Chapter 11
Restoration of Degraded and Desertified Lands: Experience from Iceland

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Abstract Land degradation and desertification are a real threat to the future of human civilization in addition to being large contributors to the risks of climate change. Iceland has a long history of desertification and land degradation since its settlement by humans about 1,100 years ago. Organized battle against destruction of woodlands and soil erosion in Iceland began with a law that was set in 1907, establishing the Icelandic Soil Conservation Service (ISCS). Experience from the last 100 years shows that the key to success is reaching people through involvement and education using participatory approaches to soil conservation. The current goals of the ISCS are mitigation of land degradation, revegetation of eroded land, and attaining sustainable land use.

Climate mitigation through carbon sequestration in soil and vegetation with land restoration and revegetation must give full consideration to multiple goals, including those of the conventions of combating desertification and conserving biological diversity. In Iceland carbon sequestration is regarded as an added benefit of land restoration efforts, but not a goal in itself. Ecosystem restoration and carbon sequestration through revegetation demonstrates the synergic effects of land degradation and desertification on other environmental goals.

Keywords Desertification • Land degradation • Carbon sequestration • Land restoration • Land management • Afforestation

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Abbreviations

IPCC Intergovernment Panel on Climate Change
ISCS Icelandic Soil Conservation Service
NIR National Inventory Report

11.1 Introduction

Land degradation and desertification are a real threat to the future of human civilization. The Millennium Ecosystem Assessment has ranked land degradation among the world's greatest environmental challenges that is hampering efforts to achieve the Millennium Development Goals in all ecoregions of the world. Vegetation and soil is being lost at an alarming rate in many parts of the world, leading to a wide range of environmental and socio- economic degradation and hazards. Close to 95% of food production is soil based, which therefore makes soil the most precious resource on Earth. With the interaction of current soil losses and projections on population growth, how can enough food be secured in the coming years? The same applies to many of the various services provided by the interlinked ecosystems of the globe. Water storage is dependent on the health of watersheds, but a growing proportion of the world's population is already facing water shortages. A land area of about two billion ha is prone to degradation processes and increases annually by 5–10 million ha (Oldeman 1994).

Desertification is a global problem, not only in its consequences, but also in its extent. It is far from being confined to land degradation in arid, semi-arid and dry sub-humid areas. The world's forests and woodlands are being reduced at an alarming rate in many parts of the world, and large areas are being overgrazed. The weakening of the vegetative cover can lead to a chain of ecosystem disturbances, further reducing the resilience of the ecosystems towards greater degradation. If prolonged, this can lead to desertification in a wide range of moisture regimes.

Land degradation and desertification are also large contributors to the risks of climate change. Land use changes contribute about 25% of agents causing climate change (IPCC 2007a). Equally important is that soil organic matter is the second biggest carbon pool in the planet after the oceans. Climate change, via changes in rainfall patterns and increases in average temperatures, will put further pressure on soil quality and will increase the risk of desertification.

The more carbon we keep in or add to the soil, the less carbon dioxide we will have in the atmosphere. This will not only aid in mitigating global warming, it will also diminish desertification risks, thereby sustaining agricultural production and allowing us to keep feeding the ever growing world population. The more affluent countries of the world must increase their efforts in assisting countries in need. Our common future depends on common solutions.

11.2 Experience from Iceland

Iceland has a long history of desertification and land degradation since its settlement by humans about 1,100 years ago. Organized battle against destruction of woodlands and soil erosion in Iceland began with a law that was set in 1907. Therefore Iceland has possibly the world's oldest Soil Conservation Service (ISCS), established 1907. The main goals of the current law for the ISCS are mitigation of land degradation and desertification, revegetation of eroded land, and attaining sustainable land use.

Iceland is located just beneath the Arctic Circle, on the Mid-Atlantic ridge, one side belongs to the European-, the other to the American tectonic-plate. Its size is 103,000 km^2 and population of about 315,000 people in 2008. The climate is cold temperate to alpine, mean temperature in the south ranges from around −1°C to +11°C.

Iceland was settled by Scandinavian Vikings around 874 AD. They came to a vacant country, although some Irish monks may have had some dwellings there. The Saga period, the first few centuries, was prosperous. The foundation for the initial wealth of the Icelanders was the fertility of the land. About 60% of the country was covered with lush vegetation when it was first settled in 874 (Bjarnason 1942), but today, it is left with only about 35% vegetative cover (Guðjónsson and Gíslason 1998). The forest cover, mostly Downy Birch, *Betula pubescens*, was significantly reduced from 25% since settlement (Bjarnason 1942), to 1.1% in recent decades (Guðjónsson and Gíslason 1998). There are several indications that land decline began soon after settlement. The woodlands were cut for fuel and timber or burned to get space for agriculture and grazing. Regeneration was hampered by heavy grazing and the woodlands began to reduce in size. Some of the Sagas, written about 200 years after these episodes, already then spoke of woodlands *of the past* in some areas. With the reduction of the woodland cover, sensitive soils lost their shelter. Unsustainable land use, interacting with frequent volcanic eruptions and climatic fluctuations, marked the beginning of dramatic ecosystem destruction that still lasts.

For about 1,000 years, Iceland was a country of self subsistence, to a large extent based on hay- and grazing-based livestock production in a harsh environment. Winter survival of livestock was the main determinant of population size until the late nineteenth century. There were many severe winters. If the sheep starved and died, so did the people.

Keeping the nation alive took its toll. The pressure exceeded the ecological capacity, and catastrophic soil erosion and desertification devastated large parts of the country. Much of remaining vegetation is severely degraded. A national survey of the nature and extent of soil erosion was completed in 1997, revealing that serious soil erosion is still occurring in about 40% of Iceland (Fig. 11.1, Arnalds et al. 2001).

There is much at stake for the Icelandic nation in restoring soil fertility. Not only soil and vegetation in extensive areas have been lost. Biological diversity has been greatly reduced, land fertility diminished, hydrology altered and local climate changed. Immense amounts of carbon have been lost (Figs. 11.2–11.5). Since settlement, around 20 million tons of carbon stored in vegetation may have been lost (Jónsson and Óskarsson 1996), and 120–500 million tons of soil organic carbon (Óskarsson et al. 2004). Iceland may have lost in total the equivalence of at least

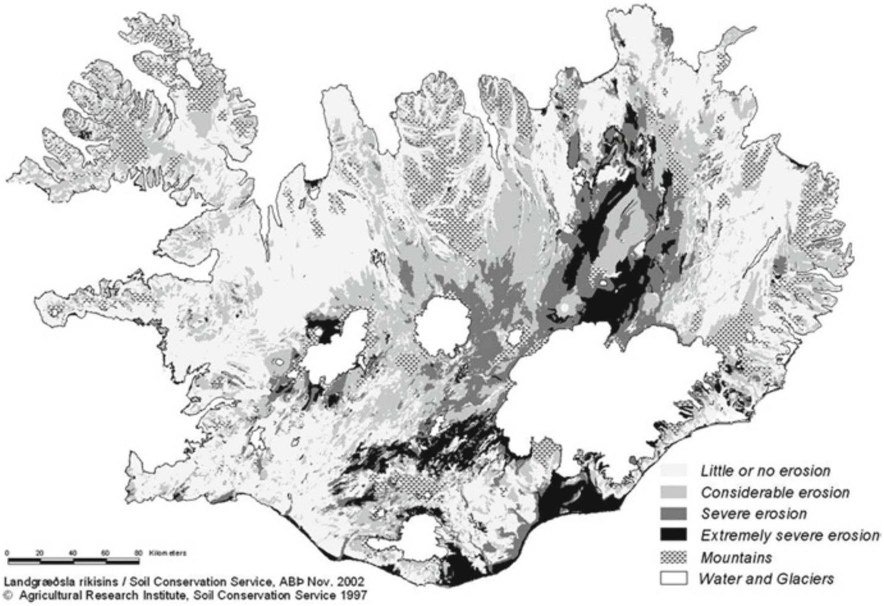

Fig. 11.1 Soil erosion in Iceland. Of the total area of Iceland of 103,000 km^2, little or no erosion covers an area of 37.3%, considerable erosion 22.5%, severe erosion 11%, and extremely severe erosion covers 6.2% (Arnalds et al. 2001)

Fig. 11.2 Erosion escarpments at Arnardrangur in W-Skaftafellssýsla county, show vividly the magnitude of soil erosion. The erosion has resulted in the complete removal of the soil profile down to bedrock or the lava surfaces leaving isolated islands or areas with some remaining soil and degraded vegetation. The complete lack of vegetation on the eroded surfaces shows that erosion in this site is still ongoing and severe. (Photo, Björn Barkarson ISCS)

Fig. 11.3 Þjórsárdalur valley in Árnessýsla county. Hardy grass species are used for reclamation in order to stabilize the surface of vast areas that was a source of sand drift prior to reclamation. Fertilization is required for 2–4 years to begin with in order to facilitate and speed up natural plant succession. Seeded species regress as fertilization effects wear off and natural succession continues the process. Area to the right on the photo shows the condition of the land prior to action, a deserted area with no vegetation. (Photo, Sigşrúður Jónsdóttir ISCS)

1.6 billion tons of CO_2 since 874. This is 500 times more than emissions in the baseline year of 1990. These figures are likely to be underestimates. It is difficult to assess the fate of the carbon. Much of the finer and the more valuable soil is blown long distances, much of it being lost to the ocean. Some is redistributed making remaining soils thicker, and some is carried by water either for resettlement or lost to lakes and the ocean.

Fighting catastrophic erosion is a legal responsibility of the government. During the last 100 years the key to success has usually been found by reaching people through involvement and education. Since 1990, there has been an increase in participatory approaches to soil conservation. A number of policies and practices have been set into action to arrest land degradation and to restore land and soil quality.

The highly successful “Farmers heal the land” project includes a “cost sharing” partnership with farmers, with conservation work jointly funded by government and farmers. The evolving “Better farms” project combines the forces of soil conservation, forestry, extension and nature conservation in aiding land users to produce their own property plans. The farmers have the highest stakes, as their income depends directly on the quality of the land. They play a key role in carbon sequestration. They own most of the land to be restored and with their machinery and knowhow they have an enormous capacity. About 600 farmers (25% of the total

Fig. 11.4 Beach Wildrye (*Leymus arenarius*) has been used to stabilize drifting sands and eroding fronts in Iceland for more than a century. It is the only plant species that is capable of tolerating and halting sand drift. It does not tolerate competition well and a decline of vigour in *L. arenarius* is commonly observed on sand dunes in Iceland that have become stabilized and colonized by other vascular plant species (Photo, Elín Fjóla Þórarinsdóttir ISCS)

number of farmers) participate with the Icelandic Soil Conservation Service in "Farmers heal the land".

A major step in conservation was taken with the current contract on agricultural support between sheep producers and the government. It has a cross-compliance clause, i.e. about a third of the support is dependent on quality of land use. Starting in 2003/2004, farmers must verify sustainability of their operation to the ISCS in order to obtain a full subsidy. Farmers not meeting standards must submit a conservation and land improvement plan for ISCS approval.

A Parliament agreed program gives the ISCS an operational framework for the period 2003–2014. This forms Iceland's equivalence of a National Action Plan for Combating Desertification. This 12 year program emphasizes mitigating land degradation and desertification, reclamation, sustainable land use, research, extension and awareness-raising. It includes provisions for strengthening cooperation with non-governmental organizations (NGOs), land users and other interest groups. Measures will be taken so that soil conservation will be in line with policy on development and nature conservation. The strategy also aims to fulfill international agreements on desertification and nature conservation that Iceland is a party to.

The 2008 government budget of the ISCS is US $6 million. With a population of 315,000 this is equivalent to about US $19 per capita.

Fig. 11.5 Remnants of lush birch (*Betula pubescens*) shrubs and forest still remain in eroded sites, shown here in Hraunteigur S-Iceland. These small isolated forest remnants bear evidence to the extensive woodlands and prolific ecosystems that were in place in the past (around 1850) in all of the northern part of Rangárvallasýsla county in S-Iceland. After extensive erosion the remaining vegetation was highly degraded such as the birch in this photo. (Photo, Sveinn Runólfsson ISCS)

11.3 Carbon Sequestration and Climate Change

Warming of the climate system is unequivocal, both carbon dioxide and global temperatures are rising (IPCC 2007b). The greenhouse effects add on natural fluctuations, making them more extreme. Climatic change might have more profound effects in Iceland than most of its inhabitants realize, both on its sensitive and vulnerable nature and on the active lifestyle of the Icelanders. However, these effects are hard to predict, and they could turn out to become either highly beneficial or catastrophic, with a wide range in between.

Iceland may be regarded as a cool country, and it is on the borderline for crop agriculture. A slight increase in the mean annual temperature could make Iceland the nicest spot on Earth, with a very comfortable climate. Iceland is in a warm period, possibly with the highest mean temperatures since before year 1200. As a result, glaciers that cover 10% of the island are retreating. Some estimates even predict that much of the glaciers will have disappeared after about 200 years at the current rate. Iceland would then lose one of its strongest characters and sources of beauty.

Iceland is blessed with plentiful hydrological- and geothermal power. Over 99% of electricity production and almost 80% of total energy production comes from hydropower and geothermal energy. More than 80% of houses in Iceland are heated with geothermal hot water, and most of the rapidly growing large scale industry is based in hydrological power. No other nation uses such a high proportion of renewable energy resources as Iceland. The composition of sources of emission of greenhouse gases in the baseline year of 1990 therefore may be unusual, with industry, transportation and fishing roughly emitting close to a third each. The transformation to sustainable energy took place long before 1990. Iceland therefore has more limited options than most other nations in reducing greenhouse gas emissions. This uniqueness was met in the Kyoto protocol by allowing Iceland to increase its emissions by 10% above the 1990 baseline during the first commitment period. A special clause to the Protocol has also been approved that allows countries with small overall emission and where single projects have a large effect, to exclude emissions from projects above a certain size up to a total of 1.6 million tons of CO_2 per nation. Some call this the "Icelandic clause".

Left with limited options for reducing greenhouse gas emissions, carbon sequestration is a significant tool in the Icelandic Climate Change Action Program in meeting commitments for the Kyoto Protocol. This is based on the fact that reducing emissions, preventing degradation of soil and vegetation, and carbon sequestration are all important tools in meeting the goals of conserving climate. With regard to land fertility, CO_2 may be regarded as a misplaced resource that vegetation can convert back to organic matter, to be stored in biota and soil.

Encouraged by the success of mitigation and restoration work for 100 years, the Icelandic government decided to use carbon sequestration in soil and vegetation to meet emission targets for year 2000 and established a special action program for 1997–2000. This led to some fund increase for halting soil erosion, revegetation and reforestation, compared to previous years.

A data base is being built up for carbon sequestration bookkeeping purposes for both soil conservation and forestry. Research so far indicates an average carbon sequestration rate for revegetation of 0.75 tons carbon/hectare per year, or 2.75 tons of CO_2 equivalents (NIR 2007). Revegetation in Iceland often involves converting previously unvegetated area ('other land') into grassland. Much of this carbon is stored in the soil. This may be regarded as a rather high rate, but volcanic soils as those in Iceland can store high amounts of carbon. In re- or afforestation the annual C removal factor of 1.2 t C ha^{-1} is used in the UNFCCC inventory as a precautionary estimate of data from Icelandic Forest Research, including both surface biomass and below ground biomass of coarse roots in living biomass (NIR 2007). The rate ranges widely whether it is from forestry in reclamation- and other poor condition or under better conditions using introduced species. Carbon sequestration in Iceland due to revegetation in 1990–2005 amounts to more than −244 Gg CO_2 (NIR 2007). There is no shortage of land to be reclaimed in Iceland, and it is of vital importance for the Icelanders to improve living conditions and increase food security for the future.

In carrying out projects of carbon sequestration for climate conservation purposes, full consideration must be given to multiple goals, including those of the conventions of combating desertification and conserving biological diversity. In Iceland the carbon sequestration is regarded as an added benefit, but not a goal in itself. A misplaced resource is being returned back to the land for a variety of purposes benefiting both current and future generations. Carbon sequestration by restoration of land health should not be regarded as an "escape route" from reducing emissions. It is an additional tool, a true win–win opportunity for both preventing climate change and meeting food requirements and other needs of the worlds growing populations. Ecosystem restoration and carbon sequestration through revegetation also demonstrates the synergic effects of mitigating land degradation and desertification on other environmental goals.

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