Land degradation neutrality. How to reverse land degradation with conservation agriculture practices?

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Abstract

Land degradation is a global problem and is a consequence of natural, but even more to human activities. The target 15.3 (Goal 15 "life on land" from United Nations Sustainable Development Goals) aims to reduce desertification and restore land and degraded soil towards a World without land degradation. Land Degradation Neutrality can be achieved by using a Sustainable Land Management (SLM), which includes Conservation Agriculture (CA) practices. Despite the differences in the studies carried out, it is clear that CA practices improve soil environment and therefore soil productivity. A key aspect to the adoption and implementation of CA practices is involving planners, farmers, stakeholders and policy makers and explain the long-term advantages.

Keywords: Land Degradation, Sustainable Development Goals, Sustainable Land Management, Conservation Agriculture.

Introduction

In 2014, United Nations (UN) established their agenda for 2030. Seventeen sustainable development goals (SDG's) and 169 targets were announced with the aim to live in a more prosperous and sustainable world. The goals and targets announced aim to integrate in a balanced way the 3 different pillars of sustainable development: the economic, social and environmental (UN, 2015).

Land degradation is a worldwide phenomenon and is defined by the long-term losses of productivity and ecosystem functions as consequence of natural or human made disturbances (Bai et al., 2008). Land degradation is strongly linked to the three pillars of sustainable development, since depends on social development (e.g. population increase), economical status (e.g. political instability) and climate change (e.g. drought) (Eckert et al., 2015). Land degradation is directly and indirectly related to several of SDG's (Akhtar et al., 2017), however, is specially connected with the goal 15, Life on Land. Goal 15 is especially focused on four key areas: 1) loss of biological diversity, and degradation in 2) land, 3) forests and 4) mountains. This goal demands the governments to stop biodiversity loss and land degradation, and restore, protect and promote a sustainable use of the land (Barbut, 2018). Under the target 15.3, it is aimed to by "2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve and land degradation-neutral world[1]".

Land Degradation Neutrality (LDN) aim is to enhance or maintain land-based natural capital and its associated ecosystem services (ES). Neutrality entails that there is no net loss of land-based ecosystems and their services in relation to a baseline level (Cowie et al., 2018). It is extremely urgent to restore the ecosystems as consequence of the enormous

[1] https://www.un.org/sustainabledevelopment/biodiversity/

economic, social and ecological costs. To meet the target of LDN it is crucial to involve planners, stakeholders and policymakers (Pacheco et al., 2018).

For the sustainability of our planet, it is crucial to reduce and reverse land degradation process. It can prevent as well the achievement of the other 16 SDG goals (Barbut, 2018). Soil management plays an important role on land degradation. Intensive practices and the use and abuse of herbicides and pesticides are responsible for soil degradation and the long-term decrease of soil productivity, while conservation agriculture (CA) can reduce soil degradation and increase soil productivity (Pereira et al., 2017). LDN cannot be achieved without CA practices, since agriculture is one of the major drivers of land degradation. Therefore, for soils continuing to have the capacity to supply ES in quality and quantity, intensive land use practices and the disservices associated (e.g. erosion, pollution, contamination, human health) should be reduced (Pereira and Murillo, 2018). The objective of this work is to make a revision of the soil CA practices important to achieve LDN.

Costs of land degradation: A global picture.

The estimations of land degradation are not conclusive and present high discrepancies. Total estimated degraded area varies from 1 to 6 billion ha and has important spatial differences. The inconsistencies between studies are attributed to the methods applied. They capture different aspects of degradation but neglect the full picture. The methods used are based on 1) expert opinion 2) satellite images 3) biophysical models and 4) abandoned cropland (Gibbs and Salmon, 2015). From all methods, perhaps the most accurate is the satellite images based since shows the actual land degradation and is not limited to certain types of land use.

Despite the differences, it is estimated that 75% of terrestrial ecosystems are affected by land degradation and this number can rise to 90% by 2050, if we continue with business as usual practice. 52% of the world agriculture area is affected by degradation, mainly as consequence of poor agricultural practices that lead to soil salinization, acidification, soil crusting and sealing, compaction, organic matter decline, nutrient imbalance, loss of biodiversity and pollution. Land degradation affects a total of 3.2 billion persons (half of global population). This is especially critical in economies under development and affect especially woman and children (Barbut, 2018; Alexander et al., 2018). Figure 1 shows the global loss of annual net primary productive (an indicator of land degradation) between 1981-2003, and it is clear that is especially evident in central Africa and southeast Asia. Nevertheless, is not limited to these areas. Land degradation can also be observed in Alaska, Central America, Iceland and Eastern Asia (Figure 2). It is is not a phenomenon exclusive of arid and semi-arid areas and it is observed also in latitudes where precipitation is abundant. The human expansion and the associate impacts in temperate and polar areas are a cause of land degradation (Hennig et al. 2015; Houghton and Nassikas 2017; Barrio et al., 2018).

The impacts of land degradation are especially evident in poor communities that depend importantly on natural resources, however, affects also industrialized economies. Non-sustainable practices are responsible for the degradation of non-renewable resources at human time scale such as the soil. Previous works highlighted that:

- At global level, land degradation costs per year approximately 300 billion US dollars, and affects especially Sub-Saharan Africa. Land degradation affects approximately 54% of regulating, supporting and cultural ES at global scale (Nkonya et al., 2016);

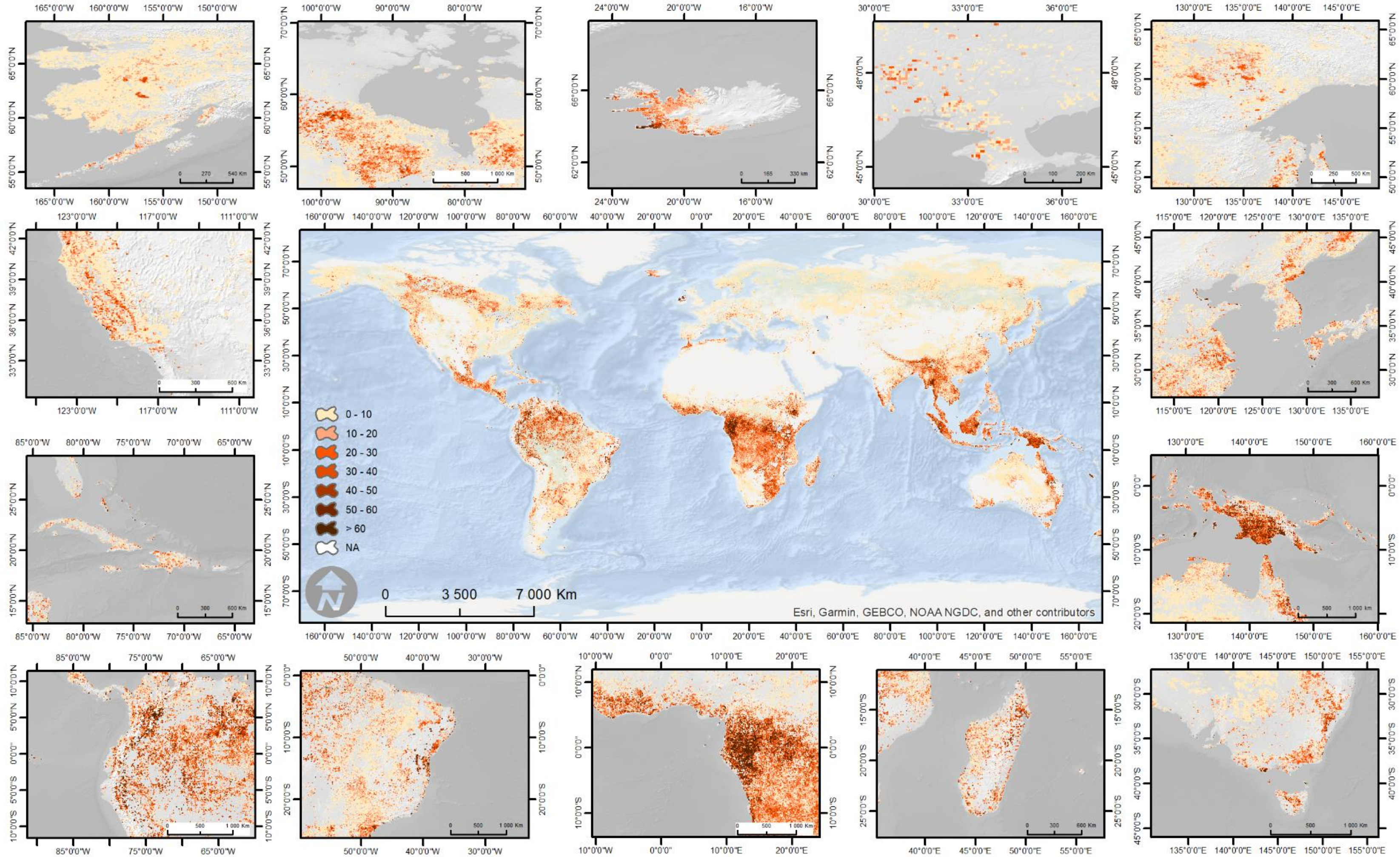

Figure 1. Global loss of net primary productive between 1981-2003 (FAO, 2003)

Figure 2: Evidences of land degradation

- Land degradation processes causes a loss of 6.3 trillion dollars of ES value for impaired ecosystem function. Agriculture alone contributes with 1.7 trillion dollars (Sutton et al., 2016);
- Agriculture impacts on land degradation have a global cost of 500 billion US dollars per year (Pacheco et al., 2018);
- Soil erosion in European Union (EU) affects 12 million of ha and represents an important loss in agricultural productivity (approximately 1.25 billion Euros). This is especially observed in Italy; however, other Mediterranean countries have important losses as well (Panagos et al., 2018);
- In United Kingdom and Wales soil degradation costs range from 0.9 to1.4 billion pounds, mainly as consequence of soil compaction, erosion and organic matter loss (Graves et al., 2015);
- In Italy, the costs of agriculture impact on land degradation are 12 Euros/ha (Salvati and Carlucci, 2010);
- In 2009, the total costs of land degradation in Russia as consequence of land cover change was estimated in 189 billion US dollars (Sorokin et al., 2016);
- In the Baltic region, Estonia, Latvia, Lithuania, Poland, Belarus, Kalinagrad (Russia) and Pskov (Russia), land degradation costed between 2001 and 2009 8.6 billion US dollars. The biggest costs were observed in Belarus (3 billion US dollars) and Poland (1.5 billion US dollars) (Braun and Mirzabaev, 2016);
- In Tanzania and Malawi, the annual costs of land degradation are approximately 2.5 billion US dollars (Nkonya et al., 2016);
- The total costs of land degradation in Central Asia (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) are about 6 billion US dollars (Nkonya et al., 2016).

The costs of inaction are much higher than the costs of action (e.g. Mirzabaev et al., 2015), therefore is crucial to implement practices that reduce the disservices caused by agriculture intensive management and maintain and increase the ES supply (Pereira et al., 2018).

Conservation agriculture practices to reverse land degradation

To achieve LDN target, the adoption and implementation of sustainable land management (SLM) practices are crucial (Kust et al., 2017). SLM is defined as "*the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions*[2]". The sustainability of agricultural production is linked with climate, but especially to the land use practices, therefore implementing correct practices according to the biophysical and socio-economic conditions is key for the rehabilitation of degraded land and ensure the long-term productivity (Figure 3).

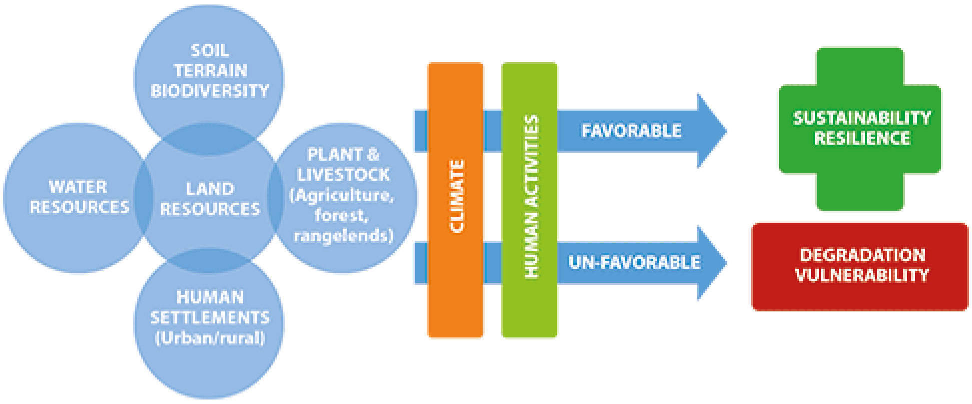

Figure 3. Sustainable land use practices impact on land. Source: http://www.fao.org/land-water/land/sustainable-land-management/en/

There are hundreds of soil management practices, most of them traditional (IUCN, 2015), that can reverse land degradation and have positive impact on soil conservation and agricultural productivity, enhance resilience against pests and diseases and biodiversity. More recently, several CA practices have been implemented with a positive impact on soil environment and agricultural productivity. CA is based on 3 principles: 1) permanent or semi-permanent soil cover, 2) minimum tillage and soil disturbance and 3) frequent crop rotations. Several practices are encouraged in CA such as disease and pest management, limited tractor traffic, application of green manures and cover crops and no burning of residues. Long term studies demonstrated that the adoption of CA practices is better for soil biota compared to the use of mineral fertilizers and pesticides (Henneron et al., 2015).

Crop diversification is a practice used under CA management and previous works observed that increases soil fertility, agricultural productivity and reduce poverty as identified in Italy (DiFalco and Zoupanidou, 2017), Zimbabwe (Makate et al., 2016), Kenya (McCord et al., 2015) and India (Birthal et al., 2015). Other CA practices such as wide crop rotation, reduced/no tillage and cover crops revealed to be highly beneficial for soil productivity, water retention and carbon sequestration comparing to conventional practices in Southeast Asia (Le et al., 2018), India (Das et al., 2018), Africa (Thierfelder et al., 2015) and Europe (Garcia-Gonzalez et al., 2018). Ranaivoson et al. (2017) found that cover crops reduced water evaporation and weed emergence and increased water infiltration, organic carbon retention and nutrient status compared to bare soil. Nevertheless, some works highlighted as well that some shortcomings are observed from CA management, such as reduced yields

[2] http://www.fao.org/land-water/land/sustainable-land-management/en/

and weed management problems (Buchi et al., 2018). It has been observed also that CA management did not contribute to soil organic carbon stocks increase (Cheesman et al., 2016).

The studies available are not unanimous regarding the advantages of CA management, especially in yield production, that is much high using conventional practices as consequence of the use of fertilizers that facilitate short-term revenues. The important question is the cost of this high productivity to the environment, society and long-term economy. It is proven that unsustainable practices are the cause land degradation that coupled with climate change are responsible for poverty and famine in the less developed areas of the globe. The advantages of sustainable practices such as CA are well known and their adoption and implementation by planners, farmers, stakeholders and policy makers is crucial to reverse the current land degradation trend and meet the objectives of LDN in 2030. The implementation of SLM (including CA) can be done in the context of SDG's, encouraging global and national initiatives to reduce land degradation (Mirzabaev et al., 2016). Overall, the application of CA practices can reduce and reverse the long-term land degradation and contribute to LDN in 2030. Nevertheless, this adoption and implementation is strongly tied to the acceptance of planners, farmers, stakeholders and policy makers.

Conclusion

LDN is a serious commitment that we have with our world and with the future generations. At the current rate of land degradation as consequence of unsustainable agricultural practices (use and abuse of fertilizers, pesticides and herbicides and industrial monocultures), the loss of ES and ecosystem functionalities is enormous. Despite the lack of consensus about CA advantages, it is clear that reverse land degradation trends, by increasing soil fertility, carbon storage and water retention and infiltration. Several studies are contradictory regarding yield production. Nevertheless, most of the works carried out point to the fact that soil environment is improved and this is key to achieve LDN and sustainable agricultural production. Raising awareness among planners, farmers, stakeholders and policy makers is crucial to reverse land degradation trends.

Acknowledgments

This work has been supported by Croatian Science Foundation under the project "Soil erosion and degradation in Croatia" (UIP-2017-05-7834) (SEDCRO).

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