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Carbon sequestration potential under different land use system in ravenous watersheds

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Abstract
To find out reason and exact mechanism of deep Chambal formation, complete profile was excavated and studied to identify the reality. Maps of all five districts (Bhind, Datia, Gwalior, Morena and Shivpur) of Gird region for ravine lands were developed with the help of remote sensing & GIS software and area was estimated. The reason of deep ravine advancement and unsuccessful story of past approaches were identified. To identify suitable crop rotation along with different agro-horti-medicinal and silvi-pastoral systems were studied. The potential of carbon sequestration through various modules was monitored. The potential and suitable crop rotation (Pearl millet- Wheat, Pearl millet- Gram or –wheat) for ravineous land was identified. The use of Silvi- pastoral and crop production system and partially changed topography can help in checking soil & water loss and save the land for restoring eco-friendly agro-ecosystem and soil health.

Keywords: Carbon sequestration potential, land use system, ravenous watersheds

Introduction
Ravine land is the land whose capacity to produce biomass and provide other goods and ecosystem services has declined due to natural or anthropogenic factors. There are several types of degraded lands with impaired soil quality and functionality. Types of degraded lands, depending upon natural and anthropogenic factors, can be physical, chemical, biological, and ecological. Because of the low/net ecosystem/biome productivity, degraded lands have lower soil and the terrestrial carbon (C) pools than their counterparts in undisturbed ecosystems and on un-degraded lands. Thus, the ecosystem goods and services provisioned by degraded land of poor soil quality are low. There may be a strong correlation between the terrestrial/soil C pool and the net primary productivity (NPP).
Ravine lands are the most physically degraded form of once cultivated fertile land presently unsuitable for agricultural production, Formation of ravines has resulted into not only a loss of non-renewable land resource but also destruction of rural economy and creation of socio-economic problems through dacoit-infestation in many areas. Out of estimated 4.386 M ha area under ravines in the country about 0.683 M ha is in MP. These ravines are formed mostly along the river Chambal, Sindh, Betava, Kunwari and other tributaries of main river Yamuna

Material and methods
The carbon content of soil as well as biomass under different modules were estimated with the help of carbon analyser and conventional method. The experiment was started during the year 2011-12.

Crop/Plant Biomass Carbon
Biomass carbon is defined as the total mass of living plant organic matter expressed as oven –dry tons or oven dry tons per unit area. Estimates may be restricted to the above ground portion of the vegetation, or to trees only, or to three components (such as foliage, wood etc.).
The carbon content of vegetation can be estimated by simply taking a fraction of biomass as (Magnussen and Reed, 2004)

$$C = 0.475 \times B$$

Where, C is the carbon content and B is oven dry biomass

Different modules: diversified cropping system (M_1), Agri-Horti module (M_2), Horti-Pastoral module (M_3), Silvi-Medicinal Module (M_4), Silvi-Pastoral Module (M_5)

Result and Discussion

Bio-Mass Carbon in Different Modules

The bio-mass carbons of different modules were estimated for the end of year 2012-13, 2013-14 and 2014-15. The bio-mass carbon was highest in Horti-Pastoral module (M_3) followed by Agri-Horti module (M_2), Silvi-Pastoral Module (M_5), Silvi- Medicinal Module (M_4) and diversified cropping system (M_1) during 2013-14, while Horti-Pastoral module (M_3) followed by diversified cropping system (M_1), Agri-Horti module (M_2), Silvi-Pastoral Module (M_5), and Silvi-Medicinal Module (M_4) in 2012-13. There is highest change in biomass carbon is 89 percent in module M_5 followed by 85 percent in M_3, 84 percent in M_4 and 80 percent in M_2. (Fig.1)

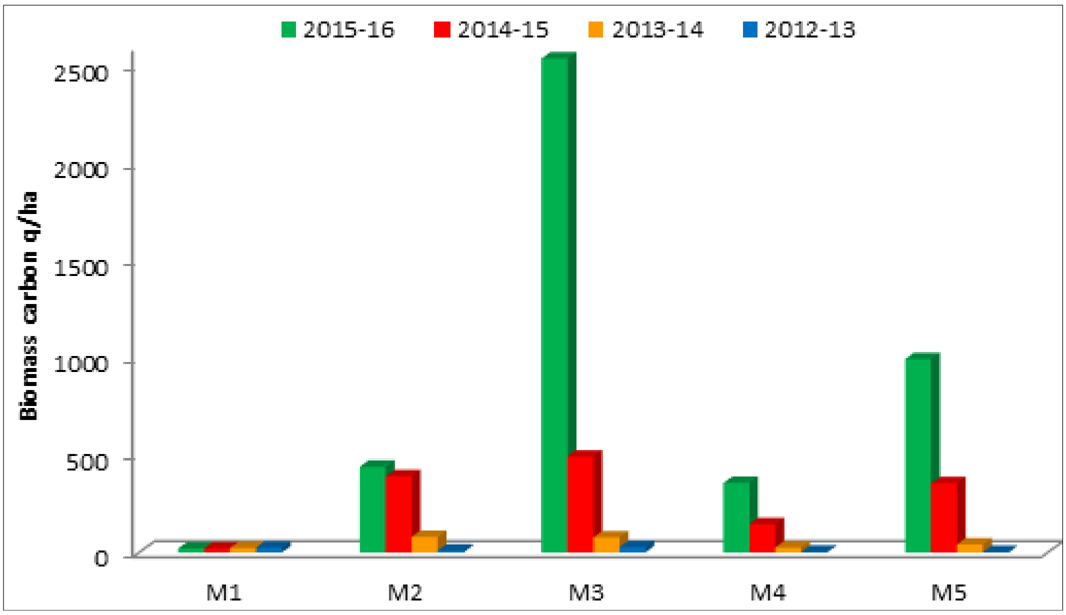

Fig 1: Biomass carbon in different modules of Ravine Management

(b) Biomass Carbon in Different Types of Trees/Plant

The average biomass carbon was highest in Fruit trees followed by silvi, Medicinal, forest, crops, trees and Grasses plants during 2014-15 (Fig.2.)

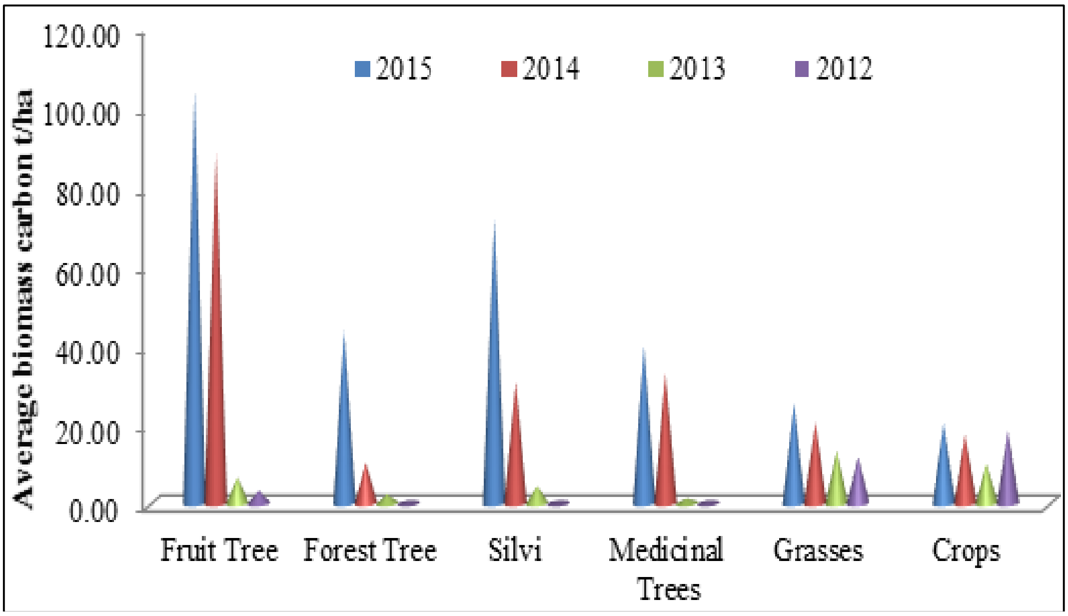

Fig 2: Average Biomass carbon produced by different types of tree, grasses and crops

(c) Biomass Carbon in Different Trees

The results revealed that among the fruit trees drumstick have highest biomass carbon during the experiment period followed by Khamer, Siras, Seashum, Neem Arjuna, Ber, karanj, and anola during 2014-15. while ber, and highest biomass carbon after Drumstick (Fig. 3). The decrease in biomass carbon of Pomegranate, Guava and Custard apple was recorded in 2013-14 due to the frost. All the silvi trees (Khamer, Sagon and Seasham) including forest and medicinal tress performing well during 2014-15 as compared to 2013-14 and 2012-13. In fruit trees the average biomass carbon was very low except Drumstick and Ber during study period.

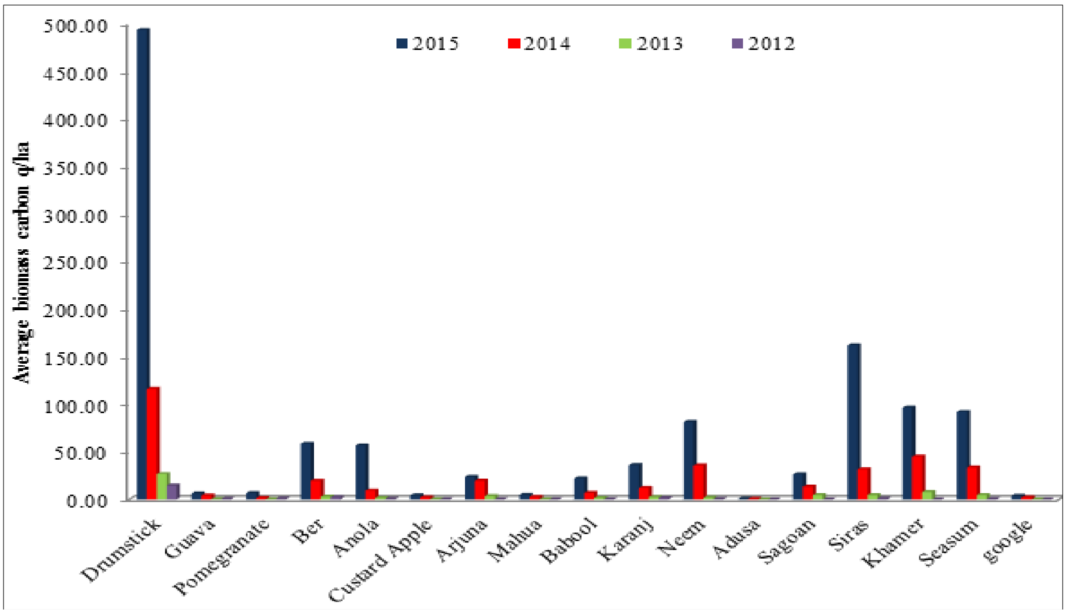

Fig 3: Biomass carbon stored in different types of trees planted in the study Area

(d) Biomass carbon in Grasses

The biomass carbon was highest in paragrass (41.8 kg/ha) followed by plamarosa (29.4 t/ha), lemon grasses (16.8 kg/ha), Napier grasses (12 kg/ha). While desi grass only 0.1 kg/ha biomass carbon (Fig. 4).

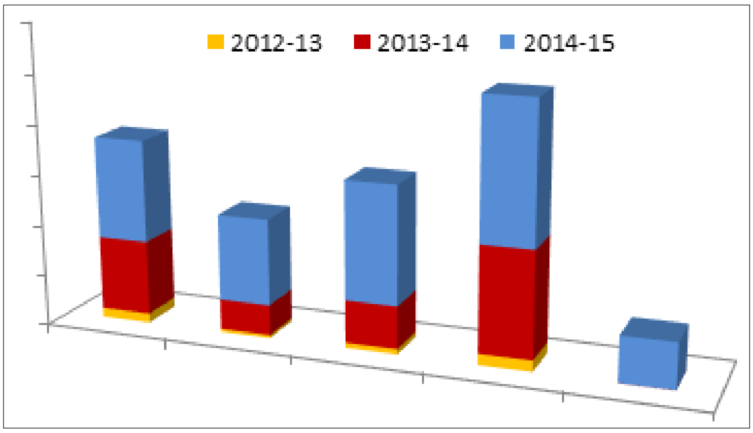

Fig 4: Contribution of different grasses in biomass carbon

(e) Biomass Carbon in Crops

The average biomass carbon was highest in pearl-millet in both years followed by cluster bean and black gram in kharif season while during rabi season the average biomass carbon was highest in wheat crop followed by mustard and gram. Fig. 5 & 6

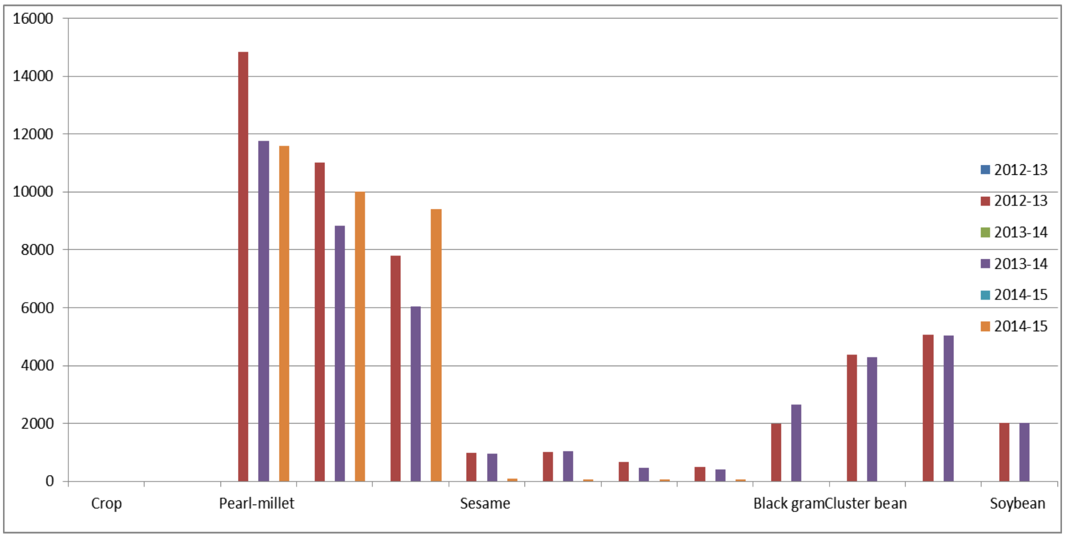

Fig 5: Average Biomass carbon in *kharif* crop

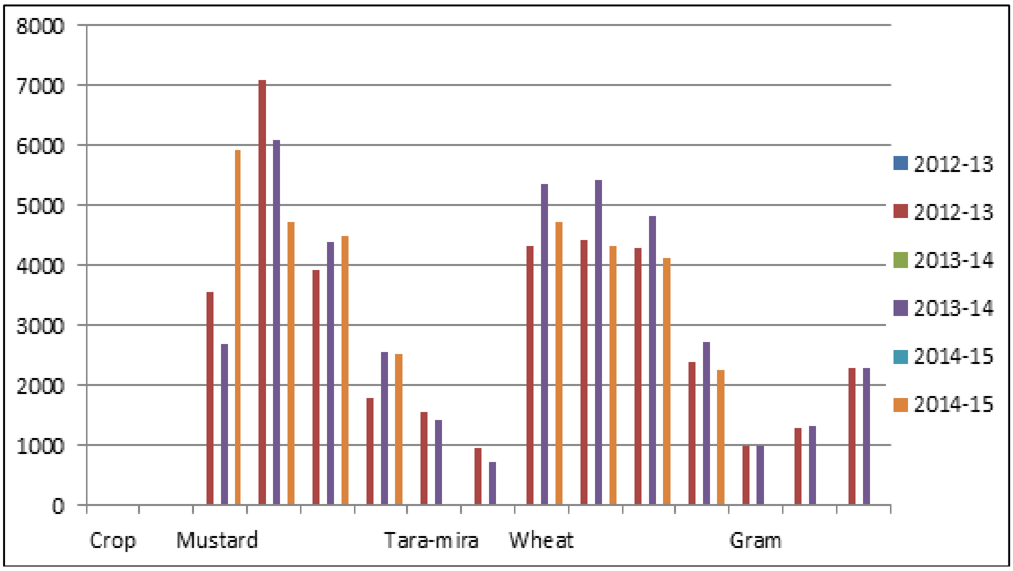

Fig 6: Average Biomass Carbon in *rabi* crop

Total Carbon

Total carbon content in different plant and soil was analyzed by total organic carbon analyzer.

(a) Total Carbon in Different Plants

The total carbon content (%) in different trees is maximum in teak (59.6%), Arjuna (54.3%), sheshum (53.6%) and karanj (47.9%), while lowest in drumstick (30.8%) followed by siras (39.7%) (Fig.7).

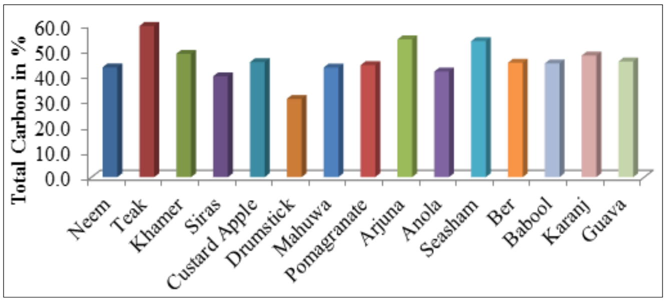

Fig 7: Total carbon in different plant planted in the study area

(b) Total Carbon in Different Crops

Total carbon content in different field crops of kharif season grown in experimental area under diversified cropping system and agri-horti modules is shown in fig. 8 The analysis shows that the pearl millet was maximum carbon content (37.8%) followed by maize (36.8%). The carbon content in moong, seasame, urid, soybean and cluster bean ranged between 34.5% to 32.5%.

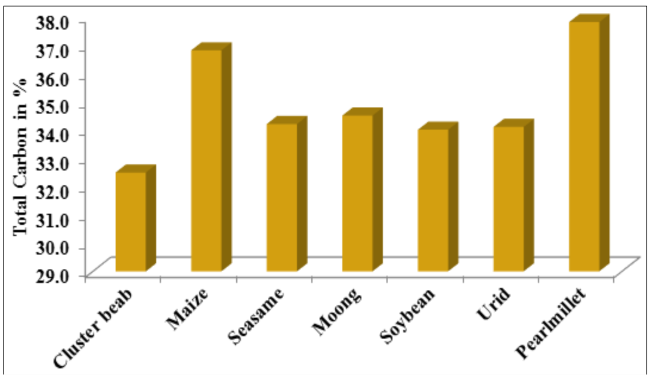

Fig 8: Total carbon in different crops

(c) Total carbon in Grasses

The total carbon was highest in napier grass which is 20.6% followed by pamarosa 16%, para 15%, desi 10% and lemon 8.2% (Fig.9.).

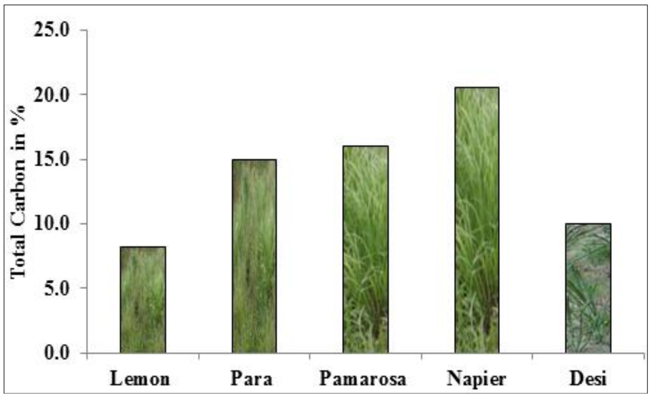

Fig 9: Total carbon in different grasses

(d) Total carbon and Total Organic Carbon

The total carbon and total organic carbon in soil was highest sequestrated in Silvi-Medicinal module (M_4) that is 1.55% and 0.73%, respectively, followed by Silvi-Pastoral module (M_5), Agri-horti module (M_2), Diversified cropping system (M_1) and Horti-Pastoral Module (M_3) fig. 10.

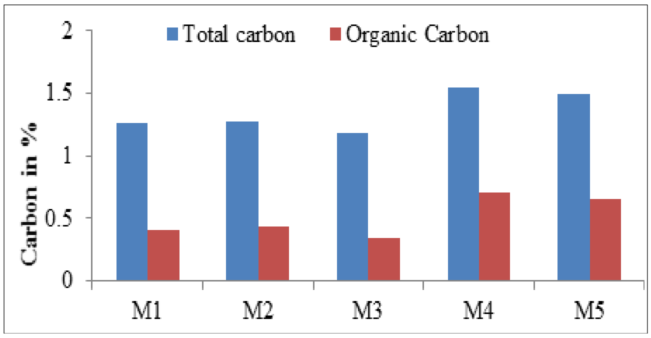

Fig 10: Total and organic carbon in different modules

Carbon Sequestration in Soil

Three years result showed that there was significant increase in soil organic content (Table, 1 & fig, 11) due to different modules. The organic carbon which was just 0.11- 0.12% at start of experiment now came upto a level of 0.30 to 0.35% under various modules in surface soil. During first year it was maximum in M_1 and M_5 but there was more improvement in silvi-pastoral module (M_5) as time is increasing. This value will increase many fold in coming time due to increasing age of trees.

Table 1: Organic Carbon at different depth of soil in different modules

Management module	Organic carbon in soil (%)					
	2012-13		2013-14		2014-2015	
	0-15	15-25	0-15	15-25	0-15	15-25
M1	0.26	0.22	0.35	0.32	0.38	0.34
M2	0.23	0.18	0.34	0.29	0.36	0.30
M3	0.16	0.18	0.30	0.23	0.34	0.26
M4	0.22	0.23	0.33	0.31	0.36	0.33
M5	0.26	0.20	0.32	0.26	0.37	0.28

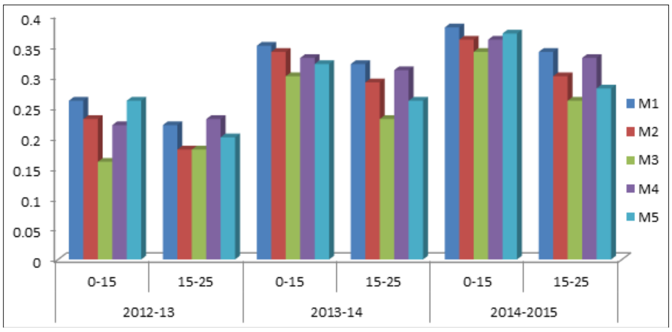

Fig 11: Total carbon at different depth of soil under different modules

Conclusion

Ravines are described as a "Cancer of the Land" and is the severest or a erosion. Potentially, the table lands of this area are highly productive under better managed conditions. The climate and the quality of soil and water are good. The area is free from major insect pest and diseases of the crops. Thus, if properly managed these ravines can be converted into lush green areas providing better food, fodder, fuel wood and fiber resulting into better socio economic environment to the people of the ravines.

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