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- theories, methods and tools for analysing, modelling and addressing these risks and disaster
- measures for integrative risk and disaster management

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Editorial

Soils form the basic substrate of terrestrial ecosystems, support many human activities and provide together with water a multitude of highly valuable ecosystem services. Desertification, Land Degradation and Drought (DLDD) resulting from various factors including climatic variations and human activities are the most threatening ecosystems' change impacting the livelihood of whole mankind and the poor in particular. More than 2 billion people live in arid, semi-arid and dry sub-humid areas, the so called drylands. The underlying biophysical and anthropogenic causes of land degradation are multiple and overlapping. Desertification can trigger a vicious circle of environmental degradation, impoverishment, hunger, migration and conflicts, putting the socio-political stability of the affected countries and regions at risk.

Considering DLDD as a slow-onset emerging natural and /or human induced disaster at the core of climate change, asks for an integrative approach to tackle the underlying risk factors. The process of soil formation is so slow that soil can be considered a nonrenewable resource. Toward 2050, rising population and incomes are expected to call for 70 percent more food production globally, and up to 100 percent more in developing countries, relative to 2009 levels. Thus, healthy soil is essential to the survival of humanity. Only an integrative and holistic approach, considering all phases of the risk cycle and integrating all stakeholders will lead to sustainable land management not only in drylands.

For efficient and effective prevention and mitigation measures against DLDD, it is essential to assess the economic and social impacts of DLDD and identify the most relevant actors such as land users, land owners, governmental authorities and industries. Further, it is necessary to analyse how institutions and policies influence those actors. The range of barriers such as insufficient financing and resourcing, weak scientific basis and knowledge exchange, insufficient advocacy and awareness, or an inadequate legal basis limit both the implementation and effectiveness of mitigation and prevention measures.

Despite the increasing impacts of DLDD, a global consensus on the increasing economic costs of inaction is missing. This makes the prioritization of measures to prevent or mitigate DLDD substantially more difficult using an economic argument. However, methods exist to do cost-benefit analysis for mitigation and prevention measures. Cost-benefit-analysis can be an adequate tool and powerful enough to help decision-makers objectively choose among different land use management strategies

and pursue effective and resilience building interventions.

In order to develop and implement evidence-based and scientifically sound methods for monitoring and assessing DLDD and their consequences, a holistic approach is of utmost importance. It is vital to build bridges between the many different disciplines, sectors and society as a whole, in order to develop and establish integrative solutions for a more sustainable future.

Providing a platform for the exchange of intersectorial experience and transdisciplinary knowledge is one of Planet@Risk's main goals. The papers in this Special Issue on Desertification present state-of-the-art research reports, case studies for good practices, scientific reports and working papers in the field of economic assessment of desertification, land degradation and drought (DLDD), of sustainable land management practices (SLM) of drylands, and of resilience building.

All papers in this Planet@Risk Special Issue on Desertification are based on presentations given during the United Nations Convention to Combat Desertification (UNCCD) 2nd Scientific Conference on "Economic assessment of desertification, sustainable land management and resilience of arid, semi-arid and dry subhumid areas", held 9-12 April 2013 in Bonn, Germany (<http://2sc.unccd.int/home/>). The Global Risk Forum GRF Davos, as lead institution selected by the Bureau of the Committee of Science and Technology, organized the UNCCD 2nd Scientific Conference.

This Special Issue shall provide guidance to governments and non-governmental actors alike, on why they should and how they can, together, reduce the impacts of DLDD and support affected countries and communities to improve land management practices for increased resilience and sustainability.

I would like to thank the Editorial Board members who secure the quality of the journal and the authors for their valuable work they share with us. I wish you a lot of new insights with this Planet@Risk Special Issue on Desertification!

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Is the EIRR, the Economic Internal Rate of Return of Projects to Combat Desertification and Land Degradation Evaluation a Relevant Tool for Evaluation?¹

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Abstract – The economic internal rate of return (EIRR) is considered as a useful tool, both for advocating investments in the areas of land rehabilitation and poverty alleviation and for economic evaluation. This communication reviews the main literature on EIRR and discusses its relevance, particularly with respect to short-term and small size projects. It highlights the many constraints associated with its calculation and underlines its usefulness and limits in relation to local perspectives, local societies and their natural environment.

Keywords – Economic internal rate of return, projects to combat desertification, economic evaluation.

1. Introduction and background

Evaluation in economics implies the measurement of impacts of specific actions, by comparing beneficiaries' situation after the actions to control situations there have been no action (Garraabé et al, 2012). Originally, the internal rate of return is a financial and management tool, defined as the interest rate at which the cost and benefit of a project discounted over its lifetime are equal. As a percentage, it compares the average annual profits discounted to the amount invested over a precise period of time. It is referred to as the most common measure of profitability of an investment. The IRR informs on the internal profitability structure of a given investment². Therefore, it can be used to demonstrate the profitability of investments in development projects as compared to the profitability of financial investments in the same amounts of money. Development sector and international cooperation institutions usually distinguish between the *ex ante* IRR that is used to guide decision-making on future investment and the *ex post* IRR that is more used to support advocacies towards decision-makers and funders. *Ex ante* IRR is required in most project documents as one key indicator to be analyzed prior to making final decisions about funding or implementing a project. This is particu-

larly a practice at FAO and IFAD with most agricultural development projects. *Ex post* IRR has been promoted mostly by C. Reij through his various works and studies, and it is used to demonstrate how actions to combat desertification reveal profitability in difficult environments such as dry zones (Reij and Steed, 2003 ; Reij and Smaling, 2008 ; Botoni and Reij, 2009). The idea is to show that in regions where high rates of rural poverty exist, and where resources are limited, like in arid zones, investing may be profitable. C. Reij calls this *ex post* IRR the economic internal rate of return (EIRR) because it is based upon real data by contrast of the *ex ante* internal rate of return which is only based on assumptions about the benefits of the project. The communication presents the EIRR and discusses its relevance for evaluating short-term actions and projects to combat desertification and land degradation mostly implemented by civil society organizations in Western Africa. It relies first, on a literature review focused on the Sahel Studies (Botoni and Reij, 2009) and second, on the evaluation of a specific project, e.g., the Regional Initiative for Global Environment/Combating Desertification (IREM/LCD) in the Sahel, co-funded by the French Global Environmental Funds, French Ministry of Foreign Affairs and the Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel (CILSS) between

¹This article is based on a presentation given during the UNCCD 2nd Scientific Conference on "Economic assessment of desertification, sustainable land management and resilience of arid, semi-arid and dry sub-humid areas", held 9-12 April 2013 in Bonn, Germany (<http://2sc.unccd.int>).

²The internal rate of return is an indicator of the internal structure of profitability of a given project: per se, it does not inform on the comparison between several projects outputs. For such a comparison, investors use the net present values of projects

³Nine countries are concerned :Burkina Faso, Cap-Vert, Gambia, Guinea-Bissau, Mali, Mauritania, Niger, Senegal, Chad

2000 and 2008. That project funded small size projects from civil society organizations in the CILSS region ³.

2. Lessons learned from the Sahel studies and remaining challenges

The most known studies using *ex post* EIRR for advocating investments towards actions to combat desertification and land degradation in poverty contexts are the CILSS coordinated Sahel Studies (Botoni et Reij, 2009). An earlier study commissioned by the Global Mechanism of the UNCCD convention (Reij and Steeds 2003) evaluated projects impacts, 20 years after their implementation; a time long enough for assessing the impacts of actions like forest plantations and for collecting relevant data on changes. It also permits to minimize the impact of annual rainfall variation on projects outputs. Finally, it allows more precise evaluation of average annual benefits, and enables the measuring of ecological changes (Requier-Desjardins et al, 2011). Over this period of time (1980-2000), roughly, ten dry and ten humid years have been experienced; but this trend varied from site to site. This literature review presents the main results of EIRR calculations with respect to naturally assisted regeneration of trees, forestry and agro-forestry park plantation, and soil and water conservation on cultivated lands. The main impacts of interest concern timber and non-timber production, and pastoral and agricultural activities. Only provisioning services are quantified and valued in monetary terms.

2.1. Main results of the Sahel studies

In the Sahel studies, EIRR are calculated for only long term projects and the work is based on information collected after twenty years of implementation. In addition to project reports, the data are collected through stakeholders analysis. Moreover, in order to evaluate project impacts in terms of service provision, especially for the Niger sites, comparisons are made between project sites and non-project (control) sites where no action was taken (Abdoulaye and Ibro, 2006). In this process, the project length fits the temporal scale of EIRR evaluation, allowing more precise evaluation of average annual benefits, on one hand, and on the other hand, enabling the measuring of ecological changes (Requier-Desjardins et al, 2011).

The types of benefits that are valorized comprise of wood production, and improved yields for agriculture and pastures. The project costs comprise of all implementation costs, from plantation costs (seeds, plants, labor, equipments), to maintenance costs (such as watering, tenure, surveillance and supervision, etc.). The calculation of the average annual benefit, as based on a series of field data shows that at least six years are necessary for projects to yield returns in terms of timber production. Annual yield increase on project sites averages 5% for crops and pastures and is used for annual benefit calculation, as based on local prices (Botoni and Reij, 2009). Best and most striking results are observed on assisted natural regenera-

tion (ANR) sites where diverse plant species are spared on cultivated lands to grow naturally under farmers' protection. These strategies may be later supported by specific projects and national policies (Sendzimir et al., 2011; Garity et al., 2010 ; WRI-PNUD-PNUE, 2008). In the Sahel studies, these practices show EIRRs of 31% in Niger and 24% in Burkina Faso (Botoni and Reij, 2009). Other EIRR are calculated in more generic terms, on same time length, comparing the return between forest plantation and fruit forestry in Niger. Figures are obtained based on theoretical analysis and field investigations. In the first case, 6 steres of timber and a surplus of 15.5 kg of forage are produced after a period of 6 years with associated EIRR averaging 13%. In the second case, acacia gum production is to be also included in the return from the sixth year, estimated returned of 1.5 kg acacia gum per tree must be added at the end of the sixth year; which increases EIRR to 31% over twenty years. This calculation is based on a very optimistic rate of 100% trees survival, which is unrealistic given the field constraints. Other studies on tree survival rate in Niger show that only 25% of trees would survive after plantation (Boubacar et al, 2005), clearly showing that the actual rates of return are lower. Another case study concerns filao tree plantations for sand dune fixation in Senegal littoral. By enabling the cultivation of vegetables in neighboring pits, planting holes filled with organic matter, as they enabled the cultivation of vegetables through the practice of "zaï" (a traditional land rehabilitation practice that uses planting pits), these investments proved to be indirectly beneficial to the local populations. There, in such situation, the consideration of the income generated by selling the crops produced into the calculations, increases the EIRR to 20% over the period of twenty years. However, specific rules must be set to respect a threshold for the forest exploitation in order for the system to remain sustainable through time. Finally, the rapid changes in the yields production with associated returns as induced by soil and water conservation practices on cultivated lands have been extensively studied and documented (Reij et al, 2005 ; Hien et al, 2004; Hassane et al, 2000; Somé et al, 2000) . In effect, Reij and Steeds (2003) report a EIRR of 20% for a small-project in Illela district, Niger after seven years (1988-1995) where soil management techniques including bunds, half-moons and zaï were applied (Hassane et al, cited in Reij and Steeds, 2003). These studies showed how worth it is to invest on natural resources rehabilitation in dry rural areas. From ecosystems services stand point, it must be noted that EIRR calculations only consider provisioning services, meaning services for which a local market does exist ⁴.

2.2. The challenges

EIRR being based on project logical framework information, it helps to define and measure project outcomes. However, it tends to be solely concerned with expected costs and benefits, ignoring some others. Many projects would generate social and environmental costs on neigh-

⁴C. Reij and his team do not only use EIRR for advocating investment towards land rehabilitation, but also consider qualitative outcomes such as environmental, social, and institutional impacts.

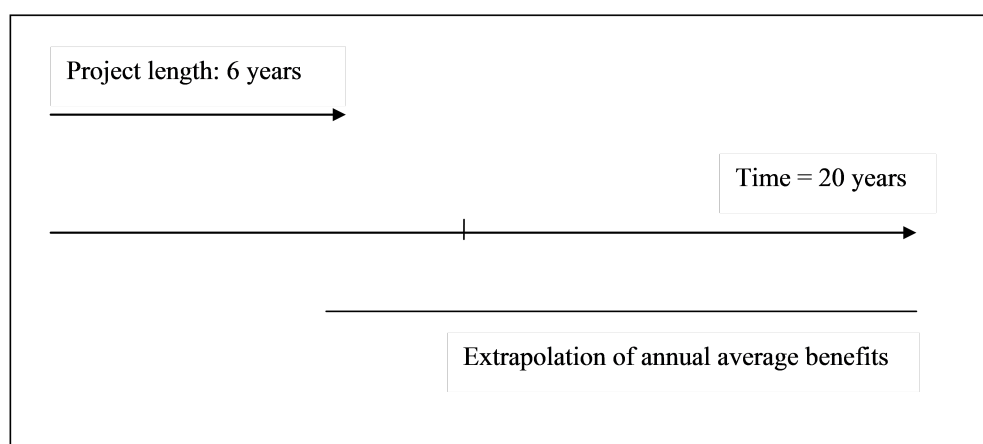


Figure 1: Data extrapolation for the calculation of a short-term project EIRR

bor areas which are ignored in the EIRR calculation because this calculation only refers to the space occupied by the project and not to a coherent local land unit. The institutional and organizational aspects (action coordination level) have quantifiable costs, but are hard to valorize in monetary terms and therefore, are hardly integrated into the calculation of benefits, even when they are mentioned in the logical framework as expected results. Though, they are necessary for ensuring sustainability. These aspects are fundamental when evaluating and calculating EIRRs for short and medium term projects, as the expected environmental results may not appear during the project, but eventually after the project duration because ecological cycles do take place over longer period of time (see fig.1). This is the same with projects such as forest plantations where ecological benefits take time to be observed. Extrapolating annual benefits calculated during or at the end of a project over a larger period of time is also a challenge as a result of rainfall variability in dry regions. However, the latter two limitations have been overcome in the Sahel studies because these studies only consider long-term projects; e.g. exceeding twenty years. The reality remains that overseas development projects are generally of short-term durations. Another challenge relates to the documentation of and access to project results pertaining to the effects on production. In clear, it is necessary to use a monitoring system in order to collect relevant data for quantifying annual benefits, not to rely solely on experts' judgments and generic knowledge from national agro-economic research institutions that are based on a diversity of contexts.

A last challenge is that EIRR is often calculated assuming a discount rate of 10%, which is too high for natural resources (Martinez-Allier in TEEB, 2009) because, by contrast to financial capitals, the latter do not forcedly increase with time. With respect to actions and projects to combat desertification, the literature is poor on comparative data on discounting rates for EIRR. After overviewing the constraints for calculating a robust EIRR, we can now reflect on the complexity of the approach as compared to the use and utility of its quantification. To be short, the EIRR is not informative on how beneficiaries and local populations share the project benefits. It is a

tool designed for advocacy makers, investors and projects contractors that has been promoted by some civil society organizations at various levels and which help to promote specific actions like the practice of assisted natural regeneration. The level of constraints compared to the comprehensive dimension of the indicator remains unclear.

3. Case study: regional initiative for global environment / combating desertification in the Sahel (2000-2008)

To better illustrate the constraints for calculating EIRR, we present and discuss the calculation of EIRR for a set of micro-projects developed by the French fund for global environment between 2000 and 2008. This economic approach is part of the overall external evaluation, which encompasses the evaluation of the design and governance of micro-projects and institutional projects.

3.1. Major features of the project

The project called Regional initiative and Global Environment for combatting desertification in the Sahel (Africa) (IREM/LCD) was coordinated and monitored at the regional level by CILSS. It funded 33 micro-projects for less than 100 000 Euros each, presented by civil society organizations and rural collectivities. The latter contribute 50% of project costs. These micro projects are short term (two years on average), and aimed to improve both, the natural environment and the income of local people. In the *ex post* evaluation, some EIRR calculations are made on specific micro-project axes using data obtained from the projects reports and from the scientific literature on the region. Management costs at regional level are not included in the calculations. Only investments provided by the donor (50% of overall cost) are considered. Also, only the provisioning services defined in project logical frameworks are taken into account. In fact three micro-projects allowed the calculation of EIRR for specific activities only, filling the gap of information collected at local level and revealing the needs for capacity building for the local administration in the context of the decentralization of natural resource management. Table 1 shows results for tree

Table 1: Examples of ERR – IREM/ LCD for three micro-projects (Source : Deygout and Requier-Desjardins, 2007)

Project / Country	Activities measured/objectives	Activities measured/objectives	Minimum time to recover investment
Dune pastures restoration and timber production (2005-2007) Mali	plantation of <i>Eucalyptus</i> / avoiding deforestation	28% / 3 years	3 years
Rehabilitation of a common zone in Bareina (2004-2006) Mauritania	Plantation <i>Acacia Senegal</i> / Arabic gum production and Avoiding sand silting	4% / 8 years	7 years
Environment restoration and soil and water conservation (2003-2005) Burkina Faso	Infrastructures against erosion on cultivated land	16% / 3 years	3 years

planting and soil and water conservation projects. Several assumptions were made about the sustainability of the projects with respect to their ability to maintain or to create annual benefits after their respective ends. These assumptions appear audacious given that only few projects are sustainable after they end. With lack of control sites and appropriate project monitoring system, many extrapolations were also made using data from the literature to define annual average benefits.

3.2. The results

The attempt to calculate EIRR has revealed an acute scarcity of relevant information; which is logical because the project was first designed for capacity building of civil society organizations in project administrative, financial, and technical management. Impact driven monitoring activities were not a priority. However, it has been observed that these micro-projects are potentially profitable. Unsurprisingly, commercial plantation of *Eucalyptus* and soil and water conservation infrastructures showed the highest rates of return.

Five women and youth associations have benefited from land use contracts from local authorities, and support from a 2-year project (2005-2007) for tree planting over land areas of 5 ha each plantation under the supervision of an NGO based in Bamako and which is the principal investigator. Four of them planted *Eucalyptus* and one chose *Acacia Senegal*, in an attempt to develop a green belt around Timbuktu and to improve beneficiaries' income by the selling of timber⁵. Wells and motor pumps were provided for supply of water for human use and for watering the trees. At the end of the projects, a first evaluation showed that among the four *Eucalyptus* micro-projects, the plantation rate for each of the four targeted zones varied from 0% (one case), to 50% (two cases) and 95% (one case). At the end, only 9,75 ha are effectively planted in *Eucalyptus* e.g. 48,75% compared to the expected 20 ha. The short duration of the project (2 years) did not allow significant production for commercialization nor valorization of the trees planted. Therefore, projects reports and available literature (Bazin et al, 2007; Deygout and Requier-Desjardins, 2007; USAID, 2006) were used to do the financial evaluation, following certain assump-

tions. *Eucalyptus* trees produce marketable timber after 3 years (USAID, 2006). While annual costs and benefits were derived from projects budgets and accountability in the AMEN reports sent to CILSS and FFEM, commercialization data were drawn from USAID study on *Eucalyptus* value chains. Three years after the plantation, a first commercial exploitation results in a EIRR of 28%. Considering 25% of initial expectations are met (5 ha are effectively planted instead of 20 ha) the EIRR over three years would drop to -1%.

Such results reveal first the sensitivity of project output to climatic stress and to beneficiaries' organization and coordination, two elements that impact strongly on trees survival. Second, if positive EIRR can be reached after three years, this is not telling much about environmental benefits after the trees are cut, nor on the use of economic benefits.

Regarding soil and water conservation techniques, the Tind Yalgré Association in Burkina Faso submitted a project aiming at increasing land fertility in five villages over two years (2003-2005) through the building of stone bunds across cultivated lands and the use of compost. These techniques are well-known since the 1980s and have been extensively documented by the Institut National de l'Environnement et de la Recherche Agronomique (INERA), and by international partners (Requier-Desjardins, 2007; Dabiré, 2004). As the project reports give too little data on the impacts on the provisioning services (e.g. the variations of yields), the calculation of the EIRR relies on precise figures about the increase of yields derived from same techniques implementation (Kabore and Reij, 2004 ; Hien et al, 2004 ; FAO, 2001 ; Mazzucato and Neimeijer, 2000 ; Some et al 2000) in similar agro-climatic zones of Burkina Faso.

Over 100 ha of cultivated land initially planned, 93 ha were treated with soil and water conservation techniques. Moreover, 10 ha of land were also reforested. Cultivated land on which infrastructures were implemented are individually appropriated and final project evaluation reports reveal that trees were also individually managed on reforested areas with good results for *Eucalyptus*. The EIRR evaluation on treated cultivated lands relied on two scenarios regarding the level of benefits that can be obtained from the bunds and from the use of compost when African

⁵The association that chose to plan *Acacia Senegal* resulted in less than 5% planting on the 5 ha; it will be left out of our calculation

Table 2: Economic benefits and cost associated to a project implementation

Benefits	Costs
Job creation	Job loss
Creation of income generating activities (products, services)	Loss of activities
Creation of environmental services (positive externalities)	Loss of environmental services (negative externalities)
Creation of social networks and collective organization	Loss of social networks and collective organization

millet production is grown (Hien et al, 2004; Some et al 2000). When agroclimatic conditions are fair, yields may increase from 0,7 tons per ha to 1,7 tons per ha; when the rainy season is normal, yields increase only from 0,7 tons to 1 tons per ha. No prices being available in project reports, average producers prices were drawn from FAO documents for the period 1995-2005 for calculating the EIRR. With optimistic scenario on yield change, a positive EIRR was found over three years, three years being the minimum to recover the amount invested. In the second scenario, the EIRR on the same period is negative and ten years are needed to get positive return under this trend. These results show that climate and rainfall variability do impact strongly on the results of actions to combat desertification. This makes projects profitability rates highly variable.

For *Eucalyptus* plantations, no calculation was made because of the lack of information on final results, and also because the evaluators underlined the absence of local markets for timber.

In Baraina (rural Mauritania), a local association named ADD (Association for sustainable development) has developed a 2-year (2004-2006) *Acacia Senegal* plantation project under IREM/LCD. Through a logical framework the project planned for a global and dynamic development of the village, advocating an enhanced protection of the houses and infrastructures against sand silting in order to avoid associated collective costs and to create spaces for cultivation. EIRR calculation only focused on income making by women and youth who are the most vulnerable and who provide free labor for project implementation. Mature plantations yield arabic gum for market and other directly provisioning services, just as was the case with a similar project implemented between 1989 and 1994. In this case, the association had chosen to plant the trees before the rainy season in order to benefit from longer rain watering periods and to allow the trees to growth within a short time. Unfortunately, the location of most of treated dunes above the water dams (funded by the project) did not facilitate their watering, resulting in only 22% survival. The evaluation was solely concerned with arabic gum valorization and so, ignored the avoidance of collective costs. As a result, the EIRR is low, and seven years may be necessary to recover the initial investment. With 50% of tree survival rate, provisioning services and improve income would have raised the EIRR to 15% after seven years". In effect, considering that the cost for building a single house for a family removed by sand silting is much higher than the overall project cost, the project benefit would have exceeded the investment for year I. Unfortunately, EIRR methodology

does not take avoided costs or opportunity cost into consideration (see table 2).

Regarding the ADD projects, result suggests that such kind of investment looks more like local public good creation and need a different approach for evaluation, the returns in terms of Arabic gum yield should not be seen as most important point.

4. Conclusion

The analyses of the literature and of the three micro-projects results show that EIRR is most based on the valorization of provisioning services. This weakness results from the fact that the primary objective in reducing desertification is to generate income for alleviating poverty. There is a contradiction resulting from the fact that no data are available on profit sharing between community members, except for actions on cultivated private lands. This supports the suggestion that more attention should be given to the selection strategy of IREM/LCD project beneficiaries. EIRRs were high when some socio-economic aspects were considered in the calculations; suggesting that project-induced problems, such as the sharing of efforts and benefits and land property rights which create important social costs, must be solved so as to facilitate the consideration of associated costs in EIRR calculation. IREM/LCD selection criteria took into account this issue of property rights in an attempt to secure the investments and to ensure a long-term sustainability for the natural resources. Another limitation is associated with project site selection. Site selection must be in line with local regulations, not to induce adverse effects on neighboring areas. In effect, not all positive EIRRs should raise high expectations of local administrations, natural resources managers and institutions, as a high EIRR observed on one land can hide important processes of land degradation on another land. In other words, EIRRs tend to ignore the risks associated with the local landscape or with the management envisioned on selected sites. Therefore, a landscape approach would be advisable. Another approach would be to privilege avoided costs over provisioning services in order to demonstrate the benefit of invested resources for community sustainability; hoping that the investor will consider this as an internal rate of return. Alternative economic evaluation also suggests an inventory of all the costs and benefits associated to the project. This would necessitate that said costs be valorized in monetary terms under specific assumptions and that project induced changes be well identified and quantified.

Also, the implementation of EIRR approach with local collaboration can generate positive local externalities in

terms of local capacity building such as through collective learning through evaluation processes, contribution to local and territorial development processes and governance by improving monitoring systems. Yet, these advantages remain unconsidered in the EIRR calculation, limiting the use of EIRR only to experts and investors. The procedure leading to the calculation of EIRR must be reviewed to take into account the above important aspects so as to make EIRR a more inclusive environmental evaluation tool for a wider range of users.

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The Drylands Development Model in Argentina's Central West: the Case of Mendoza Province¹

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Abstract – Argentina's central west encompasses a vast dryland territory, organized on the basis of a great contradiction: the confrontation between oasis and rainfed area (desert lands with no irrigation). Within a territory under arid conditions with different desertification levels, Mendoza is a paradigmatic case. The development model fostered at the end of the 19th century was based on the supremacy of strategic resources: water and soil. A mode of regional development reliant on irrigated lands was since then supported to consolidate the wine export model. Nowadays, Mendoza's non-irrigated lands and their people are marginal, not merely by the effect of a restrictive environment but also by the combined action of a fragile environment and the weightier social, political and economic forces that have banished them to the system's margins. Analysis of the region's history informs that non-irrigated spaces provided both strategic natural resources for development of irrigated areas and labor for starting productive activities. Simultaneously, non-irrigated lands were curtailed in their right of access to strategic resources for their social reproduction: water and land. This report delves further into the analysis of the dynamics of territory construction whereby some territories stand as central while others are relegated to marginal positions. The analysis goes deeper into a case study with signs of a serious process of territory impoverishment, social exclusion and progress of desertification.

Keywords – drylands; desertification; development model; Mendoza province, Argentina

1. Introduction

Continental Argentina stretches between latitudes 22° and 55° south, for as long as 3700 km, over an area of 2,758,829 km². This vast extent of land determines a wide variety of climates, from subtropical in the north to cold climates in the southern end and mountain regions, with predominance of temperate climates in most of the country. According to a water regime, the country is divided into three great regions: the humid region, occupying 21% of the land area; the sub-humid and semi-arid region, covering approximately 27.50%, and the arid region – the largest one – that represents 51.50% of the country's area, extending along the western and southern part of the continental area, in the shade of the Andes mountains. Thus, Argentina is the South American country with largest proportion of arid, semiarid and dry sub-humid lands. The relationship between precipitation and potential evapotranspiration defines areas with predominance of deficient water regimes in 70% of Argentina's

territory (figure 1).

About 30 % of the country's population lives in these drylands. Approximately one third of these people live below the poverty line. Despite the magnitude attained by drylands at national level, and the severity of the desertification processes affecting them, this has not translated into public policies that help prevent or control degradation processes. Argentina is known more for being the "world's breadbasket" than for being the "country of drylands" (Abraham et al., 2009). With promotion and development policies historically focused on the productive centers of the humid Pampas, the other regions remained peripheral to the State's interests and were inserted, in a subordinate fashion, as providers of inputs, natural resources and labor. Since colonial times, the design of our country's lines of communication and transport converge on the capital, to facilitate concentration of wealth and communication with abroad, fundamentally through the port of Buenos Aires. The best territorial expression of this policy is the macrocephalic Federal Capital. This sit-

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Figure 1: Drylands of Argentina. Source: SIG desert LADYOT, IADIZA-CCT-CONICET Mendoza

uation changes only relatively with the consolidation of regional economies. Although in the late 19th and early 20th centuries, the provinces lying outside of the Pampas region would launch regional development projects that enabled them to engage in the development guidelines issued from Buenos Aires, trying to compete with produce from the Pampas region, they would replicate in their own territories proposals for development that resulted in new polarities and imbalances. The Argentinean drylands would remain systematically excluded from the development projects that country and provinces endowed to themselves. The national policy relative to natural resources is inscribed in our constitution. In a federal state, every province is the master and sovereign of its natural resources, among which is water that, in the case of irrigated lands, is inherent to the land. This legal framework resulted in very different situations, depending on the political-institutional maturity of each province, but overall signaled by a repetitive abuse of dryland resources which were the basis for building the wealth of central territories, whereby the provinces were excluded from the process. The province of Mendoza, lying in Argentina's central west, is highly illustrative of this situation: its total land area is under dry conditions, with strongly fractured structuring patterns (Abraham et al., 2009). On the

one hand are the concentrations of cities and rural areas that developed with the benefit of irrigation (oases) and on the other hand vast rural territories with no irrigation and dispersed rural population primarily centered on livestock production (figures 2 and 3). This panorama of extreme polarization between oasis and desert is complete if one considers that the province has developed relying on its oasis territories, whereas there is a striking absence of policies for non-irrigated drylands. Such scenario depicts a situation of strong territorial imbalance (figure 4). The notion of desert here retrieved alludes to those territories showing hyper-arid and arid conditions, that is, negative precipitation-evapotranspiration balance. Clarifying this is necessary in the case of Argentina because the term desert has been strongly criticized for having been used as a legitimating argument to legitimize one of the major extermination campaigns recognized in national history (Campaign of the Desert). Even admitting that those criticisms must be particularly taken into account, avoiding the desert-depopulation association, its use in this work tries to recover the environmental particularities that desert spaces exhibit and turn them into unique places in the planet, such as is acknowledged in specialized international literature. The objective of this paper is to analyze the causes of desertification in Men-

doza relating them to the historical dynamics of territorial construction.



Figure 2: Vineyards under irrigation in the oasis



Figure 3: Goats for subsistence activities in non-irrigated dryland



Figure 4: The border between irrigated drylands (oasis) and non-irrigated (desert)

2. The development model that generates territorial imbalance, social exclusion and marginalization

2.1. The causes of the desertification in Mendoza

Mendoza, at the foot of the Andes range, lies in the central west of Argentina, between latitudes 32° and $37^{\circ}35'$ south and longitudes $66^{\circ}30'$ and $70^{\circ}35'$ west, over an area of 150,839 km², with a total population of 1,741,610 people (INDEC, 2010). From the viewpoint of its geographic position, it is strategically located at the crossroads between the two southernmost capitals in South America (Santiago de Chile and Buenos Aires), which is reflected in space through increased flows of trade and people. The province features a heterogeneous natural landscape, signaled by aridity, constrained water and soil resources, biodiversity loss, natural hazards and desertification, revealing sharp economic and territorial imbalances, whose maximum expression is the contrast between irrigated areas (oases) and non-irrigated areas (desert). Since the late 19th century, with the consolidation of a regional economy focused largely on an irrigated viticulture model, at the expense of the degradation of the non-irrigated area and extraction of its natural and social capital, we can speak of the existence of two Mendozas: the green forested city, a place of abundant water and prosperity, and the desert, a place signaled by critical desertification processes. This Argentinean province provides an interesting scenario for analyzing the macroeconomic policies that favored desertification processes for it enfold an apparent paradox: it exhibits environmental problems of considerable gravity, intimately associated with its location in drylands, and is at the same time perceived in the national context as a successful regional economy that has managed to overcome and capitalize on its arid conditions, in favor of a productive activity that finds in them the main source of comparative advantage. A series of natural conditions –low rainfall, a broad temperature range, long sunlight hours and scarce humidity– associated with actions for territory modeling substantiated in a wide irrigation network, gave birth to three oases in Mendoza that allow development of viticulture. Outside these oases, however, similar environmental conditions have resulted in critical desertification processes. The possibility of accounting for this apparent paradox leads to assume that the historical process of forming irrigated and non-irrigated territories has promoted in Mendoza a differentiated and polarized development of oasis areas, which concentrate resources, people and, most of all, power, and non-irrigated areas that are incorporated in a subordinate position to the oases and which will be the areas exhibiting the strongest evidence of desertification. The fact that non-irrigated lands are the ones to show the most severe desertification processes should not, however, lead to assume that the causes of degradation are not confined to overgrazing resulting from irrational individual actions (Torres, 2010). Quite on the contrary, the structural causes of desertification would be related to large, temporal deep processes, closely linked to the regional development project that the province and its hegemonic groups have promoted

over time. In short, although inscribed in unique territories from the environmental perspective, the causes of desertification in Mendoza will not be found associated with locally expressed natural or human-induced disturbances, they will be found in strong association with a regional development project, clearly hegemonic, which prioritized inserting Mendoza into the national context and Argentina into the global context and which, in so doing, subordinated its dryland territory.

2.2. Political and macroeconomic conditions of desertification in Mendoza: recovering the historical dimensions of the process

Upon arrival of the Spanish, which in Mendoza was by the year 1551, the province was occupied by four ethnic groups: Huarpes, Puelches, Pehuenches and Olongastas (Prieto, 1985). The Huarpes settled in the northern part of the present territory of Mendoza, always in the vicinity of the current course of the Mendoza River. Some inhabited the piedmonts and depressions that make up the present "Mendoza's northern oasis" and others the surroundings of the Guanacache system of lakes and wetlands, in the lower part of the basin (currently "non-irrigated drylands"). On the basis of a scattered settlement pattern, the people located in depressions and piedmonts were distributed in villages, with water provided through ditches, a basic infrastructure for water management that allowed them to harness snow melting from the mountains and overcome the region's arid conditions and made possible the development of some crops. Relatively far away from these groups, the Huarpes inhabiting the plains also showed a scattered pattern of settlement along the margins of lakes, rivers and streams (Abraham and Prieto, 1981). The main productive activity was associated with the lake system and combined hunting, fishing and collection, in addition to cultivation of some plant species when the temporary overflow of rivers allowed it. Strong linkages developed between both territories over time, not only because of their common dependence on the same watercourse (currently Mendoza River) but also because of an active interchange of products between both groups. Once settled in the north of Mendoza, the Spanish focused on occupying the irrigated lands, which housed two thirds of the Huarpe population (Prieto and Abraham, 1994) and which they had modeled by building ditches and canals. The progressive displacement of the Huarpe groups soon proved insufficient to the expanding Spanish groups, so these went on to conquer new territories, now more distant, which were incorporated to the fledgling oasis by expanding the irrigation network. The whole colonial period would witness this dual process of growth, namely, expansion of irrigated lands onto non-irrigated lands, and cornering indigenous people in territories with low likelihood of being irrigated. At the same time, although the interchange process would not stop, they would show growing trends towards imbalance, so that whereas the former would focus on irrigated cultivation of cereals and forage, on fattening livestock for later sale to Chile and on producing alcohol and wine (Prieto

and Abraham, 2000), the "downstream" territories home to the displaced Huarpe groups would become the major source of particularly personnel and fish for the oases (Abraham and Prieto, 1981:127). It is at this stage that a territorial development model strongly associated to water begins to take shape, which would enable consolidation of the "Viticulture Model" across the 20th century and would allow the region to link up, without competing, to the Humid Pampas-Port axis, already hegemonic at that time. In the context of the international division of labor, Argentina in the late 19th and early 20th centuries stands as a supplier of agricultural and livestock products coming from the humid Pampas, with Great Britain as their main destination. The productive specialization achieved in the country, serviceable to foreign requirements, brings increased foreign investment, expansion of the railroad network, an exponential increase in exports and setting up of a policy of attracting immigrants aimed at meeting growing demands for labor. The interior of the country would have to quickly adjust to the national scenario. Some regions would do so by avoiding the great Pampean competitor, maximizing the comparative advantages derived from their soils and climate. Such is the case of sugar cane production in Tucumán and wine making in Mendoza, both mounted on experiences that had been developing since past times and that, however, consolidate definitely in the context of a national organization according to the role assigned to Argentina in the international scenario (Romagnoli, 1997; Campi and Richard Jorba, 1999).

Throughout the 20th century, the vine and wine industry consolidates definitely in those territories of Mendoza that managed to get hold of irrigation water and of the most suitable agricultural soils. Migration flows from Europe, many of them coming from regions with a wine making tradition, would in turn provide the knowledge and labor required for model tuning. Always depending on mountain snowmelt, but increasingly caught in the irrigation network, the Mendoza River flows would, over time, cease to provide water to the "downstream" territories in the northern oasis, jeopardizing the water supply that fed the lake and wetland system that supported fishing and crops (figure 5). The demands for water posed by the expanding oases will soon be joined by rising demands for timber by Mendoza city, and in the same way as with water, timber will be extracted from the territories lying east of the city, "downstream" of the Mendoza River (figure 6).



Figure 5: Drying of Guanacache Wetland (Ramsar site)



Figure 6: Dry bed of the Mendoza river in the lower basin

2.3. *Current situation: recommendations to decision makers*

Throughout the 20th century, there are three concurrent processes on the plains in eastern Mendoza: sustained decrease in surface water available (now destined for the oasis areas), massive removal of forest resources (destined for urban areas) and progressive but nonstop introduction of goat livestock, the only one which due to its characteristics could cope with increasingly restrictive environmental conditions. Towards the end of the 20th century and beginning of the 21st century, the vine and wine industry in Mendoza experiences a deep restructuring process that drives it away from the making of common and table wines to undertake the making and trading of fine wines destined for the international market (Bocco, 2003). Again, it is the world-system transformations that provide an enabling framework for these changes, directed to position local products in international consumer markets. Concomitantly, desertification processes advance and become deeper in non-irrigated drylands. Thus, even though it is usual to associate desertification with overgrazing, and in this region the greatest responsibility is also ascribed to the latter, the analysis should necessarily lead to reflection on the also traditional association, which some

authors promote, between overgrazing and irrational individual action (Thomas et al., 2011). Rather the contrary, a sensitive look on the history of these territories reveals that the differential situations now existing in Mendoza are the result of complex frames of unequal relationship sedimented through time, where irrigated spaces have made an extractive use of the resources –natural and human- of non-irrigated spaces. The consolidation of viticulture and oases commands at the same time the subordination of other actors and territories and, moreover, determines removal of certain natural resources that are invariably put to the service of a regional economic project disputed outside the territories currently exhibiting visible signs of desertification. The presented case reveals that, although the dynamics of unequal relationship between irrigated and non-irrigated lands acquires a territorial dimension, it does not come down to disputes explainable in strictly environmental terms. In any event, these are territory-anchored disputes which express and result from power relationships. Nature, therefore, does not play a particular role; on the contrary, the parts of nature that become a resource, because of the use that is made of them, give materiality to exploitative processes that find a way of expression in desertification. Finally, if at the provincial territorial scale these processes and dynamics are to be considered structural causes of desertification, at local scales their visualization should necessarily invite to review the arguments placing on victims the exclusive responsibility for problems. Drylands exhibit conditions of territorial imbalance and a lack of political and social equity. The pattern of economic and demographic concentration is similar in the irrigated territories, which have managed to capitalize strategic resources such as water, soil and population, to detriment of non-irrigated drylands. From this emerges the recommendation to repair this situation by restoring the goods and services of these degraded ecosystems and restoration the rights of access to land and water by local populations. Knowing the real causes of desertification and its consequences for these territories becomes a real matter of historical repair.

3. Conclusions

With a territory fully extending under dry conditions, with different levels of desertification, the province of Mendoza is a paradigmatic case of organization based on a great contradiction: the confrontation between irrigated drylands, “oases”, and non-irrigated drylands, “desert”. The major causes potentiating the risk of desertification lie in the weakness of integral and inter-sector coordinating policies, which translates into territorial imbalance with negative effects on social, economic and environmental dimensions, policies that have historically been practically absent from non-irrigated territories in contrast to a diversity of policies for the oases and promotion of their activities (Abraham, 2009). The development model encouraged by dominant groups at the end of the 19th century was based on mastering two strategic resources: water and soil. From there, a model of regional

development was favored, which was strongly centered on irrigated lands in order to consolidate the wine export model. "Downstream" territories were not paid the same attention; rather, they were integrated in a subordinate way in the exclusionary model of regional development posed by local elites. This being so, current desertification processes, particularly critical in these lands, are not the exclusive result of restrictive environmental conditions, rather, they are imbricated with the historical dynamics of territorial construction. Analysis of the region's history reports that non-irrigated spaces worked as providers of strategic natural resources for the development of irrigated areas and of labor for implementing the dominant productive activities. Simultaneously, non-irrigated territories were curtailed in the exercise of their right of access to strategic resources for social reproduction (Abraham and Torres, 2011). When strategies are designed only for the oases, by omission, decisions are being made for the rest of the territory. The challenge to take on is planning with a system criterion that articulates the relationship between oases and non-irrigated areas, while giving way to historical repair actions.

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Water and soil conservation practices in the Sahel: an analysis of their potential to increase resilience of rural livelihoods¹

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Abstract – In the Sahel, people have always faced extreme climate conditions with high rainfall variability. Rising population density, unsustainable cultivation practices and depletion of natural resources, particularly of soils, continue to accelerate desertification. This situation is further exacerbated by the effects of climate change, resulting in increased stress on the eco-systems and higher vulnerability of the rural population. Since the 1980s, German development cooperation (GDC) has been providing support to people in the Sahel region through development and implementation of improved natural resource management strategies and approaches. A special emphasis was put on soil and water conservation (SWC), and soil protection and restoration (SPR). In this paper several techniques and approaches of SWC / SPR are presented. Their contribution to improving the resilience of prevailing agro-sylvo-pastoral systems and to reducing the vulnerability of rural populations is also examined. A special focus is on water spreading weirs, a relatively new technology introduced in the Sahel by the Swiss and German development cooperation for the rehabilitation of degraded dryland valleys. This technique is part of a spatial approach that combines several land management techniques that reduce soil erosion and improve soil fertility and food security. Finally, the paper gives policy and technical recommendations for up-scaling the techniques presented in order to contribute to sustainable land management and resilience building on the ground.

Keywords – soil and water conservation, resilience, climate change adaptation, food security

1. Introduction

More than 10 million people in the Sahel suffered from food crises in 2010 (Gubbels, 2011). Also in 2012, a significant percentage of the population in the region was affected by food insecurity. This situation was exacerbated by the conflict in northern Mali that forced many people to leave their home regions. Globally, about 18 million people are at risk of hunger within the West African Sahel (European Commission, 2012). Food security crises in the

Sahel have a cyclic character and are caused by complex factors, the most determinant of which are natural phenomena such as droughts and locust outbreaks (Sendzimir et al., 2011). The periods of 1942-49, 1968-73 and 1982-84 comprise the most illustrative drought-related famine events in the region (Reij et al., 2009).

Inter-annual climate variability is a typical characteristic of dry regions like the Sahel. People have learnt over time to cope with and to adapt to permanent water scarcity, erratic rainfall and risks of climate related

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shocks. But due to different factors, such as high poverty rates, changing socio-economic and political conditions, population growth and degrading natural resources some of these traditional adaptive strategies have become insufficient, while others prove to be unsustainable (UNCCD et al., 2009). Meanwhile, due to new political and economic conditions other traditional practices and approaches such as the farmer managed natural regeneration (FMNR) in Niger which had been abandoned in favour of rather unsustainable practices, are now being reconsidered and promoted (Sendzimir et al., 2011; Reij et al., 2009).

In general, drylands are more vulnerable to the effects of climate change because the populations have low adaptive capacity. Therefore in the Sahel in particular, climate change must be seen as an additional pressure to the already unstable livelihoods. Increased dependence on natural resources adds to ecosystem fragility, increased poverty and unfavourable political conditions to complicate vulnerability in dry areas (Sørensen et al., 2009).

Therefore, strengthening the adaptive capacity of vulnerable households should be the lead action when seeking to enhance resilience of rural livelihoods in the Sahel. As explained by Frankenberger et al. (2012: 3), this commends that the nature and extent of access to and use of resources be the focal points in order to succeed durably. Resilience and vulnerability being oppositely related, reducing vulnerability means increasing resilience. Frankenberger (2012) proposed descriptive pathways specific to either concept, stating that households that are able to adapt to shocks and stresses (adaptive capacity) and to incrementally reduce their vulnerability are on a resilience pathway. The holistic framework of resilience is appropriate to guide long term and multisectoral interventions, integrating emergency operations, reduction of risks as well as climate change adaptation and development (Gubbels, 2011). An important resilience factor in rural Sahelian areas is *agro-ecological agriculture* which encompasses such conservative practices as agro-forestry, integrated livestock/agriculture, soil and water conservation, crop management and integrated pest management, etc. These approaches contribute to secure and/or increase agricultural yields, to regenerate natural resources, and to improve income, resulting in improved food security and resilience (Gubbels, 2011).

This paper is to present some of the key factors determining vulnerability and resilience of rural livelihoods in the Sahel region. It also discusses the potential of sustainable land management practices such as soil and water conservation (SWC) and soil protection and restoration (SPR) as based on GDC practical experiences.

2. Main factors determining resilience in the rural Sahelian region

The causes of instability in the Sahel region are complex and cut across several sectors. They include low productivity, inadequate access to food and health care, malnutrition, missing social safety nets, and poor infrastructure (Mertz et al., 2009; European Commission, 2012). Underlying causes include the degradation of ecosystems and

the effects of climate change that destabilize agricultural production systems. Economic disparities and weak public institutions further contribute to lessen resilience in the region. In the following sections, selected resilience factors with special effects of the natural resource base will be presented in more detail.

2.1. Population growth

The population of the African continent has grown at 2.5 per cent annually for the past 60 years from 186 million in 1950 to 856 million in 2010 (UNDP, 2012). In most of the Sahelian countries the population grew even more than 3 per cent per year. In 2050 the African population will probably reach 2 billion, whereas faster growth is projected for East and West Africa. This rapid growth combines with shifting diets towards processed food, meat and dairy products to increase the pressure on food systems and natural resources. It is expected that food supplies will double in the next few decades (UNDP, 2012; Foley et al., 2011). However, the expansion of agricultural areas in the tropics must not be considered as a solution, as experience shows the increase of acreage has more effect on reducing biodiversity than on increasing food supply. In effect, across the tropics, between 1980 and 2000 83 per cent of new agricultural land came at the expense of forests, while 55 per cent came from intact forests and another 28 per cent from disturbed forests (Gibbs et al. 2010; Foley et al., 2011). Consequently ecosystem services are being depleted while greenhouse gas emission increases. Therefore, more effort in technical improvement is needed on existing agricultural lands, fuel crop production needs to be reduced for international demands and awareness about birth control promoted.

Indisputably, all of these factors make soil fertility management an essential key to agriculture sustainability (Kandji et al., 2006).

2.2. Land degradation

Measuring the extent of desertification on a bigger scale always relies on qualitative assumptions and scientific models. According to Zika and Erb (2009), globally about 23 per cent (12 Mio. km²) of drylands are affected by desertification. Some authors suggest even higher numbers, reaching up to 71 per cent (36 Mio. km²) (Dregne u. Chou 1992). According to the GLASOD study, desertification in Africa is particularly alarming as about 10 per cent of the continent's land area is affected (Oldeman et al 1991). Estimates by Reich et al., (2001) attained 46 per cent of the African land mass, with over 485 Mio. people concerned. The situation is compounded by climate change and increasing population pressure. In effect, between 1990 and 2025 the average agricultural area per capita in Sub-Sahara Africa will decrease by 61 per cent to 0.63 ha (Norse et al 1992). In some areas of Niger in particular, up to 50 per cent of the landmass have already become totally unproductive due to land degradation (Gubbels, 2011). Soils in the Sahel are very fragile, poor in plant nutrients and prone to erosion. Torrential summer rains

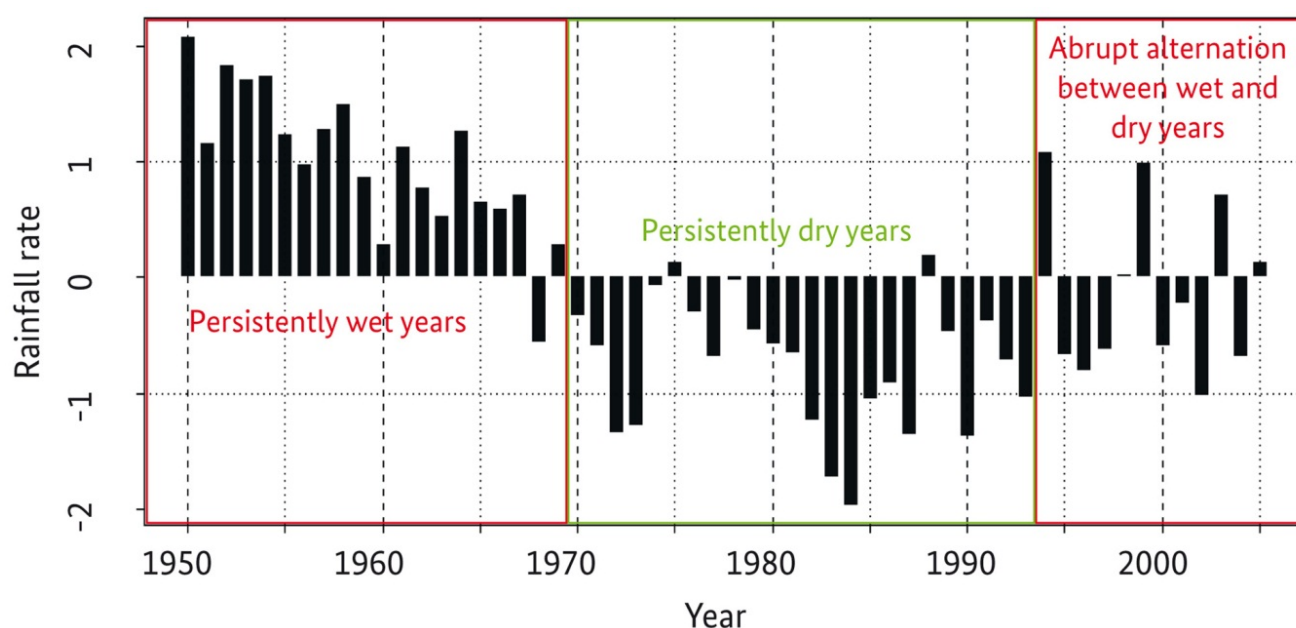


Figure 1: Rainfall variations in the Sahel (Sarr; N'Djafa Ouaga, 2009). Positive values indicate years with rainfall levels exceeding the average of the period 1950-2006, and negative values indicate years with rainfall levels lower than the average for that period.

and limited soil water absorption capacity cause high water runoff (40 per cent of annual precipitation are common) making soils highly sensitive to erosion and crusting. About 100 tonnes of soil per hectare per year are common rates of rain erosion. Additionally in some areas, wind erosion can amount to 150 tonnes per hectare. Wind and water erosion are considered the main constraints to agricultural sustainability in the Sahel, contributing to a large extent to desertification (Kandji et al., 2006). Land degradation is caused by different other factors, including the following:

- Insufficient or non-existent spatial planning; land use plan for sustainable land management is often missing or not implemented
- Traditional strategies of natural resource management have become unsustainable under continued population growth, mostly because they tend to encourage abusive exploitation (overgrazing, bushfires, deforestation and abusive wood cutting and pruning, etc.)
- Insufficient / lack of land tenure security that favours unsustainable land use practices
- Increasing climate risks such as droughts and onset of desertification process
- Salinisation as a result of improper irrigation

Indisputably, all of these factors make soil fertility management an essential key to agriculture sustainability (Kandji et al., 2006).

2.3. Climate change

The Sahel is characterised by wide climate variations with succession of dry and wet years and irregular rainfall between (200-600 mm). Temperatures in West Africa in-

creased by an average of 0.5-0.7°C between 1951 and 2001, with an increase of around 0.7°C in the minimum temperature and 0.35°C in the maximum temperature (Sarr and N'Djafa Ouaga, 2009). This climate variability stands as the major constraint to assuring food security in the region (Kandji et al., 2006).

As shown in figure 1, analysis of the rainfall pattern in the Sahel reveals three important climate periods:

1. 1950-1968: a period of high rainfall with year-to-year variability and an overall downward trend;
2. 1968-1993: a dry period with high year-to-year variability;
3. 1993-2006: a period of very high year to year variability with humid years alternating with dry years.

Climate projections predict a warming of 0.2°C to 0.5°C per decade across the African region, with higher temperatures within the Sahel and in central southern Africa (Kandji, 2006). As a result, local conditions will exacerbate because of higher evapotranspiration. While predictions are unclear about future trends of rainfall, the following may still be expected:

- Higher temperatures and more frequent heat waves
- Decline of annual precipitation in North and South Africa; increase in East Africa
- Longer drought periods in North and South Africa, and shorter droughts in East Africa
- Increase in rainfall intensity over the whole continent
- Decreasing trend in the duration of the wet season in parts of West Africa

Even under unchanged annual precipitation, higher rain intensity will combine with frequent droughts and floods to increase risks of soil erosion and vegetation de-

struction (Mertz et al., 2009; Kandji et al., 2006; Sørensen et al., 2009).

3. German development cooperation in the Sahel

Since the eighties of the 20th century, German Development Cooperation has developed and implemented soil and water conservation approaches in the Sahelian countries. Big rural development projects in Niger, Burkina Faso, Chad and Mauritania supported rural populations by providing knowledge about soil and water conservation technologies.

Communities and user groups have been trained in land use planning and implementation of measures that reduce water run-off and improve soil fertility. These efforts were accompanied with management instruments such as “local conventions” signed between user groups to prevent conflicts, and helped to protect vast landscapes against desertification. Similar approaches were used by other international partners and donors like FAO and the Swiss Cooperation (SWC). Because of increased poverty and vulnerability in the region, the SWC approach included social measures, such as Food-for-Work or Cash-for-Work in order to encourage participation, with expectation that in the long-term the people will understand the positive impact on the environment and on their livelihoods and will therefore become sensitive to land degradation. Reclaimed lands are used for agriculture, grazing and forestry. Livelihood systems become more diversified and resilient against droughts and other adversities. Soil and water conservation/soil protection and restoration (SWC/SPR) measures were one of the priorities of the German cooperation in the Sahel region. The following sections will discuss these measures in detail.

4. Soil and water conservation/soil protection and restoration (SWC/SPR)

SWC/SPR measures aim to achieve various goals:

1. to improve water management,
2. to increase the productivity of croplands, forestlands and rangelands and
3. to ensure sustainable management at the environmental, social and economic levels.

With regard to beneficiary groups in particular, the goal is to improve income, food and nutrition security by guaranteeing, increasing and diversifying production in order to enable them to cope better with lean seasons. In social terms, the goal is to improve the organisational capacities of rural communities, to promote rational use of natural resources and to prevent conflicts. Overall, SWC/SPR measures contribute to raise the water table, improving water availability for humans and animals. In environmental terms, they improve local ecology through soil erosion control, and improved soil fertility. SWC/SPR measures therefore improve and stabilize the livelihoods of local populations, and increase their resilience against external factors.

SWC/SPR measures are implemented taking into account the topographical units of the entire watershed, including plateaus, slopes, pediments and valley bottoms. These topographical units have different types of soil, vegetation and capabilities and are often exploited by different user groups under different forms of land tenure (figure 2).

The plateau areas are usually communal lands with shallow, infertile, stony soils. As such, they are generally over exploited as grazing lands and for various forest products, including wood, straw, fruits, bark and other non-ligneous products.

Slopes also have shallow, stony soils with grass and bush cover. Under the effect of highly erosive rains that characterise the region, small ditches and gullies impart the landscape of the plateaus and hillsides, and contribute to limit their use for grazing areas.

Pediments are located in the piedmont areas of the plateaus. They have gentle slopes and are prone to sheet and gully erosion. Because of their deeper and more fertile soils, pediments are predominantly used for rain-fed agriculture.

The valley bottoms have deep, more fertile soils enriched with fertilising elements transported from upstream. Because of their moisture advantage, valley lands are used to grow high moisture demanding crops such as rice and maize during the rainy season; but they are also used as grazing lands. During the dry season, the shallow water table enables irrigation agriculture for subsistence and cash crop production. In general, the water streams that converge to the valley are strong and loaded with alluviums, and therefore, often cause severe erosion, clog the water beds and damage the hydro-agricultural infrastructures.

There is no one-size-fits-all technical solution in land management: Each situation needs specific measures that must take into account the land use objectives, the specificities of the land to be improved (topography, soil properties and structure, type of degradation, vegetation cover, watershed influence, etc.), as well as the local climate factors (rainfall characteristics, temperatures, evapotranspiration rates, wind characteristics). Therefore, the assessment of whole watershed becomes essential for success as this permits to select the most appropriate techniques and approaches to combine, not to propose strategies that would be technically and economically inaccessible to the farmers and which would not have plausible direct effects. This assessment must be conducted using participatory methodologies, involving the local populations and even people from neighbouring areas. Such participatory assessments enable to bring to light potential conflicts over lands, to raise the populations' awareness about the stakes of land degradation, and to facilitate their adhesion to project activities. Effective participation of the population strengthens their expertise in SWC/SPR techniques along with their organizational and management capacities, and cuts down project costs.

The roles of SWC/SPR measures are rather simple: They break the speed, and therefore the strength of the water flow, stopping or slowing it down, in order to give

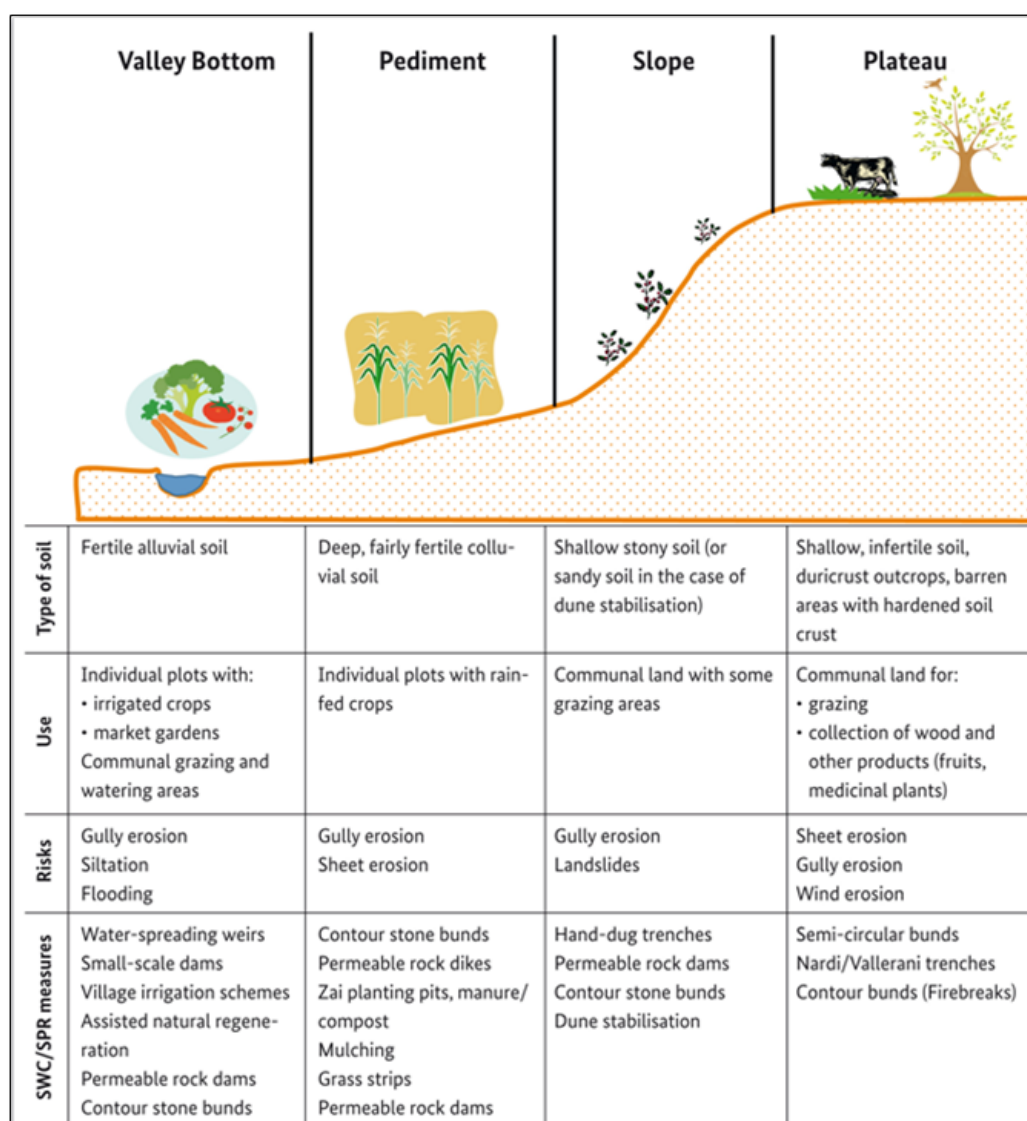


Figure 2: Toposequence diagram. Source: Nill and Dorlöchter-Sulser (2012).

time to the water to infiltrate the soil. This way, the water table is recharged to better feed the plants. In so acting, SWC/SPR measures reduce, not only rainwater loss, but also fertilisers (manure and chemical fertilisers) losses.

5. Water spreading weirs

Water spreading weirs are a relatively new technology aimed at rehabilitating degraded inland valleys. Introduced in the Sahel in the late nineties by Swiss and German development cooperation, this technology has been refined during the last 10 years and is now widely implemented in Burkina Faso, Niger and Chad with potential for further up-scaling.

Water spreading weirs are stone and cement constructions that extend from one side of the valley to the other. Usually built in a series to stabilise the entire valley, the weirs allow spates to flow over and flood the land below, thereby increasing the area that is usually flooded. Because speed of the water flow is reduced, fertile soil is deposited, and water infiltrates into the ground, lifting the

water table. This allows farmers to grow crops all year round (rain-fed and irrigated), even on formerly degraded lands, thereby contributing to food security and resilience. In most cases rehabilitated lands are used for production of high value crops like vegetables. Although cost-benefit studies are still underway, there are indications that the cost of rehabilitation ranges between € 400 – 2000 per hectare and can be recovered with the additional harvest of one year, depending on the type of crop, state of degradation, the type of valley and the region. In any case, the cost of a water spreading weir is much lower than that of a dam.

Both the effectiveness and sustainability of water spreading weirs require:

1. participatory planning with the local population,
2. that they be considered as a land use planning instrument;
3. clear land rights, and
4. the creation and training of local maintenance structures.



Figure 3: Example of a water spreading weir. Photo: © GIZ/Klaus Wohlmann

Although the maintenance of the weirs are little demanding, it is advised to develop the technical capacity of local contractors and government officers, mostly to cope with important damages that may happen. These technical capacities must be passed-on to subsequent groups and generations in order to ensure long term sustainability.

In conclusion, water-spreading weirs permit the rehabilitation of degraded inland valleys and constitute an effective means for erosion control and agricultural soils rehabilitation. They contribute to optimise water and soil management, thereby increasing agricultural production, sustainably. Water spreading weirs are not a stand-alone technology, but they complement other anti-erosion measures, e.g. on hillsides and on plateau areas. They form an integral part of watershed management and can be implemented in a wide range of environmental conditions. Therefore, they are suitable for up-scaling to other semi-arid regions within and beyond the Sahel.

6. Conclusions and recommendations

SWC/SPR measures are effective ways of improving water resources management and of reducing the degradation of soil, vegetation and biodiversity. As such, they contribute to mitigate the effects of climate change, improving soil fertility, plant cover and biodiversity toward more secure livelihood and higher standard of living for rural communities. Training in SWC/SPR techniques also result in more appropriate land use planning at the local and communal levels, more rational use of natural resources, more secure land tenure and less risks of conflicts.

The adoption of SWC/SPR measures is a promising solution for countries in the Sahel, but it requires a long-term commitment. To implement these measures over a geographic area wide enough to achieve significant impacts would necessitate sustained state-wide commitment over several generations. More specifically, gov-

ernments must ensure that communities are well organized and effectively adopt SWC/SPR measures. Without close monitoring, SWC/SPR programs will lose momentum. While international support is necessary to finance investments, experience has shown that only this kind of long-term commitment leads to success. Traditional short-term projects can only contribute specific investments in the broader land improvement framework.

6.1. Recommendation for the promotion and implementation of agro-ecological practices

In order to ensure that the most vulnerable groups are reached the impact of agro-ecological systems must be monitored across farmers of all economic classes (see also Gubbels, 2011).

Rather than promoting isolated SWC/SPR techniques, synergic approaches should be advocated, combining several techniques and methods in flexible ways in order to ensure that the social, economic and environmental specificities of the area are taken into account (see also Reij et al., 2009). To design a coherent package of appropriate technical measures for addressing ecologic and social priority vulnerabilities, a landscape approach based on spatial analyses and planning would be advisable.

By combining and inter-linking techniques and approaches that address individual household interests with those that address communitywide interests, local ownership and thus sustainability will be fostered. As local ownership is strengthened, farmer-to-farmer based experience exchange and trainings must be promoted.

6.2. General recommendations

Long-term measures including rehabilitation and sustainable management of fragile ecosystems are necessary to address root causes of vulnerability. Development pro-

grammes must therefore foresee long term engagement. One priority in order to ensure the feasibility of long-term measures must be the promotion of stable and secure land tenure which includes traditional land use and resource management regimes as well as modern property regimes.

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Towards Improved Decision-Making in Degraded Drylands of Southern Africa: an Indicator Based Assessment for Integrated Evaluation of Restoration and Management Actions in the Kalahari Rangelands¹

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Abstract – The loss of ecosystem resilience and land productivity is a major problem in drylands of southern Africa. This needs to be addressed in an integrated way linking science to society. Identifying best practices for land restoration and sustainable land management in a process combining local and scientific knowledge is therefore very important as regional perspectives are created and knowledge shared among affected land-users. A corresponding bottom-up framework was suggested by the multinational EU-project PRACTICE, which has been tested in arid Kalahari rangelands of South Africa. Following the identification of a multi-stakeholder platform (MSP) related to the livestock farming community of the study area, the participants' baseline assessment and site-specific indicators for the evaluation of locally applied restoration and management actions to combat desertification were obtained in a participatory process. The MSP ranked the relative importance of the indicators on an individual basis using the pack-of-cards method, and re-ranked these indicators following group discussions. The individual ranking results were combined and integrated with biophysical and socio-economic measurements for the indicators through a multi-criteria decision analysis (MCDA), which ranked the alternative actions according to their relevancy and performance. The MCDA outcome was shared back with the MSP to stimulate group discussion and re-evaluation of the restoration and management actions aiming at improving management decision-making in Kalahari rangelands. The steps of this participatory approach are documented and results and the overall potential for implementation in local and national policy frameworks is critically discussed.

Keywords – *best practice, local knowledge, multi-stakeholder platform, participatory process, social learning, South Africa.*

1. Introduction

Subsistence in the rural dryland areas worldwide depends on the effective and sustainable utilization of the natural resources, which are increasingly threatened by land degradation, mainly due to extensive droughts and mismanagement, such as overgrazing. The African conti-

nent is spatially the most impacted with more than 70% of its agricultural drylands being already desertified (Hoffman and Ashwell, 2001). In particular the socio-ecological systems of sub-Saharan countries underwent dramatic changes in recent decades due to the combined effects of land use change (away from traditional practices like pastoralism towards sedentism) and climate change (Archer

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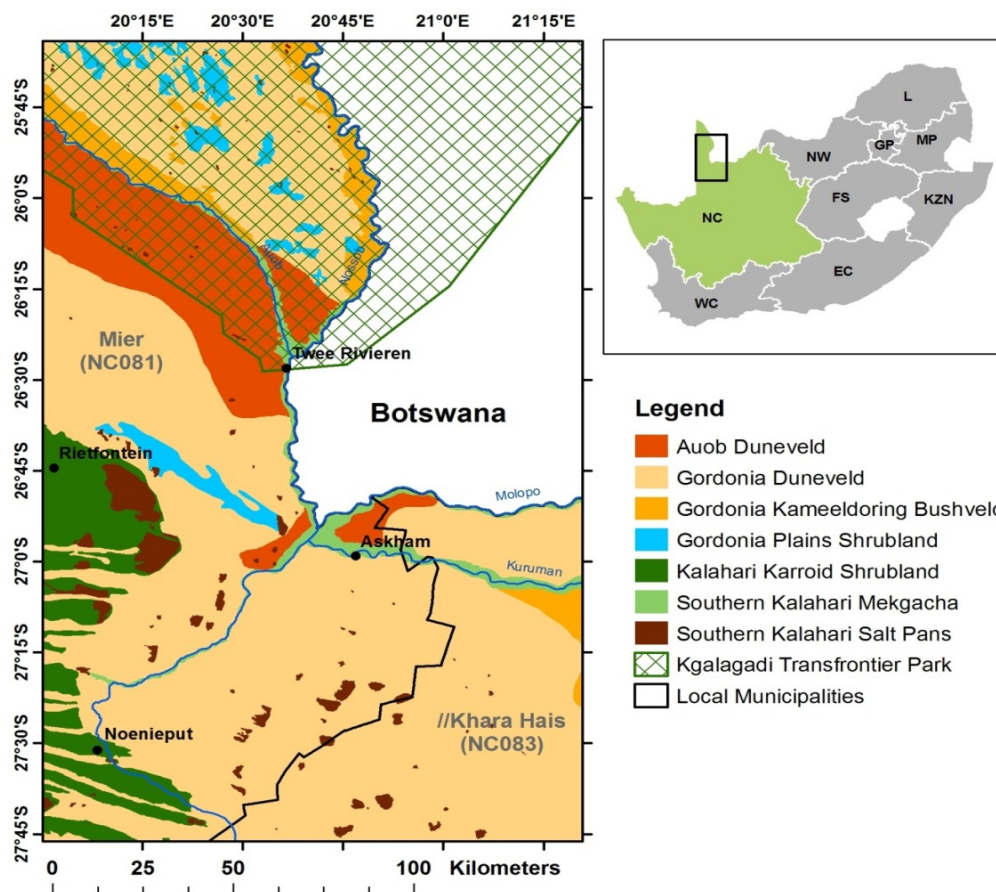


Figure 1: Location of the study area (Mier municipality) in the Northern Cape Province (NC) of South Africa. Shown vegetation types follow Mucina and Rutherford (2006).

and Tadross, 2009; Oba et al., 2000). This development is also symptomatic for South Africa, with serious environmental, social and economic implications for the country (Hoffman and Ashwell, 2001; Milton and Dean, 1995; Palmer and Bennett, 2013).

Land degradation is a complex and dynamic process driven by a multitude of factors including biophysical and socio-economic factors. Recognizing their interrelated impacts, any monitoring and assessment framework of land degradation should be based on an integrated and multidisciplinary approach (Vogt et al., 2011; Von Maltitz, 2009). In this respect, Sommer et al. (2011) point out that local participation is both ethically desirable and practically essential. Although South Africa has a relatively long history of combating land degradation emerging in the second half of the 20th century, it took a while until the needs of environment and development (e.g. community participation) started to be considered together (Hoffman and Ashwell, 2001). However, many land-use practices in rural areas are still driven by inappropriate policy frameworks, which emphasize the urgent need for local-level governance institutions assisting land users in sustainable land management (Palmer and Bennett, 2013; Von Maltitz, 2009).

Attempts in South Africa's drylands to mitigate degradation at local scale should make use of land-user knowledge and actively involve them at all levels of project

planning, decision-making and execution (Botha et al., 2008; Reed et al., 2006; van Rooyen, 1998). This principle of linking science to society by combining traditional/local knowledge with ecological (academic) expertise for improved decision-making and sustainable environmental management is nowadays perceived a necessity in order to combat the loss of ecosystem resilience and land productivity, for creating local to regional perspectives and to share knowledge for the benefit of the socio-ecological environment (Fraser et al., 2006; Reed, 2008). A corresponding bottom-up framework is therefore suggested by the international, European Commission-funded project PRACTICE (Prevention and Restoration Actions to Combat Desertification. An Integrated Assessment) aiming at filling the gap of systematic evaluation of practices for land restoration and sustainable land management in a participatory and integrated manner (www.ceam.es/practice). In the course of the project, an evaluation protocol was developed and tested for its general applicability in different socio-economic and biophysical contexts and syndromes of land degradation in selected dryland sites worldwide (Rojo et al., 2012).

The present paper reports the application of the evaluation protocol exemplified by a case study from degradation-prone Kalahari rangelands of South Africa. First, the single steps of the participatory PRACTICE approach are documented and results presented. Sec-

ond, lessons learned and shortcomings observed are highlighted and concluded with a way forward. Finally, the overall potential for implementation in local and national policy frameworks is briefly discussed.

2. The socio-ecological environment

The PRACTICE approach is presently applied in two different cultural and biophysical settings of the Kalahari farming area in South Africa comprising different land tenure systems in the Mier municipality of the Northern Cape Province (test completed) and the wider Molopo area of the North West Province (evaluation running). The focus of the present case study lies on the Mier rural area just south of the Kgalagadi Transfrontier Park, between the Namibian and Botswana borders (Fig. 1). It forms part of the arid southwestern Kalahari basin receiving between 150–200 mm of rainfall per year mainly from January to April. Study sites encompass two broad rangeland types:

1. the duneveld characterized by nutrient-poor aeolian sand forming linear dunes intersected by dune streets and covered by open, savanna type vegetation (Auob and Gordon *sensu* Mucina and Rutherford (2006); Fig. 1), and
2. the rather level hardveld on loamy, stony soils with a prominent dwarf shrub vegetation (Kalahari Karroid Shrubland *sensu* Mucina and Rutherford (2006); Fig. 1).

Livestock farming with mostly mixed herds of sheep, goats and cattle, as well as game ranching are the two main land use activities in especially the duneveld area (Van Rooyen, 2000). However, most properties (leased or owned) are relatively small (< 2500 ha) and allow for smallholding to semi-commercial farming only. They have little infrastructure, such as fencing to make paddocks and watering points for better distribution of livestock and rotational grazing options. Many of the local farmers are not able to expand or develop their farms because of financial constraints. This causes inflexibility in employing ecologically sustainable management practices and forces farmers to utilize continuous grazing systems with inadequate water availability. In combination with a highly variable climate, rangelands in the study area easily deteriorate (Van Rooyen, 1998), which may result in profound regime shifts characterized by a loss of ecosystem resilience and rangeland productivity. Related degradation processes include either the loss of vegetation cover and an associated dune remobilization (Bhattachan et al., 2012) or an increase in woody vegetation (bush encroachment) (Van Rooyen, 2000), as well as changes in plant diversity and abundance patterns of plant functional groups (Rutherford and Powrie, 2010).

3. The integrated assessment

The PRACTICE integrated assessment protocol (IAPro) (Bautista and Orr, 2011) was applied to identify suitable and widely accepted practices for desertification mitiga-

tion in Kalahari rangelands of the Mier area. The protocol integrates both the human and biophysical dimensions of desertification in seven steps, four of them being fully participatory. The participatory part includes the identification of local stakeholders (SHs) and their engagement, a baseline evaluation of actions and indicators, a weighting of indicators, as well as a collective integrated evaluation of actions (Rojo et al., 2012).

3.1. Identification and evaluation of actions and indicators

In Mier, IAPro step 1 and 2 were conducted simultaneously in a semi-structured interview due to logistic constraints. A diverse set of SHs was identified through a local consultation process and chain referrals, which resulted in a selection of 28 SHs forming the multi-stakeholder platform (MSP) to be involved throughout the study (Fig. 2A). Information was obtained on the participants' baseline evaluation of locally applied land management and restoration actions, and site-specific indicators identified from the participants to be selected for action evaluation from the individual semi-structured interviews.

The interviews revealed that the most commonly applied actions to mitigate desertification in the Mier area include: (1) chemical shrub control (duneveld only), (2) good management (i.e. rotational grazing, resting periods, herding), (3) dune stabilization by brush packing (duneveld only), and (4) revegetation by transplanting grasses (predominantly in hardveld). A total of 30 ecological and socio-economic indicators were mentioned and/or proposed by the interviewees. A final set of meaningful indicators was short-listed by taking into account aspects of redundancy, popularity, data availability and collectability. Combined with expert-selected common indicators based on the ecosystem services approach, this resulted in a condensed list of 11 refined indicators for evaluating the identified actions (Fig. 2B and Table 1).

In IAPro step 3, the MSP established the relative weight of the final set of indicators. Following Figueira and Roy (2002), indicator prioritization was processed via the revised Simos' procedure or pack-of-cards method. Participants were asked independently to rank cards symbolizing the indicators according to their perceived importance and to insert blank cards to reinforce ranking differences. After computation of both the individual and integrated SH perspectives (*sensu* Figueira and Roy, 2002), the resulting normalized weighting (Fig. 2B, first iteration) was presented to the MSP during a workshop. Participants were encouraged to discuss each other's results in small sub-groups, followed by an open group discussion and a second round of weighting for potential re-ordering the indicators should their perspectives have changed. The integrated collective weighting of indicators was indeed different from the first iteration (Fig. 2B). This might indicate a potential social learning effect through the exchange of views and experiences between land users, as well as individual and group reflections on the issues discussed. The SHs clearly rated the indicators 'grazing capacity' and 'biodiversity' (referring to fauna and flora)

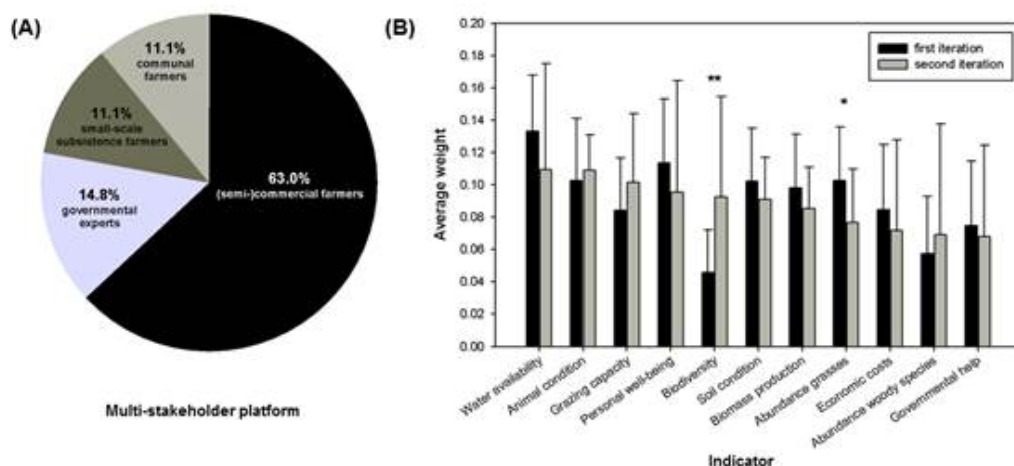


Figure 2: (A) Composition of the multi-stakeholder platform and (B) relative importance of indicators averaged over individual stakeholder perceptions (group composite weights) before (first iteration) and after (second iteration) group discussions. Bars represent means $\pm$ SD; asterisks indicate significant differences at * $p < 0.05$ and ** $p < 0.01$ (Mann-Whitney-Wilcoxon test).

higher and ‘abundance of grasses’ lower in the second run, with the latter two being assigned a significantly different mean weight after the group discussions (Fig. 2B). In both iterations, the availability and supply of water was ranked highest as this indicator promotes the application of better management strategies, such as rotational grazing. Second highest was ‘animal condition’, which is a function of the ‘grazing capacity’ of the rangeland (third rank). Aspects related to personal factors such as finances and future well-being of the family played obviously an important role for Kalahari farmers when evaluating the actions (Fig. 2B).

3.2. Combining stakeholder perspectives with quantitative data

Ecological indicators were also quantitatively evaluated in the field (IAPro step 4) based on the FIXMOVE methodology for standardized rangeland assessments (Morgenthal and Kellner, 2008). Field measurements followed a preferential sampling approach by asking the SH to determine the sampling sites according to their perception of what their most degraded area, rangeland in best condition or successful restoration site is. No quantitative data could be gathered for social or economic indicators for reasons of being not directly measurable (e.g. personal well-being) or confidentiality (e.g. economic costs). For these, SHs were asked to rank each action in order of decreasing impact on the indicator (compare Table 1).

In IAPro step 5, the results from the indicator ranking in step 3 were combined and integrated with respective biophysical measurements for the indicators through a multi-criteria decision analysis (MCDA) using ELECTRE IS (Ait Younes et al., 2000). This is an outranking procedure based on pairwise comparisons of all the alternative restoration and management actions according to their relevancy (indicator relative importance representing SH perspectives) and performance (indicator quantification). The method identifies the indicators that are either indif-

ferent (meaning have a similar performance in both actions being compared) or supportive for a certain action over another. Based on this, outranking relationships are constructed, where one action outranks another when it is at least as good as the other, as underlined by enough supportive arguments (integrated data).

As shown for the duneveld, a good management action (GM) in the Kalahari rangelands outranked dune stabilization but was equally good as shrub control (SC) (Fig. 3A), although there were a couple of indicators where the preference was weak in favor of GM over SC (Fig. 3B). Accordingly, GM provided best results in terms of biomass production and grazing capacity, whereas SC effectively decreased the competition for moisture and soil nutrients between shrubs and grasses, thus favoring the latter. SC also contributed to an increase in soil organic carbon due to litter accumulation. It should be noted that the MCDA does not identify the best option possible on an absolute scale but rather provides a relative ranking and information on which action outranks each other as a function of the indicators considered (Bautista and Orr, 2011).

3.3. Integrated evaluation of actions

A final step of IAPro (step 6) is the collective integrated assessment of the locally implemented actions based on the results of the weighting exercise of indicators, the subsequent MCDA, and related group discussions during the workshop. This step integrates scientific and local knowledge, biophysical data and SH perspectives for the purpose of a more informed re-evaluation. An adapted language, easily accessible figures and other visualizations were used to summarize all participatory outputs. As was also done in IAPro step 2, SHs were asked to rate each action on a scale from 1 to 5 (very bad to excellent choice). The rating was performed in an open, interactive setting allowing for ongoing discussions and exchange of opinions.

All respondents perceived the application of ‘good

Table 1: Stakeholder rating of actions using a 1-to-5 Likert scale (pre- / post- integrative assessment (% of responses)).

Categories	Criteria	Indicator/proxy	Unit	Good management	Shrub control
Supporting services	Soil fertility	Soil condition	% organic carbon	0.1±0.02	0.2±0.08
Regulating services	Resource regeneration	Grass abundance	plants m-2	14.0±3.9	25.7±11.9
	Ecosystem integrity	Woody abundance	rank*	1±0.4	2±0.7
Provisioning services	Grass phytomass	Biomass production	kg ha-1	2755.7±374.1	2238.4±343.5
	Forage production	Grazing capacity**	ha LSU-1	4.7±1.4	4.4±1.2
Economy	Meat production	Animal condition	rank*	1.2±0.4	2.4±1.0
	Water availability	Water availability	rank	1.1±0.25	2.1±0.8
	Labor & material costs	Economic costs	rank*	1.1±0.3	2.3±0.9
	Sustainability	Personal well-being	rank*	1.1±0.3	2.5±1.0<
Biodiversity	Subsidies	Governmental help	rank*	1.9±1.0	1.9±1.4
	Species diversity	Grass diversity	H'	1.04±0.2	0.9±0.6

* effect of action on the indicator as assessed by stakeholders (1 = affecting the most to 6 = no effect)

** overestimated for Kalahari duneveld; applied method needs to be adapted (relations remain the same)

Table 2: Stakeholder rating of actions using a 1-to-5 Likert scale (pre- / post- integrative assessment (% of responses)).

	Excellent choice	Very good choice	Moderate choice	Bad choice	Very bad choice
Good management	62.1 / 100	24.1 / 0	13.8 / 0	0 / 0	0 / 0
Shrub control	55.2 / 75	20.7 / 25	10.3 / 0	3.4 / 0	13.8 / 0
Dune stabilization	44 / 10	40 / 70	12 / 10	0 / 10	4 / 0

management' as an excellent choice. The majority of the SH (75%) also rated 'shrub control' as excellent, whereas the rating of 'dune stabilization' was less consistent and overall lowest (Table 2). Compared to the first assessment done in IAPro step 2 (pre-integrative assessment, Table 2), the final action rating remained basically the same, but the underlying pattern was more distinct showing clearer preferences (Table 2).

4. Discussion and conclusion

4.1. Challenges and lessons learned

The case study showed that the tested IAPro is a promising tool for a locally-contextualized assessment and evaluation process of actions applied to mitigate land degradation. As concluded by Rojo et al. (2012), the general

strength of PRACTICE is its bottom-up approach for assessing both environmental sustainability and social acceptance and integration. The iterative nature of weighting options, group discussions, and collective integrated assessments is central to establish a more diversified understanding and hybrid knowledge based on local and scientific expertise (Fraser et al., 2006). The participatory steps of IAPro furthered the information exchange among SHs. It can be assumed that being more informed would allow land users to adapt more effectively to changing environmental conditions and observed signs of rangeland deterioration, respectively. The exchange between SHs also has the potential to create opportunities for co-operative actions for the benefit of the local farming community. Indeed, the overall response of the Mier MSP was positive, appreciating in particular their direct involvement, learning-effect and immediate transformation of in-

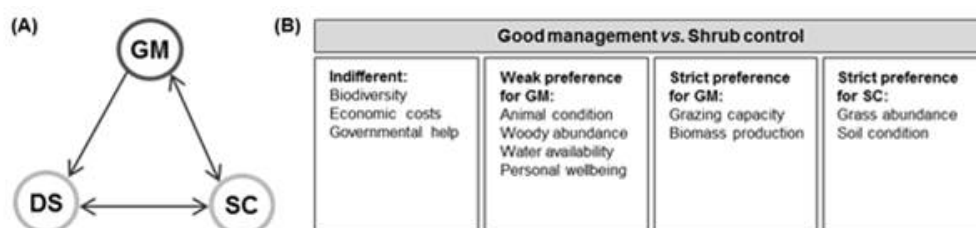


Figure 3: Outranking relationships of the MCDA performed for the duneveld. (A) Graphical expression (GM = good management; SC = shrub control; DS = dune stabilization; direction of arrows indicate an outranking relation, two way arrows mean an equal performance), (B) example of a comparison of pairs of alternatives

put into outcome of practical value. This feedback shows that locally important factors were captured by identifying indicators relevant to the SHs.

The positive perception by the SHs was certainly furthered by the fact that the conducted combination of indicators specific to local-scale needs with scientific-based indicators allowed to address locally-contextualized key ecosystem services. Such an integrated indicator selection is regarded a necessity to achieve sustainable land management goals (Sommer et al., 2011). The original list of 30 indicators suggested by the interviewees documented the wealth of information available among land users as also found elsewhere in the Kalahari region (Reed et al., 2008). This can be seen as a significant benefit, as the complex variety of land user perspectives is addressed (Reed et al., 2006) and the set of indicators is less likely too simple and incomplete (Fraser et al., 2006). However, as was done in the present study, a short-listing of the indicator set is necessary to avoid too much detail at the expense of the overview (Sommer et al., 2011). Short-listing criteria used included popularity and collectability, which bore conflicts. A couple of identified indicators, particularly those addressing popular socio-economic issues, such as economic costs, personal well-being or water availability, could not be directly quantified as they either did not specifically constituted the rangeland condition or were confidential in nature. Unfortunately, the qualitative ranking procedure chosen for these indicators showed to be too abstract for some of the participating SHs, and thus needs to be adapted for the sake of confirmability. Challenging for the integrative process of identifying a suitable indicator set were the different types of indicators suggested. Defining an indicator as being reflective of the degradation status, personal well-being must be regarded an indirect indicator reflecting secondary or consequential interactions which "carry a heightened risk of incorporating the expression of conditions associated with but not intrinsically part of the condition" that is assessed (Mabbutt, 1986). Further, water availability, which was suggested by most SHs as the most critical indicator, is rather a predictor indicating the risk or vulnerability to degradation than an indicator (Mabbutt, 1986).

Another critical point of overall importance for the successful application of the PRACTICE approach was related to the remote location of the study sites in combination with time- and budget constraints, which exacerbated timing and frequency of the quantitative evaluation of indicators in the field. Due to the intrinsic spatio-temporal environmental heterogeneity of drylands, biophysical once-off assessments are not representative and do not account for the need of multi-temporal information (Sommer et al., 2011). A shortcoming with respect to representativeness is also given by the biophysical assessment based on a preferential sampling approach, which has some disadvantages related to the subjective course of action. On the other hand, this type of approach gives the SHs some kind of control and increases their acceptance in site selection (van Rooyen, 1998). It showed to be difficult to identify enough suitable sites for replications in order to reduce the variability in data caused by the

heterogeneity of both the biophysical environment and with respect to differences in management strategies and restoration design. In the course of the running case study in the Molopo area, the number of replicates was significantly increased. However, this kind of effort is very time consuming and requires a good knowledge of an area.

It turned out that the Mier community was already "over-workshopped" by many projects in recent years taking place in the area. This can result in a consultation fatigue, especially if their involvement in participatory processes gains them little reward (Reed, 2008). In addition, the huge distances between localities in the Kalahari farmers have to take into consideration when invited to workshops may result in low participation rates at critical participatory steps of IAPro, which is especially true if no financial expenses at least for travel costs can be rewarded. Varying participation rates can be problematic for a sound interpretation of results. For example, the weighting of indicators in at least two iterations including group discussions (IAPro step 3) should ideally be implemented in a single meeting with all the SHs being present (Bautista and Orr, 2011). Unfortunately, due to logistic and financial constraints the gap between first and second round of the ranking exercise was longer than one year. In addition, not all SHs involved during the first iteration could participate also during the second. Thus, although group means of normalized weighting results were taken into account, the observed shifts in indicator ranks might partly be attributed the time gap, due to which in the meantime other factors may have caused the change in mind, as well as an incomplete set of SHs. Outcomes then have to be interpreted with care.

Land-user perceptions of what is meant by certain aspects, such as "land degradation" or "biodiversity", can differ substantially (Reed et al., 2008). As in the Mier case, this can be particularly evident when comparing different land use systems (e.g. commercial vs. communal), and even in similar biophysical and socio-economic contexts, pointing out that implications are only of relevance at a certain local scale to particular SHs and must be adapted from case to case (Reed et al., 2006; Von Maltitz, 2009). In this respect, the question arises how conducive it is when the MSP contains categories of farmers having a completely different socio-economic background, as is the case comparing freehold ((semi-)commercial) and communal farmers. Contrary to commercial farmers, communal farmers largely don't have the ability to respond decisively to land degradation due to the absence of governance institutions and property rights, competition for resources, absentee livestock owners or economic inflexibility (Palmer and Bennett, 2013). Environmental awareness is also a question of ownership related responsibilities. Shared ownerships in a communal land management setup reduce individual liability and motivation to conserve natural resources (Van Rooyen, 1998). These factors mitigate against the technical implementation of cost-intensive restoration actions or appropriate management actions without external support and legal policy frameworks. For example, although the present study revealed that shrub control is perceived an excellent action

and is preferred above others (compare figure 3 and Table 2), high associated costs for chemicals are a core constraint often hampering its application, particularly on communal land. Thus, the dependency on funding and resources supplied by national and provincial government is a critical factor for sustainable land management in the Mier area. Therefore, it might be advantageous to realign the MSP by stratifying involved farmers according to specific socio-economic settings and farming objectives. This would certainly optimize the identification of suitable and affordable practices based on an improved problem-specific contextualization.

Overall, the preliminary indications suggest that the PRACTICE approach is promising for evaluating restoration and management actions in Kalahari rangelands. However, replication and comparisons are essential for proper evaluation of participatory approaches (Reed, 2008). Thus, it remains to be seen how well it performs under the different socio-economic and biophysical setting of the Molopo area, which will then allow for a more detailed and critical evaluation of the framework. Accordingly, and as requested in step 7 of IAPro, dissemination of results will take place after completing this second Kalahari case study in order to support knowledge sharing between land users, farming communities, extensions officers in comparable social, economic and environmental contexts, including researchers and the wider desertification community.

4.2. *The way forward*

Combating desertification needs to take place particularly at the local level, but concerted action must be enabled by appropriate institutional mechanisms and structures adapted to the particular land tenure forms in South Africa (Von Maltitz, 2009). Thus, the challenge is now to find ways to promote the use of PRACTICE results and the approach itself at local scales and to couple it with local-level institutions. Facing the need for the formulation of environmentally sound and socio-economically accepted prevention and restoration projects to combat desertification in South Africa, an adjusted PRACTICE approach might also represent a promising tool for the exploration of potential alternatives for management and/or restoration options, i.e. other than identified by the local MSP. There is quite a high degree of overlap between the framework of the PRACTICE approach and the participatory approach for land degradation adaptation in other parts of the Kalahari rangelands developed by Reed et al. (2007, 2008), showing many conceptual and methodological parallels. The PRACTICE approach differs mainly in representing in first instance an evaluation tool for management and/or restoration actions (i.e. action assessment), whereas the work of Reed et al. (2007, 2008) ultimately adds up to providing a monitoring tool (i.e. degradation assessment). Combining best practices from both frameworks might be promising to create a more holistic framework for improved decision-making and sustainable land management embedded in a long-term monitoring program.

5. Policy oriented recommendations

Any national and international project that assesses land degradation and restoration actions which will help land users to improve land management decision making must comply to the National Action Programs (NAPs) of the three International Conventions (i.e. UNCCD, CBD and UNFCCC). The NAP of especially the UNCCD emphasizes popular participation and the creation of an enabling environment designed to enable local people to reverse land degradation. The NAP also acknowledges the medium-term strategic framework of government, which is an outcome based approach, similar to that followed by the PRACTICE project. There is already a wealth of information related to combating desertification, land degradation and mitigating the effects of drought (DLDD), which has been collected by universities, government, non-governmental and research organizations through national and international research projects (e.g. PRACTICE, LandCare, Desert Margins Program, Kalahari-Namib Project or LADA (Land Degradation Assessment in Drylands)). The challenge now is that South Africa's government, in collaboration with all these organizations, creates a supportive policy environment including a comprehensive information system, which makes the information available and more accessible in a format understandable by any SH. This should be facilitated by the established multi-stakeholder-based National Coordinating Body (NCB), whose function is to advise government on the appropriate policies, strategies and action plans for the implementation of South Africa's NAP for the UNCCD. The Committee on Science and Technology (CST) is a subsidiary body of the NCB, and as such has the function, among others, to help with the improvement of coordination, integration and prioritization of DLDD issues and collating related scientific information that is of use and needed by all SH. The NCB as a whole should therefore play a leading role in the design, formulation and establishment of a South African information system on DLDD, sustainable land management and dryland restoration.

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Sustainable Land Management (SLM) Projects in Tajikistan: Experience and Lessons Learned¹

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Abstract – Three cross-linked projects with SLM component have been/are implemented/ in Tajikistan : Community Agriculture and Watershed Management Project (CAWMP): 2004 – 2012; Land Registration and Cadastral System for Sustainable Agriculture Project (LRCSP): 2005-2014; and Environmental Land Management and Rural Livelihoods Project (ELMARL): proposed for 2013-2017. CAWMP and ELMARL have a Global Environmental Facility (GEF) supported component. The projects' SLM policy is successive, although different projects cover diverse directions of agricultural development: community actions and participatory capacities building, peculiarities of land privatization and fragmentation, and climate change adaptation. The synergy of the projects environmental results appears in: Awareness raising in environmental risks assessment, application of environmentally and economically effective technologies in farm production; Experience in water-, soil- and energy-saving technologies in rural areas; Improvement of sanitary and ecologic conditions in villages; Rehabilitation of degraded lands (incl. irrigated) and increase of soils fertility; Rehabilitation and access to pastures; Fixing erosion on slope lands by woodlots, horticulture, haying, etc. Lessons learned for further results development are the following. Negative: Low skills of project environmental staff, Weak contacts with governmental stakeholders responsible for environmental issues, Lack of information sharing and low use of Web opportunities, Weak integration with other projects and donors. Positive: Growth of level of national environmental Non Governmental Organizations (NGOs), High effectiveness of local small interventions (bottom-up) in comparison with national-level activities (top-down), Replicability and sustainability of environmentally sound activities, Increasing attention to pastures as an important natural resource, Rising possibilities and capacities to space imagery use.

Keywords – sustainable land management, World Bank, international projects, best practice

1. Introduction

World Bank (WB) is a large organization, sees itself as a knowledge bank, and allocates resources to capacity building and knowledge management. It has thematic areas, communities of practice, is a GEF Implementing Agency, participates in a number of global and regional efforts in knowledge management and sharing related to SLM.

World Bank secures funding for SLM through its Rural Land Resources Management (LRM) Program which de-

velops and promotes knowledge-based technical, social, institutional and policy choices which focus on: Developing sustainable land management through improved land tenure systems and community natural resources management; Raising the profile of the risk and vulnerability impacts of climate change on communities' natural resources, (land/water) and promote appropriate adaptation mechanisms; Mainstreaming of integrated approaches to Land and Water resources management for food security and poverty reduction; Creating and strengthening an enabling environment, which will enhance national, re-

¹This article is based on a presentation given during the UNCCD 2nd Scientific Conference on "Economic assessment of desertification, sustainable land management and resilience of arid, semi-arid and dry sub-humid areas", held 9-12 April 2013 in Bonn, Germany (<http://2sc.unccd.int/home/>).

gional, and global capacities to implement the convention to combat desertification and restore degraded lands.

SLM has been defined by WB as a knowledge-based process that helps integrate land, water, biodiversity, and environmental management (including input and output externalities) to meet rising food and fiber demands while sustaining ecosystem services and livelihoods.

SLM Projects in Tajikistan described here are: Community Agriculture and Watershed Management Project (CAWMP): 2004 - 2012; USD 16,75 mln (GEF LD: USD 4,5 mln); Land Registration and Cadastral System for Sustainable Agriculture Project (LRCSP): 2005-2013; USD 10,6 mln plus extension to 2015 with USD 10,0 mln; Environmental Land Management and Rural Livelihoods Project (ELMARL): proposed for 2013-2017 (PPCR USD 9.45 mln and GEF LD USD 5.4 mln, USD 1.75 mln from local communities = USD 16.6 mln).

The cross-cutting issues of the projects are: Land degradation and land management; Water resources (irrigation and drinking water supply); Energy efficiency, alternatives; Climate change vulnerability and adaptation; Poverty and people livelihoods, farm productivity; Mountains ecosystems: globally important biodiversity and natural habitats; Deforestation, forest degradation; Rangelands (overgrazing, access to, carrying capacity)

2. Basics environmental and social issues and facts

2.1. Land degradation

Most of the 2.5 m ha agricultural land they farm is pasture, only 206,000 ha were in perennial crops and orchards, and there were few significant irrigation systems. Rural poverty, shifts in land management responsibilities, lack of integrated land management, inappropriate agriculture, and poor access to technical support are causing increasing land degradation. About twenty percent of the population live in hilly and mountain areas where access to most government services is limited. Much of the population is using steep hillsides to grow cereal crops. In turn, land degradation contributes to further impoverishment through mudslides (ruining villages, roads and farmland, and irrigation and water systems), soil-erosion (undermining agricultural productivity) and silting of waterways used for drinking water and irrigation. However, highlands had good productive potential if appropriately farmed.

2.2. Mountain ecosystems

Tajikistan has globally important mountain ecosystems with diverse flora and fauna, including many of economic importance, and under threat. Pastures, for example, hosted over 3000 plant species, but face threats from localized over-grazing. The wild-growing fruit plants of Tajikistan represent a unique genetic resource for agriculture. The mountain areas of southern and south-eastern Tajikistan are the major regions for conservation of wild-growing fruits (apples, pears, apricots, mulberries, cherry plums and plums, among others), nuts (walnuts

and almonds), grapes and berries (currants, sea-buckthorn berries). Forest areas, which covered only 3 per cent of the country's territory, decreased by about 15 per cent due to the need for firewood.

2.3. Farm privatization

Officially, some 55 per cent of all arable land had been converted into lease farms, joint stock companies and family farms. However, in lowland cotton growing areas, farmers were still not free to make their own management decisions, while in highlands they lacked the capital needed to exploit productive potential. Furthermore, there are also large tracts of pasture, formerly under the control of state farms, which are under the control of Jamoats (multi-villages committees). These pastures faced problems of inadequate maintenance as well as arbitrary and inequitable access to grazing rights and land use.

2.4. Climate change and vulnerability

Climate variability and change are likely to pose additional and significant risks, particularly for those pursuing subsistence agriculture or pastoralism, and only reinforce the need to follow sound land resource management principles. Climate projections suggest Tajikistan will experience higher temperatures, reduced rainfall and higher evapotranspiration with an increased frequency of extreme events. These changes will lead to impacts, such as fluctuations in the hydrological cycle - especially from glacial retreat and flash floods - with downstream consequences nationally and regionally for agro-ecosystems and water resources.

Bank-financed projects within Tajikistan had already established culturally-appropriate, community-managed models for:

1. allocation of land use rights in ways which ensure transparency, with participation of the community in the allocation of parcels, legitimacy (through involvement of traditional local institutions), conflict management, and land tenure security;
2. management of investments in irrigation infrastructure and their subsequent operation through Water User's Associations;
3. establishment of efficient technology transfer mechanisms through Farmer Information and Advisory Services, and
4. establishment of a credit mechanism for seasonal agricultural needs through revolving funds via Non-Banking Financing Organizations.

In addition, the Bank is applying best practices and lessons developed by international NGOs and donors, such as the Agha Khan Foundation (AKF), UNDP, USAID, GIZ, DFID, German Agro Action (GAA), and others.

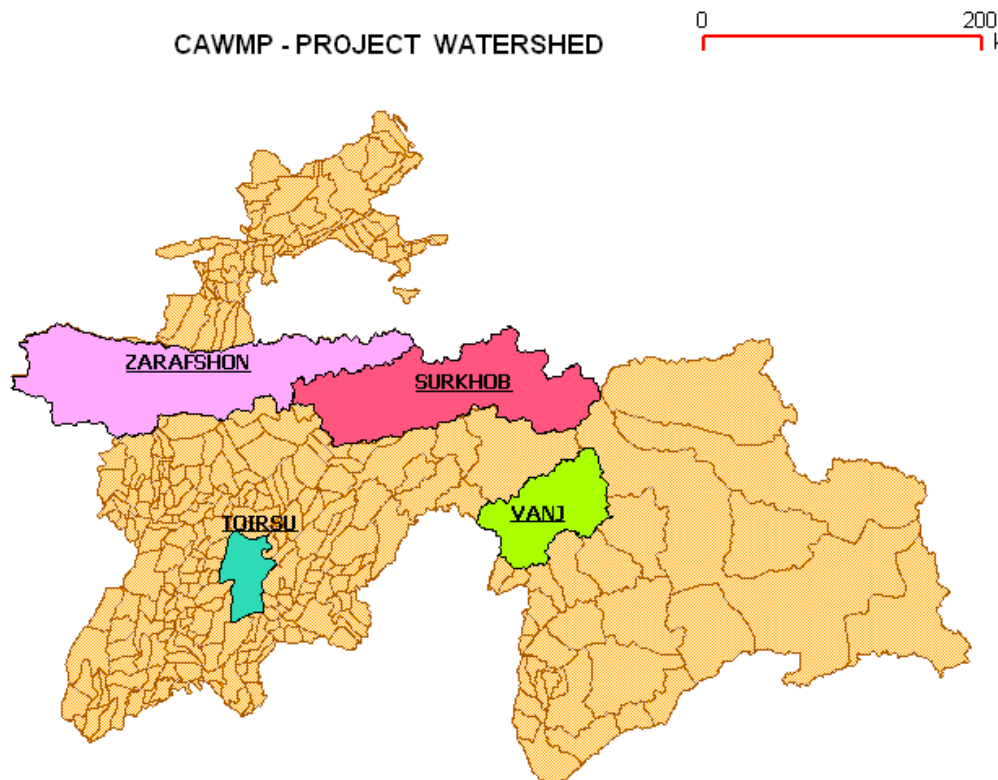


Figure 1: Location of 4 project watersheds in Tajikistan

3. Community agriculture and watershed management (2004-2012)

Rural Production Investments included the following categories of activities. Farm Productivity Improvement: Individuals, and groups of farming households, invested in productivity enhancing activities of their choice, most of which provided immediate income. Investments could include inputs for annual crops, horticulture, livestock, processing, distribution, leasing, and credit facilities.

Land Resource Management: This subcomponent enabled local people to adopt more sustainable use of fragile lands, and provided land use certificates after three years of maintenance, subject to continued good land use. The combination of appropriate income-generating investments with soil conservation proposed to enhance the organic content of soil and create incentives for sustainable land use by better addressing interests of local people. Groups of households working on contiguous areas could make long-term investments such as horticulture, woodlots, or fodder, combined with soil and moisture management structures. Blended financing from GEF almost quadrupled the land area covered beyond the level that could be supported by the government on purely national grounds.

Rural Infrastructure: Investments to rehabilitate rural infrastructure were made to community groups. Typical investments complimented agriculture and land resource management subprojects, were small scale (about USD 4800 on average), and included drinking water, small irrigation, access track rehabilitation, and small power generation.

The project location in 4 watersheds (Zarafshon, Surkhob, Toirsu and Vanj) is shown in figure 1.

3.1. Groups of SLM in CAWMP

In CAWMP all SLM activities (subprojects/technologies) can be combined into 7 groups with similar environmental effect for environmental monitoring and impact assessment purposes:

1. Farming and horticulture on irrigated plain lands,
2. Farming and horticulture on slopes (incl. irrigated and rainfed lands),
3. Agroforestry,
4. Rangelands management and livestock,
5. Beekeeping
6. Local processing and handicrafts, water- and energy-saving technologies, improvement of drinking water supply, mills, iron works, refrigerators, poultry,
7. Irrigation systems, rehabilitation of irrigation canals, construction of small dams, bridges, roads, pipelines.

3.2. Eligibility criteria for CAWMP subprojects

Eligibility criteria for subprojects included meeting at least one of the following impacts on fragile lands:

- Prevent/reduce soil erosion,
- Increase vegetative cover through perennial crops and pasture,
- Provide soil and moisture conservation,
- Improve soil quality,

- Improve water use efficiency,
- Increase sustainable fodder/wood supply,
- Increase sustainable renewable energy supply,
- Increase integrated pest management.

These criteria ensured an environmental focus, and kept the grant proposals consistent with a list of eligible activities which is critical for a large-scale, community-driven project. The criteria helped avoid diversion of grant funds to investments not directly related to land sustainability. Combining income-generating investments with environmental criteria encouraged sustainable land use by addressing vital interests of local people. The criteria were used also to monitor local environmental impacts.

3.3. Ideas/methods/messages from CAWMP/LRCSP (incomplete list) for SLM

Soil conservation approaches and measures are very different and can be combined in the following technologies mainly oriented on the improvement of soil fertility and prevention of desertification and deterioration:

- terracing of steep slopes with further planting of orchards, woodlots, vineyards according relevant environmental and marketing conditions,
- composting and "organic farming";
- multicropping and intercropping;
- crop rotation;
- integrated pest management with biological methods application;
- river banks and canals protection with gabions and planting trees and bushes;
- drainage rehabilitation in the salt-affected areas.

Energy savings and alternative energy sources that prevent cutting trees and use of manure for fuel:

- springs as natural refrigerators,
- solar energy for heating and drying (incl. fruits),
- water mills and pumps,
- small hydropower stations.



Figure 2: Stabilization of slopes and haymaking



Figure 3: Fixing gullies



Figure 4: Terracing for horticulture



Figure 5: Cleaning field from stones

Table 1: Number and Variety of Subprojects

Subprojects categorized by main activities:	Number	USD	Measure	Total amount	Area covered, ha
Bee-keeping	159	288584	Bee hives	2584	
Livestock development (purchasing live-stock)	510	679197	heads	6433	
Yak breeding	4	10573	heads	40	
Poultry farming	99	136920	heads	11324	
Horticulture	1443	2675981	ha	2644	2644
Annual crops	157	278332	ha	495	495
Plant nursery	14	17242	ha	6	6
Potato production	27	42755	ha	24	24
Small enterprises for agricultural processing	140	209166			
Drinking water for livestock	13	26281	ha	7048	7048
Drinking water supply	170	450364	m	67791	
Terracing of slopes and planting trees	79	142699	ha	278	278
Wool processing	5	7946			
Fishery	4	12724	ha	7	7
Biogas	3	8536			
Rehab and opening the road to pasture	171	359677	ha	33636	33636
Repair of pump stations	7	22084	ha	444	444
River banks protection	32	85074	ha	1508	1508
Repair and built of small bridge	56	140305	m	842	4050
Rehabilitation of small hydropower stations	24	41719	kWt	189	
Repair of electric transformer	2	5107			
Canal rehabilitation and repairing for irrigation	217	607241	m	19646	1250
Drainage rehabilitation	7	14771	km	5	340
Use of solar energy	5	4026	kWt	8	
Cattle pen building and repairing	30	67791	m ²	17885	21250
Stones removing for horticulture	2	8000	ha	4	4
Pasture improvement	152	455135	ha	23061	23061
Vineyards	62	166281	ha	431	431
Woodlots	69	136057	ha	80	80
Planting of herbs	6	9949	ha	57	57
Composting	5	2260			
Building of small dams for small water reservoirs	1	2812	m ³	125	
TOTAL	3675	7115589			96631



Figure 6: Contour planting of nut and fruit trees for stabilization of slopes



Figure 8: Pasture improvement by growing productive plants on degraded soils (Izen – Kochia)



Figure 7: Drip irrigation and soil surface mulching for horticulture



Figure 9: Cattle pen on the road to summer pastures

Pasture (rangelands) rehabilitation and improvement technologies and approaches includes separately or integrated in different cases the following measures:

- pasture rotation;
- creation of watering/drinking ponds for animals;
- breeding of more effective and adaptive livestock (yaks, special kinds of sheep) and poultry (turkey);
- sowing of substantial grasses (alfa-alfa, sainfoin, izen, teresken);
- rehabilitation and building of shelters for animals (kosharas, cattle pens);
- rehabilitation of access to pastures (roads and bridges);
- planting of shelterbelts;
- building of fences and obstructions for animals;
- veterinary service support;
- fodder supply.

In general these approaches decrease the overgrazing, limit the animal pressure, and improve soil quality and the risk of soil erosion and mudflows.



Figure 10: Trees nursery



Figure 11: River bank protection

Water saving technologies prevent soil water erosion in uplands and salinization of the irrigated lands in the valleys. Separately or integrated includes the following activities:

1. drip irrigation (including primitive hand-made forms), especially for fruit trees, vineyards and vegetables;
2. screening of canals and furrows with film or plastic grooves preventing ineffective infiltration and loss of water;
3. tubing and pumping of irrigation water flows;
4. building of small ponds and water reservoirs;
5. soil moisture preservation, including mulching of soil surface, creation of special obstructions around trees, special technologies for the preparation of planting holes, snow retention;
6. integrated approach for effective use of water resources on different soils and for different plants.

3.4. What does CAWMP have to offer for SLM, KM and DS?

Pluses:

1. CAWMP is the first project in Tajikistan to attempt mainstreaming SLM into rural production, innovator on several fronts (partnerships, fund flow and management, participatory decision-making);
2. there is much to share from CAWMP and dissemination for practitioners, agencies, projects working in SLM, agriculture and NRM, e.g., Bank wrap-up meetings involved all implementing partners, and
3. project-site exchanges, farmer "good practice" competitions with follow-up workshops, facilitating organization led exchanges, dissemination strategy and activities.

Minuses:

1. knowledge management is still nascent, language barriers limit access, lessons learnt and project documents need organization and systemization, e.g. basic data

on all investments, data on environmental aspects impacts, reporting on environmental impacts into overall national and global database, etc.

Fund flow and management innovations: Decades of World Bank international operational experience has shown that top-down land use planning and/or top-down technical prescriptions can encounter problems such as:

1. investment selection that is inappropriate because it does not fully take into account local environmental or social and economic conditions, constraints, and risks;
2. lack of local stakeholder ownership and sustainability;
3. high and sometimes wasteful transaction costs that do not result in meaningful and sustainable implementation of field-level or policy improvements.

It was therefore very important to address issues such as:

1. the incentive framework,
2. the participatory framework (with an understanding of the power relationships and dynamics) for planning, implementation, and monitoring,
3. realistic considerations of factors affecting post-investment sustainability,
4. transaction costs, cost effectiveness/efficiency,
5. realistic results targets, assessment process, and learning culture for on-going participatory problem solving and improvement.

By focusing on highland areas the focus was on the poorest experiencing the most severe land degradation - but complementing existing lowland area initiatives. Rather than working solely with village-level institutions - the Project strengthened Jamoat-level institutions to better coordinated community initiatives. The design of the institutional structure and sub-granting mechanisms clearly demonstrated a participatory approach whereby the ideas came from individuals - and the CIGs were instrumental in bringing together people and ideas. This was in contrast to the past where most activities focused on humanitarian aid rather than support for rural agricultural production - which was a foreign concept for local people. Ultimately, changing this perception and attitude became one of the more important challenges at implementation.

Granting funds from the bottom-up was also considered a better model than the previous top-down approaches - where the record of such investments was uncertain.

Training should be timely and appropriate. Training as a prerequisite before investment was integral to sustainability - since local knowledge contained gaps in more modern and environmentally-sustainable techniques.

Long term sustainability requires community involvement early on and full awareness of the level of operating expenses that will be required to maintain the investment. Participation by and consultation of local communities and individuals at the outset better ensured the fi-

nancial sustainability of investments. The financial management aspect of farm and rural investments was part of the initial training package to precede investment.

All stakeholders need to be included. Project preparation activities involved all key stakeholders: national, raion and Jamoat level authorities; NGOs; local communities including village elders, farmers, livestock owners, and women. Key stakeholders who would be involved directly in the Project include village leaders and village members, women, local government representatives, technical staff of the line ministries located primarily at the raion level, and staff of the PIUs and existing PMU at the central level. NGOs would provide technical assistance during the facilitation and proposal development phase at the village level and JDCs would act as decision-makers and comprise of elected officials from the communities.

3.5. *How to streamline SLM: 2 possible ways*

First way: CAWMP is directly SLM oriented project. Nevertheless not every NRM and LM activity is sustainable. Although small farmers are intended to be the basement for the agricultural sector in Tajikistan, the main problems for such farmers are low skills in the sustainable environmental land and water management and weak management of complicated agroecosystem. We observe a few example of unsustainable LM (misuse of irrigation water, increase of the risk of mudflows and soil erosion, overgrazing, etc.). Several basements are necessary in SLM oriented projects to mitigate risks: Eligibility indicators, M&E indicators, outcomes and outputs indicators.

Second way: not all projects are directly SLM oriented: LRCSP is not a SLM project, but provided risks for SLM as a result of land passed into ownership of users with low environmental skills and responsibilities. Training on integrated environmental and sustainable land management for new users and governmental responsible officers is quite necessary

4. Land registration and cadastre systems for sustainable agriculture (2005-2013)

Project Development Objective is to expand farmland restructuring to enable more rural people to become independent farmers and take management decisions in response to market forces and to initiate the strengthening of tenure rights and services for other land users. Findings from the earlier Bank's projects in Tajikistan and other countries indicate that improving farmers' tenure security and ability to make farm management decisions has a positive impact on land and soil management and therefore on the environment in general. On the other hand, based on experience to date, new farmers and land users are generally not aware of sustainable agricultural approaches and methodologies or environmental safety. Therefore farmers might not anticipate the possible negative effects (e.g., on soils) associated with their agricultural practices (-e.g., overexploitation of soils without crop rotation, weak usage of organic fertilizers, salinization of

irrigated lands in flat areas, soil compaction and loss of soil structure, etc.). This poses some environmental risk and could cause unfavorable changes in land quality, including soil erosion, reduction of organic matter in soil, and land degradation. Farmers should monitor for possible changes with clear and simple indicators (e.g., changes in soil structure, soil organic content and others) in restored and rehabilitated lands. To stipulate proper on-farm water management the subcomponent supporting establishing of WUAs (water users associations) with small irrigation investments has been also included.

4.1. *Trainings on the base of the "good farmers practices" identified*

Challenges realized from the CAWMP:

1. demoplots organized by academic institutes have limited capacities. Experienced farmers have more successful stories to disseminate, and should be studied by academic scientists and relevant NGOs for further application and knowledge management, and
2. it is impossible to train all local farmers, and the accent should be addressed to the governmental officials at the raion level responsible for land, water and environmental monitoring and control, and key representatives of WUAs and local NGOs, for further training and control of local farmers.

Practical approach includes four basic stages:

1. identification and assessment of the best practice farm sites to determine the best (least hazardous) soil improvement and pest management techniques under different agro-climatic conditions,
2. mobilization of farmers through awards for best practices,
3. training of trainers program (and use of best practice sites as training plots) for local environmental, agricultural and land officers, NGO technical specialists, water user associations, and others, and
4. preparation and publication of an illustrated album on dehqan farms environmental land management methods for dissemination and trainings.

Trainings focus on learning through agro-ecosystem analysis and discussions, field visits to existing examples of good and bad practices, and mass media campaigns. The aim of training is to strengthen the ability of local agricultural, environmental, land and water officers and specialists to identify environmental risks and determine the sustainability of farmland under different agro-climatic and soil conditions and under different methods of land use and crops. The training enables officials to identify pests, determine damage thresholds, make prudent control decisions, and safely and cost-effectively control land degradation and pests.

Through this subcomponent, the project improves institutional and human capacity, promotes sustainable agricultural technology transfer and adoption, enables

the integration of scientific and traditional knowledge, and promotes informed decision-making to solve local problems. Based on best practice, the subcomponent improves communication between research institutions, farmers, and extension agents and promotes the adoption of promising methods generated by farmers with scientific support

Total number of farmers participated in the beat farmers competition organized in 36 raions was 495 households, among which 108 have been selected as a demo-plots with awarding, and 782 of specialists have passed environmental trainings

4.2. *Lessons learned for further results development*

Negative:

- low skills of project environmental stuff;
- weak contacts with governmental stakeholders responsible for environmental issues;
- lack of information sharing and low use of Web opportunities, and
- weak integration with other projects and donors,

Positive:

- growth of level of national environmental NGOs;
- high effectiveness of local small interventions (bottom-up) in comparison with national-level activities (top-down);
- replicability and sustainability of environmentally sound activities;
- increasing attention to pastures as an important natural resource, and
- rising possibilities and capacities to space imagery use.

5. **Environmental land management and rural livelihood project: 2013-2017**

5.1. *Pilot Program for Climate Resilience*

Tajikistan is one of the 12 countries and regions participating in the Pilot Program for Climate Resilience (PPCR) supported by Multilateral Development Banks (MDBs): World Bank (WB), European Bank for Reconstruction and Development (EBRD) and Asian Development Bank (ADB). The PPCR contributes to opportunities for Tajikistan to pilot critical approaches and measures in order to integrate climate resilience into its overall development strategies and planning.

5.2. *ELMARL-GREAT collaboration*

The GIZ/DFID GREAT (Growth in the Rural Economy and Agriculture) programme is supporting sustainable economic growth in rural areas and has strong synergies with the combined PPCR/GEF financed operation, since their programmes will support sustainable land management, as well as strengthen market development and provide other capacity building that would help the PPCR/GEF-

supported producers.

The overall Project Development Objective (PDO) and Global Environmental Objective (GEO) is to enable rural people to build their productive assets in ways that sustainably improve natural resource management and build resilience to climate change in selected climate vulnerable sites.

The proposed project would comprise two components implemented over five years: Rural Production and Land Resource Management Investments; Knowledge Management. Project sites would comprise districts in three different agro-ecological zones - uplands, hill lands and lowlands

Peculiarities: Nationally implemented and managed; Executive agency: Committee for Environmental Protection (small experience, but provides more environmentally oriented activities); To rise incentives beneficiaries had to contribute their own resources in the form of labor, material and cash, for at least 20% of the total value of any investment under component 1.

Component 1: "Rural Production and Land Resource Management Investments" includes three types of activities:

1. "Sustainable village-based rural production and land resource management" aims to promote the adoption of innovative rural production and land management measures, by providing small-scale grants at the village level to help rural livelihoods become more resilient to climate change in selected vulnerable districts. Prior to village level planning, participatory jamoat-level environmental analyses would be conducted to help beneficiaries assess and understand the extent of resources, threats and impacts and the relationships between these factors. Similarly, jamoat-level assessments of community-based adaptation to climate change would be prepared. These assessments will enable participants to factor in the potential impact of climate change on livelihoods and vulnerability to disasters by using local and scientific knowledge (where available) of climate change and its likely effects. Local knowledge would include information about trends and changes experienced by communities themselves and strategies these communities have used in the past to cope with similar shocks or gradual climatic changes.
2. "Larger-scale initiatives in sustainable community land management (pastures and water use)". Certain natural resource issues are better addressed at scales beyond the village. Of particular concern, to both sustainable land management and productive rural livelihoods in the context of climate change, are pasture management and on-farm water management. While pasture degradation and access are pressing issues in both lowland and upland areas, the consequences of poor water management are especially critical in lowland areas where agriculture depends primarily on irrigation. Comprehensive pasture and fodder assessments and evaluation of the feed/fodder balances would be carried out to inform plan development in

eight selected jamoats. The plan would define:

- a measures to improve pasture productivity, such as rotational grazing, protecting areas for regeneration, pasture rehabilitation, improving access to remote pastures, and needs for supplementary fodder production;
- b grazing utilization levels;
- c animal health requirements and breed improvement measures;
- d investment needs; and
- e implementation responsibilities, targets and indicators.

Through on-farm water management in lowland areas existing Water User Associations (WUAs) and dekhan farmers would be supported to introduce, test and demonstrate practices that could contribute to improving on-farm water management and efficiency, maintain soil quality and reduce land degradation, and increase resilience to climate change. An action plan would be prepared by the WUA with the support of locally-based NGOs, and jamoat agronomists and environment officers. Soil and irrigation water quality tests would be carried out along with an assessment of cropping patterns and productivity to provide information for the plan. The action plan would propose water saving and soil conservation technologies that could improve water use efficiency such as improved leveling and drip irrigation, reduce salinity, protect soil such as conservation agriculture and tree-planting, and improve soil fertility such as inclusion of legumes in the rotation or composting.

Component 2: "Knowledge Management and Institutional Support" will provide facilitation services and technical support for rural populations to plan, implement and manage rural investments. Relevant data collection and analysis, and information exchange for wider adoption of sustainable land management will also be supported. A comprehensive training, analysis, dissemination and networking program will be instituted to improve skills and knowledge in key topics such as environmental assessment and monitoring; integrated land, water and grazing management; integrated pest management (IPM); pollution control; and climate change adaptation. The project will support analytical work on topics that include soil quality and extent of land degradation, market development and access, grazing management and livestock production, potential incentive policies for sustainable land management practices, and changes in productivity and environmental conditions resulting from technological change, etc. The aim is to provide guidance for the design and sustainability of rural investments both within and beyond the project. Dissemination will be supported through a focus on exchange and learning between project sites and with similar initiatives, including farmer-to-farmer exchanges and best farmer practice competitions, plus sharing results and lessons learned with national and regional stakeholders. Contracted trainers, NGOs, and specialists will carry out programs at farmer, community, local government and management level by.

Support will also be included for project evaluation, including assessments at project mid-term and completion.

The ELMARL design took into account experience from CAWMP and LRCSP projects as well as lessons learnt from other donors, such as DFID, GIZ, Aga Khan Foundation, UNDP, Caritas, Helvetas, and others:

- *smaller farming units with tenure security and having freedom to farm independently of government mandates* can contribute to increasing the adaptive capacities of farmers. Such farming units made more investments and adopted more environmental management practices than large collective farms.
- *direct investment support to farmers through a systematic small grants program*, coupled with facilitation and training can build entrepreneurial capacity through a learning-by-doing approach. Farmers can assume responsibility for sustaining their livelihoods in financially and environmentally sound ways.
- *fixed budgets with limits on funds available for each type of rural production investment, village and, household are effective ways for villagers to allocate resources.* Such mechanisms can foster prioritization of investments by cost-effectiveness and risk. Combined with participatory planning, they can also support even wider distribution of project financing than expected.
- *a multi-stakeholder approach to project implementation* with partnerships between government and civil society is worthwhile even in contexts where limited prior experience and local conditions make management challenging. Such approaches can improve project transparency and accountability, increase respect for partners' strengths, and provide new learning opportunities for project participants.
- *identifying and highlighting innovative farmers is an effective way to encourage replication* since these farmers demonstrate technologies that are adapted appropriately to local climatic and other conditions.

6. Policy oriented recommendations

The experience of SLM oriented WB's projects in Tajikistan has provided a number of effective approaches to define and select the most suitable examples and technologies for environmental land management, preventing land degradation and increasing adaptation in conformity with improvement of rural people livelihoods in poorest countries.

7. Conclusion

The WB projects' SLM policy is successive, although different projects cover diverse directions of agricultural development: community actions and participatory capacities building, peculiarities of land privatization and fragmentation, and climate change adaptation.

The synergy of the projects environmental results appears in:

- awareness raising and knowledge management in en-

vironmental risks assessment, application of environmentally and economically effective technologies in farm production;

- experience in water-, soil- and energy-saving technologies in rural areas;
- improvement of sanitary and ecologic conditions in villages;
- rehabilitation of degraded lands (incl. irrigated) and increase of soils fertility;
- afforestation and alternative timber sources from woodlots.
- rehabilitation of pastures and access to;
- fixing erosion on slope lands by woodlots, horticulture, haying, etc.;
- energy savings and alternative sources;
- on-farm irrigation and water management;
- watershed and pasture management;
- poverty reduction.

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Topsoiling and Subsoiling as Rainwater Harvesting Techniques for Arid Climates: a Case Study from Sudan¹

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Abstract – Yield of rainfed crops has recently showed a declining trend due to rainwater mismanagement aspects rather than water availability per se in Sudan. The objective of this study was to evaluate and recommend the best in situ rainwater harvesting techniques that can ensure sustainable crop productions under arid conditions of the central Sudan. This was done through monitoring of soil moisture content, soil moisture depth, infiltration rate, crop evapotranspiration (ET_c), yield and green water footprint. Data collection lasted for two consecutive experimental seasons, using the 1-factor completely randomized design. The tested in situ rainwater harvesting techniques were topsoiling and subsoiling tillage. The conventional bund rainwater harvesting techniques (locally known as *Terraces*) coupled with zero tillage that is adopted widely by the local farmers was taken as a control. It was found that the collected data of both topsoiling and subsoiling superior were superior over the control, suggesting that topsoiling and subsoiling were win-win techniques (increasing crop yield and improving soil hydrological properties) under the arid conditions of the central Sudan. This was questioned the current Sudanese governmental belief on the zero tillage for upgrading the rainfed agriculture.

Keywords – topsoiling; subsoiling; zero tillage; rainwater harvesting; arid conditions

1. Introduction

The dramatic growth of human population necessitates the production of more food, which would put more pressures on the limited fresh water resources. The hard approach of construction of dams had unanticipated social, economic and environmental costs, which should be well considered (Gleick, 2003: 1524). Thus, in arid climates water policy shall focus less on engineering problems and more on the efficient use of existing water resources (Bijan and Ali, 2002: 128).

Arid and semi arid lands cover around 30% of the total world area (Sivakumar et al., 2005: 31), which was projected to increase by 5-8% due to climate changes (IPCC 2007: 50). The low and irregular precipitation of these environments resulted in difficulty coping with environmental stress, droughts and climatic change (Sivakumar et al., 2005: 52), leading to massive food insecurity, environmental degradation, poverty and incapability to combat climatic changes (IPCC, 2007: 65; Vohland and Barry, 2009: 120).

Livelihood security in Eastern and Southern Africa is

strongly dependent on rainfall distribution and land management practices among small holders' farmers as the rainfed agricultural sector produces over 95% of the food (Rockström, 2000: 1). However, water rather than land is the limiting factor. Thus, future food production has had to be achieved through a better field water management. This calls for water conservation practices or a green revolution, especially in rainfed agriculture (Rockström et al., 2009: 1). Among these practices rainwater harvesting is tremendously prompted by the national and international water related agencies (Vohland and Barry, 2009: 120). Positive impacts of rainwater harvesting techniques (RWHT) on increasing yield of rainfed crops, especially in arid and semi arid areas, have been thoroughly investigated and shown successful results (Tian et al., 2003; Motsi et al., 2004; Li et al., 2006; Ito et al., 2007; Rockström et al., 2010). Moreover, RWHT can stabilize agricultural productions and make them more productive and more resilient toward climatic changes (Vohland and Barry, 2009: 120).

The ensuring continuation into the future for optimal generation of livelihoods will depend on the sustainability of RWHT, which in turn depends on reliable water

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supply and production, increase rainwater productivity and minimal negative impacts on natural resources (Pachpute et al., 2009: 2817). Vohland and Barry (2009: 120) examined the effect of RWHT on the sustainability and found that RWHT improved infiltration and groundwater recharge, enriched soil nutrients, increased biomass and yield and improved farmers' income. However, the low rate of adoption of RWHT was the main problem, since RWHT are practiced currently only on 3% out of 960 Mha of arable and permanent crops in Africa, Asia and Latin America (Pretty et al., 2003: 217). The inadequate policy and budgetary allocation, lack of technical know-how and limited scientific and socioeconomic knowledge on rainwater harvesting are the main factors that limit the success of RWHT for upgrading smallholder livelihoods in Sub Saharn Africa (Pachpute et al., 2009: 2817).

The Nile Water Agreements in 1959 has stipulated a limited share for Sudan in the Nile River. This has constrained the irrigation development in Sudan. Accordingly, the growth rate of the agricultural sector is dominated by the performance of rainfed sector (Ayoub, 1999: 489). Two types of rainfed agriculture are practiced in Sudan: the dominant traditional and the mechanized sectors. Crop yields under rainfed agriculture are far beyond its potential, resulting in a poor sustainability. A report by the Food and Agriculture Organization of the United Nations, FAO (2006: 21) stated that farmers have had to increase their cultivated area by 75% in order to maintain the same level of the 1970/1971 income. This is attributed to rainfall variability and loss of soil fertility (Ayoub, 1999: 489). Shamseddin (2009: 153) attributed the low yield to water mismanagement. In the period 1970s-1990s, a number of rainwater harvesting projects were implemented in order to combat the effects of drought. However few succeeded due to the lack of technical know-how, and to inappropriate approaches of selection with regards to the prevailing socio-economic conditions (FAO, 2011a).

Recently, the Sudanese government has believed that zero tillage practices have the potential for improving rainfed agriculture performance (FAO, 2011). However, a mixture of successful and unsuccessful results of adopting zero-tillage was documented worldwide (Unger et al., 1998; Mupangwa et al., 2006; Ito et al., 2007; Oloro et al., 2007; Wang et al., 2007). Mati (2004: 14) called that in East Africa zero tillage was not promising due to poor infiltration (as soils are easily self-sealing) and costs of herbicides being prohibitive.

The construction of surrounding dykes on a flat land with no till and plant distances of a one meter (20000 plant ha) is the locally widely adopted practice by poor traditional rainfed farmers, in the central Sudan. On one hand, this practice can be considered as a rainwater harvesting technique, as it concentrates within-field sheet runoffs to the crop. On the other hand, it is a zero tillage practice. Evaluating this conventional practice (hereafter referred to as BT) against furrows (FT) and chisel (CT) practices was the general aim of this study.

2. Materials and Methods

The study area is located in the central Sudan. The climate is arid and characterized by a low rainfall concentrated to three months (July-September). Seasonal rainfall ranges from 200-300 mm, coupled with a high evapotranspiration rate of 2600 mm, with a daily average ranges from 5.5 – 9.5 mm. The length of growing period is 75-90 days. This gives a cumulative potential evapotranspiration of 460-560 mm during the growing period. Thus, water supply is very limited.

Rainfall and length of dry period are the most important climatic variables, in the region (FAO 2006). The region is susceptible to repeated drought cycles, especially during the periods 1970s and 1980s that have witnessed the severe drought, resulting in catastrophic consequences, i.e. mass lost of souls, destroyed vegetation covers, failure in biomass production, displacement and social stability (Osman and Shamseldin, 2002: 1862). Thus, the drought has been related to famine, civil unrest, ill-health and desertification and in turns as a constraint upon development in Sudan (Hulme, 1987: 326; Osman and Shamseldin, 2002: 1862). Hulme (1986: 44) stated serious deterioration of growing conditions in the arid climate (200-300 mm) of the central Sudan. Thus, drought and dry spells (short periods of water stress due to the poor distribution of rainfall) often caused serious impacts on crop yield, especially if dry spells occur during a critical water sensitive development stage, e.g. flowering stage (Rockström, 2000: 3).

2.1. The field experiments

The experiments last for two consecutive seasons (2006/2007-2007/2008), at the Faculty of Agricultural Sciences, University of Gezira (14.5° N and 33.5° E). Since the primary goal of this study was to draw a conclusion on impacts of tillage on the rainfed crop production, the 1-factor completely randomize design was applied. The tillage factor was separated into two levels, viz. topsoiling, i.e. furrow, and subsoiling, i.e. chisel), that are in-situ RWHT (defined as maximizing benefits from rainfall where it falls). The control was the locally widespread bund (locally known as Terraces) RWHT coupled with zero tillage. Thus, the experiment total number of runs was six; each run has a size of 13 x 70 m. Selected phenological data, i.e. root length development, leaf number, disease and insect situation were observed, too.

The experimental site belongs to the central clay plain, where the soil is Vertisols with a clay percent of 52-58% (Elias et al., 2001: 153). The soil was prepared in early July. The cultivated crop was sorghum (the dominant staple food crop in the country). In order to avoid water stagnation problems, plants holes were placed a little bit higher than the beds of the furrows (0.7 m wide); using a conventional planting method, traditionally known as Saluka, with 0.2 - 0.3 m distance per hole (3 - 4 seeds per hole). The same procedure was followed on chisel plots, but on flat lands. On the control plots the distance between holes was 0.7 – 0.8 m and 3-4 seeds per hole. The re-

planting process was done after one week of germination. Thinning and weeds clearance operations were carried out timely by direct labor. Soil moisture contents were measured using the gravimetric sampling method. The crop evapotranspiration (ET_c , mm/day) was estimated following the procedure mentioned in (Mekonnen and Hoekstra, 2010: 9) as follows:

$$ET_c = K_s \times K_c \times ET_o \quad (1)$$

$$K_s = \frac{S[t]}{(1 - p)S_{max}} \quad (2a)$$

if

$$S[t] < (1 - p)S_{max} \quad (2b)$$

otherwise

$$K_s = 1 \quad (2c)$$

Where, K_s is the dimensionless water stress coefficient, depending on the available soil moisture in the root zone), K_c is the crop coefficient and ET_o is the reference evapotranspiration (mm day⁻¹), $S[t]$ is the actual available soil moisture at time t , S_{max} is the maximum available soil moisture in the root zone (mm), and p is the dimensionless fraction of S_{max} that crop can extract without suffering a water stress. Values of p were taken as 0.6-0.8. The gravimetric sampling accuracy was found as 19.9%. K_c values were taken from Adam (2005). ET_o was calculated using CROPWAT 8.0 program on the basis of Penmann-Monteith, where the necessary climatic data were obtained from Wadmedani station. Tests of significance were done using t-test. In situ infiltration tests were carried out using a double ring infiltrometer, based on the empirical equation of Kostiaikov-Lewis:

$$Z = kt^a + ct \quad (3)$$

where Z stands for the cumulative infiltration (L), t is the opportunity time, c is the basic infiltration rate (L T⁻¹), k is a coefficient representing the water layer that enters the soil during the first unit of time (L T⁻¹) and a is a coefficient that usually ranges between 0.2-0.8. The efficient use of water was indicated through the water footprint concept (WFP, m³/kg), following the procedure mentioned in Hoekstra et al. (2009: 26) where grain yield and green crop evapotranspiration data were used [$WFP \approx ET_c/\text{yield}$]. Tests of significance were done using t-test in the SPSS statistical package.

3. Results and Discussions

3.1. Hydro-climatic conditions

The average rainfall of the region was found to be 268 mm (1975-2005), of which 97% was concentrated to two

months (July and August). Therefore the total rainfalls of the first and the second experimental seasons, 270 mm and 327 mm respectively could represent normal and above normal hydrological conditions, respectively. However, the first season experienced a better rainfall temporal distribution as during the second season two dry spells of 17 days for each were recorded. Also, during the second season the shorter time spans between rainfall events (Fig.1) resulted in water stagnation problems. Therefore, the first season was better than the second from a rainfed hydrological conditions point of view.

According to Figure (1) the proper sowing date could be very important in combating drought and climate change. During the second season the majority of rainfall events (62%) were received prior to the sowing date, compared to only 28% of the first season (most of the local farmers sow after 20th of July). Therefore, it is misleading to judge the agricultural season as good or bad without considering the sowing dates. Therefore, there is a badly need to carry out in depth studies on the impacts of climate change on the proper sowing date.

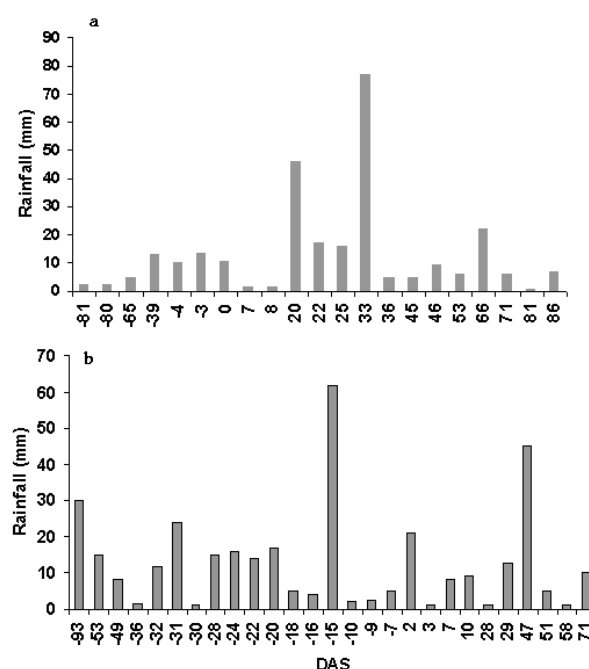


Figure 1: Rainfall distributions during the first (a) and the second (b) experimental seasons in the central Sudan. DAS refers to days after sowing

3.2. The implementation of in situ RWHTs

During the normal hydrological conditions of the first season, the implementation of FT and CT resulted in significant increasing in the soil moisture content ($P \approx 0.01$), compared to the BT. This is confirmed the results obtained by Motsi et al. (2004: 1071) who found that tied ridges retained the highest soil moisture content compared to the flat plowing in Zimbabwe. Also, the average maximum wetted profiles were found deeper at FT and CT plots (1.0 m depth) compared to 0.6 m of the BT. Fig. (2a) showed that during the initial and vegetative growth stages (15

July-10 September) the soil moisture content of the BT was larger than those of FT and CT, but the opposite holds true for the remaining growth stages. This was attributed to three reasons: (1) the large distances between plants of the BT (1.0 m apart) lead to large bare soils, which in turn increased the evaporation part; (2) the FT and CT practices were capable to retain more soil moisture from very low rainfall event conditions that overcome the terminal droughts. Vadez et al. (2011: 652) found that the transpiration efficiency could significantly explain yield differences under terminal droughts in sorghum; (3) the redistribution of soil moisture was better under FT and CT. Laddha and Totawat (1997: 241) found that deep tillage was superior to shallow tillage practices as it significantly reduces the bulk density, increases soil porosity and profile water contents, compared to zero tillage, in a sandy loam soil condition. According to the results farmers should consider two essential technical points under arid conditions: the first is that replanting is unavoidable process under arid rainfed condition since in this study replanting process compensated approximately 30% of the recommended plants intensity, i.e. most of the rainfed-farmers do ignore the replanting process. The second point is the placing of planting holes a little bit higher than the beds of the furrows so as to avoid the water-logging conditions that usually follow the consecutive rain storms events in clay soils. Considering these two points it could be safely saying that topsoiling and subsoiling were better than the zero tillage in conserving soil moisture during the normal hydrological conditions of the arid environments.

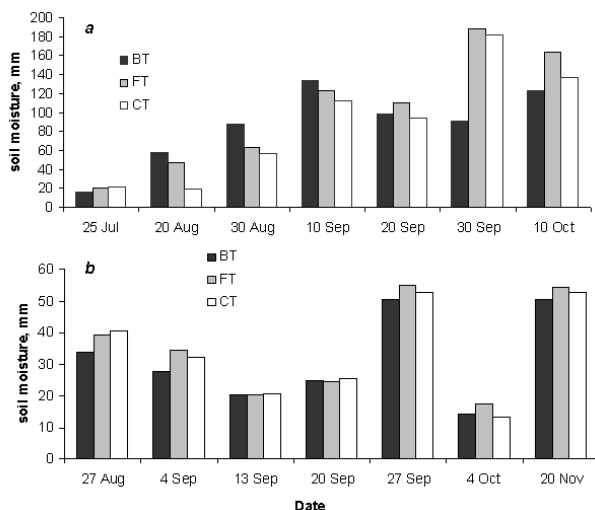


Figure 2: Soil moisture content during the first (a) and second (b) seasons

The significant differences found in soil moisture contents of the first season lead to significant variation ($P \approx 0.01$) in daily ET_c values of the BT, FT and CT (Fig. 3a). However, the seasonal ET_c values showed insignificant differences (Fig. 4). Thus, rather than the seasonal, the daily hydrological differences would have the significant contribution on the progress of the growth season in the arid environments. It is therefore the daily time span data are more valuable than the monthly and yearly data in

order to evaluate or predict the performance of the arid rainfed agriculture.

Table (1) shows the final obtained sorghum grain yields, which were found significantly different ($P \approx 0.01$). It is obvious that both of FT and CT produced the highest yields compared to the BT. Of the tested systems the FT is the best, suggesting that during a drier season furrows system is the best practice to adopt under arid climates. Noting that during the first season the majority of rainfall events (65%) was less than the threshold for initiating sheet flows that starting at 13 mm (Shamseddin, 2009: 88). For clarification, 65% of the received rainfall events were found less than 10 mm, 20% were between 11- 20 mm, 5% were between 21-30 mm and 10% were more than 40 mm. It is therefore furrows system is capable to capture more rainwater under low rainfall amounts conditions of the central Sudan.

The wet conditions of the second season lead to insignificant differences in soil moisture contents (Fig. 2b), resulting in insignificant differences among the daily and seasonal ET_c values (Fig. 3b). The final yields however of both CT and FT were found significantly higher ($P \approx 0.01$) than that of the BT, as shown in Table (1). Those differences were attributed to the impacts of both dry spells and water stagnation problems as previously discussed. Accordingly, (FT) and subsoiling (CT) practices are more successful than the zero tillage (BT) in tolerating dry spells and water stagnation problems that can be likely occur during wet years under the arid vertisols of the central Sudan. It is worth mentioning that topsoiling is frequently adopted in the central Sudan, however, it was mostly performed against the contour. In addition, the monoculture of sorghum crop jeopardized the sustainability of the rainfed system (Blokhuys, 1993: 45). Thus, more extension effort is needed to raise the awareness of the local farmers.

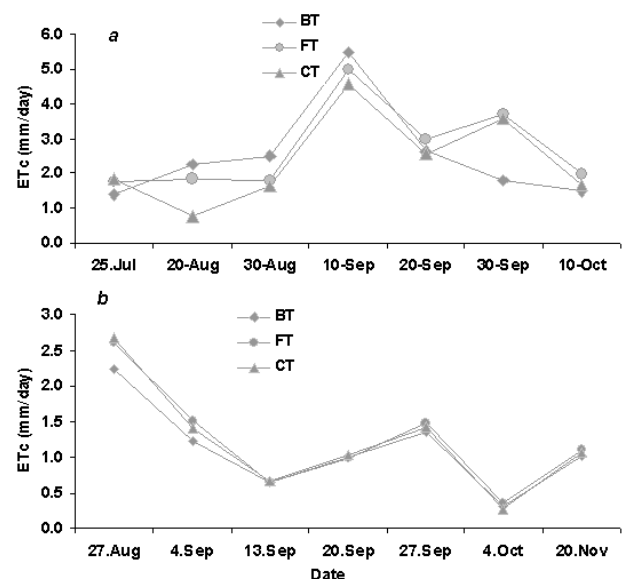


Figure 3: Actual evapotranspiration (ET_c) values for the first (a) and the second season (b)

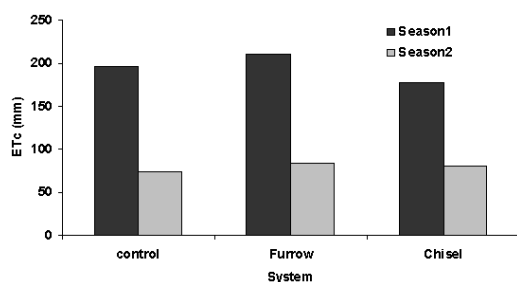


Figure 4: The seasonal crop evapotranspiration during the first (season1) and the second (season2) experimental seasons for each cropping system

Table 1: Sorghum yields (kg/ha) for the topsoiling (FT), subsoiling (CT) and the control (BT) during the first (season1) and the second experimental seasons

	FT	CT	BT
First season	1880	1623	493
Second season	396	625	90

3.3. The infiltration tests

It is likely that thunderstorms enhance the formation of the structural soil crust under the arid vertisols, resulting in impermeable layers which cause low infiltration rate and restrict seedling emergence. Hence, tillage practices such as FT and CT could destroy those impermeable layers, facilitating penetration of water and reducing thus evaporation losses. On the other hand, due to soil moisture fluctuations cracks are used to be developed under vertisols, enhancing entering of water into the soil and also could increase substantially evaporation losses (Elias et al., 2001: 155). Thus, the infiltration tests were carefully generated at free cracking conditions, i.e. the average soil moisture content was 46 mm for the upper 30 cm depth (the total water holding capacity is 230 mm/m).

Of the infiltration data, those of CT and FT were found greater than those of BT. The basic infiltration rates were found to be 4.8 cm h^{-1} for CT, 4.2 cm h^{-1} for FT compared to 1.8 cm h^{-1} for BT (data of BT infiltration test is taken from WMII database). Regardless of the insignificant differences between FT and CT data, the cumulative infiltrated volume of the CT showed a large standard deviation of 176.7 mm compared to only 61.3 mm for FT. Thus, the soil hydrological characteristics of the topsoiling and subsoiling were better than the zero tillage. This is attributed to the unmet principle of leaving at least 30% of crops residual (zero tillage) under arid conditions due to the low plant density used, which is used to be taken as a drought tolerance technique by local farmers. Mohanty et al. (2007: 420) found that the basic infiltration rate of vertisols was greater after the subsoiling tillage (5.65 cm h^{-1}) than the topsoiling tillage (1.84 cm h^{-1}), under rainfed conditions. However, Reynolds et al. (1995: 117) found no consistent trends for the near-saturated hy-

draulic conductivity values (almost equals the basic infiltration rate) on tilled and untilled soils. Generally, Vohland and Barry (2009: 122) indicated that in situ rainwater harvesting practices improve the infiltration and groundwater recharge. However, in this study only tillage practices would result in similar results.

3.4. The field water footprint

The impacts of in situ RWHT on the crop water use were investigated through the concept "water footprint, WFP". The normal conditions of the first season resulted in WFP values of 1100, 1100 and $4000 \text{ m}^3/\text{ton}$ for FT, CT and BT, respectively. During the second season, these WFP values have increased by 90%, 16% and 110% because of dry spells and water stagnation problems (Fig. 5). Obviously the zero tillage practice (BT) tends to reduce crop yield during wet conditions, agreeing with the results of Wang et al. (2007: 239) who found a yield reduction of 10-15% with no-till practice; and disagreeing with their results that zero tillage performs better in dry years, compared to conventional tillage practices in the arid lands of China.

Globally, Mekonnen and Hoekstra (2010: 17) estimated the green WFP of the rainfed sorghum at $2857 \text{ m}^3/\text{ton}$, suggesting that the WFP under the arid climate of the central Sudan could not approach the global one without the adoption of rainwater harvesting techniques. Succinctly, FT and CT could provide rooms for water savings (85%) in the arid conditions of the central Sudan.

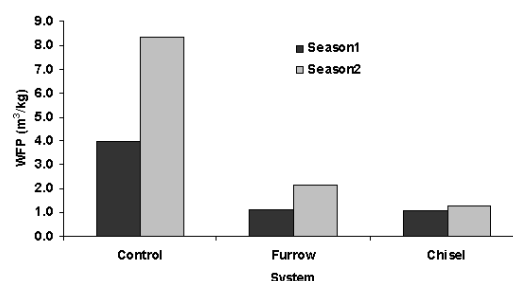


Figure 5: Water footprint (WFP) for each cropping systems during the first (season1) and the second (season2) experimental seasons in the central Sudan

4. Conclusion

Due to the limited irrigation water supply, rainfed agriculture is the largest contributor for livelihood generation in the central Sudan. Thus, it has large effects in the sustainability of natural resources. Therefore, practices leading to a sustainable rainfed agricultural system are very important. Currently, most of rainfed farmers adopt widely the bunds rainwater harvesting technique, which was found unsustainable practice relative to the topsoiling and subsoiling, which could provide win-win benefits, i.e. from agricultural (increase crop yield) and soil management (improve soil properties) point of views. The adoption of the topsoiling and subsoiling practices among

rainfed farmers however requires political will, facilitation of proper equipments and capacity building programs among agricultural extensionists and farmers as well. The successful story of zero tillage is a site specific. Thus, there is a badly need for validating the Sudanese government believes on zero tillage before expanding its adoption.

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Are the Most Valuable Resources in Dryland Areas Isolated Wetlands?¹

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Abstract – In dryland regions wetlands stand out as areas where water and nutrients accumulate, plant and animal production potential is high, and production risk is low. Wetlands are therefore much sought after in dryland regions, by farmers, pastoralists, fishermen, collectors of natural products, and also wildlife. Economic data from reports on some of the 1,000 isolated wetlands in Niger, presented here, demonstrate this importance to people living at the isolated wetlands as well to people living farther away. The importance of the isolated wetlands is even greater in times of drought. At the same time the isolated wetlands are under threat of disappearing because of increasing human pressure, climate change, land use change in their catchments, etc.. Descriptions of selected wetlands in Niger visited in the mid-1990s and again twelve years later show this, too. Integrated participatory management of wetlands in dryland regions must be effectuated as soon as possible, so that these very important natural resources will be used wisely and sustainably, and not used up. The UNCCD should put this high on its list of priorities.

Keywords – *Sahel, isolated wetlands, economic value, threatened ecosystems, participatory integrated management*

1. Introduction

Water is what makes life possible in the arid and semi-arid regions of the world that the UNCCD is primarily aimed at. In arid and semi-arid regions rainfall is very undependable. Wetlands, on the other hand, are areas where water is concentrated, thus reducing production risk. Nutrients from sediments and livestock manure are concentrated at wetlands as well, thus increasing ecological and agricultural production potential in comparison with the surrounding drylands. Because of this low production risk and high production potential, wetlands in arid and semi-arid regions are much sought after by people as well as animals. Wetlands also facilitate the utilisation of the drylands surrounding them. In short, in dryland areas wetlands are extremely important resources.

Unfortunately wetlands in dryland areas are also under severe threat. These threats include conflicts of interests between different users and user groups, desertification, climate change, demographic change and socio-economic change, as well as lack of (integrated) management.

In this paper I use the wetlands of Niger to illustrate the value of wetlands in the Sahel and other arid and

semi-arid regions, and to emphasise the need to use them wisely. In section 2 the various types of wetlands that occur in Niger are discussed. This is followed in section 3 by a description of their use for different purposes, in the wet season, in the dry season, and in different types of years. In section 4 the economic value of isolated wetlands to different user groups is quantified. In section 5 interactions between different types of wetland use, and with surrounding uplands are discussed. Recent trends and present and future threats to these wetlands are reviewed in section 6. In section 7 conclusions are drawn, and policy recommendations made.

Brouwer (2013) is a powerpoint presentation of this contribution, with pictures telling most of the story. Note that while many of the data are not recent, the story they tell remains valid. And, given the security situation in Niger of the past years, collecting new data is problematic.

¹This article is based on a presentation given during the UNCCD 2nd Scientific Conference on "Economic assessment of desertification, sustainable land management and resilience of arid, semi-arid and dry sub-humid areas", held 9-12 April 2013 in Bonn, Germany (<http://2sc.unccd.int/home/>).

2. Wetland Types in Niger

2.1. The few large floodplains

The river Niger drains a catchment of 1.5 million km². It flows over a length of 550 km through SW Niger. The flow at Niamey, the national capital, varies between 0-1800 m³ s⁻¹, with an average of 1030 m³ s⁻¹ (MHE-Niger, 1990a). This average flow was only half as large during the 1980's, due to increased off-take and lower rainfall (MHE-Niger, 1991c). Along the river in Niger there are 63.000 ha of floodplain, i.e. on average an inundation zone 570 m wide on either bank. Approximately 10.800 ha of floodplain have been converted to irrigation area, mostly for growing rice. (MAE-DEP, 1991: 28; MHE-DFPP 1991).

In the east of the country the Komadougou Yobé forms the border with Nigeria. This river used to flow ten months per year, but in the mid 1990's it only flowed for six months per year. This was due to a prolonged period of lesser rainfall, but also to the construction of dams upstream: in 1991 there were already 18 of them, with a total storage capacity of 2.6 billion m³ (MHE-Niger, 1991a).

Lake Chad consists of two major basins. In its very south-east Niger borders on the northern basin, which receives its water primarily from the Komadougou Yobé and from overflow from the southern basin. Partly as a result of greatly diminished flow in the Komadougou Yobé, the Niger part of Lake Chad was dry from about 1988-1998. The dry period caused very large parts of it to be invaded by *Prosopis juliflora* shrubs. (MHE-Niger, 1991a; W.C. Mullié pers. obs.)

2.2. The numerous smaller wetlands

In the north of Niger there are a number of oases, with orchards, grape and date production (de Beaufort and Czajkowski, 1986; MHE-Niger, 1991d). Little information is available about these wetlands. Throughout the country there are also a number of dry, 'fossil' valleys, sometimes kilometres wide, dating from the time that the Sahara and Sahel were much wetter than now, approximately 6-10.000 years ago. In most of these valleys water hasn't flown for centuries, some still carry water from time to time, while in all these ancient valleys groundwater is often close to the surface. (MHE-Niger, 1990a-e, 1991b-c)

Finally there are a large number of more or less isolated inland wetlands or lakes, called 'mares' in French. They are often located in depressions in the old drainage systems. There are more than 1000 in Niger alone, varying in size between 10 and 2000 ha at maximum extent. Some are very temporary, and only hold water a couple of months each year. Others contain water much longer. A number are even permanent, and always, or almost always, have water (MHE-DRE-Niger, 1993). These wetlands are enormously dynamic. Some disappear due to silting up (MHE-Niger, 1992; Piaton and Puech, 1992), but new ones appear as well. One such new wetland is at Dan Doutchi, in a depression that filled up as the drought broke in 1975: it now covers 1800 ha when full (Brouwer and Mullié, 1994b). By far the greatest number of these

isolated wetlands is to be found south of 15° N, in approximately the 300-600 mm rainfall zone, between the line Mali-Tahoua-Lake Chad and the borders with Nigeria and Benin.

Outside of Niger, in only two regions of south-eastern Mauritania there are at least 244 such isolated wetlands (Cooper et al., 2006). In other parts of the Sahel their prevalence is without any doubt similar.

3. The use of isolated wetlands in Niger for various purposes – differences between the wet season and the dry season and from year to year

See Brouwer (2009, on-line) for more detailed information on the use of isolated wetland in Niger at various times of year.

3.1. Cropping

During the rainy season there is little cropping activity or horticultural activity around isolated wetlands in Niger. Only crops like floating rice can cope with rising or permanently high water levels. During the rainy season, farmers with access to both wetland frontage and upland fields will be working on their upland fields, where they grow their staple food, pearl millet.

In agricultural statistics in Niger a distinction is seldom made between *dry-season* cropping that is irrigated, and dry-season cropping that is dependent on residual moisture in the soil. In the latter, as the water in wetlands recedes, crops are sown in the emerging soil. As the water stored in the soil is used up by the crop, supplementary irrigation is sometimes applied. Dry season cropping concerns crops like onions, tomatoes, beans, sweet potato, cabbage, lettuce and peppers (*pers. obs.*). These crops have a much higher nutritional value than the staple millet. Much of the dry season cropping is for (international) commercial purposes.

There is *inter-annual variation* in the area used in Niger for dry season cropping. During the years 1984-1991 it varied between 42.000 ha and 64.000 ha, rice not included (MAE-Niger, 1993). Dry season cropping was most extensive during 1984 and 1989: 63-64.000 ha, vs. <54.000 ha in other years. These two years were respectively a drought year and a year with patchy rainfall and poor millet harvests in many parts of the country. This shows that the total area useable for e.g. recession agriculture cannot be reduced with impunity: areas not used during good rainfall years may be an essential safety net during years of poor rainfall (Brouwer and Ouattara, 1995).

3.2. Livestock rearing

During the rainy season wetlands can provide drinking water to livestock, although the availability in the uplands of green feed and surface pools makes that less necessary. In some wetlands, but mostly along the Niger river, the grass 'bourgou', *Echinochloa stagnina*, may be grown during the wet season on rising water levels. When the water level has dropped it is harvested for hay.

During the dry season isolated wetlands can provide drinking water for livestock, and also grazing. Herders can bring in local cattle and small ruminants to drink every day, or every few days. Transhumance herders only use a particular wetland during a limited time of the year, as a part of their annual treks that sometimes cover thousands of kilometres.

No data could be found on *inter-annual differences* in utilisation of isolated wetlands by livestock. With livestock numbers decreasing during drought periods, utilisation by livestock of wetlands for drinking will also be lower during droughts. It should be noted that a particular isolated wetland may be important for livestock only once very so many years, when it can, and the other wetlands cannot, provide what the livestock and herders need. But if that year that wetland is not available because it has been used for other purposes, the whole associated livestock rearing system may collapse.

3.3. Fishing

During the rainy season fishing activity is generally low. Measures to increase fish production, such as re-stocking and increasing aquatic vegetation for fish to spawn in, do take place during the rainy season (MHE-DFPP, 1991).

Fishing mostly takes place during the dry season, when fish stocks have had time to grow and/or are driven closer together as the water level recedes. The main species caught are *Clarias gariepinus* (catfish), *Tilapia nilotica*, *T. zillii* and *Lates niloticus* (Nile perch). Also *Bagrus bayad*, *Protopterus annectens* (lungfish) and *Auchenoglanis* sp. (Brouwer and Mullié, 1994a).

Inter-annual variation in rainfall will lead to inter-annual variation in the maximum water level in isolated wetlands, and thus to variability in fish production in those wetlands. A nation-wide drought in 1984 did indeed lead to low fish production the following year, as mentioned in section 4.3. During drought years more aestivating lungfish *Protopterus annectens* may be dug out of the mud of dried out wetlands to serve as hunger food (Raverdeau, 1991; Cheferou Mahatan, 1994; Brouwer and Mullié, 1994a).

3.4. Hunting and tourism

Hunting was largely banned in Niger in 1974, other than by traditional means. In 1996 hunting was legalised again on a much larger scale (Brouwer et al., 2001). The rainy season is not the preferred season for hunting, except for the collecting of eggs of e.g. Comb Duck *Sarkidiornis melanotos*. These eggs may be put under chickens and the hatched ducklings raised for later consumption (*pers. obs.*). For tourism, too, the rainy season is not the preferred season. Although the landscape is beautifully green at that time of year, travel to isolated wetlands along unsealed roads can be quite difficult. There are also many more mosquitoes than during the dry season.

The dry season is when most hunting in Niger takes place. Even before 1996 it was not uncommon for ducks and geese to be hunted with shotguns, at least along the

Niger river. Live decoys and baited lines have been used as well (Giraudoux et al., 1988; Mullié et al., 1996). We have also seen little boys use catapults, as well as glue-sticks, to catch birds coming in to drink (Brouwer and Mullié, 1994a). Birds may also be caught as by-catch on fishing lines with hooks. In the local markets a multitude of animal species, including species found at isolated wetlands, are for sale for medicinal and magical purposes. To what extent these animals are caught in Niger itself is not clear (Brouwer and Mullié, 1994a).

There are no data about *differences between years*, as there is as yet little or no hunting or tourism at isolated wetlands in Niger. Note that hunters often do not live at the wetlands they hunt at. If the local population does not profit from the hunters, the hunters may not be welcome. The same goes for tourists, of course.

3.5. Collecting of natural products

Local people collect natural products from their wetland during the whole year. These include wood for cooking; wood for construction (trees around wetlands are often larger than those growing further away from water); clay for brick making and pottery; water for domestic purposes, including the washing of clothes; plant (and animal?) products for traditional medicinal and magical purposes (Brouwer and Mullié, 1994a).

Products collected primarily during the dry season include the fruits and tubers of water lilies *Nymphaea* sp. for human consumption; bourgou *Echinochloa stagnina* to feed livestock; and water for agricultural purposes (Brouwer and Mullié, 1994a). Collectors may be local but may also come from further away.

3.6. Biodiversity

The vegetation of isolated wetlands in Niger, if present, often shows a concentric pattern, in which the dominating species varies with the depth and duration of inundation. Closest to the shore there is generally a zone dominated by the grass species *Vetiveria nigritana* (shortest inundation time); then follow *Oryza longistaminata* (wild rice), *Echinochloa stagnina* (bourgou), and finally *Nymphaea lotus* and *N. caerulea* (waterlilies, where there is water a meter or more deep at least four to five months of the year). In addition to these herbaceous species there may or may not be trees, sometimes in dense stands. These include various *Acacia* species, and *Mitragyna inermis*. (Mullié et al., 1999)

During the rainy season most mammals as well as most birds are not very dependent on isolated wetlands, as there will be sufficient surface pools for drinking throughout the landscape. The wetlands in the Liptako Gourma region north-west of Niamey harbour an important population of Black-crowned Cranes *Balearica pavonina*, a Sahelian species that is threatened throughout its range by disappearance of wetlands, disturbance and capture for the live bird trade (Meine and Archibald, 1996; Brouwer and Mullié, 2001).

During the dry season large mammals such as an-

telopes, buffalo, elephants, hyenas, jackals, foxes, and even lions used to come to drink at isolated wetlands in Niger. However, other than foxes there are very few large mammals left in Niger, outside 'W' National in the south-west of the country. Waterbird counts were conducted every year during January-February during 1992-1997, along the Niger River as well as at isolated wetlands throughout the country. In total more than 100 species of waterbird were observed during those counts, and almost 40 species of raptor. During the dry season Niger is host to an estimated 1.8 million waterbirds on average. Most of these have been born in Europe or Asia, and some fly more than five thousand kilometres to spend the Eurasian winter in Niger. Niger's wetlands are therefore also important to the conservation of Europe's and Asia's biodiversity. (Mullié and Brouwer, 1994a, 1994b; Mullié et al., 1999; Brouwer and Mullié, 2001)

There is clear *inter-annual variation* in the importance of isolated wetlands in Niger for waterbirds. Two thirds of the waterbirds in Niger, on average about 1.2 million, use the isolated wetlands, depending on how much rain has fallen the preceding rainy season. The Niger River becomes more important when the rains have been poor and the isolated wetlands only partly filled.

4. ECONOMIC VALUES OF ISOLATED WETLANDS

See Brouwer (2009, on-line) for more detailed information on the economic values of isolated wetland in Niger

4.1. Dry season cropping

In the 1990's, financial returns per hectare per year in dry season cropping varied from 60.000 (low input *Dolichos lablab*) to 1.300.000 (onions) F CFA, or from \$ 200 to \$ 4.300 per ha per year (Raverdeau, 1991; Cheferou Mahatan, 1994). An upland millet crop would average \$ 70 per ha per year (Brouwer and Mullié, 1994a). Around Illela, Niger, women each worked about 200 m² of land during the dry season, while men worked about 2000 m² (Cheferou Mahatan, 1994). Some people worked their own land, others rented it at up to \$ 200 per ha per year. Introduction of motor pumps meant less people were needed to work the same area of land (Andreas Mueller, Projet Marécage Illela, *pers. comm.* 1994).

It is worth noting that irrigation projects may provide food and shelter to bird pests, particularly during the dry season when normally they would perish (Morel, 1971; Mullié, 1994). And irrigation projects, too, have a finite life: for irrigated areas in SE Australia the period of usability is estimated at 150-200 years (Meyers, 1994).

4.2. Livestock raising

Estimated livestock numbers, trade and production prices in Niger, from 1980 to 1991, are given in MAE-Niger (1993: 95-105). Cattle fetched about \$ 130-200 per head in 1990, bulls \$ 230-300, rams \$ 26-43, goats \$ 13-20. As an example of economic turnover, in the Region of Tahoua the exploitation rate (trade and slaughter) of cattle, sheep and

goats in 1990 was given as 5.1, 9.9 and 6.9% respectively (MAE-DEP, 1991). Livestock clearly form a very important part of economic activity in Niger. If it is assumed that one-third of livestock production in Niger is dependent on isolated wetlands for its water supply, then the value of wetlands to livestock production in Niger was around \$ 35 million per year in the early 1990's (Brouwer, 2009).

4.3. Fishing

In 1989, the *fish* catch in the Region of Tahoua alone, one of the seven rural Regions of Niger, was estimated at 430 tons, with a value of more than \$ 250.000 at the wetlands where they were caught (MHE-DFPP, 1991). In the capital Niamey the value of the fish was 5-10 times higher (*pers. obs.*). In 1993 it was estimated that, with an investment of \$ 1 million, the fish production in the Region of Tahoua could be increased to 1.500 tons per year, with an annual value of close to \$ 1 million at the then current prices. A total production of 2000 tons per year was considered achievable. (MHE-DFPP, 1991). Data for all of Niger are given in Figure 1 as well. Before 1975 fishermen at isolated wetlands in the Region of Tahoua were almost all from Nigeria (MHE-DFPP, 1991). At times this led to conflicts about access rights to wetlands (MHE-DFPP, *pers. comm.* 1994).

4.4. Hunting and tourism, collecting of natural products and biodiversity

As there is as yet little or no hunting or tourism at isolated wetlands in Niger, its potential is completely undeveloped. On the value of collecting of natural products, and of biodiversity, no data could be found. What value would conservationists in Europe attach to for instance the millions of waterbirds from Europe that spend the northern winter at isolated wetlands in the Sahel?

4.5. Summary of economic data

Table 1 summarises the estimates of the very considerable annual values that isolated wetlands in Niger had for different uses in the early 1990's. Since then the population of Niger has doubled, from 6 to 12 million. Utilisation by the local population of especially isolated wetlands has increased accordingly. Over those twenty years, the prices that are being paid for products from the wetlands have increased enormously as well. In short, isolated wetlands in Niger are generally even more, much more, important than they were twenty years ago. Except of course those wetlands that have already become seriously degraded, reducing their production value.

Table 1: Some estimated economic values of isolated wetlands in Niger in the early 1990's. See Brouwer (2009), on-line.

Product	Season	Year	Extent and value	Remarks
Cropping	rainy		?	Value probably quite low; cropping priority is uplands
Copping	dry	1991	42-64.000 ha/yr \$200-\$4300 per ha	area greater following poor rainy season in uplands; high nutrition, high value crops
Livestock keeping	rainy & dry	1991	\$35 million per year	value of traded livestock that was dependent on wetlands for water
Fisheries	rainy & dry	1978-1985	1.100-5.000 tons per year	fish catch at all isolated wetlands, in Niger, value to fishermen
Fisheries	rainy & dry	1978-1985	\$ 5-20(-40) million per	fish catch at all isolated wetlands in Niger, city prices
Fisheries	rainy & dry	1989	430 ton, \$250.000 per year	Region of Tahoua only; value in Niamey 5-10x greater; potential 2.000 ton
Hunting & tourism	dry		?	potential completely undeveloped
Collecting of natural products	rainy & dry		?	water, wood, clay; plant & animal products
Collecting of natural products	dry	drought years	?	waterlily fruits and tubers, and lungfish, are emergency food in times of drought
Biodiversity	rainy		?	almost no information
Biodiversity	dry		?	average 1.2 million waterbirds in Jan-Feb; other species?

For some users, such as pastoralists, isolated wetlands are essential to their way of life. For other groups, having access to wetlands as well as drylands increases the range of crop and livestock production options, from which they can choose depending on how good the local rains and the flood levels of the wetland are or were. As many authors have reported, risk reduction is a major goal for resource-poor farmers in the Sahel (e.g. Ubels and Horst, 1993: 29; Brouwer and Mullié, 1994a).

5. INTERACTIONS BETWEEN WETLANDS AND UPLANDS AND BETWEEN DIFFERENT TYPES OF WETLAND USE

Values of isolated wetlands for a particular purpose also depend on interactions with utilisation for other purposes. Sometimes such interactions are competitive and negative, sometimes they are positive. They can be local and intermittent, but also long-distance and permanent. For a full evaluation of links between isolated wetlands in the Sahel and associated uplands, and interactions between different user groups see Brouwer (2009), available on-line. The following points are a summary of what is writ-

ten there.

Interactions between wetlands and uplands

- Uplands can provide water and nutrient-rich sediments to wetlands, but too much water and/or too much sediment is detrimental
- Too many dams and too much water off-take upstream will cause downstream wetlands to deteriorate or even die.
- Raising the outflow level at a particular wetland will effect the water regime and the vegetation at the wetland and downstream.
- Activities around wetlands can provide extra income that can be invested in uplands, and vice versa; but there can also be competition for resources, including labour.
- Isolated wetlands are linked to local grazing areas by local livestock, and to more distant grazing areas and wetlands by transhumance livestock. The wetlands and grazing areas further south help make it possible to exploit the rainy-season livestock production potential of the northern Sahel. Without dry-season watering and grazing in the south, there can be no graz-

ing in the north.

Cropping effects on other uses

- Fish can spawn among the residues of the crops of the preceding dry season.
- Increased dry season cropping would make an isolated wetland less attractive for livestock raising, hunting, tourism, collecting of natural products, biodiversity, and possibly fishing. In providing additional dry season employment opportunities, dry season cropping may also lead to a reduction in seasonal outmigration in search of work.

Livestock raising effects on other uses

- Browsing, grazing and trampling by livestock can destroy the wetland vegetation, leading to a reduction of habitat for waterbirds and other animals, and also to a disappearance of resources for people.
- Fishing and biodiversity can profit from livestock rearing because of the transfer of nutrients by livestock to isolated wetlands. The livestock watered at isolated wetlands in Niger have been estimated to contribute up to 10 tons of manure and associated urine per hectare per year, containing 300 kg N, 30 kg P and the associated energy of the organic matter for use by detritus-eating organisms (unpubl. data). This has an enormous effect on plant and animal production at the wetlands, including fish production and waterbird presence (see Brouwer, 2009). These latter uses will suffer if livestock raising is crowded out or disappears for other reasons.
- It is not clear to what extent dry season cropping around isolated wetlands also profits from the transfer of nutrients by livestock to those wetlands. It would be very interesting to investigate that, given the conflicts between farmers and pastoralists at wetlands, with pastoralists often having to give way to farmers and give up access to wetlands and grazing resources.

Fishing effects on other uses

- Isolated wetlands may be linked to other areas through fishermen that come from elsewhere to fish at the wetland.

Collecting of natural products effects on other uses

- Harvesting of aquatic and fringing vegetation at wetlands, trees as well as herbs, by locals and by people from upland areas, is too often unsustainable and destructive, leading to a reduction of habitat for waterbirds and other animals, and also to the disappearing of resources for people.

Biodiversity and Hunting and tourism effects on other uses

- Biodiversity at isolated wetlands is obviously important to collectors of natural plant and animal products.
- The introduction, accidental or otherwise, of plants such as Water Lettuce *Pistia stratiotes*, Water Hyacinth *Eichhornia crassipes*, and bulrush *Typha* sp., may affect the collection of natural products.
- Biodiversity is likely to be negatively affected, immediately or eventually, by increases in dry season cropping; degradation or destruction of aquatic and fringing vegetation by farmers, fishermen, herders and/or livestock; by an increase in disturbance by the same groups; by changes in the flooding regime through the raising of the outflow level of the wetland and/or increased retention of water upstream in the catchment; by too much hunting or hunting at too many wetlands; and by overcollection of natural products.
- Waterbirds at a particular wetland link that wetland with the other wetlands they frequent. These include wetlands in the same area with which the wetland forms a habitat system for all or part of the year; as well as all the other wetlands along the flyways of the birds concerned. Bird ringing and satellite tracking studies have shown that migratory birds link Niger to at least 83 other countries, from Guinea to NE Canada, across Scandinavia to Siberia, and down via the Caucasus and the Middle East to Madagascar and South Africa.

6. Recent trends and threats to isolated wetlands in the Sahel

A number of recent trends at, and changes to, isolated wetlands in the Sahel have already been mentioned in the previous section. Many of them are part of, or related to, world-wide demographic, climatic, environmental and socio-economic changes. The casual observer will say that whether these trends are seen as opportunities or threats will depend on one's point of view. However, that is not completely correct. For not overly large wetlands near Zinder, southern Niger, Framine (1994) already estimated that, without proper counter measures, it would take only 10-20 more years for a change from an aquatic to a marshy ecosystem to be effected. At the same time it was said that 20-30 years after farmers move in, wetlands will be degraded for all kinds of use, including cropping. This degradation is confirmed by data in Table 2, where a comparison is made between the situation at a dozen isolated wetlands in southern Niger in 1992-1997 and in 2006-2008. In my considered opinion much of this degradation at isolated wetlands in Niger is due to a lack of PINReM, Participatory Integrated Natural Resource Management.

Table 2: Examples of changes happening at isolated wetlands in Niger, from 1992-1997 to 2006-2008 (Based on Brouwer 2010, available on-line). IBA = Important Bird Area according to BirdLife International (Fishpool and Evans, 2001).

Wetland	Examples of changes
Kobadié wetland , 50 km SW of Niamey along the road to Ouagadougou, ca. 20 ha	1992-1997: wonderful looking wetland with lots of trees and full of waterlilies, many birds; used by local people was very moderate 2006: all large trees (<i>Khaya senegalensis</i>) and most medium size trees (<i>Mitragyna inermis</i>) were cut; many more people were present, lots of disturbance, and few birds.
IBA Kokoro wetland , 30 km NE of Téra and 150 km NW of Niamey, max. 2,100 ha	1992-1997: up to 13,108 waterbirds of 44 species in a glorious setting of flooded grassland surrounded by patches of <i>Acacia nilotica</i> forest, red dunes, huge granite boulders and palm trees 2008: large areas of fringing <i>Acacia nilotica</i> forest had been cleared; a lot more vegetable gardens had been constructed; and grazing pressure by livestock on the aquatic vegetation had increased enormously (perhaps in part because of the poor rains the preceding year, but most likely because of an increase in population and livestock size); waterbirds were concentrated in a much smaller area of the original wetland and were much less in number (approx. 7,200).
IBA Namga or Namaga wetland , and 40 km NE of Téra and 150 km NW of Niamey, max. 500 ha	1992-1997: up to 13,190 waterbirds of 54 species; 2008: the wetland had mostly dried up due to poor rains in 2007; the adjoining village, from which the wetland received its name, had grown significantly; only about 1,200 waterbirds were observed.
Mari wetland , 10 km NE of Tillabéri, 100 km NNW of Niamey, max. 270 ha	1992-1997: up to 4,266 waterbirds; 2006: no waterbirds present because an earthen dam had been constructed to raise the level of the outflow of the wetland, while the (former?) wetland had been almost completely taken over by farmers.
Yaya wetland , 40 km W of Birni N’Konni	1992-1997: a total of 122 waterbirds was counted in this nice little wetland, next to a village; 2006: although still quite nice and with some waterbirds, now there was a clear increase in population and human activity when compared to the situation ten years earlier.
IBA Dan Douthi wetland , 80 km NW of Birni N’Konni, max. 1800 ha; originated in 1975 after a huge rainfall event which followed the drought of 1973-1974	1992-1997: up to 55 species of waterbird; 2006: an earthen dam had been built to raise the level of the outflow of the wetland; still a lot of water present, with people, fishing activities and vegetable growing and some other human influence; very few waterbirds still present in the area.
IBA Tchérasa reservoir , 6 km NE of Birni N’Konni	1992-1997: 15,000 Cattle Egrets and 3,000 other waterbirds (mostly ducks) present in January 1994; 2006: large areas of <i>Acacia nilotica</i> had been cut, especially in the areas where the Cattle Egrets used to roost; an increase in human population and activity was obvious.
Galmi reservoir , 60 km E of Birni N’Konni	1992-1999: up to 1,033 of waterbirds; 2006: few waterbird present, while the population pressure and fishing activities appeared to have increased
Tabalak wetland , 25 km NE of Tahoua along the road to Agadez, max. 1,150 ha	1992-1997: up to 5,464 waterfowl of 48 species; Tabalak used to have quite a few trees along its northern end (<i>Acacia nilotica</i> , <i>A. albida</i> , <i>Prosopis juliflora</i> , and <i>Balanites aegyptiaca</i>), but in 1993 many of these were cut; in 1993-1994, about 20% of the perimeter was covered by vegetable gardens, while 80% was accessed by livestock; 2007: many less waterbirds, in combination with a big increase in human population and human activities; it appeared that 80% of the perimeter was now covered by vegetable gardens (with some narrow passages for livestock that want to reach the water, and only 20% was freely accessible to livestock).

Continued on next page

Table 2 – Continued from previous page

Wetland	Examples of changes
Liptako-Gourma region , where the countries of Niger, Burkina Faso and Mali meet.	The Liptako-Gourma is an area with (still) lots of great wetlands, threatened by population increases, migration and climate change. Some of the wetlands are probably also threatened by the construction of a dam in the Niger River at Kandadji, south of Ayorou, about 80 km south of the Niger-Mali border. Dam construction implies employment and (temporary) settlement of laborers; this condition attracts people that provide goods and services to these laborers, causing, e.g.: construction of housing, for which timber is cut; in dry areas much of the timber grows in drainage lines and around wetlands; provision of firewood, for which wood is cut; growing of vegetables, mostly around wetlands, which means less access to those wetlands for pastoralists and destruction of the bordering vegetation.

Because of the continuing urbanisation, the demand for rice in Niger, and elsewhere in West Africa, will continue to increase. There have been proposals to develop a further 70.000 ha of land for irrigation in Niger, out of 210.000 ha considered suitable, much of it around isolated wetlands. The market for various other crops grown around wetlands will no doubt increase as well. In addition there is the increasing pressure due to population growth, which in Niger is estimated at 3.1% per annum or more. That growth percentage means a doubling of the population in less than 23 years, and a quadrupling in 45 years. Around wetlands the pressure will grow even faster, due to migration to wetlands from upland areas.

What effects climate change will have on all this is uncertain, but no-one appears willing to bet that the effects of climate change will be positive in the Sahel. This in spite of the fact that the drought of 1973-74 has led to the creation of quite sizeable (up to 1800 ha), new isolated wetlands in Niger.

All in all, there is no doubt that the human pressure on wetlands in Niger will increase enormously during the years to come. It remains to be seen how the poorest people will fare under such conditions if they are not offered help. Under present conditions, in particular poor people still have a lot of (traditional) access to wetlands and their resources. The danger is that those traditional access rights will be diminished by new developments. Transhumance pastoralists, present at isolated wetlands only part of the year, are likely to lose out to farmers, present all year round. At the same time conversion of upland grazing areas to millet fields has forced pastoralists to try their luck further north, where as yet there is less pressure from agriculture. This has caused for instance Peuhl to graze their herds in formerly Touareg areas, again leading to conflicts. Fishermen, collectors of natural products and biodiversity are also likely to be affected.

What then is the best way to further manage and develop Sahelian wetlands? Unfortunately, there is no simple answer. What is important is that it is realised how things came to be as they are, and what side effects proposed changes may have. Certainly, without creation and/or maintenance of the right infrastructure and macro-economic climate, wetland management and development will come to nought (cf. Breman, 1992). What is also clear

is that management and planning will have to be participatory to be successful (cf. Dugan, 1990; Ubels and Horst, 1993; Kouokam, 1994). In addition, appropriate attention will have to be paid to traditional techniques for utilising the wetlands; to possible tradeoffs between the various types of wetland utilisation for production and conservation; and to the different roles of men and women in the traditional production processes, with women often working smaller areas and growing different crops (Ubels and Horst, 1993; Cheferou Mahatan, 1994). Finally, management and development of Sahelian wetlands will without doubt have to take account of the intimate relationships that exist between the use of wetlands; the use of the drylands that surround them; and the use of other areas further away and at other times of year by people and animals that use the isolated wetlands in the Sahel only during particular seasons.

I would like to add that the importance of isolated wetlands to many user groups is not just limited to the Sahel. Scoones (1991) gives a similar but more wide-ranging evaluation of the importance of small wetlands in semi-arid areas of Africa. Other relevant publications include Dugan (1990), Claude et al. (1991), Hollis et al. (1993), and Sally et al. (1994).

7. Conclusions and policy oriented recommendations

From the above it will be clear that isolated wetlands in the Sahel, and arguably in other arid and semi-arid regions of the world, are

- natural resources that are very valuable to a quite a number of user groups,
- under severe threat from a number of processes that include desertification,
- poorly known.

There is no recent synthesis of what is known about these isolated wetlands, and not even a good inventory of what wetlands there are, how they are utilised, what their value is, and how they might best be managed.

What the UNCCD should do with urgency for isolated wetlands in the Sahel, and probably in other arid and semi-arid regions of the world, together with the Ramsar Bu-

reau, national Ramsar Committees, and other national and international bodies, is:

1. make an inventory of, and database with, all wetlands larger than e.g. 10 ha when they are full (or perhaps >50 ha to start with)
2. add to that database information on the physical characteristics of each wetland, its utilisation by people, its biodiversity, its economic value, and the threats to its functioning
3. encourage the formulation and implementation of National Wetland Programmes that will in due course take over the coordination of the first two tasks, and that will promote and help implement wise use of all wetlands, through Participatory Integrated Natural Resource Management based on the Ecosystem Approach of the Convention on Biological Diversity.

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Analysis of Plans, Programs and Policies to Combat Desertification in the State of Ceara – Brazil in the Period 2004 to 2012¹

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Abstract – According to the State Program of Action to Combat Desertification and Mitigate the Effects of Drought (PAE/CE), the State of Ceara-Brazil has three centers configured with Areas Susceptible to Desertification which are the Hinterlands of Inhamuns, the Hinterlands Irauçuba and Center North and the Hinterlands of Medium Jaguaribe, encompassing twelve municipalities and covering a total area of 26,432,65km². It is known that the problem of desertification in State of Ceara acquired more notoriety from the Arid Project which subsidized actions such as the elaboration of the National Program of Action to Combat Desertification and Mitigate the Effects of Drought. Since then, although with a smaller intensity than expected, noted that strategies to combat the phenomenon is being implemented in the State. In this context, the objective of this study is to conduct a systematization of the major Plans, Policies and Programs (PPP) in the State of Ceara in the period from 2004 to 2012. To this end, documentary and bibliographic searches were carried out. The systematization was made taking as parameters: objective of intervention, implementation year, managing agency, participation of society, geographical area, obstacles faced and benefits from the results obtained. It was found that the low participation, the supervision of PPP and reduced integration between policies are factors that limit the implementation and the control of actions.

Keywords – *Environmental crisis. Government intervention. Political action*

1. Introduction

The state of Ceara, located in Northeastern Brazil, has 92% of its territory entered into the Semi-Arid Tropics, has an economy based in primitive, predatory and extractive models of the natural resources, thus making it susceptible to desertification. With this operation, without awareness of preservation, Leite et al. (1994:3) found that about 15,128,8 km², accounting for 10.2% of the total territory of Ceara, are under a dangerous desertification processes. It is known that an integrated and coordinated information and systematic observation, based on appropriate technology and global, regional, national and local plans is essential for understanding the dynamics of the processes of desertification and drought and this system is also important to develop appropriate measures to deal with desertification and drought and improve the socio-economic conditions (UNCED, 1992:185). With this systemic thinking, Rodrigues (2006:8) studied the various factors that cause

the phenomenon of desertification and found that thirty-one municipalities in the state of Ceara are on a high level of susceptibility to desertification, encompassing an area of 33,969km², corresponding to 22.82% of the total area of the state. With this scenario, given the gravity of this serious environmental problem that affects the territory of Ceara, it is essential to development of Plans, Programs and Policies (PPP) which cause significant actions that can help combat the phenomenon of desertification. It is good to consider that these PPP should be based on Chapter 12 of Agenda 21 - a document prepared in the United Nations Conference on Environment and Development - which has the following programs:

- Developing and strengthening integrated development programs for poverty eradication and promotion of alternative livelihood systems in areas prone to desertification;
- Development of anti-desertification programs and in-

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tegrating them into national development plans and national environmental planning;

- Development plans for drought and schemes to mitigate the results of drought, devices that include self-help for drought-prone areas and designing programs to address the problem of environmental refugees (UNCED, 1992:184).

Following these recommendations, the state of Ceara developed actions to study and clarify the phenomenon of desertification in its territory. Thus, from the 90s of the twentieth century, several researchers have tried to identify the causes, consequences and intensity that this serious environmental crisis generated in an area or region. Among the most diverse works produced can be emphasized:

- In 1992, when it happened, in Fortaleza, the International Conference on Climate Variations and Sustainable Development (ICID) began studies on the issue of desertification in the state of Ceara, with the participation of the Fundação Cearense de Meteorologia e Recursos Hídricos do Estado do Ceara (FUNCEME) that detected through satellite images, areas with obvious signs of degradation susceptible to desertification;
- In 1994, the Conference National and Latin American Seminar on Desertification (CONSLAD) and preparation of actions to combat desertification which continued until 1998, however, some actions have not obtained the expected results and others have not been implemented due to bureaucratic obstacles at both federal and state levels;
- In 1995, development and implementation of the Project Arid coordinated by Department of Planning and FUNCEME that was responsible for research on natural resources. This project aims to mitigate the impacts of desertification adopting strategies to implement the Sustainable Development;
- In 1995, the Federal University of Ceara, in partnership with german research institutions, implemented the Waves Program that had as its main objective to study the degradation/desertification in production systems

in semi-arid region of Ceara in trying to establish the scientific basis for formulating strategies economic and ecological sustainable development in semi-arid territory of Ceara;

- In 1998, the state government of Ceara represented by the Superintendência Estadual do Meio Ambiente (SEMACE) convened a multidisciplinary group with the purpose of preparing the State Plan to Combat Desertification, thus demonstrating a commitment to environmental problem;
- In 2003, the Programa Selo Município Verde, in order to assign certification will recognize that environmental policies successful in improving the quality of life of the municipal population; to achieve this certification, the municipality shall, among other things, create Conselho Municipal de Defesa do Meio Ambiente (CONDEMA) that aims to establish the basic guidelines of municipal policy environment, establish standards for the prevention, control and environmental monitoring and propose plans, projects and expansion and sustainable development of the municipality.

But the state of Ceara not stopped developing actions to combat desertification phenomenon, because it recognizes the seriousness of the environmental problem into its territory and its population. So, faced with this situation, this research aims at a systematization of the main Plans, Programs and Policies (PPP) in the state of Ceara in the period from 2004 to 2012. Therefore, there were documentary and bibliographic research. The systematization was made following as parameters: objective intervention, year of implementation, managing agency, society participation, geographic area served, obstacles faced and results.

2. Results and Discussion

This section is intended to present the plans, programs and policies (PPP) elaborated in the state of Ceara in the period from 2004 to 2012. We analyzed ten main PPP related to the prevention and combating of desertification and are exposed in table 1.

Table 1: Plans, Programs and Policies (PPP) to combat desertification in the state of Ceara – Brazil in the period from 2004 to 2012.
Source: Adapted from CEARA, 2010.

a. PROÁGUA SEMIÁRIDO	
Year of implementation	2008 – 2011
Objective	Contribute to improving the quality of life of the population, especially in less developed regions of the country, through planning and management of water resources simultaneously with the expansion and optimization of water infrastructure, to ensure the sustainable supply of water in adequate quantity and quality for multiple uses.
Management agency	Secretaria Estadual dos Recursos Hídricos
society participation	No Information
geographic area served	State of Ceara

Continued on next page

Table 1 – Continued from previous page

b. PROGRAMA DE COMBATE À POBREZA RURAL – PROJETO SÃO JOSÉ	
Year of implementation	2008 – 2011
Objective	Implement actions for sustainable rural development, contributing to rural poverty reduction, strengthening participatory strategy and increasing the integration of all actors involved in the process.
Management agency	Secretaria Estadual de Desenvolvimento Agrário
society participation	No Information
geographic area served	It operates in 177 of the 184 municipalities in Ceara, with priority for the 40 lowest index of Social Development - IDS.
c. PROJETO CRÉDITO FUNDIÁRIO	
Year of implementation	2008 – 2011
Objective	Develop new model of agrarian restructuring, in which landless laborers and smallholders, through their associations, negotiate land acquisition directly with landowners getting reimbursable financing for land acquisition and non-reimbursable financing for investment in infrastructure and productive.
Management agency	Secretaria Estadual dos Recursos Hídricos
society participation	No Information
geographic area served	Every State of Ceara, with the exception of the cities of Fortaleza, Maracanaú by Eusebius and to count on the rural population and have a negligible economic vocation with potential for industrial development.
d. PEACE – Programa de Educação Ambiental do Ceara	
Year of implementation	No Information
Objective	Promote internalization, the discipline and the strengthening of the environmental dimension in the educational process, in order to prevent and stop the negative impacts on the environment, contributing to improving the quality of life in the state of Ceara and improvement of process interdependence Nature Society, necessary the maintenance of life on Planet Earth.
Management agency	Conselho de Políticas Públicas e Gestão do Meio Ambiente
society participation	No Information
geographic area served	State of Ceara
e. PROGRAMA DE GERENCIAMENTO E INTEGRAÇÃO DOS RECURSOS HÍDRICOS DO CEARA	
Year of implementation	No Information
Objective	Larger supply and guarantee water for multiple uses and increase the management efficiency of the integrated system, promoting the efficient use of multiple and participatory management of water resources.
Management agency	Secretaria Estadual dos Recursos Hídricos
society participation	No Information
geographic area served	State of Ceara
f. PROGRAMA DE DESENVOLVIMENTO HIDROAMBIENTAL	
Year of implementation	2000 – 2008
Objective	Promote sustainability of water resources of the State of Ceara.
Management agency	Secretaria Estadual dos Recursos Hídricos
society participation	No Information
geographic area served	Municipalities of Pacoti, Palmácia, Canindé, Paramoti e Aratuba.
g. PROGRAMA DE CONVIVÊNCIA COM A SECA	
Year of implementation	2008 – 2011
Objective	Increase the water security and food security of the state population.
Management agency	Secretaria Estadual dos Recursos Hídricos
society participation	No Information
geographic area served	152 municipalities in the period from 2007 to 2009, covering 100% of the cities most affected by the drought

Continued on next page

Table 1 – Continued from previous page

h. PROJETO MATA BRANCA	
Year of implementation	2008 – 2011
Objective	Contribute to the preservation, conservation, sustainable use and management of biodiversity of the Caatinga biome in Bahia and Ceara, promoting the sustainable development of priority areas, with the participation of rural communities, living in social criticism, in areas susceptible to degradation.
Management agency	Conselho de Políticas Públicas e Gestão do Meio Ambiente
society participation	Yes
geographic area served	Municipalities of Crateús, Independência, Novo Oriente, Quiterianópolis e Tauá.
i. PROJETO DE ESTUDOS DE ÁREAS DEGRADADAS SUSCEPTÍVEIS AOS PROCESSOS DE DESERTIFICAÇÃO NO ESTADO DO CEARA	
Year of implementation	No Information
Objective	Classifying and mapping degraded areas susceptible to desertification processes in the municipalities of the state of Ceara, in 1:250,000 scale by analyzing physical and biological processes using geotechnology.
Management agency	FUNCEME – Fundação Cearense de Meteorologia e Recursos Hídricos
society participation	No Information
geographic area served	Municipalities of Jaguaribe, Jaguaratama, Jaguaribara, Alto Santo, São João do Jaguaribe, Iracema, Potiretama, Morada Nova, Limoeiro do Norte, Icó e Orós.
j. ZONEAMENTO ECOLÓGICO-ECONÔMICO DAS ÁREAS SUSCEPTÍVEIS À DESERTIFICAÇÃO-ASDs EM IRAUÇUBA/CENTRO NORTE E INHAMUNS	
Year of implementation	No Information
Objective	Investigate the processes of desertification and generate a legal instrument for territorial compatible with ecological, social and economical for areas susceptible to desertification (ASD) of Irauçuba / North Central and Inhamuns
Management agency	FUNCEME – Fundação Cearense de Meteorologia e Recursos Hídricos
society participation	No Information
geographic area served	Municipalities of in areas susceptible to desertification (ASD) of Irauçuba / North Central and Inhamuns.

After this explanation, it appears that the state of Ceará is following the actions and programs proposed by Agenda 21. Another highlight is the Law 14.198/2008 establishing the State Policy to Combat Desertification Prevention and which, among other actions, stimulates political management of natural resources to ensure the necessary territorial integration of such management actions to prevent and combat desertification. Thus, it is evident that the government of the state of Ceara, universities and civil society are concerned with environmental issues and seek to develop programs, plans and policies in an attempt to operationalize sustainable development models in the state.

3. Conclusions

It was found that the low participation, the supervision of PPP and reduced integration between policies are factors that limit the implementation and the control of actions. With the analysis of Plans, Programs and Policies (PPP) in the state of Ceara many documents have been prepared, and to reach their governance, are needed collaborative arrangements of a set of interconnected and diverse social actors. For Fatorelli and Mertens (2010), the integration of public policies include actions such as information

exchange, transparency and management of political conflicts, working together, synergies between policies and the use of common goals in the formulation stage.

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From Vulnerability to Resilience: Agroecology for Sustainable Dryland Management¹

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Abstract – This paper explores the main institutional and political factors contributing to the gap between evidence and mainstream policies/funding priorities in dryland management. It explores two agricultural paradigms: firstly, it explores the dominant paradigm that favours modernization, economies of scale and specialisation. Secondly, it explores the agroecological paradigm with resilience of farming communities and their ecosystems as its central concept. It then discusses a number of practical experiences, each illustrating that agroecological approaches can lead to triple wins: increased productivity, increased natural resource sustainability and increased food security. But sharing good practices alone is not enough to bridge the gap. The role of research-based evidence is one among the many variables that influence policy making and implementation. Other variables include values, political affiliation, experiences, expertise, stakeholder organisation, the role of the media and pressure. Building agro-ecological resilience is a challenging concept for policymakers as it requires a fundamental change in agricultural investment patterns, towards enabling small-scale family farmers to develop their skills, expertise and voice, and towards full-fledged support for the up scaling of agroecological practices.

Keywords – Resilience, agroecology, family farming, paradigm shift, knowledge building

1. Introduction

The theme ‘Desertification, Sustainable Land Management and Resilience’, which was also the title of the conference organised by the UNCCD is highly relevant in the context of the multiple interlocked crises the world is facing today. As per UN estimates, 1.5 billion people around the world are directly affected by land degradation, while every year 12 million hectares of land become unproductive through desertification. The effects are worsened by climate change. Pastures are scorched, and crops, trees and livestock do not survive.

The impact can be devastating. For example, impoverished dryland communities in the Sahel and the Horn of Africa are experiencing high levels of chronic malnutrition, hunger, child mortality and migration, in an environment that is at risk of degradation beyond repair. Humanitarian aid to cope with these crises is costing millions of dollars each time and leaves many new projects in its wake.

Desertification and land degradation are not just natural phenomena. They are the outcomes of long-term over-exploitation and mismanagement of fragile ecosystems. To address these problems, we cannot resort to the same ways of thinking that have led to this situation. We need to take a different perspective, which is already presenting itself.

Evidence built by an increasing number of scientific reports and by innovative farmers around the world, all show that a new paradigm for agricultural development is unfolding that has a strong basis in local innovation and resources. The interesting thing is that this paradigm is emerging out of practical experiences on the ground (Altieri and Toledo, 2011; Gliessman, 1998).

The UNCCD observes the collective failure to convince policymakers of effective Sustainable Land Management (SLM) approaches as a key factor limiting the dissemination and application of good practice. This paper will explore the main institutional and political factors contributing to the frequent gap between evidence (from

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practice) and mainstream policies/funding priorities. The paper draws practical lessons and experiences from different parts of the world.

2. The dominant Paradigm

Over the past few decades the neo-liberal modernization paradigm has asserted a position of dominance (Long 2001, Blakie 2000, Bauman 2003, Slater 2004, Escobar 2010). It has transformed agriculture and other domains of society into a state that has been characterised in terms of 'risk' (Beck 1992), 'vulnerability' (Marsden 2009), and 'fragility' (Scheffer 2009).

Under neoliberal modernisation people and resources became part of global networks and flows (Urry 2000, Davis 2004, Marsden 2009). National governments and institutes such as the World Bank, the IMF and the world trade organization embarked upon a mission of privatization, commoditization, financial deregulation, decentralisation and trade liberalization. While this has provided opportunities to some it has also led to the creation of new powers, particularly large multinational organizations that thrived in these new circumstances with more access to resources, markets and labour. At the same time modern global ways of producing and consuming were pushed forward to replace local ones. Governments, research institutes and extension services pushed for monocropping, specialization, and the use of chemical fertilizers, improved seeds and agro-toxins. This also led to the further integration of agriculture in, and subsequent subjection to the workings of, the global market.

While initially driven by (inter)national public institutions, this model of agricultural development is increasingly pushed by large multinational agribusiness corporations. The IAASTD (2009) found that the adoption of agrochemicals and mono-cropping has benefitted transnational corporations with "near-total control" of food production (<http://www.groundswellinternational.org/sustainable-development/burkina-faso/women-farmers-feed-the-world/>). These corporations are moreover exerting increasing influence on the course of science, policy and regulation. Agribusiness companies have aggressively promoted their products through PR activities, industry lobby groups, funding academic research and directly influencing government policy (Holt-Giménez and Shattuck, 2011). Watchdogs estimate that in 2012 alone, Monsanto has spent \$4,730,000 on lobbying the US government (OpenSecrets.org, 2002). The patent laws that Monsanto has lobbied for have diminished farmer breeding rights (Kloppenborg, 2010). Legal assaults of Monsanto against farmers violating their property rights have been reported (CFS, 2004).

These developments have created two types of vulnerabilities. First, it has created a superfluous group of urban and rural dwellers, coined by Breeman (1996) as foot-loose labour and by Bauman (2003) as outcasts of modernity. People and local communities have been displaced, excluded or marginalised because they were not modern or had to make way for modern development projects or

agribusiness. Rural-urban migration was the result and as not all could be absorbed by the cities, slums were created and a new class of transnational refugees emerged (Davis 2004). During the 1980s, structural adjustment policies promoted by the World Bank and others pushed African and other governments to privatise land and focus on industrial farming. In addition, large scale 'development' projects such as dams, mines and pipelines, also often supported by financial institutions, pushed farming communities off their land, increasing rather than alleviating poverty. The World Bank is now playing a key role in the global rush for land by providing capital and guarantees to big multinational investors. Oxfam found that more than 60 per cent of investments in agricultural land by foreign investors between 2000 and 2010 were in developing countries with serious hunger problems, while two thirds of those investors plan to export everything they produce on the land (Oxfam, 2012). Many small-scale farmers and pastoralist communities living in such areas were forced to leave and work in towns and cities or on large scale commercial plantations or farms. Food aid is dispensed during periodic droughts and shocks while this perceived 'inevitable' transition goes on. Sometimes, as is the case for many dryland areas, entire regions were excluded. Investment in ecologically fragile and drought prone areas were not seen as being economically feasible.

Second, these developments have led to the institutionalisation of unsustainable modes of production. The Green Revolution, beginning in the 1940's, pushed for the widespread use of chemical fertilizers, pesticides, and machinery. The Green Revolution did result in increased agricultural productivity. However, such increases were not without environmental and social consequences and some areas (particularly in Africa) were excluded from productivity gains altogether (Matson et al., 1997; Pimental et al., 1973). For tens of millions of small-scale farmers who live in fragile drought prone areas, industrial inputs like hybrid or genetically engineered seeds, chemical fertilizer, pesticides, or irrigation are unsuitable or unaffordable. Similarly, this type of agriculture has resulted in the degradation and depletion of natural resources, for example, years of water-intensive farming has depleted water tables, while increased use of chemicals has severely damaged soils. Although the failure of the Green revolution, especially in Africa, is increasingly recognised, a New Green Revolution is gaining momentum. The New Green Revolution is still driven by the belief that yield increases require intensive use of chemical fertilizers and pesticides, but also promotes high-yielding varieties and emphasises the creation of input and output markets. Environmental concerns are also being acknowledged and presently the concept of 'sustainable intensification' – broadly defined as a means to increase productivity while reducing environmental impacts such as pollution and resource degradation – has gained widespread acceptance (Fish et al., 2014; Garnett et al., 2013). Both the New Green Revolution and sustainable intensification represent a reformed version of the dominant paradigm. Proponents of this paradigm focus on measurable efficiencies. For example yield per hectare or per other inputs such as nitrogen and

water. While this is a valuable concept in itself, it is limited in that it favours analysis of individual cropping systems, livestock systems or value chains. When approaching whole farming systems, everything cannot be reduced to a measurable input or output such that by default certain modes of production are favoured (Malezieux, 2012). Further, neither sustainable intensification nor the New Green Revolution acknowledges the sociopolitical drivers of sustainability (Darnhofer et al., 2010). As a result, policies tend to prioritise export oriented, commercial production in areas that have access to reliable rainfall, inputs, roads and markets and perpetuate social exclusion.

3. Agroecology

3.1. *A sustainable alternative?*

In response to the vulnerabilities and shortfalls of the 'Green Revolution' type of farming many farmers have sought alternative farming practices. In areas untouched by modernisation farmers have continued to innovate using the resources they had at hand and according to local needs and possibilities. Over the past decades, farmers, and the NGOs and scientists working with them distilled a set of principles from a variety of these experiences which was coined agroecology. Agroecology is one of the central recommendations of the IAASTD (2009) and is often referred to as a practice, a science and a movement. (Wezel et al, 2009). Agroecology is now increasingly being adopted and articulated by peasant movements worldwide.

Agroecology sees the farm as a system. A healthy and active soil forms the basis. The core principles of agroecology include recycling nutrients and energy on the farm, rather than introducing external chemical inputs; integrating crops and livestock; diversifying species and genetic resources in agroecosystems over time and space; and focusing on interactions and productivity across the agricultural system, rather than on individual species (Altieri and Toledo; de Schutter, 2011). In contrast to neoliberal modernisation, agroecology is based on techniques that are not delivered top-down but developed on the basis of farmers' knowledge and experimentation. Therefore, agroecology is highly knowledge-intensive, for example, local knowledge systems, including knowledge about agrobiodiversity are indispensable. Furthermore, agroecology takes strength from existing socio-cultural structures such as local institutions governing natural resources.

Benefits of agroecology include increased productivity and incomes for farmers, enhanced food security, improved adaptive capacity for the changing climate, regeneration of natural resource bases and greater autonomy for farmers. These benefits are the building blocks of a more resilient agriculture, defined by the United States Agency for International Development (USAID, 2012) as the ability of people, households, communities and systems to adapt and recover from shocks and stresses in a manner that reduces chronic poverty and facilitates inclusive growth. The two types of vulnerabilities outlined

in Section 2.1 – namely marginalisation of farmers and farming communities and institutionalisation of unsustainable farming practices – can be considered the polar opposites of a resilient agriculture. Benefits from agroecological approaches remain contested. For example, it is often claimed that necessary agricultural productivity (measured in efficiency terms) can only be reached with technology such as fertilizer and improved seeds (Tilman et al., 2011). However, tangible links between agro-ecological approaches and resilience are increasingly recognised and for this reason, agroecological approaches in many forms emerge as promising alternatives to neoliberal modernisation. For example, agrobiodiverse farming underpinned by traditional crop and livestock varieties (created by farmers) out-perform hybrids in terms of suitability to local conditions, resistance to pests and disease outbreaks and capacity to adapt to extreme weather events (Jarvis et al., 2011; Ratnadass et al, 2011). Furthermore, reduction of external inputs into farming systems (e.g. seeds, nutrients and fossil fuels) not only mitigate greenhouse gas emissions and better align farming practices with ecological cycles supporting productivity, but also break the cycle of dependence on expensive, often unaffordable technologies and reduces farmers' risks caused by fluctuating commodity prices and energy markets (Altieri, 1999). Finally, the ultimate value, that agroecology places on farmers' knowledge and increased autonomy, serves to redistribute power towards farmers and farming communities (Gliessman, 2013; Van der Ploeg; 2008).

3.2. *Successful agroecological experiences in dryland regions*

In dryland areas unaffected by modernisation local knowledge systems have been better preserved in most cases, as well as their (knowledge about) agrobiodiversity and their local institutions governing natural resources. These systems are well adapted as they have evolved under local climatic and bio-physical conditions and in accordance with local values. They hold within them promises to move towards a more resilient agriculture. A diverse array of practices in dryland areas have shown to increase resilience in several ways. First, they build resilience to drought and climate change. This includes the conservation and improvement of indigenous seeds and breeds that require less water and are adapted to harsh conditions, the restoration of traditional water storage structures and the use intercropping in pest management.

Many civil society organisations have worked closely with local communities and interested scientists, to develop and document holistic approaches to dryland management. These approaches are powerful because the technical, social and governance dimensions are closely integrated (Burger, 2012). Day by day, successful agroecological experiences are increasing (de Schutter, op.cit.). Though a key feature of agroecology is that it is locally specific and diverse, some initiatives have scaled up massively, as can be seen in the Sahel.

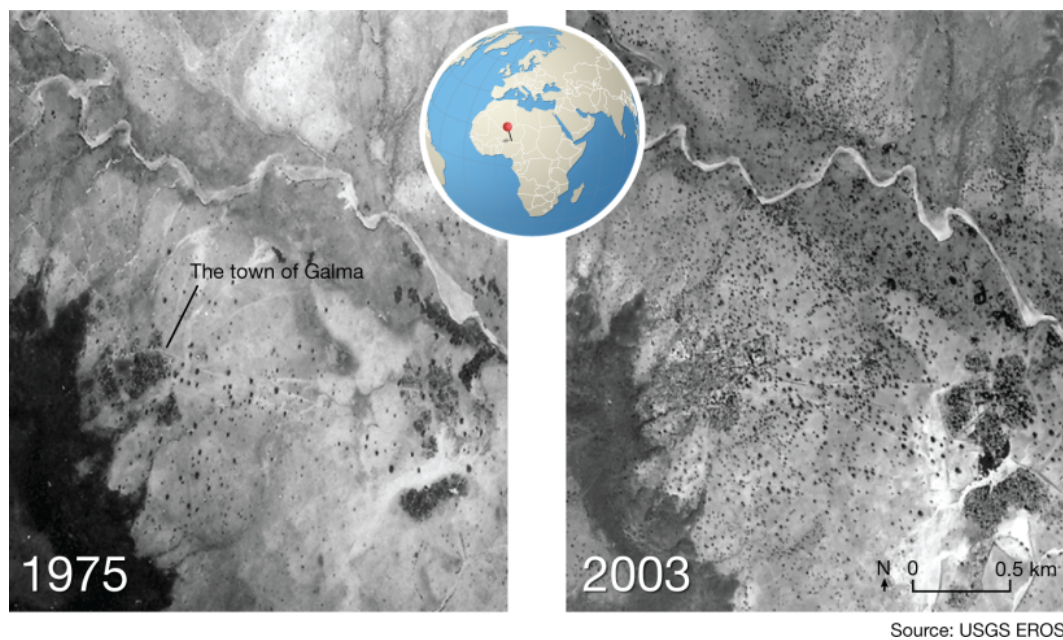


Figure 1: Increase in Tree cover

3.2.1. Soil restoration in the Sahel

In southern Niger, there is considerable evidence that sustainable intensification of small farming systems, which integrate food production, trees and livestock, using low external inputs, agro-ecological methods, and crop diversification, can “re-green” denuded landscapes, reduce risks and improve food security for small-scale farmers. The best documented techniques include “zai” planting pits, rock bunds on the contour and half moons water catchments. Also very crucial is farmer managed natural regeneration (FMNR) of trees: farmers protecting and growing trees on their own land.

Through FMNR, small-scale farmers in Niger are producing an estimated additional 500,000 tons of cereals a year which helps feed about 2.5 million people (Rinaudo, 2007). The World Bank estimates the annual production value of the new trees is at least \$US 260 million, which flows directly back to farm families, either as cash or as produce (World Bank, 2010). In the region of Maradi in Niger alone, in 2008, a very conservative estimate is that 62,000 farm families practicing a full version of FMNR have generated an additional gross income of US\$17 - 23 million per year, contributing 900,000 to 1,000,000 new trees to the local environment (Haglund, et al. 2009).

The “re-greening” of about 5 million hectares in southern Niger has been described by an informed writer on the environment, Mark Hertsgaard as “one of the great success stories in the field of climate change and agriculture” and “the single largest environmental transformation in Africa” (Rinaudo and Yao, 2009).

Regreening Africa is a farmer led innovation movement. In Niger, desertification and soil degradation, low soil fertility, unreliable and erratic rainfall patterns combined with high levels of pest attacks make agricultural activities very risky. In some zones of Niger, up to 50% of the landmass is totally unproductive because land degra-

dation and erosion have resulted in hardpan formation (Rinaud and Yaou, 2009). This means that when it rains, water cannot infiltrate the hard soil. Extensive water runoff and flooding occur, destroying crops and increasing erosion even further. Few farmer families have sufficient organic matter to maintain soil fertility. As a consequence, in many parts of Niger, even in good years, many poorer farm families do not produce enough food to meet their family’s nutritional needs for more than three to six months (Rinaud and Yaou, 2009).

Determined to break this cycle of permanent food and nutrition insecurity, the new government of Niger recently outlined the “3N Initiative” (Nigeriens Nourishing Nigeriens). There is still considerable controversy, however, about the model to follow to increase aid and investment in agricultural development. Despite repeated commitments by key donors and the government to support small-scale farmers (Rinaud and Yaou, 2009), agricultural policies and practices often remain biased to farming in more favourable areas, and to large irrigation schemes.

However, as noted above, there is considerable evidence that agroecological methods can transform the landscape, and rehabilitate degraded land. Where farmer managed natural regeneration and complementary soil and water conservation techniques have been practiced in Niger, degraded land was restored to production, crop yields have increased, water tables have risen and resilience to shocks has strengthened (Rinaud and Yaou, 2009), financial benefits through sale of tree products and increased grain and livestock production are estimated to be up to \$250 per hectare (Rinaud and Yaou, 2009). FMNR adoption appears to increase household gross income by about 46 and 56 USD) per capita, or by between 18 and 24 percent (Haglund et. al, op.cit.) .

What is significant about these practices in Niger is that it is largely a farmer led movement. This “re-greening” began in 1985, supported by a few NGOs that

built on farmers' knowledge, and farmer to farmer approaches to learning and innovation. Supportive policies on decentralised, community based natural resource management, particularly over trees on farmers own land, and were another factor for success. This combination of learning from farmers, using low cost appropriate technologies, supportive policies, and eventually catalytic support by NGOs, contributed to eventually achieving a "critical mass" of practice within villages, and spontaneous widespread adoption. The massive increase in tree cover is so widespread, that the effects can be seen in satellite pictures comparing landscapes from 1975 to 2003.

However, even with this evidence, the new 3N Initiative in Niger is still largely influenced by the dominant Green Revolution thinking, investing in expensive seeds, external inputs, and large scale irrigation. This is limiting the much needed investment to further spread agroecological techniques such as farmer managed natural regeneration which, in addition to increasing production, also contributes to resilience to drought, re-greening of the environment, inclusive growth and farmer autonomy.

3.2.2. Biomass and water retention in Ethiopia

Land degradation is one of the most serious problems facing Ethiopia today. Yield reduction is high as a result of loss of topsoil to support farming. In order to improve crop yield in the region, the Ethiopian Government adopted the Sasakawa Global (SG) 2000 package, which is based on the use of high input demanding varieties and chemical fertilisers. The Institute for Sustainable Development, an Ethiopian NGO implemented a project using agroecological principles and compared its performance with that of the SG package in neighbouring villages.

Experiments were carried out in pairs of the following villages: Abomsas, Adi Nifas, Guimse and Ziban Sas. The use of chemicals and high-input demanding seeds on the one hand and use of technologies such as biomass and water retention techniques were used in other villages. After five years of the project, impressive results in soil management; productivity increase in crop yield; rehabilitation of grazing lands (that was left wasted) and water conservation were observed. Farmers obtained yields equal to those of the high external input farmers while their straw yields were higher. This provided them more fodder and composting material.

The key to the success of this project laid in the systematic involvement of almost all of the stakeholders. The project offered a range of choices and farmers adopted those that suited their ecological and social setting. As the project's results were convincing, it has been upscaled in a large UNDP-supported Programme (Edwards and Belay, 2003).

3.2.3. Seeds and local varieties in Brazil

Practices that use and conserve agrobiodiversity in the Brazilian semi-arid region of Paraíba form an important livelihood strategy for family farmers. However there are not recognised by governments as such. AS-PTA and

ASA-PB, two non-governmental organisations, sought to have successfully managed to strengthen, upscale them and ground farmer seed systems in public seed policies and programmes (Petersen et. al., forthcoming, Curado et. al., 2013).

Identifying and enhancing the visibility of these practices was a crucial first step. ASA-PB started this process in 1996. In collaboration with the local farmers' union, they carried out a participatory appraisal to identify local bean varieties in the municipalities of Solânea and Remígio. They found 67 varieties of beans with different characteristic traits including resistance to droughts and pests, taste and acceptance in the market. They also identified mechanisms that enhance diversity and seed security. Farmers store their seeds and exchange them with other families, allowing for the free circulation of genetic material and of the knowledge associated with each variety in the communities. Local church based organisations had established seed banks in the drylands of Paraíba in the 1970's. These proved highly effective in times of drought, when crops fail and farmers' own seed stocks are depleted. The bank lends seeds to the farmers which the farmers return, with a small percentual increase, after the harvest.

The local seed banks formed an important entry point to establish a seed security system. ASA-PB organisations established the Seeds Network, a platform for knowledge exchange on seed practices and the conservation of agrobiodiversity. This network links 230 seed banks in 61 municipalities, covering 6500 family farms in Paraíba. The seeds network formed a space for critical analysing and proposing policies. A drought in 1993 triggered a protest where ASA-PB and other social movements challenged the state's measures that were based on the notion of tackling the effects of drought. Alternatives were proposed based instead on living with the semi-arid.

As a response the national government launched a seed banks policy. The state created its own seed network, which consisted of existing community seed banks, and that supported the stocking hereof. This donation of seeds also provided impetus for communities to construct new seed banks. The banks however were replenished with conventional rather than local seeds. The next protest took place in the drought of 1998/99, after which local seed banks were again refilled with conventional seeds. ASA-PB persuaded the government of Paraíba to acquire local seeds from farmers for the year after. The initiative however stumbled against a legislative barrier. Local seeds were not recognised as seeds and could therefore not be distributed officially by the state through the seed bank network. The government bypassed this by acquiring the seeds as "grains", transferring them to ASA-PB who in turn distributed them through their seed bank mediators. In 2002 a law in Paraíba enabled direct transfer. When local varieties became formally recognised by the national government in 2003, which was largely the result of pressure by the National Articulation for Agroecology (ANA).

Despite the successes booked by the programme in Paraíba and some other states, most government seed programmes continue to be biased towards the conventional paradigm. They argue that improved seeds have been sci-

entifically proven to work under semi-arid conditions and that initiatives such as those by ASA-PB, while desirable, cannot be scaled up to reach all the farmers that are in need of seeds. Consequently, ASA-PB saw the necessity to engage with science.

To prove that local use, management and conservation practices are effective and viable, the Seed Network partnered with Embrapa, the governments most influential agricultural research agency. This was an opportunity to gain acceptance in academia and legitimacy in the eyes of the civil servants involved in seed programmes.

All Seed Network organisations were involved in the research that followed, which sought to compare the performance of local and conventional varieties. The research team used participatory methods to determine which varieties to compare, on which locations to test and how the interaction between farmers and researchers should proceed. Together with farmers, they identified performance parameters. These included grain quality, plant health, and the amount of straw on the plant and the effect of intercropping with other crops. Local varieties outperformed conventional varieties in all regions and in all the three years that the experiment lasted. Conventional varieties only yielded better in highly fertile soils with plenty of rainfall, which are exceptional conditions for family farmers in the semi-arid region. The varieties that performed best in a certain area were usually also varieties that found their origin there. Local varieties were also found to produce more biomass, highly valued as animal feed especially in the erratic climate of the region. Research also showed that the seed storage facilities constructed by farmers, often using only local materials, performed well even though no pesticides were used.

Although the research only confirmed what farmers already knew, local practices were now scientifically recognised.

4. Creating an enabling policy environment

Governments and donors still have a long way to go in mainstreaming the agroecological paradigm. This involves enabling small-scale farmers to develop their skills, expertise and voice, while supporting their use of agroecological farming practices. This requires a truly integrated perspective on dryland management, breaking down institutional barriers and improving collaboration between stakeholders. However robust the agroecological initiatives are, there are challenges preventing a more comprehensive upscaling.

In the past ten years, donors have been giving lower priority to sustainable natural resource management. They shifted their focus to farmer integration into global markets and global value chains. However, as Bill Vorley, one of the authors of a report of a three year knowledge program said: “contrary to the prevailing narrative, and what NGOs, policymakers and donors expect, interventions that aim to upgrade small-scale farmers into high-value, formal supply chains and modern markets tend to benefit only 2-10 per cent of farmers”(Vorley et. al. 2012).

Many institutions have not yet grasped that building

agroecological resilience requires a fundamental change in agricultural investment patterns. For example, while the UNCCD argues that it is important to build “production systems based on the intensification of locally available and adapted biodiversity, using local knowledge”, its finance mechanism emphasises encouraging private sector investments and market-based mechanisms (Rowan: 2012). Why doesn't the UNCCD encourage investments in strengthening small-scale farmers' capacities and the up scaling of local agroecological practices?

4.1. Understanding the force field

As we can see from the experiences described above, sharing good practices alone is not enough. Use of evidence is only the beginning of a political process. Equally important, even when an evidence-based policy is adopted, implementing it properly is quite another matter. The role of research-based evidence is one among the many variables that may influence a policy maker when public policies are formulated. Some other relevant variables include values, political affiliation, experiences, expertise, stakeholder organisation, the role of the media and pressure.

When designing a strategy to bring evidence for SLM in dryland regions to the attention of policy makers, it is therefore important to understand the strategic opportunities. Mapping the force field in which one operates is one way of getting there- it is fundamental to understanding power dynamics and potential windows of opportunity. Some of the key questions that require an answer when mapping the force field include:

- What are the existing policies and how do they favour or constrain SLM?
- What is the political context which shapes decision making related to SLM and what is the role of evidence in this context?
- Who are the “policy makers” that need to be convinced?
- Who are the actors, including social movements and scientists, supportive of SLM?
- What policy influencing strategies are most effective for each of these actors, and at which moment in time?
- Which are the factors and actors in the way of agroecological practices being mainstreamed?

Once these questions are answered, and the spectrum of actors and their strengths is drawn out, an effective strategy for the push for SLM and agroecological policies in dryland regions can be developed. Strategies to influence policy include advising, advocacy, lobbying and activism, which can be informed by either evidence or interest and values.

5. Policy recommendations

Below follow a few recommendations to three major categories of actors in the dryland arena: policymakers and donors, CSOs and farmer organisations, and scientists.

5.1. Recommendation to policymakers and donors: Agricultural investment patterns need to change

Mainstreaming the agro-ecological approach will be a crucial step in finding structural solutions for major global challenges- one of them is the massive degradation and desertification of land. Building agro-ecological resilience requires a fundamental change in agricultural investment patterns. For example, the UNCCD argues for a case in point to build production systems based on the intensification of locally available and adapted biodiversity using local knowledge. This would require enabling small-scale farmers to develop their skills, expertise and voice, while supporting their use of agro-ecological farming practices. Furthermore, it requires a truly integrated perspective on dryland management which means breaking the silos and much more collaboration between all stakeholders involved. It also requires careful listening to farmer experiences on the ground.

Over the past decade, resources available to CSOs and Farmer Organisations working on degradation and desertification have declined due to shifting priorities of donors. For this reason, donor organizations should critically review this situation and be open to the active role that local level institutions and CSOs can play. They should make resources available to support initiatives to scale up agroecological approaches in drylands, including initiatives that support local knowledge building and sharing.

5.2. Recommendation to CSOs and FOs: Strengthen engagement with policymakers

The key challenge for CSOs and Farmer Organisations is how to engage with policymakers. It is difficult to convince policymakers about the effectiveness of agroecological approaches on the ground. CSOs have to invest in understanding political decision making processes and how to engage and deal with power imbalances, but also in strengthening their technical agroecological knowledge. There is therefore, an urgent need to improve documenting and packaging and in their experiences so that these can be effectively communicated.

The focus should not only be on influencing policies; it is equally important to look at opportunities to support government in the implementation of good policies.

5.3. Recommendation to scientists

The call for change is gradually getting louder. Numerous agroecological experiences have shown that the involvement of scientists in participatory research processes with local farmers adds significant value through the exchange of knowledge between farmers and scientists. Scientists can play a key role in bridging the gap between local experience and scientific evidence. However, the success of this can only come about if scientists listen well and open their minds towards a new way of understanding local farmers by working towards a multi-functional approach to agriculture. If scientists succeed in this, they are ready

for a refreshing scientific experience that may well lead to many valuable new perspectives and insights.

6. Conclusions

The resilience of farming communities and their ecosystems depends to a large extent on their ability to develop their skills and voices to choose their own development pathway. Scientific evidence is only the beginning of policy change in dryland management. Most importantly, policy-makers need to acknowledge that a different approach is needed; one that is based on participation of indigenous and local communities and that combines indigenous knowledge with the latest scientific findings about sustainable dry land management. Capitalising on successful practical experiences requires a deeper grasp of agroecological principles on the one hand, and of policy processes on the other. For example, in Iran, nomadic pastoralists have collaborated with scientific bodies such as the CESNESTA who help them to use the land more sustainably and conserve natural resources. It requires curiosity and an open mind. The call for change to sustainable agriculture is getting louder in both policy and scientific debates. Farmers are becoming more and more powerful in voicing their concerns and proposals. Additionally, there is a growing movement of conscious consumers' organizations who want responsible food systems. Policymakers are facing the huge costs of disasters caused by climate change, degradation and desertification. Part of the solution is within reach; it is time to act.

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