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Review Article

Review: Role of Vetiver Grass (*Vetiver zizanioides L*) for Soil and Water Conservation in Ethiopia

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Abstract: Today land degradation is a critical issue in developing country including Ethiopia; as a result, it threats agricultural crop productions, which expose the people under the power of poverty. Applying an integrating with physical structure or alone vetiver grass contributes incredible benefits in reversing degraded land via soil and water conservation practice. Therefore, the aim of this paper was to review the role of Vetiver grass for soil and water conservation in Ethiopia. Vetiver grass was introduced in Ethiopia since 1970s in Jimma research center for the purpose of preventing invasion of couch grass in the coffee production area and later time it was used for soil and water conservation purpose. Due to its exceptional characteristic, vetiver grass plays great roles in reducing soil erosion, runoff and improving soil fertility, and soil moisture and terrace formation. Even though it has been restoring degraded land for more than fourth decades in Ethiopia there are no enough documents. The advantages of Vetiver grasses were not yet known in Ethiopia except some that of soil and water conservation. Therefore, further research, experience sharing, and documentation should be encouraged throughout the country.

Keywords: Land Degradation, Soil Erosion, Soil and Water Conservation, Vetiver, Stabilization

1. Introduction

Land degradation through soil erosion it the critical issues over the worldwide including Ethiopia country [38]. About 40% of the world's agricultural lands were seriously degraded, where 80% of this degradation is caused by soil erosion [8, 20]. The loss of soil was not only degraded environment but also it affects the reliability of economy [36]. Therefore, soil erosion causes a chronic environmental and economic trouble [50]. Such kind of challenge is very painfully in developing countries, where rural agrarian agriculture is the backbones of an economy [31, 53] and it contributed 42-45% of the total gross domestic product of the country [55].

In Africa alone, around 5-6 million hectares of agricultural lands have been affected by land degradation each year through soil erosion [30]. In Ethiopia, over 1.5 billion tons of topsoil is lost from the highlands due to topsoil erosion [42]. In Melko the amount of soil lost was estimated to be 82.3 tons of soils were eroded annually [46]. The highest rate of soil loss occurred from cultivated lands, which is ranging from 50 tons/ha/years to 179 tons/ha/years [4]. This threats agricultural production which in turn increasing rate of food insecurity [26, 54]. Due to this aggressive problem, the governments and development agencies gave attention substantial resources in promoting soil conservation practices as part of efforts to improve environmental conditions and ensure its sustainability and increase agricultural production [29]. The government understanding the negativity of land degradation on crop production and living standard of people; introduces new technology in order to restore and rehabilitate the degraded land in Ethiopia [7]. This mitigation is use through widely participating of the community at all levels. Soil and water conservation (SWC) practices include both physical and biological measures such as soil and stone bunds, agronomic practices (minimum tillage, grass strips, and agro-forestry techniques) and water harvesting options like trying ridges and check dam constructions in the

degraded area [26]. Much time the mitigation measure was taken to curb the soil erosion problem is only with the physical structure (Soil bund) without integrating with biological measures that were not a good guaranty for constantly reducing soil erosion problems. Obviously, the benefits have been obtaining from physical structures alone and the integration of physical structures with biological have a huge gap in controlling soil erosion and reducing runoff. As many kinds of literature show that integration of physical with biological soil and water conservation is accounted as the best alternative methods for minimizing soil erosion problems [54]. Besides, properly application of crop practice like multiple cropping, and high-density planting also playing a great role in reducing soil loss [23].

Because, it is easily applied by individual farmers on their land and require low resources like labor, budget and hand tools. Among, the integration of physical and biological soil and water conservation, Vetiver grass playing a major role. Therefore, this paper is trying to review the integration of physical structure with biological grass species, specifically Vetiver grass.

2. Vetiver Grass in Ethiopia

The introduction of vetiver grass in Ethiopia was not definitely known because some literature reported that it was introduced in 1971's by a British agronomist who has been worked in the Jimma Research Center (JRC) as a coffee intensification program [16], others say it was imported by Ethiopian coffee researchers, who were gone India for educational, while others say, it was introduced by an Indian scientist, who has been worked as an expatriate in the Jimma research center. However, from all these points the cornerstone is its not indigenous grass.

The purpose of its introduction was mainly to demarcate the different coffee estates and to control the expansion of toxic grass called *Cynodondactylon*. Additional, Vetiver grass is introduced to Ethiopia in mid-1980, to the Jimma Research Station to the nearby coffee state farms and NGO, with the intention of utilizing it for mulch and conserving soil erosion.

Since 1984 for the first time vetiver grass go out of JRC to government coffee site and demonstrated area by Menschen für Menschen (MfM) a German-based NGO in order to use it as mulching and soil erosion control purposes. In following years, Vetiver grass was distributed to some districts of Illubabor, Debrezeit, and Holetta Research Center, primarily for solving soil erosion problem [9]. In the 1990s, the distribution of vetiver was extremely spread to all the part of the country including Bale zone in Sinana Agricultural Research Center [15], Somali region [49], Wolayta, Gonder, Tigray [25, 24]. Currently, vetiver grass was accepted as the best alternative method in alleviating soil erosion and runoff by different Governmental sectors, Non-Governmental Organization like GIZ, farmers and by a private investor. An application of vetiver system for erosion control and slope stabilization has been implemented in Ethiopia account about more than four decades [1, 9].

3. Effects of Vetiver Grass for Soil and Water Conservation

The contribution of vetiver grass in solving soil erosion which created through runoff is internationally recognized because around 120 countries have been already using it for controlling soil erosion and reducing runoff because vetiver grass has unique characteristics [46]. The productivity capacity of degraded land decline; this due to decline in soil depth and soil fertility, which means on-site effect [17] this ground fact was verified through a conducted survey, which revealed that around 71% of the farmer responded that crop yield was reduced due to the soil erosion while around 29% disagreed.

There are many strategies developed to overwhelm such a critical problem. Among them vetiver grass is the best biological method, which effectively curtails soil erosion. The effectiveness of vetiver grass applying in single or integrating with physical structure like disposal structures (cutoff drain, waterway), water harvesting structures (micro basin and ponds reservoirs), and gully treatment (check dams) [6]. The best alternative method of retarding a loss of soil fertility is applying terrace on farmland with Vetiver grass [44]. The perfectness of Vetiver grass in soil erosion control through coffee based cropping system in Jimma Agricultural Research Center reported that Vetiver grass was mostly good for reducing flood velocity and curbing the movement of soil when its growth is after three years [45].

In Jimma agricultural research center experiment revealed that after three years Vetiver hedge was mature and under a rainfall of 1348 mm/per annum; Vetiver hedgerows reduced runoff from 139 mm on untreated bare land to 37mm on bare land with Vetiver, and 17 mm with Vetiver and coffee [5]. The main reason why vetiver grass is good for controlling soil erosion and enhancing soil deposit is due to its unique morphological and physiological characteristics [21]. It has very strong fibrous root system which goes depth into the soil and forms a tightly knitted network that binds underground soil together and retards water flow, assisting water to seep into the soil. It is amazing perennial grass species, which has an ability to tolerate drought and harsh climate condition and can grow at any soil types and climate condition but also it not has negative side effects on a crop. In humid agro-ecological zones, the severity of soil erosion is high because of high runoff. In such circumstance, the amount of rainfall seeps or soak into the soil is low. Establishing hedge in a contour by using vetiver grass has advantages in reducing soil erosion and control soil fertility removes consequently it enhance soil moisture which in turn support in improving crops yield [52, 9].

Reversing of degraded land through the use of vetiver grass is easy, less expensive and comfortable [10], especially it is not difficult to the farmers for adopt on their farmland [28]. Multiplied and disseminated vetiver grass to farmers

were show significance in reducing soil erosion, rainfall runoff, improve soil fertility and increase soil moisture [49].

3.1. Soil and Water Conservation

Bund stabilization with Vetiver

Applying only physical structures alone is nothing for sustainable reducing soil erosion and runoff. Because it has direct and indirect effects. Directly it reduces the farmer's land size (cultivable) by 8.6 percent and reduces soil fertility then indirectly reduces the amount of yield approximately by 7 percent [3]. However, it could be reversed by using bund stabilizer grasses [2]. The integration of physical and biological soil and water conservation is the keystone for mitigating soil erosion. Because the farmer realized that the integration of physical with biological application contributes more benefits than introducing physical alone.

The farmer highly appreciated an integration of soil bund with vetiver grass than that of soil bund alone to reduce soil erosion [2, 54]. Similarly, *funya-juu* with vetiver grasses establishment is very effective in restore and rehabilitate degraded land than constructed *funya-juu* alone in Northwest Ethiopia [19]. In other words, the combination will also plays a great role in modifying the availability of organic carbon concentration in cultivating land, which the conserved field has more organic matter (OM) than no conserved field (Figure 1). In contrast, application of physical structure alone does not have any support in improving soil nutrients [35] and not enhance fertility and soil nutrients [54]. Obviously, the organic matter was increased by 52.30 percent under an integration of soil bund with vetiver grass than non-conserved farmland [41].

Figure 1. *Farmland protected Vetiver with terrace in Metu- Ethiopia*

In other hands, the main introduction of physical or biological strategies is to break the slope of the land. An especial biological measure like Vetiver grass is more essential in slope stabilization practices, which planted across the slope in contour, then make a barrier to water flow or minimize runoff and enhance soil deposition. Besides, to minimizing surface erosion on sloping land, because it has a massive root system which can enhance in stabilizing the steep slope.

Figure 2. *Vetiver hedges formed terrace, Illubabor.*

During in past two decades (1990 - 2010) as a number of agencies got involved in expanding the use of Vetiver for land management especially in Western Ethiopia (Illubabor, wellega) [27]. Vetiver, systems are being further expanded by the SLM program of the MOARD in its program areas in the country. The most common species are *Vetiveria zizanioides* and is best suited to form a contour strip on various land uses for protecting and or control soil erosion. Lines of Vetiver slips that form consecutive strips are spaced more or less in the same way physical measures are spaced one-meter vertical interval between two strips on gently sloping land and from 1.5 – 2.5-meter vertical interval on slopes greater than 10 %. Although Vetiver can be planted using single tiller it is better to plant two to three slips so that

a thicker and wider hedge is established. The spacing between two consecutive lines is determined by the vertical spacing are discussed above, but its performance increases when the spacing between two slips is 10-15 cm for soil erosion control and 40-50 cm for other purposes. Vetiver grass is the most preferable grass than desho and setaria grass strip because it is very quickly building terrace and store soil at upside of strips then it reduce runoff and soil loss in Jijiga Area, Northern Part of Somali Region [49].

There is a concrete evidence that properly established of Vetiver hedgerows (Figure 2) was the reduced soil loss to acceptable levels (< 3 tons/ha) and runoff by as much as 70 percent according to the slope and soil type [48].

River bank stabilization and dam protection

Soil erosion caused by improper design and construction of roads is one of the serious environmental problems in Ethiopia. Considerably large numbers of gullies have been formed in Ethiopia as a result of improperly placed culverts, turnout ditches, and roadside drains. Measures taken to curb the problem have been very minimal in the past, but recently there are encouraging initiatives and actions taken to prevent road caused problems using Vetiver grass. The (Figure 3) shows some of the preventive and control measures taken on a newly constructed road on the Nekempt Gimbi road side.

Figure 3. *Vetiver established on roadside in Nekemte- Gimbi.*

Sustainable Land Use Forum (SLUF) and its partners have verified and applied the Vetiver system for soil and water conservation example for gully treatment (Figure 5) and infrastructure protection (Figure 4) in the Amhara and Afar regional states respectively. As previous literature finding shows that the vetiver grass is very nice for soil and water conservation because it is easy, realistic, and low-cost, not need more resources and very efficient and effectives in sediment control, land stabilizations, and rehabilitation [40].

Figure 4. *Vetiver grass used for infrastructure protection in the Afar region [40].*

Figure 5. *Vetiver application in gully treatment in Amhara region [39].*

The combination of the deep root system and thick growth of the Vetiver hedges will protect the banks of river and stream under flood conditions. Its deep roots prevent it from being washed away while its thick top growth reduces flow velocity and its erosive power. Some literature showed that about 90 % of spring dried due to the environmental degradation in Tulube peasants association. However, after the introduction of Vetiver grass to the area from 2005 to 2010, 96% springs were recovered/recharged and permanently served throughout the year as the source of water for a community while 4% only still dried [43]. Additional the hand dug well also increased as well. There is a clear correlation between Vetiver hedgerows and improved groundwater recharge around 30% [12]. Vetiver grass is the supergrasses for water and soil conservation, which used in stabilizing irrigation engineered earthworks, land rehabilitation, and soil pollution mitigation [22]. As water is approaching the canal, the hedgerows of Vetiver trap silts first while the latter is allowed to flow down into the canal. Vetiver root systems bind the soil together and rebuilt the canal edges from eroding. In addition, Vetiver can be planted along roadsides, road shoulders, and irrigation canals as well as on slopes, binds the soil together and restore fertility to the land. In the same way, river banks that have undercut/scouring effect were protected by planting Vetiver clumps without splitting into tillers. Accordingly assessment report, the role of Vetiver grass system in soil and water conservation in Kuraz Sugar development which found in South Omo Zone in the plain areas of the lower Omo basin of the south nation nationality people region state (SNNPRS), Vetiver was preventing soil erosion and conserving soil moisture in sugar cane fields. It is also a significant maintenance in drainage canals of the projects in which it may need irrigation-engineering works, have multiple environmental applications and offer inexpensive and reliable solutions to soil degradation, loss of soil fertility, ground water recharging, water quality enhancement and site rehabilitation in relation to industry and intensive commercial agriculture in the future [51].

Mulch by Vetiver grass

Soil erosion is the way of removing topsoil, which comprised various soils organic and nutrients [34], so due to this enormous soil, essential nutrients became removed [33]. Consequently, the capacity productivity of land reduced [11, 18]. As previously expressed, vetiver grass is contributing incredible support in reducing soil loss and runoff through direct planting but also it can be used for mulch purpose especially it is clipping at the rate is 7.5 ton/ha [14]. Land covered with vetiver grass mulching help to prevent the bare land from rainfall falling energy (Splash erosion) then it helps infiltration of the water into the soil then eliminate soil erosion and runoff [13]. In Ethiopia, using vetiver grass for mulching really recognized particularly in a coffee production area, southwest part of the country (Figure 6). Mulch of vetiver grass has many advantages in coffee plantation area like reduce soil erosion, increase soil moisture, soil fertility and finally enhance coffee quality [9]. As a result, it controls the soil mass from direct detachment by rainfall, which may minimize the amount of soil to be taken away and in other hands when its stems, roots, and leaves were decomposed it create good condition for microbial, whose helps for building soil fertility [49]. It is ratified that using the vetiver grass after 2-3 years age for mulching purpose plays a great a vital role in enhancing soil water holding capacity, soil component particularly organic matter automatically improved [32]. The combination of physical and biological measures is not only valuable to reduce soil erosion and runoff but also it used for soil protection and mulching [9, 54].

Figure 6. *Advantages of vetiver grass mulching in the coffee plantation [9].*

4. Conclusion and Recommendation

Land degradation is the critical issue thought out in developing country including Ethiopia because it is adverse impact on the environment and agricultural production, which expose the people under the power of poverty. The integration of physical with biological soil and water conservation is the best alternative strategy in curbing land degradation. Accordingly, it is amazing types of grass species, which plays a vital role in reducing soil erosion, and restoring degradation of land through storing sediment, hold water and enhancing the water holding capacity of a soil. Generally, depending on this reviewed the following recommendation points are forwarded:

(1) Physical structure of soil and water conservation alone, not enhance the sustainability of rehabilitation of degraded land it should be combined with grass species especially Vetiver grass.

(2) The government and other concerned bodies should give more attention to the advantages of Vetiver grass exception of soil and water conservation practices.

(3) There is no more research done on the effectiveness of Vetiver grass advantages rather than some of soil and water conservation even though it's not enough so further research conduction should be done.

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