Impact of SWC practices on sediment losses and discharge in the headwaters of the Lake Tana Basin in the Ethiopian highlands

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Introduction

- Land degradation in the form of soil erosion is a serious problem.
- This problem is very severing in the highlands of Ethiopia due to population pressure (Hurni et al., 2005).
- Problems
  - Reduce land productivity
  - Frequent flooding
  - Sedimentation
  - Reducing base flow
  - Reducing lake water quality

Introduction

- Specific study in the highlands of Ethiopia shows
  - increasing trend of surface runoff and sediment yield (Conway, 2000; Elshaw and wheater, 2009; Tessema et al., 2010; Gebremicheal et al., 2012).
  - 58% of Chemoga watershed, parts of Blue Nile basin, suffers from a severe erosion risk, with a soil loss of more than 80 $tonha^{-1}y^{-1}$ Beweket and Teferi (2009) .
  - 18% of the Lake Tana basin is highly vulnerable to erosion. It estimated average sediment yield of 30 $ton\text{-}ha^{-1}$ $year^{-1}$ Setegn et al. (2009)

Introduction

- Considerable efforts have been made
- Most of the implemented soil and water conservation works were not successful (Bewuket and Sterk, 2002; Grunder, 1988; Dejene , 2003)
  - Lack of genuine involvement of the framers on technology selection,
  - Low participation in implementation of soil and water conservation,
  - A top down approach

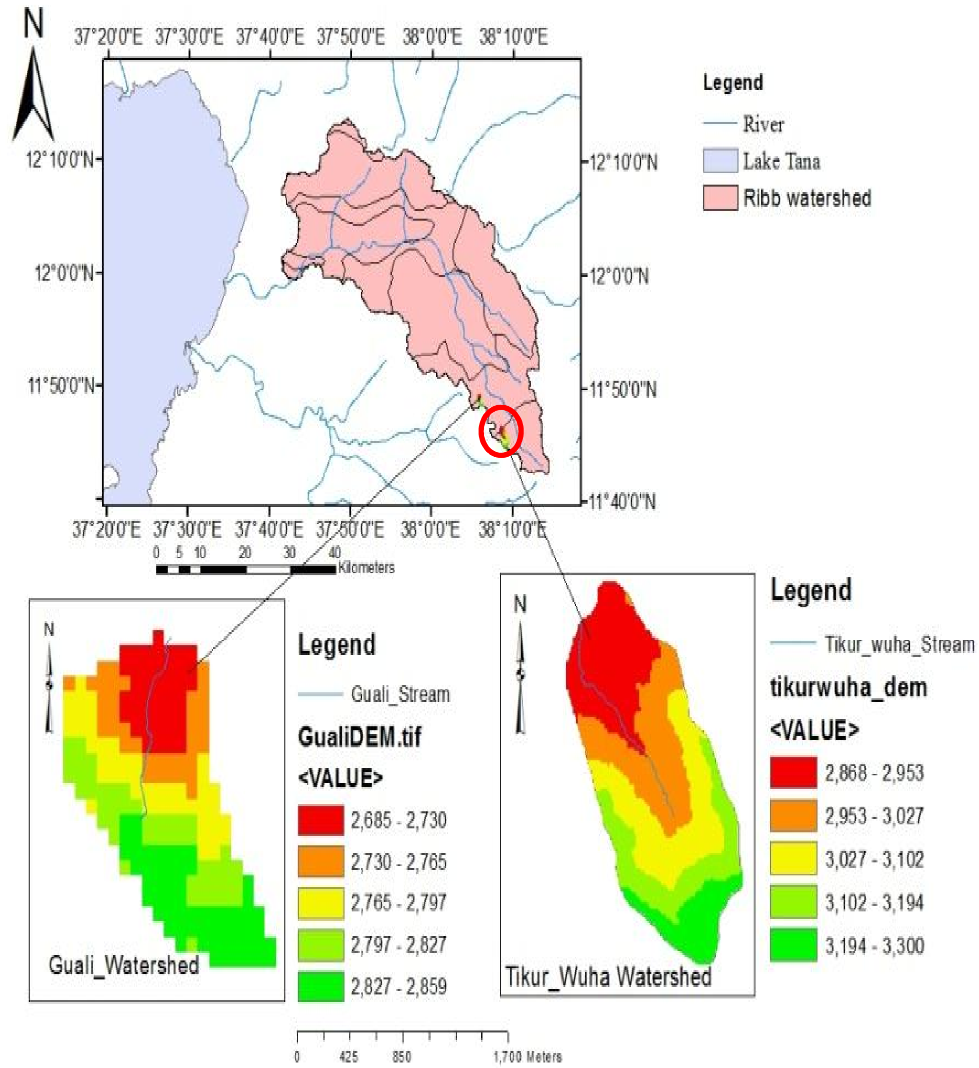
Objective

- Evaluate the impacts of an **integrated community-managed** soil and water conservation works at the micro-watershed level on **sediment load** and **runoff volume** in two agricultural watersheds of the Tana basin.

Description of study area

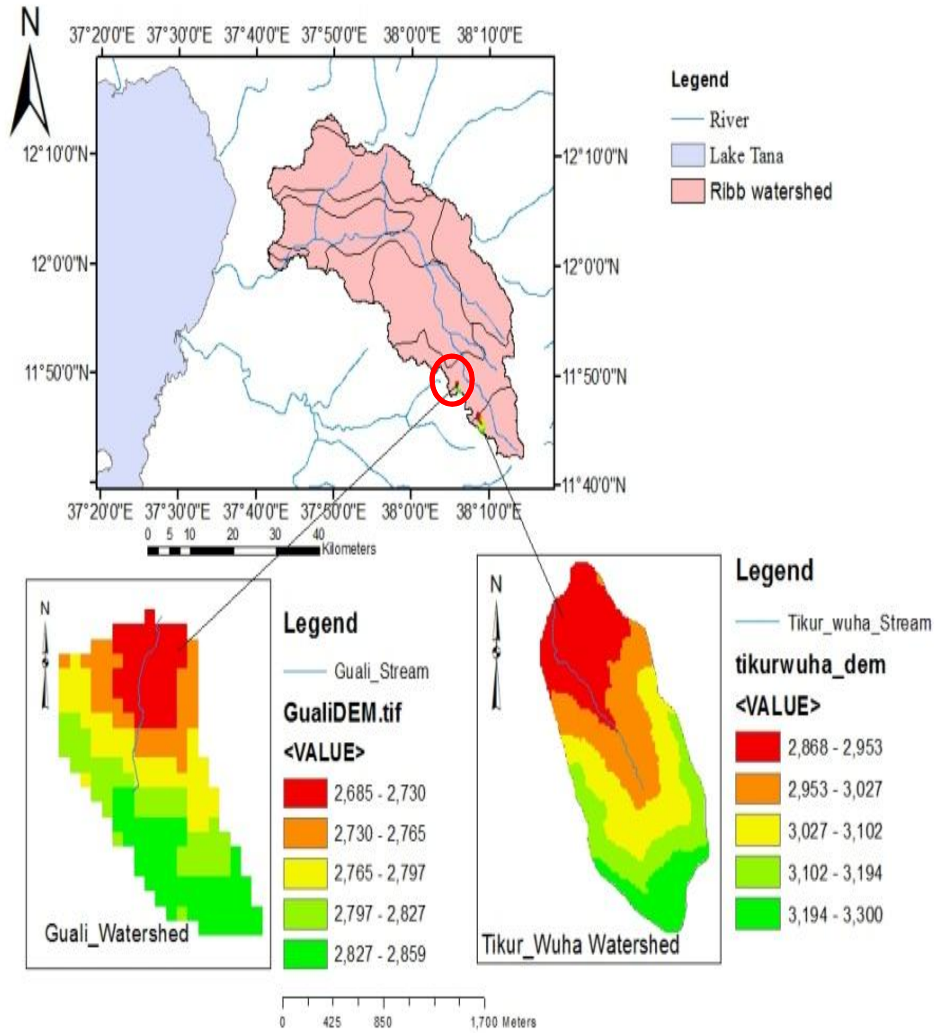
Tikur-Wuha community watershed

- Area = 500 ha
- Slope : 0.6% - 84%,
- Altitude : 2868 -3300 m
- Land use
  - agriculture53%
  - forest, bushes and shrubs 25.3%,
  - bare land 13.2%,
  - grazing land 8.3%,
  - settlement 0.3%
- Soil type – chromic Luvisols
- The depth of the soil
  - (95-55cm) at low and mid slopes
  - (25cm) on the top slope



Description of study area

- Guali community watershed
  - Area : 190 ha
  - Slope : 0.8% - 33%
  - Altitude : 2685 - 2859 m
  - land use
    - Agriculture : 60%
    - Forest lands, bush and shrubs = 20.9%,
    - Grazing land : 11.5%,
    - Bare land : 7.2%
    - Settlement : 0.4%
  - Soil type : chromic Luvisols
  - The depth of the soil
    - (70cm) at the bottom slope
    - (25-15cm) at the mid and top slope



Implemented soil and water conservation works

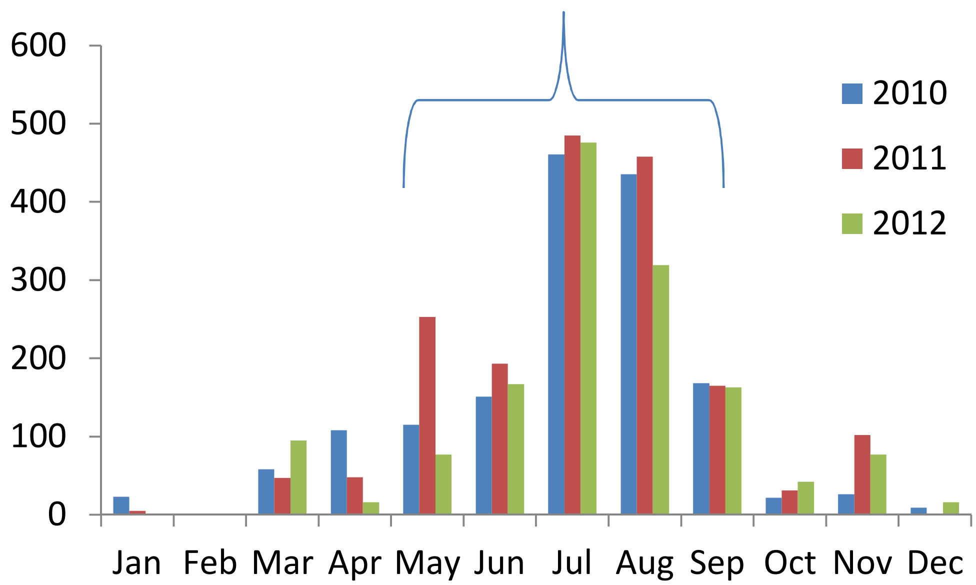
Soil and water conservation type	Unit	Tikur-Wuha watershed			Guali watershed		
		2010	2011	2012	2010	2011	2012
Plantations	Ha		0.3	8.5	0	2.4	0
Gully treatment	m^2	100	2000	100	0	1100	0
Soil and water conservation works on agricultural lands	Ha	16.5	24.5	14.8	0	38.1	3.7
Degraded land treatment	Ha			29			
Total	Ha	16.5	25	52.3	0	40.5	3.7

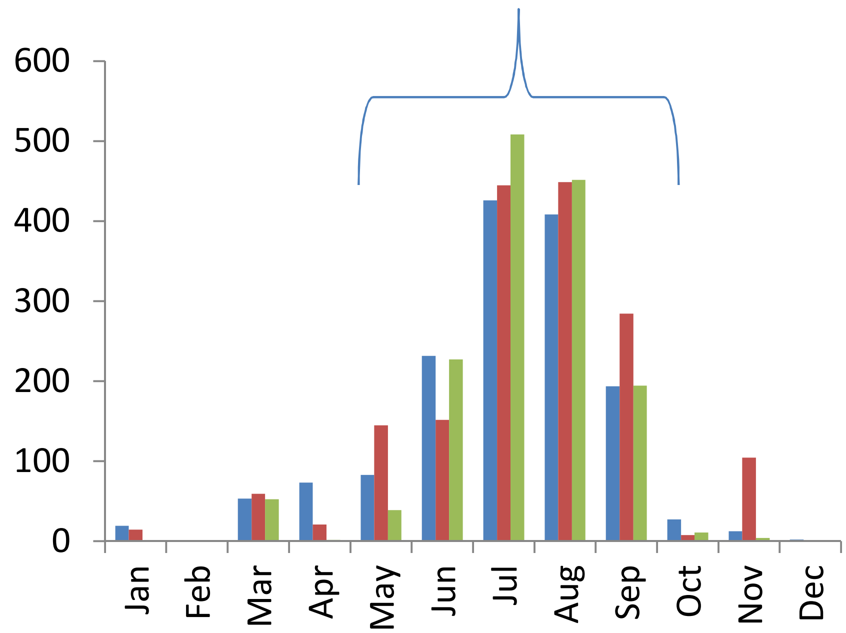
Data

- The following data were collected from Tana-Belese integrated water resources development project (2010-2012)
  - Rainfall
  - Discharge
  - Sediment

Results

- The rainfall pattern of both watersheds is unimodal and concentrated from May-September;

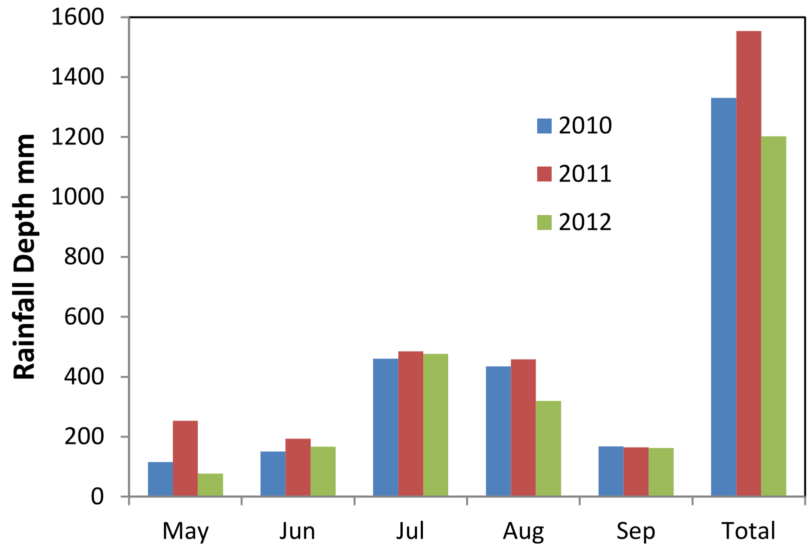




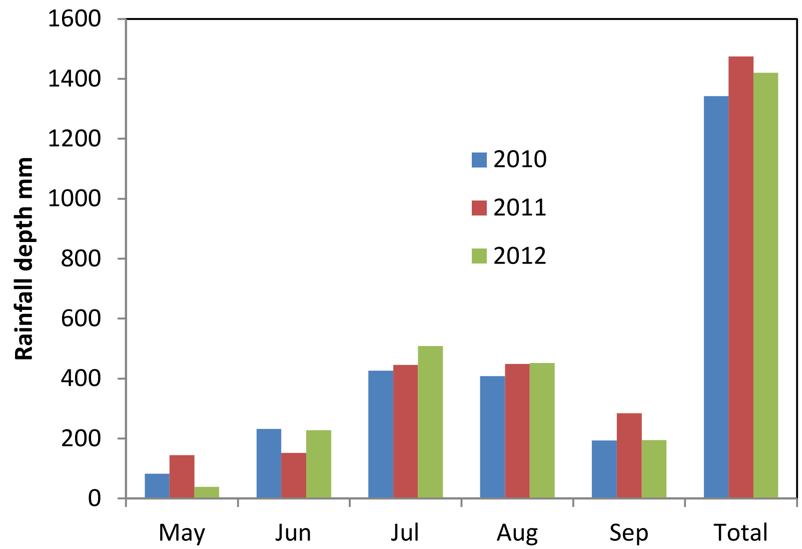
- 2011 the wet period and 2012 the dry period in both watershed
- The difference between the wet and dry period was **339**mm in Tikur-Wuha and **192mm** in Guali watershed.
- The average rainfall of Tikur-wuha (1604mm) greater than Guali watershed (1567mm) by 37mm

Results

- During the wet period period (May-September) the average rainfall of
  - Guali 1412mm
  - Tikur-wuha 1362mm
  - Difference = 50mm
- At a 95% confidence level there is no a significant difference (p=0.6)



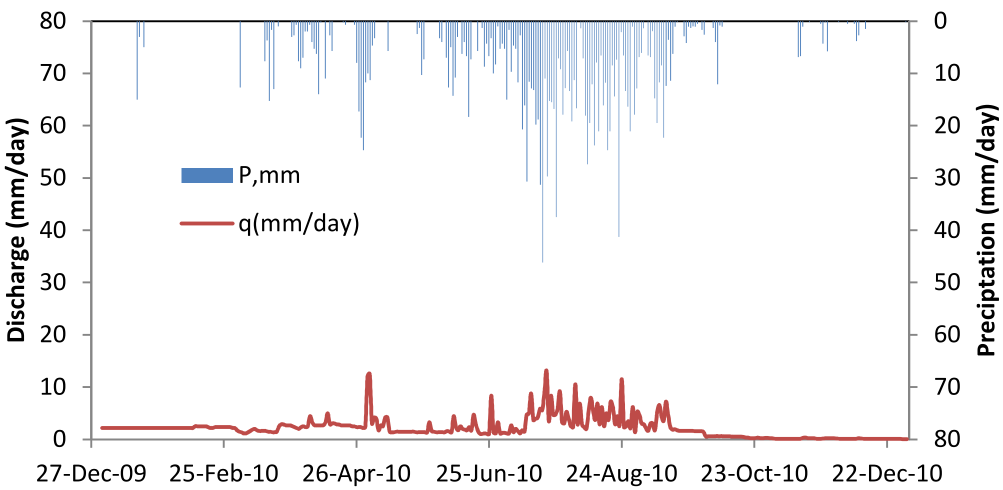
Tikur-wuha watershed

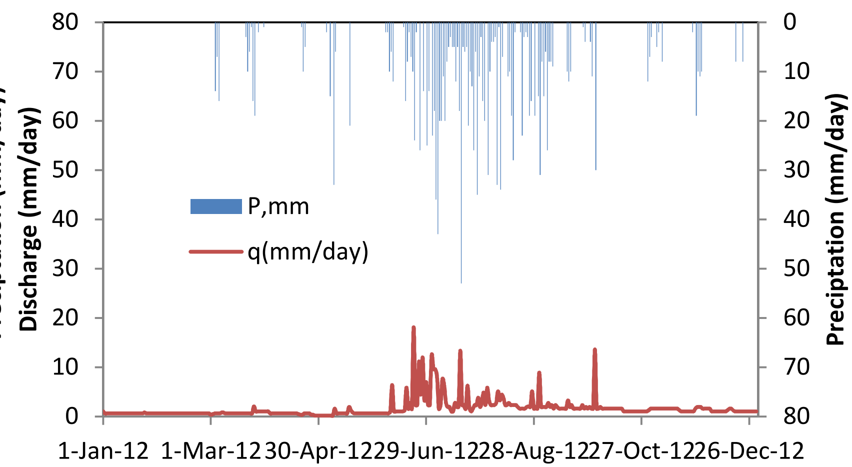


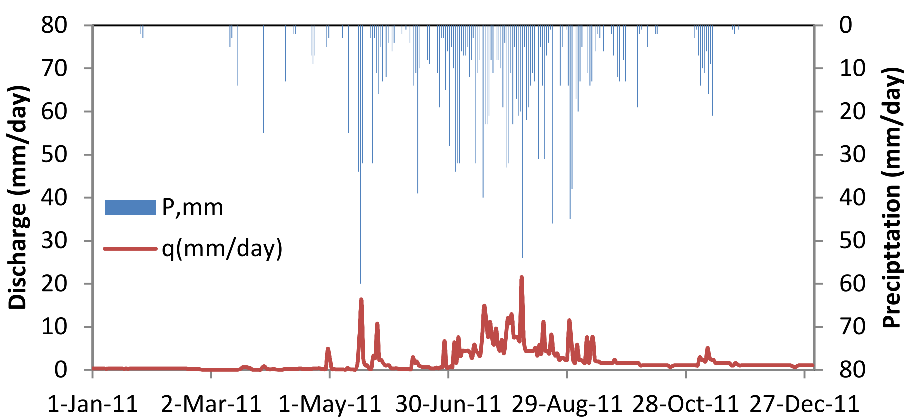
Guali watershed

Results

- **Annual Runoff depth of Tikur-Wuha watershed**



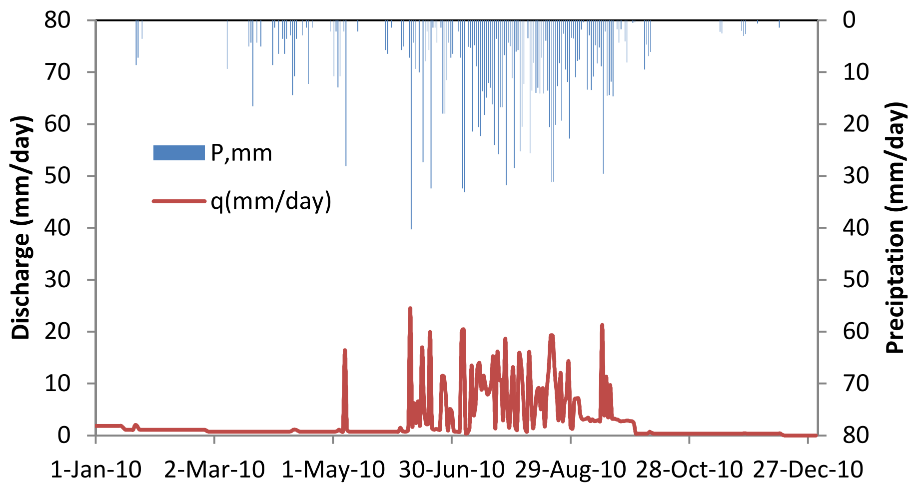


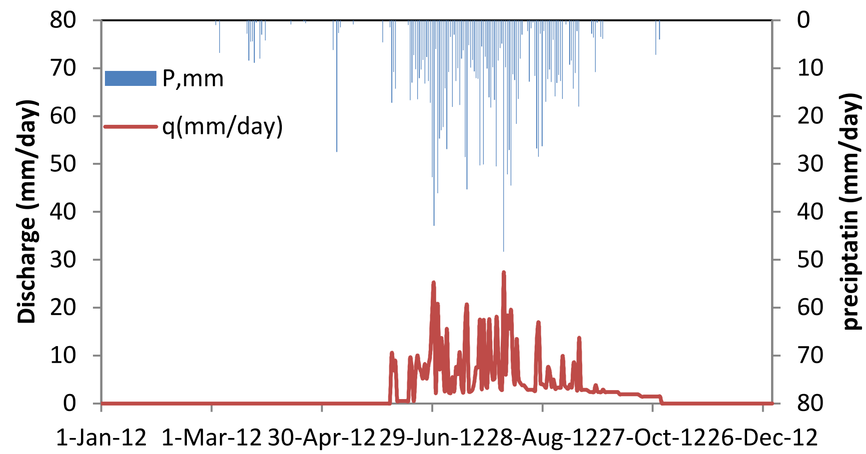


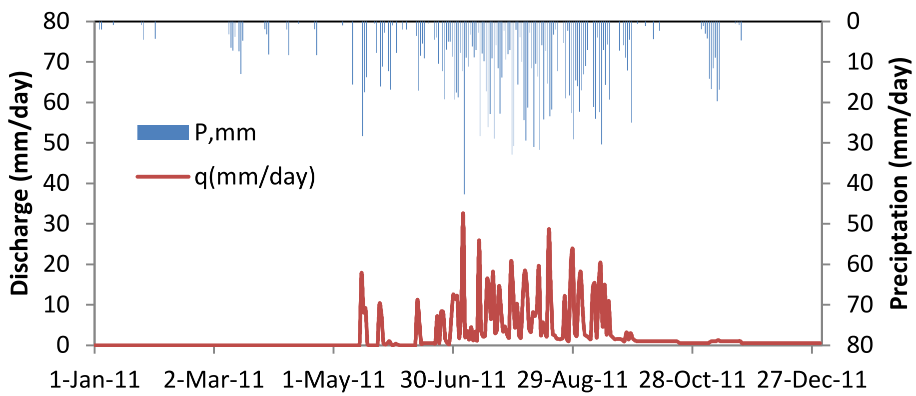
Year	Annual runoff depth mm	% of Change
2010	791	
2011	685	(13%)
2012	592	(14%)

Results

- **Annual runoff depth of Guali watershed**



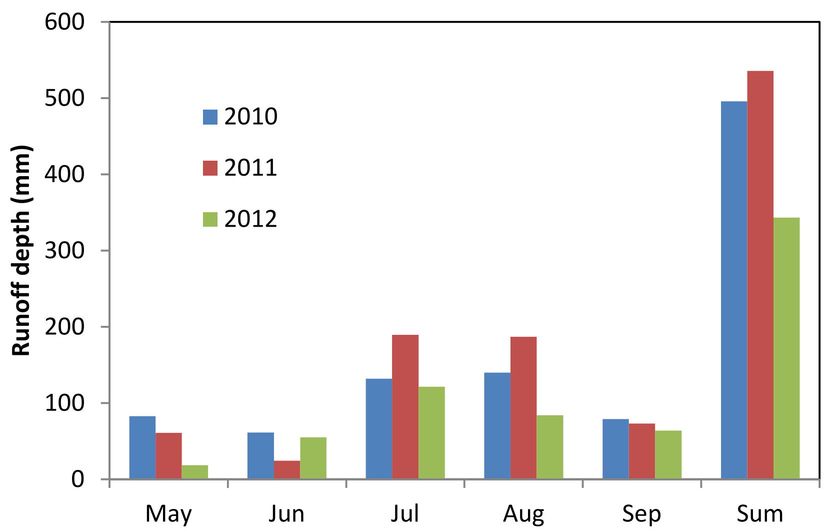




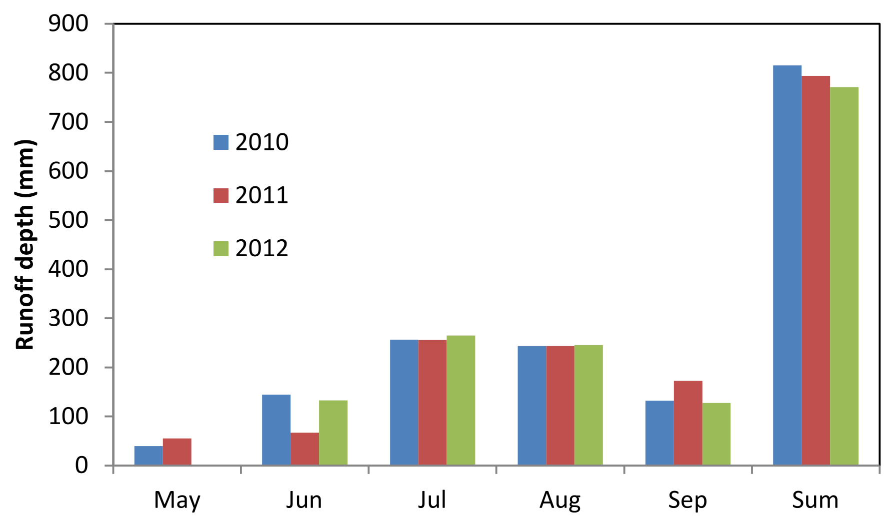
Year	Annual runoff depth mm	% of Change
2010	965	
2011	859	(11%)
2012	830	(3%)

Results

- **Runoff Depth during Wet period (May – September)**
  – In Tikur-wuha watershed it increased by 8% in 2011 but decreased by 36% in 2012 due to increased rainfall by 17% in 2011.
  – In Guali watershed it decreased by 3% in 2011 and 2012 due to small variation on rainfall amount between 2010-2012.



Tikur-wuha watershed

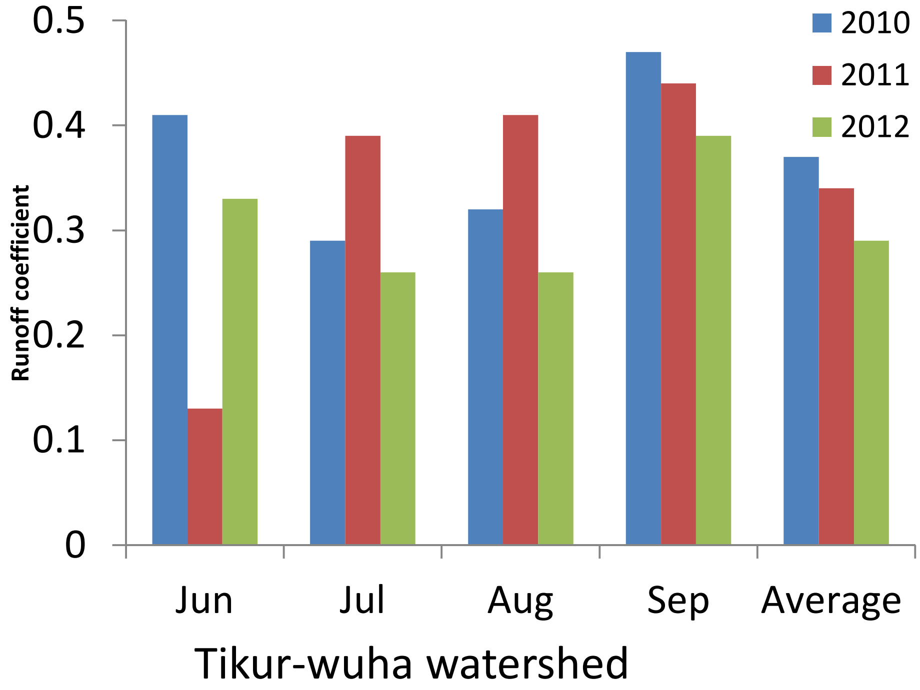


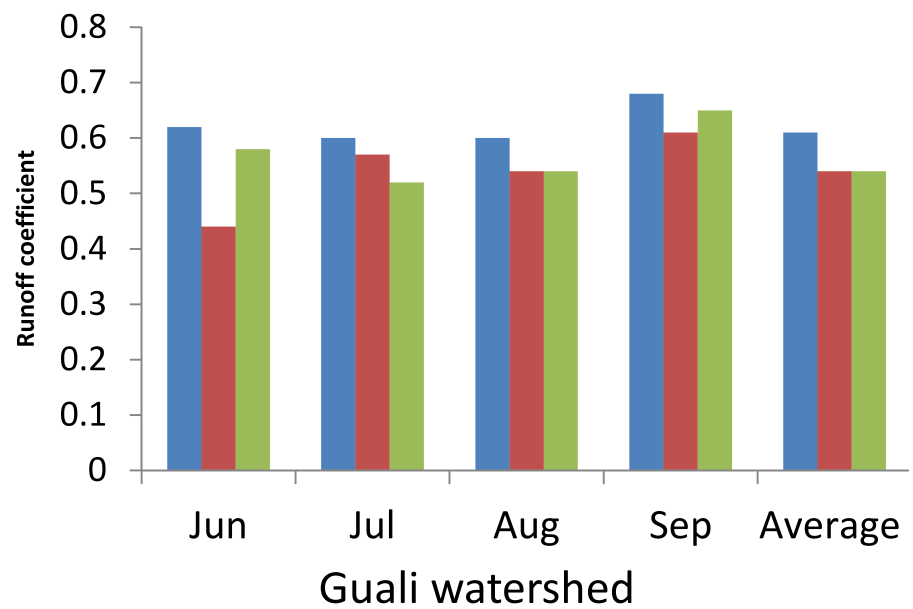
Guali watershed

Results

The runoff coefficient (wet period)

- It decrease by 8% in 2011 and 15% in 2012 in Tikur-wuha watershed.
- It decreased by 11% in 2011 but did not any change in 2012 in Guali watershed due to small change in rainfall amount (4%)
- Temporally Rc is increasing trend from June to September in both watershed





Results

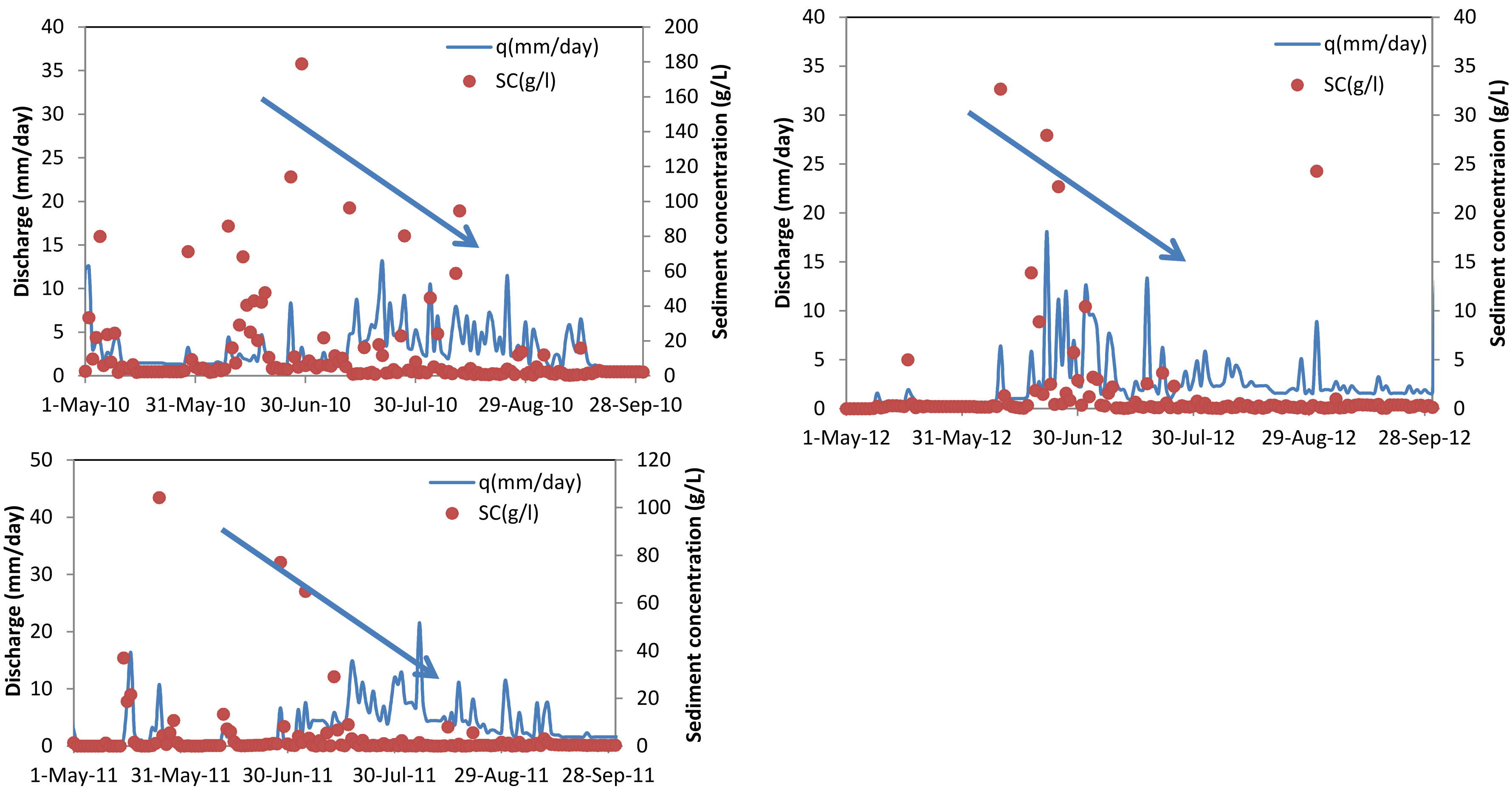
Sediment concentration

- The average sediment concentration of Tikur-wuha watershed decreased by 62% in 2011 and 55% in 2012
- Sediment concentration of Guali watershed did not change in 2011 but it decreased by 33% in 2012

	Tikur-wuha			Guali		
Month	2010	2011	2012	2010	2011	2012
May	11.3	9.5	0.5	1.8	1.0	0.0
June	26.6	5.7	6.4	8.1	1.3	0.6
July	12.0	6.2	1.8	4.4	9.5	7.7
August	9.4	1.1	0.3	3.6	7.4	3.9
September	2.7	0.8	1.7	3.4	1.8	1.6
Mean	**12.4**	**4.7**	**2.1**	**4.2**	**4.2**	**2.8**
Stand dev	24.7	17.2	7	8.4	9.7	7.8
Max	178.9	144.9	50	61.3	58	52.4
Min	0.3	0	0	0.1	0	0

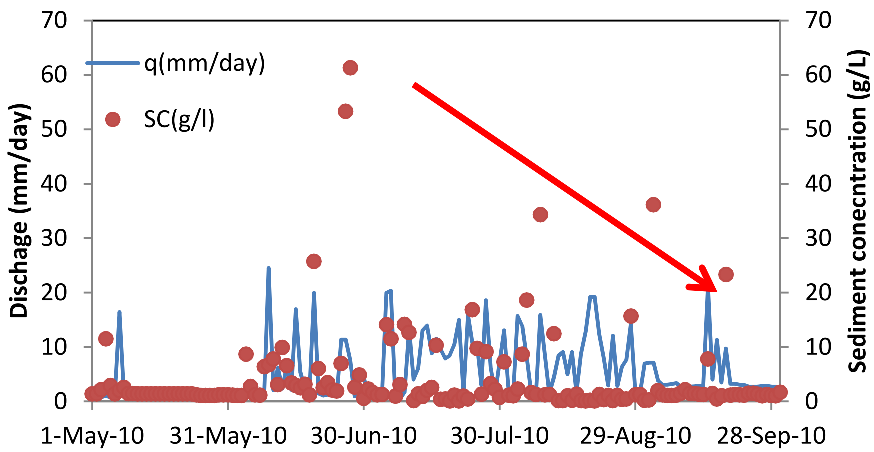
Results

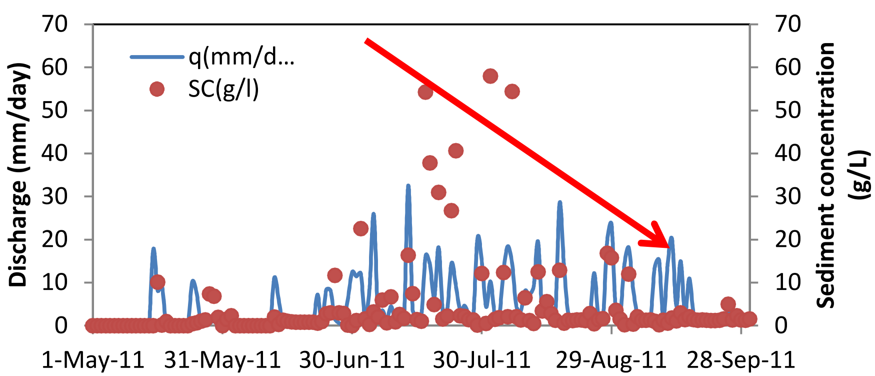
- Temporal variation of sediment concentration of Tikur-wuha watershed

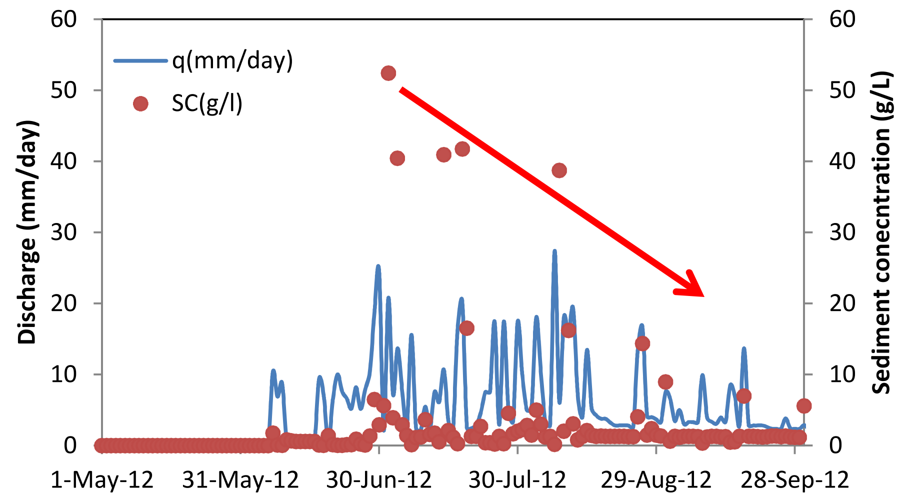


Results

- Temporal variation of sediment concentration of Guali watershed







Results

- **Sediment load**
  - Sediment load reduced by 48% in 2011 and 30% in 2012 in Tikur-wuha watershed
  - Sediment load reduced by 1% in 2011 and 35% in 2012 in Guali watershed.

	Annual sediment load (ton/ha/year)		% Change	
year	Tikur-wuha	Guali	Tikur-wuha	Guali
2010	98	71		
2011	51	70	(48%)	(1%)
2012	36	46	(29%)	(35%)

Discussion

- Factors contributing for reduction :
  - Due to incorporation of different soil and water conservation technology.
    - increasing the infiltration rate of the soil
    - improving the drainage system
    - Change of land cover
  - Decreased rainfall amounts in 2012,

- The results are similar to other findings by Hurni et al. (2005) ; Herweg and Ludi (1999); Nyssen et al.(2009); Nyssen et al.(2004); Dagnew et al.(2015); Kassie et al.(2008); Guzman et al., 2013)

Discussion

The probable reasons for difference in rate of reduction in two watersheds :

i. starting time

- In Tikur-Wuha in 2010
- In Gulai in 2011;

ii. Technology and area of extent difference

- 29 Ha of Degraded land treatment in Tiku-wuha watershed
- SWC works continued in Tikur-wuha while in Guali highly engaged in 2011 only
- Limited works on gully treatment in Guali watershed (2200 m^2, 1100 m^2)

Treated gully in Tikur-wuha

Degraded land treatment

Discussion

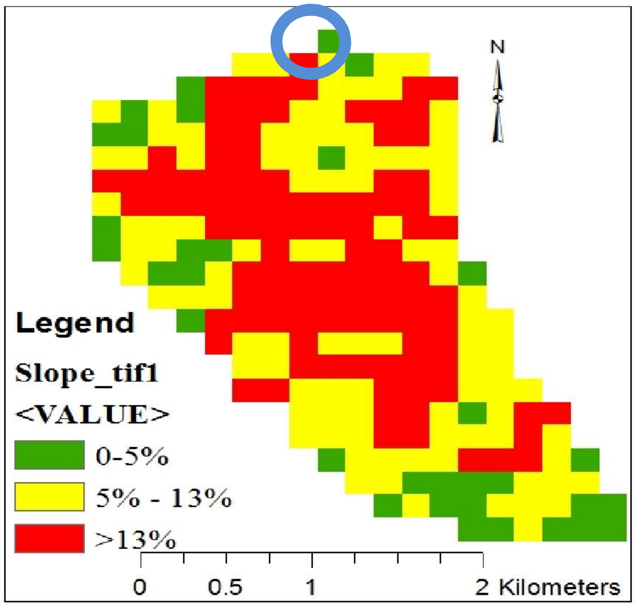
iii. The soil depth

- The hill side/mid slope of the watershed is the recharge area, and the bottom slope is the discharge area(Bayabil et al., 2010)
- In Guali watershed, mid and top slope areas are shallow depth of soil (25-15 cm)
- In Tikur-Wuha watershed, mid (hill side) areas have moderate soil depth (95-55cm)
- The runoff components (direct flow, interflow and groundwater flow) are affected by the soil depth (Montanar et al., 2006)

Discussion

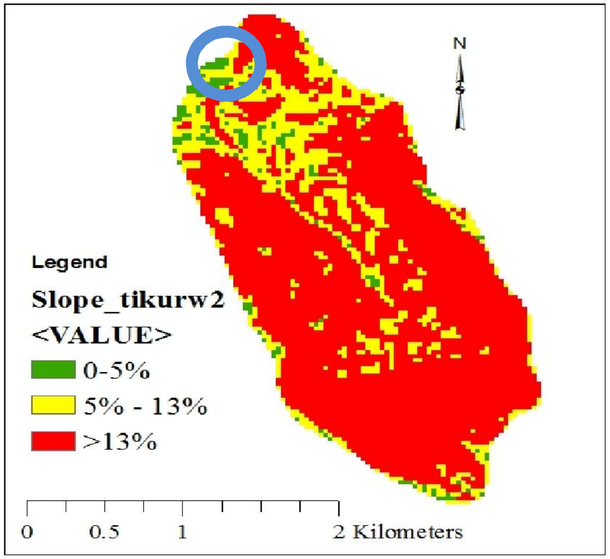
ii. Landscape position contribute for deposition

- Guali watershed is flat at top and has a steep slope nearer to the outlet of the watershed,
- Tikur-Wuha watershed is a steep slope at the top and gentle slope towards the outlet of the watershed.



Guali_Watershed Landscape postion

Stream profile of Guali



Tikur_wuha watershed landscape postion

Stream profile of Tikur-wuha

Conclusion and recommendation

- Incorporating different soil and water conservation structures into integrated watershed management practice can effectively reduce
  - Average sediment concentration (wet period) 83%, 33%
  - Annual sediment load 63% ; 36%
  - Runoff volumes (wet period) 31% ; 5%
  - Runoff coefficient (wet period) 22% ; 11%

Conclusion and recommendation

- Factors for difference in reduction rate between the two watershed
  - variation in soil depth
  - landscape position
  - starting time
  - Technology area of extent and difference
- To sustain the result, the project should continue to strengthen the communities' natural resource management skills.
- Government agencies should extract the lessons and practices, then scale up these community-based interventions to basin scale

Acknowledgments

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THANK YOU