverables

a) Deliverables for the scenarios

The result of this subproject will feed into the scenarios mainly via the large-scale models (P3.1.1). However, qualitative estimations of extinction risks for plant and animal species as well as changes in stocking capacity can be used directly in the scenarios to evaluate alternative adaptation options for their sustainability.

b) Deliverables for WEAP

Deliverables to WEAP are via the large-scale vegetation models and TRAIN-ZIN (P3.1.1, P4). Economic information (water productivity) will be delivered via P3.2.

c) Further deliverables for stakeholders

Many of the data of this subprojects feeds into the models and will be up scaled to a regional level and presented as maps (see P3.1.1). In addition, we will produce a set of criteria to evaluate extinction probabilities of plants under climate change. These can be used by stakeholders in two ways:

1) The extinction risk of plant species (e.g. species with high economic value) which are not part of our study system can be evaluated.
2) A list of plant species most vulnerable to climate change will be prepared. Changes in abundance of these species can serve as indicators of climate and land use change (i.e. early warning system) and stimulate the establishment of monitoring programs for single species by ministries and nature conservation authorities.

d) Scientific deliverables

As pointed out above, we will be able to utilize the empirical findings of this subproject to address the usefulness of the bioclimatic envelope approach. Additional working titles of manuscripts for this subproject are

1) Adaptive response of multi-species assemblages to climate change is possible (KT et al.).
2) Seed bank as a buffer to climatic variations in Mediterranean ecosystems (MS et al.).
3) Rangeland value of Eastern Mediterranean ecosystems under climate change (RP et al.).

Finally, we aim at maintaining the research sites in Israel as Long Term Ecological Research sites (LTER). Today, the system we have established in Israel is unique in the world in its extent, experimentation, coverage of extremely different climatic conditions and the amount of different data collected continuously. Since our systems may be highly resistant against climate change, we regard it as compulsory to maintain these four sites and their climatic manipulations for the scientific community. Maintenance could be realized at relatively low costs (compared to costs of establishment), and the scientific outcome could be considerable. The sites could furthermore serve as educational platforms for demonstrating ecological impact research to the broad public.

Working plan

a) Overview

In general, our activities will be limited to those key monitoring activities which have been done in all previous years and which we regard as mandatory. No new research will be initiated, and most monitoring activities will not be continued (i.e. plant-animal interactions, interactions among plants, plant demography, seedling densities). The letters in brackets following the paragraph titles indicate the initials of the main responsible principal investigator.

Maintenance and monitoring of abiotic variables (MS) will continue in all four study stations along the aridity gradient as in phase II. Meteorological data collected at the study sites is currently available online for all GLOWA Jordan River participants at: http://meteo-tech.co.il/glowa/glowa_common_data.php. This high resolution climatic data (hourly base) includes soil moisture and soil temperature at the main two habitats of the study areas (open gaps between shrubs dominated by annuals and shrub understory). Additional meteorological parameters measured includes: air temperature and humidity, solar radiation

(PAR), rainfall, wind speed and direction. This data will be collected also during phase III and made available for all GLOWA JR modelers. A regular soil sampling of soil key parameters (NH_4, NO_2, NO_3 and available P) will be continued at the study areas twice a year (summer and winter). Changes in climate and soil parameters will serve as explanatory variable for associated vegetation structure.

The rainout shelters at the study sites will be newly prepared before each rainfall season. The irrigation systems will be maintained and repairs will be done where necessary. A new irrigation system will be installed which is safe against vandalism and stealing and which will greatly reduce maintenance cost on the long run. The fencing at the study area will be strengthened to prevent wild boars and domestic grazers entering the study plots.

Plant community monitoring activities (KT): The annual counting in permanent quadrats in different microhabitats, the four stations each in Israel and Jordan, and the climate and grazing manipulations will be continued until the end of phase III, following the standard protocol developed in previous phases. Counting will be done on a species level. Previously, counting was done twice a year (germination count and reproductive count). For minimizing monitoring activities, only adult counts will be done in phase III. The data will be analyzed with established routines developed in phase II (multivariate analyses and generalized linear models for single species response) for evaluating directional changes in species abundances with the climatic manipulations.

Seed bank monitoring (MS) will be continued by collecting soils with their respective seed banks in autumn before the onset of the rainfall from the study sites along the two climatic gradients under manipulated grazing and rainfall. Continuation of the experiments and monitoring is necessary to shed more light on short-term vs. long-term resistance and provide stronger evidences about the potential effects of climate change on soil seed bank dynamics. Soil collection and germination will follow the standard protocol developed in phase I and II. Furthermore, estimations of seed production will be carried out by collecting dry vegetation of key species just before dispersal (April). Ordination analysis of seed traits along the aridity gradient will be carried out considering dormancy, dispersal capabilities and seed size as key parameters for all species (approx. 250).

Monitoring of plant diversity and associated biomass production (JK) by the herbaceous vegetation will be continued until the end of phase III, due to the apparent high resistance of the vegetation to medium-term climate manipulations. Recording of species presence in permanent 2 x 2 m quadrats will be continued in the four sites in Israel. Species diversity and biomass will be monitored following standard protocols developed in phase I and 2. Changes in vegetation structure across years and climate manipulations will be analyzed using different diversity, dominance and evenness indexes, Q statistics, SHE analysis, similarity analysis, rank/abundance plots. Changes in the community composition will be compared with changes in the seed bank. This research effort will provide a detailed database on vegetation dynamics covering 10 years of monitoring.

Shrub expansion after cessation of grazing: preliminary work initiated in phase II will be continued in phase III. Species composition and shrub cover by species will be determined along 10 transects of 50m perpendicular to each side of the site fences: grazed (outside) and ungrazed (inside).

Monitoring of plant community response to grazing and reseeding (RP, SO, SD, KT): This section, which is conducted along the Jordanian climate gradient, tests the effects of the predicted climate change on rangeland quality and the possibilities to manage the fodder value and biodiversity via temporally enabling grazing cessation. For that purpose, a transect along a rainfall gradient has been established in phase II (Wadi Shueib, Jordan). At four locations along the gradient with different mean annual precipitation and different rainfall variability along that gradient the effects of grazing cessation on rangeland quality and plants and seed bank diversity have been investigated. Due to high inter-annual variability in rainfall, the monitoring in these plots needs to be continued, since the recovery from several thousand years of intensive grazing is probably slow. Only long-term studies - even if using a space for time approach - will allow evaluating the response of the vegetation to the predicted climatic changes as well as the underlying mechanisms. The general plan for phase III is to continue the basic monitoring of the experimental plots by two groups (German and Jordanian) in year 1 and one group (Jordanian) in years 2 and 3 to enable smooth transfer of methodology and data analysis procedures to the Jordanian partners. Two types of experiments have been established in phase II: grazing enclosures (four climates, two slope expositions) and reseeding with local seed bank, but only the first will be monitored further. Annual monitoring of experimental plots includes biomass per unit area, plant cover per life form, species composition/diversity and species frequencies. The data on medium-term land use (grazing) effects on productivity, diversity, erosion risk (measured as percent open space) and plant cover will serve to validate the large-scale models (P3.1.1.). In order to set the preconditions for making the sites into permanent research sites in Jordan, monitoring will be continued by the Jordanian team until the end of phase III. However, the data needed as input to the models will be delivered by mid-phase III.

Monitoring adaptive potential (KT):

a) Final monitoring: For monitoring micro evolutionary changes in response to the treatments, seeds of plants of dominant species will be collected at the latest possible date (2010) within the treatments, bagged individually, stored in the field for oversummering and grown in a greenhouse at Tübingen during 2010/2011. Focal traits will be measured (germination fractions, phenology, plant size and fecundity) for evaluating whether the ten-year selective regime (i.e. continuous climatic change) has led to a change in the frequency of traits in the populations. We will then use our established models (based on simple matrix models adjusted to incorporate variability in trait expression) whether these changes are adaptive, i.e. whether they infer a higher fitness under the imposed climatic conditions.

b) Modeling extinction risks and assocuated changes in diversity: We further propose to make use of phase II data and one large effort of trait screening for evaluating species extinction risk on a community level. These data will serve to create simple models of extinction risk for most component species types, and for improving the models in P3.1.1. The first step is to identify similarity of species to the phase II focal species and the key life history traits that indicate vulnerability to climate change. Seedling survival has been measured for the entire community throughout the past seven years. Seed weight has been measured for approx. 30% of the plant community (Sternberg, in prep), and seed dormancy has been measured for approx. 180 plant species (Sternberg & Tielbörger). Seed production can be inferred from biomass data (7 years) and fecundity-biomass relationships (phase II). The remaining challenge for evaluating extinction risk (resp. adaptation probability) on a community level is a final large screening of the adaptive traits, an evaluation of the genetic variation behind and a test of adaptive capacity by means of existing models. We aim at applying the models of phase II to at least 20% of all component plant species. Data for approx. 40 species from the Israeli and the Jordanian transect has been obtained in phase II. The remaining data will be collected during the first season at all stations by growing genetically defined plants (plants from single mothers collected in phase II) in a greenhouse and measuring the above key traits and their associated within-population variability. This will yield an estimate of genetic variation within populations-the 'raw material' for adaptive change. The data will be used in separate models for each species from each site and each of the climate scenarios for evaluating whether the amount of genetic variation is sufficient to allow adaptation to climate change. Climate change will be simulated by using the entire range of the scenarios produced in P4 with a focus on effects of extreme events on extinction probability. By analyzing sensitivities of the (approx. 100) models (species), we will be able to identify a few easy-to-measure key traits (indicators) that may explain a large amount in variation in vulnerability of the species to climate change. Our preliminary results from phase II have indicated that seed size- which has been measured for approx. 50% of all component species- may be one such easy-to-measure trait which is correlated with variation in climate-driven traits. These traits will be determined in the last season for a maximum number of species possible (we aim at approx. 500 plant species. A list of indicators (species and species traits) for climate change and overgrazing, and suggestions for a monitoring program will be delivered to the relevant stakeholders (e.g. RSCN, SPNI, Ministries of Environment, Ministries of Agriculture, various NGOs) via the scenario exercise and regular meetings.

Integrated data analyses: The soil and vegetation data collected at the four plus four sites with different climate and manipulations will be analyzed in an integrated manner (e.g. as in Holzapfel et al. 2006). Here, vegetation response at various organizational levels to climate and grazing will be related to soil properties and hydrology. Two sets of data will be analyzed integratively: the overall data from the two gradients (focus on land management for managing climate change and resistance of systems to climatic drivers vs. land use, by KT) and from the transect in Israel (focus on challenge of bioclimatic approach via integrated assessment, by MS and KT). The data obtained from the two climatic gradients will also be used for evaluating the generality of the findings about plant strategies (adaptation probability), community structure and productivity with respect to effects of climate, weather and grazing regime (KT). The major outcome of these integrated analyses are a series of scientific and applied manuscripts as well as fact sheets for stakeholders which are co-authored by the scientists of P3 and associated subprojects (see working titles of manuscripts).

Establishment of LTER (MS, JK): A fist step will be to evaluate the minimum data that needs to be collected to obtaining meaningful results about ecosystem response to climate change and land use change. One important step in that respect is to identify those variables that are the easiest to measure and that are at the same time most indicative of the system's response (KT, MS, JK). The most likely are climatic data, soil moisture (TDR), annual plant community structure (quadrat counts once a year or seed bank species composition), plant cover per life form, open space cover, and biomass. Further, we will establish routines of data storage and analyses that can be easily applied by technical staff- we aim at two permanent technicians for the continuing data collection and plot maintenance in Israel. Finally, we must make our stations 'fit' to last for several more years by strengthening some of the structures and investing into irrigation systems which can not be stolen or vandalized. Negotiations will be initiated with a recently approved national LTER web in Israel to get additional funds to maintain the stations.

b) Milestones

Task 1

02/2011: Region-wide maps of ecosystem properties under CC and land use scenarios (with P3.1.1)

06/2011: Final monitoring data: community structure, biomass, seed bank

08/2011: Final data about microevolutionary change under cc

Task 2

08/2010: Delivery of calibrating and validating data to P1.2.1, first data ready for models: extinction probability for 200 species, biomass and diversity for P3.1.1

02/2011: Models run for extinction probabilities

02/2011: First maps of biodiversity (with P3.1.1)

06/2011: Follow-up meetings of wrap up conference (with stakeholders)

08/2011: Final data analyses

Task 3

08/2010 Delivery of data on land use effects on ecosystem properties to P3.1.1

02/2011: Green water and biodiversity session in wrap up conference

06/2011: Integrated data analyses, improvement of P3.1.1 models with multi-species data on extinction risks

08/2011: Integrative/ trans-boundary data manuscripts submitted

Task 4

08/2010 Manuscript and fact sheets on indicators of climate change and grazing pressure

02/2011: Integration of stations in global and national LTER network

06/2011: Country- specific stakeholder workshops for disseminating P3.1 results

08/2011: Final reports and products (e.g. indicators, maps, fact sheets) for stakeholders, final manuscript submission

3.1.3: ANIMAL BIODIVERSITY

Israel: T. Dayan (Tel Aviv University)

Palestinian Authority: M.S. Ali-Shtayeh (Biodiversity and Environmental Research Center, BERC), A. Saleh (Al-Quds University)

Introduction

a) Background

In the past phases we studied patterns of faunal biodiversity along a rainfall gradient and patterns of biodiversity under different land use and land management practices, and have modeled the projected distribution changes of mammals and fruit flies in response to climate change scenarios and how they are expected to be influenced by national planning scenarios.

In phase III we would like to capitalize on the data and modeling performed in phases I and II, fine-tune them and link them with other spatially explicit models produced by other projects. We would like to study how projected changes in climate (climate change scenarios), development (planning scenarios), modeled changes in land use (socio-economic models, LandSHIFT model), and modeled changes in water availability (hence land use practices), are anticipated to affect patterns of biodiversity in the Jordan River Basin in The Palestinian Authority and Israel.

We wish to capitalize on the research performed in phase I (Israeli partner alone) and phase II (Israeli and Palestinian partners) of GLOWA JR as well as other projects the partners are involved in, their respective areas of expertise (biodiversity, ecology, conservation biology, entomology, agriculture, and agricultural pest management), and their connections with stakeholders in their respective states (e.g., Palestinian Ministry of Agriculture, UN Food and Agriculture Organization, Palestinian Environmental Quality Authority, Palestinian Water Authority, Israeli Ministry of Environmental Protection, Israel Nature and Parks Authority, Open Lands Institute, and various Palestinian and Israeli environmental and agricultural NGOs).

Our goal in phase III is to provide expert input into issues that are of importance to stakeholders in our two states, and where the researchers are involved and influential in the decision making process. Moreover, we wish to further integrate our research results with those of other projects (climate change models, ecosystems, socio-economic and agricultural modeling, LandSHIFT model, WEAP, and provide input plausible input into SAS scenarios). Therefore, our data collection in phase III will be limited to missing agro-biodiversity data and we will focus on analyses of existing data (generated by earlier GLOWA JR work as well as data produced in other projects) in cooperation and in light of other ongoing analyses, and to fine-tuning and updating our spatial models. We will focus on integration, including developing integrative input into biodiversity and ecosystem service management policies west to the Jordan River.

b) Key results and key products from phase I and II

Modeling approach: During the past year the present and future distribution of each terrestrial mammal species west to the Jordan River was calculated using the MaxEnt model (a relatively new model which works well for small sample sizes) and the maps of present and two future scenarios were then compared in order to study changes in distribution. Moreover, during the past year this analysis was upscaled to the assemblage level: the species maps were mounted to create a total species map which contains both species number and probability of occurrence for each 1*1 km grid cell. Similarity indices were computed and drawn on a map to show the degree of change between present and two different future scenarios. The direction of change (increase or decrease in species number) was also calculated. Our analyses show that many Mediterranean species will shift their distribution westward especially in the central parts of the country. Some species that require cooler climates will move northward and higher in elevation. Most desert species will increase their distribution northward. Psammophylic species will not change their distribution. At the community level, the similarity maps computed for each future scenario show that the "green" scenario which assumes a full adherence of the Kyoto protocol results in greater similarity to species composition of the present. The business as usual scenario resulted in a much greater change in species composition. In both scenarios two main 'hot' areas were found, with a greater degree of change in species composition. In the Dead Sea basin and the Arava valley number of species is expected to decline and in the western Negev there is an increase in species number. Different groups of species reacted differently (predators differed from herbivores etc.)

Experimental approach: Within Israel we found significant differences in species richness and abundance of all taxonomic groups among the stations. Beetle species richness increased from south to north, while their abundance decreased in the same direction. Lizard abundance increased from north to south while mammal abundance increased in the opposite direction. Cluster analysis of beetle families showed a high similarity between the two central sites. Vertebrates exhibited high similarity in the two northernmost stations. The southernmost station differed greatly from the other sites for all the taxonomic groups. Beetle abundance increased from supplemented rainfall plots to control plots and from control plots to drought treatment plots, conforming to the pattern found between sites.

In the Palestinian rainfall gradient grassland sites, arthropod population levels recorded were lower in the northern Merkeh-Jenin grassland site than those at the southern Tallouza-Fara' grassland site. In the overgrazed grassland sites, arthropod population levels recorded over the study period were similarly lower in the northern Merkeh-Jenin overgrazed grassland site, than those at the southern Tallouza-Fara' overgrazed grassland site. Insect population levels and fluctuation patterns with time were similar to those of total arthropods over the same study period and areas. Fluctuation patterns of ant populations were also similar to the general pattern detected for total insects and arthropods. On the other hand, although showed similar fluctuation patterns, beetle populations levels were higher in the northern study area sites than those in the southern study area sites. Non-insect arthropod (spiders, scorpions, etc.) population levels on the other hand were higher in the northern Merkeh-Jenin study area, than in the southern Tallouza-Fara' study area.

c) Overall goal

Provide comprehensive analysis of the projected effect of different climate change scenarios, under different SAS scenarios, different planning scenarios, and using LandSHIFT.R land use output, on the conservation of species and communities in the Jordan River Basin (and how this biodiversity is expected to interact with agriculture using the olive fruit fly as a test case), and to produce recommendations for stakeholders on the preservation of open landscapes for future conservation.

Deliverables

a) Deliverables for the scenarios

Results of this subproject will provide distribution maps with spatial conservation recommendations for other spatially explicit projects; input regarding crop pest projected distribution into the agricultural projections; input regarding species extinctions risks under different scenarios; recommendations for proactive conservation measures. We will furthermore provide P1.1. with available land planning scenarios for Israel.

b) Deliverables for WEAP

We will provide P1.2. with available land planning scenarios for Israel.

c) Further deliverables for stakeholders

The Jordan River Basin is heavily overpopulated and decision-makers as well as green and social NGOs are heavily involved in developing means for preserving the open landscapes of the region while supporting the social, cultural and economic needs of a growing human population. Because habitat loss, fragmentation and transformation are the key cause for biodiversity loss, conserving the open landscapes of the region is crucial for preserving biodiversity and ecosystem services. In phase III we aim to provide stakeholders with information regarding changes in species distributions and community structure under different climate change scenarios and how these changes interact with different planning scenarios, how to plan for preserving the region's biodiversity, and what are the costs and benefits of different agricultural practices in terms of biodiversity conservation, and thus how different scenarios of changes in agriculture and land use practices are expected to impact biodiversity in this region.

d) Scientific deliverables

Although climatic envelope models have their limitations, they are currently the best available tool to study projected spatial patterns of species and communities in response to climate change scenarios. We will fine tune the distribution maps we developed in phase II using the leading model MaxEnt to predict future changes, and study how different climate change scenarios, different planning scenarios, and different land-use scenarios, all interact to produce changes in biodiversity. Moreover, we will focus on a single crop pest species and study how a crop pest is expected to respond to climate change and in turn is expected to affect agriculture under different climate change scenarios. Thus we plan multi-disciplinary research at the interface between biogeography and community ecology, planning (geography), agriculture, and economics.

Working plan

a) Overview

- Integrative analyses of the effect of different land use and land management practices on patterns on biodiversity and how future changes in agriculture are expected to impact patterns of community structure and composition. Data so far available on arthropods and small mammals in pine plantations under different management practices, grazing, natural shrubland, Mediterranean maquis, and preliminary data on vineyards. In phase III we will produce supplemental data for different agricultural management practices of a major regional crop – olive groves, which will be studied at a gradient of agricultural intensity. These data will provide information on how different land use and land management practices impact patterns of biodiversity, and how future land use patterns are expected to impact biodiversity.

- Based upon climate change scenarios (project 4.1), projected changes in land use scenarios (project 3 and LandSHIFT model), planning scenarios for Israel and The Palestinian Authority (produced by the Israel Planning Authority and the Palestinian Ministry of Agriculture and Ministry of Planning) we would like to analyze the projected distributions of mammals west to the Jordan River under different scenarios. This work was already carried out for climate change scenarios and Israel's National Plan 35, although this work must now be fine-tuned to fit it with other modeling studies; in phase III we will integrate our work with outcomes of spatial models of other projects, modify our predictive time scales to fit in with those of other groups, add the Palestinian planning scenarios, and bolster our database with additional data to be accumulated by Palestinian partners.
- Focus on a single significant crop pest, the olive fruit fly, and analyze projected changes in its distribution in light of climate change scenarios, which may impact agriculture in the region. During phase I we carried out such an analysis based only upon Israeli data and using an earlier class of spatial model. We now wish to capitalize on this phase I adding data from the West Bank and upgrading our modeling work to a new probabilistic model (MaxEnt). Outcomes of this modeling work will be compared with different agricultural land use scenarios to assess future impact of this serious crop pest.

b) Milestones

03/2009: Mammal distribution & community models modified to fit with other groups, some analyses with planning scenarios

09/2009: Projected distribution of fruit flies and its analysis with projected agricultural land use changes

03/2010: Complete analyses of interaction between climate change, land use change and planning scenarios

02/2011: Special biodiversity session in wrap up conference

SUBPROJECT 3.2: ASSESSING THE SOCIOECONOMIC BENEFITS OF ECOLOGICAL SYSTEM SERVICES AND THEIR INTEGRATION INTO MODELS OF OPTIMAL LAND-USE UNDER CLIMATE CHANGE IN THE JORDAN RIVER BASIN

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Israel: A. Fleischer (Hebrew University of Jerusalem), M. Shechter & I. Kan (University of Haifa)

Jordan: A. Salman & E. Karablieh (ATEEC)

Palestinian Authority: T. Hijawi (AAA/PARC)

Introduction

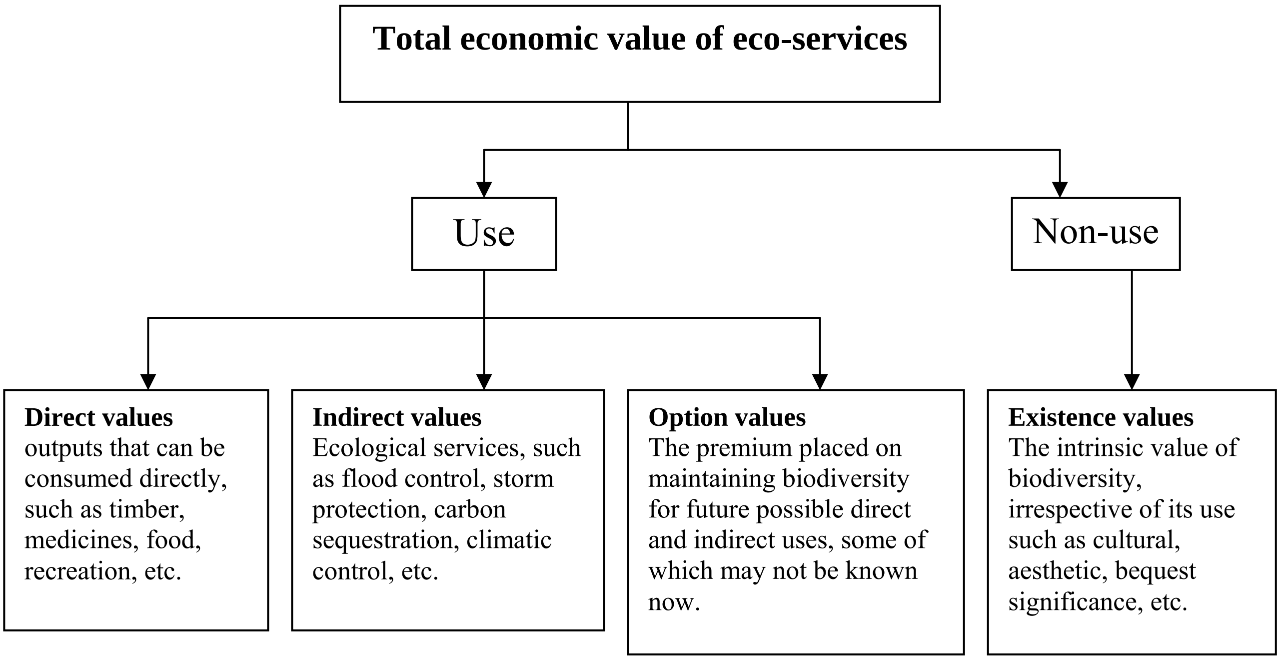
a) Background

Most of the subprojects in GLOWA JR determine the impact of climate change on the natural systems such as water supply, vegetation and on the whole ecosystems. These ecosystems are providers of different services to the local community. The value of these services is not always assessed. The important contribution of this subproject is to translate these changes in the natural ecosystems to their economic value to the local communities that depend on them. This important link will allow the results of the different subprojects in phase I and II to be articulated in the integration programs and to asses their impact on the human population in the region. The numerous eco-services, including those yielding (relatively easily) measurable socioeconomic benefits, such as recreational (use and nonuse) services associated with natural landscapes, but also other, more intrinsic values, such as biodiversity preservation, groundwater protection, gene pool enrichment, and other.

One very important component of ecosystem service provision involves the preservation of biodiversity. Ecosystem ‘goods’ (such as seafood, forage, timber, and many pharmaceutical and industrial products) and services (the conditions and processes of natural ecosystems that support – inter alia – human activity and sustain human life) represent the benefits society derives, directly or indirectly, from the functions of biodiversity.

Biological assets, such as genes, species and ecosystems, have values that are difficult or impossible to measure in market prices. However, if policymakers need to decide upon trade-offs between, say, economic development and biodiversity protection, it is fundamentally important to know what is being traded-off against what. Therefore, in order to make comparisons involving environmental goods and services, it is required to have an idea of the economic value of these environmental assets.

The flora and fauna of the eastern Mediterranean region is highly diverse. One of the main reasons for the diversity of species is the unique climate: cool, wet winters and hot, dry summers, as well as its location at the two major landmasses, Eurasia and Africa. Over recent times, the region has suffered from three main disturbances: over-grazing, fires and cutting down. The total economic value of the ecological services stream can be shown in the following chart (Fig. 3.1).



Direct values
outputs that can be consumed directly, such as timber, medicines, food, recreation, etc.

Indirect values
Ecological services, such as flood control, storm protection, carbon sequestration, climatic control, etc.

Option values
The premium placed on maintaining biodiversity for future possible direct and indirect uses, some of which may not be known now.

Existence values
The intrinsic value of biodiversity, irrespective of its use such as cultural, aesthetic, bequest significance, etc.

Fig. 3.1: Total economic value of the ecological services stream

There are very few studies, if any, which attempt to generate comprehensive measures for such a diverse semi-arid region as the Jordan River Basin, with a level of detail and richness of information.

We will base our values on the results from phase I and II and on other works done in other world region using the commonly used method of benefit transfer. The research outputs of the various socioeconomic modules in phase II, focused on (a) optimal agricultural land and water use in the region (under some climate change and global change scenarios), in Israel, Jordan and The Palestinian Authority, and (b) valuation of recreational benefits associated with open spaces, in Israel only, under climate change scenarios. In order to realize the above extension of the socioeconomic research to cover a wider list of ecosystem services, in all three political entities in the Jordan River Basin, would require a complementary research strategy in order to avoid exorbitant research costs. A possible way out of this dilemma (not ideal, but much cheaper to execute!), is the so-called benefit transfer method. It should facilitate obtaining well-founded and theoretically sound welfare measures of climate change impacts on the natural environment, in addition to agriculture.

A variety of studies have been conducted worldwide yielding published lists of monetary valuations concerning diverse environmental issues (e.g., the Environmental Valuation Reference Inventory (EVRI), which is a database of valuation studies accessible through Internet). The question that has been the focus of attention for researchers and decision makers (and is the core of our study) regards the feasibility of using these valuations for further applications with sufficient accuracy. In other words, the issue is whether preferences estimated from a study site could be transferred to an alternative site, referred as a policy site, to predict the behavior of the residents there (Bateman et al., 2002; Hanley et al., 2006). The process of transferring existing economic valuations of nonmarket environmental goods or impacts (benefit or damage) from one site (study site) to a new different study (policy) site through economic valuation techniques is called the Benefit Transfer (BT) method. In essence, this involves using existing data to make predictions in a new policy subject in a cost-effective way (Boyle and Bergstrom, 1992; Brouwer, 2000; Oglethorpe et al., 2000). The transfer can be conducted between sites in the same country as well as between different countries, although the later raises among others, the issue of the monetary units.

Conducting original valuation research for each specific policy action is usually advisable because of its higher accuracy. However, because valuation of externalities is always difficult and sometimes even not feasible, and because implementation of valuation methods is usually pricey and time-consuming, the benefit transfer method was developed as an alternative way to value externalities, given the challenges inherent in determining their actual cost, enabling the use of welfare estimates from existing studies in the evaluation of new policies. The use of BT as an alternative valuation method has some advantages. From a practical perspective BT has the advantage of reducing both time and financial resources that are needed to develop separate evaluations for each individual policy decision. From a methodological viewpoint, BT may provide a degree of consistency in decision-making through the use of common parameters across studies (Johnson and Button, 1997; EC, 2000).

Despite its potential drawbacks involving a risk of biased estimates, BT is now generally accepted as an appropriate method for valuation, particularly when the degree of accuracy does not have to be high, as in cases of initial screening of projects, establishing limits within which parameters may lie, and when a large number of relatively standard but linked policy issues are being addressed (EC, 2000). Oglethorpe et al. (2000) add that the marginal savings by not carrying out surveys at all may be relatively greater than the marginal increase in error created through BT. Certain strict conditions and criteria have to be met, however, for a valid BT process. First of all, the quality of the potential study-site values is critical to the quality of BT because if original-study results are questionable in terms of validity and reliability, their use in new policy contexts will only result in more controversy (Boyle and Bergstrom, 1992; Brouwer, 2000). The original values must be examined to determine whether they are sound and adequate for transfer in terms of data collection procedures, statistical methods, and the nonmarket valuation application itself. Then, transferability needs to be evaluated for both study and policy sites, using objective criteria and checking for equality or at least great similarity at both the study and policy sites, regarding the environmental attribute valued, population affected, and site characteristics (ODPM, 2002; Boyle and Bergstrom, 1992). Note that although the BT method is based on a strong hypothesis that the study site and the policy site are perfect substitutes, practically, “sufficiently similar” sites are acceptable (Rozan, 2004).

Three broad approaches are in use for BT: transferring mean unit values, transferring benefit functions, and transferring meta-analysis functions. We recommend that the second approach be employed in the present study, for transferring ecological system values between the political entities, given that all three occupy similar ecological regions in the Jordan Basin.

b) Key results and key products from phase I and II

In phase I and II we evaluated the monetary value of the utility the local population accrue from the landscape of grazing land (Fleischer and Sternberg, 2006) and different agricultural crops such as field crops, orchards, flowers and vegetables. We also obtained the profits farmers generate from growing different field crops and live stock (Fleischer, A., Lichtamn, E. and Mendelsohn, R. [forthcoming]). These values will be used in evaluating the economic value of some of the ecosystem services. These values will have to be adjusted to the different countries according to given socio-economic indicators.

c) Overall goals

To generate monetary estimates of the benefits of ecosystem services associated with natural and open space land-uses in the Jordan Basin, and how they will be impacted by climate (and global) change.

To assess and value the unique characteristics of the region in terms of ecosystem service provision, treating them in terms of a portfolio of the various ecological characteristics, and incorporate them into an over-all economic valuation model of land use changes associated with climate change impacts.

Deliverables

a) Deliverables for the scenarios

An important economic indicator reflecting the impact of changes in natural systems on the society is the total level of welfare in the economy. Total level of welfare is the sum of producers surplus (in simple words these are the profits producers generate, in our case these are the farmers' profits) and consumers surplus (this is what measure the utility the local population elicit from the natural systems). This important indicator is used in the economics of natural resources literature as a measurement of the impact of changes in the quality of the natural resource on the economy. This indicator should become an important output of the different scenarios translating the changes occurring in the natural systems to monetary value in the local economy. We will supply the values of the welfare level under the different scenarios indicating the impact of the changes on the local human community. We will furthermore provide P1.1.with available demographic and economic scenarios, information of international food trade and available planning scenarios.

b) Deliverables for WEAP

The main deliverable to WEAP is indirectly via 'water productivity' estimates based on water demand of ecosystems and their associated value.

c) Deliverables for other projects and subprojects

We will deliver to subproject 3.1.1 a layer of information responding to the simulated vegetation maps. The result will be another map only with economic value complimenting the map delineating the vegetation distribution in the region. We expect the interface with this subproject to be the most active one since we will receive the information from them concerning the ecosystem translate it into economic value. Once the economic value of the welfare level will be produced by us we will return them to subproject 3.1.1 and they will produce the additional layer of maps with economic values.

LandSHIFT: Values for the different ecosystems to be used in their land use models.

d) Further deliverables for stakeholders

The deliverables to stakeholders will be the welfare level, similar to the scenarios. An additional deliverable will be the maps produced by subproject 3.1.1 based on our value which will demonstrate in a visual and condensed form the economic impact of climate change to the local community.

e) Scientific deliverables

We see potential for highly innovative and novel scientific papers based only on the integration of the information collected by the natural science based subprojects (P3.1) and us providing a social science based analysis. In studies dealing with global climate change (GCC) issues, a division between the life and social sciences is commonly found. Life scientists emphasize the forecasting of different future climate change scenarios or the resulting changes on ecosystems and their functioning. On the other hand, the economic impact of GCC on the human community is generally dealt with by social scientists. In their analyses, the life science aspects (e.g. change in plant biomass production, biomass loss) are either assumed or taken as a given from other works. In this study of the region we will integrate findings from both life science and economic analyses.

Input from other projects

a) Scenarios

Level of income, population and economic development under the four scenarios are indicators necessary to adjust the values obtained by benefit transfer method to our region.

b) Other projects

We have to receive early in phase III from sub project 3.1.1 maps showing the projected vegetation productivity (economic value), composition (aesthetic value), and biodiversity (aesthetic value) and landscape vulnerability (economic value) as ecosystem services. We would also need maps of floristic diversity for integration in measures of overall biodiversity.

Working plan

a) Overview

(1) The first step will consist of identifying plant species that are representative of the different habitats common in the region. Their distribution under different scenarios will be obtained from subproject 3.1.1 (also from previous phase).

(2) For the selected species, we aim to determine the relevant characteristics that relate to the various eco-services which they are purported to provide. The determination of characteristics will primarily be based on existing ecological knowledge about the nature of the eastern Mediterranean habitats. The characteristics are supposed to cover a broad spectrum, relating to the following services:

Forests: The lexicographic definition of forest is “a large area covered with trees and undergrowth”. This definition is rather general and quite banal and does not mention the ecological and economic importance of forests. For example, forests play a role in recycling the earth’s water, carbon, and oxygen, as well as producing other important substances. They also provide habitats for animal and plant species and contribute to the resilience and stability of ecosystems. In addition to these ecological attributes, forests also have an economic importance, for example as fuel and as wood for construction and the manufacture of paper. Moreover, forest can be used for a wide range of recreational purposes, including walking, camping and bike riding. The value of forests consists of two main elements. The first element relates to the commercial value, while the second element contains amenity values. Mentioned that the commercial value is based on cutting trees for dilution and not clear-cutting of the trees. Amenities values can be defined as the natural and physical qualities of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes. Here, these values include environmental and recreational values. The total value of forests (q_1) is the sum of the net present value of the timber ($NPV(V_t)$) and the amenities values (V_f).

Pasture: Pasture can be defined as use of land for grazing livestock; it is a form of food production. The main essence of this characteristic is the use of land as a substitute for artificial food. In other words, the pasturing of grazing livestock implies that the herds consume trees and other woody vegetation instead of artificial food. As such, herd owners who pasture their animals require less artificial food than those who decide not to pasture their livestock. Good pasture allows efficient management of open spaces, lowers the risks of fire, enlarges the biodiversity in nature habitats and preserves the open space landscape. The Israeli government acknowledges the importance of the qualities and stimulates the pasture of herds in the Mount Carmel area. To this end, the government provides indirect financial support to herd owners in the form of land, food and other facilities. The value of pasture is the marginal saving in costs. This expenditure reduction reflects the saving in money of the herd owners.

Medical uses: Throughout history, mankind has used a large variety of plants as medicines. Nowadays, the demand for medical plants from the pharmaceutical industry is growing. Medical plants have a market price, which is established in a stock exchange of medical plants. In this stock exchange market, there is an international trade of medical plants and herbs. For the value of medical plants, we may employ the price of medical plants as set by that stock market.

Agricultural gene reservoir: Agriculture as a human effort is actually a long-term bet. We do not possess full foresight that would inform us which of the species will have the highest importance in the future. An extinction of species may cause an irreversible damage and loss of information to the reservoir of genes. Therefore the real value of this characteristic is tantamount to the value of gene diversity. Since there are no known applied methodologies to calculate the value of genes diversity, we suggest using the proxy market of cultivated seeds, which probably reflects a lower value.

Landscape and recreational values: Here (to the extent that these services are not already taken into account under 'forests'), common and often used environmental valuation methods (direct, such as CVM, or indirect, such as Travel Costs) for eliciting WTP, can be employed.

Pharmaceutical products: Biodiversity is a source of new industrial pharmaceutical products. Wild species in their struggle to capture prey, escape predators, resist infection, and enhance reproductive success have evolved chemical mechanisms more elaborate and inventive than chemists can presently synthesize. If these chemical mechanisms could be adapted and refined for human use, they could be of great value. Following this example, we propose to base the value of this characteristic on the Dixit-Stiglitz model suggested by Craft and Simpson (2001).

Endemism and rarity: Endemic species is species that commonly found in a specified area. It is hard to transfer an endemic species to other reserve or park since there is a species competition, genetic adjustment problems, discrepancy to the area and etc. therefore an extinction threat is severe and real. Rich geographic areas with endemic species are termed "hotspots". Identification of the hotspots means that areas with large variety of endemic species, with an extinction threat, may be identified. Rare species in a natural park or reserve do not imply that the species are non-renewable. A rare species in a reserve can be widespread in another area. A rare species may be facing a threat of irreversible loss, since its population is relatively small. Some of the species are naturally rare and some of them are exogenously rare (e.g. human actions may damage the species). Part of rare species may be endemic species, that an irreversible damage will extinct them forever. Rare species have existence value, which reflects the moral value of the society. Once a species is extinct than we loss all the genetic information embodied in the species. Since it is difficult to extract the non-use value (NUV) of endemic species from a WTP study, especially when it refers to non-charismatic species, we must assign an arbitrary value to the fraction of a NUV attributable to this characteristic of an ecosystem service.

Other services: Preventing and preserving erosion, other soil quality related services.

Note that some characteristics, e.g., endemism and rarity, and agricultural gene reservoir, may be viewed as depletable services, while others are renewable.

(3) Next, economic models will be used to valuate each characteristic. Economic valuation of the selected ecological characteristics will be carried out using a variety of appropriate economic methods. We plan to focus mainly on the flora rather than the fauna of the area, partly because of convenience and partly because vegetation types may indicate where particular animal species occur.

(4) The 4th step will involve valuing the selected species by assessing, for each species, the relative importance (weight) of the various characteristics making up it service streams.

(5) In the 5th step, the economic value of the prototype natural habitats, made up of groups of species, as determined by the ecologists, will calculated. Thus, the total value of habitat h=1...l, TV_h is the sum of the total value of species i=1...m, TV_i times the relative abundance α_{ih} of the species in the plot and parameter β which represent the (hypothesized) ecological relationships of the ecosystems. These values will form the basis for land-use allocation decisions over the entire region. The sum of species' values reflects (at least) part of the value of a habitat. Of course, we should also aim to assess the complexity, resilience and stability of the ecosystem; although we admit that here we might face insurmountable methodological difficulties at this stage of our knowledge. Next, the total value of an area is the sum total of the value of all species in that area and other values of the ecological relationships in and with the ecosystem.

b) Milestones

Task 1

12/2008: Defining and identifying the ecosystems that can be evaluated in the region

02/2011: Special session wrap-up conference: water productivity in nature

08/2011: Final publications

Task 2

12/2008: Using data from phase I and II and economic models evaluation of the different attributes of ecosystems will be produced

02/2011: Special session wrap-up conference: land use scenarios

08/2011: Final dissemination, fact sheets

Task 3

08/2010: Provide values of ecosystems services to be used in the maps produced by 3.1.1 and LandSHIFT. Provide welfare levels to SAS scenarios

SUBPROJECT 3.3: INTEGRATED MODELING OF LAND-USE CHANGE AND ENVIRONMENTAL IMPACTS

Germany: R. Schaldach & J. Koch (University of Kassel)

Israel: M. Shechter & I. Kan (University of Haifa), A. Fleischer (Hebrew University of Jerusalem)

Jordan: A. Salman & E. Karablieh (ATEEC)

Palestinian Authority: T. Hijawi (AAA/PARC)

Introduction

a) Background

Land-use change is one of the most important processes to understand and model environmental change (Foley et al., 2005). The conversion of natural land to settlement and agriculture has been identified as key factor in changing of green water fluxes (Röckstrom, 1999), and in the endangerment of biological diversity (Sala et al. 2000). The relation between human land use activities and the environmental change can be described as a coupled human-environment systems with socio-economic as well as ecological and biophysical components as sub-systems (GLP 2005).

For better understanding of these processes and their relations to natural resources of the GLOWA JR region, subproject 3.3 aims to model and simulate land use changes and, in cooperation with other GLOWA JR subprojects, their effects on the regional water demand and ecosystem services. For this purpose, the spatially explicit integrated land use model LandSHIFT will be soft-coupled to existing economic models of the region (for example Kan et al. 2007a) and used to compute land use scenarios. A detailed description of the model is given by Alcamo and Schaldach (2006) and Schaldach et al. (2006). The model combines both human and environmental aspects of the land system and simulates the spatial-temporal dynamics of land use activities like settlement, livestock grazing as well as rainfed and irrigation agriculture. The rationale of the model is to downscale the regional or country-level demands for area intensive commodities and services to a spatial grid. Central elements are algorithms for suitability analysis and demand allocation. While suitability is determined by methods from the field of multi-criteria analysis, demand allocation is by simulating competition of the different land use activities for the best suited grid cells in order to fulfill the given demands. Competition is modeled in two steps. First, a hierarchy of land use activities is specified. For example, land is allocated to new settlement area before new cropland. The second step is to allocate land within a particular land use activity. For instance, the allocation of different crop types on arable land is done by a modified version of the Multi Objective Land Allocation algorithm originally developed for the field of regional planning (Eastman 1995). The resulting GIS maps will be used to visualize the effects of decision making on changes of the land use pattern and to communicate the scenario outcomes to the stakeholders involved in the scenario building process. Moreover, the land use scenarios form the link between human decision making processes and its consequences for changes in ecosystem service values and the regional water balance.

b) Key results and key products from phase II

The central activity in phase II was the adaptation of the global version of the LandSHIFT model (Alcamo and Schaldach 2006; Schaldach et al. 2006) to the project region. For this purpose, the spatial resolution has been changed from five arc minutes to one square kilometer and a database containing biophysical and geographical information needed by the model for resource allocation has been constructed. Moreover, the model algorithms have been adapted to the regional conditions (Koch and Schaldach 2006).

As the basis of scenario calculations, a database has been set up, containing the driving forces for the four scenarios given by the SAS team. Moreover, the model has been adjusted to enable the integration of land use information from other GLOWA JR subprojects into the calculations (SP2 – Production values for fruits, vegetables and cereals, SP9a – carrying capacity and biomass production of semi-natural vegetation (Köchy and Jeltsch 2007)).

A map of base year land use and land cover has been generated and simulation runs for the four region-specific scenarios up to the year 2050 were carried out. Additionally, land use related indicators, e.g. cropland expansion and stocking rates were calculated.

Furthermore an assessment of climate change impacts on representative field crops in Israeli agriculture has been conducted (Haim et al. in press). The results will help to further improve and test the yield simulations by the LandSHIFT model.

c) Overall goal

There are four main objectives of this subproject.

1) Building of comprehensive land use scenarios

The first objective is to compute integrated land use scenarios as basis for an assessment of the impacts on ecosystem services and water demands by the major land use activities as listed in Tab. 3.5. Two major tools will be used for the analysis. First, the economic models developed in phase II of the project. In phase III these models will be applied to analyze the impacts of changing climate and water availability on agricultural production on the regional level. As a major step forward, the VALUE model (Vegetative Agricultural Land Use Economic Model) will also consider aspects of eco-tourism-based landscape values in its calculations (Kan et al. 2007b). The output of this analysis will then serve as input to the LandSHIFT model that computes spatial explicit land-use maps. LandSHIFT will be improved to distinguish between irrigated and rainfed agriculture with emphasis on irrigation with effluent water and the corresponding risk for soil degradation. Also the effect of climate change on crop yields will be taken into account in greater level of detail by using the climate scenarios developed in phase II.

2) Computation of development potential for agriculture

Here, we use LandSHIFT to calculate maps of the maximum spatial extent of irrigated and rainfed agriculture as well as the use of treated wastewater in irrigated agriculture (P3.4) for the different scenarios in order to assess shifts in the development potential for these land use activities up to 2050. For grazing and other ecosystem services, comparable maps will be provided by subproject 3.1.

3) Assessment of water demands and ecosystem services

Third goal is to provide model results (GIS maps) as input for the assessment of land use change effects of ecosystem services and water demands for the scenarios and the potential maps. Ecosystem services are covered by subprojects 3.1 and 3.2 while green water fluxes and water demand by irrigation are calculated by subproject 4.2 and 4.3. Within subproject 3.3 additional environmental impacts that are important for the scenario analysis are evaluated:

- Grazing and its feedbacks to vegetation degradation for the different scenarios (with 3.1, Martin Köchy & Rüdiger Prasse).
- Climate change impacts on crop yields (in close collaboration with Pedro Berliner, 3.4).
- Water demands by livestock (drinking water) and settlement.
- Impact of changing land use pattern on regional values of ecosystem services (see work packages for more detailed explanation).

4) Communication of spatial land use dynamics and its impacts on water demand and ecosystem services to the scenario building process

The fourth objective is to use LandSHIFT as a means to communicate the spatial simulation results regarding the dynamics of land use change and its effects on water and ecosystem services to the stakeholders that are involved in the scenario exercise. The aim is to support the comparison and evaluation of the scenario outcomes as well as the development of strategies for a more sustainable use of land and water resources.

Tab. 3.5: Major land activities, related ecosystem services and associated “type of water”.

Land use activity	**Type of water**	**Ecosystem service**
Livestock grazing	Blue water, green water	Meat production
Multifunctional use of undeveloped land	Green water	Eco-tourism, biodiversity, recreation, soil conservation, water recycling etc. + Meat production
Protect undeveloped land	Green water	Eco-tourism, biodiversity, recreation
Rainfed farming	Green water	Agricultural production & biodiversity
Irrigation farming	Green water Blue water Treated wastewater Rainwater harvesting (P4)	Agricultural production
Adapted agricultural management (e.g. reduced soil compaction)	Blue water (Groundwater)	Soil conservation + Water for domestic and industrial use

Deliverables

a) Deliverables for the scenarios

- Maps of land use change (e.g. grazing dynamics, open space and expansion of cropland) and water requirements (amounts) for livestock and settlements to support the development of strategies for sustainable water use and land management.

- Maps of impacts of land use change on ecosystem services (see project 3.2).
- Via TRAIN-ZIN: The spatial representations of land use effects on water supply for the four different scenarios.

b) Deliverables for other projects and subprojects

Spatially explicit land use and land cover maps in 1 km resolution serve as input for

- The coupled TRAIN-ZIN model: run-off calculations (settlement area), soil infiltration (e.g. grazing) as well as green and blue water fluxes (vegetation cover and water use by irrigation).
- The calculation of ecosystem service values as done in 3.2
- The faunal-biodiversity models to assess impacts of changing land use pattern on animal biodiversity.
- The GLOWA JR central GIS (P1.3)

c) Further deliverables for stakeholders

d) Scientific deliverables

- Improved land use scenarios computed by LandSHIFT. These will be based on new calculations of the socio-economy models for the water and open space related scenarios of phase III and include a more detailed representation of rainfed and irrigated cropland. Furthermore climate change impacts on crop yields and grassland NPP is covered based on the climate change scenarios developed in phase II.
- Maps of the development potential for rainfed and irrigated cropland under four scenarios.
- Maps of water demands by settlements and livestock.

Working plan

a) Description of the work

1) Development of comprehensive integrated land use scenarios

- New calculations by the socio-economic models, considering scenario drivers of water availability and climate change (if not already covered by 3.2) and integration of the results (amounts of crop production under rainfed and irrigated agriculture) as model drivers into the LandSHIFT database (by MS, AF, IK, AS, EK, TH).
- Development of a more detailed initial map of crop distribution around the year 2000.
- Calculation of spatially explicit crop yield maps under climate change conditions.
- Refinement of the LandSHIFT routines for spatial suitability analysis which currently focus on geographic and biophysical factors. Here new economic oriented factors like distance functions and marginal revenue are integrated as well as data on existing national planning constraints (e.g. conservation area, preference areas for different land use types).

- Refinement of the agricultural module of LandSHIFT to distinguish between rainfed and irrigation agriculture.
- Development of a new module for LandSHIFT that spatially allocates new areas for eco-tourism (or comparable activities) based on the ecosystem value maps, the scenario storylines and corresponding outcome from the economic models as well as existing planning preferences.
- Development of a more detailed representation of the grazing dynamics and livestock management in corresponding LandSHIFT module (together with P3.1.1).
- Calculation of land use scenarios based on the newly developed phase III scenario drivers and the outcome of the socio-economy models for agricultural production under rainfed and irrigated conditions, associated with the availability of various water sources (natural freshwater, desalinated, treated wastewater and brackish water) and institutional arrangements.

2) Computation of development potential for agriculture

- The new routines for suitability analysis are applied to identify the maximum spatial extent of irrigated (including irrigation with TWW, P3.4) and rainfed cropland under the climate and economic scenario conditions. As input for the scenario exercise this data will be merged with similar data for open space and rangeland that will be provided by subproject 3.1.

3) Assessment of water demands and ecosystem services

- Adaptation of program routines from a hydrological water-use model to calculate water demands for livestock and settlement areas in dependence of scenario assumptions about climate change and development of societal welfare (GDP).
- Calculation of spatial maps of water demands for these land use activities for the new land use scenarios and the potential maps developed in step 2.
- Compilation of water demand maps from subproject 3.1 and subproject 4, as well as maps of ecosystem service values from subprojects 3.1 und 3.2. These maps are stored in a common GIS format in order to support visualization and communication to stakeholders.
- Use LandSHIFT for and analysis of changes in ecosystem values (on grid level and aggregated for regions) due to land use changes under the different scenario conditions. Here, we can also investigate the effects on land use pattern when ecosystem values are considered in the suitability assessment routines of the model. This work is based on outcome from 3.1 and 3.2.

4) Communication of spatial land use dynamics and its impacts on water demand and ecosystem services to the scenario building process.

- This includes the development of a GIS database with model results for data such as water demand, crop yields and ecosystem services as computed by different subprojects. The focus lies on the visualization of the model dynamics for the scenarios and the resulting effects on water demands and ecosystem services as well as on communicating the development potentials to the Stakeholders in the scenario process. This work will be conducted in collaboration with the University of Tübingen (GIS database from phase II).

Tab. 3.6: Schedule for subproject 3.3

	Month 1 - 12												**Month 13 - 24**												**Month 25 – 36**											
WP 1 **Prepare new runs of socio-economic models**	▨	▨	▨	▨	▨	▨	▨	▨						▨	▨	▨																				
WP 2.1 **Synthesis of crop distribution map 2000 (3.4)**	▨	▨	▨	▨										▨	▨	▨																				
WP 2.2 **Calculation and test of crop yields under CC (3.4)**	▨	▨	▨	▨	▨	▨	▨	▨						▨	▨	▨																				
WP 3 **Integration of tww irrigation maps (3.4)**	▨	▨	▨	▨	▨	▨	▨	▨						▨	▨	▨																				
WP 4 **Implementation of LandSHIFT modules**	▨	▨	▨	▨	▨	▨	▨	▨						▨	▨	▨																				
WP 5 **Integration of input from 3.1.2 and 3.1.3**									▨								▨					▨	▨	▨	▨	▨	▨	▨								
WP 6.1 **Simulation of new storylines**									▨	▨	▨	▨					▨	▨	▨	▨		▨	▨	▨	▨	▨	▨									
WP 6.2 **Calculation of water balance (4.1)**											▨	▨												▨	▨	▨	▨									
WP 6.3 **Calculation of ecosystem services (3.1, 3.2)**											▨	▨												▨	▨	▨	▨									
WP 6.4 **Calculation of animal biodiversity (3.1.3)**											▨	▨												▨	▨	▨	▨									
WP 7 **Synthesis of Stakeholder meetings**				▨									▨								▨															
WP 8 **Synthesis of final report and wrap up**																	▨	▨										▨	▨	▨	▨	▨	▨	▨	▨	▨

b) Schedule annotation

- Assumptions about Stakeholder meetings: Month 2, 1, 20
- WP2 comprises collaborative work with Pedro Berliner and Bernd Marschner (subproject 3.4).
- WP6 includes every detail needed for producing new results for the stakeholder meetings (these tasks may overlap with the preparation and implementation tasks).
- This task also includes coordination with other subprojects that further process our results.
- Input links to 3.1 are specified as 1 month coordination tasks.

SUBPROJECT 3.4: ENHANCING WATER PRODUCTIVITY IN AGRICULTURE

Germany: B. Marschner (Ruhr-University Bochum)

Israel: P. Berliner (Ben Gurion-University), Y. Chen (Hebrew University of Jerusalem), U. Mingelgrin (ARO Volcani Center)

Jordan: F. Ziadat (ATEEC)

Palestinian Authority: M. Almasri (An-Najah University)

The main goal of this subproject is to consolidate data from phase II about water productivity in agriculture and to fill some crucial gaps in the available data. A focus will be on the systematic evaluation of means to enhance water productivity in agriculture (e.g. by mulching, P3.4.1) or to use 'New Water' sources in irrigated agriculture (focus on treated wastewater, P3.4.2). The main outputs of this project are maps of suitability for different agricultural practices which will be used directly in LandSHIFT for modeling optimal land allocation. Since this subproject provides data for LandSHIFT, the major workload will be in the very beginning of phase III.

3.4.1: WATER PRODUCTIVITY IN AGRICULTURE

Israel: P. Berliner (Ben Gurion-University)

Introduction

a) Background

The reduction in water availability for agriculture as a result of a range of global change drivers, in particular climate change and population increase will affect the various groups living in the Jordan basin in different ways. The outputs of GCM's indicate that there will be a reduction in the total amount of rain and an increase of extreme events in the Upper Jordan Valley (Alpert et al. 2007). Both aspects will negatively affect agricultural activities by decreasing the amount of water availability for agriculture. Prolonged drought periods between rainfalls may lead to crop failure even though the rainfalls that "clamp" the dry period may be high. Irrespective of the precipitation regime, water absorbed by the soil can evaporate directly to the atmosphere through the soil surface. This fraction of the rainfall, which is non-productive in terms of crop production, will increase if potential evaporation rates increase due to the expected temperature increases.

It is clear from the above that the impact of rainfall and other climate parameters on agricultural productivity cannot be properly assessed by simply analyzing monthly or annual rainfall data and that it is of great importance to analyze the sequence and distribution of precipitation events. The latter was the key ingredient of the models we tested and verified during phase II (project 11).

During phase II (project 11) we dealt with only two crops, wheat and cotton, which were selected because they typify winter rainfed and summer irrigated crops, respectively. There are however additional crops and various types of fruit orchards grown in the region.

In view of the limitations described above and in order to supply to the integrating models (LandSHIFT and WEAP) data that will allow the proper assessment of future climate scenarios on the regional water budget we intend to:

- **Determine the main crops/orchards grown in the JRB.** We will carry out a quick survey (internet or telephone) in order to obtain the necessary information from the various regional councils. This data is readily available and it may be even possible that within each or some of these regional councils the spatial distribution of these crops will be available. This would enable us to immediately determine the main crop/orchard-soil combinations.
- **Adapt the wheat model** to describe the main features of the responses to water shortage of other main crops and orchards within the Jordan basin. The approach of the aforementioned model being the parameterization of the water stress for the various phenological periods, aggregating them into a seasonal stress index and empirically relating the latter to yield (Hanks, 1974; Hanks and Rasmussen, 1982). Yield data for the crops and orchards that will be selected will be obtained from the literature (Shalhevet and Bielorai, 1978), from the yearly reports of the regional Councils and in the case of afforestation use the parameterization derived for the Yatir Forest.
- **Evaluate the effectiveness of mulching** the bare soil in between the rows of crops or orchards in order to increase the water availability to the crops. This evaluation will be carried out using the various models described earlier.

b) Key results and key products from phase I and II

- Mulching the intercrop row with polyethylene sheet decreased evaporation and increased the gross water use efficiency of irrigated cotton and dryland wheat.
- Field verified wheat model.
- Field verified cotton simulation model.
- Simulation model that describes the effect of mulching on mass and energy (water and heat) fluxes in the soil (by the end of phase II).
- Coarse distribution of expected yields for wheat and cotton for future climate scenarios for the various soil classes in the upper-western Jordan valley.
- Water balances of clearings and afforested areas in the Yatir region.
- Analysis of the economic impacts of climate change on Israeli agriculture (with Socio-economics group).

c) Overall goal

Adapt the tested semi-empirical models for the set of crops/orchards/forests that cover the largest part of the JRB. Run the models for the most frequent soils for a variety of soil depths for the various future scenarios (after corrections) and compute the averages and the corresponding statistics for each of the combinations. The mosaic of results will be supplied to LandSHIFT and/or WEAP.

Deliverables

a) Deliverables for WEAP

Yield distribution and effects on water demand (via TRAIN-ZIN) for the main types of rainfed crops/orchards-soil combinations within the Jordan River basin, using the available climate data generated by the GCM's.

b) Deliverables for other projects and subprojects

Estimates of the expected yield decreases of the selected crops/orchards in the JRB and an assessment of the effectiveness of mulching with polyethylene as a possible means to counteract this trend (to the socio economic group in order to assess economic feasibility).

Internal drainage patterns for the various crop/soil combinations (P4.2).

c) Further deliverables for stakeholders

Estimates of the expected yield decreases of the selected crops/orchards in the JRB and an assessment of the effectiveness of mulching with polyethylene as a possible means to counteract this trend (after the S-E assessment and if it is economically feasible).

d) Scientific deliverables

Expected changes of moisture fluxes into the atmosphere from the JRB as a result of climate change (with the Climate group)

Changes in internal drainage patterns in the JRB as a result of climate change (with the Hydrology group).

Working plan

a) Overview

In order to properly determine the best suited agricultural crop-types under the changing climatological properties in the future scenarios, the following information is required:

1) The spatial distribution of the now existing rainfed/ irrigated crop types in order to determine the main crop/orchard-soil combinations.
2) Apply the evapotranspiration and yield model to crop/orchard – soil combinations found in 1), in order to obtain the future yield distribution for the various scenarios.
3) Apply the evapotranspiration and yield model to crop/orchard – soil combinations found in 1), introducing the changes that result from mulching.

b) Milestones

2008-2009: Determination of the main crop/ orchard distribution in the Jordan basin and calibration of the additional models.

2009-2010: Map the future yields of the main agricultural types within the Jordan River basin under the different climate scenarios and the changes due to the introduction of polyethylene mulching.

3.4.2: REGIONAL BASED LAND EVALUATION FOR EFFLUENT REUSE

Germany: B. Marschner (Ruhr-University Bochum)

Israel: Y. Chen (Hebrew University of Jerusalem), U. Mingelgrin (Volcani Center)

Jordan: F. Ziadat, (ATEEC)

Palestinian Authority: M. Almasri (An-Najah National University)

Introduction

a) Background

For this final stage, phase III will build strongly on results from the two previous phases with the central goal being scientific integration, synthesis and translation of results for application. As an outcome of the last phase, the soil suitability map for wastewater irrigation will provide a risk assessment on a relatively coarse scale (1:250 000). The applicability of this map for specific land use planning and effluent allocation will be limited due to the scale. Therefore, a detailed land evaluation for effluent reuse with focus on the regional agricultural areas will be a useful completion in phase III. This project will also contribute to project 2 (wastewater evaluation). New water sources as reclaimed wastewater for reuse in agriculture are an important issue in the overall goal of GLOWA JR.

b) Key results and key products from phase I and II

Treated wastewater (TWW) reuse for irrigation purposes can have detrimental effects on the physical, chemical and biological soil properties (Feigin et al. 1991; Jüschke et al. 2004; Jüschke and Marschner 2006; Jüschke 2007; Tarchitzky et al. 2007). As a key result of project 8 (phase II; wastewater) and from phase I effects on e.g. soil organic carbon, soil structure, soil hydraulic conductivity and hydrophobicity were determined. By the end of phase II relevant parameters (e.g. soil structure) will be assessed and compiled in a risk analysis based on a soil suitability map for Israel, the Westbank and the Jordan Valley (1:250 000). This will be the key product of phase II. Therefore, this map will be more generalized, but can be used for integration into the LandSHIFT model. For local application as a decision support this map needs to be refined with focus on the actual land use and crop suitability. This needs to be in a larger scale (i.e. 1:50 000).

Geographically explicit information on available wastewater resources and qualities also was set as a deliverable outcome of phase II. Due to difficulties in data accessibility this needs to be followed in phase III.

c) Overall goal

In this work package the information compiled in phase I and II will be integrated into the LandSHIFT model through close collaboration with subproject 3.3. Furthermore, the GIS based results will be made available for regional decision makers or farmers at a local scale. The soil suitability map and the risk analysis for TWW irrigation are the basis of detailed information for decision support, which will provide an applicable resolution of the gathered data. The recommendations for land use options regarding TWW irrigation will need to be developed in close cooperation with the regional and local stakeholders, such as water authorities, agricultural extension service and farmer associations.

Deliverables

a) Deliverables for the scenarios

Region-wide, spatially-explicit, quantitative information about the potential of certain areas for TWW application at a relevant scale will be delivered for the scenarios.

b) Deliverables for WEAP

Region-wide, spatially-explicit, quantitative information about the potential of certain areas for TWW application at a relevant scale will be delivered for WEAP. Detailed information of available TWW sources will contribute to WEAP with the background of regional applicability in agriculture.

c) Deliverables for other projects and subprojects

The suitability maps generated in this subproject will deliver information to LandSHIFT for evaluating optimal land allocation under different scenarios. Data will be prepared for direct use in LandSHIFT and for the GLOWA JR GIS (project 1.3).

d) Further deliverables for stakeholders

The product from this work package will be the spatial information based on a GIS which can be directly used by the stakeholders for land use planning. This system supports local stakeholders in their decision processes related to the quality and quantity of TWW reuse under different soil types in certain agricultural regions. The information (maps with supplemental information) will be delivered to the stakeholders via direct contact and workshops.

e) Scientific deliverables

The process of developing the maps including data sources and scientific background for blending of the data will be presented in scientific manuscripts.

Working plan

a) Overview

In a first step, the soil suitability evaluation for TWW irrigation produced in phase II will be made available for integration into the LandSHIFT model. This will be achieved through close collaboration with project 3.3 by including modifications with respect to the different scenarios used there. In a next step, a spatial refinement of the soil suitability maps for TWW irrigation will be conducted. As discussed at the working group meeting in Herrenberg (June 2007), pilot catchments or areas for which detailed data is available will be chosen for each region for the development of the maps. At the current stage of discussion, these areas will be Wadi Faria (West Bank), Lower Jordan Valley (Jordan) and the Nahal Harod watershed (Israel). For these study areas, all data on soils, topography, land use, hydrology and TWW availability will be compiled in a GIS at a scale of preferably 1:50 000. Data about TWW resources will be obtained in close collaboration with the colleagues from the SMART project. Furthermore, the results of the EXACT multilateral working group on water resources regarding water resource management planning will be integrated. If detailed data on TWW resources will also not become available in this phase, certain assumptions regarding the current and future local availability and quality of TWW will be made. By relating this to the soil suitability for irrigation with certain TWW qualities on a local scale and to plant water requirements and water productivity (from project 3), scenarios for sustainable land use options and crop options will be developed and presented to the stakeholders. This can furthermore provide detailed information for WEAP.

b) Milestones

08/2009: The maps obtained in the last phase will be processed and supplied for the LandSHIFT modeling group and adapted according to their scenarios. Furthermore these maps will be prepared for use in the hydrological models (P4.2).

Data for the land classification for selected pilot areas will be merged.

06/2010: Land classification according to irrigation suitability for TWW irrigation for the selected pilot areas (scale 1:50 000) is developed.

In a next step, specific land use options with the respective irrigation scenarios will be developed for the pilot areas. Again, these scenarios will be discussed with the stakeholders, especially with respect to their criteria for decision making. Based on these results, a draft GIS system for TWW irrigation options will be developed.

12/2010: Presentation of a draft GIS system for TWW irrigation options for the selected pilot areas.

Once the criteria for selecting land use options with respect to TWW irrigation have been developed together with the local stakeholders, the maps will be further refined, so that they can be applied to other project areas within the region. At this stage, workshops will be organized to present this approach to other local stakeholders and the expertise of the project participants will be offered support regional planning activities, including integration into the WEAP tool.

02/2011: The maps for TWW irrigation planning has been made known and available to the regional and local stakeholders and has been applied to selected irrigation projects in the region. The results are ready for presentation at a final conference.

06/2011: Final report is made available to the coordination.

PROJECT 4: CLIMATE AND HYDROLOGY

Coordination

Germany: J. Lange (University of Freiburg), L. Menzel (University of Kassel)

Introduction

a) Background

This project integrates ideas from a multinational team, including scientists from all participating countries in GLOWA JR. It deals with the current and future hydrological conditions in the Jordan River Region (JRR), the impact from land-use and climate change and the assessment of mitigation options in order to optimize water use and water availability on different scales. The proposed approach applies the methods and tools developed and extensively tested during GLOWA JR phase II, in principal the coupled hydrological models TRAIN-ZIN. According to the recommendations of stakeholders, more attention is given to the analysis of hydrological droughts and to possible new water sources in detailed studies in focus areas and regional scale assessments. The four main scenarios identified by SAS in phase II will be addressed, as well as future land-use patterns as simulated by LandSHIFT. All outputs are regional patterns and maps. Both in focus areas and in the entire Lower Jordan River Catchment (LJRC) a soft, transient coupling between TRAIN-ZIN and WEAP is carried out to include maps of water balance components. As such this project is central for the translation of hydrological information from various scales (including current conditions and scenarios) into a regional WEAP to produce sound options for water management. Furthermore, regional water availability patterns serve as a base for stakeholders to come up with realistic scenarios in SAS and for a refinement of land-use change scenarios carried out with LandSHIFT.

b) Key results and key products from phase II

The coupling of the green and blue water models only started in phase II of GLOWA JR. During this phase, the models TRAIN and ZIN were extensively tested against experimental data, and significant improvements regarding process representations could be implemented in the models. One of the major tasks in phase II however was the coupling of both models, resulting in a tool which reflects the most relevant hydrological processes (including blue and green water fluxes) in the semi-arid environment of the project region. The TRAIN-ZIN model was then applied to carry out a number of process based simulations of water resources in the region. Data on historical hydro-meteorological extremes (1991/92: wet and 1998/99: dry) in comparison to an average year (2002/03) are available to highlight the present, climate induced variability of water resources. These formed the input of process oriented hydrological simulations on different scales. Hence an important first step towards a better identification and classification of future events under the impact of climate change was reached, an issue which will be treated with high priority during phase III. First climate scenarios were used to give rough estimates (on a coarse spatial resolution) of the impact of climate change on water resources and irrigation water demand in the region. Preliminary studies of the impact of land-use change on hydrological conditions in the Lower Jordan Region were also addressed during phase II.

c) Goals of phase III

- To simulate (blue and green) water resources and the occurrence of water stress under different scenarios of environmental change (including land-use and climate), water use and new water availability.
- To evaluate the impact of environmental change on the average long-term changes in blue and green water fluxes and the water availability in the region.
- To investigate the impact of future extreme hydro-meteorological events on the water situation in the region, with special focus on droughts.
- To assess the potential for water harvesting and managed aquifer recharge to contribute to the region’s water supply and to mitigate water stress under both average and extreme conditions.
- To support scenarios for the restoration of environmental flows in the Lower Jordan River through water availability investigations, including both environmental change and possible mitigation measures.
- To perform a close link to WEAP by, soft transient coupling to TRAIN-ZIN and to consider feedbacks between water use and water availability.
- To include feedbacks between water availability and land-use and thus provide input to the generation of refined land-use change scenarios by LandSHIFT.
- To feed the GLOWA JR central GIS (P1.3) with selected and relevant data and maps regarding current and future water resources in the project region.

SUBPROJECT 4.1: REGIONAL CLIMATE SCENARIOS

Germany: H. Kunstmann & A. Heckl & G. Smiatek (Forschungszentrum Karlsruhe, IMK-IFU)

Israel: S.O. Krichak & P. Alpert & P. Kunin (Tel Aviv University)

Introduction

a) Background

Projections of future climate conditions, particularly of future spatial and temporal distribution of temperature and precipitation, are a central prerequisite for the delineation of adaptation and mitigation strategies in the Jordan River area. Due to the sharp climatic gradient in the region, global climate scenarios have to be downscaled to higher spatial resolutions to account for regional and local climate patterns. While phase II has focused on determination of high resolution regional climate change scenarios, the need for a) transient runs (i.e. continuous climate change information instead of e.g. 30 year time slices) and b) uncertainty ranges due to different global climate models (HadCM instead of ECHAM only) was identified. In phase III, focus is set on the delineation of uncertainty ranges and an additional new focus on the statistical analysis of extreme events.

b) Key results and key products from phase I and II

High resolution regional climate change information was obtained by dynamical downscaling of global climate scenarios with MM5 at IMK-IFU driven by ECHAM4 data till 6 km resolution and RegCM3 at TAU driven by HadCM3 (50 km) and driven by ECHAM5 data till 12 km.

Additionally, data sets derived from RegCM in 50 and 20 km resolution were made available from ICTP in Trieste and elaborated at TAU. The time series of projected meteorological fields were subsequently applied in impact assessment, primarily hydrological, agricultural and vegetation dynamic impacts assessments. In phase III, the set of regional climate change projections will be further extended to allow the derivation of uncertainty ranges on base of a concerted methodological approach. Tab. 4.1 gives an overview on the regional climate scenarios elaborated in phase I and II and the additional scenarios proposed for phase III.

c) Overall goal

Overall goal is the extension of regional climate scenarios finally allowing the derivation of uncertainty bounds for future climate conditions.

Tab. 4.1: Scenarios available for GLOWA JR after phase II and additional scenarios as proposed for phase III (bold font).

Global Model	Regional Model	Scenario	Resolution	Time Slice	Institute	Phase
ECHAM4	MM5	CT	54	1961-90	IMK-IFU	I+II
ECHAM4	MM5	CT	18	1961-90	IMK-IFU	I+II
ECHAM4	MM5	CT	6	1961-75	IMK-IFU	I+II
ECHAM4	MM5	B2	54	2070-99	IMK-IFU	I+II
ECHAM4	MM5	B2	18	2070-99	IMK-IFU	I+II
ECHAM4	MM5	B2	6	2070-85	IMK-IFU	I+II
ECHAM4	MM5	CT+A2	54	1961-2050	IMK-IFU	I+II
ECHAM4	MM5	CT+A2	18	1961-2050	IMK-IFU	I+II
ECHAM4	MM5	CT+B2	54	1961-2050	IMK-IFU	I+II
ECHAM4	MM5	CT+B2	18	1961-2050	IMK-IFU	I+II
HadCM3	**MM5**	**CT+A2**	**54**	**1961-2050**	**IMK-IFU**	**III**
HadCM3	**MM5**	**CT+A2**	**18**	**1961-2050**	**IMK-IFU**	**III**
HadCM3	**MM5**	**CT+B2**	**54**	**1961-2050**	**IMK-IFU**	**III**
HadCM3	**MM5**	**CT+B2**	**18**	**1961-2050**	**IMK-IFU**	**III**
HadAM3P	RegCM3	CT	50	1961-90	TAU	I+II
HadAM3P	RegCM3	A2	50	2071-2100	TAU	I+II
HadAM3P	RegCM3	B2	50	2071-2100	TAU	I+II
NASA FV GCM	RegCM3	CT	50	1961-90	TAU	I+II
NASA FV GCM	RegCM3	A2	50	2071-2100	TAU	I+II
ECHAM5	RegCM3	CT + A1B	50	1960-2050	TAU	I+II
ECHAM5	RegCM3	CT + A1B	12	1960-2050	TAU	I+II
ECHAM5	**RegCM3**	**A2**	**50**	**1960-2050**	**TAU**	**III**
ECHAM5	**RegCM3**	**A2**	**12**	**1960-2050**	**TAU**	**III**
ECHAM5	**RegCM3**	**B2**	**50**	**1960-2050**	**TAU**	**III**
ECHAM5	**RegCM3**	**B2**	**12**	**1960-2050**	**TAU**	**III**
ECHAM4	STAR	CT		1958-1996	PALAST	I+II
ECHAM4	STAR	A1B		2007-2040	PALAST	I+II

Deliverables

a) Deliverables for the scenarios

An extended set of regional climate scenarios will be provided:

IMK-IFU: HadCM3 1960-2050 in 54 and 18 km for emissions scenarios A2 (pessimistic CO_2 increase) and B2 (optimistic CO_2 increase).

IMK-IFU applies its 200 processor Linux cluster and HPC clustered storage facilities for these CPU and disc storage demanding simulations.

TAU: ECHAM5 1960-2050 with 50 km resolution in the free atmosphere and 12 km resolution for determination of surface parameters 1960-2050 for emission scenarios A2 and B2.

TAU: Mean seasonal patterns of minimum, maximum, and mean air temperatures, mean and maximum winds (magnitude and direction), net absorbed solar radiation, precipitation, and evapotranspiration averaged for 1961-1990, 1990-2010, 2015-2035, 2010-2040 and 2030-2050 over the region 25N-40 N; 25E-40E.from each of the simulation runs.

TAU: Evaluation of frequencies of occurrence of extreme temperature, wind and precipitation events including determination of their return periods over several sub-regions in the GLOWA JR area for 1961-1990, 1990-2010, 2015-2035, 2010-2040 and 2030-2050 over the region 25N-40 N; 25E-40E.from each of the simulation runs.

b) Deliverables for WEAP

The 2-dim surface meteorological fields (temperature, precipitation, humidity, wind speed, radiation) of the regional climate scenarios will be used in hydrological models that in turn feed into WEAP for further subsequent impact analysis.

c) Deliverables for other projects and subprojects

Climate change scenarios and uncertainty bounds will be provided to all impact WP's. Spatial representations of climate change scenarios will be made available for the central GIS (P1.3).

d) Further deliverables for stakeholders

The major results will be compiled in a comprehensive set of metadata (maps, figures & tables) that will be used for directly communicating expected climate change to stakeholders.

e) Scientific deliverables

Extended set of regional climate scenarios and uncertainty ranges of expected change of climate variables, statistically evaluated (means, variances, signal to noise ratios, etc.).

Working plan

a) Overview

Dynamical downscaling with MM5 using a nested approach providing climate change information in 54 and 18 km resolution. After finishing simulations with the global model ECHAM4 and the IPCC scenarios A2 and B2 in phase II, the same range of simulations will be built with the global model HadCM3 in phase III. There will be 8 scenarios (2 global driving models, two emission scenarios, two resolutions, compare to Tab. 4.1) plus one additional very high resolution run (6km) available finally from IMK-IFU.

b) Milestones

09/2009: HadCM3 +MM5, 54+18km, A2 und B2 1960-2050.

09/2009: ECHAM5+RegCM3, 50 + 12 km (Sub-BATS) A2 and B2 1960-2050.

08/2010: Final statistical analysis finished. Recommendation whether HadCM3 or ECHAM4 driven regional climate scenarios should be used for impact analysis, based on validation with long term observed station data for recent climate.

06/2011: presentation of results at wrap-up conference.

SUBPROJECT 4.2: IMPACT OF ENVIRONMENTAL CHANGE ON WATER RESOURCES IN THE LOWER JORDAN RIVER

4.2.1: WATER BALANCE PROJECTIONS

Germany: J. Lange (University of Freiburg), L. Menzel (University of Kassel)

Introduction

a) Background

In this work-package the different climate and land-use scenarios generated during phases II and III of GLOWA Jordan River will be evaluated regarding their impact on the water balance and on its individual elements, as well as on the changing distribution of green and blue water fluxes. For example, drier climate conditions might reduce the availability of green water and thus require a higher use of blue water for irrigation purposes. Based on these results, the combination of land-use and climate changes will be investigated, in cooperation with the LandSHIFT subproject (P3.3) which has not been done in phase II. In parallel to these major tasks, recent climate extremes as well as recent land-use changes will be addressed and the TRAIN-ZIN model will be validated at the large scale. The work is carried out in continuous and close cooperation between the two German working groups, thus no clear separation is possible for all tasks listed below. However, in order to indicate a division of the workload, the group with the main responsibility is named first when the detailed tasks are described.

b) Key results and key products from phase II

- Coupling of the TRAIN and ZIN models as a prerequisite to cover the entire water fluxes (green and blue) of the semi-arid and arid parts of the Lower Jordan River Region (JRR).
- First round computation of the water balance in focus areas (Wadi Faria and Nahal Harod) and in the entire Lower JRR under current conditions, including a coarse consideration of soils (FAO world soil map) and land-use (GLCC global land cover characterization). Work based on TRAIN-ZIN.
- First round computation of the scenario water balances of the entire JRR (i.e., including the upper parts of the basin), with focus on the vertical (green) and aggregated (water availability) water fluxes, based on TRAIN. A number of preliminary climate and land-use scenarios have been included.
- Preliminary conclusions regarding the impact of climate and land-use change on the water balance and the consequences for future irrigation water demand of agriculture of the region.

c) Goals for phase III

- Detailed assessment of the water balance and of the green / blue water fluxes of the Lower JRR based on refined maps of the main land-use and land-cover types (delivered by LandSHIFT) and on soil conditions (detailed soil map elaborated by the Marschner group at the end of phase II). Work based on TRAIN-ZIN.
- Detailed consideration of current extreme conditions based on refined input data available in phase III, and assessment of the present impact of climate variability on the range of hydrological extremes in the Lower JRR. Work based on TRAIN-ZIN.
- Computation of fast track results by TRAIN-ZIN from a number of environmental change scenarios. The data will then serve to further develop and refine the scenarios.
- Application of the land-use change scenarios from LandSHIFT and of a selected set of the new and consolidated climate change scenarios and determination of water balance changes for the Lower JRR (based on TRAIN-ZIN) and for the entire JRR (including its upper parts) (based on TRAIN).
- Assessment of the combined impact of land-use and climate change on future water availability and its implications for future water use in the agricultural sector.
- Assessment of the range and severity of future hydrological and agricultural droughts for the Lower JRR (TRAIN-ZIN) and for the entire JRR (TRAIN) from the analysis of the climate scenarios.
- Large scale validation with a basin-wide view on changing distributions of blue and green water fluxes.

Deliverables

a) Deliverables for the scenarios and for WEAP

- Detailed maps of blue / green water resources (averages of total water availability and individual water balance components), based on hydrological simulations of current conditions and of scenarios defined by SAS, LandSHIFT and the climate models. The maps cover the Lower Jordan River Region on a 1 x 1 km spatial resolution (blue and green water fluxes, TRAIN-ZIN). The scenario maps also include the Upper JRR with main focus there on green water fluxes and aggregated, cell specific water availability (TRAIN). Maps are fed into the coupled WEAP-TRAIN-ZIN and serve as input to LandSHIFT.
- Report on the impact of environmental change scenarios (land-use, climate) on the water resources of the region and on the frequency and severity of future droughts, including selected maps and hydrographs.
- Short report which documents the results of a comparison between recent and future impacts of land-use and climate change on the water resources.

b) Further deliverables for stakeholders

- Selection of maps for the GLOWA GIS.
- Land-use scenario maps showing highest mitigation options regarding the adverse impact of climate change on water resources (joint deliverable with the LandSHIFT group).

c) Scientific deliverables

Working titles for manuscripts

- Impacts of climate and land-use changes on water balances in the Eastern Mediterranean and adopted mitigation strategies.
- The hydrological impact of recent land-use changes in the light of climate variability.

Working plan

a) Overview

Task 4.2.1a: Water balance and green / blue water fluxes for the Lower JRR

Based on the achievements and first round simulations carried out in phase II of the project, a refined consideration of the green and blue water fluxes will be carried out for the entire Lower JRR. While the first simulations in phase II were processed on a coarse spatial resolution of 18 x 18 km will the new resolution be in the 1 x 1 km domain. In phase II, apart from the focus areas, global maps of land-use and soils (with a related, coarse spatial resolution and few details) were used for the TRAIN-ZIN simulations. During the final stage of phase II however, detailed land-use and soil maps from LandSHIFT and the Marschner group will be available which can be used in phase III for TRAIN-ZIN. Therefore, a more detailed consideration of physiographic characteristics and spatial details of the region will be enabled which enhances the potential of TRAIN-ZIN to represent the blue and green water fluxes of the region with great detail.

The following parameters will be considered on a daily time step and will be aggregated to optional time slots, according to the requirements of WEAP:

- Plant available soil water and soil water stress
- Actual evapotranspiration
- Irrigation water demand in agriculture
- Blue water availability (surface runoff, discharge, percolation)

The data on blue and green water availability will be delivered to WEAP for defined sub-catchment nodes. The data on soil water availability, soil water stress and irrigation water demand will be classified into the major land-use types considered in LandSHIFT (focus on three major agricultural crops and natural vegetation) and subdivided into dry, average and wet seasons. The results of this analysis will be delivered to LandSHIFT with the aim of a refined simulation of land-use and land-cover in the project region for current conditions.

Work load will be equally distributed among the German partners:

Freiburg: Focus on slopes, urban areas and other areas with fast runoff formation, deliver blue water availability.

Kassel: Focus on agricultural crops and natural vegetation, deliver data on green water availability.

Task 4.2.1b: Application of environmental change scenarios (climate, land-use)

This task deals with the impact of environmental change on the water resources (green and blue water availability, water stress) of the region. Therefore, a set of environmental change scenarios will be fed to the TRAIN-ZIN model system. It includes the land-use scenarios from LandSHIFT and a selected number of the climate change scenarios generated during the first months of phase III. The work of this task will strongly profit from experience gained during phase II of the project: The simulation of environmental scenarios will be facilitated by a standardized modeling approach with defined input from the scenario groups and model output according to the requirements of WEAP. A fast track approach will enable the production of water scenarios within a very short time frame, but on a coarse spatial resolution (18 x 18 km). In contrast to phase II however, final, consolidated scenarios will be analysed by TRAIN-ZIN on a high spatial resolution of 1 x 1 km. In accordance with task 4.2.1a, the following parameters will be considered:

- Plant available soil water and soil water stress
- Actual evapotranspiration
- Irrigation water demand in agriculture
- Blue water availability (surface runoff, discharge, percolation)

The data on the individual water balance components as well as on irrigation water demand will be aggregated from daily resolution to monthly and annual means and made available for WEAP. The related baseline data from task 4.2.1a will be compared with the scenario data, and maps of mean changes over the whole area investigated will be generated.

The investigations on future green and blue water fluxes will be carried out for the whole JRR and its broader environs. TRAIN-ZIN will be applied to the Lower JRR (focus on blue water fluxes, i.e., percolation and surface runoff) (Freiburg group) while TRAIN will be applied to the whole JRR and neighbouring regions (focus on green water fluxes and aggregated water availability, i.e., the sum of percolation and surface runoff on the grid cell level) (Kassel group). High resolution maps with spatial patterns of water resources will be generated for mean monthly and mean annual scenario conditions.

Task 4.2.1c: Scenario based development of mitigation options

Based on the available, consolidated scenarios, a combined consideration of both land-use and climate change impact on the water resources of the JRR will be possible during phase III of the project. Preliminary, rough estimates regarding climate and land-use change impacts were presented during the last months of phase II, based on the TRAIN model. Both the low spatial resolution however and the consideration of only few land-use classes as well as the lack of information regarding blue water fluxes resulted in coarse estimates regarding the projected changes in water resources. In phase III, the coupled TRAIN-ZIN model will be run with a selected number of combinations of climate and land-use change scenarios on a high spatial resolution (1 x 1 km), including all the land-use classes considered in LandSHIFT. In addition to Task 4.2.1b are the goals of this task

- To feedback the impact of climate change on water availability and water stress to LandSHIFT with the aim to initiate refined land-use change simulations.
- To identify the land-use change scenario with best options regarding the mitigation of adverse climate impacts on water resources. It is envisaged that LandSHIFT will generate refined land-use scenarios based on information on future plant available soil water and soil water stress as well as on future irrigation water demand. Therefore, future land-use change scenarios will be developed in an iterative process between the LandSHIFT and TRAIN-ZIN work groups.

The outcome of this Task will be land-use scenario maps showing highest mitigation options regarding the adverse impact of climate change on water resources. These maps will be presented during the following SAS workshops.

Task 4.2.1d: Large scale validation with remote sensing data

So far, the output of TRAIN-ZIN and its two major modules (i.e., the TRAIN and ZIN models) could only be tested against small-scale data from experimental sites and research catchments, such as measured soil moisture or latent heat fluxes at individual field plots or surface runoff and discharge at intensively investigated slopes or at gauges of small Wadis. Apart from the two focus areas Wadi Faria and Nahal Harod a large-scale validation was not yet possible, mainly because of missing continuous and reliable river gauge data. There is however the necessity to have independent data which can help to validate the performance of the TRAIN-ZIN model on the large scale. A reliable option comes from remote sensing, especially regarding the determination of soil moisture and evapotranspiration as internal variables in the modeling process. Remotely sensed estimates of evapotranspiration are available from investigations during phase II of the project, however limited to small areas within the JRR. It is therefore planned to generate maps of evapotranspiration and soil moisture over large parts of the JRR based on remote sensing. The areal coverage and the temporal resolution of the maps will be determined during the initial period of phase III, with the decision based on the availability of respective products from different sensors. Work will be carried out in joint collaboration between the TRAIN-ZIN modeling groups (Kassel-Freiburg) and based on a subcontract with the Department of Remote Sensing, University of Trier, Germany (Jun.-Prof. Dr. Michael Vohland).

Task 4.2.1e: Analysis of the impact of recent land-use changes

In addition to the analysis of recent hydro-meteorological extremes (seasons 1991/92 and 1998/99) which helps to reproduce the range of present climate variability, a study of recent land-use changes can contribute to the uncertainty range of future land-use change impact analyses. For example, overgrazing effects, which will be included in the land-use change scenarios of phase III, are known to have impacts on the distribution of water between surface runoff and infiltration/soil moisture (i.e., the division between blue and green water). These effects come from changes in Leaf Area Index and a modification of the infiltration characteristics of soils and have not been studied so far in the project region. Therefore, it is not clear yet how strong these impacts are on hydrology. It is also known that overgrazing has occurred over recent time scales, i.e., it is not exclusively a problem of the future. Another hydrological effect comes from expanding afforestations or irrigated areas which have possibly an impact on the percolation characteristics of the soils and on evapotranspiration. Therefore, the expansion of irrigated areas both at recent and future time scales has had and will have (still unknown) hydrological impacts. The land-use change scenarios generated during phase III of the project will include changes in the expansion of irrigated agriculture and of grazing intensities and they will be analysed by TRAIN-ZIN (Kassel-Freiburg). In order to compare the future hydrological impacts with impacts from similar, recent developments, we will carry out an analysis of a sequence of remotely sensed maps generated during phase II of the project. These maps show recent changes in the distribution of irrigated agriculture and of vegetation densities / vegetation coverage as a consequence of different grazing intensities. The investigations will be limited to few, fast track model runs and will cover parts of the Lower JRR only. The main deliverable will be a short report which documents the results and which is aimed at supporting the better classification of hydrological effects from projected, future land-use changes.

b) Milestones

Task 4.2.1a

03/2009: Water balances for main land-use types

09/2009: Detailed maps (1x1 km) of blue / green water resources

Task 4.2.1b

03/2010: Long-term averages and high resolution maps (1x1 km) of water balance components for scenarios

Task 4.2.1c

09/2010: Scenario maps with land-use mitigation options

Task 4.2.1d

03/2010: Report on large scale validation of TRAIN-ZIN

Task 4.2.1e

09/2010: Report on hydrological effects of recent and future land-use changes

4.2.2: HYDROLOGICAL DROUGHT ANALYSIS

Germany: J. Lange (University of Freiburg), L. Menzel (University of Kassel)

Israel: T. Grodek, E. Morin, Y. Enzel (HUJ)

Jordan: I. Oroud (Mu'tah University)

Introduction

a) Background

The extremely high sensitivity of the hydrological systems in the Jordan River catchment (Enzel et al. 2006) to relatively small shifts in yearly rainfall makes the issue of droughts of major importance for water management and planning in the region. The relatively short rain season, December – February, produces most of the yearly rainfall and thus the winter rain is expected to support the water demands during the long hot and dry summer. Therefore, rainfall decrease in several percentages from the annual average may be translated into drought conditions during the winter period and at the successive summer. Drought conditions affect immediately rainfed crops, and land may become unproductive; rivers may dry out or stay at base flow level and springs may reduce discharges due to the lower rainfall recharge into aquifers combined with the growth of groundwater extraction due to the shortage of other water resources. The severity of the hydrological drought is strongly dependent on the spatial and temporal distribution of rainfall within the rainy season and also on the sequential occurrence of dry years. Consecutive dry years of the recent and distant pasts already demonstrated the dramatic propagation of decreasing water availability.

Drought research has many approaches. The two main ones are:

- Downscaling from global and regional climate models that can help estimating the probability of future risks. This approach, although potentially describing the characteristics of future scenarios is admittedly weaker on estimating the magnitude of the change and the frequency. The weakness comes from various directions but includes the difficulties in modeling the climate of the eastern Mediterranean region (in comparison with other regions). Also from previous GLOWA JR phases the high uncertainty of the climate scenarios became apparent and needs to be addressed. The past (at all temporal scales: 20th century, hundreds to thousands of years) has seen severe droughts in the Levant to levels unpredicted by models.
- Upscaling from record to climate: climatic and hydrologic analyses of droughts and seasonal to multiyear causes such as changes in the hemispheric, synoptic, and meso-scale climatology.

The integration of the two approaches allows asking basic questions that are crucial to planners and inhabitants of the region:

- Were recent documented droughts less or more intensive or frequent, longer or shorter, than what is predicted?
- What can we learn from the down- and up-scaling on the true, real nature of droughts in terms of causes, rainfall shortage, discharge, storage and management?

- Can we improve the predictability at scale of season to years in advance on the consequences of the droughts rather on their intensity, frequency, and duration?

For doing so this project combines both downscaling (model-driven) and upscaling (data-driven) approaches, as we do not have the privilege of avoiding data, analysis or collaboration in the face of such a potential regional disaster. The adopted TRAIN-ZIN model from GLOWA JR phase II can be used in both approaches.

- In the downscaling approach a close link to the climate scenarios and their analysis of climatic extremes (P4.1) is established. Using the outcome of the different climatic scenarios as input, the hydrological and agricultural (regarding soil water deficit and irrigation water demand) impact of future meteorological droughts is studied by TRAIN-ZIN and TRAIN for the whole Jordan River Region. Intensities and recurrence intervals of green and blue water droughts are outlined.
- In the upscaling approach the statistical analysis of recent observed data provides recurrence intervals of the extreme season 1998/99. Based on simulations from phase II process detailed studies on drought impacts, distribution and propagation are possible in the Lower Jordan River Catchment. These help to assess regional drought vulnerability and possible mitigation strategies in water management (see P4.4).

b) Key results and key products from phase II

- TRAIN-ZIN-Water balance simulations of a historical drought (1998/99) in comparison to an average season

c) Goals for phase III

- Assessing recurrence intervals of hydrological droughts and connected meteorological conditions for the entire Jordan River Region (with P4.1).
- Studying impacts of predicted future droughts on soil moisture deficits (agricultural droughts) for the entire Jordan River Region.
- Evaluation of drought processes and mitigation options in the lower Jordan River catchment.
- Influence of drought conditions on land-use and irrigation.

Deliverables

- Assessment of hydrological boundary conditions related to droughts.
- Spatial distributions of precipitation in drought years utilizing radar rainfall data (maps).
- Sensitivity of droughts to hydro-meteorological indices.
- Determination of frequencies for hydrological droughts in the region in the past, present and future.
- Determination of the spatial extent of hydrological droughts in the region affecting rainfed agriculture (maps).

- Assessment of processes and hydrological driving forces, caused by e.g. specific land-use, which intensifies droughts in catchments.
- Evaluation of management options to mitigate drought impacts and predicted adverse hydrological developments from climate change.

a) Scientific deliverables

Working titles for manuscripts

- Droughts in the eastern Mediterranean: causes, processes and mitigation strategies
- Frequency of droughts in the Eastern Mediterranean in the present and future and related drought vulnerability

Working plan

a) Overview

Task 4.2.2a: Data driven drought analysis (HUJ)

This task is aimed on the analysis of droughts following the upscaling approach. In order to determine the expression “drought”, the relationships between meteorological and hydrological conditions in dry years will be investigated (Daniels 2007). Statistical examination of the sequence of dry years (Beersma and Buishand 2007; Calanca 2007; Labedzki 2007) including various components of the hydrological cycle (precipitation, river flows and springs) will be performed based on an existing database constructed during phase II of GLOWA JR in addition to other available data. The statistical analysis will indicate the probability of a sequence of dry years and their hydro-meteorological characterization. Relevant indexes are obtained from time series of hydrological data (rainfall from ground stations, river runoff and spring discharge) and from the spatial distribution of precipitation computed from radar data. Longer term rain amounts from the radar will be computed utilizing the method developed by Morin and Gabella (2007). A special focus will be put on characteristic space-time precipitation patterns causing the enhancement of hydrological droughts. In many ways, we propose to answer a simple question:

- What is a drought in this region in quantities of rainfall, discharge of springs and streams, and water availability?

The results of this effort will contribute directly to the modeling efforts within GLOWA JR as it will supply the information against which model should be tested and their results estimated. The analysis will be applied to the entire catchment of the Jordan River using data from the upper and lower catchment.

Task 4.2.2b: Drought scenario analysis (Kassel-Freiburg)

In this task a close link to the climate scenario group is established and their data on projected climatic changes and future climatic extremes is used as a direct input to TRAIN to evaluate simulated hydrological and agricultural drought impacts. A model resolution of 1 x 1 km will be chosen and the entire Jordan River Region will be simulated. Special focus will be on the vertical water fluxes during droughts (since no lateral water flows occur), the intensity of necessary irrigation for different crops in agriculture and the development and severity of water stress conditions during the evaluated periods. Hence the meteorological analysis of future droughts by P4.1 will be completed by an analysis of consequences for hydrological and agricultural droughts covering green water deficits. First strategies towards an optimised land-use will be evaluated based on the indicators developed during the first working step and exchanged with LandSHIFT (P3).

Task 4.2.2c: Drought processes and mitigation (Freiburg-Kassel)

In the two focus areas (Nahal Harod and Wadi Faria) detailed information on ongoing processes during the historical drought 1998/99 will be analysed by TRAIN-ZIN: During this season almost no surface runoff was generated. With the help of the highly distributed information available from phase II it will be possible to analyze where the little natural rainfall was lost to evaporation and how unproductive water loss (e.g. by bare soil evaporation) can be minimized. Also the analysis of the partitioning of water used by natural vegetation and by agriculture will be possible at the catchment scale. This information will then be extrapolated to the entire Lower Jordan River basin and together with P3 (LandSHIFT) guidelines for a wise land-use (i.e., regarding the possible extent of agriculture) to minimize drought impacts can be produced. However, also other mitigation options regarding the optimization of water resources during extreme conditions, e.g. RWH, MAR, see P 4.3, will be evaluated.

Task 4.2.2d: Spatial distribution of drought in Jordan (Mu’tah)

To check the drought analysis, the spatial distribution of drought, particularly in the mountainous areas of Jordan, will be studied (Mu’tah). The effect of climate change on the frequency, severity and extent of drought will be evaluated. A comparison will be made between future trends of drought following climate change and past events to assess the seriousness of this emerging natural hazard. This comparison will provide a perspective of the relative magnitude of drought. Based on soil moisture budgeting using daily meteorological data, it is anticipated to assess various drought indices and also provide the agricultural potential of various areas in Jordan. As such, it is expected to present the most likely suited drought index for future assessments. Currently, the 250 mm divide roughly separates rainfed agriculture and pasture lands. It is anticipated to answer the following questions:

- What would be the new divide given warmer climatic conditions and/or decreased precipitation?
- How would such a climate change be translated geographically in a migration of this divide (also addressed in P3.1)?

It is a well known fact that climate processes and variability are major forces impacting natural vegetation and agricultural practices. Although the divide and shift may be investigated using a biophysical/ecological model, climate-oriented assessments do provide in depth assessment of many subtle, yet very important, features which are likely invisible to other investigators. In this perspective the present task is complementary to other participating GLOWA JR colleagues.

b) Milestones

Task 4.2.2a

03/2009: Assessment of hydrological boundary conditions related to droughts (short report)

03/2009: Spatial distributions of precipitation in drought years utilizing radar rainfall data (maps)

09/2009: Sensitivity of droughts to hydro-meteorological indexes (short report)

03/2010: Determination of frequencies for hydrological droughts in the region in the past, present and future (short report)

Task 4.2.2b

08/2009: Determination of the spatial extent of hydrological droughts in the region affecting rainfed agriculture (maps)

Task 4.2.2c

03/2009: Assessment of processes and hydrological driving forces that intensify droughts in catchments (short report)

03/2010: Evaluation of management options to mitigate drought impacts and predicted adverse hydrological developments from climate change (report)

Task 4.2.2d

09/2009: Identification of most suited drought index for future assessments

09/2010: Analysis of the effects of the climate change on the boundary of rainfed agriculture

4.2.3: INTERACTIONS OF CLIMATE (TEMP. PRECIPITATION. CO_2) AND LAND-USE (AFFORESTATION) ON WATER YIELD

Germany: J. Lange (University of Freiburg), L. Menzel (University of Kassel)

Israel: D. Yakir (Weizmann Institute of Science)

Introduction

a) Background

In this project we focus specifically on the effects of land-cover and land-use changes (shrubland to forest) on the water yield (WY, the difference between rainfall gains and evapotranspiration losses). Understanding and predicting variations in the water yield, in space and time and their interactions with changes of land-cover, both anthropogenic (afforestation) and climate driven (desertification), must be used as an important tool in formulating national and regional water management policies. These aspects are often neglected in assessing the present and future regional hydrological assessments.

It was estimated (Stanhill 1991) that land-use change in Israel, from extensive tree cover (e.g. 10,000 years ago) to intensive agriculture (today) significantly increased water yield (~70%). Smaller changes were associated with man-made land-use changes from woody to herbaceous vegetation. A main consequence of widespread decrease in evapotranspiration due to land-use changes is increase in runoff, contributing to flood, erosion and loss of fertile soils (e.g. Gedney et al. 2006). In the Mediterranean coastal areas, large-scale deforestation likely had significant feedback and led to decreasing rainfall in the past. This is supported by evidence that in semi-arid regions tree vegetation enhance convective precipitation (Charney 1975 and consequent studies). Evapotranspiration provides a supply of moisture, reducing the temperature of the Planetary Boundary Layer (PBL) compared to that above dry land. The clouds and precipitation are generated in the different PBL's resulting from dry or wet land surface can be quite different.

Consideration of the links between land-cover and water yield is further complicated by important tradeoffs that must be considered quantitatively. Deforestation and afforestation are also significant for carbon sequestration and for surface radiation budget (Bala et al., 2007), with potential economic consequences. This is particularly relevant as we recently demonstrated in the framework of GLOWA JR that semi-arid forest can sequester up to 3.5 t C ha-1, which is above the European average (see global Fluxnet website). Further, we recently showed that this relatively high carbon sequestration potential is at least partly due to CO_2 enhancement of forest water use efficiency (WUE), in the semi-arid area. We also show that the 40 years old forest had more than three times more carbon than the original, 'native', shrubland, both above and below ground.

b) Key results and key products from phases I & II

A key outcome of phases I and II of GLOWA JR is the achievement of annual scale data from fife consecutive years with large interannual variations. This brings us to the limit of providing a robust picture of the effects of afforestation at the dry limit of the Jordan River Region on the local carbon, water and energy budgets. We show that:

- Water use efficiency (WUE) has significantly increased over the past 30 years (extending current measurements with tree-rings).
- Carbon (biomass) accumulation for this low precipitation forest is unexpectedly high (up to 3.5 t C ha^{-1} during GLOWA JR, above global average for forests) and more than triple C storage compared to local shrubland.
- We provide evidence that the increase WUE and high rates of carbon accumulation are due to increasing atmospheric CO_2 and ecophysiological adjustments to drought in the plants.
- Afforestation reduced runoff from as high as 35% in some seasons in the ‘native’ shrubland to essentially zero.
- Soil evaporation is strongly influenced by the seasonal annual vegetation below the forest canopy.
- Afforestation of shrubland significantly changed the radiation/energy characteristics of the surface, including: A newly identified canopy-scale greenhouse effect; large decrease in albedo and increase in annual net radiation; large increase in sensible heat and decrease in long wave radiation fluxes, in going from shrubland to forest.
- The pine forest show a suit of adaptation and adjustments to the local environment, compared to European pine forests. This clearly shows that information cannot be easily extrapolated across climatic regions.
- Within our climatic regions, extension of our field study to two sites in central and northern Israel that showed that results can be spatially expanded to regional scale based on a single intensive site, such as Yatir, and few secondary sites, as all sites show continuum, progressive responses to climate.
- Initial steps were carried out to test and calibrate the TRAIN-ZIN models to the afforestation system.

c) Overall goals

- Adaptation and transfer of the existing massive dataset collected during phases I & II to the TRAIN-ZIN modeling efforts as early as possible in phase III.
- Complete the comparative analysis of the water, energy, and carbon in the forest vs. the background shrubland, in Yatir, and along the North South precipitation gradient in the three sites established in phase II.
- Introduce quantitatively, based on the long-term data-set, the effect of increasing atmospheric CO_2 on plant WUE and consequently on the hydrological (and carbon) budgets in the semi-arid region.
- Implement and test our data (for forest and shrubland) within the TRAIN hydrological model, providing realistic assessments of the interactions between land-use (forest/native-shrubland), climate and management, and obtaining a modeling tool to assess different scenarios of the climate change/land use change (native shrubland-forest).
- Extension of our data set into phase III, based on the automated monitoring station in the Yatir forest and periodic monitoring of the native shrubland, to provide 1) A unique, long-term perspective of the climate-land cover interactions, and 2) The

Deliverables

a) Deliverables for the scenarios

- A fully calibrated and tested TRAIN-ZIN model for afforestation in the semi-arid zone as a realistic tool for scenario development. A fully analyzed data-set of hydrological, energy and carbon budget of semi-arid forests in the Jordan River region. At stage-1 existing data will be implemented in TRAIN-ZIN at the beginning of phase III at stage-2, the model will further interact and tested with additional data during the development of phase III.

b) Deliverables for WEAP

- Summary and adaptation to WEAP of the hydrological annual budgets under different precipitation regimes of local pine forest and shrubland along the precipitation gradient in the Jordan River Region. (Using the two stage-approach noted above).

c) Deliverables for other projects and subprojects

- Extensive and unique data set for the development and application of the TRAIN-ZIN models to vegetation, forests and native shrubland, in the semi-arid region of the Jordan River basin. Extensive data set for comparative analysis with the Ecological subproject on native herbaceous vegetation along the precipitation gradient.

d) Further deliverables for stakeholders

- The results on afforestation and land-use effects (native shrubland to forest) will provide a valuable management tool for land-use management in the semi-arid climate that are not available today. This will include the carbon sequestration potential of local forests compared to native shrubland, quantitative effects on runoff compared with native shrubland, relationships with planting density, tradeoffs with grazing.

e) Scientific deliverables

Potential titles:

- Tradeoffs among carbon sequestration, water runoff (yield), and surface temperature associated with afforestation of native shrubland in the semi-arid region.
- Data-calibrated hydrological model of afforestation effects on local hydrology.
- Comparative hydrology and carbon cycling in forests and shrubland along the precipitation gradient in Israel.
- Interactions of climate change, management and land-use changes on local and regional water yields.

Working plan

a) Overview

Task 4.2.3a: Implementing existing data into TRAIN-ZIN

A fully calibrated and tested TRAIN-ZIN model for afforestation in the semi-arid zone will serve as a realistic tool for scenario development. First existing data from previous GLOWA JR phases will be implemented into TRAIN-ZIN. Therefore data will be immediately adapted and transferred to the modeling efforts (TRAIN-ZIN) by a joint field-modeling team. Existing data will be selected for WEAP and for calibrating ecosystem water budgets. The effect of increasing atmospheric CO_2 on plant WUE and consequently on the hydrological (and carbon) budgets in the semi-arid regions will be introduced quantitatively into TRAIN-ZIN based on the long-term data-set.

Data are organized in hydrological years from October Y(n) to September Y(n+1). The following parameters will be included into TRAIN-ZIN: NEE, ET, [CO_2-atm], [H_2O-atm], radiation fluxes (short and long wave, PAR and diffuse), H, LE, soil water content, soil and air temperature, RH, precipitation, wind speed and direction, barometric pressure. Data also includes computed values based on these measured parameters and is available at the ½ h time resolution. Data from the GLOWA phases I and II (time series from Oct 2002 until Sept 2007) are available for immediate use. At the very beginning of phase III they will be used for TRAIN-ZIN modelling and the five year water balance will be simulated within six months (see milestones). Based on the measured parameters detailed above a modified TRAIN-ZIN model code will be produced to account for CO_2 fluctuations and first regional simulations of effects of increased CO_2 on water availability will be ready within one year after the beginning of phase III. Throughout phase III simulated TRAIN-ZIN water budgets are regularly updated by continuously collected data at six month delay (required for quality control of the data).

Task 4.2.3b: Comparative forest/shrubland assessments

Long-term monitoring of water, energy and carbon budgets through the inter-annual climate variability in the intensive Yatir site and the auxiliary field sites in the Judean hills and Carmel Mt. will be continued including forest/native shrubland comparative assessments. Dynamic interactions between the field-based team and the TRAIN-ZIN team in Germany will be at the focus. Data on all relevant parameters on time resolutions from ½ hour through daily, monthly and annual will be adapted for the TRAIN-ZIN applications. After initial adaptation for modeling efforts, continuous calibrations of the model runs against observations will be carried out. The large inter-annual variations in climate variables over the 5 years data of phase I & II will be used at the early stages with testing against new accumulated data during phase III. Hence TRAIN-ZIN will be run for the semi-arid forest and native shrubland vegetations covers interactively with the scenario developments as climate change inputs. This will facilitate comparative data analysis for forest vs. shrubland under climate change scenario inputs. These results will be checked against data for forests/shrubland along the precipitation gradient under the climate change scenario inputs.

b) Milestones

Task 4.2.3a

03/2009: Simulations of five year water budgets using the collected data of GLOWA phases I and II

09/2009: Simulations of water budgets by the adopted TRAIN-ZIN model accounting for the effect of increased CO_2

Task 4.2.3b

03/2010: Simulations of water budgets for shrubland/forests

09/2010: Simulations of water budgets for shrubland/forests under climate scenario conditions

SUBPROJECT 4.3: RAINWATER HARVESTING (RWH), MANAGED AQUIFER RECHARGE (MAR) AND SUSTAINING ENVIRONMENTAL BASEFLOW (SEB)

Germany: J. Lange (University of Freiburg), L. Menzel (University of Kassel)

Israel: P. Berliner (Ben Gurion University)

Jordan: I. Oroud (Mu'tah University)

Palestinian Authority: M. Almasri & A. Jayyousi & H. Shaheen (An-Najah University)

General Background

This subproject aims at investigating the cumulative and complementary effects of two water sources (RWH and MAR) to mitigate water scarcity across the region. It will also identify the most appropriate locations to implement the respective measures. Investigations will largely be based on existing knowledge and data and will be model supported, i.e., findings will be fed into the TRAIN-ZIN model which will evaluate the hydrological effects of the analyzed, small-scale measures on basin and regional scales, with special regard to expected water shortages from climate change. The model will also highlight possible negative effects of RWH. More intense water harvesting in headwaters might reduce available water downstream which is then lost for managed aquifer recharge or for sustaining river baseflow. Application of the TRAIN-ZIN model will enable the creation of suitability maps for RWH and MAR across the Lower Jordan River Basin (LJRB) and also will help to develop probable options for sustaining environmental baseflow in the Lower Jordan River (SEB).

4.3.1: RAINWATER HARVESTING (RWH)

Germany: J. Lange (University of Freiburg), L. Menzel (University of Kassel)

Israel: P. Berliner & J. Ben-Asher (Ben Gurion University)

Jordan: I. Oroud (Mu'tah University)

Palestinian Authority: M. Almasri & A. Jayyousi & H. Shaheen (An-Najah University)

Introduction

a) Background

In general rainwater harvesting (RWH) is a technology used for collecting and storing rainwater from rooftops, the land surface or rocky catchments. This method is one way to enhance blue and green water availability which has been used in the region since more than two-thousand years by the Nabateans making their prehistoric civilization flourish. They used both urban and rural RWH techniques. Recently, growing scarcity and intersectoral competition for water between all users in the region, along with groundwater depletion and the problems facing major surface water control systems have raised interest in refreshing water harvesting systems that capture rainwater wherever it falls. RWH is economically viable (inexpensive), can be utilized by individuals or state-run agencies, is a reliable renewable resource with little investment or special management, is relatively easy to use, environmentally safe, and little energy is needed for water transport. Furthermore, RWH can be used at small and large scales.

- In its simplest *urban* form, rainwater is collected at the edge of a roof. As the rooftop is the main catchment area, the amount and quality of rainwater collected depends on the area and type of roofing material. Reasonably pure rainwater (also for domestic purposes) can be collected from roofs constructed with galvanized corrugated iron, aluminium or cement sheets, tiles and slates. Roofs with metallic paint or other coatings are not recommended as they may impart tastes or colour to the collected water. Rooftops should also be cleaned regularly to remove dust, leaves and bird droppings. Storage tanks should provide an adequate enclosure to minimize contamination from human, animal or other environmental contaminants, and a tight cover to prevent algal growth and the breeding of mosquitos. Inside cities lower quality water can also be collected by larger scale systems from paved surfaces like roads or parking lots.
- *Rural* RWH uses natural hillslopes as collecting areas and involves improving runoff capacity of the land surface (e.g. by clearing or altering vegetation cover or reducing soil permeability by the soil compaction). Care is needed to minimize soil erosion. Overland flow from hillslopes is either directly retained on the slope by small storage reservoirs (on surface or underground) created by low cost (e.g. earthen) dams, or - in larger scale systems - is conveyed into agricultural fields at the valley bottom by a system of conduits. Due to infiltration there is a possibility of high rates of water loss, and - because of the often marginal quality of the water collected - rural RWH is mainly suitable for agricultural and livestock purposes.

This work package aims at summarizing and utilizing findings from phases I and II. In rural systems, using existing data, the efficiency of water retention structures built along slopes and channels is evaluated which is affected by their sizes, characteristics and distances between them. Also urban RWH-systems can be evaluated, since in phase II hydrological data in urban areas has been collected and can be analyzed accordingly. Adopting RWH-systems to areas with extensive vegetation cover is usually costly and not easy to implement in agricultural areas. However, it is easy to implement in areas that have not been hitherto intensively exploited for agricultural production and advantageous in areas in which no irrigation water conveying systems are in place. Within the Jordan River Basin, the East and West areas appear to be appropriate regions for RWH implementation. The RWH-potential will be evaluated by slope-scale modeling, checked in Israel, Jordan and in the West Bank by existing empirical data and finally compiled into the basin-wide TRAIN-ZIN model to show large scale effects.

b) Key results and key products from phase II

- Hydrological data on surface runoff generation from natural hillslopes and urban areas.
- TRAIN-ZIN model simulations on surface runoff generation which serve as estimates for maximum RWH potentials.

c) Goals of phase III

- Evaluating the regional, real potential of different RWH-techniques (rural and urban) under present and scenario conditions.
- Assessment of possible (negative or side effects) large scale impacts (upstream-downstream conflict) of RWH.

Deliverables

a) Deliverables for WEAP and SAS

- Suitability maps for RWH in focus areas and in the entire LJRB.
- Maps of RWH-potentials in the entire LJRB including scenario conditions.

b) Scientific deliverables

Working titles for manuscripts

- Regional impacts of Rainwater Harvesting – harm or benefit?
- Integrated assessment of Rainwater Harvesting suitability in the LJRB using multiple methods on different scales

Working plan

a) Overview

Task 4.3.1a: Model based evaluation at the slope scale (BGU)

The RWH-potential will be evaluated at the slope scale by conceptual runoff modeling as a function of the slopes’ characteristics (inclination, soil type and depth), and rainstorm characteristics (i.e. rainstorm intensity and amount). Results will be further used for determining the optimum geometry of the water retention structures based on the extreme rainstorm events. An evaporation model includes the effect of slope inclination and aspect on incoming global radiation. The evaporation routine will be applied during rainless (dry) periods in order to evaluate soil water content at the beginning of each storm for different soils and slope angles. Sub-daily rainfall distribution will be addressed by statistical tools in combination with existing information from radar data.

Task 4.3.1b: Empirical analysis in the West Bank and in Jordan (Mu'tah, WESI)

In parallel the model based RWH-potentials will be compared to empirical studies evaluating existing information in the region. General RWH-potentials of different catchments in the West Bank and in Jordan will be regionalized and mapped. Here existing knowledge and information from previous GLOWA JR-phases can be used, e.g. the empirical link between water yield (availability within a given area / catchment) and precipitation, or the link between soil moisture / water yield and slope orientation / steepness. In Jordan detailed microclimatic models will be used to investigate vertical heat and moisture transport to predict hydrological and agricultural potentials of slopes with different orientations and steepness. In the West Bank the analysis will concentrate on the Faria catchment, where existing focus area knowledge from phase II (e.g. runoff data from the two constructed flumes and the successfully applied TRAIN-ZIN model) can be used to directly assess harvestable amounts of water and different dictating parameters. These empirical studies will provide an independent "check" on results produced by slope-scale, model-based estimations. RWH- potentials will be evaluated for different natural and synthetic techniques (systems). For instance, a 200 m^2 rooftop in a 500 mm rainfall zone could produce up to 60-80 m^3 of fresh water annually that can be utilized for domestic purposes with the minimum level of cost.

Task 4.3.1c: Estimating large scale RWH potentials (Freiburg, Kassel, BGU, Mu'tah, WESI).

Finally, the regional, large scale impacts of RWH-measures (techniques) will be assessed using the TRAIN-ZIN model. In the areas identified previously, RWH-potentials will be simulated under different rainfall intensities and the impact on regional water resources will be assessed during average years and especially during droughts (1998/99). This analysis will show possible negative impacts of RWH on the distribution of regional water resources including MAR and SEB (see below). In terms of a regional assessment first areas with general RWH-suitability (under present land-use) will be defined. Then estimates on quantitative RWH-potentials (m^3 of storage per km^2), i.e. RWH-potential maps for the entire LJRB will be given. Maximum RWH-potentials can directly be deduced from unit volumes of overland flow already simulated in phase II and will serve as an early starting point for LandSHIFT scenarios. Then, step by step RWH-potential maps will be refined by the smaller scale analyses (Tasks 4.3.1a/b). Since both climate and land-use changes are implemented into TRAIN-ZIN scenario runs (see P4.2.1), different RWH-potential maps will be produced for scenario conditions defined by LandSHIFT (P3.3) and projected climatic changes (P4.1).

b) Milestones

Task 4.3.1a

09/2009: Estimation of RWH-potentials at the slope-scale depending on slope-soil-rainfall information.

09/2010: Full scale implementation of the hydrological and evaporation models and optimization of RWH-systems under a variety of slope angles, aspects and soil types.

Task 4.3.1b

09/2009: Estimation of RWH-potentials for different natural and synthetic systems.

09/2010: Map of general RWH-potentials in the West Bank and in Jordan will be developed.

Task 4.3.1c

03/2009: Estimation of maximum RWH-potentials (m^3 storage per km^2).

09/2009: Creation of a RWH suitability map.

03/2010: Quantitative estimation of RWH-potentials (m^3 storage per km^2).

03/2011: Creation of RWH-potential maps for land use and climate change scenarios.

4.3.2: MANAGED AQUIFER RECHARGE (MAR) – SUSTAINING ENVIRONMENTAL BASEFLOW (SEB)

Germany: J. Lange (University of Freiburg), L. Menzel (University of Kassel)

Palestinian Authority: M. Almasri & A. Jayyousi & H. Shaheen (An-Najah University)

Introduction

a) Background

Two complementary ways of using flows in the streams on both sides of the Lower Jordan River will be investigated in this sub-project.

- Managed aquifer recharge (MAR): Hydraulic structures can be placed inside the streams to temporally store floodwater of rainfall events and to allow a controlled percolation into the ground at predefined locations.
- Sustaining environmental baseflow (SEB): Many karstic springs exist in the tributaries of the Lower Jordan River and are used for different purposes. It is interesting but has never been studied, how much spring discharge must theoretically be diverted to the streams to reach the Lower Jordan River to keep up environmental baseflow.

Both procedures can be estimated by the transmission loss routine in the TRAIN-ZIN model. Quantifying diminishing floods will yield estimates of available floodwaters to be stored by dams or recharge ponds (MAR) and will directly show the necessary spring flow in the streams for SEB. In both phase II focus areas (Harod and Faria) large springs exist with known water yields and quality. Hence first assessments are quickly possible. Water quality deterioration (mainly wastewater inputs) will be included with known data from phase II (Faria catchment). For MAR also losses due to evaporation will be regarded and the impact on underlying aquifers is assessed by groundwater modeling (Faria catchment). In a final step focus area knowledge will be upscaled to the entire LJRB.

b) Key results and key products from phase II

- The TRAIN-ZIN model simulations in focus areas and in the entire LJRB with possibilities to quantify river flows available for MAR and SEB.

c) Goals of phase III

- Evaluating best locations and the possible impacts of MAR.
- Evaluating different options for SEB in the Lower Jordan River.

Deliverables

a) Deliverables to WEAP and SAS

- Suitability maps for MAR in focus areas and in the entire LJRB.
- Report on different options for SEB in the LJRB.

b) Scientific deliverables

Working titles for manuscripts

- Artificial enhancement of groundwater recharge in the Lower Jordan River Basin.
- Options for restoring the Lower Jordan River in an area of limited water resources availability.

Working plan

a) Overview

Task 4.3.2a: MAR investigations in the Faria catchment (WESI)

A detailed MAR investigation will be carried out in a phase III focus area, the Faria catchment. Efficiencies of possible sites for MAR will be chosen based on soil characteristics and subsurface geologic features and formations. Central inputs to be included are available volumes of streamflow at different locations within the channel network. These can directly be derived from TRAIN-ZIN simulations of phase II. For hydrogeological information a close collaboration with the SMART project is intended. Since Faria is one of the focus basins also in SMART, detailed information on geology and hydrogeology is collected within this project and can be used to identify appropriate MAR-locations in terms of aquifer storage and infiltration characteristics. SMART-information will also help to study the impact of MAR on groundwater and springs. Here the parameterization of WEAP-MODFLOW can be improved by SMART-information. A general agreement to collaborate in the Faria catchment was reached; specific steps will be arranged by the local partners (WESI). In return SMART will obtain simulated flow characteristics in the streams of the Faria catchment and connected volumes lost by transmission losses, both at average and drought conditions. To include water quality into the analysis, existing data on stream water quality (often deteriorated by wastewater) and groundwater quality will be analyzed. Since groundwater pollution by MAR must be excluded, locations with high potential of wastewater contaminants will be excluded.

This task will be mainly carried out by a PhD at An-Najah University building upon the results gained in GLOWA JR phase II. External supervision will be executed by the University of Freiburg (Prof. Weiler) and includes a nine months stay in Germany.

Task 4.3.2 b: MAR and SEB analysis in the entire LJRC (Freiburg-Kassel)

Using the regional TRAIN-ZIN-simulations spatially distributed information on volumes of river flow and volumes of transmission losses along the stream courses can be calculated for the entire LJRB. To determine possible MAR-locations the underlying aquifers will be classified with the help of geological maps (porous, karstic, sandstone and other hard rock aquifers) and combined with the spatially distributed analysis of available river flow. As such rough estimates of MAR-capacities can be obtained for the LJRB and displayed in maps.

As a second aspect SEB will be analyzed. In model scenarios in the two focus areas (Harod and Faria) the all available spring discharge is assumed to be diverted into the rivers. The transmission loss routine in the TRAIN-ZIN model then calculates the amount of flow lost to the underground before it enters the Lower Jordan River. Both focus areas are known to include the largest springs in the western side of the Lower Jordan River and have the highest potential for SEB (a part form opening the dam at the lower end of the Kinneret Lake). Especially springs of increased salinity inside Nahal Harod, which cannot be used for domestic purposes directly, seem to be appropriate.

b) Milestones

Task 4.3.2a

09/2009: Analysis of available water (quantity and quality) for MAR.

03/2010: Suitability map of MAR-potentials in the Faria catchment.

Task 4.3.2b

09/2009: General map of MAR-potentials in the LJRB

09/2010: Detailed evaluation of MAR-locations and capacities.

03/2011: Report on different options for SEB in the Lower Jordan River.

SUBPROJECT 4.4: SOFT COUPLING OF WEAP AND TRAIN-ZIN FOR CONJUNCTIVE GREEN / BLUE WATER MANAGEMENT IN THE LOWER JORDAN RIVER

Germany: J. Lange (University of Freiburg), L. Menzel (University of Kassel)

Israel: T. Grodek & E. Morin & Y. Enzel (Hebrew University of Jerusalem)

Others: H. Hoff & E. Kemp-Benedict & J. Sieber (SEI)

Palestinian Authority: M. Almasri & A. Jayyousi & H. Shaheen (An-Najah University)

Introduction

a) Background

In this subproject, WEAP will be coupled to TRAIN-ZIN by transient data exchange at pre-defined nodes of the channel network. With this tool, options for sustainable blue / green water management can be outlined based on existing knowledge (project phases I and II, P4.2) and RWH, MAR and SEB-options can be implemented (P4.3). As such the simulation of hydrological feedbacks becomes possible: While WEAP allows scenarios of management decisions regarding distribution of water resources (also including additional amounts of water from desalinization, or the Red Sea-Dead Sea Canal; P1.2, P2), TRAIN-ZIN can update the water balance with this additional water to be used, e.g. for irrigation and/or MAR, SEB. In the TRAIN-ZIN model relationships between soil water status and transpiration for different crops and other vegetation types will be implemented, information will be shared with LandSHIFT to arrive at realistic scenarios of crop distribution. Also water lost by channel transmission losses in the Wadi channels can be calculated. The updated water balance is then returned to WEAP which facilitates accurate statements on the amount of water actually needed for different purposes. After the successful coupling, a tool is ready to model scenarios requested by other subprojects, e.g. regarding new water sources. Data exchange with the WEAP-project (P.1.2) will be intense – in P1.2 management options of the regional WEAP (including both the upper and lower Jordan River) are studied, but physically the coupled WEAP-TRAIN-ZIN system stays in Freiburg.

b) Key results and key products from phase II

- Adopted TRAIN-ZIN model simulations in focus areas and in the entire LJRC.

c) Goals of phase III

- Generation of a WEAP-TRAIN-ZIN modeling system to simulate water management options and feedbacks to the water balance

Deliverables

a) Deliverables to WEAP and SAS

- Soft, transient coupling of TRAIN-ZIN to WEAP in focus areas and in the entire LJRC.
- Results of applications with the WEAP-TRAIN-ZIN requested by other subprojects.

Working plan

a) Overview

Task 4.4a: Soft coupling of WEAP to TRAIN-ZIN in Focus areas (Freiburg-Kassel-HUJ-WESI)

Technically the transient, soft coupling of WEAP and TRAIN-ZIN will be done in two scales. Based on the experiences from coupling TRAIN and ZIN, the coupling is first performed and tested at the basin scale in the focus areas Nahal Harod and Wadi Faria. Here the existing models from phase II can be directly used. Once a local WEAP is set up in Freiburg for these basins, transient data exchange can start at the very beginning of phase III. For this purpose, an infrastructure will be created that allows the exchange of data, e.g. withdrawal of water and water balances, and consequently feedbacks between the two systems.

The tool is then ready for implementation of different water management options, predefined by and undertaken in close cooperation with the WEAP subproject P1.2. In Wadi Faria main options of basin management include the use of waste water for irrigation (in close cooperation with the Marschner group, see 4.3.3), but also MAR/SEB (4.3.2) and RWH (4.3.1) potentials can be studied. Implementing experiences from 4.2.2 the efficiencies of these measures under drought conditions can be studied and estimates of drought vulnerability and a drought risk assessment is possible. In Nahal Harod, a typical agricultural basin, optimization of water use efficiencies of both rainfed agriculture and irrigation might lead to additional water resources.

Task 4.4b: Soft coupling of WEAP to TRAIN-ZIN at in the Lower Jordan River catchment (Freiburg-Kassel)

In the regional scale, transient data exchange will be set up between the regional WEAP and the regional TRAIN-ZIN models covering the entire LJRC. Benefiting from the experiences in the small scale, the soft, transient coupling will start early in phase III, but can step by step be improved by basin scale experience. Data will be exchanged at certain nodes of the channel network. The WEAP-TRAIN-ZIN modeling framework will finally be used for the execution of modeling tasks assigned by other subprojects, e.g. concerning the consequences of land-use changes or the effects of new water sources. The model will be configured and run according to the requirements of these subprojects that depend on the TRAIN-ZIN model for delivering results such as changed water balances to the WEAP model and thereby to the project. Thus, the SAS-scenarios on different options of water availability can directly be implemented for the Lower Jordan River. Subsequently, results can be integrated in the WEAP system for the whole Jordan basin administered by the WEAP subproject 1.2. All applications will be executed in cooperation with this subproject.

b) Milestones

Task 4.4a

03/2009: Soft coupling of WEAP and TRAIN-ZIN in focus areas

Iterative: September 2009 until March 2011: Implementation of water management options to calculate feedbacks on the water balance

Task 4.4b

09/2009: Soft coupling of WEAP and TRAIN-ZIN in the entire LJRC

Task 4.4c

Iterative: September 2009 until March 2011: Application of the WEAP-TRAIN-ZIN tool in the LJRC

Annex 4.1: Overall working plan project 4

Tab. 4.3: Overall working plan project 4.2, 4.3 and 4.4.

Task	**Deliverable**	**Milestone**
4.2.1 Water balance projections		
4.2.1a	Water balances for main land-use types	March 2009
	Detailed maps (1x1 km) of blue / green water resources	September 2009
4.2.1b	Long-term averages and high resolution maps (1x1 km) of water balance components for scenarios	March 2010
4.2.1c	Scenario maps with land-use mitigation options	September 2010
4.2.1d	Report on large scale validation of TRAIN-ZIN	March 2010
4.2.1e	Report on hydrological effects of recent and future land-use changes	September 2011
4.2.2 Hydrological drought analysis		
4.2.2a	Assessment of hydrological boundary conditions related to droughts (short report)	March 2009
	Spatial distributions of precipitation in drought years utilizing radar rainfall data (maps)	March 2009
	Sensitivity of droughts to hydro-meteorological indexes (short report)	September 2009
	Determination of frequencies for hydrological droughts in the region in the past, present and future (short report)	March 2010
4.2.2b	Determination of the spatial extent of hydrological droughts in the region affecting rainfed agriculture (maps)	Aug/2009
4.2.2c	Assessment of processes and hydrological driving forces that intensify droughts in catchments (short report)	March 2009
	Evaluation of management options to mitigate drought impacts and predicted adverse hydrological developments from climate change (report)	March 2010
4.2.2d	Identification of most suited drought index for future assessments	September 2009
4.2.2d	Analysis of the effects of the climate change on the boundary of rainfed agriculture	September 2010
4.2.3 Interactions of climate (Temp., Precipitation, CO2) and land-use (afforestation) on		

water yield		
4.2.3.a	Simulations of water budgets by the adopted TRAIN-ZIN model accounting for the effect of increased CO_2	September 2009
4.2.3.b	Simulations of water budgets for shrubland/forests	March 2010
	Simulations of water budgets for shrubland/forests under climate scenario conditions	September 2010
4.3.1 Rainwater harvesting (RWH)		
4.3.1a	Estimation of RWH-potential at the slope scale depending on slope-soil-rainfall information	September 2009
	Full scale implementation of the hydrological and evaporation models and optimization of RWH systems under a variety of slope angles, aspects and soil types.	September 2010
4.3.1b	Estimation of water harvesting potentials for different natural and synthetic techniques	September 2009
	Map of general RWH potentials in the West Bank and in Jordan	September 2010
4.3.1c	Estimation of maximum RWH-potentials (m^3 storage per km^2)	March 2009
	Generation of a RWH suitability map	September 2009
	Quantitative estimation of RWH potentials (m^3 storage per km^2)	March 2010
	Generation of RWH-potential maps for land-use and climate scenarios	March 2011
4.3.2 Managed aquifer recharge (MAR) – sustaining environmental baseflow (SEB)		
4.3.2a	Analysis of available water (quantity and quality) for MAR	September 2009
	Suitability map of MAR potentials in Faria catchment	March 2010
4.3.2b	General map of MAR potentials in the LJRC	September 2009
	Detailed evaluation of MAR locations and capacities	September 2010
	Report on different options for SEB in the lower Jordan River	March 2011
4.4 Soft coupling of WEAP and TRAIN-ZIN for conjunctive green / blue water management in the Lower Jordan		
4.4a	Soft coupling of WEAP and TRAIN-ZIN in focus	March 2009

	areas	
	Implementation of water management options to calculate feedbacks on the water balance	Iterative: September 2009 until March 2011
4.4b	Soft coupling of WEAP and TRAIN-ZIN in the entire LJRC	September 2009
4.4c	Application of the WEAP-TRAIN-ZIN tool in the LJRC	Iterative: September 2009 until March 2011

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ANNEX A: ABBREVIATIONS

AAA	Arab Agronomist Association
AIES	Arava Institute for Environmental Studies
ATEEC	Arab Technologist for Economical and Environmental Consultations
AVOW	Alternative Visions of Water
BEM	Bioclimatic Envelope Models
BERC	Biodiversity & Environmental Research Center
BGR	Federal Institute for Geosciences and Natural Resources / Bundesamt für Geowissenschaften und Rohstoffe
BGU	Ben-Gurion University
BMBF	Federal Ministry of Education and Research
BT	Benefit Transfer
CC	Climate Change
CD	Compact Disc
CPU	Central Processing Unit
CVM	Contingent Valuation Method
E	East
EC	European Commission
ECHAM	European Centre Hamburg Model (a Global Climate Model)
ET	Evapotranspiration
EVRI	Environmental Valuation Reference Inventory
EXACT	Executive Action Team
FAO	Food and Agriculture Organization of the United Nations
GCC	Global Climate Change
GCM	General Circulation Model
GDP	Gross Domestic Product
GIS	Geographical Information System
GLCC	Global Land Cover Characterization
GLOWA	Global Change in the Hydrological Cycle
GLOWA JR	GLOWA Jordan River Project
GTZ	German Technical Cooperation / Deutsche Gesellschaft für Technische Zusammenarbeit
H	Sensible heat
HadCM	Hadley Center Climate Model
HPC	High Performance Computing
HUJ	Hebrew University of Jerusalem
HWE	House of Water and Environment
HYMKE	Hydrological Model for Karst Environment
ICTP	International Centre for Theoretical Physics
IDA	International Development Association

IMK-IFU	Atmospheric Environmental Research Division of the Institute of Meteorology and Climate Research / Institut für Meteorologie und Klimaforschung, Research Centre Karlsruhe
IPCC	Intergovernmental Panel on Climate Change
IPCRI	Israel-Palestine Center for Research and Information
IWRM	Integrated Water Resource Management
JAC	Joint Advisory Committee
JRB	Jordan River Basin
JRR	Jordan River region
KfW	German development bank / Kreditanstalt für Wiederaufbau
KLL	Kinneret Limnological Laboratories
LAI	Leaf area index
LandSHIFT	Model for land simulation to harmonize and integrate freshwater availability and the terrestrial environment
LASCAM	Large Scale Catchment Model
LE	Latent heat of evaporation
LJRC	Lower Jordan River catchment
LSU	Lifestock unit
LTER	Long-term ecological research stations
MAR	Managed aquifer recharge
MENA	Middle East and North Africa
MM (e.g. MM4, MM5)	Mesoscale Model (version 4, 5) (a Regional Climate Model)
MoA	Ministry of Agriculture (Palestinian Authority)
MODFLOW	Three-dimensional finite-difference groundwater flow model
MOST	Israel Ministry of Science Culture and Sports
MWI	Ministry of Water and Irrigation (Jordan)
N	North
NCARTT	National Center for Agricultural Research and Extension
NEE	Net ecosystem (CO_2) exchange
NGO	Non-governmental organization
NUV	Non-use value
NVP	Net present value
NWC	National Water Carrier (Israel)
NWMP	National Water Master Plan (Jordan)
PA	Palestinian Authority
PAR	Photosynthetically Available Radiation
PARC	Palestinian Agricultural Relief Committees
PBL	Planetary Boundary Layer
PHG	Palestinian Hydrology Group
PWA	Palestinian Water Authority
RegCM3	A Regional Climate Model based on MM4
RSCN	Royal society for the conservation of nature
RSDSC	Red Sea-Dead Sea Conduit

RWH	Rainwater harvesting
SAS	Story and Simulation
SEB	Sustaining environmental baseflow
SEI	Stockholm Environment Institute
SHK	Student helper / Studentische Hilfskraft
SMART	Sustainable Management of Available Water Resources with Innovative Technologies Project
SPNI	Society for the Preservation of Nature in Israel
TAU	Tel Aviv University
TDR	Time Domain Reflectometry
TRAIN	SVAT-model, originally to simulate Transpiration and Interception
TV-L	State employees salary scheme TV-L
TWW	Treated wastewater
UJR	Upper Jordan River
UK	University of Kassel
UN	United Nations
UT	University of Tübingen
VALUE	Vegetative Agricultural Land Use Economic Model
WADISCAPE	Spatially explicit landscape model
WEAP	Water Evaluation and Planning Tool
WESI	Water and Environmental Studies Institute
WHK	Research assistant / Wissenschaftliche Hilfskraft
WP	Work package
WTP	willingness-to-pay
WUE	Water use efficiency
WY	Water yield
ZALF	Leibniz Centre for Agricultural Landscape Research
ZIN	Rainfall-runoff model, originally used in the ZIN watershed

ANNEX B: DELIVERABLES

Table A.1: Expected main deliverables of all subprojects.

Project	Deliverable	Due Date	To
1.1	Potential management strategies for the four scenarios	iterative	1.2
1.1	Final scenario information for vegetation modeling: median small livestock density per climatic/geographic region, use of uncultivated land for other purposes than rangeland that might affect the vegetation.	07/10	3.1.1
1.1	Quantitative data about level of income, population growth and economic development	12/09	3.2
1.1	Final scenario information for land use modeling (e.g. technological development and state-specific and scenario-specific attitudes)	07/10	3
1.2	Regional and sub-regional water balance and economic evaluation for the four scenarios	iterative	1.1
1.2	Information about water supply from various sources incl. new water sources	iterative	3, 1.1
2	"New Water" from water transfer (e.g. Red Sea-Dead Sea Canal): Estimates of annual yield (m^3/yr), lifetime of resource (yr) (e.g. of fossil groundwater), "quality level" (to be defined), spatial distribution of resource and potential distribution to demand sites, and preliminary estimates of costs ($/$m^3$) and side impacts.	First results: 02/09 Final results: 12/09	1.1, 1.2
2	"New Water" from desalination: Estimates of current and future annual volume of desalination (m^3/yr) (seawater and brackish water); spatial of resource and potential distribution to demand sites, preliminary estimates of costs and side impacts	First results: 02/09 Final results: 12/09	1.1, 1.2
2	"New Water" from waste water re-use: Estimates of current and future annual volume of usable wastewater (m^3/yr) (volume in different quality categories); spatial distribution of resource and potential distribution to demand sites, estimates of costs (in cooperation with P3.4.2)	First results: 02/09 Final results: 12/09	1.1, 1.2
2	Blue Water Demand (current situation and business-as-usual scenarios): Estimates of current and future annual water withdrawals (m^3/yr), water consumption(m^3/yr); water productivity ($/$m^3$-yr); spatially and temporally (e.g. seasonal patterns) defined. For following water-use sectors: - Domestic - Irrigation - Livestock - Manufacturing - Electrical generation - Tourism Demand Management: Estimation of water savings potential for above water-use sectors together with preliminary estimate of costs ($/$m^3$)	First results: 02/09 Final results: 12/09	1.1, 1.2
2	Virtual water flows: annual flows of imports and exports, origin / destinations and value of imported / exported commodities, trends and future potential	First results: 02/09 Final results: 12/09	1.1, 1.2

Project	Deliverable	Due Date	To
2	Scenario driving forces in Israel, Jordan and PA: Data on demographic and economic development, international food trade and national planning strategies (in cooperation with P3.2, P3.3 and P1.1)	First results: 02/09 Final results: 12/09	1.1, 1.2
3.1.1	Required projections of biomass, LAI, vegetation height, cover and stocking capacity for GLOWA climate scenarios and land use scenarios: (equations, interpolated results, maps)	04/09	1.1, 3.3, 4.2
3.1.1	Required projections of biomass, LAI, vegetation height, cover and stocking capacity for new GLOWA climate and land use scenarios: (equations, interpolated results, maps)	12/09	1.1, 3.3, 4.2
3.1.1	Regional maps of vulnerability of biomass production and biodiversity	04/10	1.1, 3.3
3.1.1	Runoff and ground water recharge values for specific watersheds	12/09	1.2, 4.2
3.1.1	Maps and values of water (rain) productivity in rangeland	12/09	1.1, 1.2
3.1.1 3.1.2	Maps of floristic diversity and extinction risks	12/09 refined 12/10	1.1, 3.1.3, 3.2
3.1.1	Final maps of ecosystem services in open space under climate change and land use change	12/10	1.1, 3.2, 3.3
3.1.2	Data input of extinction probability, biomass and diversity	08/09 refined 10/10	3.1.1
3.1.2	Data input of calibrating and validating data, land use effects for large-scale vegetation models	08/10	3.1.1
3.1.3	Maps of mammal distribution under GLOWA climate and land use scenarios and regional planning scenarios	03/09	1.1, 3.1.1
3.2	Values of ecosystems to be used in maps	08/10	3.1.1, 3.3
3.2	Welfare levels under the different scenarios	08/10	1.1, 3.3
3.3	Maps of land use change (e.g. grazing dynamics, open space and expansion of cropland) and water requirements (amounts) for livestock and settlements	iterative	1.1, 3.1.1
3.3	Maps of impacts of land use change on ecosystem services	12/09	1.1
3.4.1	Yield distributions and effects on water demand for the main types of rain-fed crops/orchards-soil combinations	08/09	4.2, 3.2, 3.3
3.4.1	Internal drainage patterns for the various crop/soil combinations	08/09	4.2, 3.2
3.4.1	Crop/orchard distribution	08/09	3.3
3.4.2	TWW irrigation maps	08/09	1.1, 1.2, 3.3
3.4.2	Region-wide, spatially-explicit, quantitative information about the potential of certain areas for TWW application at a relevant scale	06/10	3.3, 1.1, 1.2
3.4.2	Suitability maps for evaluating optimal land allocation	06/10	3.3
4.1	Future downscaled climate simulations: Evaluation of average trends and probability of climatic extremes	09/09	1.1, All impact projects
4.2.1	Water balances for main land use types	03/09	1.1, 1.2, 3.3
4.2.1	Maps of blue/green water resources	09/09	1.1, 1.2, 3.1.1, 3.3
4.2.1	Long-term averages and high resolution maps of water balance components for scenarios	03/10	1.1, 1.2, 3.3

Project	Deliverable	Due Date	To
4.2.1	Scenario maps with selected land-use mitigation options	09/10	1.1, 1.2, 3.3
4.2.1	Impact of environmental change scenarios on water resources	09/10	1.1, 1.2
4.2.2	Spatial distributions of precipitation in drought years utilizing radar rainfall data (maps)	03/09	1.1, 1.2, 3.1.1, 3.3, 4.1
4.2.2	Determination of the spatial extent of hydrological droughts in the region affecting rainfed land use (maps)	08/09	1.1, 1.2, 3.1.1, 3.3
4.2.2	Evaluation of management options to mitigate drought impacts and predicted adverse hydrolog. impacts from climate change	03/10	1.1., 1.2, 3.1.1, 3.3
4.2.3	Simulations of water budgets by the adopted TRAIN-ZIN model accounting for the effect of increased CO2	09/09	1.1, 1.2
4.2.3	Simulations of water budgets for shrubland/forests	03/10	1.1, 1.2
4.2.3	Simulations of water budgets for shrubland/forests under climate scenario conditions	09/10	1.1, 1.2, 3.1.1
4.3.1	Quantitative estimation of RWH potentials (m^3 storage per km^2)	03/10	1.1, 1.2
4.3.1	Generation of RWH-potential maps for land-use and climate scenarios	03/11	1.1, 1.2, 3.3
4.3.2	Suitability map of MAR potentials in Faria catchment	03/10	1.1, 1.2
4.3.2	Detailed evaluation of MAR locations and capacities	09/10	1.1, 1.2
4.3.2	Evaluation of different options for SEB in the LJRC	03/11	1.1., 1.2
4.4	Soft coupling of WEAP with TRAIN-ZIN in the LJRC	09/09	1.2
4.4	Implementation of water management options to calculate feedbacks on the water balance	Iterative	1.2

ANNEX C: SCHEDULE OF GLOWA JR PHASE III

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1.1	1.1a Scenario Panel meetings		▨												▨												▨										
	1.1b Consultation with stakeholders							▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨						
	1.1c Elaboration of storylines			▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨		▨	▨	▨	▨						
	1.1d Quantifying storylines	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨						
	1.1e Preparing input for scenarios	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨						
	1.1f Preliminary sustainability analysis													▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨						
1.2	1.2a Definition of adaptation options to be evaluated in each WEAP model	▨	▨	▨	▨	▨	▨																														

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1.2	1.2b Data consolidation and assimilation in the WEAP models	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																		
	1.2c Testing WEAP results with stakeholders and adjustments													▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨						
	1.2d Presentation and discussion of WEAP results (dissemination) within and beyond GLOWA (1.3a)																			▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
	1.2e WEAP support for partners and water management institutions, incl. implementation for operational use	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
	1.2f WEAP training workshops in each country								▨												▨												▨				
	1.2g WEAP mainstreaming with SAS scenario development		▨												▨												▨										
1.3	1.3b Direct meetings with stakeholders	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
	1.3c Presentation of a Scenario-Viewer		▨												▨												▨				▨						

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1.3	1.3d Distribution of GIS data (maps) produced in GLOWA JR	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	1.3e Distribution of Scenario Workshop Reports				■												■												■								
	1.3f, i Scientific Papers and Other Printed Products, Website	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
	1.3g Kick-off meeting, status conference and final wrap-up conference		■													■															■						
	1.3h Follow up meetings																															■	■	■	■	■	■ >>
2	Data consolidation	■	■	■	■	■	■	■	■	■	■	■	■																								
	Identification of remaining data gaps, collecting additional information													■	■	■	■	■	■	■	■	■	■	■	■												

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3.1.1	3.1.1a Final projections of biomass, LAI, vegetation height and stocking capacity based on final climate simulations	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																				
	3.1.1c climatic extremes and their effect on the vulnerability of ecosystem services									▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨												
	3.1.1d Application of the existing regional vegetation-runoff model to other watersheds	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨												
	3.1.1e Floristic diversity, vulnerability assessment, initial extinction risks (maps), indicators									▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨															
	3.1.1f Guidelines, reports, manuscripts and wrap-up																									▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
3.1.2	3.1.2a Data input of extinction probability (improved estimates), biomass and diversity to 3.1.1	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨						
	3.1.2b input of calibrating and validating data, land use effects to 3.1.1	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨												
	3.1.2c integrated data analysis													▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨

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3.1.2	3.1.2d Manuscripts, wrap-up and dissemination																					▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
3.1.3	3.1.3a Impact of land use and management practices on biodiversity patterns	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨													
	3.1.3b Wrap up and dissemination, indicators of land use change and climate change																				▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
3.2	3.2a Prepare new runs of phase 2 socio-economic models	▨	▨	▨	▨	▨	▨	▨	▨						▨	▨	▨																				
	3.2b Analysis and evaluation of the monetary benefits of ecosystem services	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨												
	3.2c Wrap up, publications and dissemination																									▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
3.3	1 Calculation and test of crop yields under CC (3.4l)	▨	▨	▨	▨	▨	▨	▨	▨						▨	▨	▨																				
	2 Integration of TWW irrigation maps (3.4)	▨	▨	▨	▨	▨	▨	▨	▨						▨	▨	▨																				

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3.3	3 Implementation of LandSHIFT modules	▨	▨	▨	▨	▨	▨	▨	▨						▨	▨	▨																				
	4 Integration of input from 3.1.2 and 3.1.3									▨								▨					▨	▨	▨	▨	▨	▨	▨								
	5 Simulation of land use under different climate change and SAS scenarios																												▨	▨	▨	▨	▨	▨	▨	▨	▨
	6 Synthesis of final report and wrap up																	▨	▨										▨	▨	▨	▨	▨	▨	▨	▨	▨
3.4.1	3.4.1a Synthesis of crop distribution map 2000	▨	▨	▨	▨										▨	▨	▨																				
	3.4.1b Determination of the main crop/orchard distribution, calibration of the additional models.	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																								
	3.4.1c Map the future yields of the main agricultural types under cc scenarios and changes due to the introduction of PE mulching.													▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨												
3.4.2	3.4.2a TWW irrigation maps	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																								

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3.4.2	3.4.2b Suitability maps													▨	▨	▨	▨	▨	▨	▨	▨	▨	▨														
	3.4.2c Development of land use options, stakeholder dialogue																							▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
	3.4.2d Wrap up, dissemination																							▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
4.1	4.1a Simulation runs of climate change scenarios	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																							
	4.1b Final statistical analysis														▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨												
	4.1c Wrap up, publications and dissemination																									▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
4.2	4.2.1 Water balances for main land-use types (with 3.1.1)	▨	▨	▨	▨	▨	▨	▨																													
	4.2.1 Detailed maps (1x1 km) of blue / green water resources	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																							

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
4.2	4.2.1 Long-term averages and high resolution maps of water balance components for scenarios														▨	▨	▨	▨	▨	▨																	
	4.2.1 Scenario maps with land-use mitigation options																				▨	▨	▨	▨	▨	▨											
	4.2.1 Impact of environmental change scenarios on water resources	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																							
	4.2.2 Spatial distributions of precipitation in drought years utilizing radar rainfall data	▨	▨	▨	▨	▨	▨	▨																													
	4.2.2 Sensitivity of droughts to hydro-meteorological indices; identification of most suited drought index for future assessment	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																							
	4.2.2 Determination of frequencies for hydrological droughts in the region in the past, present and future														▨	▨	▨	▨	▨	▨																	
	4.2.2 Determination of the spatial extent of hydrological droughts in the region affecting rainfed agriculture	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																								
	4.2.2 Evaluation of water storage options to mitigate impacts of drought and extreme events								▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																	

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4.2	4.2.2 Analysis of the effects of climate change on the boundary of rainfed agriculture (with 3.1.1)														■	■	■	■	■	■	■	■	■	■	■	■											
	4.2.3 Simulations of five year water budgets using the collected data of GLOWA phases I and II	■	■	■	■	■	■	■							■	■	■	■	■	■	■	■	■	■	■	■											
	4.2.3 Simulations of water budgets by the adopted TRAIN-ZIN model accounting for the effect of increased CO2	■	■	■	■	■	■	■	■	■	■	■	■	■																							
	4.2.3 Simulations of water budgets for shrubland/forests (with 3.1.1)														■	■	■	■	■	■																	
	4.2.3 Simulations of water budgets for shrubland/forests under climate scenario conditions (with 3.1.1)																				■	■	■	■	■	■											
	4.2 Wrap up, publications and dissemination																									■	■	■	■	■	■	■	■	■	■	■	■
4.3	4.3.1 Optimization of RWH systems under a variety of slope angels, aspects and soils types														■	■	■	■	■	■	■	■	■	■	■	■											
	4.3.1 Estimation of water harvesting potentials for different natural and synthetic techniques	■	■	■	■	■	■	■	■	■	■	■	■	■																							

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4.3	4.3.1 Generation of RWH-potential maps for land-use and climate scenarios																				▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨					
	4.3.1 Quantitative estimation of RWH potentials (m³ storage per km²)								▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																	
	4.3.2 Analysis of available water (quantity and quality) for MAR	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																							
	4.3.2 Suitability map of MAR potentials in Faria catchment											▨	▨	▨	▨	▨	▨	▨	▨	▨																	
	4.3.2 Detailed evaluation of MAR locations and capacities in the LJRC														▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨											
	4.3.Evaluation of different options for SEB in the lower Jordan River																				▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨					
	4.3 Wrap up, publications and dissemination																									▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
4.4	4.4 Soft coupling of WEAP and TRAIN-ZIN in focus areas	▨	▨	▨	▨	▨	▨	▨																													
	4.4 Soft coupling of WEAP and TRAIN-ZIN in the entire LJRC	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨																							

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4.4	4.4 Application of the WEAP-TRAIN-ZIN tool in the LJRC incl. implementing water management options													▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨					
	4.4 Wrap up, publications and dissemination																									▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨