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Recycled Farming to Prevent Soil Erosion and Degradation

[Aashna Anand]

***Abstract*—This paper describe the various issues due to extensive farming as the result of enormous pollution growth with an innovative solution to address the soil erosion and degradation by "Recycled Farming".**

***Keywords*—Recycled Farming, Soil Erosion, Soil Degradation, Farming Environmental Problem**

I. Introduction

Population grew from 2.6 to 7.2 billion from 1960 to 2015 and is expected to grow 11.2 billion by 2100. Though Earth, land to water ratio is almost same, more natural forest and vegetation land is converted to farming land to grow more crop and meet world food demands. In last 50 years, crop production has increased by 3 times. Extensive and repetitive farming over several centuries resulted in many farming environmental issues. These issues are soil erosion, degradation, water runoff, deforestation, flooding, waterways clogged, and use of chemical based fertilizer. Due to plowing, top soil gets loosen, which contains microorganism, minerals etc. These loosen top soil runoff during rain or water irrigation. As this happens repeatedly over the decades, it results in soil erosion. Many parts of the world, use the same land to grow a particular crop to maintain country top ranking, which leads to soil degradation. Example, in Brazil 55 million tons of soil is degraded due to soy production to maintain its top ranking. Recycled farming is an innovative solution, where farming lands are divided in different plots size with pathways. These pathways contain small plants and long grasses, which holds the soil strongly and prevent soil loosening. A systematic plumbing work has to be done in each farming plot (like plumbing at modern house) with defined water inlet pipes and outlets pipes. During water irrigation or too much rain, if water runoff along with the soil then it will go through the pre-defined outlet pipes. At the exit of outlet pipes, a pebble based filtering is designed to prevent soil runoff and allow only water to go and store in a nearby well. Later, filtered soil will be moved to nearby fertilizer plants, where it will be mixed with crop leftover and develop fertile soil. This fertile soil will be recycled to farm lands to prevent both soil erosion and degradation. The recycled water collected at the well will be pumped to farm land for irrigation purpose. A simulation has been performed for "Recycled Farming" and a model is developed and presented at School Eco Trade Show, which was highly appreciated by Academia and National Newspaper "Korea Herald".

II. Population Growth and Its Impact on Farming

As per United Nation, Department of Economic and Social Affairs, world population has grew from 2.6 to 7.2 billion from 1960 to 2015 and is expected to grow till 11.2 billion by 2100 as shown in Figure 1 [1].

In Figure 2, as per United Nation, food and agricultural organization (FAO) the crop production grew from 3.8 billion tons to 12.5 billion tons in during the same time period [2].

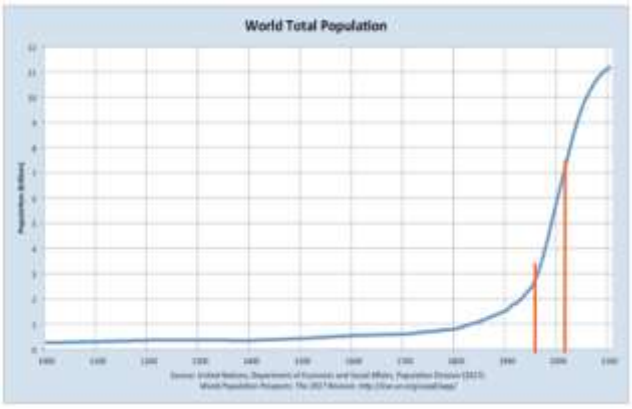

Figure 1. World Population exponential growth [1]

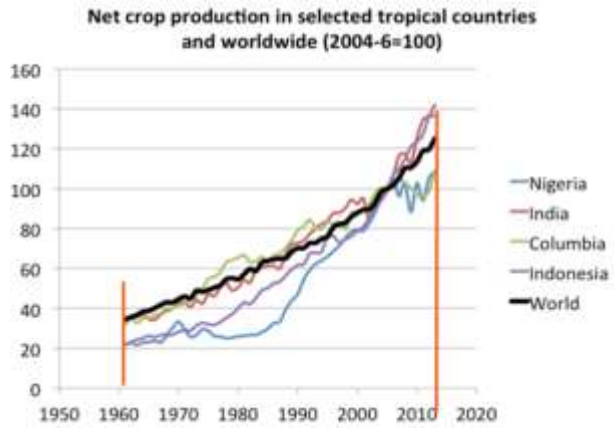

Figure 2. Net Crop Production Worldwide as per UN FAO [2]

This concludes that increase in population growth resulted in increase in farming exponentially.

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III. Soil Structure

Figure 3 shows that there are 5 layers of top soil. These are as below:

O Layer contains organic materials and decomposed leaves, twigs. This part is brown or black color.

A Layer contains minerals and organic materials. This part moves clay and other materials, such as iron and calcium, to the B part. The color of this part is light brown or black.

E Layer is composed of light-colored materials that result to leach clay, calcium and iron to the lower parts. A and E part together leach the things.

B Layer is enriched with clay, iron oxide, silica and other things that were leached from the top parts to this part.

C Layer is composed with weathered materials like rock.

The topsoil is approximately 120 inches (3 meters) in depth.

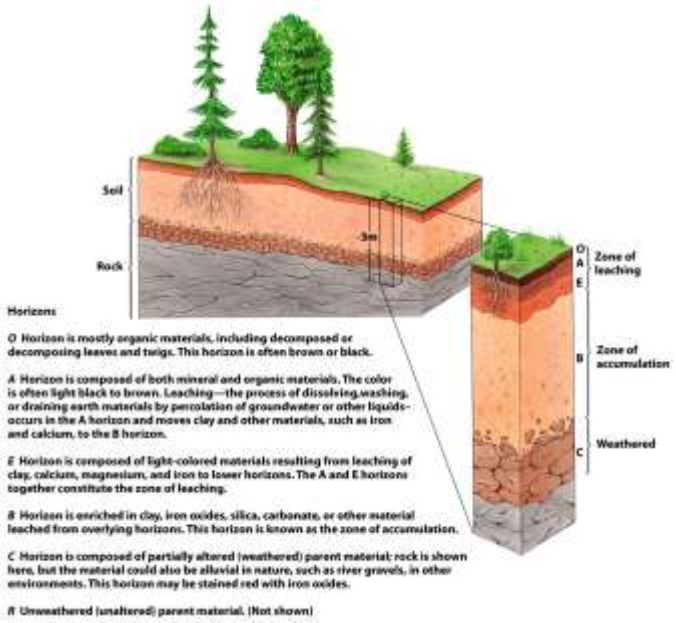

Figure 3. Soil Structure [3]

During farming, plows are used to dig the O and A layer of soil up to 14 inches to bow the seeds. So top soil, which contains microorganism and minerals gets loosen.

IV. Farming Environmental Issues

Doing too much farming causes many problems. Those problems are like soil erosion, degradation, water runoff, deforestation, flooding, waterways clogged, and use of chemical based fertilizer.

A. *Soil Erosion*

Soil Erosion is caused due to when natural vegetation (microorganism and minerals) is cleared and farmland is ploughed, the exposed topsoil is often blown away by wind or washed away by rain.

If we use the soil for farming 2 or 3 times repeatedly, then soil erosion will start to happen. But after many decades, the topsoil will be moved away and the land would be cracked.

Example: As per UN FAO, currently 40% of soil in Africa is degraded. Degraded soil diminishes food production and leads to soil erosion. Soil erosion in Africa threatens food supplies. As per UN FAO, 100% of the food production need to be increase by 2050 in Africa.

Figure 4. Soil Eroded Land

Place	Biome	Pasture management	Erosion plot size or method	Soil loss (t ha⁻¹)	Reference
Madagascar	Humid Tropic	ND	watershed	0.03	Fournier (1967)
Kenya	Savannah	D	watershed	53.3	Barber (1983)
Kenya	Savannah	ND	watershed	1.1	Barber (1983)
Texas	Prairie	ND	watershed	0.012	Bennett et al. (1954)
Wisconsin	Prairie	ND	watershed	0.22	Bennett et al. (1954)
Nepal	Prairie	D	watershed	35	Fleming (1983)
South Africa	Prairie	D	plots	6.5	Dlamini et al. (2011)
Zambia	Savannah	ND	Cesio 137	2.5	Collins et al. (2001)
Kenya	Savannah	ND	watershed	1	Dune (1979)
Brasil	Savannah	ND	plots	9.1	Dedeseck et al. (1986)
Brasil	Atlantic Forest	ND	plots	0.4	Bertoni & Lombardi (1990)

Figure 5. Soil Degraded (D) and Non Degraded (ND) Countries [4]

Figure 5 shows that countries with degraded (D) land. For example Kenya, Nepal and South Africa have 53.3, 35 and 6.5 tons/hector of soil loss [4].

B. *Soil Degradation*

Soil degradation includes loss of organisms, decline in soil fertility (quality) due to repeated natural same vegetation for several decades or centuries.

Effect of Soil Degradation:

- Loss of water inside the soil
- Dryland
- Loss of organic matter
- Fertility decline
- Soil acidity or alkalinity structure decline

Example: Brazil lose 55 million tons of topsoil every year. This leads to reduced soil fertility and degraded land.

Figure 6. Soil Degraded Land

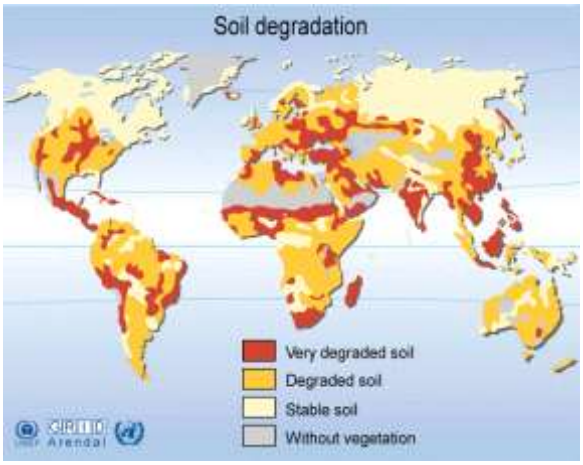

Figure 7. Places at World with Different Types of Soil [5]

In Figure 7, as per United Nations Environment Program (UNEP), this is a map which shows red color is very degraded land, yellow color is degraded land, white color is stable soil and grey color is without vegetation.

C. *Water Runoff*

Water runoff happens due to excessive rain or irrigation which cause for topsoil to be softened. These softened topsoil moved away easily by water runoff.

D. *Deforestation and Flooding*

Deforestation is when men cut down the trees to use for farming and other purpose.

Effect of Deforestation:

- Carbon dioxide will increase in air
- Habitat loss of animals
- Some animals get extinct
- Increase in probability of flood

In Figure 8, as per World Resources Institute 2000, show Converted Forest & grassland for farming & other purposes:

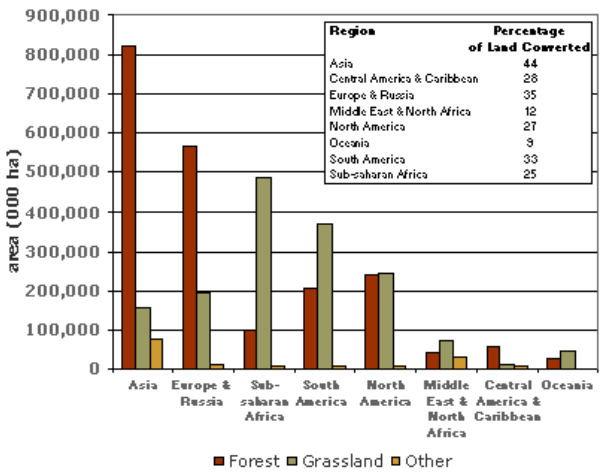

Figure 8. % of Forest and Grassland Converted into Farming Lands [6]

Cause for flooding:

- Due to deforestation
- Due to soil erosion (top soil cannot absorb water)
- Poorly constructed plantation drainage systems

Effect of flooding:

- Harms to living beings, human and their property
- Further it degrade soil

E. *Waterways Clogged and Polluted*

Loosen soil due to deep ploughing for farming causes top soil to carried off in rain or irrigation water.

These polluted water are mixed with rivers and lakes, which cause for water to be clogged and polluted.

Effect of water clogged and polluted:

- Serious damage to freshwater and marine habitats, as well as the local communities that depend on these habitats
- Use of pesticides and fertilizers carried in rainwater and irrigation runoff can pollute waterways and harm wildlife.

Figure 9. River Sedimentation

F. *Chemical Based Fertilizer*

Pesticides are chemicals that are sprayed to plants so that it can remove insects away from plants.

Effect of Pesticide:

Pesticides cause harm to the ecosystems and living beings

Land Pollution – Soil mixed with pesticides

Water Pollution – Pesticide mix with rain water

Air Pollution – Burning crop waste, contains harmful gases due to use of pesticides

Example: In Nov 2017 at Delhi, the air pollution reached to the dangerous level due to biomass burn and that created a lot of smoke.

Figure 10 shows Delhi air quality in November 2017, which shows carbon monoxide increased to dangerous level of 500.

Figure 10. Air Quality in Delhi [7]

V. Existing Solutions

To solve these farming environmental problems, scientists developed many solutions. These solutions are like contour plowing, avoid overgrazing, crop rotation system, pest management etc.

A. *Contour Plowing*

Contour Plowing means plowing perpendicular to the slopes and as horizontally as possible to the "contour" of the land horizontally.

The benefits of contour plowing are:

- One of the most effective ways to reduce soil erosion
- Also uses less fuel and time

Figure 11. Contour Plowing

B. *Avoid Overgrazing*

Avoid over grazing means to not allow cows and other animals to graze grassland so heavily that the vegetation is damaged and comeout, and the ground becomes liable to erosion.

C. *Crop Rotation System*

Crop Rotation System means to not grow the same type of plant again and again on the same land. For example not to grow the rice crop again and again. If we don't grow the same thing again and again then the same nutrients will not be lost from the soil. That means using the crop rotation system, soil degradation can be prevented.

D. *Pest Management*

History of Pesticide:

a) Initially in 1910, arsenic used as fertilizer, which was harmful to pests and organisms both.

b) Later in 1930, petroleum was used as fertilizer as it contains nicotine.

c) Around 1960, Aldrin and dieldrin used as fertilizer.

It found as toxic to humans. Even breast milk found with these harmful chemicals!

d) Latest, we used predators and parasites to control pests. Such as ladybugs, parasitic wasps.

Use organic pesticide (Neem, Salt Spray, Mineral Oil) is environmental and farming friendly.

VI. Recycled Farming Solution

Solution presented in this paper is named as "Recycled farming". Recycled farming is an innovative solution to prevent soil erosion, degradation and water runoff by recycling the soil and water.

A farm land is divided in different plots size with pathways as shown in figure 12. These pathways contain medium size plants in the middle and long grasses at the side, which holds the soil strongly and prevent soil loosening. Also when the water is going on the plants, to make the water be equal in every farmland.

A systematic plumbing work has to be done in each farming plot with inlet and outlet pipes as shown in figure 12. During water irrigation or too much rain, if water runoff with soil then it will go through the pre-defined outlet pipes.

Figure 12. Recycled Farming Project Model

At the exit of outlet pipes, a pebbles based filtering is designed as shown in figure 12 to prevent soil going into the well and only allow water to go and store in a nearby well. The pebble system will be supposed to be big. Incase more mud comes in the well, it is okay because the well will be cleaned time to time.

Later, the filtered and deposited soil will be moved to a nearby fertilizer plants storage, where it will be mixed with crop residue, cow dung and develop fertile soil (fertilizer for the plants).

This fertile soil will be recycled to farm lands, which prevents both soil erosion and degradation.

The recycled water collected at the well will be pumped to farm land for irrigation purpose or during droughts.

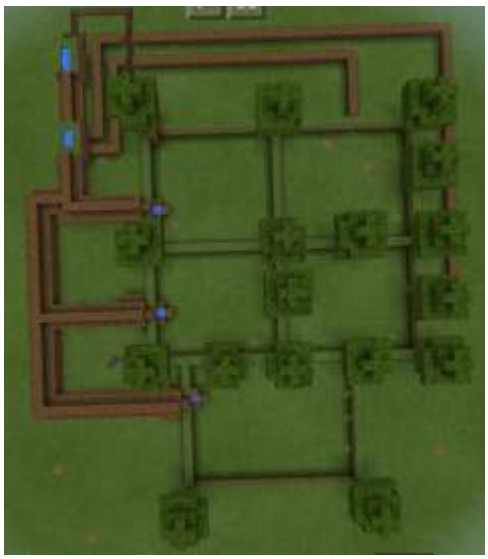

Figure 13. Simulation Model at Minecraft

Here is a simulation model which was created using Minecraft before devoloping project model.

VII. Conclusion and Future Work

Recycled farming is a unique and innovative solution to prevent soil erosion and degradation by recycling the soil and water in a scientific way. As future work, this solution should be implemented in a real pilot project. This solution also has to be discussed with United Nation Food and Agriculture Organization (FAO) to implement the places having extreme eroded and degraded soil.

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Aashna Anand is a young inventor and 5th grade student for Korea International School (KIS), South Korea. She has developed expertise to understand farming environmental issues. Recently she has developed “Recycled Farming” solution, which can prevent soil erosion and degradation, which occur due to extensive and repetitive farming. As part of Eco Trade Show organized by her school (KIS), her recycled farming solution was praised by Academia and national newspaper at “Korea Herald”.

Link to the Korea Herald website:

http://www.koreaherald.com/list.php?ct=020109000000