PRIVATE SECTOR AND NATURAL CAPITAL

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Global Nature Fund

NATURAL CAPITAL ASSESSMENT FOR TRENCHLESS PIPE LAYING

GSTT

TRACTO-TECHNIK

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Umwelt Bundesamt

Impressum

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1. Goal of the pilot study

Natural capital assessments allow companies to assess and evaluate the environmental impact of a product, project or corporation (Infobox 1). The results enable better business decision-making. By conducting two pilot studies, the Global Nature Fund (GNF) and its project partners have gained crucial initial experience in conducting such assessments. This document provides information on various aspects of the first pilot study.

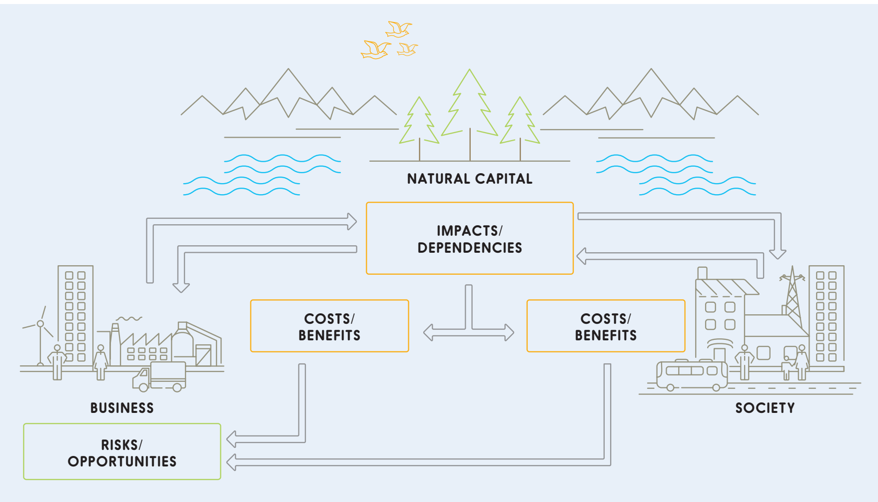
INFOBOX1:
NATURAL CAPITAL

can be defined as the world´s stocks of natural assets – both renewable and non-renewable – which include soil, air, water, minerals and all living things, benefical and crucial to the survival of mankind.

Goal of the analysis

The pilot study was carried out by GNF, in corporation with proponents of the „trenchless" technology (Infobox 2), in order to assess ecological benefits of the technology. One of the most important parts of the study was to present the results to potential clients both within and outside Germany. This is particularly relevant in Germany, as infrastructure measures are implemented by the public sector, and thus decisions are still mainly based on conventional economic indicators – although there is an obligation to consider common welfare e.g. nature and the environment.

Contracts are awarded based primarily on the costs of raw material, labor, machinery and other direct costs involved in the respective construction project. Thereby, little attention is paid to the considerable, immediate or long-term impact pipe laying has on nature and the environment, by cutting trees or from pollution caused by construction machines. The project partners need to ensure that these and other environmental impacts have a higher priority in planning, evaluating and awarding contracts for pipe construction. Natural capital assessments are an important tool to make this possible. During the assessment, the environmental impacts of trenchless pipe laying are compared to those of open construction. Thereby, various environmental aspects are highlighted, which are currently still ignored when it comes to awarding construction contracts and which should be considered in future decisions, once the results are properly evaluated.



Natural capital impacts and dependencies: conceptual model (NCC 2016)

INFOBOX 2:
PROJECT PARTNER

TRACTO-TECHNIK GmbH & Co. KG *develops and builds machines for the underground installation and trenchless renewal of pipelines.*

German Society for Trenchless Technology e.V. (GSTT) *GSTT promotes the trenchless technology in Germany and internationally (58 Members).*

2. Brief description of the technologies: open and trenchless construction

Open Construction

Laying a pipe line with the open construction method requires the creation of a trench along the entire length and working width of the pipe. The removed soil is usually transported away from the site. Once the pipe is in the ground, the area has to be restored.

During the construction period, various heavy machines such as excavators/diggers and bulldozers are employed. In urban areas, traffic diversions are unavoidable while construction is ongoing. These activities lead to increased emissions of air pollutants and greenhouse gases (Fig. 1).

Trenchless Technology

The trenchless technology only requires a receiving hole and an entrance pit although a number of intermediate excavation pits are necessary in the case of long pipelines. The remaining surface soil stays undisturbed. As a result, less soil has to be excavated and a smaller area has to be restored. Thus, the construction time can be considerably shorter, in comparison to open construction (Fig. 2).

However, the excavated material from both technologies needs to be transported by trucks and disposed of elsewhere. Additionally, new soil of a suitable quality is needed, in order to fill the created pit(s) and restore the landscape.

Fig. 1: Traditional open construction

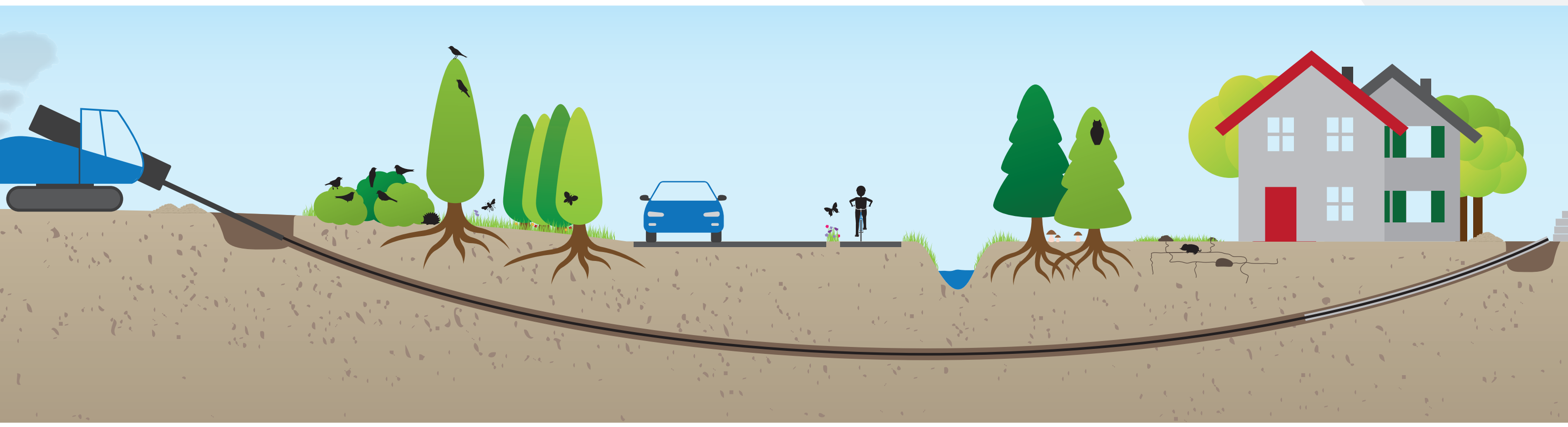


Fig. 2: Trenchless pipe laying with the Horizontal Directional Drilling method

3. Scope of the pilot study

The impact of pipe laying operations on natural capital depends on many different factors. An important aspect is the presence of animal and plant habitats in the immediate vicinity that may be affected by construction. The effect on humans is determined by the number of people who live, work or pass through the construction site and are consequently exposed to the environmental effects. Also relevant is the amount and texture of the soil that needs to be removed, as this determines the energy expenditure of the construction machines and impact on soil-dwelling organisms. In order to demonstrate some general statements about environmental impacts of both methods, a hypothetical construction site is described below.

We assume that a 1,000 m long plastic (HDPE) drinking water pipe needs to be installed in a residential district in Berlin. Here we analyze two methods: a) the trenchless pipe installation using the horizontal directional drilling method (HDD, see Infobox 3), and b) the conventional, open construction method. The analysis focuses on the differences between the two techniques, whereby the environmental effects that are similar for both methods (e.g. pipe manufacturing), are not considered.

However, not only the environmental impact caused directly by the construction is relevant. There are also changes to natural capital in the various stages of the value chain, e.g. the production of raw materials and materials, transport, as well as the disposal of the soil. These aspects also differ in the two scenarios.

INFOBOX 3:
HORIZONTAL DIRECTIONAL DRILLING METHOD

During the Horizontal Directional Drilling, a pilot hole on the designed path is drilled. While the drilling head operates, a drilling fluid (mixture of water and bentonite) is pumped into the hole. This drilling fluid stabilizes the bore hole and supports the removal of the drill cuttings. Once the drilling head reaches the receiving hole, it is replaced by a reamer with a larger diameter. This enlarges the hole when pulling back and simultaneously installs the pipe.

4. Identification of the relevant environmental impacts (Materiality assessment)

The materiality assessment helps companies to select relevant environmental impacts to be considered in the natural capital assessment. To this end, a list of impacts on natural capital caused by the two construction methods is compiled. Subsequently, the relevance of these environmental impacts is assessed using two criteria: On the one hand those aspects, in which the two methods clearly differ, need to be considered in order to assess the differences in the inherent environmental impacts. On the other hand those changes in natural capital need to be taken into account, where the damage and costs are borne by the general public and not the construction company. These include costs caused by the damage and destruction of vegetation or the consequences for the health of local residents (Table 1).

INFOBOX 4:
ECOSYSTEM SERVICES

Ecosystem services are direct or indirect benefits that people obtain from ecosystems. This includes services such as natural raw materials, fresh water, climate and erosion regulation, as well as water purification.

Table 1: Materiality assessment

Natural capital impact driver	Activity	Natural capital impact	Relevance
Greenhouse gas emissions (GHG emissions)	Fuel combustion for the use of construction machines and the transportation of soil. Traffic jams or diversions due to the construction site.	GHG emissions contribute to global climate change. This can affect human health and can lead to changes in the natural environment.	GHG emissions arising from fuel combustion are regarded as relevant. Due to the larger pit, more machines and transport vehicles are needed for the open construction. Furthermore, construction time is longer for most open constructions. According to our scenario, a construction site in a residential area is likely to result in only minor traffic obstructions, which is therefore not taken into account.
Air pollutants	During construction, various airborne pollutants are released, including fine dust particles, nitrogen oxide, volatile organic compounds and others. A large part of these pollutants are generated by the combustion of engine fuels.	Airborne pollutants harm human health and can lead to crop yield losses.	Due to the high level of machine use, airborne pollutants are very relevant for this analysis. Emissions from traffic obstructions are not taken into account for the aforementioned reasons.

Natural capital impact driver	Activity	Natural capital impact	Relevance
Water use	The trenchless technique (HDD) requires water for the drilling mud. The open design, on the other hand, does not require any use of water.	Water use can affect the water cycle and can increase water scarcity.	With regards to water use, the two methods differ significantly, so this aspect is relevant.
Groundwater level drawdown	In open pipe installations, measures for groundwater drawdown are necessary for soils with high groundwater levels.	The drawdown of the groundwater level has a considerable effect on existing soil layers, causing either soil compaction or soil/land subsidence. Plants potentially lose access to water and dry out. Trees and shrubs become more susceptible to pests.	The relevance of the environmental impact depends on the installation depth of the pipe, amongst others. In this scenario – a construction site in a residential district in Berlin – the groundwater level is low. Measures for lowering the groundwater level are not necessary and excluded from this analysis.
Material use / Resource use	Bentonite is a mixture of different clay minerals and, mixed with water, is used as a drilling mud. This drilling fluid stabilizes the bore hole and supports the removal of the drill cuttings. In addition to this, diesel is used for the construction machines and trucks.	The production of bentonite and fossil fuel causes GHG and other emissions. Additionally, water and land use is necessary for mining. This can have different environmental effects, which are taken into account in the respective environmental impact categories (GHG emissions, air pollutants, etc.).	Bentonite is only used in the trenchless technique and is therefore deemed relevant. Diesel represents the primary use of resources and contributes to changes in natural capital which is why it is also considered relevant.
Land use	Land use on construction site: Vegetation is removed, soil is excavated and modified in its composition. Sometimes trees are cut down. Beyond the construction site, land is also used for the cultivation of rape as fuel component.	One cubic meter of soil contains several trillion organisms (e.g., bacteria, fungi, spiders). They coexist in complex functional contexts. Ground movements can damage the roots of trees or cut off the water supply. As a result, trees can only make a limited contribution to important ecosystem services, such as absorbing greenhouse gases and regulating the local climate (Infobox 4). The land used for the cultivation of energy crops is no longer available as a habitat for further plants and animals.	The influence of land use on plants and animals is relevant, but cannot be quantified due to the complex biological interactions. In order to take this effect into account, at least to some extent, two clear factors are included in the assessment: (1) The impact on trees due to machine use. (2) The loss of habitat both on the construction site itself and indirectly through the production of raw materials.

Natural capital impact driver	Activity	Natural capital impact	Relevance
Waste / Excavated soil	When removing soil, one needs to differentiate between loaded and unloaded material. Loaded material must either be disposed of or cleaned and reprocessed, whereas unloaded soil can be re-installed immediately.	Soil is often contaminated and requires land use for disposal or further treatment. This land use and the change in natural capital are included in the land use category.	The open construction method requires much more excavation. The impact on the environment is considered relevant and therefore included in the analysis.
Noise	Construction machines cause noise pollution.	Noise emissions have an impact on human health. It can affect general well-being and lead to illness.	Due to the longer construction time and the use of more machines, the open construction emits more noise than the trenchless pipe installation. However, the extent of the damage is strongly dependent on the assumptions made in the case study. Therefore, we only consider them qualitatively.

5. Data collection and evaluation

Once we have identified the relevant impacts on natural capital in both methods, we measure and evaluate them. First, resource consumption (water, fuels, land consumption, other raw materials) and emissions (greenhouse gases, air pollutants, noise) must be determined. This is done by conducting expert interviews, literature research and by applying LCA models[1]. The absolute consumption and the total emissions serve as a basis for the monetary valuation of the change in natural capital. The corresponding costs rates are determined using scientific literature, expert interviews and publicly accessible databases, all of which are summarized in the following table.

Table 2: Cost rates and data sources for the natural capital assessment

Category	Value	Unit	Valuation approach and cost categories	Year	Sources
Climate change					
Greenhouse gases	106	€ / t CO_2-eq	Climate costs for limiting global warming to a maximum of 2 °C temperature increase (450 ppm).	2015	Interpolated and inflation-adjusted value, German Federal Environment Agency (http://bit.ly/2woxzQL)
Water consumption					
Water costs	1.81	€ / m^3	Market price for the provision of drinking water.	2015	Berliner Wasserbetriebe (http://bit.ly/2w99huX)
Health damage caused by water extraction	0.04	€ / m^3	Determination of environmental costs by means of average health damage (DALY, VSL[2]) due to water extraction and resulting potential water shortage.	2016	Life cycle assessment data from ReCipe (http://bit.ly/2iTWzNH)

[1] LCA stands for Lifecycle Assessment. LCA models translate complex scientific contexts into easily comprehensible indicators. Since not all information can be made available, one speaks of models (highly simplified representations of reality).

Category	Value	Unit	Valuation approach and cost categories	Year	Sources
Land use and soil					
Biodiversity loss through land use	1,128,318	€ / (species x year)	Annual (modeled) average costs to protect a species from extinction (derived from the cost of protecting a species so that it can be lowered one category in the IUCN red list for endangered species).	2012, 2015, 2016	Life cycle assessment data for the number of affected species: ReCipe (http://bit.ly/2iTWzNH); McCarthy (http://bit.ly/2k7bdy6) for the estimation of the costs incurred, BfN species protection report (Artenschutzreport) for the proportions of the risk categories among the German creatures (http://bit.ly/1PW3tGX).
Tree damage	106	€ / (tree x year)	Benefit-Transfer: By estimating the loss of ecosystem services due to tree damage. Annual ecosystem services (energy, air quality, resilience against climate / flood, CO_2 absorption, aesthetics) of a tree in Berlin.	2006	New York Park Administration (http://bit.ly/2joluDZ) , Berlin Senate (http://bit.ly/2jQpWje)
Disposal of excavated soil	8.25	€ / m³	Market price for disposing of the soil in a landfill.	2017	Median value of 10 different costs sourced from the internet. (http://bit.ly/2jT2d2e, http://bit.ly/2kj8BfF, http://bit.ly/2k80iV0, http://bit.ly/2kjsHe7)
Air pollution					
Nitrogen oxides (NO_X)	15,400	€ / t NO_X	Environmental costs based on health damages (DALY), biodiversity loss, crop damage and material damage.	2010	German Federal Environment Agency (http://bit.ly/2w9B8eA)
Particulate matter (PM_{10})	33,700	€ / t PM_{10}	Environmental costs based on health damages (DALY).	2010	German Federal Environment Agency (http://bit.ly/2w9B8eA)
Non-methane volatile organic compounds (NMVOC)	1,700	€ / t NMVOC	Environmental costs based on health damages (DALY), biodiversity loss and crop damage.	2010	German Federal Environment Agency (http://bit.ly/2w9B8eA)
Noise emissions[3]					
Noise		No linear relation	Benefit Transfer: Valuation of reduced quality of life by using the decrease in property prices.	2015	Senetra (http://bit.ly/2j5ooxN)

[2] Using DALY (Disability-adjusted Life Years) and VSL (Value of Statistical Life), health injuries can be modeled as monetary losses.
[3] Noise emissions are considered relevant, but are not included in the results due to the great uncertainties in the monetary valuation.

6. Results of the natural capital assessment

The open construction method **at the hypothetical construction site** results in a natural capital impact of EUR 40,228, whereas **the trenchless pipe installation** with the same basic hypothetical set up, caused natural capital costs of EUR 1,662. This is **EUR 38,565 less and thus only 4 % of the damage costs for open construction.**

Table 3 shows the environmental impact of the open construction (yellow points) and the trenchless construction (blue points), whereby the size of the points indicates the extent of the environmental impact. In compiling the table, we considered each impact category and the environmental impacts along the entire value chain.

As illustrated in Table 3, **the trenchless construction method has considerably lower natural capital costs than the open construction**, in almost all categories at every stage of the value chain. The most significant differences are associated with the use of transportation (EUR 8,841), processes on the construction site itself (EUR 17,226) and for the soil disposal (EUR 12,407). Air pollution caused by the use of machinery on the construction site and during the transport has a high impact on people's health. Up to EUR 21,680 in natural capital damage through air pollution can be avoided by applying the trenchless construction, as it requires less machinery and has a shorter construction time. Another important advantage of the trenchless construction is that it has a decisively lower interference with the soil and the plant and animal world. The low space requirement results in only EUR 147 natural capital costs. In contrast, the open construction causes biodiversity losses equivalent to EUR 13,817. The impact on biodiversity is therefore almost 94 times higher.

Table 3: Natural capital assessment results

	Resources		Transport		Site		Disposal	
	OPEN	TRENCHLESS	OPEN	TRENCHLESS	OPEN	TRENCHLESS	OPEN	TRENCHLESS
	22 €	2 €	2,171 €	18 €	1,237 €	193 €	0 €	0 €
	47 €	3 €	X €	X €	0 €	44 €	58 €	59 €
	29 €	2 €	X €	X €	1,248 €	13 €	12,540 €	132 €
	< 1 €	< 1 €	6,744 €	56 €	16,132 €	1,140 €	0 €	0 €
Total	98 €	7 €	8,915 €	74 €	18,617 €	1,390 €	12,598 €	191 €

Total amount:

Open Construction	40,228 €
Trenchless Technology	1,662 €

Global Warming

Water usage

Biodiversity loss due to land & soil use

Air pollution

7. Conclusion and next steps

First of all, it should be noted that any construction project, such as the pipe installation, has negative effects on workers, residents and flora and fauna. However, each case must be assessed individually as the impacts on natural capital of each respective technology, are largely dependent on construction site conditions. Overall it is evident that the open construction method leads to much greater changes in natural capital than the trenchless technology. The natural capital assessment allows the evaluation of these environmental effects in monetary terms and is a measure for comparison of the two methods. Environmental impacts are assessed in the form of medical costs for people, costs for restoration or maintenance measures of flora and fauna, as well as losses in recreational value associated with a loss of biodiversity. Additionally, this study demonstrates that the total costs of open construction would be considerably higher if the impacts on natural capital were included. If these costs were taken into account in the (public) tendering, it could have a significant influence on decisions. The public sector, in particular, is a key player in integrating the environmental effects of infrastructure measures into decisions and promoting incentives to reduce impacts on natural capital.

The pilot study clearly shows that setting the scope is an important step in the analysis. Depending on whether the construction site of interest is in a city, near the sea or in the mountains, the respective natural capital impacts and thus the results can vary. Additionally, involving a wide variety of experts is useful to identify relevant environmental impacts and to make realistic assumptions. It is also important to note that the natural capital assessment is an iterative process. During the study, new findings can lead to adjustments to previously assumed parameters, but also to modification of the scope or assessment methods. For instance, noise emissions associated with the construction site and transports were deemed relevant, but the quantitative and monetary valuation of these impacts was proven to be too complex for this analysis and therefore will be assessed through further investigation.

This study is the first detailed analysis in a series of publications on natural capital assessments in Germany. Potential clients interested in taking infrastructure measures should be informed about costs to natural capital and encouraged to take these into account in future. Recommendations for political action to further promote natural capital assessments will be presented in a policy paper.