Approach for assessing environmental handprints

Laura Lakanen[1*], *Kaisa* Grönman[1], *Heli* Kasurinen[1] *Saija* Vatanen[2], *Tiina* Pajula[2], *Katri* Behm[2], and *Risto* Soukka[1]

[1]Lappeenranta-Lahti University of Technology LUT, P.O. Box 20, FI-53851 Lappeenranta, Finland
[2] VTT Technical Research Centre of Finland Ltd, P.O. Box 1000, FI-02044 VTT, Finland

Abstract. The need to reveal positive environmental consequences of offerings has risen as urgent climate actions are needed from companies. The environmental handprint approach was developed to indicate the positive environmental impacts of a solution offered to a client. The environmental handprint approach builds upon the previously published carbon handprint approach. The approach follows the guidelines of ISO standards on Life Cycle Assessment (LCA) but complements them with instructions for calculating positive environmental impacts. The environmental handprint framework allows consideration of several different environmental impacts including climate impacts, air quality, and utilization of nutrients, water and resources, and it can be applied to products, services, organisations and projects. The framework consists of four main stages: 1. Handprint requirements, 2. Additional LCA requirements, 3. Quantification, 4. Communication. The handprint approach provides an important addition to life cycle studies. Handprints can be used by organizations to communicate the environmental benefits of their products, services, and technologies. They also serve as an aid to identify improvement potential throughout the life cycle of an offering, thus supporting product development and decision making. Case studies supported the methodology development. A case related to water handprint in water treatment in the mining industry is presented in this paper.

1 Introduction

In recent years, sustainability goals have become increasingly important to steer companies' actions. Measuring the environmental performance of products and services has concentrated on negative life cycle impacts, and there has been an increasing interest for indicators that reveal positive environmental consequences of offerings. Various companies and organizations that have already minimized their own footprint have been lacking the means to showcase the environmental benefits their offerings can enable to their customers. LCA studies, based on ISO LCA standards [1,2], provide valuable information of the environmental burden of a product system from cradle to grave. However, specifications to these general LCA standards are needed to improve the accuracy of assessments and to widen the scope of studies towards assessing positive impacts. For example, ISO 14067 [3] on the carbon footprint of products specifies the principles, requirements and guidelines for the quantification and reporting of the carbon footprint of a product, thus complementing ISO 14040 and ISO 14044 standards. However, the guidelines for assessing positive environmental impacts of offerings have been lacking. Approach to measure positive impacts

[*] Corresponding author: laura.lakanen@lut.fi

of actions has been recently introduced by Norris et al. [4]. The Sustainability and Health Initiative for NetPositive Enterprise (SHINE) handprint framework developed by Norris et al. aims to quantify environmental, economic, and social positive changes caused by an actor when compared to business-as-usual situation. Biemer [5] has also presented the ideas of handprints by emphasizing a positive way of thinking and well-meant actions to promote sustainability. The carbon handprint approach by research institution VTT and LUT university introduced by Grönman et al. [6] and Pajula et al. [7] provided general principles and instructions for assessing the carbon handprint of a product or service. Based on the most up-to-date definition [8] a handprint refers to *the beneficial environmental impacts that organizations can achieve and communicate by offering products and services that reduce the footprints of others.*

Footprints, in general, describe the environmental burden throughout the life cycle of a product system. Carbon footprint, for example, is usually calculated based on actualized data on company's or product's greenhouse gas emissions and removals. Handprint, however, is a comparative indicator, which describes about the emissions or consumption that can be reduced or avoided using a certain product instead of a baseline product. Thus, the handprint is equal to the possible or actualized reduction in the footprint of the user of the offering. The handprint can be created by two means: Using an offering that carries a lower environmental burden than the baseline offering (cradle to gate processes), e.g., through improved resource efficiency in manufacturing; or through the environmental impact reduction which actualizes while using the offered solution (gate to grave processes), for example through energy efficient products. Also, a combination of both means is possible in order to create a handprint, see Figure 1.

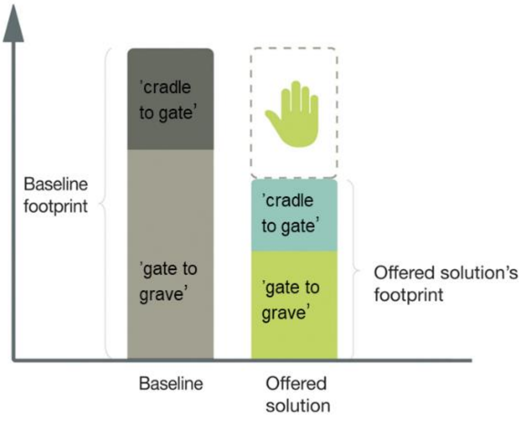

Fig. 1. Handprint is created if the footprint of the offered solution is lower than that of the baseline solution while used by the same customer (modified from [8]).

The carbon handprint approach gives guidelines only for assessing positive climate impacts, i.e., reduction in greenhouse gas (GHG) emissions. However, a framework for evaluating positive environmental impacts for other impact categories with wider application options has been lacking. The environmental handprint approach presented in this paper, aims to respond to the need for specific guidelines to assess positive impacts of products, services, organizations, and projects for several environmental impact categories including climate change, air quality along with nutrient, water, and resource use. The environmental handprint approach from the air quality perspective recently presented by Lakanen et al. [9] is another example for an environmental handprint besides the handprint presented in this present article.

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2 Materials and methods

The framework is based on the carbon handprint approach introduced by Grönman et al. [6] and Pajula et al. [7]. The environmental handprint approach is also closely linked to the standardized LCA method with some specific complements for assessing positive environmental impacts. Environmental handprint is an umbrella concept including various positive environmental impacts. The framework for the environmental handprint is presented in Figure 2.

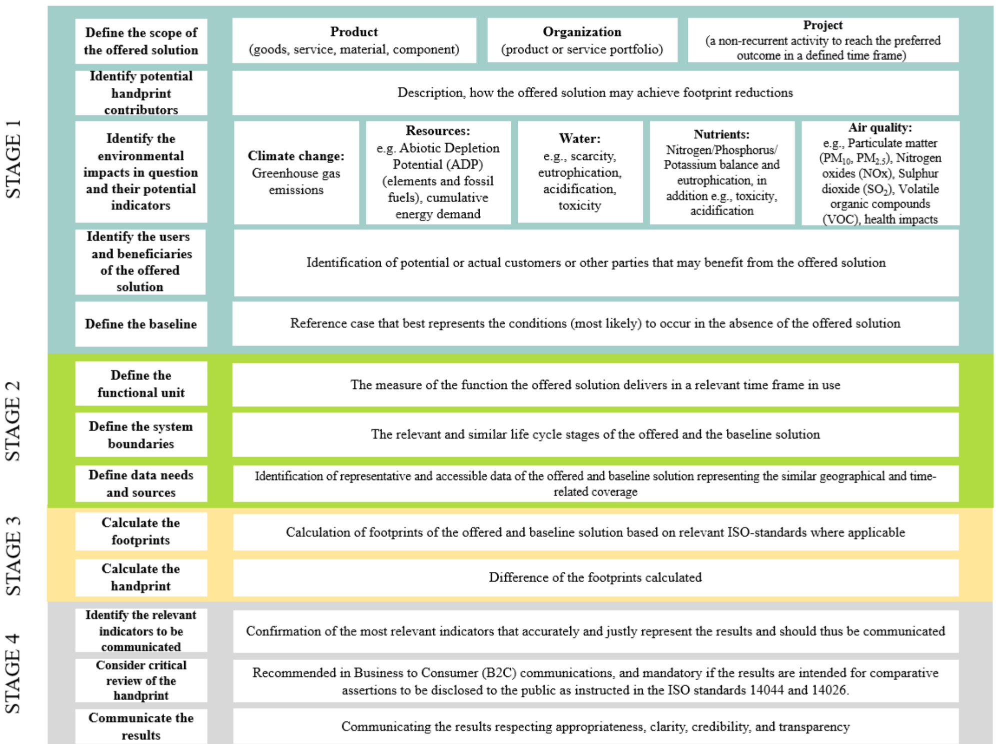

Fig. 2. The framework for the environmental handprint.

The framework consists of four main stages, which are: 1. Handprint requirements, 2. Additional LCA requirements, 3. Quantification, 4. Communication. Each stage comprises several steps, which guide in quantifying and communicating the handprint more precisely. Especially the first stage is specific to a handprint assessment when compared to a traditional LCA assessment, and thus explained here briefly.

In Stage 1, one must first define, whether the handprint assessment is done in a product or an organizational level, or if a project's positive environmental impacts are evaluated. Next, a hypothesis is made about how the offered solution would contribute to reducing footprint of its users. These mechanisms may be derived, for example, from the use of recycled, renewable, or less polluting materials and energy, from increased lifetime or performance, reduced waste or losses or through increased carbon capture and storage. The choice of these mechanisms in question determines which environmental impacts are relevant to be included in the study. Figure 2 presents the recommended indicators when assessing the handprint related to climate change, resources, water, nutrients, and air quality. Further guidelines for conducting the handprint assessment for these different environmental impacts can be found from the final report of the environmental handprint project [10].The fourth step is to identify the users of the studied offering. The handprint calculation always includes the use phase either through an actual or potential user using the studied offering compared to a baseline offering. Thus, handprint studies are always user specific. However, in situations where specific user cannot be identified, e.g., in the case of bulk products or heterogenous customers for the offering, a representative average user may be used in the assessment. However, also in these cases, geographical boundaries need to be kept similar. The final step at Stage 1, defining the baseline, is presumably the most critical on the results of the handprint assessment. The baseline sets the point of comparison, and it should be selected with conservative justifications and reported transparently. For more detailed guidance on the baseline determination procedure, the reader is advised to refer to the Carbon Handprint Guide v. 2.0 [8], which was composed in tight connection to the environmental handprint approach work presented in this paper. In the guide, the following Stages 2-4 of the handprint assessment are also presented.

Case studies, representing several Finnish companies with different offerings from varying industrial sectors, were done to support the framework development. Case studies were performed for all impact categories and applications described in the environmental handprint framework. The case study of water handprint assessment for a water purification technology used in the mining industry is presented in the following subsection.

2.1 Case study: Water handprint of water purification technology

In the case study, the environmental handprint approach from the water quantity and quality perspective was considered to assess potential water handprint of water purification technology. The water handprint approach described in the environmental handprint framework may consist of many indicators, which can be divided into two main categories, as in the water footprint standard ISO 14046 [11]: water scarcity impacts (water quantity) and water quality impacts. In the presented case study, a water scarcity handprint, and a water quality handprint in terms of eutrophication were quantified.

In this case study, the novel water purification technology is used in a water treatment plant in a mining company located in Northern Finland. In a baseline situation, water from underground and open mining operations can be directed to wetlands to be biologically treated. However, the area of the wetlands must be large enough to ensure sufficient removal of nutrients and impurities and moreover, purification potential of the wetlands is strongly dependent on the season and outside temperature. Novel water purification technology, referred here as the offered solution, aims to remove solid matter, dissolved minerals, and metals as well as nitrogen compounds from wastewater before it is released to the wetlands, which reduces emissions to receiving water bodies. Additionally, the share of the purified water from the water treatment plant can be recycled and used in enrichment processes of the mining company, which replaces the primary water intake and decrease overall water consumption. The framework for the case of the water purification technology is presented in Figure 3.

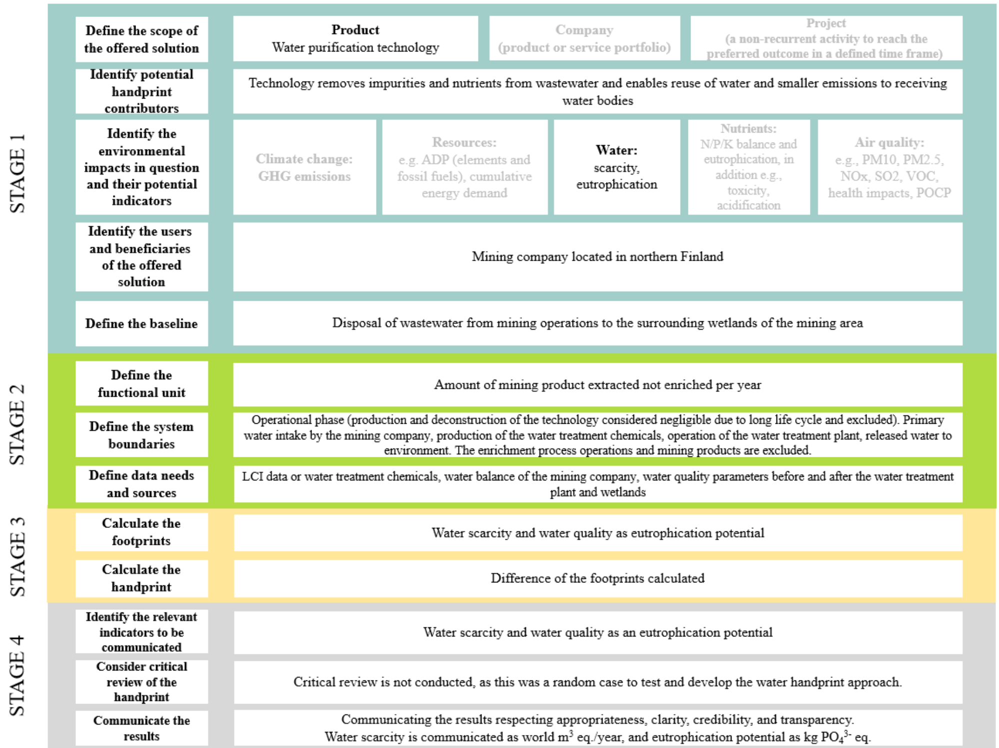

Fig. 3. The water handprint framework for the case of the water purification technology.

To quantify potential water handprint for the water purification technology, water scarcity and water quality footprints for the baseline and offered solutions were determined. The handprint was calculated as a difference between the footprints. The data for water streams of the mining operations were acquired from the environmental permit document of the mining company, which also stated the amounts of water treatment chemicals used per year. The amounts of chemicals used in one month were as follows: Sodium hydroxide (NaOH) 0.05 tonnes (t), ferric sulfate ($Fe_2(SO_4)_3$) 1 t, and polyacrylamide 0.05 t. Water consumption during the production of chemicals was taken from the Ecoinvent database. Table 1 illustrates water consumption volumes used for water scarcity handprint calculation.

Table 1. Water consumption volumes of the baseline and offered solution in water scarcity handprint calculation.

Water consumption / hour	Direct primary water consumption, m^3/h	Recycled water, m^3/h	Indirect primary water consumption, m^3/h
Baseline solution	35	0	0
Offered solution	23	12	0.035

The scarcity factors for each water consumption location are derived from AWaRe (Available Water Remaining) methodology by Boulay et al. [12], which also defined the calculation unit of cubic meters of world equivalent per year (m3 world eq. /y) for scarcity assessment. Local scarcity factors of 0.9 for the plant and 1.1 for chemicals were used.

In the quality assessment, for the baseline it was assumed that the wetlands remove approximately 87% of nitrogen which is bound in NH_4 (NH_4-N) and 3% of nitrite and nitrate-N (NO_2+NO_3-N). The estimated baseline is 7,000 kg N emissions and 40 kg P emissions per year, which were converted to PO_4^{3-} eq. with the CML 2001 general eutrophication impact factors. For the studied solution, the removal efficiency of the process is 75% of nitrogen bound in NH_4 (NH_4-N) and 78% of nitrite and nitrate-N (NO_2+NO_3-N) [13].

3 Results and discussion

Based on water handprint assessment, water scarcity handprint is 94 m^3 world eq. / year, which corresponds to 34% of the annual water demand of the baseline. The water quality handprint in terms of eutrophication showed to be 460 kg PO_4^{3-} eq. / year, meaning a 63% reduction in the eutrophication potential compared to the baseline solution. Both water scarcity and water quality handprints are presented in Figure 4.

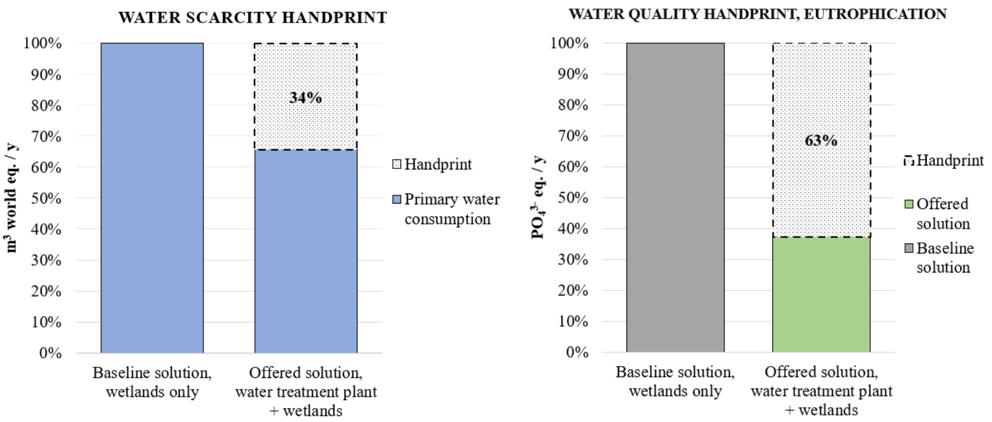

Fig. 4. Water scarcity handprint and water quality handprint as a eutrophication per year in the case study.

The results of the case study show that water purification technology can reduce both water consumption and eutrophication potential compared to the baseline solution. Consequently, the provider of water purification technology may communicate both water scarcity handprint and water quality handprint for its water purification technology when used by the specific mining company in the specific year. The results show that water handprint is a useful and a practicable method for quantifying changes in water use and quality when a new solution is introduced in market or when comparing existing solutions.

With handprints organizations and companies are able to show environmental benefits of their products, technologies, and services, as well as scientifically show their environmental responsibility. Handprint assessment also provides information on improvement potential throughout the life cycle of an offering, thus supporting product development and decision making. For companies, the handprint is not only an effective marketing and communication tool, but also gives valuable information for customers in decision-making.

4 Conclusions

Transition towards more sustainable production and consumption requires actions, which bring about positive changes throughout the value chain of offerings. The approach to assess environmental handprints provides a systematic, scientific-based approach to assess beneficial environmental impacts of products, services, organizations, and projects. It allows consideration of several impact categories including climate change, air quality and utilization of nutrients, water and resources thus providing a multi-purpose indicator for many applications.

As footprints measure principally the negative life cycle impacts of products and services, environmental handprint approach provides a way to assess and communicate positive environmental impacts hence offering a necessary extension for life cycle studies.

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