IMPACTING THE CLIMATE THROUGH LANDSCAPE RESTORATION

How local changes can have a global impact

2020 White Paper

COOLING DOWN THE PLANET

JUSTDIGGIT.ORG

Title: Impacting the climate through landscape restoration

Subtitle: How local changes can have a global impact

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1 INTRODUCTION

The Earth's ecosystems are under escalating pressure due to rapid population increase and climate change. Results presented by UNCCD (2011) confirmed that 25% of Earth's land mass is seriously degraded, climate change impacts crop yield by 15-50%, while desertification impacts biodiversity with 27,000 species disappearing every year. They stressed that by 2030 half of the world population (4 billion people) will be living in areas of high water stress, water scarcity might displace up to 700 million people and GDP in dry lands is 50% lower than in non-dry lands, impacting 1,5 billion people.

Justdiggit (www.justdiggit.org) is a Netherlands based non-profit organisation working on landscape restoration in Africa. Using water harvesting, agroforestry and climate resilient agriculture, supported by media & communication, we aim to increase local water availability and restore the vegetation cover in degraded areas. At larger scale, these landscape changes may alter local climatic conditions (evapotranspiration, temperature, cloud formation), which in turn can lead to large scale climate impacts.

To achieve this, Justdiggit implements large scale regreening programs and supports other landscape restoration initiatives with media & communication to increase their impact. A short introduction to Justdiggit and our activities can be viewed in this video: https://vimeo.com/378796341

This white paper gives a more detailed description of the processes and theory behind our ambition to impact the regional climate by restoring degraded landscapes.

People are invited to share their knowledge with us. Please use what you find in this document. Both positive and negative feedback on our projects, methods and theoretical claims are more than welcome.

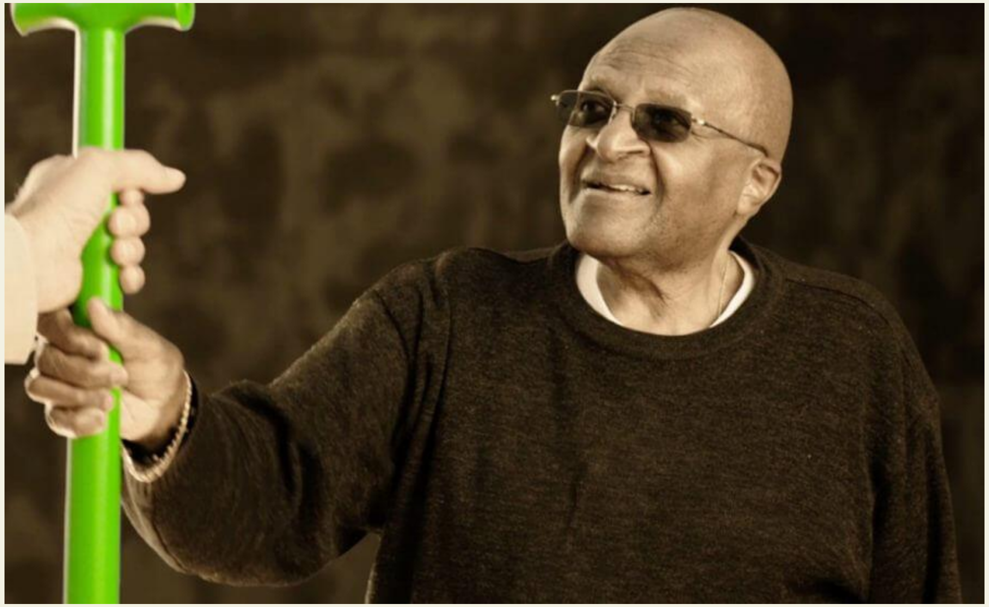

Figure 1: Justdiggit patron Desmond Tutu

2 PROBLEM DEFINITION

At present, there are many locations where rainwater flows away rapidly through surface runoff into streams and rivers, transporting fertile soils, leaving the land dry and bare. The philosophy of regreening itself is straightforward. By retaining rainwater, vegetation will have a chance to grow which creates a healthier local ecosystem. This has positive effects on the local climate, which in turn affects regional rainfall. Increased rainfall allows for more vegetation to emerge, and a positive feedback loop occurs. The first step of rainwater harvesting breaks the negative vicious circle and creates a better environmental situation for ecosystems, people and the natural environment. This concept is shown schematically in Figure 2.

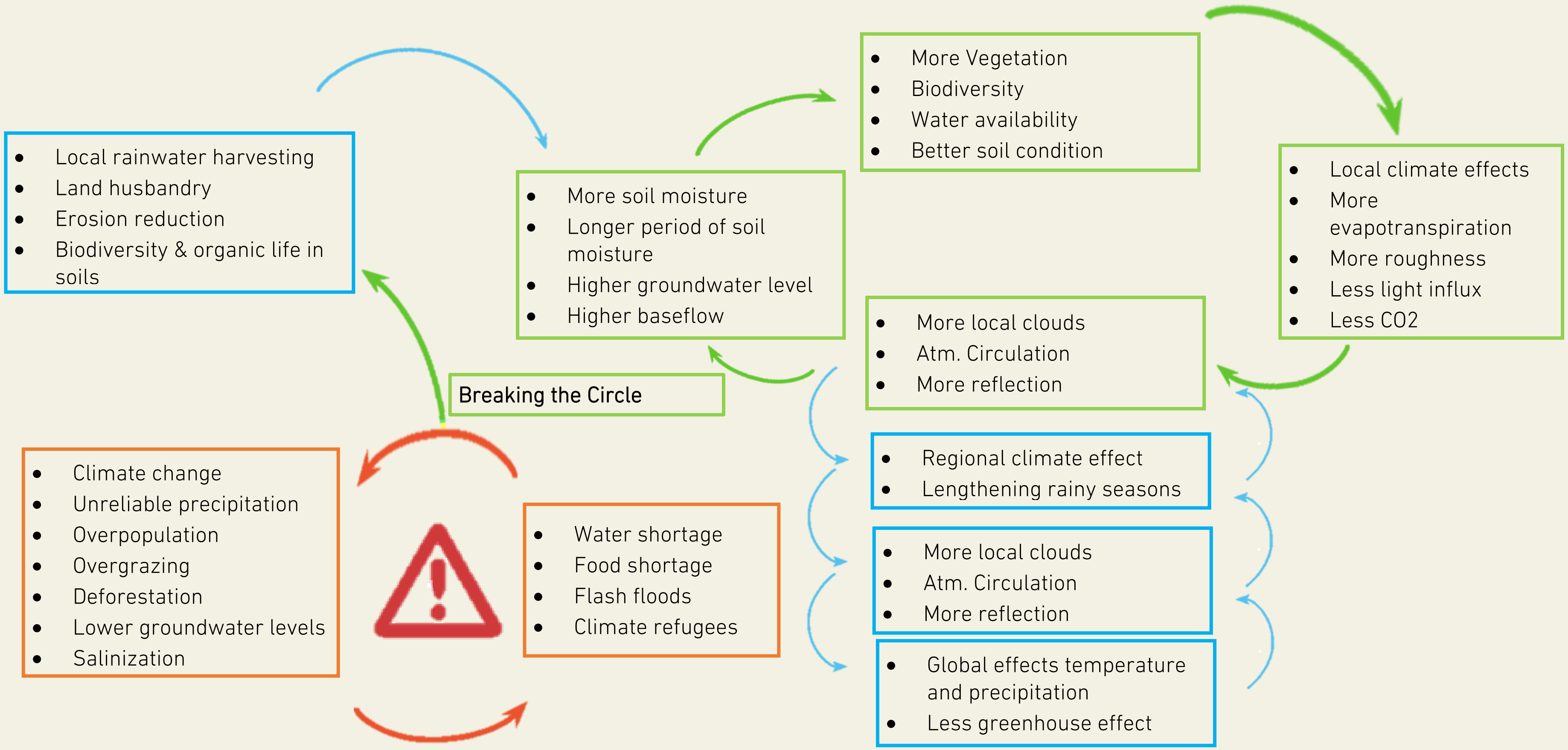

Figure 2: Schematic representation of the effects of water harvesting and regreening.

Around the world there are many initiatives working to regreen the Earth. An enormous amount of knowledge and data is available in reports, documentaries, and scientific articles. The report you are reading aims at combining available information to substantiate the Justdiggit theory of change and identify positive and negative arguments on this approach.

The blocks in the figure above will be elaborated in this document. At the end of this report an overview of the literature used is given.

2.1 Negative Feedback Loop

For centuries people used natural resources to build a living. Since the number of people was relatively small, the people lived in harmony with the ecosystems they inhabited, resulting in enough water, food, and materials without depleting the source. During the twentieth century the world population grew rapidly (UN, 2015). In turn, an increasing number of people needs food, water, and commodities, which put ever more stress on the utilized ecosystems. This higher demand leads to overexploitation of many ecosystems, which are unable to restore and recuperate. This puts these systems in a perpetual circle with negative feedbacks, illustrated in Figure 3.

At present, the world population is still growing and the consumption per capita is rising, increasing stress on land, soils, and available resources. With respect to land degradation, the key feature is that land shortage in the region has led to widespread agricultural use of areas vulnerable for land degradation (FAO, 1994).

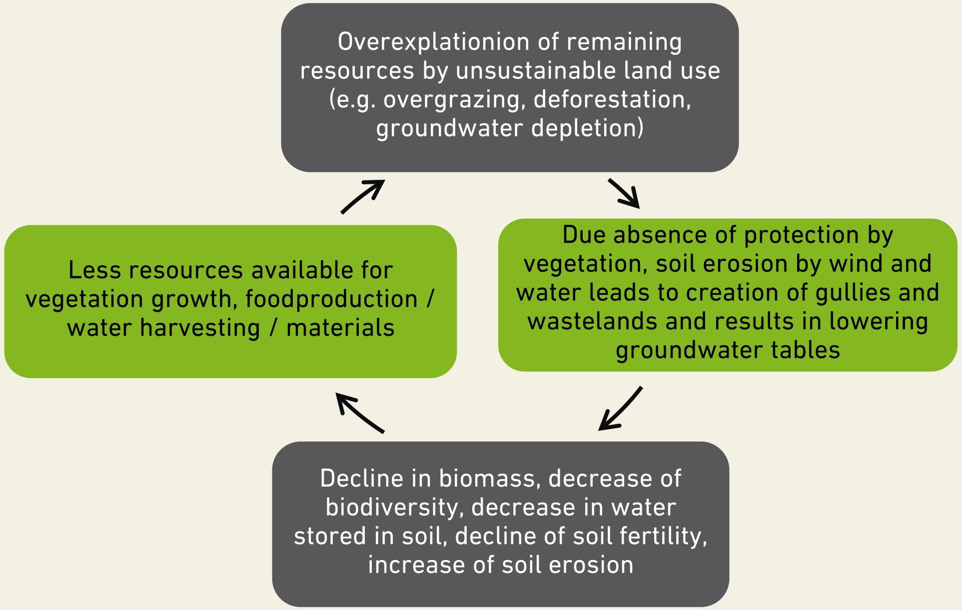

Figure 3: a simplified representation of the negative feedback loop that leads to land degradation

2.2 Causes And Consequences Of Land Degradation

Why is ecosystem restoration needed? The productivity from agriculture has a monetary value. But natural systems, biodiversity, biomass, water infiltrating the soils are often not valued in the same way, but are 'Natural Capital' (Mazzotta, 2000). It seems that non-investing in natural resources leads to destruction and desertification of previous fertile lands.

By degradation lands will become barren, available water and production of foods diminishes and water and food scarcity will occur. This will have several direct and indirect effects:

- In healthy ecosystems water is stored during rainy seasons in soils, naturally delaying the runoff to rivers and feeding downstream wetlands, aquifers (underground water bearing layers) and rivers. The whole catchment benefits the entire year from natural storage during the wet season. Barren lands are less able to hold water, leading to rapid discharge of rainfall. These systems are degenerated, and fertile soils eroded, water is not stored during rainy seasons. Downstream wetlands, aquifers and springs will dry, raising the pressure on the decreased amounts of water left.
- Since less water is available during extended dry seasons and downstream rivers bearing less water, water stress has downstream effects on ecosystems and social economic stability.
- Less water leads to less vegetation. Trees and plants provide the vital service of photosynthesis by taking CO_2 from the air and providing oxygen, reducing greenhouse effects.
- People living in these barren regions are expected to migrate to other regions as climate refugees (Walter, 2005; UNHCR, 2016). The UN already is developing plans to cope with climate refugees.

These negative effects of soil erosion already show the consequences of poor land management. It implies that healthy ecosystems have large benefits. The negative feedback loop can only be broken by drastic changes in land management. Measures should be taken to retain water, so it will be available longer into the dry season, and ecosystems can be restored. The process of ecosystem restoration results in a better future regarding for example more wealth, increasing income, food (security and quality), health and education. Many organizations are already taking measures to prevent environmental degradation and desertification, and to restore ecosystems and reduce related poverty, such as the UNDP-UNEP Poverty-Environment Initiative is doing in Mozambique (UNEP, 2014). It is a fundamental principal to harvest and retain as much water as possible. If rainfall is lost through runoff or evaporation, it will gradually degrade the ecosystem (Liu and Lawton, 2012; Liu and Lawton, 2014). After thousands of years, the ultimate effect is a collapse of the entire ecosystem.

The Millennium Environmental Assessment arranged a clear scheme of processes from human actions leading to poverty or improved well-being (Walter, 2005). The scheme is shown in Figure 4.

At present, large areas are affected by soil degradation and desertification, affecting the lives of millions of people (FAO, 1994; WHO, 2016). Large degraded areas mean opportunities for the future: large areas can be improved, ensuring future generations to survive. If people are the problem, they can also be the solution (Liu and Lawton, 2014). Since the negative spiral is self-enhancing, action should be taken to break out of this negative spiral, and change things positively. By taking measures people can prepare for climate change, making them less vulnerable for the effects of climate change (FAO, 2014).

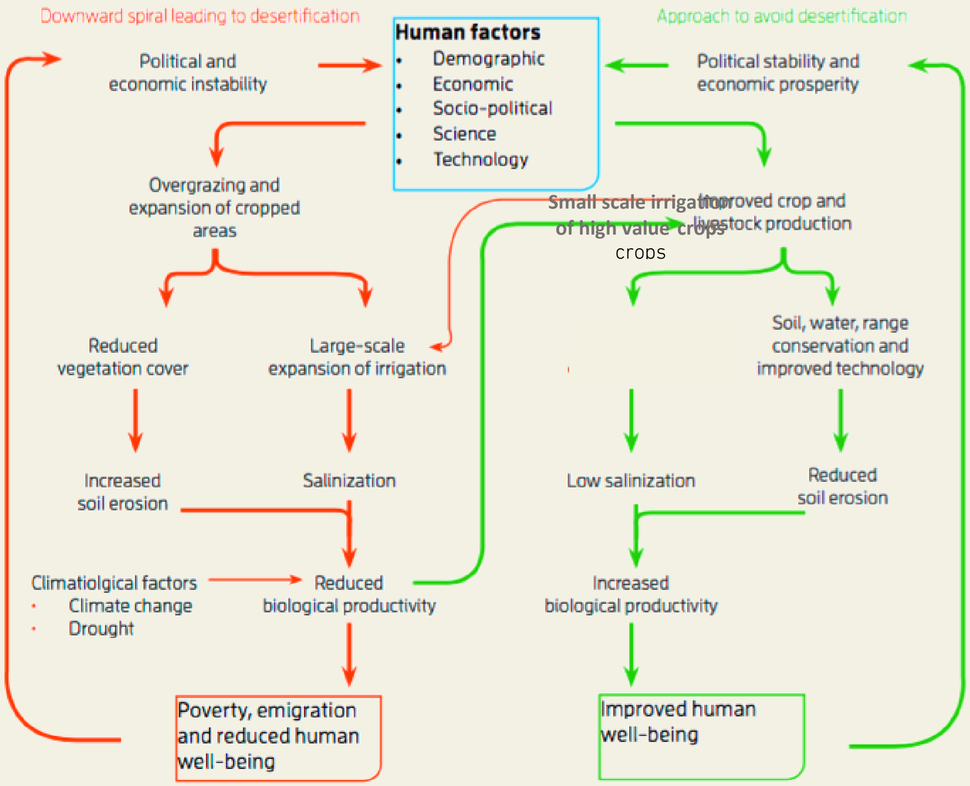

Figure 4: Positive and negative feedback factors, leading from negative human factors to poverty, or from positive human factors to improved human well-being.

Earlier mentioned problems may be aggravated by the effects of the ongoing anthropogenic global warming, and by (multi)decadal natural climate variability.

2.3 The Value Of Ecosystems

The community of living organisms (plants, animals, humans, and microbes) in conjunction with the non-living components of their environment (things like air, water, and mineral soil), interact as a system. This system of living organisms and non-living components form an ecosystem. Humans are fully dependent on earth's ecosystems and the services that they provide, such as food, clean water, the air we breathe, disease regulation, climate regulation, spiritual fulfilment, and aesthetic enjoyment (Mazzotta, 2000; Walter, 2005; Liu and Lawton, 2012; Liu and Lawton, 2014).

Some services that are provided by ecosystems to humans:

- Food
- Water
- Materials
- Climate regulation
- Regulation of diseases
- Wastewater treatment
- Cultural services
- Nutrient cycling

Since humans depend on ecosystems, the degradation of ecosystem services represents a loss of a capital asset (Walter, 2005). As mentioned, restoration of ecological systems starts with water. Our vision is to harvest and retain water, jumpstarting Mother Nature in restoring ecosystems. In the next chapter the processes and feedback loops will be described in more detail.

3 OUR APPROACH IN NINE STEPS

Local interventions can lead to large scale impacts through feedback loops, both positive and negative. The whole process is a complex web of 9 steps with interactions as displayed in Figure 5.

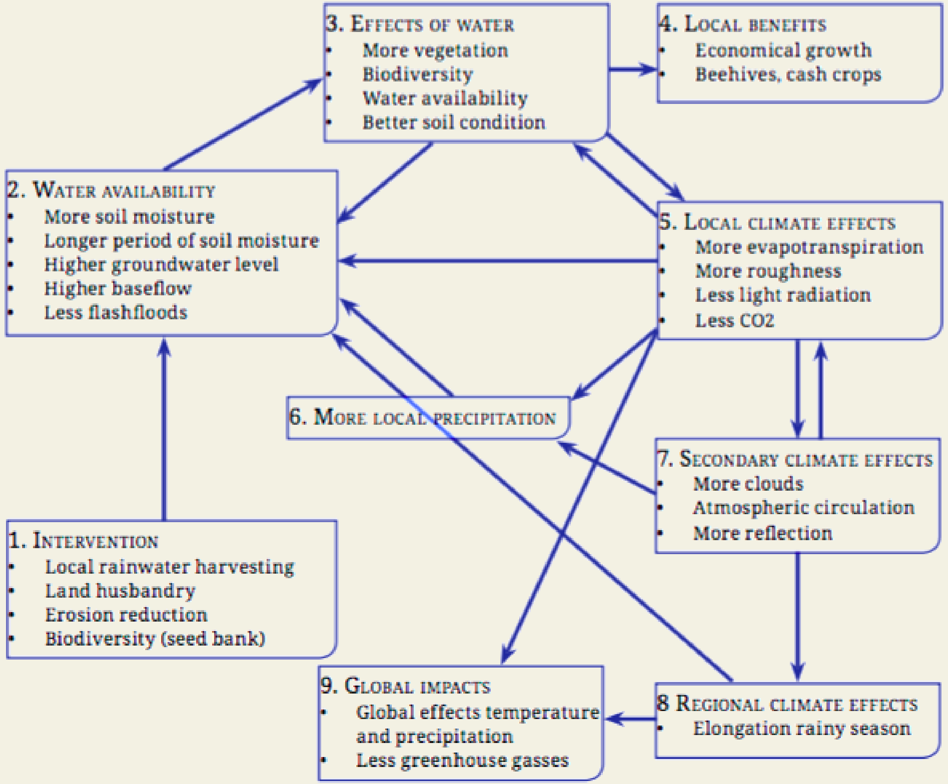

Figure 5: Nine steps how local interventions can lead to global impacts.

The main steps how local changes can lead to a global impact are summarized in Figure 6.

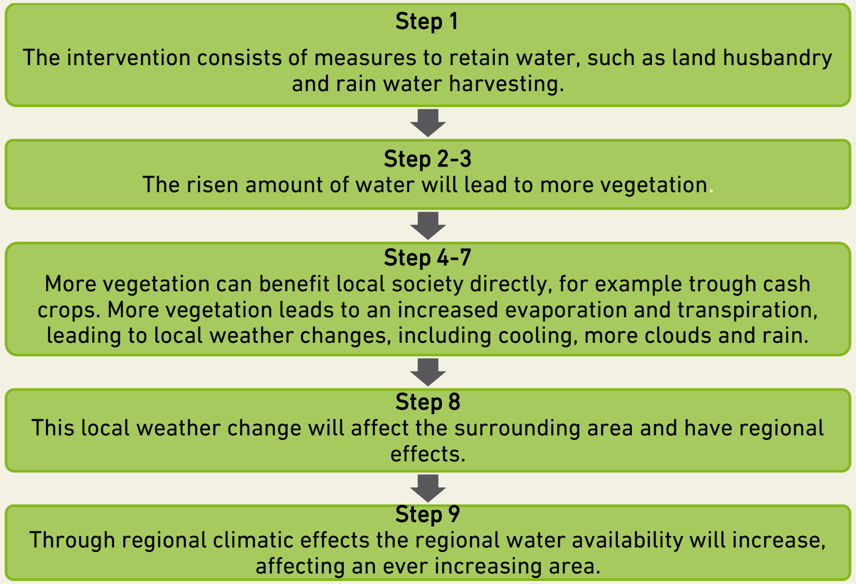

Figure 6: Overview of effect directions of the nine identified steps in the process.

Each of these steps are described in the following paragraphs. Therein we elaborate on the individual contribution of the step to the processes identified in Figure 2 (see Chapter 2) and how they are interlinked (see Figure 6).

3.1 Step 1: Intervention

The first step is to intervene in the present system and break the circle of land degradation. Water retention and restoration of vegetation is at the basis of this step. Many techniques are available to harvest water on different scales, such as contour bunds, terraces, trenches, and dams (IFAD, 2011). Depending on local conditions (gradient, soil type, amount of rainfall, etc.) and culture (farmers or pastoralists) the most suitable techniques are selected. Other helpful soil moisture interventions include permaculture, conservation agriculture, agroforestry, farmer-managed natural regeneration, soil and water conservation. When done on a large scale, this will increase soil moisture and plant growth (UNEP, 2006; Taylor, 2007).

For large impacts and quick results groundworks can be executed to be able to harvest water, which could be combined with reseeding if the soils do not contain enough seeds (Liu and Lawton, 2012; Liu and Lawton, 2014). Through the vegetation soils will develop, and water can percolate into the soils, resulting in more water infiltration, groundwater, and soil moisture.

Figure 7: Semi-circular water bunds in Tanzania that capture runoff water and increase infiltration [image: Justdiggit]

A study by Dale et al. (2000) has shown that there are five fundamental and helpful ecological principles for the land manager and beneficiaries. The ecological principles relate to time, place, species, disturbance, and the landscape. They interact in many ways. The following guidelines are recommended for land managers:

- Examine impacts of local decisions in a regional context, and the effects on natural resources.
- Plan for long-term change and unexpected events.
- Preserve rare landscape elements and associated species.
- Avoid land uses that deplete natural resources.
- Retain large contiguous or connected areas that contain critical habitats.
- Minimize the introduction and spread of non-native species.
- Avoid or compensate for the effects of development on ecological processes.
- Implement land-use and land-management practices that are compatible with the natural potential of the area.

Stakeholder management is of paramount importance. As always, if people do not support a project, it is bound to fail. Providing the option to take land out of use to restore it could be promoted. In this period water harvesting techniques can be implemented and the vegetation cover can. People should be convinced that the trees and other vegetation will provide a more profitable land and should not be removed. The mentality of "Even on healthy soils one cannot eat trees" can be encountered. But it should be explained and demonstrated that vegetation has benefits through shade, soil restoration and enlarging water infiltration capacity. The positives balance out the negatives easily. Insights on several water conservation techniques are for example collected by WOCAT (WOCAT, 2007).

3.2 Step 2: Water availability

Through step 1 more water will infiltrate in the soil increasing soil moisture, which in turn can provide plants more nutrients (Keesstra, 2006). Infiltration of (rain) water will recharge groundwater, elevating groundwater levels and increase groundwater flows. Groundwater is replenished, which leads to a slowed down discharge through springs over time. When water is retained and infiltrated, peak discharges are lowered, slowing down erosion, preventing flash floods and downstream flooding (Taylor, 2007). Infiltrated water also increases the base flow of rivers during dry periods.

Figure 8: A river with sediment-rich water flowing into the ocean [image: Tom Roorda]

3.3 Step 3: Effects of water availability

A higher soil moisture content yields a higher potential for plant growth. More plants contribute to more biodiversity and the rehabilitation of an ecosystem. The plant roots also enable rainwater to infiltrate into the soil, leading to an even increased water availability (positive back loop to step 2). More soil moisture is available, and for a longer period. This results in a longer growing season (Taylor, 2007). Vegetation growth supports an open soil structure, enhancing infiltration. Soil becomes more fertile and vegetation can grow. Soil develops through an increase in organic matter, which in turn holds moisture, and contains nutrients and carbon. The organic matter attracts micro-organisms thus creating a healthy living soil.

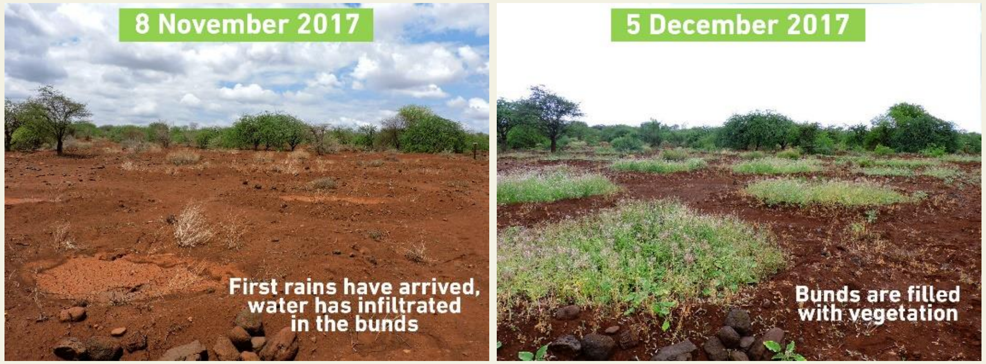

Figure 9: The vegetation can react very rapidly to changes in soil moisture as can be seen in these photographs from Kuku, Kenya [image: MWCT/Justdiggit]

In the first period of restoration measures must be taken to prevent young seedlings being eaten by livestock. The area should be protected from grazing until the local ecosystem is strong enough to regenerate itself. Financial compensation can be given to people who cannot grow crops for this period or keep cattle from grazing. Once a healthy vegetation is present, it is possible to survive droughts. Perennial root systems cause grasses to regrow and local microbiological habitat communities are protected from UV radiation and can grow, improving the soil (Liu and Lawton, 2012; Liu and Lawton, 2014).

Soils will not react to greening in the same way everywhere. Where rainfall is particularly intense, and where soil is particularly clayey or degraded physically, there is greater potential for overland flow and near-surface through flow to contribute to storm flows. In these situations, the best opportunity to restore degraded catchments is through forestation. Where soil is deep and porous and comparatively less disturbed, the effect of forestation on storm flows will be modest and more pronounced through lowered base flows (Scott et al., 2005).

As mentioned, plants cause increased infiltration and more soil moisture. On the other hand, vegetation takes up moisture and transpires moisture, drying the soil. In the start-up period of an ecosystem especially, this may lead to temporarily dryer soils than before. The net effect, the periods in which soil is dryer and the period in which a healthy soil is formed, depends on many factors, such as vegetation type and (rain) water availability. The processes are complex and not always fully understood, but in all cases, vegetation has a positive effect on soil health (Brown, 1997; Keesstra, 2006; WOCAT, 2007).

Soil and water conservation measures will also reduce soil erosion (Taylor, 2007) and land degradation (Liu and Lawton, 2012; Liu and Lawton, 2014). The effects are mainly local (increase in soil moisture, reduced soil erosion) to regional (higher river base flow, higher groundwater levels, reduction of floods and a reduction of soil erosion (and deposition).

3.4 Step 4: Local benefits

Effects such as improved soil conditions and higher soil moisture content are beneficial for agriculture and rangelands. These improved soil conditions will enable vegetation to grow, improved vegetation conditions mean more cash crops, more fodder, more shadow, potential for beehives, etc.

With elevated groundwater levels water wells can yield more water. Overall, communities benefit from increased food, water, and economic security (Taylor, 2007). In turn, this improves livelihoods and creates opportunities for employment, improved health and education (Taylor, 2007; IUCN, 2016).

3.5 Step 5: Local climate effects

Vegetation transpires moisture, which cools down the surrounding air (Werth and Avissar, 2002; Kravčík, 2007) as visualized in Figure 10 by thermal photography. This is direct cooling through vegetation, but also shadow will provide cooling (Pielke Sr et al., 2006; Reij, 2013; EGA, 2016). Reij (2013) shows that vegetation helps to reduce the heat. Even a bit of cover reduces soil surface temperatures by 6 °C. More recent evidence from Justdiggit landscape restoration projects in Kenya shows a reduction in soil temperature of over 10 °C as can be seen in Figure 11.

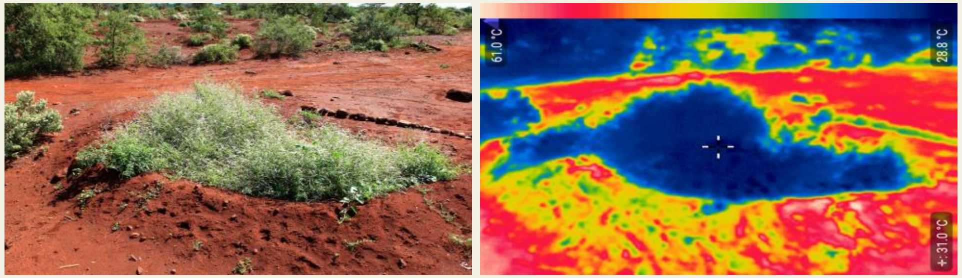

Figure 10: Thermal photograph (right) showing the difference in temperature of vegetation compared to bare soil (blue = low temperatures, red = high temperatures) [image: Sander de Haas].

In tropical landscapes, the importance of forests in cooling local temperatures is recognized by residents (Meijaard et al., 2013; Sodhi et al., 2009). Using the sun's energy, individual trees can transpire hundreds of liters of water per day. This represents a cooling power equivalent to 70 kWh for every 100 L of water transpired (enough to power two average household central air-conditioning units per day). (Ellison et all, 2017).

Figure 11: The difference in soil temperature with and without vegetation can be huge [image: Sander de Haas]

In general, observations and modelling studies agree that afforestation and reforestation decrease near-surface temperatures (Pielke Sr et al., 2006). Analysis of catchment scale landscape restoration in Tigray Ehtiopia shows that the increase in soil moisture and evapotranspiration provides a climate regulation effect in the watershed which resulted in an average decrease in land surface temperature of 1.74 °C (Castelli et al., 2019).

Regreening on a sufficiently large scale, by shrubs and trees with roots deep enough to sustain green leaves longer into the dry season than grasses can, will increase evaporation. This enhanced atmospheric moistening may lead to additional cloud formation and rainfall generation, especially in the aftermath of the rainy season and when helped by orographic lifting (near mountains) (Alterra, 2015).

Figure 12: Orographic cloud at the top of a mountain [Image: NASA]

Vegetation also has effects on the flow of clouds. Clouds formed over sea are transported inland. The new vegetation creates more surface roughness, slowing down cloud transport. Because of this deceleration clouds are concentrated and compacted. Since compact clouds rain out more, more vegetation results in more rainfall (Pielke Sr et al., 2007).

For maximum impact on cloudiness, studies indicate that working in swathes of land 10 km long in a chess board or fishbone pattern can be particularly effective (Taylor, 2007). Added moisture (and drag) from green (and aerodynamically rough) shrubs and trees may trigger and amplify convective rains in conditions that would stay below the thresholds for initiating convection if only withered grasses would be present. This particularly holds in conditions already close to this threshold, i.e. prior and after the rainy season proper. Thus, the wet season could be prolonged, enabling the establishment of more perennials and starting a self-reinforcing process. Additional benefits are related to a reduced variability of rain and an amelioration of heatwaves through evaporative cooling (ALTERRA, 2015). The local climate effect leads to a larger water availability (step 2) and to more vegetation (step 3), inducing a positive feedback loop.

A third factor is the uptake of CO_2. Through the process of photosynthesis, plants use energy from the sun to draw down carbon dioxide from the atmosphere to create the carbohydrates they need to grow. Since carbon dioxide is one of the most abundant greenhouse gases, the removal of the gas from the atmosphere may temper the warming of our planet as a whole (NASA, 2016). Given the fact that CO_2 is a well-mixed greenhouse gas, there is a direct global mitigation effect (Edenhofer et al., 2014). Pielke Sr et al. (2006) lists 34 papers with results supporting the conclusion that there is a significant effect on the large-scale climate due to land-surface processes. This weight of evidence supports the contention that land surface changes affect the climate (Taylor, 2007).

3.6 STEP 6: MORE LOCAL PRECIPITATION

Higher relative humidity has been found to raise the likelihood of precipitation. A 10% rise in relative humidity can lead to two-to-three times the amount of precipitation (Fan et al., 2007; Khain, 2009).

Figure 13: Transpired water from a plant [Image: Ming Kei College, Hong-Kong]

Brown (1997) illustrates that vegetation facilitates an active role in local condensation of moisturized air at low altitudes in mountain areas. Captured moisture by condensation and stem flow, provides sufficient water to roots for growth and maintenance. Well-watered rootzones hold generally more water and prevent excessive loads of rain from runoff by overland flow.

As mentioned in the previous step, the local climate effects cause more local rainfall. This is the result of two factors (as mentioned before):

- More clouds due to increased evapotranspiration
- More rain through compaction of clouds, caused by an increased surface roughness

Increased rainfall in turn influences local water availability, forming a positive feedback loop (to step 2). Los et. al. looked at the Sahel and used satellite evidence and models to establish that vegetated areas increase rainfall by as much as 30% as compared to non-vegetated areas (Los et al., 2006).

The current paradigm about the expected vegetation-atmosphere feedbacks are still topic of debate in scientific communities. For instance, Angelini et al. (2011) rejects the hypothesis that local rainfall comes primarily local evaporation. They found that changes in vegetative cover and state influence the temperature and moisture content of the surface and atmospheric boundary layer but are not reflected in observable precipitation changes.

3.7 STEP 7: SECONDARY CLIMATE EFFECTS

Secondary climate effects affect the availability in turn, forming positive feedback loops. Vegetation evaporates moisture, leading to cloud formation. Cloud formation has three main effects (Taylor, 2007):

- Low altitude clouds: reflect sunlight back to space (large albedo effect) which directly cause cooling of planet. The NASA Earth Radiation Budget Experiment (ERBE) proved conclusively that on average, clouds tend to cool the planet (Ramanathan et al., 1989; Taylor, 2007; Boucher et al., 2013).

- Deep convective (thunderstorm) clouds: carry heat from the earth surface to the atmosphere (convection) from where it is radiated into space, this too causes direct cooling of the planet.

- Increased rainfall (local and regional effect) (volume and duration of rainy season) cause increased soil moisture which lead to increased growth of vegetation. This is a carbon sink and reduces greenhouse gasses which indirectly cools the planet.

Trees and forests too contribute to the intensification of rainfall through the biological particles they release into the atmosphere, which include fungal spores, pollen, bacterial cells and biological debris. These volatile organic compounds enhance condensation (Hallquist and Wenger, 2009; Riccobono et al., 2014) and thereby promote rainfall (Castelli et al., 2017).

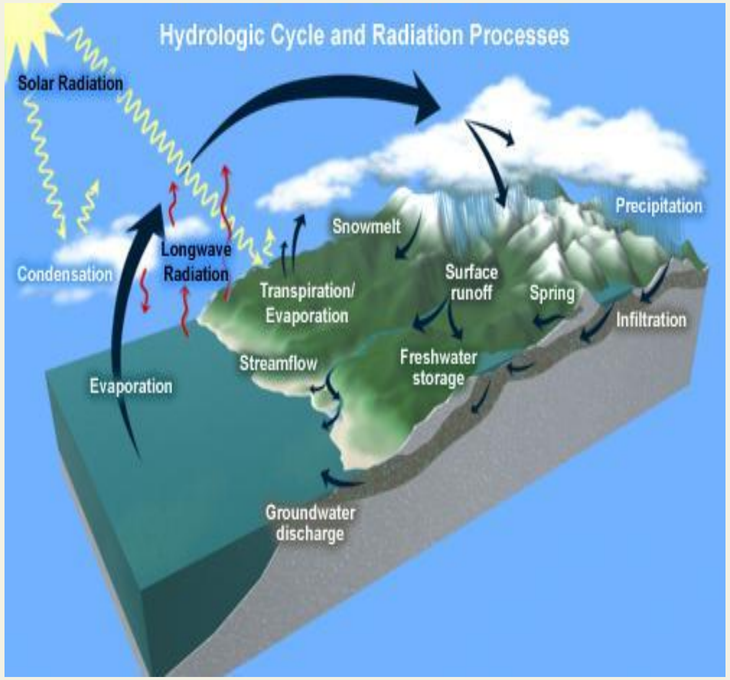

Figure 14: Hydrologic cycle and radiation processes [adopted from NOAA, 2016]

3.8 Step 8: Regional climate effects

Human agricultural land-cover changes can have strong and quite distant effects. The feedback and transport of the atmosphere response due to a landscape change influences vegetation and soil processes at large distance from where the surface change occurred. Also, land-cover changes, both positive and negative, may have significant effects on circulation regimes (such as major jet streams, Hadley cells, monsoon). These shifts in circulation allow the effects of land cover change to be experienced far from regions where the land-cover changes occur (surface-induced teleconnection patterns). This faraway effect is called teleconnection.

The clouds formed at a certain location are transported to adjacent regions. In these adjacent regions clouds have cooling effects, as described in step 7.

Landscape patterning influences the spatial structure of surface heating, which produces focused regions for deep cumulonimbus convection (Pielke R.A, 2001); especially in the tropics and during midlatitude summers. These alterations in cumulus convection tele connect to higher latitudes, which significantly alters the weather in those regions (Taylor, 2007).

Since more water is available and retained in the soil, evapotranspiration continue longer before the soil is dry, elongating the growing season. The rainy seasons also start earlier, because the moisture content of the air is higher, and cloud formation takes place earlier. Xue and Shukla (1996) found that soil moisture reduction not only brought forward the end of the rainy season in West Africa but also delayed its onset. It can be reasoned that the opposite is true as well: increasing soil moisture will increase and lengthen the rainy season. A study for the Indian sub-continent indeed shows that a wetter land surface will trigger some additional precipitation (especially just before and after the monsoon season) and a significant fraction of the evaporation will return to the same river basin as precipitation (Tuinenburg, 2013).

3.9 Step 9: Global climate impacts

The regional climate effects radiate out to even larger areas. If the total area of locations where interventions are carried out increases, an even larger area will be affected. With all positive (and negative) feedback loops global climate impacts are reachable.

The study of Van der Ent et al. (2010) shows that moisture evaporating from the Eurasian continent is responsible for 80% of China's water resources. In South America, the Río de la Plata basin depends on evaporation from the Amazon forest for 70% of its water resources. The main source of rainfall in the Congo basin is moisture evaporated over East Africa, particularly the Great Lakes region. The Congo basin in its turn is a major source of moisture for rainfall in the Sahel. Furthermore, it is demonstrated that due to the local orography, local moisture recycling is a key process near the Andes and the Tibetan Plateau. Overall, it shows the important role of global wind patterns, topography and land cover in continental moisture recycling patterns and the distribution of global water resources (Van der Ent et al., 2010).

Proving a global impact of large-scale landscape restoration projects is difficult, especially since there are many spatial and temporal natural variations which make it difficult to draw definitive conclusions. But several scientific studies indicate the impact of land surface changes on the regional climate, additionally there is the teleconnection process via which local changes have impacts at a great distance. Combined this makes a great case that when carried out at a large enough scale, landscape restoration could impact the global climate.

4 WHERE TO START?

As has been showed in Chapter 1, large parts of the planet are currently degraded or in the process of degradation. It is important to determine where our projects will be most effective on a local, regional, and global scale, to make sure the impact is as big as possible. Several factors determine this:

- Status of degradation.
- Physical conditions.
- Social factors.
- Impact on climate.

4.1 Status of degradation

Areas which are recently degraded or are currently degrading seem the most promising to restore. This is because most of these areas still have some vegetation and/or seeds, soil structure, soil biology and organic matter left. This means that the intensity of the intervention can be much smaller (especially when the state of degradation is still limited), and the effects of the intervention are visible sooner and on a larger scale. Also, the regional effects will be quicker and larger.

4.2 Physical properties

The key factors in our projects are increasing water infiltration, improving soil conditions, and restoring vegetation. This demands that the physical conditions of the areas we work in are suitable and that techniques are implemented that are suitable for that area. The main criteria are soil type, organic matter content, geology, and gradient of the land. These criteria influence the ability of the soil to infiltrate and retain water, which is the basis of land restoration. It also determines how easy it is for vegetation to recover.

4.3 Social factors

To allow a successful implementation of the project, sustainable continuation and follow up, it is crucial that communities, governments (at different scales) and implementing organizations (such as NGO's) are involved from the start of the project. This means they will participate in the project outline, as well as implementation and sustainability of the project. Especially communities (that own or live on the land) need to be fully aware and committed to the project and require extra attention in the process for the project to succeed on the long term.

4.4 Combining the key physical factors

The status of degradation and physical properties can be analysed based on maps (e.g. geology, soil), remote sensing data (e.g. degradation, vegetation cover) and GIS analyses (slope, catchment properties) (Burger et al., 2016). Combining this information with analyses of the impact on climate (through models) and social factors will result in an assessment of areas that are most suitable for restoration (Alterra, 2015).

5 SYNTHESIS

Currently, about 25 percent of the world exists of degraded lands (FAO, 2011), and an additional 12,000,000 hectares degrades each year (UNCCD, 2011). This has local effects (waste lands, drought, and famine), regional effects (decreased rainfall) and global effects on the climate (increasing temperature, less rainfall). Land degradation and its effects are a negative vicious circle, meaning that the negative effects will increase continuously if there is no intervention.

5.1 WATER HARVESTING AS THE KEY

Water harvesting is the key to breaking this negative vicious circle. By harvesting water and allowing this water to infiltrate, the amount of soil moisture can be increased which allows vegetation to recover. This regreening has many positive local effects on vegetation, biodiversity, soil conditions, water availability and the livelihoods of people (Taylor, 2007; Liu and Lawton, 2012; Liu and Lawton, 2014; IUCN, 2016). Apart from these local benefits, regreening can induce changes in the local climatic conditions (Pielke Sr et al., 2006; Taylor, 2007). When carried out on a large enough scale the increased vegetation cover also increases the amount of evapotranspiration and thereby the moisture in the air. This causes local cooling and changes in air circulation. All these processes can increase local cloud formation, temperatures and rainfall.

Figure 15: Semi-circular water bunds in Tanzania filled with vegetation [image: Justdiggit]

5.2 GLOBAL CHANGE

The effects of global climate change may be slowed down and more time is available to take measures to prepare for climate change. Actual impact on communities, and their ecosystems, is determined more by local and regional change. So any actions at the regional level creating regional climatic improvement and decreasing climate vulnerability is worthwhile, whether or not there is a large global impact (Taylor, 2007). If large scale landscape restoration does indeed not only improve the conditions locally, but ultimately has a global climate impact as well, the outcome would be phenomenal.

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