CHALLENGES AND OPPORTUNITIES OF SOIL CONSERVATION AND LAND MANAGEMENT IN THE DRY AREAS

EXPERT GROUP MEETING (EGM) ON DRY-LANDS

ISLAMIC DEVELOPMENT BANK HQ

JEDDAH, K.S.A. 18-20 FEBRUARY 2013

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Introduction

Land degradation is a serious problem, particularly on vulnerable agricultural lands to soil erosion, which signifies the temporary or permanent decline in the productive capacity of the land (UN/FAO definition). Erosion is one of the most common problems around the world. Sanders (2004) considers that erosion and soil degradation issues have contributed to the decline of great civilizations in Egypt, China or Greece. The annual costs of soil erosion in the US are estimated between US$ 30 billion and US$ 44 billion (Morgan, 2005). In the dry areas, soil erosion is strongly contributing to desertification, which is a serious problem in many countries in Asia and Africa (UNEP, 2000).

The on-site effect of erosion are particularly important on agricultural lands where it leads to an important loss of fertility which can ultimately leads to an abandonment of the land (Morgan, 2005). Erosion also creates environmental damages through sedimentation pollution and increased flooding. Thus, off-site effects costs can often outweigh those arising from the loss of soil in agricultural fields. Furthermore, eroded soil may loss 75 to 80% of their carbon content (Morgan, 2005) and so contribute to climate change by emission of carbon in the atmosphere.

Soil erosion is particularly important problem in developing countries where a large part of the population lives in rural area. Most of the rural incomes are depending on natural resources. Erosion control and land conservation are, in this context, crucial issues.

This brief paper explains efforts to reduce soil erosion and improve soil fertility. The approach followed relies on assessing the extent and distribution of soil erosion in the dry areas, promoting the implementation of soil and water conservation (SWC) interventions taking into consideration the bio-physical and socio-economic environments. Sustainable development of areas affected by land degradation in the dry areas required knowledge of the impact of SWC interventions in reducing soil erosion and improving soil productivity and fertility.

Summary of challenges

- Identifying hot spot areas for soil erosion and identify severity of water and wind erosion: This is because the area affected is so large and implementing SWC practices over this area is not possible. Therefore identifying areas with high erosion rates and/or those with negative effect on increasing soil erosion in other areas (down the stream), will assist in targeting those areas and associated communities to implement SWC interventions that will show an obvious and tangible impact.
- Providing enabling environment (finance) and diversification options: Farmers and land users, in most cases realize the problem of soil erosion and the direct effect on productivity, and in some cases, the indirect effects on the environment. However, they don't have the financial means to invest in soil and water conservation, especially because these interventions are usually not a direct income generating activities. The benefits of implementing SWC are more obvious on the long run and/or for sustaining the environment. The farmers can't wait for these benefits and

therefore they need financial support to cover the investment costs of SWC program. Furthermore, an income generating activities should accompany the SWC program to produce some benefit in the short run, which enable the farmers to survive and invest in SWC program.

- Adaptation to climate change and extreme events: Most climate change scenarios expect less rain in the dry areas and more frequent extreme events, such as erosive rainstorms with high intensity. In some cases, one erosive rain event might cause very high erosion if the field is not properly protected at the right time when these storms are expected. Therefore, understanding the temporal and spatial distribution of these events to formulate effective adaptation strategies is necessary to avoid further land degradation in already degraded and fragile agro-ecosystems.
- Impact of implemented technologies: any conservation plan associated with implementing new SWC intervention should be accompanied by an informative monitoring system. This is to assess the impact of the implemented interventions on the livelihood, in reducing land degradation to tolerable levels and on the environment. The challenge is to design and implement an affordable and yet effective monitoring plan to deal with countless number of biophysical and socio-economic variables under which these interventions operate.

Summary of opportunities

- Identifying hot spot areas for soil erosion and identify severity of water and wind erosion: GIS and remote sensing technologies provide solutions to aid the mapping of land degradation phenomena in general and soil erosion in particular. ICARDA is developing methodologies that incorporate field surveys, GIS, remote sensing and modeling to achieve this.
- Providing enabling environment (finance) and diversification options: ICARDA is testing the applicability of micro-finance system to provide enabling environment to encourage and facilitate the implementation of SWC interventions by farmers and their families. Furthermore, ICARDA is promoting the incorporation of diversification options as income generating activities, which support the implementation of SWC and empower the women in the land degradation mitigation and adaptation process.
- Adaptation to climate change and extreme events: ICARDA is analyzing the distribution and frequency of erosive storms to understand the trend of change. Target fields are identified and suitable SWC interventions are implemented to adapt to this change.
- Impact of implemented technologies: ICARDA is developing monitoring systems at field and watershed levels to assess the impact of the implemented SWC interventions. These use measurements and modeling at the two levels, coupled with the best available technologies.

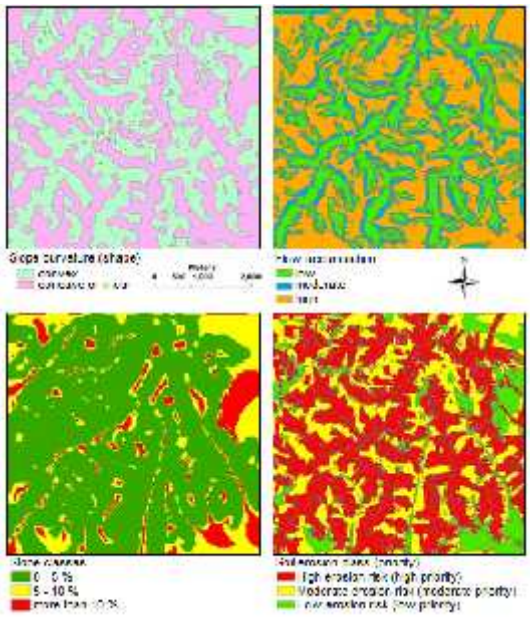
More details are provided in the text below as well as the full paper submitted for the same meeting.

Assessment of the extent and distribution of soil erosion

An example of using survey data and GIS is to identify extent and distribution of erosion is from the northern mountains of Syria. Land degradation in that area is increasing and land managers are looking for new methods to manage and monitor land erosion, which can assist for targeted and cost-effective conservation interventions. A map of erodible land has been created using topographic parameters for the whole catchment. With an active participation of the involved communities, areas for erosion were identified and targeted with optimum SWC measures to improve productivity and enhance environmental sustainability (Ziadat et al., 2013). Land ownership map was overlaid with produced erosion map to show the erosion status of the field and conservation practices, which can define priorities for SWC implementation.

GIS layers of flow accumulation, slope degree and surface curvatures were derived to produce priority erosion map. Flow accumulation and slope have been classified into three categories (1 = high, 2 = medium and 3= low), and land curvature in to two categories (1= high and 2= low). The classification was refined in the field using erosion evidences and the judgment of local farmers to create final priority map. The use of GIS facilitates many iterations to arrive at reasonable results, which was finally appraised by the community.

The map was verified using field observations and with community participation. The map was used to prioritize the implementation of SWC interventions in fields with high erosion risk.



Implementation of soil and water conservation interventions

After identifying the areas with high risk of soil erosion and with the participation of the communities, areas with high implementation priority and the promising interventions are identified. This is usually associated with field days and meetings with farmers and communities to raise awareness about the importance of managing water and land resources and to train them to facilitate the implementation.

Examples of some promising soil and water conservation interventions are listed below:

Continuous contour stone bunds

Semi-circular stone bunds

Intercropping with cover crops

Reduced tillage

Graded contour stone

Trenches and check dams

Technical and socio-economic considerations

In some cases, farmers and communities are aware of productivity reduction as a result of erosion. In other cases, raising awareness is necessary to inform the farmers about productivity losses as well as environmental issues. Technically, there are various options, which suits, or can be tailored to fit, various biophysical conditions. However, challenges to implement sustainable land management and soil conservation interventions are still numerous. Among these is the enabling environment, represented by favorable economic situation of the farmers and their families. Two approaches are followed here to cope with these considerations. The first is to introduce various diversification options in addition to the technical solutions explained previously and the second is providing financial means to facilitate the implementation of erosion fighting alternatives.

It is crucial to facilitate enabling environments that provide the farmers with enough financial resources to implement these interventions. This was achieved by organizing the community to elect a committee called the Land Management and Diversification Committee. The farmers and their families apply to get a loan for the Committee and clarify the measures and activities to be performed. The farmer and his family should repay the loan within two years. The committee shall examine new applications and the granting of loans for other farmers and their families in the village and this means that all the inhabitants of the village will benefit from these small interest-free loans. This experience was tested in some communities and many successful examples of implementing soil and water conservation interventions together with some diversification options were noted.

Assessment of the impact of soil and water conservation interventions

A number of low-cost soil and water conservation interventions are implemented by farmers but the effectiveness of them on soil loss has not been evaluated properly. It is important that when new practices are brought into use, there impact on reducing the extent, rates and frequency of water erosion is monitored. The challenge is to adopt an easy and accurate method that enables assessment, within reasonable cost and time, and in the same time, answers the questions raised by farmers and planners.

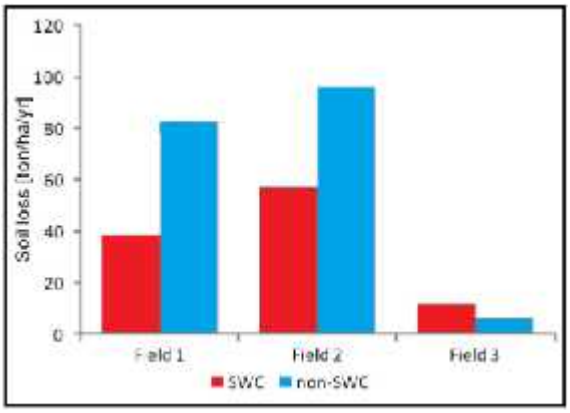
At field level, the impact is assessed by comparing rill erosion from fields with and without SWC structures. Part of the first field has semi-circular stone bunds and part of the second field has continuous stone walls, and each field has comparative part without SWC structures. The assumption made here is that the difference in rill formation between the two parts of the field is mainly due to the presence/absence of SWC structures. A number of measurements of both depth and width were taken for each rill to get an average of the cross-sectional area. These measurements of average cross-sectional area and length were used to calculate the volume and weight of soil displaced from the rill during a known period of time (between tillage and measurement time).

Comparing the results of rill erosion assessment in two adjacent and relatively similar fields, one with SWC interventions and the other without, indicated high impact on reducing rill erosion (table 1). The semi-circle bunds reduced the total rill erosion from 138.9 to 82.9 ton/ha and reduced the number of rills from 25 to 13 (Sakai, 2010).

Table 1: soil losses from fields with soil and water conservation interventions and from fields without any interventions.

Parameter	Field 3a Semi-circle bunds	Field 3b No interventions	Field 5a Continuous stone bunds	Field 5b No interventions
Field area (m^2)	1400	1400	3000	3000
Average slope (%)	37.1	38.7	29.9	26.8
Number of rills	13	25	0	26
Total volume of rill (m^3)	10.0	17.5	0	3.56
Soil bulk density (Mg m^{-3})	1.16	1.11	1.12	1.15
Soil loss (ton/ha)	82.9	138.8	0	13.6

To study the effect of soil and water conservation interventions in soil erosion, the amount of hill slope erosion for fields with and without soil conservation structures was assessed. Two-meter Gerlach troughs are used for the measurement of surface runoff and sediment concentration. The results showed clear benefits of soil and water conservation interventions in reducing soil and water losses at the farm level. The investment in implementing these interventions is justified by experimental results as well as by the farmers' observation of improvement in the yield and reduction of soil and water losses (Zanden, 2011).



At watershed level, measurement and modeling are used to determine surface runoff and sediment yield resulting from the watershed. The concept of paired-watersheds is used where two, relatively identical, sub-watersheds are used. The community installed SWC in one sub-watershed and the other was without any interventions. The two sub-watersheds were equipped with weirs and sensors for water level and turbidity measurement to determine their surface runoff and soil erosion. The soil conservation measures led to a 44% reduction of sediment yield compared to the untreated watershed (Sommer, et al., 2013).

Parameter	Main outlet	Treated watershed	Untreated watershed
Rainfall (mm)	856	856	856
Surface runoff (mm)	178.3	21.1	23.0
Sediment yield (t ha^{-1})	2.9–27.6	3.7	6.5

Concluding remarks

Assessment of the extent and spatial distribution of erosion prone areas help in implementing sustainable soil conservation interventions

Raising farmers' awareness, providing enabling environment and promoting family-based diversification options are important feature to enhance the uptake of SWC interventions and reduce land degradation

Modeling and measurements at watershed and field levels can be used to assess the on-site and off-site impact of soil conservation interventions on productivity, soil fertility and environmental pollution

An integrated and participatory approach to identify priority areas, facilitate implementation by communities and assess the impact on productivity and environment is being developed to mitigate land degradation in the dry areas.

References

Morgan, R.P.C. (2005), Soil Erosion and Conservation, Troisième Edition, Blackwell Publishing Ltd.

Sakai, H. 2010. Farmers' participation in soil and water conservation practices and its effect on soil erosion in sloping olive groves in northwest Syria. Arid Land Research Center, Tottori University, Japan. MSc Thesis.

Sanders, D. (2004), Soil Conservation, in Land Use, Land Cover and Soil Sciences, [Ed. Willy H. Verheye], in Encyclopedia of Life Support Systems (EOLSS), Developed under the Auspices of the UNESCO, Eolss Publishers, Oxford ,UK, http://www.eolss.net.

Sommer et al., 2013. Unlocking the potential of rainfed agriculture in Ethiopia for improved rural livelihoods (UNPRA Ethiopia). Final report. Under preparation.

UNEP (2000). Global Environmental Outlook 2000, Chapter Two: The state of the environment, West Asia, Land and Food. Retrieved from: http://www.unep.org/geo2000/english/0107.htm.

Van der Zanden, E. 2011. Soil erosion control on sloping olive fields in northwest Syria. Utrecht University, the Netherlands. MSc thesis.

Ziadat et al., 2013. Improving community livelihoods by implementing water harvesting and soil conservation techniques in the mountains of Syria. International Center for Agricultural Research in the Dry Areas (ICARDA). Under preparation.