Abstract Volume
7th Swiss Geoscience Meeting

Neuchâtel, 20th – 21st November 2009

9. Water and land resources in developing countries: towards innovative management and governance

sc | nat

Geosciences
Platform of the Swiss Academy of Sciences

Centre d'hydrogéologie

9. Water and land resources in developing countries: towards innovative management and governance

Hans Hurni, Urs Wiesmann, Thomas Breu

NCCR North-South; Centre for Development and Environment; Swisspeace Foundation; Swiss National Science Foundation; Swiss Agency for Development and Cooperation; Commission for Research Partnerships with Developping Countries (KFPE)

9.1 Ehrensperger A. : Bioenergy in Africa: Opportunities and threats of Jatropha and related crops

9.2 Exarchou J., Salim N. : Water Governance as a tool to ensure sustainable and secure human development, in the Middle East

9.3 Goetschel L., Péclard D. : Conflicts and natural resources. Research results and outlook

9.4 Liniger HP., Schwilch G., Mekdaschi Studer R. : Local and regional sustainable land management options based on assessed experiences

9.5 Maselli D., Ur-Rahim I. : From a technocratic to a custodianship approach: Putting herders at the centre of pasture management in Kyrgyzstan

9.6 Mejri Z., Ben Hamza C., Hatira N., Abidi R. : Repartition et hydrochimie des aquiferes de l'extremite nord occidentales flysch numidien, (Tunisie septentrionale)

9.7 Notter B., Hurni H., Abbaspour K. : Using the SWAT hydrological model to quantify water-related ecosystem services in a large East African watershed

9.8 Thüring M., Trotman A., Moore A. : Caribbean Water Monitor: Small island states, water resources and climate change

9.9 Wolfgramm B., Bühlmann E., Liniger HP.,Hurni H. : GIS-based decision support for soil conservation planning in Tajikistan

9.1

Bioenergy in Africa: Opportunities and threats of Jatropha and related crops

Ehrensperger Albrecht[1]

[1] *Centre for Development and Environment, Universität Bern (albrecht.ehrensperger@cde.unibe.ch)*

The development of the bioenergy sector is pushed worldwide in face of climate change and the expected shortage of fossil fuels. Biofuels have the potential to raise export revenues, to create new jobs and to develop industries in developing countries, but also to reduce dependency on oil imports (KOJIMA and JOHNSON 2005, SIMS, HASTINGS et al. 2006). More biofuel also means less use of fossil fuels. Models show that this would help reduce the price of oil, to the benefit of other developing countries that cannot grow biofuel feedstock. As a consequence of these environmental and economic opportunities, production of bio-ethanol from corn and sugar cane and production of biodiesel from rape and soy oil rapidly grew over the last years. However, current research unveiled significant impacts of bioenergy on the environment (ZAH, HISCHIER,GAUCH, LEHMANN, BÖNI and WÄGER 2007; SCHARLEMANN and LAURANCE 2008), on land use competition between energy and food crops (REINHARD and ZAH 2008; SEARCHINGER, HEIMLICH et al. 2008), as well as a strong dependence of the biofuels market on subsidies (STEENBLIK 2007).

This Bioenergy in Africa (BIA) project addresses important issues of sustainable development in connection to the production of biofuels, like food security, poverty alleviation, rural development and natural resources. By using a systemic approach, the project will provide pathways towards realistic and sustainable production of bioenergy in Eastern Africa. The approaches by which the opportunities of biofuel production can be maximised and its threats minimised are at the core of this approach. They include land use, livelihood strategies, natural resources management and policies. Specifically, the project looks at four aspects of biofuel production (see figure next page):

1. **Crop growth and processing**: Assessing sustainable bioenergy production potentials and processing of Jatropha biomass in different production systems and under different environmental and cultural settings.
2. **Impacts of biofuel production**: Assessing the socio-economic and environmental impacts of biofuel production in local contexts with a focus on local livelihoods and natural resources dynamics.
3. **Global policy, trade and certification**: Assessing the influence of external socio-political and economic decision-making processes on the regional and local biofuel production processes in Eastern Africa.
4. **Potentials of biofuel in Eastern Africa**: Upscaling findings in view of providing relevant decision-making and planning tools at the national and regional levels in Eastern Africa.

The integration of project results at a regional scale will provide highly relevant baseline information for a broad range of potential users. Concrete impacts are expected as follows:

- At the local scale: Enhanced capacity of farmers in crop production and biofuel processing.
- At the sub-national scale: Enhanced capacity of concerned governmental offices at district and provincial levels, to be achieved again via support to the extension services.
- At the national and regional scales: Better and more sustainable planning and policy making in relation to bioenergy production. Strengthening of the Eastern African Region through advocacy of its needs, priorities and potentials.
- At the global level: Impact on the global discourse on biofuel

REFERENCES

Kojima, M. and T. Johnson (2005). Potential for Biofuels for Transport in Developing Countries. Washington, World Bank: 150

Reinhard, J. and R. Zah (2008). "Consequential Life Cycle Assessment of the Environmental Impacts of an Increased Rapemethylester (RME) Production in Switzerland." Biomass & Bioenergy.

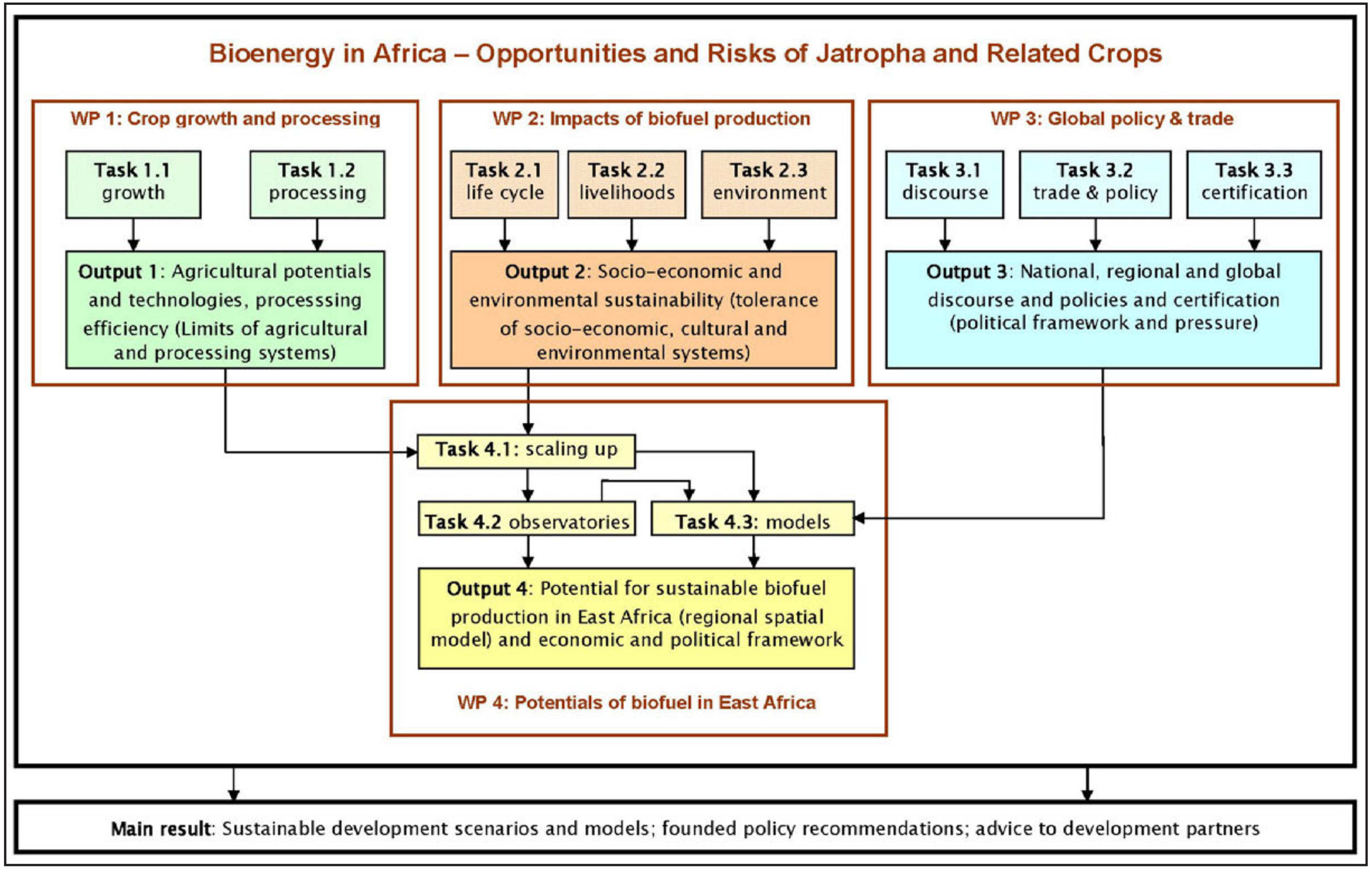
Scharlemann, J. P. W. and W. F. Laurance (2008). "How green are biofuels?" Science 319: 43-44.

Searchinger, T., R. Heimlich, R. A. Houghton, F. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes and T.-H. Yu (2008). "Use of U. S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions from Land Use Change." Science 319 (5867): 1238 - 1240.

Steenblik, R. (2007). Government support for ethanol and biodiesel in selected OECD countries - A synthesis of reports addressing subsidies for biofuels in Australia, Canada, the European Union, Switzerland and the United States, GSI - Global Subsidies Initiative: 82.

Sims, R., A. Hastings, B. Schlamadinger, G. Taylor and P. Smith (2006). Energy crops: current status and future prospects. Global Change Biology.

Zah, R., R. Hischier, M. Gauch, M. Lehmann, H. Böni and P. Wäger (2007). Life Cycle Assessment of Energy Products: Environmental Impact Assessment of Biofuels. Bern, Bundesamt für Energie, Bundesamt für Umwelt, Bundesamt für Landwirtschaft: 20.


Bioenergy in Africa – Opportunities and Risks of Jatropha and Related Crops
WP 1: Crop growth and processing
Task 1.1 growth
Task 1.2 processing
Output 1: Agricultural potentials and technologies, processsing efficiency (Limits of agricultural and processing systems)
WP 2: Impacts of biofuel production
Task 2.1 life cycle
Task 2.2 livelihoods
Task 2.3 environment
Output 2: Socio-economic and environmental sustainability (tolerance of socio-economic, cultural and environmental systems)
WP 3: Global policy & trade
Task 3.1 discourse
Task 3.2 trade & policy
Task 3.3 certification
Output 3: National, regional and global discourse and policies and certification (political framework and pressure)
Task 4.1: scaling up
Task 4.2 observatories
Task 4.3: models
Output 4: Potential for sustainable biofuel production in East Africa (regional spatial model) and economic and political framework
WP 4: Potentials of biofuel in East Africa
Main result: Sustainable development scenarios and models; founded policy recommendations; advice to development partners

9.2

Water Governance as a tool to ensure sustainable and secure human development, in the Middle East

Exarchou Joanna[1], Salim Nidal[2]

[1] Global Institute for Water Environment and Health (GIWEH), Geneva- Switzerland.www.giweh.ch
[2] Global Institute for Water Environment and Health (GIWEH), Geneva- Switzerland.www.giweh.ch

A large proportion of the water resources in the Middle East is trans-boundary and final arrangements on water allocation between different countries in the region are not yet in place for “fair and equitable apportionment”. The Middle East region’s natural water is not only threatened, it is also threatening!

Water quality and quantity are the main challenges of the region. Beyond the challenges related to the management of resource scarcity there are hydro-political and trans-boundary considerations. The majority of the water resources in the region is rivers and aquifers that cut across borders. Other than the fact that this often hinders the efficient and equitable management of this water, the prospect of witnessing serious water conflicts in different parts of the region is very real.

When water resources in one community become scarce or threatened, the economic, social and environmental risks increase for everyone. Thus, a proactive integrated management approach is needed to balance the competing needs for this limited resource. “Water Sustainability” is a collaborative community-driven initiative, which requires the active participation of all members in the community. It seeks to establish new creative and coordinated water management strategies based on value addition and security for all stakeholders in the community.

The key aspects to be considered for the future prospective are the role of governance, while governance is considered as a process, so it is important to know 'how' it is done. Rules are brought in and decisions are made. From the other side, governance is a product (e.g. good governance, good decision making, bad governance).

One of the aims of the region is to improve sustainability through better water use efficiency and conservation. Water efficiency can be improved by adopting structural measures like improving technologies and non-structural measures such as water pricing, awareness raising, etc.
The second level of efficiency is related to the allocation and re-allocation of water resources to specific, higher-value uses and more equitable use by all stakeholders.
The highest level of efficiency is related to the inter-basin trade of water. As water is quite a bulky item to transport, trading water in its real form is costly, which is the reason why the concept of virtual water might comes into picture.

Governance in its several contexts such as (corporate governance, international governance, national governance and local governance) is needed in the area.

Cooperation in the management of scarcity and quality does not only occur at the government level but also that of corporations. The CEO Water Mandate within the Global Compact is an opportunity at the highest levels of management to commit to the improvement of water use efficiency.

9.3

Conflicts and Natural Resources. Research Results and Outlook

Laurent Goetschel[1], Didier Péclard[1]

[1] *Swisspeace Foundation, Sonnenbergstrasse 17, CH-3000 Bern 7 (laurent.goetschel@unibas.ch)*

The relations between natural resources and conflicts have a long history. For centuries, societies have used certain natural resources to pursue their interests and political goals. Until the end of the 18th century, for example, wood was of crucial importance to the sea powers. Today, oil is in the headlines of the media worldwide as an indispensable component of superpower politics, but also as a cause of conflict. This situation is referred to as geopolitics of conflicts connected with natural resources (so-called resource conflicts; see Le Billon 2005). However, states do not have the monopoly over appropriation of natural resources for political or military purposes. Control over natural resources or their use is also a significant factor with regard to tensions and even conflicts between societal groups – independently of whether the resources at stake are non-renewable (such as diamonds) or renewable (such as water or soil). Despite their long existence, the relations between natural resources and conflicts remain problematic and must be critically scrutinised. Based on various case studies we demonstrate that the notion of a direct causal link between the environment and conflicts, although widespread in the scientific literature, has no real empirical basis. Likewise, it is necessary to question the heuristic significance of this classical perspective: concentrating on ecological causal relations bears the risk of not paying due attention to the real historical, political and economic dimensions of these conflicts.

REFERENCES

Baechler G, Böge V, Klötzli S, Libiszewski S, Spillmann KR. 1996. *Kriegsursache Umweltzerstörung. Ökologische Konflikte in der Dritten Welt und Wege ihrer friedlichen Bearbeitung.* ENCOP Vol. 1. Zurich and Chur: Rüegger.

Bichsel C. 2006. *Dangerous Divides: Irrigation Disputes and Conflict Transformation in the Ferghana Valley* [PhD dissertation]. Bern: Institute of Geography, University of Bern.

Brock L. 1998. Umwelt und Konflikt im internationalen Forschungskontext. *In:* Carius A, Lietzmann KM, editors. *Umwelt und Sicherheit. Herausforderungen für die internationale Politik.* Berlin: Springer, pp 37–56.

Carius A, Baechler G, Pfahl S, March A, Biermann F. 1999. *Umwelt und Sicherheit: Forschungserfordernisse und Forschungsprioritäten.* Berlin: Ecologic.

Environmental Change and Security Project (ECSP). The Woodrow Wilson International Center for Scholars. http://www.wilsoncenter.org/ecsp; accessed on 9 September 2009.

Hagmann T. 2005. Confronting the concept of environmentally induced conflict. *Peace, Conflict and Development* 6:1–22.

Le Billon P. 2005. The geopolitical economy of 'resource wars'. *In:* Le Billon P, editor. *Geopolitics of Resource Wars.* London and New York: Frank Cass, pp 1–28.

Mason SA. 2004. *From Conflict to Cooperation in the Nile Basin: Interaction between Water Availability, Water Management in Egypt and Sudan, and International Relations in the Eastern Nile Basin.* Zurich: Center for Security Studies, Swiss Federal Institute of Technology Zurich

9.4

Local and regional sustainable land management options based on assessed experiences

Liniger Hanspeter[1], Schwilch Gudrun[1], Rima Mekdaschi Studer[1]

[1] *Centre for Development and Environment, University of Bern, Hallerstrasse 10, 3012 Bern, Switzerland (hanspeter.liniger@cde.unibe.ch; gudrun.schwilch@cde.unibe.ch; rima.mekdaschi_studer@cde.unibe.ch)*

Sustainable Land Management (SLM) uses all types of land resources (soils, water, animals and plants) for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and ensuring their environmental functions. Water management cannot be separated from land use, thus all SLM technologies are related to water, by controlling surface runoff and increasing infiltration, and as a result, store more water in the soil. Without conservation measures the combined water loss through runoff and evaporation often leaves less than half of the rainfall – or irrigated water – available for crops or other vegetation.

Depending on the climate, two major categories can be differentiated: In humid environments soil erosion and soil fertility decline are common causes of land degradation. The implication is that conservation measures have to solve the problem of excess water and its safe drainage either through the soil profile or on the surface. Here, the main aim is to reduce the rapid runoff that causes sheet, rill and gully erosion on-site and flooding, sedimentation and pollution of rivers and water reservoirs off-site (downstream). Potential SLM technologies include vegetative measures such as grass strips, green cover, agroforestry systems or structural measures such as terraces, gully rehabilitation, etc. In sub-humid, semi-arid and arid regions, the same problems may occur through erratic rainfall, but the main focus is on water conservation and improved water use efficiency, e.g. through in situ accumulation of soil moisture and reduction of the water losses by runoff and direct evaporation from the soil, or through water harvesting. Examples here include conservation agriculture, improved cover, stone lines, planting pits and basins, area enclosure and assisted natural regeneration, etc. Successful SLM technologies often involve combined measures, for example structures to collect water as well as agronomic measures to reduce runoff and evaporation losses.

Worldwide, there are numerous positive experiences of sustainable land management. These counter the prevailing and pessimistic view that land and environmental degradation is inevitable and continuous. WOCAT has developed an internationally recognized, standardised methodology involving a set of three questionnaires to document relevant aspects of SLM technologies and approaches, including area coverage. A computer-based database system facilitates data entry, retrieval and evaluation. Apart from the cases documented through WOCAT (www.wocat.org) and elsewhere, the vast body of knowledge and wealth of experience in SLM made either by projects or through innovations and initiatives by the land users themselves remains scattered and localised. There is still a rich untapped SLM diversity that is not readily available to land users, those who advise them, or planners and decision makers. Thus the basis for sound decision making (for up-scaling) is lacking and mistakes are being repeated. The WOCAT tools provide a unique method for the comprehensive documentation, monitoring, evaluation and dissemination of SLM knowledge from land users, SLM specialists and researchers from different disciplines.

A new methodology has been developed for the selection of SLM strategies, combining a collective learning and decision approach with evaluated practices documented by WOCAT. A concise process of three parts involving all stakeholders starts with identifying land degradation and locally applied solutions in a stakeholder workshop. In the second part local solutions are assessed with the standardised WOCAT evaluation tool, and in the third part promising strategies for implementation are jointly selected with the help of a decision support tool. Facilitated by a moderator, participants conduct multi-criteria evaluation to rank existing and potential SLM strategies for field trials. This involves stakeholders identifying and weighing relevant criteria (e.g. technical requirements, costs and benefits, social acceptability, etc.). An option can only be considered sustainable if its evaluation is (more or less) positive with respect to all three dimensions of sustainability: economic, ecological, and socio-cultural. Thus, the negotiated SLM option has to pay off for land users implementing it, has to have positive impacts on land resources (including soil, water, vegetation, fauna), and has to be acceptable to local actors by fitting into their socio-cultural context and practices.

However, SLM is often beyond the means, responsibility and decision-making power of individual land users. Proper planning includes both local participation (by the stakeholders) and regional overall planning where on-site and off-site impacts and their interactions are considered and regulated. This is most important with regard to watersheds, where it can involve distant communities and affect their local land use planning. Too little consideration has been given to proper assessment of on-site and off-site land use interactions that lead to regional and global damage or benefits. Areas with land degradation and good SLM practices need to be identified and the impacts assessed, for which the WOCAT mapping tool was developed. It provides key information for decision making at local, regional and national level, about where investments can best be made, and about which SLM practices have the best potential to spread.

REFERENCES

WOCAT (World Overview of Conservation Approaches and Technologies). 2007: Where the Land is Greener. Case studies and analysis of soil and water conservation initiatives worldwide. Editors: Liniger, H. and Critchley, W. CTA, Wageningen (Netherlands).

Schwilch, G., Bachmann, F., Liniger, HP. 2009: Appraising and Selecting Conservation Measures to Mitigate Desertification and Land Degradation Based on Stakeholder Participation and Global Best Practices. Land Degradation & Development, 20, 308–326.

Liniger, HP. & Critchley, W., 2008: Safeguarding Water Resources by Making the Land Greener: Knowledge Management through WOCAT. In: Bossio, D. & Geheb, K. (eds): Conserving Land, Protecting Water. CABI Wallingford.

Liniger, HP. & Schwilch, G., 2002. Enhanced Decision-Making Based on Local Knowledge - WOCAT Method of Sustainable Soil and Water Management. Mountain Research and Development, 22(1) : 14-18.

9.5

From a Technocratic to a Custodianship Approach: Putting Herders at the Centre of Pasture Management in Kyrgyzstan

Daniel Maselli[1], Inam-ur-Rahim [2]

[1] Centre for Development and Environment, Universität Bern, Hallerstrasse 10, CH-3012 Bern and University of Central Asia, Bishkek Kyrgyzstan, and Swiss Agency for Development and Cooperation, Bern (daniel.maselli@deza.admin.ch)
[2] Centre for Development and Environment, Universität Bern, Hallerstrasse 10, CH-3012 Bern, University of Central Asia, Bishkek Kyrgyzstan (irahim33@yahoo.com)

In the context of research led by the NCCR North-South and the TPP 'Pastoral Production Systems' in Central Asia, a new participatory approach and methodology has been tested where local herders are actively involved in assessing, monitoring and managing pastures. So far the assessment of pasture conditions in Central Asia has been carried out by specialists employed by state entities. Based on periodic field visits, maps indicating the potential fodder production and carrying capacity have been established and were meant to be kept up-to-date. However, these maps appear to be hardly ever used by herders and village administrations and up-dating is being hampered by lack of financial and human resources since independence.

Based on experiences from northern Pakistan, a new approach has been tested in three different villages in Kyrgyzstan. The fundamental change is linked to the recognition of local herders as the real managers and future custodians of the pastures. The innovative methodology integrates biophysical, socio-economic and institutional elements into a participatory pasture management planning system. As these elements interact in a highly dynamic and interdependent manner, change in any one is bound to modify the resulting land-use strategy. This fact leads to a need for more appropriate context specific approaches for pasture management to secure the appropriate use of pastoral resources.

After an exploratory integrated survey meant to identify the appropriate planning units, the local herders are guided in selecting appropriate indicator species for pasture monitoring. In parallel the current seasonal occupation and utilization pattern is assessed. Herders are trained to evaluate grazing land conditions. During this process, the trained herders assess the relative availability of key indicator species, the calculated stocking capacity of different management units, and the current stocking. Based on this understanding a joint rehabilitation or sustainable management strategy can be devised using a multi-stakeholder process in which local authorities are integrated.

The main innovation resides in simplifying and modifying the classical conservation monitoring tools to a herder-monitoring tool in a transition context based on participation and taking into consideration local / traditional knowledge.

REFERENCES

Anna Carr and Roger Wilkinson (2005) Beyond Participation: Boundary Organizations as a New Space for Farmers and Scientists to Interact. Journal of Society & Natural Resources, Volume 18, Issue 3 February 2005 , pages 255 – 265

van Noordwijk, M., T. P. Tomich, and B. Verbist (2001) Negotiation support models for integrated natural resource management in tropical forest margins. Conservation Ecology 5(2): 21. [online] URL: http://www.consecol.org/vol5/iss2/art21/

Dale Dore (2001) Transforming Traditional Institutions for Sustainable Natural Resource Management: History, Narratives and Evidence from Zimbabwe's Communal Areas. African Studies Quarterly 5, no.3: [The online Journal for African Studies] URL: http://web.africa.ufl.edu/asq/v5/v5i3a1.htm

Rihoy E (1995) The Commons Without the Tragedy: Strategies for Community Based Natural Resources Management in Southern Africa. Proceedings of the Regional Natural Resources Management Programme Annual Conference. Lilongwe, Malawi: SADC Wildlife Technical Coordination Unit,.

Derek Armitage1 (2005)Adaptive Capacity and Community-Based Natural Resource Management. Journal of Environmental Management Volume 35, Number 6 / June, 2005 pp 703-715

Terry Hillman, Lin Crase1, Brian Furze1, Jayanath Ananda1 and Daryl Maybery1 (2005) Multidisciplinary Approaches to Natural Resource Management. Journal of Hydrobiologia. pp 99-108

Inam-ur-Rahim and Daniel Missili (2004) Improving sustainable grazing management in mountain rangelands of Hindukush Himalayas: An innovative participatory assessment method in Northern Pakistan. Mountain Research and Development, Vol 24 No: 2 (124-133)

9.6

Repartition Et Hydrochimie Des Aquiferes De L'extremite Nord Occidentales Flysch Numidien, (Tunisie Septentrionale)

MEJRI Zouhaier[1], BEN HAMZA Chedhly, HATIRA Nouri[2] et ABIDI Riadh ;

Unité de Recherche – Géologie des Ressources Naturelles, Département des sciences de la terre, Faculté des sciences de Bizerte, Jarzouna-Bizerte.7021. Tunisie. [1]mejrizouhair@yahoo.fr; [2]nouri_hatira@yahoo.fr

La region de Kromerie, située en rive gauche de l'Oued Mejerda, se carcterise par un réseau hydrographique dense et ramifié, une topographie très accidentée et une pluviométrie annuelle 1500mm
La série Numidienne de la région de Kroumerie (Tunisie septentrionale) est subdivisée en trois termes lithologiques distincts (Rouvier, 1977). Cette série représente un potentiel réservoir hydrogéologique important essentiellement dans le membre médian gréseux (Kroumerie).

La zone naturelle de la Kroumerie est découpée par un réseau d'accidents majeurs disposées en décrochements- chevauchements de direction NE-SW à NNE-SSW senestre et sub E-W dextre (Ben Ayed, 1994). Cette structuration est à l'origine, d'une part, de la compartimentation des grès et de l'isolement différentiel des réservoirs gréseux et d'autre part, de la création d'une fracturation multidirectionnelle tardive entraînant une augmentation préférentielle de la porosité et de la perméabilité des grés consolidés des flyschs numidiens du Maghreb (Johansson et al., 1998) (Fig.1).
Les réservoirs gréseux sont caractérisés par une dynamique sédimentaire représentée par des corps lenticulaires, des chenaux, slumps. Avec des bioturbations, des filons ; ont été perturbé par le replissement d'âge quaternaire ancien et d'extrusion de Trias salifère (Rouvier, 1977).
L'alimentation de réservoirs se fait par les filons gréseux qui assurent la jonction des différentes sills parcourant les grés de Kroumerie.

Les eaux souterraines issus de réservoir gréseux des Mogods montrent des faciès hydrochimiques de type chloruré et sulfaté calci-magnésien et de type chloruré et sulfaté sodique et potassique. des concentration élevais en sulfates et en sodium, avec un dégagement d'odeur fétides,a été manquées au niveau de certains captages implantés suivant une direction préférentielle orientée NNE-SSW.
Toutefois, la composition chimique des eau souterraines, mémoire des échanges eau-roches. Constitué un support fiable de lessivage et de dissolution des lithos faciès réservoirs. La richesse en chlorure et en sodium est difficile à expliquer sans admettre que set aquifère gréseux est connecté à des faciès évaporitique du Trias., notamment dus que un accident profond est injecté par un endroit par des pointements volcaniques.

REFERENCES

Ben Ayed, N. 1994. Les décrochements - chevauchements EW et NS convergents de la Tunisie septentrionale: Géométrie et essai de reconstitution des condition de deformations. Proceedings of the 4[Th] Tunisian petroleum Exploration conference. E.T.A.P, Tunisie, 25-35.

Johansson, M., Braakenburg, N.E., Stow A.V.D. and Faugères J. Cl. 1998. Deep-water massive sands: facies, processes and channel geometry in the Numidian Flysch, Sicily. Sedimentary geology .115, 233-265.

Rouvier, H. 1977. Géologie de l'extrême tunisien: tectoniques et paléogéographies superposes à l'extrémité orientale de la chaîne maghrébine, these Doctorat ès Sc., Univ. P et M. Curie, Paris, France.

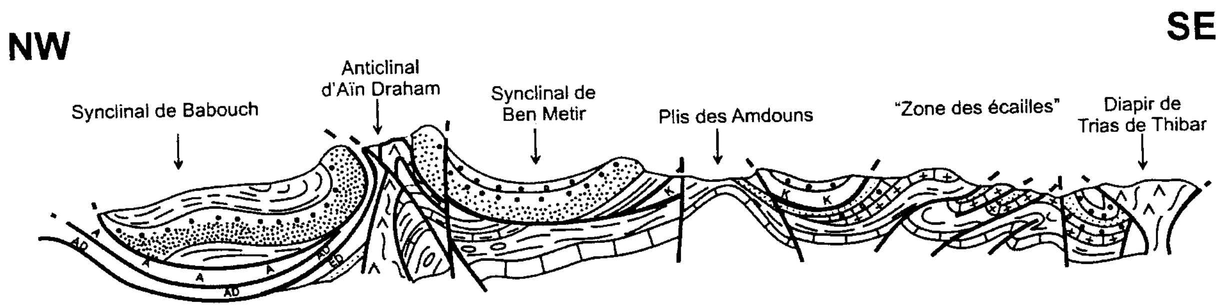


Fig .1. Coupe géologique simplifiée la structure des réservoirs hydrogéologiques de la région des Kroumerie (Rouvier, 1977)

9.7

Using the SWAT hydrological model to quantify water-related ecosystem services in a large East African watershed

Notter Benedikt[1], Hurni Hans[1], Abbaspour Karim[2]

[1] *Centre for Development and Environment, Universität Bern, Hallerstrasse 10, CH-3012 Bern (benedikt.notter@cde.unibe.ch)*
[2] *Eawag, Überlandstrasse 133, Postfach 611, CH-8600 Dübendorf*

The East African Pangani Basin, a watershed of about 43,000 km^2 located in Tanzania and straddling the border to Kenya, is characterized by an increasing demand for water-related ecosystem services. These include domestic use, agriculture, and hydropower production. The final aim of the study is to assess water availability to sustain ecosystem services for the current situation as well as possible future scenarios in the basin. We start from the assumption that an ecosystem service is realized if the availability of a resource (like water) matches an existing demand of any stakeholder in terms of quantity, quality, timing and location (Notter et al. [submitted]).

The SWAT model (Arnold et al. 1998) can be used to estimate water availability for unmeasured locations and for hypothetical situations, but under the given assumption needs to produce outputs for spatial and temporal units within which the ecosystem services of interest are transferrable. In the case of Pangani Basin, a monthly temporal resolution and spatial units corresponding to the intersection of climatic zones, subbasin boundaries, and administrative units at the Ward level is necessary. An additional challenge in our study was the lack of high quality data on climate, discharge, and water use, which makes uncertainty assessment an imperative. The mentioned challenges were met with a combination of five strategies:

a) Reducing data limitations by combining datasets from different sources, e.g. by using GIS tools to determine and implement the best possible technique for pre-processing climatic data taking into account elevation effects;
b) Implementing minor modifications to the SWAT2005 model code (corrections in the irrigation and dormancy routines, writing additional output variables, introduction of parameters that allow varying measured time-series inputs);
c) Developing a subbasin configuration procedure that takes into account administrative units and elevation zones while minimizing the number of subbasins created;
d) Applying the SUFI-2 algorithm (Abbaspour et al. 2007) for model calibration and uncertainty assessment, and additionally including uncertainty in measured time-series inputs like rainfall, temperature, point sources, and maximum allowed diversions in the uncertainty analysis;
e) Deriving proxies for water-related ecosystem services from SWAT outputs, e.g. water availability at the 95% reliability level as a proxy for domestic water, number of months per year without water stress as a proxy for agriculturally suitable land, or discharge at 75% and 95% reliability levels at topographically suitable locations as a proxy for hydropower production.

Calibration and validation of monthly discharge yields satisfactory results, with Nash-Sutcliffe coefficients of >= 0.5 reached at 8 of 12 stations, on average about 70% of measured data bracketed in the 95% prediction uncertainty, and an average width of this uncertainty range of about 1.13 standard deviations of measured data. Water quality parameters could not be calibrated for a lack of measured data, but uncertainty bands can be calculated based on the physically plausible ranges of parameters sensitive to water quality.

The calibrated model produces outputs for any required administrative unit, climatic zone, or subbasin, or any combination of these units. Preliminary results from ecosystem service quantification for the "current situation" (weather conditions from 1981-2005, land use and socio-economic data from 1997-2002) indicate that domestic, and to a lesser extent also industrial and livestock water demands are near satisfied at the 95% reliability level in those Districts that are better accessible by roads, probably because water infrastructure can be built and water rights can be obtained more easily in these areas. On agricultural land in the lowlands, where there is potential for expansion, periods without water stress are greatly prolonged where irrigation is applied, and productivity thus enhanced; however, irrigation directly impacts on hydropower potential by significantly reducing dry season discharge.
Evaluation of possible future scenarios and alternative management options has not been carried out yet but is planned for the coming months.

REFERENCES

Abbaspour, K.C. et al., 2007. Modelling hydrology and water quality in the pre-alpine/alpine Thur watershed using SWAT. Journal of Hydrology, 333: 413-430.

Arnold, J.G., Srinivasan, R., Muttiah, R.S. and Williams, J.R., 1998. Large Area Hydrologic Modeling and Assessment Part I: Model Development. Journal of the American Water Resources Association, 34(1): 73-89.

Notter, B., Hett, C., Hurni, H. and Wiesmann, U. [submitted]. Water- and Land Cover-Related Ecosystem Services: Approaches to Quantification in East Africa and Laos. Ecological Complexity: Manuscript Number ECOCOM-S-08-00227.

9.8

Caribbean Water Monitor: Small island states, water resources and climate change

Thüring Manfred[1], Trotman Adrian[2] & Moore Anthony[2]

[1] *Institute of Earth Sciences, University of Applied Sciences of Southern Switzerland, PO Box 72, CH-6952 Canobbio (manfred.thuering@supsi.ch)*
[2] *Caribbean Institute of Meteorology and Hydrology, Husbands, BB-23006 Barbados (atrotman@cimh.edu.bb, amoore@cimh.edu.bb)*

The sufficient availability of water resources is a key factor of success for any community. This project addresses the changes in the availability of water resources in the Caribbean today, and the impact of climate change. An internet-based monitoring tool – the Caribbean Water Monitor - is being developed, which indicates the current situation regarding the availability of water on two island states of the Caribbean (Barbados and Trinidad & Tobago). Based on the input of climate data – mainly precipitation and temperature – the tool assesses automatically the current situation and displays it in a comprehensive form, such as maps or trend graphs, as developed in a former project for the Caribbean island Saint Lucia (Figure 1).

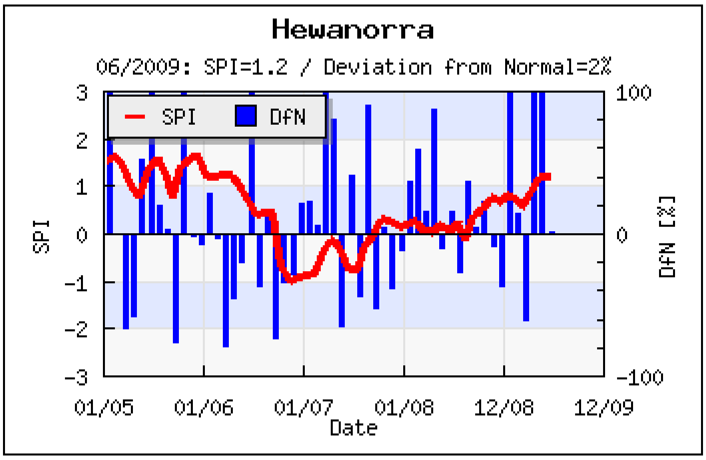


Figure 1. The usage of drought indices, such as Standard Precipitation Index or Deviation from Normal are used as support information in water resources management (www.droughtinfo.org).

The Caribbean Water Monitor is an essential tool for water resources management, and offers a help for decision support for planning and managing water resources. Climate change will require adaptation strategies. These strategies will have to be guided by assessment and monitoring tools, such as the proposed Caribbean Water Monitor.

This one-year project is developed in cooperation by a Swiss and Caribbean research partner with complementary competences, and financed by KFH-DEZA.

In our poster we show the current status of the project on the development of map based drought and water indices and the identification of climate change signatures in rainfall records of Barbados.

9.9

GIS-based Decision Support for Soil Conservation Planning in Tajikistan

Wolfgramm Bettina[1], Bühlmann Erik[1], Liniger Hanspeter[1] & Hurni Hans[1]

[1] *Centre for Development and Environment (CDE), University of Bern, Hallerstrasse 10, CH-3012 Bern (bettina.wolfgramm@cde.unibe.ch)*

Soil erosion on sloping agricultural land poses a serious problem for the environment as well as for production. In areas with highly erodible soils, such as those in loess zones, application of soil and water conservation measures is crucial to sustaining agricultural yields and preventing/reducing land degradation.

The present study, carried out in Faizabad, Tajikistan, was designed to evaluate the potential of local conservation measures on cropland to provide decision support for planning sustainable land use in a spatially explicit manner. A sampling design to support relative comparative analysis between well-conserved units and other field units was established in order to estimate factors that determine water erosion, according to the Revised Universal Soil Loss Equation (RUSLE). Such factor-based approaches allow ready application in a geographic information system (GIS) environment. Furthermore, the factor-based RUSLE model facilitates straightforward scenario modelling. High-resolution Quickbird satellite imagery was used to assess canopy cover – a major erosion control factor in the model. Standardised questionnaires designed by WOCAT (World Overview of Conservation Approaches and Technologies) were used to document local conservation measures.

The study showed first that assessment of erosion and conservation in an area with inhomogeneous vegetation cover necessitates the integration of plot-based cover derived from high-resolution satellite imagery in order to enable plot-wise conservation planning.

Furthermore, thorough field assessments showed that 25.7% of current total cropland is covered by conservation measures (terracing, agroforestry and perennial herbaceous fodder). Assessment of the effectiveness of these local measures, combined with the RUSLE calculations, revealed that current average soil loss could be reduced by low-cost measures such as contouring (by 11%), fodder plants (by 16%), and drainage ditches (by 55%). More expensive measures such as terracing and agroforestry can reduce erosion by as much as 63% (for terracing) and 93% (for agroforestry combined with terracing).

Indeed, scenario runs for different levels of tolerable erosion rates showed that more cost-intensive and technologically advanced measures would lead to greater reduction of soil loss. However, given the economic conditions in Tajikistan, it seems more advisable to support the spread of low-cost and labour-extensive measures.

REFERENCES

Bühlmann, E. 2006: Assessing Soil Erosion and Conservation in the Loess Area of Faizabad, Western Tajikistan. MSc, Centre of Development and Environment, University of Bern.

Liniger, H.P., and W. Critchley. 2007: Where the Land is Greener. Case studies and analysis of soil and water conservation initiatives worldwide. Wageningen: Technical Centre for Agricultural and Rural Cooperation.

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder. 1997: Predicting soil erosion by water: A guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE). Agriculture Handbook 703. Washington, DC: USDA.

Shi, Z.H., C.F. Cai, S.W. Ding, T.W. Wang, and T.L. Cho. 2004: Soil conservation planning at the small watershed level using RUSLE with GIS: A case study in the Three Gorge Area of China. Catena 55(1): 33-48.