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Research article

# Participatory assessment of soil erosion severity and performance of mitigation measures using stakeholder workshops in Koga catchment, Ethiopia

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ABSTRACT

Farmers possess a wealth of knowledge regarding soil erosion and soil and water conservation (SWC), and there is a great demand to access it. However, there has been little effort to systematically document farmers' experiences and perceptions of SWC measures. Sustainable Land Management (SLM) has largely evolved through local traditional practices rather than adoption based on scientific evidence. This research aimed to assess soil erosion and performance of different SWC measures from the farmers' perspective by documenting their perceptions and experiences in Koga catchment, Ethiopia. To this aim, workshops were organised in three sub-catchments differing in slopes and SWC measures. Workshops included group discussions and field monitoring of erosion indicators and systematically describing the status of soil erosion, soil fertility and yield to assess the performance of SWC measures. Results show that farmers are aware of the harmful effects of ongoing soil erosion and of the impacts of mitigation measures on their farms. Sheet erosion was found to be the most widespread form of erosion while rill damage was critical on plots cultivated to cereals on steep slopes. The average rill erosion rates were 24.2 and 47.3 t/ha/y in treated and untreated farmlands, respectively. SWC reduced rill erosion on average by more than 48%. However, the impacts of SWC measures varied significantly between sub-watersheds, and farmers believed that SWC measures did not prevent erosion completely. Comparatively, graded stone-faced soil bunds revealed maximum desired impacts and were most appreciated by farmers, whereas level bunds caused water logging. Most traditional ditches were highly graded and begun incising and affected production of cereals. Despite the semi-quantitative nature of the methodology, using farmers' perceptions and experiences to document land degradation and the impacts of SWC measures is crucial as they are the daily users of the land and therefore directly affecting the success or failure of SWC measures.



## 1. Introduction

Soil erosion is the most pressing environmental problem in the Ethiopian highlands where the topography is rugged, steep lands are cultivated and the erosivity of rainfall is high (Hurni, 1993; Herweg and Ludi, 1999; Holden and Shiferaw, 2004; Ludi, 2004). Both sheet and rill erosion exist. Sheet erosion is the spatially uniform removal of soil by the action of surface runoff and it is the initial stage of erosion by rainfall and running water (Danano, 2002; Nyssen et al., 2007; Zegeye et al., 2010). Rill erosion is the formation of shallow channels that can be smoothened out by normal cultivation (Vancampenhout et al., 2006; Yitaferu, 2007; Tadele et al., 2014). Rill erosion occurs when the runoff flow increases in depth and starts to concentrate. Both forms of soil erosion have been traditionally associated with poor agricultural practices as well as with long dry periods followed by intensive rain falling on steep slopes with vulnerable soil and low vegetation cover (Amsalu and De Graaff, 2006; Odendo et al., 2010). To reverse land degradation, the government of Ethiopia launched a massive

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soil and water conservation (SWC) program for the last three decades (Ludi, 2004). Although it is widely claimed that SWC strategies can contribute to reverting soil erosion, the performance of past SWC programs in most cases was below expectation (Ludi, 1997, 2004; Brevik, 2010).

To protect the land from soil erosion and make mitigation measures more effective, it is essential to know the areas susceptible to soil erosion, assess hazard severity and the impacts of SWC technologies. However, the assessment of soil erosion and SWC measures in field experiments is costly, must cover a wide range of biophysical parameters, is not standardised and is season-dependent (Bie, 2004; Novara et al., 2011). Models and empirical formulae have been used as tools to evaluate soil erosion and impacts of SWC measures (Vente and Poesen, 2005; Brunner et al., 2008; Fleskens et al., 2014). The applicability of models in Ethiopian conditions is limited due to lack of primary data (Yitaferu, 2007; Steenhuis et al., 2008). Tapping into farmers' knowledge could overcome some of the limitations of field experiments and modelling. Thus researchers and experts have to rely on local knowledge for quick and reliable assessment methods under local conditions (Herweg and Ludi, 1999; Carvalho et al., 2002; Stringer and Reed, 2007; Masto et al., 2015).

In the past decades, the focus has been on assessing implementation of conservation measures, while little attention has been paid to systematically documenting stakeholders' perceptions of, and experiences with SWC practices. In fact, a wealth of SWC knowledge and information exists, and there is a great demand to access it (Shiferaw and Holden, 2001; Yitaferu, 2007; Zhou et al., 2008). Sustainable land management (SLM) exists throughout the world and has in many cases largely evolved through local traditional practices rather than being adopted on basis of scientific evidence (Shiferaw and Holden, 2001; Stringer and Reed, 2007; Schwilch et al., 2012). Active inclusion of local stakeholders and valuing of local knowledge in SWC is absolutely essential to increase the uptake of conservation measures and promote understanding of their functioning (Baartman et al., 2007; Steenhuis et al., 2008). Moreover, stakeholder involvement in investigation of erosion and conservation allows for semi-quantitative statements about soil erosion patterns and impacts of SWC technologies (Daba, 2003; Schwilch et al., 2012; Fleskens et al., 2014).

The degree of public awareness of soil erosion and conservation, which is directly related to knowledge and experience of farmers, is of critical importance in order to integrate local experiences with scientific evidences and to reverse the trend of increasing environmental damage and degradation (Belay, 1992; Ólafsdóttir and Juluisson, 2000; Yitaferu, 2007; Tefera and Sterk, 2010; Pío-León et al., 2017; Stringer et al., 2017). However, available guidelines exhibit a lack of integration of the local knowledge of land users with the technical descriptions of potential solutions for better transfer, adaptation and improvement of SWC technologies (Herweg and Ludi, 1999; Bewket and Sterk, 2002; Moges and Holden, 2007; Tefera and Sterk, 2010). There is a need for understanding of farmers' decision–making in order to evaluate the impacts of SWC measures at the local level (Jabbar et al., 2000; Daba, 2003; Yitaferu, 2007; Jemberu et al., 2014; Tadele et al., 2014; Nyssen et al., 2015; Yazdanpanah et al., 2016; Capler et al., 2017). Farmers generate know-how related to the impacts of SWC measures on runoff, soil erosion, soil fertility, yield and biomass production on a daily basis. However, most of this valuable knowledge remains a local individual resource, unavailable to others working in similar areas and seeking to accomplish similar tasks (Stringer and Reed, 2007; Schwilch et al., 2012). This may be one of the reasons why land degradation persists despite many years of effort and high investment in SWC measures in Ethiopia (Herweg and Ludi, 1999; Bewket and Sterk, 2002; Ludi, 2004).

To increase the effectiveness of SWC practices and their adoption rate, promising conservation measures have to be identified by involving farmers in erosion assessment and implementation and evaluation of the impacts of SWC practices (Hurni et al., 2005; Moges and Holden, 2007; Wei et al., 2009; Schwilch et al., 2012; Nabahungu and Visser, 2013; Nyssen et al., 2015; Sileman et al., 2015). Participatory workshops empower communities by recognising the value of their knowledge and strengthening their capacity to produce knowledge that is useful to others such as governments (Stringer and Reed, 2007). Knowledge-based participatory research thus combines modern approaches with indigenous traditional knowledge and instils cultural identity (and hence social cohesion) through the process of participation (Stringer and Reed, 2007; Schwilch et al., 2012). This approach seeks to maximise the use of local and traditional knowledge and strengthen local knowledge systems, while also enabling communities to conduct conventional research to generate qualitative and quantitative knowledge that is scientifically credible (Yitaferu, 2007; Tefera and Sterk, 2010; Zegeye et al., 2010).

SWC measures can have an entirely different impact and consequently a different degree of adoption if they are transferred to other biophysical and/or socio-economic conditions (Ritsema et al., 1996; Herweg and Ludi, 1999; Baartman et al., 2007; Schwilch et al., 2012). Therefore, farmers' statements and observations can place the results from on-farm measurements and experiments in a wider context. In line with this, this study focused on farmers' perception and knowledge of soil erosion and SWC measures. The main objective of this study was to assess soil erosion and overall performances of different erosion mitigation measures by systematically documenting the perceptions and experiences of local farmers. Specific objectives were (i) to identify soil erosion types, severity and the causes of erosion as perceived by the local farmers, using participatory field assessment and group discussions, (ii) to evaluate the stability of SWC practices and their impacts on soil erosion, soil fertility and yield, and (iii) to identify promising conservation measures for SLM using local community knowledge. This study was carried out in three catchments with different topography, cultivation and SWC practices, so that possible differences between these catchments could be revealed.

## 2. Material and methods

### 2.1. Study area

This study is performed in three sub-catchments of Koga catchment, North-western Ethiopia (37° 02′ - 37° 17′ E longitude, 11° 10′ - 11° 25′ N latitude; Fig. 1). Koga catchment has a total area of 230 $km^2$ and is one of the major watersheds at the source of the Blue Nile in Amhara Regional state. Koga catchment represents a typical Ethiopian highland environment where SWC measures have been implemented on a massive scale to reduce the impacts of soil erosion and sedimentation of downstream reservoirs used for irrigation. The Koga River flows north-west with a total length of 69 km. The topography of Koga catchment is rugged with elevation ranging between 1860 and 3120 m. The climate of Koga catchment is characterised by dry (October to April) and wet (May to September) seasons. Mean annual rainfall is about 1400 mm of which more than 90% falls in the wet season. The mean maximum monthly temperature ranges from 30.0 °C in March to 23.1 °C in August (ANRS, 1999; ADSE, 2013). Soils are classified as Leptosols, Luvisols, Nitosols, Vertisols and Fluvisols (ADSE, 2013). The three study sub-catchments, Asanat (~750 ha), Debreyakob (~300 ha) and Rim (~1000 ha), have different slope steepness (Rim being relatively flat and Asanat located in the steeper upstream part of the catchment), cultivation patterns and land uses (Fig. 2, Table 1).