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Implementing SDG target 15.3 on "Land Degradation Neutrality"

Development of an indicator based on land use changes and soil values

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Implementing SDG target 15.3 on "Land Degradation Neutrality"

Development of an indicator based on land use changes and soil values

by

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Abstract

In September 2015, the UN General Assembly adopted the Sustainable Development Goals (SDGs), including target 15.3 which contains the objective to strive towards Land Degradation Neutrality (LDN) by 2030. This has opened a "window of opportunity" for many countries to strengthen policies for sustainable use of land and soils and can be seen as a chance to revive EU land and soil policies, which have seen little momentum after the withdrawal of the Soil Framework Directive proposal in 2014.

This report serves as a contribution to inform and prepare the implementation of LDN in the EU. It was developed as part of the research project "Implementing the Sustainable Development Goals on Soils"[1], carried out by Ecologic Institute on behalf of the German Environment Agency. Parts of this report have also been used in a background paper for a workshop with representatives from EU Member States held on December 6, 2016 at the European Commission in Brussels in order to exchange on approaches of implementing LDN in the EU.

More specifically, the report (i) gives an overview of the definitions and concepts behind LDN, (ii) provides a suggestion of necessary steps and guiding questions towards the implementation of LDN at the national level, (iii) gives an overview of land and soil degradation in Europe, existing monitoring schemes and policy processes that are relevant for the implementation of LDN in Europe, (iv) summarizes the ongoing process of conceptualizing and implementing LDN in Germany and, finally, the report (v) introduces an approach for a new indicator which uses land use categories as a possible proxy indicator for LDN in Germany. Each category is assigned with a certain soil value that considers the exposure to soil threats, building on and further extending the hemeroby (naturalness) concept. With regards to (iv) and (v), a report in German ("Land Degradation Neutrality - Handlungsempfehlungen zur Implementierung des SDG-Ziels 15.3 und Entwicklung eines bodenbezogenen Indikators") has been developed within the same project. It provides more detail on the German implementation process and the concept of the developed indicator. These two reports are complementary.

Kurzbeschreibung

Dieser Projektbericht setzt sich mit der Umsetzung des durch die UN Nachhaltigkeitsziele 2015 eingeführten Zieles der „Land Degradation Neutrality" (LDN) auseinander (SDG 15.3) und zielt auf eine Unterstützung der Umsetzung des LDN Zieles in der EU. Hierzu werden die Kernideen, Definitionen und Umsetzungsansätze des LDN Konzeptes auf der internationalen Ebene vorgestellt sowie eine siebenstufige Vorgehensweise zur Umsetzung des LDN Zieles für die nationale Ebene entwickelt. Schwerpunktmäßig wird auf die Ausgangslage zur Umsetzung von LDN in der EU eingegangen. Hierzu werden die wesentlichen europäischen Trends und Bodengefahren aufgeführt, ein Überblick über bestehende Boden-Monitoringaktivitäten in der EU gegeben sowie der Stand der Bodenpolitik bzw. Umsetzung des LDN Zieles in der EU reflektiert. Zudem wird in Kurzform der Stand der deutschen Umsetzungsaktivitäten zu LDN sowie ein für den deutschen Kontext entwickelter Indikatorenansatz vorgestellt, der einen Beitrag zum Monitoring von LDN leisten kann. Dieser Indikator ordnet Landnutzungen unter Einbezug des Hemerobiekonzeptes (als Maß der Naturnähe) ökologische Bodenwertigkeiten zu.
Die beiden letztgenannten Aspekte – der Stand der deutschen Umsetzung, bzw. die Entwicklung eines Indikatorenansatzes zur Unterstützung des Monitorings von LDN – werden ausführlicher in einem separaten deutschsprachigen Bericht mit dem Titel „Land Degradation Neutrality - Handlungsempfehlungen zur Implementierung des SDG-Ziels 15.3 in Deutschland und Entwicklung eines bodenbezogenen Indikators" vorgestellt. Der deutsche und der vorliegende englische Bericht sind nicht identisch.

[1] http://ecologic.eu/12876

Während der vorliegende Bericht den Fokus auf die Umsetzung von LDN in der EU richtet, wird im deutschsprachigen Bericht stärker auf die Rahmenbedingungen und Umsetzung in Deutschland eingegangen. Beide Berichte wurden im Rahmen des Projektes „Erreichen einer „Land Degradation Neutral World" - Indikatoren und Handlungsempfehlungen zur Implementierung eines SDG-Targets zu „Land Degradation Neutrality"" erarbeitet.

Table of Contents

List of Figures ... 8
List of Tables ... 8
List of Abbreviations ... 9
Summary ... 11
Introduction ... 13
1 Definitions and concepts ... 15
1.1 Preliminary considerations on terminology and concepts ... 15
1.2 What is "Land Degradation"? ... 15
1.3 What is "Land Degradation *Neutrality"*? ... 16
1.4 International agreements on indicator selection and monitoring of LDN ... 17
1.4.1 Selection of indicators ... 17
1.4.2 Data and methods of computation ... 18
2 Steps and guiding questions to implement LDN on a national level ... 19
2.1 Define and tailor LDN in the national context ... 20
2.2 Define suitable indicators ... 21
2.3 Define baseline and set targets ... 21
2.4 Specify the spatial dimension ... 22
2.5 Determine compensation mechanisms ... 23
2.6 Set up and maintain LDN monitoring system ... 24
2.7 Improve enabling environment ... 24
3 Implementing LDN in Europe – where are we starting from? ... 26
3.1 Soil threats and trends in land degradation in Europe ... 26
3.1.1 Soil sealing ... 26
3.1.2 Erosion ... 27
3.1.3 Compaction ... 27
3.1.4 Loss of soil organic carbon ... 27
3.1.5 Contamination with pollutants ... 27
3.1.6 Nutrient surplus/over-fertilisation ... 28
3.1.7 Loss of soil biodiversity ... 28
3.1.8 Desertification ... 28
3.1.9 Salinisation ... 28
3.1.10 Acidification ... 29
3.1.11 Landslides ... 29
3.2 Soil functions ... 29

3.3 Existing monitoring systems 31

3.3.1 Types of data collection in monitoring systems 32

3.3.2 European monitoring systems 32

3.3.3 International monitoring systems and relevant data/assessments 33

3.4 Implementing LDN: Synergies to other policies 34

3.4.1 Relevant international policies 34

3.4.1.1 Sustainable Development Goals (SDGs) 34

3.4.1.2 Linkages to the UNCBD and UNFCCC 35

3.4.1.3 FAO Voluntary Guidelines for Soil Management 35

3.4.2 Relevant European policies 35

3.4.2.1 EU soil policy 35

3.4.2.2 The Common Agricultural Policy 37

3.4.2.3 Climate and Energy policy 38

3.5 SDG implementation in the EU 38

3.6 Potential process to facilitate LDN implementation in the EU 41

4 Overview of German activities and project results 41

4.1 Activities in Germany to implement the SDGs/LDN 41

4.2 Tailoring of LDN to the German context: results of the research project 42

4.3 Development of a new LDN indicator concept using Land Use Change as a proxy 44

4.3.1 Categories for land use and land use change 45

4.3.2 Integration of the hemeroby concept into a land use classification 47

4.3.3 Assigning soil values to land use categories 48

4.3.4 Benefits and limitations of the indicator and transferability of the approach 50

5 References 52

6 Annex I List of interviewees 57

List of Figures

Figure 1 Steps t implement LDN on a national level 20
Figure 2 Most relevant soil threats in Germany according to expert interviews....43
Figure 3 Suitable indicators according to expert interviews 43
Figure 4 Land Degradation Neutrality: Balancing gains and losses....44
Figure 5 Development of the Land Use Change Indicator....48
Figure 6 Assigning Soil values for Land Use Categories based on soil threats 50

List of Tables

Table 1: Ecosystem services of soils and the associated soil functions 30
Table 2: Soil functions identified in the proposal for a Soil Framework Directive....31
Table 3: Comparing different land use categories 46
Table 4: Classification of hemeroby for different land uses (adapted from Fehrenbach, Grahl and Busch 2015)....47

List of Abbreviations

BMUB	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety)
CAP	Common Agricultural Policy
CBD	UN Convention on Biological Diversity
CLC	CORINE Land Cover
COP	Convention of the Parties
CSO	Civil Society Organisations
DLR	Deutsches Zentrum für Luft- und Raumfahrt (German Aerospace Centre)
EAP	Environmental Action Program
EEA	European Environment Agency
EESC	European Economic and Social Committee
EPSC	European Political Strategy Centre
ESDAC	European Soil Data Centre
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	The statistical department of the FAO
GAEC	Good Agricultural and Environmental Conditions
GEF	Global Environment Facility
GSP	Global Soil Partnership
HLPF	High-Level Political Forum
IAEG-SDGs	Inter-Agency and Expert Group on Sustainable Development Goal Indicators
INSII	International Network of Soil information Institutions
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
ISRIC	ISRIC - World Soil Information
ITPS	Intergovernmental Technical Panel on Soils
IUCN	International Union for Conservation of Nature and Natural Resources
IWG	Intergovernmental Working Group
JRC	Joint Research Centre
LDN	Land Degradation Neutrality
LUCAS	Land Use/Cover Area frame Statistical Survey
LULUCF	Land Use, Land Use Change and Forestry
MAES	Mapping and Assessment of Ecosystem Services
MDGs	Millennium Development Goals

MFF	Multiannual Financial Framework
MS	Member State
MSA	Mean Species Abundance
NGO	Non-Governmental Organisation
PFD	Policy Forum on Development
SDGs	Sustainable Development Goals
SDO	Sustainable Development Observatory
SFD	Soil Framework Directive
SLM	Sustainable Land Management
SOC	Soil Organic Carbon
SPI	Science Policy Interface
TEEB	The Economics of Ecosystems and Biodiversity
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNFCCC	United Nations Framework Convention on Climate Change
UNCCD	United Nations Convention to Combat Desertification
UNCCD SPI	United Nations Convention to Combat Desertification Science-Policy Interface
VGGT	FAO Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests
WOCAT	World Overview of Conservation Approaches and Technologies

Summary

The continuing degradation of land and soils is a severe threat to the provision of ecosystem services and economic development in Europe and globally. The pressures on land are increasing due to urbanisation, population growth and rising demands for food, feed, fuel and fibre. Halting land degradation is therefore a prerequisite for sustainable development.

In the past several years the concept of "Land degradation Neutrality" (LDN) has received increasing attention at the international policy level. "Neutrality" means that the concept is not only about halting the loss of healthy and fertile land, but also about actively reversing degradation by restoring land in order to counterbalance losses that cannot be avoided. With the adoption of the SDGs by the UN General Assembly in September 2015 including target 15.3 to strive towards LDN by 2030, it is now up to all countries to implement this goal.

However, as of July 2017 national implementation is still in the early stages, taking place in only a few countries and mainly involving the first steps of target setting. The first attempts to initiate this have been undertaken by the UN Convention to Combat Desertification (UNCCD), e.g. through the LDN "Target Setting Program", which more than 100 countries have joined thus far. In September 2016, the UNCCD Science Policy Interface also published a "Conceptual Framework" intended to support the processes to achieve this goal.

It also needs to be noted that within each country, the implementation of LDN and the definition of indicators requires the consideration of the individual national circumstances, e.g. with regards to environmental preconditions, main soil threats, trends, data availability, and also political objectives. Moreover, the SDG targets are defined in the 2030 Agenda for Sustainable Development as "aspirational and global", with each government tailoring its own national targets and indicators "guided by the global level of ambition but taking into account national circumstances". So there is not only the room for but also the intention to tailor the targets and their monitoring according to regional and national needs.

As for the EU as a whole, and most of its Member States individually, the discussion on the implementation of the SDGs in general and LDN in particular are still at an early stage. However, many argue that this implementation process is an important "window of opportunity" to bring new life into soil and land policy in the EU, and provides opportunities for integrative policies that can achieve benefits for climate change, biodiversity, food security, and support agricultural and water policies.

To explore the opportunities and limitations for a common approach for defining the concept of "Land degradation Neutrality" in the EU and to exchange perspectives on the approaches already taken or planned for defining and implementing LDN, the workshop "Implementing SDGs target 15.3 in the EU and in the Member States: Exchange on approaches to implement 'Land Degradation Neutrality' (LDN)" was held on December 6, 2016 at the European Commission in Brussels.

This report and the organisation of the expert workshop are the result of the research project "Implementing the Sustainable Development Goals on Soils"[2], carried out by Ecologic Institute on behalf of the German Environment Agency. A large part of this report served as a background paper for this workshop.

The project aimed to initiate a national discussion on the options for implementing LDN in Germany and to develop appropriate indicators that might help in monitoring the implementation. As Germany is one of the first EU countries taking efforts to implement LDN in their national policies, the expert workshop in Brussels was organized to share ideas about LDN implementation, provide experiences

2 http://ecologic.eu/12876

from Germany about the progress so far and eventually explore opportunities and limitations for a common approach in the EU. The results of the above mentioned workshop are documented in the workshop minutes available online[3].

This report serves as an overview document about the necessary starting conditions to implement LDN in the EU, and it also provides information about the main results of the German research project in English. With regard to the latter, a separate complementary report in German is available ("Land Degradation Neutrality - Handlungsempfehlungen zur Implementierung des SDG-Ziels 15.3 und Entwicklung eines bodenbezogenen Indikators"). It provides more detail on the German implementation process and the concept of the developed indicator.

Specifically, this report (i) gives an overview of the definitions and concepts behind LDN, (ii) provides a suggestion of necessary steps and guiding questions towards the implementation of LDN at the national level, (iii) gives an overview of land degradation in Europe, existing monitoring schemes and policy processes that are relevant for the implementation of LDN in Europe, (iv) summarizes the ongoing process of conceptualizing and implementing LDN in Germany and, finally, this report (v) introduces a new indicator approach to serve as a proxy indicator for LDN in Germany. This new indicator uses land use categories as a proxy indicator. Each category is assigned with a certain soil value that considers the exposure to soil threats, building and further extending the hemeroby (naturalness) concept. The general assumption of this approach is that changes in land use directly correspond with changes in the natural functions of soil and soil quality and that some land uses have less adverse effects on soil than others. The values can then be used to calculate a balance of losses and gains for areas that changed their land use and allow for the assessment of how far LDN has been achieved. However, in order to use the indicator concept in practice, the preliminary assigned categories and soil values need to be tailored to the regional circumstances and must be subject for further discussion with all relevant stakeholders.

[3] http://ecologic.eu/14648

Introduction

The Food and Agriculture Organization of the United Nations (FAO) estimates that land degradation already impacts over 20% of the world's population. Through population growth, as well as a shift in consumption patterns and an increase in the demand for meat and renewable resources, fertile soils are coming under ever increasing pressure. At the same time, significant amounts of fertile soils are already being lost to degradation processes.

Degradation is estimated to affect 30% of all soils worldwide; 33% of pastures, 25% of cultivated lands and 27% of forests are deemed degraded (Nkonya, Mirzabaev, and von Braun 2016a). Annually, an estimated 10 to 12 million hectares of fertile soil is lost due to mismanagement globally (BMUB 2013; Global Mechanism of the UNCCD 2016b). The scale of soil degradation in the EU is also significant, with approximately 22% of European land affected by water and wind erosion (Jones et al. 2012). Around 45% of the mineral soils in Europe have low or very low organic carbon content, soil contamination is affecting up to three million sites, and an estimated 32-36% of European subsoils are classified as having high or very high susceptibility to compaction (Jones et al. 2012). An increase in soil sealing has also been identified due to construction and infrastructure development (EEA 2015b).

Land degradation and restoration causes substantial costs. Soil is considered a non-renewable resource because it can take centuries to develop under natural conditions and it is impossible to completely restore once degraded. The restoration process leads to considerably higher costs than the costs incurred to avoid of degradation in the first place (FAO 2015a). The total cost of the impacts of global soil degradation amounts to more than 230 million USD annually – 0.41 % of the global GDP (Nkonya et al. 2016). The subsequent costs are not borne only by the land users and stakeholders whose livelihoods depend on the degraded soils, but also by the entire global population since soils play an important part in the provision of ecosystem services, e.g. food production as well as water and climate regulation (UBA 2015; Nkonya, Mirzabaev, and von Braun 2016a).

Given the pressure on land use and its impact on societies, land and soil protection and the restoration of degraded land have become important issues in the international political agenda and are seen as an essential prerequisite to ensure the realization of further development targets, such as the protection of biodiversity, global food security, climate protection, and the reduction of poverty.

Since 2012, the concept of "land degradation neutrality", first called" zero net land degradation"[4] also entered the global sustainable development discourse. This concept was and still is new and ambitious as it not only seeks to avoid and reduce degradation of land but also to combine it with measures to reverse degradation, in order to arrive at neutrality / no net loss.

With the adoption of the 17 UN Sustainable Development Goals (SDGs) that apply to both developing and developed countries, "Land Degradation Neutrality" (target 15.3) is now also a part of the 2030 UN Agenda for Sustainable Development.

Academic studies have been conducted to further specify a conceptual approach towards the implementation of LDN (Caspari, van Lynden, and Bai 2015) and there are many countries that have started to incorporate the LDN targets into their national policies, e.g. through the UNCCD LDN Target Setting Programme and – more recently – with the development of a "scientific conceptual framework" to implement LDN (Orr et al. 2017).

However, in Europe the debate about how to incorporate LDN into national policies is still in an early phase and many questions remain to be answered, e.g. if the "Member States are ready to achieve LDN by 2030", if the European Commission should support "a common LDN target setting and monitoring

[4] The concept behind is approximately the same, just the wording has changed slightly since 2012.

approach" (Montanarella 2016), and how a conceptual approach and process to incorporate LDN into Member States' (MS) policies would look like.

To discuss these questions and to find a suitable way forward for the specific needs of a European approach, the workshop "Implementing SDGs target 15.3 in the EU and in the Member States: Exchange of approaches to implement 'Land Degradation Neutrality' (LDN)" held on December 6, 2016 in Brussels served as an opportunity to exchange experiences and views.

This report compiles the information that was discussed at this workshop, summarizes the main workshop conclusions in terms of follow-up processes to implement LDN in the EU (chapter 3.6) and adds findings from the work on a new indicator approach (chapter 4.3) that was developed after the workshop.

Overall, the report is structured as follows: In order to have a common understanding of the potential issues of achieving LDN in Europe, the report begins by highlighting the main elements of existing conceptual approaches, explaining the relevance of key terminology used, including the definition of land degradation and land degradation neutrality, and providing information about indicators and monitoring for LDN (Chapter 1). Acknowledging that the variety of approaches to implement LDN in national contexts does not allow for a "one size fits all" solution, this report provides a suggestion for steps within a national process and guiding questions that are intended to help the national (and European) implementation of the Land Degradation Neutrality concept (Chapter 2). It then gives an overview of current policies and processes with both global and EU level relevance for implementing LDN that may provide synergies in the EU implementation process (Chapter 3). Chapter 4 briefly summarizes the current state and debate in Germany on how to implement LDN, including the possible introduction of the proposed indicator (based on land use and land use changes) to measure LDN in Germany.

1 Definitions and concepts

1.1 Preliminary considerations on terminology and concepts

Arriving at a common understanding of the key terms "Land Degradation" and "Land Degradation Neutrality" is a starting point for implementing SDG 15.3 and requires a consideration of the current terminology and concepts.

Recently, some work has been done to further specify a conceptual approach towards the implementation of LDN. In particular, the UNCCD has been very active in further defining the concept through its "conceptual framework" (Orr et al. 2017) and through the UNCCD LDN Target Setting Programme. These have helped many countries to start implementing the LDN targets in their national policies.

In particular, it is necessary to differentiate between "land" and "soil" - terms that are often used interchangeably. In July 2015, the 12th Conference of the Parties to the UNCCD agreed on a differentiation between the terms. According to the UNCCD, there are overlaps between land and soil, but they do not denote the same thing: "while soil constitutes one of the most essential natural resources of our planet, the land comprises a multifunctional ecological system, whose natural capital, soil and biodiversity, interacting with water and atmosphere, generate the flow of ecosystem services that support human wellbeing by securing the life and livelihood of individuals and communities" (UNCCD 2015, para. 22). Land therefore comprises soil, but also consists of many more dimensions and interactions with vegetation (Stavi and Lal 2015).

1.2 What is "Land Degradation"?

The term Land Degradation has long been the subject of scientific and political debate, for example in connection with the subjects of desertification, deforestation, soil erosion, or certain management approaches such as "sustainable land management". With the discussion about a "land degradation neutral world" in the context of the SDGs, the term "land degradation" has acquired new and stronger political weight.

The UNCCD has played a major role in establishing the definition and character of the term "land degradation" at the international level, in referring to Article 1 of the text of the UNCCD.

A slightly refined version of the UNCCD definition has also been included in the official definition used for the implementation of SDG target 15.3:

Land Degradation

"Land degradation is the reduction or loss of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes arising from human activities." (IAEG-SDGs 2016)[5]

At the core of this definition are the provided functions and economic value of land for agriculture and forestry, which are promoted by human activities and negatively manifest themselves in the form of measurable phenomena such as erosion, soil quality loss and loss of vegetation.

In contrast to the UNCCD definition, other institutions such as the IPBES and the Global Environment Facility (GEF) have a broader and less specific interpretation of land degradation and see it more as the loss or reduction of ecosystem services and functions and do not differentiate between human activities or natural degradation processes. All definitions share the understanding that land degradation includes both the absolute and the relative/partial loss of ecosystem functions.

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5 IAEG-SDGs (2016)

Despite the attempts to clearly define land degradation it remains a fuzzy concept or, as Caspari, van Lynden, and Bai (2015) refer to it, a "blurred entity" because it has various dimensions, occurs at multiple scales, involves a great variety of actors and above all is value-laden. This has to be kept in mind when discussing LDN in detail.

1.3 What is "Land Degradation *Neutrality*"?

Land Degradation Neutrality was first introduced as a concept in the run-up to the Rio+20 conference. In this context, the UNCCD Secretariat published a policy brief on a potential goal of "zero net land degradation" (UNCCD Secretariat 2012). In the outcome document of Rio+20 entitled "The future we want", the heads of State and Government "recognize the need for urgent action to reverse land degradation. In view of this we will strive to achieve a land degradation neutral world in the context of sustainable development" (UN General Assembly 2015).

As mentioned above, the term is included as target 15.3 under Goal 15 of the Sustainable Development Goals:

"Goal 15. Sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss." (UN General Assembly 2015)

Target 15.3 states:

"By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world" (UNDESA 2016)

The definition used in the context of SDG implementation at the international level makes clear reference to the third decision of the 12th COP of the UNCCD (Dec 3/COP12). This decision was provided by the UNCCDs Intergovernmental Working Group (IWG) and represents the general political as well as scientific consensus on the term:

Land Degradation Neutrality

"Land degradation neutrality is a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems." (IAEG-SDGs 2016)

The core and innovative part of this definition is that in order to "remain stable or increase" efforts for land restoration, rehabilitation and sustainable management are necessary if degradation processes cannot be avoided.

Nonetheless, due to the many ambiguous terms in the definition and inherent conflict of objectives, the definition of LDN needs further specification, technical guidance and adaptation to the regional context in order to be implemented. This includes, for example, the following considerations:

- **Baseline**: In order to assess if land resources remain stable or increase, a baseline needs to be set. Given the shortcomings of global available data, practical solutions need to be found.
- **Ecosystem functions**: The definition broadly refers to ecosystem functions and services. However, there are often trade-offs between provisioning, regulating and cultural services that need to be taken into account (e.g. intensifying agricultural food production increases provisioning services but often decreases regulating services).
- **Balancing quality and quantity of land degradation and restoration**: Both the "amount and quality of land resources" should remain stable or increase. However, questions remain regarding how degradation and restoration can be balanced: Within or across ecosystem types? Within what spatial scale and timeframe? How to deal with the different quality of land degradation processes (i.e. complete loss versus certain reduction in services and functions)?

In an effort to make the LDN concept more concrete, the SPI of the UNCCD defined a number of principles[6] to be followed by all countries that choose to pursue LDN. They state that "there is flexibility in the application of many principles but the fundamental structure and approach of the framework are fixed, to ensure consistency and scientific rigour"(UNCCD/Science Policy Interface 2016; Orr et al. 2017).

Building on these definitions and addressing the remaining open questions, Chapter 2 will give an overview of the necessary steps to make the LDN concept applicable and implementable in practice.

1.4 International agreements on indicator selection and monitoring of LDN

In March 2016, half a year after the adoption of the SDGs an agreement on indicators was achieved. For SDG 15.3, the indicator agreed upon is "Proportion of land that is degraded over total land". It is defined as the amount of land area that is degraded. The measurement unit for indicator 15.3.1 is the spatial extent (hectares or km2) expressed as the proportion (percentage) of land that is degraded over total land area (IAEG-SDGs 2016).

1.4.1 Selection of indicators

The **minimum set of indicators** recommended (but not compulsory, see chapter 1.4.2) for tracking progress towards LDN against a baseline is:

- **land cover**
- **land productivity** (metric: net primary productivity)
- **carbon stocks above and below ground** (metric: soil organic carbon)

These indicators are part of a set of six progress indicators used by the UNCCD to track progress in the implementation of the Convention through national reporting. They have also been included as suggested indicators for the implementation of target 15.3 (Global Mechanism of the UNCCD 2016a).

These indicators provide a practical common ground for monitoring and reporting progress towards SDG target 15.3.:

- "Land cover and land cover change has multiple applications for evaluating progress towards various SDG targets and gives a first indication of land degradation" and a first indication of a reduction or increase in vegetation, habitat fragmentation and land conversion (Global Mechanism of the UNCCD 2016a).
- Land productivity points to long-term changes in the health and productive capacity of the land.
- Soil organic carbon denotes overall soil quality (Global Mechanism of the UNCCD 2016a). On seasonal to decadal timescales, **carbon stocks** of natural and managed systems may be explained largely by changes in plant biomass ("fast variable") but, on longer time scales, soil organic carbon stocks ("slow variable") become a more relevant indicator of the functioning of the system, its adaptive capacity and resilience to perturbations (e.g., floods, drought), and thus its capacity to provide ecosystem services in a sustainable manner over the long term.

These indicators **may be enhanced and complemented by other relevant national (or subnational) indicators**, in order to obtain an even more accurate picture of the current status and progress made (Global Mechanism of the UNCCD 2016a; IAEG-SDGs 2016).

[6] 19 principles that include broad requirements such as to "protect rights of land users" and "respect national sovereignty", and more specific principles such as to "apply response hierarchy: avoid, reduce, reverse land degradation" and to "counterbalance like for like".

1.4.2 Data and methods of computation

The accompanying document to the SDG indicators provided by the UN Statistical Commission (UN-STAT) / the Inter-Agency and Expert Group on Sustainable Development Goal Indicators (IAEG) (with support from the UNCCD secretariat with regard to target 15.3) states that "in order to operationalize this global indicator, further work is needed to provide a standardized approach and 'good practice guidance' to derive the sub-indicators and help build monitoring and reporting capacities at the national, regional and global levels" (IAEG-SDGs 2016).

The current approach for measuring and assessing LDN is described as follows (IAEG-SDGs 2016):

"The most common method involves the use of site-based data to assess the accuracy of the sub-indicators derived from Earth observation and geo-spatial information. Another approach uses site based data to calibrate and validate Earth observation indices and measures where the remote sensing variable is used to predict the same biophysical variable on the ground. A mixed-methods approach, which makes use of multiple sources of information and combines quantitative and qualitative data, will likely be used to:

1. **Set Baselines** to determine the initial status of the sub-indicators in absolute values. This would include: 1) the preparation of base land cover information which builds on standard land cover ontology (e.g., LCCS/LCML); 2) the establishment of a baseline for land productivity (e.g., NPP/NDVI); and 3) the establishment of a baseline for carbon stocks, above and below ground, with an emphasis on soil organic carbon below ground and building on the IPCC's work on carbon above ground.
2. **Detect Change** in each of the sub-indicators, including the identification of areas subject to change and their validation or evaluation by a participatory national inventory of land degradation, particularly where change in two or three of the sub-indicators coincide or overlap spatially. When contextualized with information at the national and sub-national levels, areas with declining productivity and carbon stocks may be considered degraded while areas with increasing productivity and carbon stocks may be considered improving. The definition of adverse or desirable land cover changes is highly contextual and needs to take into account local ecological and socio-economic circumstances which require in-situ validation.
3. **Derive the Indicator** by summing all those areas subject to change, whose conditions are considered negative by national authorities (i.e., land degradation) while using "good practice guidance" in their measurement and evaluation of changes within each sub-indicator and their combination."

While the document of the IAEG suggests that "areas with declining productivity and carbon stocks may be considered degraded" (suggesting that if two of the three indicators show a negative trend, land is to be considered as degraded), more recent documents provided by the UNCCD refer to a **"one-out, all-out"** approach . This means, that "if any of the three indicator metrics shows significant negative change, it is considered as a loss (and conversely, if at least one indicator/metric shows a significant positive change and none shows a significant negative change it is considered a gain)" (UNCCD/Science Policy Interface 2016).

In terms of **data availability**, the IAEG-SDGs (2016) argues that:

- "For land cover and land cover change, most countries have quantitative data and mapping capacities which are derived primarily from Earth observation.
- For carbon stocks, countries regularly report to the UNFCCC according to a tiered approach.
- For land productivity, data for large geographical areas can be derived using Earth observation.

Following the 2006 IPCC Guidelines (IPCC 2006) with regards to estimation methods at three levels of detail, from tier 1 (the default method) to tier 3 (the most detailed method), the following approach for indicator 15.3.1 is proposed:

- Tier 1: Earth observation, geospatial information and modelling
- Tier 2: Statistics based on estimated data for administrative or natural boundaries
- Tier 3: Surveys, assessments and ground measurements

Each of the tiers may have a unique approach as to how driver (land management/use) and state (land resources) variables interact in a land degradation assessment (FAO 2016a), which depends primarily on the data and upscaling methods available. This approach would allow national authorities to use methods consistent with their capacities and resources. A decision tree would guide the selection of which tier to use for estimating the sub-indicators according to national circumstances, including the interpretation and availability of data. For Tier 1, global and regional data sets are available from a number of reliable sources." (IAEG-SDGs 2016).

However, since the use of the three indicators is not compulsory for the implementation of the SDGs, the next few months will show if this concept is taken up and what indicators countries will use to complement this set of indicators. Some discussions on this have already taken place within an expert meeting on land degradation that the European Environment Agency (EEA) had organized in March 2016. According to the meeting notes and the EEAs work on the Land Degradation Assessment Framework Roadmap "it appeared to be difficult to map changes in ecosystem services using only the sub-indicators adopted by the UNCCD. Additional information is required on land conditions, driving forces and impacts of these" (Verzandvoort et al. 2016).

A common use of these indicators, however, has the advantage that the actual reported results on degraded land are somewhat comparable internationally.

2 Steps and guiding questions to implement LDN on a national level

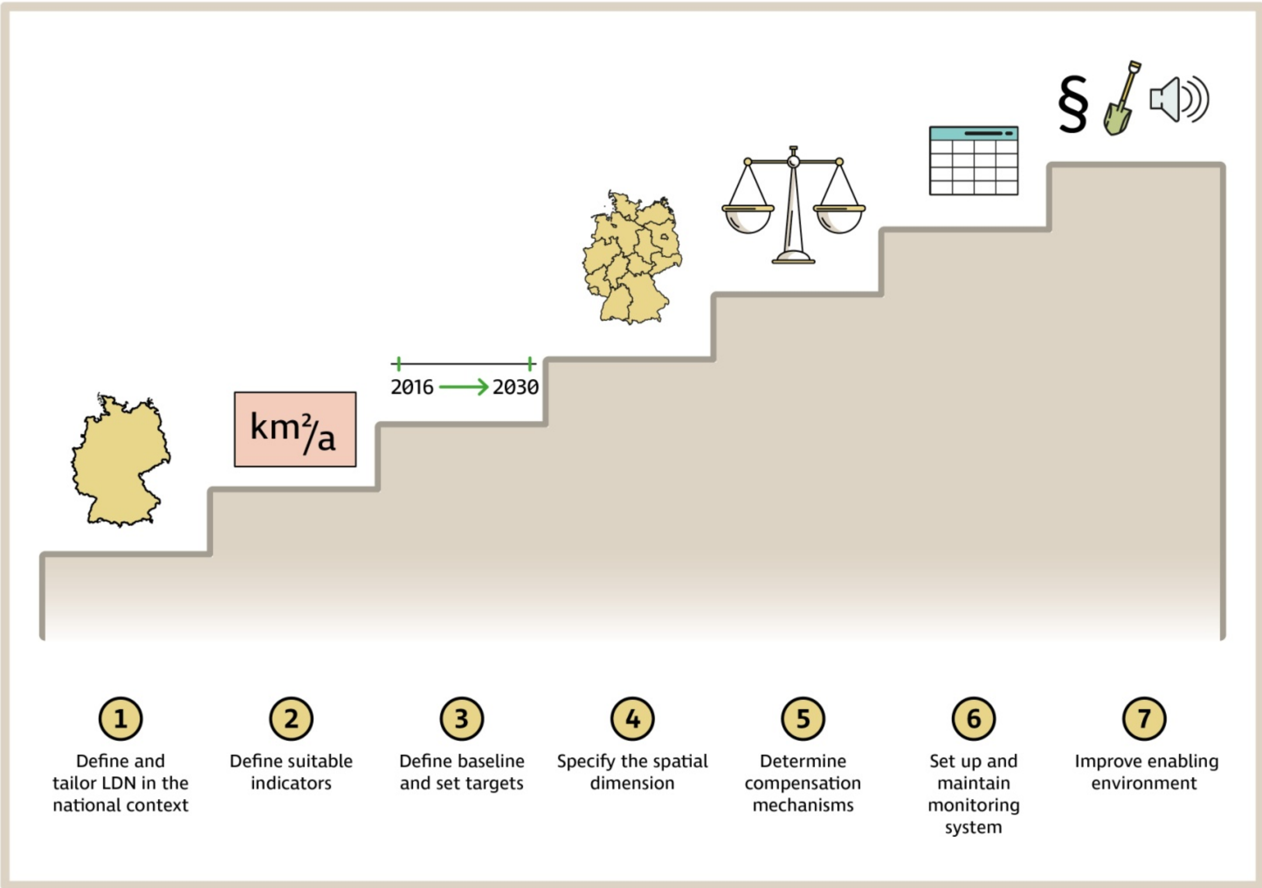
Due to the open questions derived from the incomplete definition of LDN (see section 1), many aspects of the concept need to be concretised in order to guide countries in applying the concept in practice.

Moreover, the SDG targets are defined in the 2030 Agenda as "aspirational and global", with each government tailoring its own national targets and indicators "guided by the global level of ambition but taking into account national circumstances". So there is not only the room for but also the intention to tailor the targets and their monitoring according to national needs.

Due to the complexity of land degradation, countries will need guidance for LDN incorporation into their national policies. This chapter will outline a stepwise approach for advancing the implementation of the LDN concept. The approach is divided into seven key strategic steps (see Figure 1):

1. **Define and tailor LDN in the national context**
2. **Define suitable indicators**
3. **Define baseline and set targets**
4. **Specify the spatial dimension**
5. **Determine compensation mechanisms**
6. **Set up and maintain monitoring system**
7. **Improve enabling environment**

Figure 1 Steps t implement LDN on a national level



Source: Own presentation, Ecologic Institute

The activities of the UNCCD and the target setting program are valuable sources of learning for implementing LDN, as many activities have already started before the SDGs were adopted. For example, the summary about the experiences made and lessons learned with regards to the 14 UNCCD LDN pilot projects (Global Mechanism of the UNCCD 2016b) and the summary on "Building blocks for LDN Target Setting" (Global Mechanism of the UNCCD 2016a) are very useful inputs for designing national policies. Another recent publication of the UNCCDs Science Policy Interface provides a scientific conceptual Framework for Land Degradation Neutrality, including LDN principles and suggestions for monitoring and effective implementation (UNCCD/Science Policy Interface 2016, Orr et al 2017).

Accordingly, this list of key steps and guiding questions described in more detail below builds on recent activities, experiences and publications of the UNCCD, and also goes beyond to include new thoughts on further aspects to be considered

2.1 Define and tailor LDN in the national context

Different biophysical and climatic preconditions in different countries, also in addition to varying economic developments, result in a wide spectrum of soil threats, drivers of land degradation and trends in land degradation. Some soil threats are less relevant in some countries, such as salinisation in Germany or landslides in the Netherlands, but more relevant in others. An important starting point to better understand the national context and particular needs is to carry out an assessment of historic and ongoing land degradation trends to help identify the relevant types of land degradation.

The first step therefore involves a thorough analysis of the biophysical environment and socioeconomic aspects (Akthar-Schuster et al. 2016) of the country. Building on the key drivers of land degradation, scenarios that forecast gains and losses if current land use trends continue and planned projects and policies are implemented should be compiled showing different alternatives of future development (Global Mechanism of the UNCCD 2016a). In parallel, efforts to work on a long term perspective of land use, i.e., "the progressive development of a manageable final landscape", should be undertaken (Akthar-Schuster et al. 2016).

The scenarios can help to make decisions on national priorities and goals in the context of land degradation, for example if LDN should particularly enhance the productivity of the land for agriculture or if natural soil functions should be restored.

Multi-stakeholder engagement needs to be secured from the very beginning of such target and priority setting processes (Global Mechanism of the UNCCD 2016a). Experiences made in the 14 UNCCD pilot projects showed that involving existing institutions that have already dealt with LDN related issues in the past proved more effective for most countries than creating completely new consultation bodies (Global Mechanism of the UNCCD 2016b)[7]. The assessment also showed that a high level political commitment (e.g. from ministries) is a key factor for successful LDN target setting and implementation (Global Mechanism of the UNCCD 2016a).

2.2 Define suitable indicators

Suitable indicators have to be developed considering both the national priorities of LDN (see 2.1.) as well as data availability and representation of all sectors (e.g. the indicators' relevance for agricultural, forestry and urban land).

In many of the 14 UNCCD pilot countries the choice of the three proposed indicators (see 1.3.) provided "a simple, practical way to consistently and uniformly assess the extent of land degradation. (...) Some countries used global data as the main source, while others used national data in combination with - or as an alternative to - global data, according to their needs and capacities. In isolated cases, significant differences between global and national data were found" (Global Mechanism of the UNCCD 2016b).

However, that does not automatically mean that the three proposed indicators are suitable for measuring LDN in all countries. Priorities in soil and land degradation trends as well as existing national reporting activities could direct attention onto other indicators or monitoring concepts. This also involves the question of how an aggregated indicator could be developed to reduce efforts in data collection and aggregation of different indicators in an overall LDN balance. When developing such an indicator, it needs to be kept in mind that every aggregation step bears a potential loss or distortion of information. This should be considered when choosing a methodology (Feldwisch, Balla, and Friedrich 2006). Chapter 4.3 provides a suggestion for an integrated/proxy indicator for LDN based on land use change assessments combined with the hemeroby concept.

2.3 Define baseline and set targets

SDG 15.3 sets the year 2030 as the target date to aim for global LDN. Strictly speaking, LDN does not have to be achieved by 2030, as the goal stipulates "to strive to achieve" by 2030. The time factor has two aspects: First, a baseline date needs to be set. Second, it needs to be settled at which point/soil quality the intended target state should be counted as achieved.

From the text of SDG 15.3 and the UNCCD definitions, it remains uncertain which reference state should apply to neutrality, i.e. from which original condition soil should not be more degraded by

[7] The experience of pilot countries also suggests that working groups should at least meet twice a year with the sole purpose of reviewing the LDN target setting process. The national Ministries of Finance and Planning should also be involved early in the process (Global Mechanism of the UNCCD 2016b).

2030. The UNCCD definition merely states that there is a reference period, but it is not specified further: *"the amount and quality of land resources...remain stable or increase within specified temporal...scales and ecosystems".*

Consequently, countries have to define their own "baseline". Given the ambiguity of the LDN definition, they have room to set different levels of ambition, depending if they want to achieve "stable" conditions of land resources or even achieve an improvement of the current situation. Earlier reference dates (for example the year 2000) are usually more ambitious than later ones (e.g. 2016), as land degradation has increased almost everywhere in the past decades. If a reference year is even set in the future (e.g. 2020), land use changes that are implemented prior to that year will not be considered, which could have harsh consequences regarding further land degradation (see, for example, political discussions about the relevance of reporting dates for the conversion of grasslands and the removal of landscape elements in NABU and DVL 2014).

Once the baseline is set, a clear understanding of the intended target state in 2030 needs to be developed. It has to be taken into account that compensatory or restoring measures can vary significantly in terms of their temporal effect. In other words, soil decontamination and restoration processes usually need markedly more time than soil degradation processes. The question therefore is, how different effects and timespans between degradation, regeneration and restoration should be balanced against the target state in 2030. This leads to further questions such as: Should degradation already encompass small or early decreases in soil function (Akhtar-Schuster et al. 2016), or only threats that can lead to a massive loss of soil functions/soil-related ecosystem functions (König 2016)? What is a "significant" change in soil quality, e.g. is an increase from 47 to 50 tC/ha already "significant" or should the "threshold" be higher or lower (see Conceptual Framework of the UNCCD/SPI (2016))? Such questions must also be regarded in consideration of national experiences and existing assessment frameworks.

During the UNCCD pilot project, most countries also analyzed the financial feasibility of the measures required to meet the proposed targets. Some set several targets with different levels of ambition, according to their respective capacities and potential financing opportunities (Global Mechanism of the UNCCD 2016b).

2.4 Specify the spatial dimension

For the implementation of LDN, the spatial scale for balancing degradation against restoration and regeneration must be determined. Depending on the national context it could be beneficial to separate the country in different regions with different geographical conditions (e.g. mountainous areas and plains) or administrative units (e.g. provinces or federal states). The International Union for Conservation of Nature and Natural Resources (IUCN 2015) argues for a stronger orientation on ecological parameters and proposes the ecosystem level for balancing land degradation. Similar, the Conceptual Framework of the UNCCD/SPI (2016) argues for a "landscape level" (such as catchment areas). Furthermore, it argues for counterbalancing "like for like", which means that compensation measure could apply only within the same land (use) category. It has to be noted that the smaller the scale of balancing, the larger are the efforts of aggregating results in order to track degradation neutrality at a national scale. Such a decision also involves the question of which administrative unit or body is responsible for the data collection and analysis.

Many experts who were interviewed within the German research project "Implementing the Sustainable Development Goals on Soils" raised the point to even include "extra-territorial effects" in the national balance for LDN, given that the "virtual net import of land" through the consumption of imported goods puts pressure on land resources in other countries.

2.5 Determine compensation mechanisms

Along with considering the spatial-temporal dimension of the LDN concept, compensation mechanisms need to be established. However, it must be clarified beforehand if and to which extend land and soil degradation is taking place. For this, information about the state and management of the concerned areas needs to be compiled and analysed. Two possible approaches for the determination of degradation are:

- **Benchmarks**: Reaching a fixed benchmark (e.g. concentration of pollutants, amount of soil organic carbon) would give insight into whether a soil area is degraded or recovered. However, due to the very complex characteristics of soils, it is nearly impossible to deduce such an absolute benchmark from a scientific perspective (except for some pollutant concentrations). Furthermore, benchmarks are usually defined in terms of impairments of soil functions – and for many impacts it is almost impossible to set fixed benchmarks for degradation as it is usually a gradual process. Finally, all impacts that are severe but do not reach the set benchmark would not be considered in LDN accounting or considered in the net balancing and would thus not have to be compensated.
- **Dynamics of change:** The benefit of observation and assessment of the dynamics of improvement and degradation is that they make it possible to gain a quick overview, as long as indicators are available. However, the question remains at which point compensation measures are to be undertaken when the initial condition of the considered areas varies significantly.

As outlined above, degradation must be counterbalanced against compensation measures. The UNCCD Secretariat differentiates between three main measures that can prevent or reverse land degradation (UNCCD 2012):

- **Natural regeneration**: Avoiding and reducing anthropogenic impacts (for a set period of time) on the degraded area to ensure regeneration through natural processes, e.g. laying fallow. However, by solely utilizing regeneration, degraded ecosystems have little chance to reach their original state (Ngo 2015).
- **Improved land use practices** (Sustainable Land Management)**:** Sustainable Land Management (SLM) can lead to an improvement of soil quality and thereafter stabilizes the state of the soil (Gnacadja 2012). The FAO defines SLM 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". SLM represents regionally adapted land use systems which often make sense only at the local level. In April 2014, the UNCCD recommended the World Overview of Conservation Approaches and Technologies (WOCAT) as an important SLM database. More than 470 technologies and 235 approaches for SLM are presented there. The UNCCD identifies several SLM practices, such as mulching, zero tillage, green manuring and water harvesting (UNCCD SPI 2015).
- In contrast to SLM, Landscape Management is a concept with a broader scope (Dernier et al. 2015). Unlike SLM, the Landscape Management Approach and the interlinked monitoring evaluation scale focus on the landscape level and thus on the interdependence of ecosystems. This management approach embraces important functional inter-linkages.
- **Restoration** (human activity to restore the natural basis of an ecosystem). Active restoration of ecosystems is necessary when the degree of degradation is too high to utilize the land productively and natural regeneration is not practical or too slow. The Convention on Biological Diversity defines the restoration of ecosystems as an active management process to restore a degraded, damaged or destroyed ecosystem for the conservation of ecosystem resilience and biodiversity. However, this definition does not specify at which state an ecosystem is restored,

so this has to be reassessed separately for each ecosystem. A variety of ecological factors play a role in the composition of species and functional groups that define the stability or resilience of ecosystems (cf. Tucker et al. 2013). Restoration of ecosystems requires a lot of time, as well as physical and financial expenditures. However, this approach is worthwhile if long term effects and cost reduction are considered (de Groot et al. 2013). In the global analyses by "Economics of Land Degradation" it was stated that the financial benefits of investing in the restoration of ecosystems is up to five times higher in many regions than the associated costs for a period of thirty years (Nkonya, Mirzabaev, and von Braun 2016).

For practical implementation, the UNCCD proposes a clear hierarchy between these compensation measures (UNCCD Global Mechanism 2016) in which:

- Interferences with ecosystems should be **avoided as a first priority**
- If this is impossible, **negative impacts should be reduced**
- If both are impossible, **negative impacts should be compensated** (in another location)

Furthermore, a compensation principle should be implemented that focuses on the ecosystem based inter-linkages between degradation and restoration:

1. More area should be restored than degraded (especially due to the time lag between rehabilitation and the uncertain effects of taken measures).
2. Compensation measures should be applied in similar ecosystems (i.e. the same ecosystem type)
3. Compensation measures should be in-situ or as close to the area of degradation as possible (see, e.g. Chasek et al. 2015)

2.6 Set up and maintain LDN monitoring system

To monitor and evaluate LDN achievements, a centralized land management/land degradation monitoring and evaluation information system must be established. This monitoring and evaluation system should be institutionalized within an appropriate permanent body to facilitate cross-sectoral collaboration. Whenever possible, such a system should be based on existing monitoring and evaluation systems. The information generated by these systems must be accessible to all authorities that have an impact on land use (Global Mechanism of the UNCCD 2016a).

Moreover, land cover/use, land productivity dynamics and soil organic carbon databases and data processing methodologies must be further enhanced both at the national and global levels (measurement accuracy, resolution, periodicity) to ensure effective monitoring of progress made towards the achievement of LDN targets. Although sustainable land management can be easily monitored using the land cover/land use change/land productivity indicators, further development of the soil organic carbon indicator is essential in connection with climate change policies (Global Mechanism of the UNCCD 2016a).

2.7 Improve enabling environment

Improving the enabling environment not only relates to the further development of instruments and capacity building of institutions, but also includes awareness raising and communication to foster support of the LDN process.

To achieve LDN, new possible interventions (e.g. analysis of legal, economic, social and political enablers) and measures need to be considered (Akthar-Schuster et al. 2016). It is also essential to ensure an enabling environment and responsible governance of land resources including land tenure, to establish mechanisms for integrated land use planning and to have multi-stakeholder platforms and frameworks at local, national and regional levels to collaborate in planning, implementing, monitoring and evaluating LDN interventions (Global Mechanism of the UNCCD 2016b). Also, policies that incentivise sustainable land use need to be in place. Moreover, the targets and proposed measures/interventions all need to be transposed in the relevant spatial planning tools.

For the identification of measures to achieve the targets, the selection of "bright spots" (success stories for further learning and communication on how to address land degradation) in addition to the conventional "hot spots" (areas for priority intervention) appeared to be successful in spreading the LDN concept in the 14 pilot countries (Global Mechanism of the UNCCD 2016b).

Engagement of all stakeholders in the process is essential to facilitate 'buy in' and ownership to the policies associated with the LDN targets set by governments. Such political support makes the upscaling of sustainable land management and restoration activities possible. For this to become a reality, LDN training and capacity building must be strategized (Global Mechanism of the UNCCD 2016b).

Having outlined what we consider are the necessary steps for implementing LDN at a national level, the following section reflects how the actual process in Germany to implement LDN started and where it currently (as of August 2017) stands. It has not (yet) followed the steps as outlined above. Rather, the stepwise approach was developed within the mentioned German research project, which was itself a step in the process to start implementation of LDN in Germany.

3 Implementing LDN in Europe – where are we starting from?

As shown in chapter 2, target setting and implementation of LDN must take into account regional circumstances and particularities and requires decisions that are often of a political nature. In order to support discussions on how far and in which parts implementing LDN can follow a common approach in the EU (e.g. in terms of target setting and monitoring), the following chapter will provide a first overview of information on:

- the most relevant soil threats in the EU,
- soil functions,
- existing monitoring schemes, and
- synergies to other policy processes (European and international) that are most relevant for the implementation of LDN in Europe.

3.1 Soil threats and trends in land degradation in Europe

The debate on LDN is strongly tied to the question of which functions and threats are of highest relevance within a region. The following chapter will therefore summarize the impact and role of different soil threats in the EU.

Key soil threats have already been recognized at the EU level. The Communication of the Commission to the European Parliament and the Council "Towards a Thematic Strategy on Soil Protection"[8] identifies eight main soil degradation processes. These are erosion, organic matter decline, contamination, salinisation, compaction, soil biodiversity loss, sealing, landslides and flooding[9].

In 2012, the Joint Research Centre (JRC) published an updated assessment of the State of Soils in Europe in which acidification and desertification were added as important soil threats but flooding was excluded (Jones et al. 2012). The Regional Assessment for Europe and Eurasia of the Status of the World's Soils Report does not include landslides, desertification, flooding or soil biodiversity loss as major threats to soils in Europe, but identifies nutrient surplus/overfertilisation as a relevant soil threat in Europe (FAO and ITPS 2015).

Below, we present a brief overview that incorporates all of the threats identified by these sources and possibilities for measuring them.

3.1.1 Soil sealing

Soil sealing refers to the destruction or covering of soils by buildings, structures, and partially or completely impermeable materials. Soil sealing is a serious threat because it entails the complete loss of soil functions, and is usually irreversible. Built-up areas account for about 4% of the land area in EEA countries on average (Jones et al. 2012). Despite goals to slow soil sealing, the spread of built areas continues to increase across Europe. Between 2000 and 2006 the amount of sealed area across Europe increased by about 2.7% (EEA 2015). Soil sealing is especially an issue in Western Europe (FAO and ITPS 2015).

Soil sealing is generally measured in the amount or share of built-up land (e.g. in area of built-up land divided by total land area.), or the increase in built-up land across a given span of time (e.g. % increase or absolute increase over previous year).

[8] COM(2002) 179

[9] The prevention and mitigation of the effects of floods have been addressed by the proposal for a Directive of the European Parliament and the Council on the assessment and management of floods.

3.1.2 Erosion

Erosion is the wearing away of soil by wind and water, and it impacts significant amounts of land in Europe. Erosion is primarily the result of inappropriate land management, overgrazing, deforestation, forest fires, and construction, and is affected by climate, rainfall patterns, slope, and other geophysical and land use variables (Jones et al. 2012). As soil is slow to form, significant amounts of erosion can seriously impede soil functions, since it entails the loss of soils. Erosion is estimated to affect 130 million ha of land in the EU-27 (EEA 2015). Wind erosion is especially problematic in Northern Germany, the Eastern Netherlands, eastern England and the Iberian Peninsula, and water erosion particularly affects the Mediterranean region due to its frequent droughts, which in actuality raises the risk of water erosion (Jones et al. 2012). The risk of wind and water erosion across the EU is expected to increase due to land use changes and changes in weather patterns (Jones et al. 2012).

Actual erosion is time- and resource-intensive to measure, so erosion is typically captured as erosion risk or erosion sensitivity.

3.1.3 Compaction

Compaction is the physical degeneration process of the reorganization, deformation or destruction of soil aggregates due to the application of pressure. It reduces many processes that contribute to soil functions, including biological activity, permeability, and water infiltration capacity, and can exacerbate other soil threats, such as erosion (Jones et al. 2012). The use of heavy machinery in agriculture is a main cause of compaction (FAO and ITPS 2015; Don 2016; Brunotte et al. 2016). Estimates of compaction in Europe vary; some research has found that 32-36% of soils in Europe are estimated to have a high susceptibility to compaction, whereas others claim that as little as 4% is affected by compaction (Jones et al. 2012).

Compaction can be directly measured using a variety of methods. However, this is time- and resource-intensive and widespread data is not available, so alternatively susceptibility to compaction can also be calculated.

3.1.4 Loss of soil organic carbon

The loss of soil organic carbon (SOC) is the result of both the mineralization of organic carbon in the soil and erosion (FAO and ITPS 2015). Processes of SOC loss/gain due to changing cultivation or management practices are usually slow, with the exclusion of losses due to landslides and erosion. Cultivated or disturbed soils tend to lose SOC, whereas permanent grasslands and forests can be expected to gain SOC over time (Jones et al. 2012). About 45% of soils in the EU have low SOC (FAO and ITPS 2015). There is evidence that SOC in agricultural soils is decreasing across the EU. Recent results of the CAPRESE research project suggest that SOC stocks in European soils may have been overestimated by up to 25% (EEA 2015). The Mediterranean region is particularly at risk of SOC losses, as high temperatures and droughts can accelerate SOC decline (Jones et al. 2012).

Loss of SOC can be measured in the change in SOC over a given time period using soil samples.

3.1.5 Contamination with pollutants

Soil contamination can result from natural causes (e.g. natural mineral compositions) or from human activities such as mining, agriculture, transport, and industry. Contamination covers a broad spectrum of pollutants, including heavy metals, organic chemicals, nutrients, or pharmaceuticals, and can be either point source, i.e. from a single identifiable source such as a mine, or diffuse, e.g. from agricultural activities. Contamination can have major negative impacts on the environment, e.g. on water quality or biodiversity, especially if a soil's filtering capacity is exceeded. Contaminated sites may become unusable for agriculture or other purposes. Europe's industrial history has left behind many contaminated sites, and the use of plant protection products and fertilizers in agriculture are major sources of diffuse pollution (Jones et al. 2012). In Europe, heavy metals and mineral oil are the most important pollutants (FAO and ITPS 2015). Due to a lack of unified reporting requirements, data on local contamination in the EU is poor, and data on diffuse contamination is even more limited. The best current estimates are that there are about 3 million contaminated sites across the EU (Jones et al. 2012).

Contamination can be evaluated based on pollutant concentrations determinable through soil sampling.

3.1.6 Nutrient surplus/over-fertilisation

Nutrient surplus is commonly the result of over-fertilisation. Nutrient surpluses can have substantial negative impacts on biodiversity in soil and in the environment as well as water and air quality. Over-fertilisation is also associated with contamination from pharmaceuticals (e.g. antibiotics) and inorganic compounds. Nitrogen surplus is on average higher in the EU-15 (58 kg N/ha) than in the Central and East European countries (33 kg N/ha), where farms tend to be smaller scale and producers are less able to afford fertilizers (Eurostat 2012; FAO and ITPS 2015). High phosphorous surpluses can be found in Malta, Cyprus, and north-western Europe (Eurostat 2013). Despite the existence of the Nitrates Directive which intends to limit nitrate emissions, some European countries such as Germany and the Netherlands remain consistently over the limit for nitrate concentrations. The European Commission published in April 2016 that it will refer Germany to the European Court of Justice for failing to take stronger measures to prevent nitrate pollution (European Commission 2016c).

Nutrient surplus is generally measured by nitrogen or phosphorous surplus (kg N or P/ha/year) or by nutrient input-output ratios.

3.1.7 Loss of soil biodiversity

Soil biota play a central role in many soil functions, such as releasing nutrients, degrading contaminants, maintaining soil structure, and contributing to soil water retention (Jones et al. 2012). Currently, the state of knowledge about below-ground biodiversity is still quite poor, and existing data usually refers to only a limited group of organisms, such as mushrooms or earthworms (Gardi, Jeffery, and Saltelli 2013; Jones et al. 2012). Land use change and intensification are the main driver of soil biodiversity loss, along with associated losses in above ground biodiversity, inputs of plant protection products and fertilizers, inputs of pollutants, monoculture cropping systems, tillage practices, overgrazing, fire, erosion, desertification and climate change (Gardi, Jeffery, and Saltelli 2013; Orgiazzi et al. 2015).

The Global Atlas of Soil Biodiversity (2015) includes a map of the severity of threats to soil biodiversity in which the potential threats are ranked as moderate, high, or very high in nearly all of Europe with the exclusion of the Alpine region (Orgiazzi et al. 2015, 134–35).

3.1.8 Desertification

Desertification is caused by prolonged droughts and irregular precipitation as well as unsustainable agricultural practices and water use. Desertification primarily affects southern and South-eastern Europe, from Portugal to the Black Sea, as well as Latvia (Jones et al. 2012). Calculations of sensitivity to desertification show that about 40 million ha of land in Southern, Central, and Eastern Europe have a moderate, high or very high sensitivity to desertification (Jones et al. 2012).

3.1.9 Salinisation

Salinisation is the accumulation of salts in soils, and in Europe it is usually the product of inappropriate irrigation practices, irrigation with highly mineralised water, or poor drainage. Soils affected by salinisation can become unsuitable for growing crops, and the reversal of salinisation is a difficult and costly process requiring site-specific solutions and often the use of high quality irrigation water to flush out salts (Jones et al. 2012). Around 3.8 million ha are estimated to have excess levels of salts

(FAO and ITPS 2015). Parts of Italy, Spain, Hungary, Greece, Portugal, France, and Slovakia are particularly affected by salinisation (FAO and ITPS 2015).

3.1.10 Acidification

Acidification denotes the loss of basic cations through leaching and their replacement with acidic compounds, and also entails a decrease in the soil's ability to neutralize acid, a process which is irreversible except over extremely long time-spans (FAO and ITPS 2015). The most common source of acidifying substances is fossil fuel combustion from energy production, industry or transport; however forestry and agriculture can also contribute to acidification processes in soils, such as in heathlands in north-western Europe (Jones et al. 2012). Acidification risk is expected to continue to decrease as the outcome of policies reducing acidifying pollutants become more noticeable (e.g. SO2) (Jones et al. 2012). Acidification will likely only affect certain hot spots in the future, notably the area around the German-Dutch border (FAO and ITPS 2015).

Soil acidification can be modelled based on water acidification rates and indicators of critical loads.

3.1.11 Landslides

Landslides are the gravitational movement of soil, rock, or debris down a slope. Landslides can be caused by a variety of natural factors including earthquakes or erosion of the base of a slope by rivers or waves, or by anthropogenic influences such as deforestation, cultivation, or construction. The most landslide susceptible areas are the European mountain ranges (e.g. Alps, Balkans, etc.), hilly areas on certain geological formations or soil types, and coastal cliffs and steep slopes (Jones et al. 2012). Italy is especially affected.

Landslides can be measured through landslide inventories, or through landslide risk or susceptibility maps; however, available landslide data are not harmonized at the EU level (Jones et al. 2012).

3.2 Soil functions

Soil functions are based on ecological processes that contribute to human wellbeing (ecosystem services) (TEEB 2010). Every soil function can contribute directly (e.g. through climate or water regulation) or indirectly (e.g. for food and feed production, or the development of new medicines) to the provision of ecosystem services (van der Putten et al. 2010).

The Millennium Ecosystem Assessment (2005) of the United Nations differentiates four ecosystem functions that depend significantly on the functional capacity of soils:

1. Supporting services: ecosystem services that are based on soil formation, nutrient cycles, and the conservation of genetic diversity
2. Regulating services: regulation of the climate, water quality, pollination, floods, disease, and waste treatment
3. Provisioning services: provisioning of food, water, building material/timber, fibre, and raw materials for medicines
4. Cultural services: ecosystem services that provide recreational, spiritual, and aesthetic benefits

The following table from FAO and ITPS (2015a) presents ecosystem services and associated soil functions.

Table 1: Ecosystem services of soils and the associated soil functions

Ecosystem service	Soil function
Supporting services (necessary for the production of all other ecosystem services; only indirect impacts on people)	
Soil formation	Weathering of primary minerals and release of nutrients; modification of soil texture Transformation and accumulation of organic matter Creation of structures (aggregates, horizons) for gas and water flow and root growth Creation of charged surfaces for ion retention and exchange
Primary production	Medium for seed germination and root growth Retention and supply of nutrients and water for plants
Nutrient cycling	Transformation and mineralization of organic materials by soil organisms Retention and release of nutrients on charged surfaces
Regulating services: benefits obtained from the regulation of ecosystem processes	
Water quality regulation	Filtering and buffering of substances in soil water Transformation of contaminants
Water supply regulation	Regulation of water infiltration into soil and water flow within the soil Drainage of excess water out of soil and into groundwater and surface water
Climate regulation	Regulation of CO_2, N_2O, and CH_4 emissions Carbon sequestration
Erosion regulation	Retention of soil on the land surface
Provisioning Services: products ("goods") obtained from ecosystems of direct benefit to people.	
Food supply	Providing water, nutrients, and physical support for growth of plants for human and animal consumption
Water supply	Retention and purification of water
Fibre and fuel supply	Providing water, nutrients, and physical support for plant development for bioenergy and fibre
Refugia	Providing habitat for soil animals, birds etc.
Genetic resources	Source of unique biological materials
Cultural services: nonmaterial benefits people obtain from ecosystems through spiritual enrichment, aesthetic experiences, and heritage preservation, and recreation.	
Aesthetic and spiritual	Preservation of natural and cultural landscape diversity

Source: adapted from FAO and ITPS (2015a)

Table 2 presents the soil functions as identified in the proposal for a Soil Framework Directive of the EU, which was withdrawn in 2014.

Table 2: Soil functions identified in the proposal for a Soil Framework Directive

Soil functions
biomass production, including in agriculture and forestry
storing, filtering and transforming nutrients, substances and water
biodiversity pool, such as habitats, species and genes
physical and cultural environment for humans and human activities
source of raw materials
acting as carbon pool
archive of geological and archeological heritage

Source: European Commission (2006)

The role and importance of different soils for the provision of individual soil functions and ecosystem services, as well as the demand for these functions and services, is spatially dependent (Schulte et al. 2015). All soils can contribute to the identified functions is different ways, however the intensity of provision depends on the soil type (ibid.). Some soil types can naturally store less carbon then others. On the other hand, some soils have reached a high carbon storage capacity over time, but cannot increase their carbon storage, whereas other soils still have significant potential (Huber 2016; Smith et al. 2008).

For the implementation of the LDN goal in the EU and for potentially concentrating on specific relevant issues at the national level, the question remains whether a prioritization of soil functions is useful and possible. It is worth noting that the EU Soil Framework Directive as proposed did not prioritise individual soil functions. This is due, for one, to the fact that soil functions mutually influence one another, and the strengthening of one soil function can very well have negative impacts (trade-offs) with another soil function. For example, as Braat and ten Brink (2008) show, increasing agricultural production might decrease the value of cultural and regulating ecosystem services which are reduced.

The necessity of differentiating between various ecosystem services becomes clear if a net balancing of degradation according to the LDN concept is to be carried out. This is important to note because most economic analyses of land degradation until now tend to concentrate solely on provisioning ecosystem services, i.e. increase or decrease in harvests (Nkonya, Mirzabaev, and von Braun 2016b).

3.3 Existing monitoring systems

Policy targets need to be monitored regularly to determine if the implemented measures are contributing to their goals and if trends are developing in the desired direction. Therefore, monitoring systems are of the utmost importance for the justification, conception, and performance assessment of soil protection measures (Kaufmann-Boll, Tischler, and Siebigs 2012).

In Europe and on a global scale, several monitoring systems for soils already exist which can form the basis for monitoring SDG target 15.3.

In the following section, a selection of EU monitoring systems will be presented and analyzed in regards to their suitability for monitoring SDG 15.3 implementation. Their shortcomings and potential for adaptation and improvement will also be discussed.

3.3.1 Types of data collection in monitoring systems

In Europe, soil science and soil monitoring are relatively well developed; however, across the EU there remains a lack of harmonization of monitoring data, timing, and methodologies, which hinders the creation of a comprehensive overview (FAO and ITPS 2015).

There are three fundamental approaches to monitoring soils: remote sensing, field studies, and modelling.

- In **remote sensing,** data acquired through satellite images give insight on vegetation and land use, making conclusions about soils possible. This approach has the advantage that it allows for comprehensive evaluations, but often does not offer refined results about all/multiple soil parameters, so that further data needs to be consulted in order to interpret the results to their full potential.
- **Field studies** use soil sampling or in-situ observation at locations in set intervals to determine different parameters such as, e.g. SOC content, erosion, or water capacity. Field studies are more resource-intensive in comparison to other methods, but they allow very precise data collection. Their drawback is that they only offer information on the specific point of sampling which has limitations for broader application.
- **Modelling** relies on data from field studies, remote sensing or a combination of both and calculates further parameters, predictions and trends from this data. Modelling is very useful for monitoring soil threat processes, since they can be difficult to measure directly, e.g. regarding soil compaction and erosion. Monitoring can also offer an assessment of risks (i.e. risk of erosion). The disadvantage of modelling is that it can only deliver estimates that are based on select assumptions of the model, likely resulting in deviations from the actual state of the analyzed soils.

A further assessment of monitoring systems for SDG 15.3 needs to occur once a common understanding of the implementation of the LDN goal in Europe has been arrived at and possible indicators are selected.

3.3.2 European monitoring systems

The earth observation program Copernicus is now in the operational phase and is based on measurements from satellites, planes, and land- and sea-based observation infrastructure. It builds on and continues previous European observation systems such as CORINE Land Cover (CLC) and the Urban Atlas (DLR 2016b). In addition to observing land use, remote sensing systems collect data on the marine environment, catastrophe and crisis management, climate change, and more. Satellite-based data is collected in different resolutions and cycles and supported by terrestrial in-situ surveys (DLR 2016a). Copernicus collects land cover and land cover change data, as well as further vegetation and geophysical parameters which allow the documentation of changes in land cover. This includes information on soil sealing (DLR 2016b).

The advantage of Copernicus is that a variety of parameters in Europe can be measured in a uniform manner and that the system offers data on soil threats that are difficult to collect in field studies (e.g. erosion) or which require a recent and comprehensive dataset (e.g. soil sealing). However, the observations of soil parameters made through satellites have certain boundaries. It may be possible to identify degradation "hot spots", but smaller changes of soil quality can only be determined in field studies ("ground-truthing") (Caspari 2016; Caspari, van Lynden, and Bai 2015). A comprehensive monitoring of soils solely through satellite-based systems is not technically possible at this time (Borg 2016).

The **European Soil Databank (ESDAC)** collects and publishes soil data sets for Europe. ESDAC offers datasets from the monitoring systems Copernicus and Land Use/Cover Area frame Statistical Survey **(LUCAS)** as well as further data from, for instance, other projects funded by the EU. ESDAC is however a databank and not a monitoring system because it brings existing data sets together rather than producing new data sets.

The **European Mapping and Assessment of Ecosystems and their Services, MAES** indirectly offers relevant information as well (Akhtar-Schuster et al. 2016). MAES is part of the implementation of the EU Biodiversity Strategy to 2020. While maps of ecosystems are established already for Europe, maps on a national scale are still being developed (European Topic Centre on Spatial Information and Analysis 2015). Mapping is done by using land cover data from **CORINE** as well as other data sources for the European level. This data can facilitate conclusions about soil-related ecosystem services and soil functions.

Moreover, the **JRC** report on **Land productivity dynamics** in Europe (Cherlet and Ivits 2013) can be a helpful first step in land degradation assessment. The report documents how land-productivity dynamics can be calculated from vegetation indices derived from long-term low-resolution satellite time series combined with productivity efficiency measurements derived from short, recent, medium resolution data, such as those from the SPOT VEGETATION sensor. Land-productivity dynamics can indicate levels of sustained land-quality and is therefore used as first step in land degradation assessment.

Currently the **EEA** is also working on a **technical report on methodological approaches for land degradation.**

3.3.3 International monitoring systems and relevant data/assessments

The statistical department of the FAO **(FAOSTAT)** and **ISRIC** (World Soil Information) play an important role in the collection and processing of global soil and land use data. ISRIC has worked on the improvement of the global soil database for the past 40 years. At this time, several databanks that could provide soil information on the global scale are in the development stage, such as the systems WOSIS and Soil Grids. They offer soil maps and data on soil profiles. These systems could offer a global basis for soil information in the future, for example for establishing worldwide baseline values.

Additionally, the **Global Soil Partnership (GSP)** has set the goal to build a global soil monitoring system based on national and local soil data sources. Within this framework, the GSP cooperates with the national and international institutions that collect soil data, for instance in December of 2015 with the International Network of Soil information Institutions (INSII) (Global Soil Partnership 2016).

Finally, to asses Land Degradation and LDN a number of recent and soon to be published studies can be used to improve understanding of land degradation, its impacts and approaches to reverse it. Important studies in this regard are:

- The **2015 World Soil Resources Report** from the Intergovernmental Technical Panel on Soils of the FAO (FAO 2015b).
- In **2018**, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (**IPBES**) will publish an assessment of land degradation and restoration. It will cover the following: the global status of and trends in land degradation, by region and land cover type; the effect of degradation on biodiversity values, ecosystem services and human well-being; and the state of knowledge, by region and land cover type, of ecosystem restoration extent and options. The assessment would enhance the knowledge base for policies for addressing land degradation, desertification and the restoration of degraded land (IPBES 2016).
- In **2017**, the **UNCCD** will publish its first edition of a "**Global Land Outlook**".
- As announced in early 2016 the Intergovernmental Panel on Climate Change (**IPCC**) will publish a special report in **2018** on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.

3.4 Implementing LDN: Synergies to other policies

3.4.1 Relevant international policies

3.4.1.1 Sustainable Development Goals (SDGs)

The SDGs, also called the "Global Goals", are 17 Sustainable Development Goals which include 169 targets. For land and soils, goal 15 and target 15.3 are of highest relevance (see Chapter 1.3)

However, LDN also has many relevant links to other SDGs. The other SDGs most relevant for land and soils are:

- **Goal 2 (Zero Hunger)** targets ending hunger, achieving food security, improving nutrition, and promoting **sustainable agriculture**. **Target 2.4** aims to "ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality." However, it also points out that this is to be achieved within the **carrying capacity of ecosystems**, making clear that here there is a conflict of interest. A higher demand for arable land due to population growth and increased demand for (land intensive) animal products is a hurdle for the sustainable development of ecosystems.
- **Goal 3 (Good Health and Well-being)** underlines in **target 3.9** that there is a necessity to "substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and **soil pollution and contamination**."

In addition to the directly mentioned soil related targets of goals 15, 2 and 3, there are a number of further targets that are relevant for soil conservation:

- **Goal 7 (Affordable and Clean Energy):** The implementation of SDGs related to sustainable energy affects the future utilization of soils. The transition to renewable energy has already lead to significant land use changes for the production of biomass for bio-energy. It should however also be considered that fossil fuel (coal, fracking) negatively impacts soils.
- **Goal 11 (Sustainable Cities and Communities):** The SDG on cities and settlements is relevant to soils, as soil sealing for construction leads to a reduction or complete loss of natural soil functions.
- **Goal 12 (Sustainable consumption and production patterns):** Consumption and production patterns have a multitude of effects on land use, which ranges from infrastructure for production, consumption and mobility, to the effects of diets with different ecological footprints, to influences on land use for the production of clothing, energy production, etc.

The attainability of some SDGs is dependent on sufficient conservation of soils and ecosystems. These goals include:

- **Goal 1 (No Poverty):** The goal to end poverty is closely connected to Goal 2 (food security). The status of soils is highly important in the fight against poverty, as three quarters of the world's poorest populations live in rural areas and their livelihoods are mostly dependent on farming and thereby on soils. The outflow of refugees from developing countries is also closely connected to land use issues. Therefore, soil conservation also has an effect on freedom and security (SDG 16).
- **Goal 6 (Clean Water and Sanitation):** The filtering and buffering functions of soils highly affect water quality (e.g. nitrates and pollutants). Additionally, it is possible to conserve soils by means of sustainable water management (decrease in erosion and salinisation, etc.)
- **Goal 13 (Climate change)**: Soils make up the second largest carbon reservoir in the world, after oceans. Wetlands store especially high amounts of carbon in small scale areas. The drainage

of wetlands and moors and also the conversion of grasslands, thawing of permafrost soils, etc., can cause soils to function as significant sources of CO_2-emisssions. Thus, sustainable management of soils is a key part of combating climate change.

The achievement of many the SDGs depends on the status of soils, which can only be achieved through an integrated and coherent management approach.

The SDGs were adopted by the UN General Assembly in September 2015. After the adoption of the SDGs and the agreement on (most) indicators in March 2016, the High Level Panel Forum (HLPF) in July 2016 was the first milestone on the way to the implementation of the SDGs. The session included voluntary reviews of 22 countries and thematic reviews of progress on achieving the Sustainable Development Goals.

3.4.1.2 Linkages to the UNCBD and UNFCCC

Target 15.3 also has strong linkages to the other Rio Conventions: the Convention on Biological Diversity (CBD) with biodiversity supporting many of the processes that underpin the ecosystem functioning of land, and the United Nations Framework Convention on Climate Change (UNFCCC) because of the manifold relationships between land and climate change adaptation and mitigation.

The opportunities and synergies that exist by examining LDN through the lens of the three Rio Conventions is further analysed in the recent article "Unpacking the concept of land degradation neutrality and addressing its operation through the Rio Conventions" (Akthar-Schuster et al. 2016). Also, the review of the 14 UNCCD LDN target setting pilot countries showed that the LDN target setting process contributed to the objectives of the UNCBD and UNFCCC (Global Mechanism of the UNCCD 2016b)

3.4.1.3 FAO Voluntary Guidelines for Soil Management

In 2016 the FAO developed the **Voluntary Guidelines for Sustainable Soil Management (VGSSM)** through an inclusive process within the framework of the Global Soil Partnership (GSP) (FAO 2016b). They aim to be a reference for general technical and policy recommendations on sustainable soil management (SSM) for a wide range of committed stakeholders. The guidelines were adopted in May 2016.

There are also synergies with the FAO **Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests (VGGT)** adopted in 2012. The UNCCD SPI even acknowledges that the LDN conceptual framework encourages application of the VGGT in the context of national food security to protect the rights of local land users.

3.4.2 Relevant European policies

In order to explore the opportunities and challenges for a common approach to LDN in Europe, particularly for target setting and monitoring, it is important to understand the current state of soil and land policy in the EU and the current state of an EU approach to the implementation of the SDGs.

3.4.2.1 EU soil policy

In **2006**, the European Commission published the **Soil Thematic Strategy** in an effort to develop an umbrella approach and coordinate policy on soil protection action across the various policy areas in the EU. The aim of Soil Thematic Strategy is to deliver soil protection through preventing further degradation, preserving soil functions and restoring degraded soils (EC, 2006). The Soil Thematic Strategy contains four pillars: i) awareness raising initiatives, ii) supporting research projects, iii) integration of soil protection in different policies and iv) soil legislation. With respect to the latter, a proposal for a Soil Framework Directive (SFD) was published in 2006 alongside the Soil Thematic Strategy. The SFD proposal adopted a risk-based approach to soil protection, requiring Member States to identify areas at risk for degradation (as well as already contaminated sites), define targets for soil protection and carry out programmes of measures to ensure protection (COM (2006) 232 final).

Following several years of stalled negotiations and low political interest in soil protection, the **Soil Framework Directive proposal was withdrawn in May 2014**. The arguments and the veto by a minority number of Member States against the SFD focused on the issue of subsidiarity (soil protection is locally specific and should be governed at MS / local levels), limited additional value of EU action (absence or limited presence of transboundary effects), and administrative costs.

In the absence of a Soil Framework Directive, soils remain a key natural resource not covered by a binding and integrated EU-wide approach. Thus, while air, water, and biodiversity/nature are governed through various directives and regulations, there is no binding legislative mechanism that would integrate the thematic and sectoral policy approaches relevant to soils. Moreover, the withdrawal of the SFD proposal also resulted in a lost opportunity to create a common understanding and vision around soil protection in the EU.

As a result, policy provisions on soils in the EU are fragmented and dispersed across a broad range of environmental policies, most importantly those relating to water and flooding, waste and industrial emissions, agriculture, biodiversity, forestry and climate change. A large number of EU directives contain some provisions relevant to soil protection, explicitly or implicitly stated, but the action remains uncoordinated and in some respects incomplete. For example, with regards to soil contamination, there is a gap with respects to the treatment of historic (orphan) contaminated sites. Moreover, with regards to agricultural or forest soils, there is a lack of provisions to deal with compaction and salinization (Frelih-Larsen et al. 2017) . Two recent reports by the JRC and the EEA demonstrate that policy action so far has indeed been insufficient to deliver an adequate level of protection for soils in the EU (EEA 2015b; Jones et al. 2012). With regards to future developments, political mandate for soil policy is set in two strategic EU documents. First, the **Roadmap to a Resource Efficient Europe** defines the aim that "by 2020, EU policies take into account their direct and indirect impact on land use in the EU and globally, and the rate of land take is on track with an aim to achieve no net land take by 2050" (COM(2011) 571 final)[10]. Secondly, the **7th Environment Action Programme** (Decision No 1386/2013/EU) sets out the strategic objective of "protecting, conserving and enhancing the Union's natural capital" as one of three priority objectives for environmental policy up to 2020. This, among others, entails that "land is managed sustainably in the Union, soil is adequately protected and the remediation of contaminated sites is well underway" by 2020, which in turn requires "increasing efforts to reduce soil erosion and increase soil organic matter, to remediate contaminated sites and to enhance the integration of land use aspects into coordinated decision-making involving all relevant levels of government, supported by the adoption of targets on soil and on land as a resource, and land planning objectives". The 7th EAP also states that the EU and Member States should "reflect as soon as possible on how soil quality issues could be addressed using a targeted and proportionate risk-based approach within a binding legal framework," and that by 2020 "targets should also be set for sustainable land use and soil."

Responding to these commitments, DG Environment established a permanent (and open ended) **EU Expert Group on Soil Protection** in October 2015 in order to discuss with Member States options for the implementation of soil protection provisions of the 7th EAP. While the topic of LDN was discussed for an hour at the October 2016 meeting of the EU soil expert group, it is not (yet) a particular focus of this forum.

To support the work of the Expert Group, a study entitled **"Updated inventory and assessment of soil protection policy instruments in EU Member States"** was also commissioned at the end of

10 European Commission (2011) Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Roadmap to a Resource Efficient Europe, COM(2011) 571 final.

2015. In this study (Frelih-Larsen et al. 2017), an online collaborative platform – Soil Wiki - was developed in collaboration with the Expert Group. The study provides a broad baseline overview of key policy instruments at EU and Member State level, focusing on legislative and monitoring instruments. Specifically, the Soil Wiki includes an overview of 35 EU-wide instruments and over 670 Member State policy instruments relevant to soil protection.[11]

3.4.2.2 The Common Agricultural Policy

The Common Agricultural Policy (CAP) is a central policy instrument for land management in the European Union. It is broadly accepted as a key driver behind land use, land use change and farming practices in Europe. The current CAP enables significant flexibility for how Member States implement the different provisions, which increases opportunities but also adds complexity to assessing the drivers behind land use and land degradation.

The 2014 – 2020 architecture of the CAP contains three elements with direct relevance for soil protection: direct green payments (greening requirements), cross-compliance requirements (including Good Agricultural and Environmental Condition standards), and Rural Development Programmes.

The three **greening payment components** (requiring ecological focus areas, crop diversification, and maintenance of permanent grasslands) can all integrate management practices with beneficial impacts on soil protection.

The **cross-compliance mechanism** includes three GAEC standards that address soil and carbon stocks: GAEC 4 (minimum soil cover), GAEC 5 (minimum land management reflecting site specific conditions to limit erosion), and GAEC 6 (maintenance of soil organic matter level through appropriate practices including ban on burning arable stubble). In addition, the GAEC 7 standard on a minimum level of maintenance of landscape features (including where appropriate hedges; ponds; ditches; trees in line, in group or isolated; field margins; and terraces; and including a ban on cutting hedges and trees during the bird breeding and rearing season) can contribute in particular to reduced soil erosion.

Finally, under **Rural Development Programmes (RDPs)**, two strategic priorities are especially relevant for soil protection: Priority 4 (Restoring, preserving and enhancing ecosystems dependent on agriculture and forestry), in particular the Focus area 4C (preventing soil erosion and improving soil management), and Priority 5 (Promoting resource efficiency and supporting the shift towards a low carbon and climate resilient economy in agriculture, food and forestry sectors), in particular the Focus area 5E (fostering carbon conservation and sequestration in agriculture and forestry).

Member States have a variety of measures at their disposal to fund specific soil management measures under the RDPs (such as agri-environment-climate measures, organic farming, and investments in physical assets, information and knowledge transfer). They have extensive flexibility on the types of measures they select to fund.

The CAP contains a number of potentially beneficial measures for soil protection; however, the policy has been criticised for not allocating enough resources to environmental objectives and there is room for improvement for the level of ambition of soil protection measures (e.g. transferring more funds from direct payments to rural development measures, increasing the ambition for the greening requirements and the GAEC standards). In general, moving in the direction of a structure whereby the CAP would deliver more 'public goods for public money' would also be beneficial for soil protection.

[11] The study builds partly also on the work done in the FP7 large-scale research project, RECARE, where an integrated impact assessment of EU and national policies will be completed by October 2018 (see also www.recare-project.eu for more information).

Operationalising the 'land degradation neutral world' target could provide some momentum for the European Commission and Member States to further develop policy action for sustainable land management and soil protection in the EU.

3.4.2.3 Climate and Energy policy

Soil carbon management in agricultural and forest soils has emerged as an important issue in the EU climate policy agenda over the last several years. The LULUCF Decision (Decision 529/2014/EU) set the requirement for Member States to establish mandatory emissions and removals for carbon accounting from croplands and grasslands. In the summer 2016, the Commission published a proposal for integrating LULUCF into the 2030 climate policy framework, including some amendments to the accounting framework. Depending on the outcomes of the negotiations, the climate framework 2030 could provide opportunities for soil protection in the EU by incentivising the delivery of soil carbon sequestration.

3.5 SDG implementation in the EU

The EU and all EU Member States have committed to implementing the SDGs, and EU institutions have acknowledged that achieving them requires greater coherence between policy areas and actors in both internal and external policy. The EU was a major player in the process of developing the SDGs, however implementation of the SDGs in the EU has been slow, as it has been overshadowed by the multiple crises the EU is experiencing. Specifically, the influx of refugees and migrants, the increase in terrorist attacks, Brexit and the rise of populist, anti-European movements have dominated debate and strategic action at the EU level since the passage of the SDGs.

- Though SDG implementation at the EU level has been criticized for delivering little action in 2015 and early 2016 (Niestroy 2016; SDG Watch 2016; ESDN 2016), it is being carried forward through a number of processes, the early results of which are already emerging. The first efforts on implementing the SDGs have been in EU external policy (e.g. the Revision of the European Consensus on Development and the EU Global Strategy on Foreign and Security Policy)[12]. Implementing the SDGs in internal policy began later. This chapter illustrates the elements of the SDG implementation process at the European level.
- Communication of the EU Commission "Next steps for a sustainable European future - European action for sustainability ". On November 22, 2016 the EU Commission published its Communication "Next steps for a sustainable European future - European action for sustainability" (European Commission 2016b). In its communication, the Commission endorses its full commitment "to be a frontrunner in implementing the 2030 Agenda and the SDGs, together with its Member States, in line with the principle of subsidiarity". The document also describes the two work streams that are supposed to be the EU's answer to the 2030 Agenda.
  The first work stream is presented in its Communication (and an accompanying staff working document (European Commission 2016a)) and explains the EU attempts to fully integrate the SDGs in the European policy framework and current Commission priorities. It also assesses where the EU currently stands and identifies the most relevant sustainability concerns.
  A second track "will launch reflection work" on further developing the EU's "longer term vision and the focus of sectoral policies after 2020, preparing for the long term implementation of the SDGs". The Communication also announces that the "new Multiannual Financial Framework beyond 2020 will also reorient the EU budget's contributions towards the achievement of the EU's long-term objectives"(European Commission 2016b).

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12 The Global Strategy touches on a broad spectrum of the SDGs, and addresses land degradation under priority 2 as a contributing factor to security risks.

The **Commission's Staff working document to the communication** attempts to provide "a full overview of how European policies and actions contribute to the Sustainable Development Goals, within the EU and through the EU's external action" and summarizes "the most relevant actions that the European Union is undertaking for each of the 17 SDGs" (European Commission 2016a). This mapping exercise shows the current EU policies and how they address the 17 goals. The mapping does not differentiate between targets. Therefore, the policies listed under goal 15.3 include many policies.

Those with a clear reference to land and soil are the following:

- The EU Thematic Strategy for Soil Protection[13]
- The Common Agricultural Policy (mentioned are: rural development policy, CAP helping the maintenance of agriculture in remote areas, organic farming, afforestation and creation of woodland, establishment of agroforestry systems and prevention and restoration of damages to forests, "provides opportunities to support the promotion of sustainable forest management and foresees combatting of desertification and restoration of degraded soil and the prevention of biodiversity loss.")
- The EU Habitats and Birds legislation (cornerstone of nature protection, protects 200 types of habitat through the EU-wide Natura 2000 network of protected areas, covering 18% of EU land area)
- EU Cohesion Policy ("During the period 2014-2020 EUR 35 billion will be invested in the protection of the environment, including for protecting and restoring biodiversity and soil and promoting ecosystem services and green infrastructure") (European Commission 2016a)

The communication also acknowledges that "the Europe 2020 strategy plays an important role in addressing several of the SDGs". However, "while Europe can point to good achievements and progress under all goals, strengthened implementation and further focused action in all areas will be required to implement the full 2030 Agenda by 2030" (European Commission 2016b).

- **Revision/review of Europe 2020 Strategy**: Alongside the European Parliament, Karl Falkenberg - Senior Advisor for Sustainable Development to the President of the European Commission - as well as other stakeholders advocate for the **integration of the Agenda 2030 in the review of the Europe 2020 strategy** (see e.g. Falkenberg 2016; SDG Watch 2016; Hackenesch et al. 2016). Following the review of the Europe 2020 Strategy in 2014, which included a public consultation, the Commission has planned to revise the Europe 2020 strategy with a "New Approach beyond 2020". The results of the public consultation were published in 2015, but since then the Commission has not published specific details on its action for the "New Approach".
- **Development of SDG monitoring on the EU level:** Eurostat, the statistical office of the EU, is engaged in developing an EU-level monitoring system for the SDGs and contributing to the debate on the international level about SDG monitoring. Currently, **Eurostat** is in the process of reviewing how the existing Sustainable Development Indicators from the 2001 EU Sustainable Development Strategy and other existing data can be adapted to the needs of the SDGs using Europe 2020 indicators and existing Eurostat indicators. Eurostat can already account for 30% of the 241 indicators approved by the UNSC in March 2016 with available data (Massarelli 2016). Eurostat also expects to release a publication establishing a set of EU baseline indicators, and monitoring reports will be published annually from 2017, the content of which will depend on how the SDGs are integrated into EU policy (Massarelli 2016).

[13] "The EU Thematic Strategy for Soil Protection aims at promoting a sustainable use of soil, preventing further soil degradation and preserving its functions. The proposal to integrate the land use sector into the 2030 Climate and Energy Policy Framework will incentivise climate-friendly land use and forestry."

- **Supporting activities: Senior Advisor for Sustainable Development:** Commission President Juncker appointed **Karl Falkenberg** as his Senior Advisor for Sustainable Development in September 2015. The Senior Advisor's mandate includes assessment of the implications of commitments of the Agenda 2030 within the Commission, possibilities for integration of the SDGs in EU policy, and the development of cross-policy thinking on sustainable development. In July 2016, Falkenberg and the European Political Strategy Centre (EPSC), the European Commission's in-house think tank, released a **Strategic Note on the SDGs entitled "Sustainability Now! A European Vision for Sustainability"** (Falkenberg 2016). Ahead of the Commission's official mapping exercise, this paper already advocates for stronger EU action, identifies an array of EU policies which contribute to (or hinder) achievement of the SDGs, and presents early ideas on reform options.
  With respect to land degradation, the paper dedicated the most attention to the Common Agricultural Policy (CAP) as it has the most direct influence on land use and land degradation in the EU. Even before the results of the Commission's mapping exercise have been released, calls have already been issued for reform of the CAP taking a more integrated approach and the SDGs into account (see Falkenberg 2016). The presentation of the review of the Multiannual Financial Framework (MFF) in late 2017 and proposal for the next MFF after 2020 present the next opportunity for changes to be proposed to the CAP, as well as to other relevant policies included in the MFF.
- **Efforts to involve stakeholders in EU implementation:** Several other mechanisms and forums are being utilized to involve civil society, local authorities, science, business, and other stakeholders in the EU implementation of the SDGs. These include the **Policy Forum on Development** and the **Sustainable Development Observatory** of the European Economic and Social Committee (EESC). The Policy Forum on Development (PFD) brings together Civil Society Organisations (CSOs) and Local Authorities from the European Union and partner countries in a Structured Dialogue with European Institutions and bodies (DG DEVCO 2014). Managed by the Directorate-General for International Cooperation and Development (DG DEVCO), the PFD facilitates dialogue and creates space for interaction and consultation through events, online forums, research activities, and publications. The Sustainable Development Observatory (SDO) is part of the European Economic and Social Committee (EESC), which is a consultative body to the European Union. The SDO brings together representatives of interests groups in business, trade unions, environmental and other NGOs, the liberal professions and the farming sector and manages hearings, conferences, exchange of best practice, local workshops and actions and impact studies to foster dialogue between civil society on sustainable development (EESC 2016). The SDO will be establishing a Sustainable Development Forum dedicated specifically to support interaction between European Institutions and civil society as well as between non-governmental stakeholders from different constituencies on sustainable development and the 2030 Agenda in the EU (EESC 2016).
- Meanwhile, European Institutions, Member States, and various stakeholders have called for the creation of a new and/or more ambitious EU Sustainable Development Strategy in light of the SDGs. On June 22, 2017, the **European Parliament's Environment (ENVI) Committee** adopted the Report on the Commission's Communication setting out the next steps for a sustainable European future (2017/2009 (INI)). In particular, the Report stresses that further action is needed by the Commission and the Member States in order to effectively implement the SDGs and calls on the Commission to develop, without delay, a comprehensive, short, medium, and long-term overarching strategy. The Report also urges the Commission to develop a monitoring and review mechanism for the implementation and mainstreaming of the SDGs into EU policies as well as to establish, in cooperation with Eurostat, a set of specific progress indicators for the internal application of the SDGs in the EU.

3.6 Potential process to facilitate LDN implementation in the EU

At the workshop on December 6, 2016 at the European Commission, participants also discussed the potential ways forward to implement LDN in the EU[14]. First of all, participants articulated a large need to further continue the debate on LDN implementation, both in terms of monitoring/indicators as well as political implementation and measures. There was a question though in what context this might take place. In theory several processes can be used, but there is no decision yet if any of these processes will in fact be used and how. One of the relevant opportunities are the regular meetings (bi-annual) of the EU expert group on soil organised by the European Commission. Other opportunities include the WPIEI (Council Working Party on International Environmental Issues) meetings and some of the (currently more technical) expert meetings organized by the EEA. Also, research projects can play a role in further developing a concept of LDN implementation at EU level, develop narratives, facilitating discussion between Member States and/or support pilot projects.

Participants also expressed the hope that the EU Commission takes an active role in this process and provide a forum to exchange. Finally a need for (better) coordination and connection with the activities of the UNCCD was expressed, in order to learn from these experiences and to provide impetus for the political discussion in Europe.

4 Overview of German activities and project results

4.1 Activities in Germany to implement the SDGs/LDN

Following the adoption of the UN SDGs in September 2015, Germany has committed to implement the SDGs with high ambition. Germany was also among the first 22 countries that presented their progress at the UN High Level Political Forum (HLPF) in July 2016 in New York.

The German government has chosen the National Sustainable Development Strategy ("Nachhaltigkeitsstrategie") as the key framework for achieving the SDGs in Germany. The first National Sustainable Development Strategy was adopted in 2002, setting out national sustainability goals and indicators. Since then, the government has reported on its implementation status every four years in the form of progress reports that also update the strategy's content. Every two years, the Federal Statistical Office publishes an independent indicator report with information about progress towards meeting the goals. The revised strategy, integrating Agenda 2030's ambition and goal structure, was published in January 2017 (German Federal Government 2017).

The existing indicators of Germany's Sustainable Development Strategy with relevance for land and soil include for example nitrogen surplus, organic farming area, and species diversity. Most importantly the strategy includes an indicator on land take ("Built-up area and transport infrastructure expansion", in German: "Flächeninanspruchnahme") with the objective to reduce expansion of built up area and infrastructure to less than 30 ha a day by 2030.

However, the German government also sees the need for a new indicator for land and soil, particularly to implement SDG target 15.3 on LDN but also in order to support the French "4 per 1000" initiative, presented at the UNFCCCs COP 21, that aims to enhance organic matter in soils.

The current version of Germany's Sustainable Development Strategy announced that there is ongoing work to design an appropriate indicator. There is no official timeframe, but a new indicator might become part of the revised version of the German Sustainability Strategy in 2018.

[14] See also workshop minutes available at http://ecologic.eu/14648

4.2 Tailoring of LDN to the German context: results of the research project

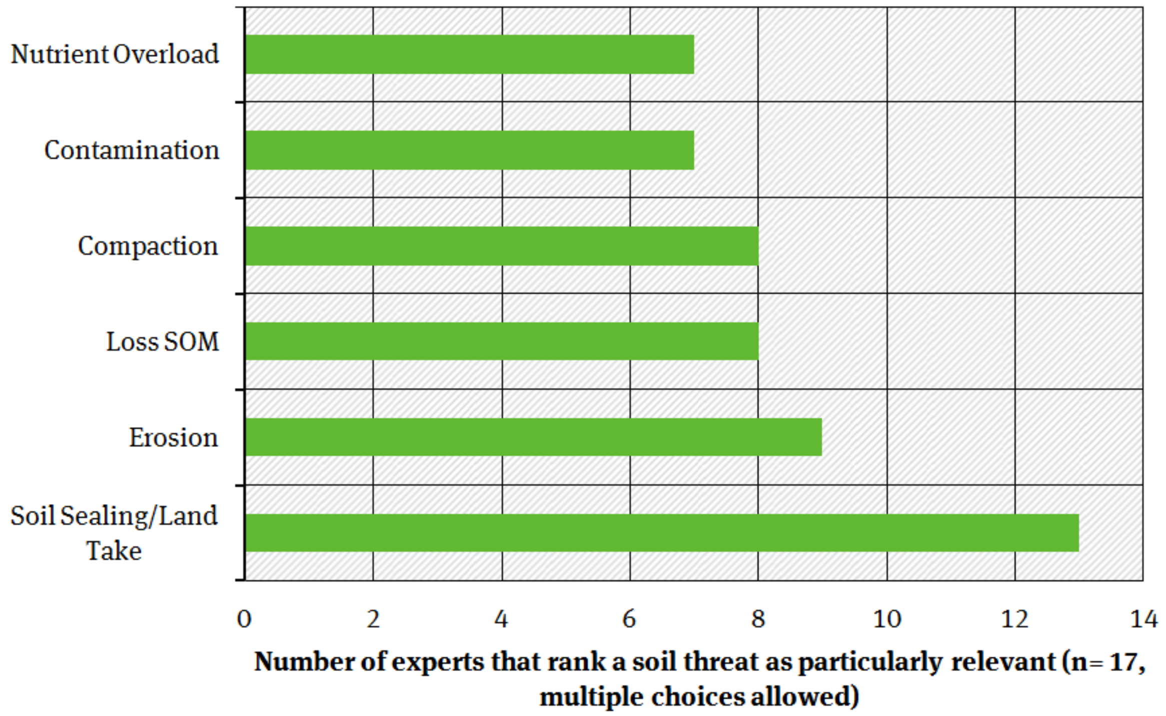
To explore how the soil related SDGs can be implemented, the German Environment Agency commissioned the above mentioned research project "Implementing the Sustainable Development Goals on Soils"[15]. The project helped to initiate the national discussions on the options for implementing LDN in Germany. A key project objective was to discuss appropriate indicators that can help in monitoring the implementation of LDN in Germany.

The focus here was laid on soil indicators. Since the terms "land" and "soil" have many overlaps but also differences, this is important to note. The focus on soil is also due the fact that the English word "land" does not translate clearly to German, but can be translated to "Boden" ("soil"), "Fläche" (i.e. "surface area") or "Land" ("country" or "countryside").

Within each country, the definition of indicators requires the LDN concept to be made more concrete, as well as the identification of the perceived main threats for land and soil (see section 2). Therefore, a first step within the project was to conduct a literature review to identify the most important soil threats and soil functions in Germany. In addition, 40 expert interviews were carried out in order to collect expert opinions on the question of whether certain soil functions and soil threats can be prioritized over others. The interviews clearly showed that creating a general hierarchy of soil functions is neither possible nor desirable. However, for soil threats, the majority of the experts who replied to this question argued that soil sealing and land take are of particular relevance for Germany. Other soil threats that were mentioned as particularly relevant were erosion, loss of soil organic matter, compaction, contamination and nutrient overload (see Figure 2). Asking for suitable indicators to monitor LDN and measure land degradation, answers look very similar and are oriented towards measuring soil threats. However, figure 3 shows that experts did not only refer to soil threats again, but also mentioned that an indicator on extraterritorial effects would be needed to include impacts on land and soil outside Germany that are due to trade and consumption patterns in Germany (see chapter 4.3.4).

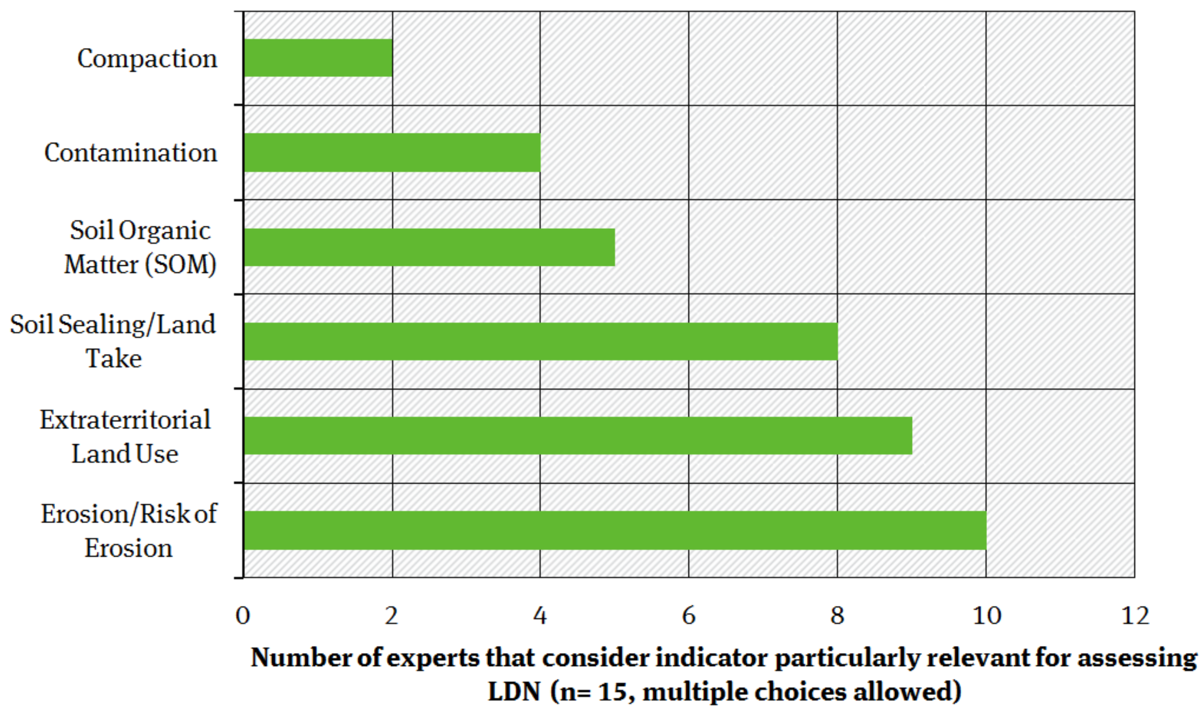
15 http://ecologic.eu/12876

Figure 2 Most relevant soil threats in Germany according to expert interviews



Source: Own presentation, Ecologic Institute

Figure 3 Suitable indicators according to expert interviews



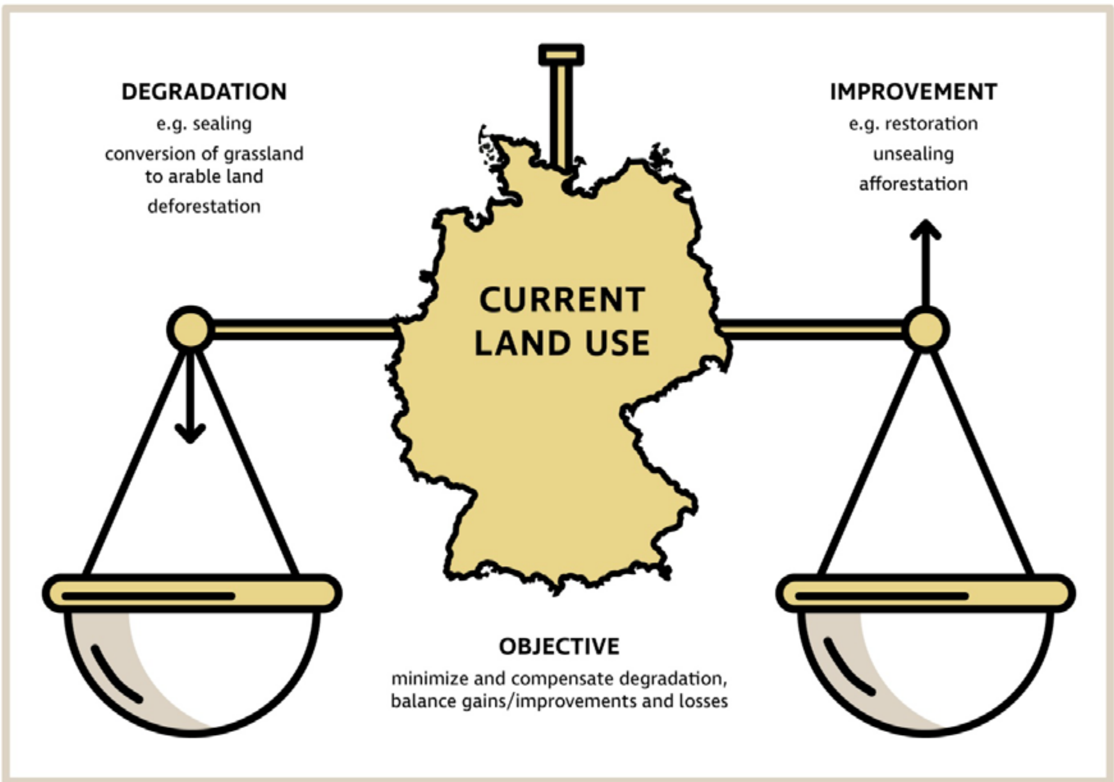
Source: Own presentation, Ecologic Institute

The preliminary results of the report were then discussed at an expert workshop on the July 6th, 2016 at the German Federal Environmental Ministry. The debate showed that an agreement on one or two main indicators for LDN that might be used for the monitoring was not yet possible. However, the discussion confirmed the results of the expert interviews about the main soil threats. In addition, there was a strong interest to further investigate whether an indicator on land use change (i.e. focusing on land management, compared to simply a biophysical indicator) can be used for monitoring LDN. The principle idea of this approach is that information on land use practices and land use changes (such as conversion of grassland to arable land, sealing of land, extension of grazing periods, etc.) allow for certain conclusions about positive or negative impacts on soils thereby saving a lot of effort compared to measuring the biophysical effects of every single case.

4.3 Development of a new LDN indicator concept using Land Use Change as a proxy

In this last section, we present a new approach for how LDN can be assessed at the national level. This indicator concept was developed to monitor soil quality changes and LDN in Germany, using information on land use categories as a proxy indicator. More specifically, each of the identified land use categories is assigned with a certain soil value that considers the exposure to soil threats, building on and further extending the hemeroby (naturalness) concept. The general assumption of this approach is that changes in land use directly correspond with changes in the natural functions of soil and soil quality and that some land uses have less adverse effects on soil than others (see e.g. FAO and ITPS 2015, Azeez 2009, Malet al. 2015, Paulsen et al. 2013). The values can then be used to calculate a balance of losses and gains based on areas that changed their land use which allows for assessing how far LDN has been achieved (see Figure 4 and Figure 5).

Figure 4 Land Degradation Neutrality: Balancing gains and losses



Source: Own presentation, Ecologic Institute

Furthermore, we assume that the degree of human impact (which is "hemeroby") strongly correlates with the ecological significance of natural soil functions. In other words, if soils are less disturbed by human activities (such as cultivation or sealing) soil functions can be better preserved or regenerated.

The approach also has the following benefits:

It avoids biophysical soil indicators (such as erosion, compaction, etc.) which are difficult to measure and imply a high level of monitoring effort.

It uses a simple approach, which is applicable to existing conditions in Germany as well as to existing data recording.

It avoids conflicting trade-offs between different soil functions, at least at the conceptual level. The focus lies on the preservation of natural soil functions and not on utility or other functions of soils. We assume that (at least in Germany) land degradation neutrality is only achieved if natural soil functions remain stable.

Below we describe the conceptual elements of the approach, which was already discussed with experts in interviews and in an expert workshop. However, what is presented here can only serve as a first conceptual approach of how LDN can be assessed through a land use change indicator at the national level. Further refinement of the indicator (value scales, consideration of restoration time within the values given, etc.) is needed before it can be applied in practice or be underpinned with political goals or instruments.

4.3.1 Categories for land use and land use change

Assessing land use and land use change in the context of land degradation neutrality requires a clear definition of land use categories that allow for conclusions to be drawn about the potential impact on natural soil functions. The derived categories should reflect the land use categories which are already used by statistical agencies and therefore build on existing monitoring activities. In Germany, the federal statistical agency (DESTATIS) differentiates between eight categories, which are further divided into several sub-categories. Data for these categories is regularly recorded by local cadastral land registers. The eight main land use categories are:

- Building and adjacent open land ("*Gebäude- und Freifläche*")
- Commercial/industrial land (including mining land) ("*Betriebsfläche darunter auch Abbauland"*)
- Recreational land ("*Erholungsfläche"*)
- Traffic areas ("*Verkehrsfläche"*)
- Agricultural land (including arable land, pastures, gardens, vineyards, peatlands, heaths, orchards, agricultural settlements and fallow land) ("*Landwirtschaftsfläche*")
- Forests ("*Waldfläche*")
- Water surfaces ("*Wasserfläche*")
- Other land uses (for example cemeteries)

In the context of LDN it is important to note that within the land categories for traffic and settlement not all areas are sealed. This distinction is important as the sealing of land in most cases goes along with severe loss of soil functions, while for example the use of urban gardens, unpaved ways, etc., still belong to building areas but often have considerably less negative impacts then sealed soils and can even be more soil friendly than some agricultural uses, for example. In Germany at least, a great share of land (approx. 50 %) classified as traffic and settlement consists of unsealed areas such as green areas or roadside vegetation.

Moreover, for ecological assessment of land use it is necessary to further divide agricultural land into the various sub categories listed above because each of them feature significant differences in soil quality and many hold great shares in total land area.

Despite the need to consider existing national monitoring systems, it is also helpful to review other land use classifications, such as those used by the Intergovernmental Panel on Climate Change (IPCC). Most land and land use change assessments conducted in academic and political contexts build on the IPCC categories of forestry, cropland, grassland, wetland, settlement and other land, which are further divided or adapted depending on the overall purpose of the assessment or the geographical context. In a recent German study, additional sub-categories have been defined in order to assess long term changes in land use and management in several federal states (Untenecker et al. 2017).

At the EU level, the CORINE Land Cover System distinguishes between three levels of land use categories. The first level divides land use forms into one of the following groups: 1. Artificial areas, 2. Agricultural areas, 3. Forests and semi-natural areas, 4. Wetlands and 5. Water bodies. The second level is highlighted in table 3 (water bodies not included). The third level is an even further refinement of the second level consisting of 44 land use categories in total. Table 3 provides an overview of the mentioned land use category systems.

Table 3: Comparing different land use categories

IPCC categories	German system DESTATIS (Basic categories, first level)	Sub-categories according to Untenecker u. a. (2017)	CORINE Land Cover (2. Level)
Forest	Forest	Forest	Forests
Cropland	Agricultural land	Arable land Horticulture	Arable land Permanent Crops Heterogeneous agricultural areas
Grassland		Grassland Heathland Shrub land	Pastures Scrub and/or herbaceous vegetation associations
Wetland	Water Surface	Fen Peatlands Water body	Inland wetlands Maritime wetlands
Settlement	Settlements and open land Industrial and commercial land Land for recreation Traffic areas	Settlement	Urban fabric Industrial, commercial and transport units Mine, dump and construction sites Artificial, non-agricultural vegetated areas
Other land	Other uses	Abandoned land Fallow Land Other	Open spaces with little or no vegetation

Source: Own presentation, Ecologic Institute

However, all of the listed land use classifications do not distinguish between land use intensity within each of the land use categories. In other words, the division between categories might be very detailed, but it cannot be detected if, for example, a conversion of conventional farming into organic farming has taken place as they are both within the same category arable land. For LDN, however, this is very important as land use intensity has a strong impact on soil functions and soil (quality) parameters.

We therefore added further detail in terms of use intensity, by developing a different system of land use categories as described below.

4.3.2 Integration of the hemeroby concept into a land use classification

Our proposed approach to classify land uses significantly builds on Fehrenbach et al. (2015) who applied the hemeroby concept to assess land use and land use change in Life Cycle Assessments (LCA). Based on a hemeroby classification (see Table 4), they assign numeric values to certain land uses according to their “naturalness”. The classification divides between seven hemeroby classes from “I natural” to “VII non-natural”. Changes in hemeroby classes correspond then with changes in values[16] (ranging between 0 and 1, not shown on this table).[17]

Table 4: Classification of hemeroby for different land uses (adapted from Fehrenbach, Grahl and Busch 2015)

Hemeroby class		Forestry	Agriculture	Other
I	Natural	-	-	Undisturbed ecosystem, pristine forest, no utilisation
II	Close-to-nature	Close-to-nature forest management	-	
III	Partially close-to-nature	Intermediate forest management	Highly diversified agroforestry systems	
IV	Semi-natural	Semi-natural forest management	Close-to-nature agricultural land use, extensive grassland, orchards, etc	
V	Partially distant to nature	Mono-cultural forest	Intermediate agriculture, moderate intensity, Short rotation coppices, fertilized grassland	
VI	Distant to nature	-	Large-area, highly intensified arable land in cleared landscape	Solar fields, wind parks
VII	Non-natural	-	-	Long-term sealed, mining lands, landfills

Source: Own presentation, Ecologic Institute

16 In German called “Naturfernepotential”, which can be translated in “distant to nature potential”.

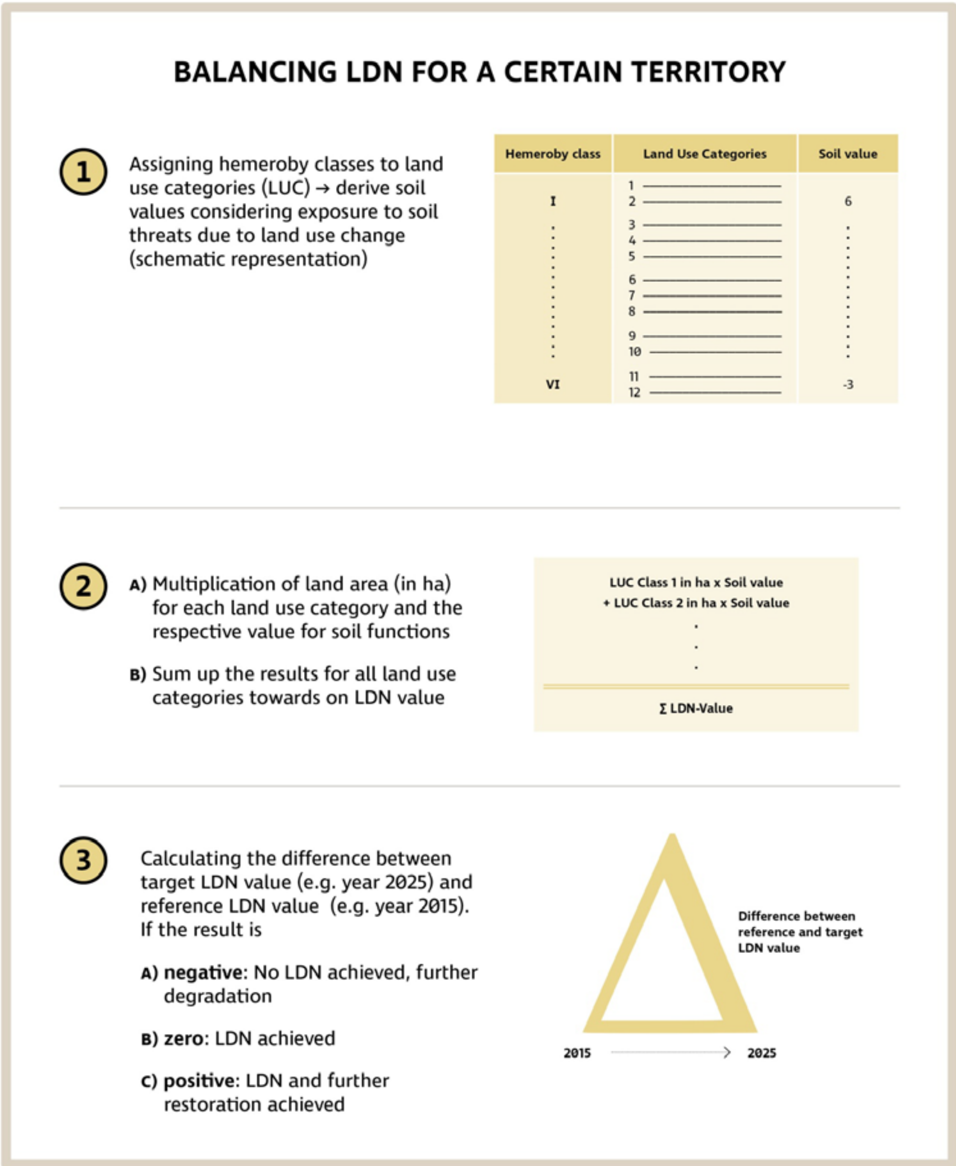
17 Values range between 1 (hemeroby class VII) and 0. A value of 1 represents the maximum distance away from a natural ecosystem, a value of 0 would mean that practically no human impact exists on the respective ecosystem. If changes between classes occur (decreasing classes) values are cut in half. A change from class I to II therefore means a change from 1 to 0,5. A change from class II to III means a change of the value from 0,5 to 0,25 and so on.

In order to make the hemeroby concept applicable for assessing LDN, we simplify the land use categories used in Fehrenbach et al. (2015) resulting in new LDN land use categories which are more strongly aligned with the categories used by the Federal Statistics Agency (DESTATIS, see above) and which can be easily detected by modern remote sensing (RS) techniques. Also, we broaden the scale of values for different land use categories and diversify land uses based on their management intensity.

4.3.3 Assigning soil values to land use categories

When arranging the new land use categories with the hemeroby classes they obtain a numeric soil value (see Figure 6). Unlike Fehrenbach (Fehrenbach et al. 2015), we chose an iterative scale with 0.5 intervals from one category to another instead of dividing the categories in half. The broader scale allows for a more flexible placement of every category according to the likely adverse effects of soil threats. With regard to a certain geographical region, land use change can then be calculated by the numeric interval between respective land use categories per hectare of land area under consideration (see Figure 5).

Figure 5 Development of the Land Use Change Indicator



Source: Own presentation, Ecologic Institute

In the LDN context, negative values can be defined as land degradation, while positive values enhance the quality of land through restauration or regeneration. If "negative land use change" is unavoidable, for example if new settlements are built on former arable land, the effected hectares need to be compensated in another place, for example by unsealing soils and subsequent planting of trees. The German impact regulation ("*Eingriffsregelung*") operates under similar conditions, however methodologies differ significantly between the German Federal States and soils are only one subject for protection besides many others (such as protected species, habitats, water, air, etc.), which often leads to an underrepresentation of soils in overall impact assessments. This simple calculation model can be further extended into an overall LDN balancing model for a certain region.

The preliminary categorization of land uses and the assignment of soil values is shown in Figure 6. While these results already found some agreement on the rough clustering of land uses and soil value assignment in an expert workshop in March 2017 and in further interviews, it needs to be noted that this table is still in a preliminary state and mainly serves to illustrate the presented indicator concept.

Specifically, spatial and temporal dimensions of degrading and compensating land use measures, as well as more detailed graduations between land use categories, still need to be elaborated on among soil scientists and discussed with national policy makers. After all, any assignment of values will reflect societal values and priorities, which also puts requirements on the transparency of the process.

In order to increase transparency, Figure 6 also includes evaluations based on expert judgement about adverse effects of soil threats due to land uses. The impact of the six different soil threats[18] is however not weighted. The illustration rather aims to make the assignment of soil values to land use categories more transparent.

[18] We chose the six soil threats that have been identified as key problems in Germany from the expert interviews and workshops.

Figure 6 Assigning Soil values for Land Use Categories based on soil threats

Soil value*	LDN Land Use Category	Sealing*	Erosion*	Loss of soil organic matter*	Compaction*	Contamination*	Nutrient overload*
6	Pristine forest Wetlands and peatlands	⇑	⇑	⇑	⇑	⇑	⇑
5,5	Close-to-nature forest management Deciduous and mixed forests	⇑	⇑	⇑	⇗	⇑	⇗
5							
4,5	Extensive and/or organic grassland management	⇑	⇑	⇑	⇗	⇗	⇗
4	Intensive forest management Coniferous forests	⇑	⇗	⇗	⇗	⇗	⇗
3,5	Conventional/intensive grassland management	⇑	⇗	⇗	⇗	⇗	⇒
3	Organic farming, Set-aside farmland	⇑	⇒	⇒	⇒	⇗	⇒
2,5							
2	Unsealed urban area (with vegetation) Photovoltaic areas	⇗	⇗	⇒	⇘	⇒	⇒
1,5	Conventional farming (arable land)	⇑	⇘	⇘	⇘	⇒	⇘
1							
0,5							
0							
-0,5	Unsealed urban area (no vegetation)	⇗	⇓	⇓	⇘	⇒	⇒
-1							
-1,5							
-2	Mining areas	⇒	⇓	⇓	⇓	⇘	⇒
-2,5	Sealed urban area	⇓	⇓	⇓	⇓	⇘	⇒
-3	Landfills	⇓	⇓	⇓	⇓	⇓	⇓

*preliminarly, exemplary values that will need further scientific evaluation

LEGEND

⇑ No adverse effects with regard to the mentioned soil threat
⇗ Few adverse effects with regard to the mentioned soil threat
⇒ Moderate adverse effects with regard to the mentioned soil threat
⇘ Significant adverse effects with regard to the mentioned soil threat
⇓ Severe adverse effects with regard to the mentioned soil threat

Source: Own presentation, Ecologic Institute

4.3.4 Benefits and limitations of the indicator and transferability of the approach

Making the proposed balancing approach operational requires a solid data base for identifying land uses and land use changes. Here, we drew on the land use categories used by the German federal statistical agency and the local cadastral land registers. In Germany, such categories are widely consistent, but in other countries a harmonisation of land use categories might be needed as the first step towards a proper monitoring system. However, the system presented can also be used in other countries.

The second step involves the question of data collection. Given the broad application and coverage as well as current developments towards further refinement of resolution and interpretation methods, it is recommended to streamline land use (change) monitoring via remote sensing (RS) techniques and data. Also, comparability between regions and countries is far more achievable using RS rather than using solely national cadastral data sets for balancing land use changes and LDN[19].

Overall, we believe that the developed approach can easily be adapted and used in other countries since it is relatively easy to use, has a clear focus on natural soil functions, and avoids the often difficult collection of physical indicators.

With regard to the German implementation, it now needs to be seen if further progress can be made in 2017 to include an indicator about soil quality and LDN within the German Sustainable Development Strategy, which will be revised until 2018 and serves as the main strategic document for the implementation of the SDGs. To support this, further discussions between soil experts and policy makers should take place in order to calibrate the proposed model that has already seen much agreement[20] for its overall structure.

The main limitation of the indicator though is that it cannot inform about changes in soil quality outside Germany that have been caused due to German consumption and trade patterns. For this reason many experts who were interviewed within the project mentioned the need to formulate a separate indicator on "extra-territorial effects" or an indicator on "ecological footprints". They argue that the consumption of imported goods puts pressure on land resources in other countries, and that this "virtual net import of land" should be considered in the efforts to implement LDN.

Finally, it should be noted that the suggested indicator as it expressed here is not directly applicable for the specific reporting requirement of target 15.3 ("Proportion of land that is degraded over total land", see chapter 1.4), since it formulates a numeric value that is either positive, negative or neutral (in the latter case LDN is achieved). However, in a modified form the presented approach could be used to express areas of degraded land and therefore suitable to report on SDG 15.3.

19 Establishing a rigorous and consistent monitoring system will only be possible through close cooperation between statistical and environmental agencies and research institutions who are familiar with using remote sensing technologies and their applications.

20 And international interest, e.g. at the Global Soil Week 2017

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6 Annex I List of interviewees

We would like to use the opportunity to thank all interviewees[21] that took the time to respond to the questions about soil threats, indicators and policy opportunities within the research project "Implementing the Sustainable Development Goals on Soils in Germany". The majority of interviews were conducted in spring and summer 2016.

- Dr. Mariam Akhtar-Schuster, Desernet International
- Dr. Mechthild Baron, SRU
- Andreas Bieber, BMUB
- Dr. Erik Borg, DLR
- Wilhelm Breuer, NLWKN
- Dr. Joachim Brunotte, Thünen Institut
- Dr. Thomas Caspari, ISRIC
- Prof. Dr. Ilan Chabay, IASS
- Dr. Axel Don, Thünen Institut
- Dr. Peter Dreher, Umweltministerium Baden-Württemburg
- Dr. Einar Eberhardt, Bundesanst. für Geowissenschaften und Rohstoffe
- Walter Engelberg, GIZ
- Dr. Alexander Erlewein, UNCCD
- Prof. Dr. Gunay Erpul, Ankara University
- Dr. Andreas Faensen-Thiebes, BUND
- Horst Fehrenbach, IFEU
- Jörn Fröhlich, Ministerium für Energiewende, Landwirtschaft, Umwelt und ländliche Räume des Landes Schleswig-Holstein
- Dr. Frank Glante, UBA
- Dr. Johannes Gnädinger, Professor Schaller UmweltConsult
- Prof. Dagmar Haase, UFZ, HU Berlin
- Prof. Dr. Alois Heißenhuber, TU München
- Prof. Dr. Katharina Helming, ZALF
- Frank Hönerbach, BMUB
- Dr. Lothar Hövelmann, Fachzentrum Landwirtschaft der Deutschen Landwirtschafts-Gesellschaft
- Sigbert Huber, UBA Wien
- Wilhelm König, Ministerium für Umwelt, Raumordnung und Landwirtschaft NRW
- Prof. Dr. Johann Köppel, TU Berlin
- Dr. Dorit Kuhnt, Ministerium für Landwirtschaft, Umwelt und ländliche Räume des Landes Schleswig Holstein
- PD Dr. Angela Lausch, UFZ
- Dr. Marco Lorenz, Thünen Insitut
- Geertrui Louwagie, EEA
- Kirstin Marx, Thünen Institut
- Prof. Dr. Graciela Metternich, School of Biological, Earth and Environmental Sciences, UNSW Australia
- Luca Montanarella, European Commission
- Elisabeth Oechtering, Bundesverband Boden e.V.
- Gertrude Penn Bressel, UBA

[21] In alphabetical order by sirname

- Thomas Preuß, DIFU
- Uriel Safriel, Hebrew University of Jerusalem
- Dr. Dietrich Schulz, UBA
- Prof. Ernst Detlev Schulze, MPI Jena, emer.
- Dr. Stefan Sommer, JRC IES
- Dr. Thomas Straßburger, BMUB
- Prof. Dr. Lindsay Stringer, Sustainability Research Institute, School of Earth and Environment, University of Leeds
- Dr. Thomas Suttner, Bayerisches Staatsministerium für Umwelt und Verbraucherschutz
- Prof. Dr. Joachim von Braun, Zentrum für Entwicklungsforschung, Uni Bonn
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- Patrick Worms, CGIAR