Submission to the

Department of Department of Culture, Heritage and the Gaeltacht

On

A Review of the Use of Peat in the Horticultural Industry

From:

Cré – Composting and Anaerobic Digestion Association of Ireland

January 31st, 2020

CONTENTS

1. Introduction

Cré welcomes the opportunity to comment on the public consultation on the proposed use of peat in the horticultural sector.

It should be noted that the UK and Norwegian Government also had recent similar consultations on the same topic. The Norwegian Government is looking to stop extracting peat for use in private horticultural by 2025 and for professional use by 2030. A climate impact assessment was done by a leading consultancy on life cycle analysis in Norway. A translated copy of this report is attached to this submission.

Established in 2001, Cré is the Composting and Anaerobic Digestion Association of Ireland. Cré (which is the Irish word for 'soil'), is a non-profit association of public and private organisations, dedicated to growing the biological treatment sector. Cré supports the production of high-quality outputs, assists the delivery of Government waste diversion and bioenergy targets, and promotes the creation of sustainable indigenous jobs.

Cré has a broad membership base ranging from compost and anaerobic digestion facilities, waste companies, local authorities, technology providers, local authorities, consultants and third level colleges. Cré is recognised by Government and agencies as the voice of the industry in Ireland and Northern Ireland. It is frequently called on to give the industry view on future policy and legislation. Cré is a member of the European Compost Network, the European Biogas Association and the Biobased Industries Consortium. Cré has a Board of Directors, a Carbon Committee, a Technical Committee, a Public Relations Committee and an Anaerobic Digestion Committee. See www.cre.ie

We appreciate that maintaining the quality of products for the amateur and professional horticulture markets is important and there is horticulture/growing media industry desire to grow more sustainably. The industry has worked towards overcoming barriers to wider adoption of peat-reduced and peat-free growing media products, especially for the amateur horticulture market, and reducing its impact on peatland degradation. The professional horticulture industry seems unlikely to substantially reduce its use of peat until peat-free growing media are well proven.

Considering waste-derived composts' potential to replace more of the peat, Ireland's composting industry has a successful track record in supplying compost for use as soil improvers (conditioners and mulches) and in manufactured topsoils and growing media in a range of markets. More use of composts in growing media in future is dependent upon supply of sufficient quantities at times of year when manufacturers require them, sufficient quality and at delivered-to-manufacturing-site prices that make them competitive with other non-peat raw/bulky materials.

Considering Ireland's waste- and non-waste derived digestates' potential future role in peat-reduced and peat-free growing media, dewatered, matured and/or partially dried digested solids could be the focus of research and development projects. Already published, relevant research should be reviewed and digestates in any such research compared with any similar ones being produced in Ireland.

Waste-derived composts used in the manufacture of growing media and as soil improvers (wholly or as an ingredient) have tended to be those made from separately collected plant materials only (e.g. garden and parks plant wastes and others from agricultural, horticultural and forestry sources). To the best of our knowledge a much lower quantity of composts derived from food and plant wastes have been used, one of the reasons being their tendency to have higher electrical conductivity properties; this is one of the factors which limits the proportions in which many waste-derived composted can be used in growing media.

These factors make increased supply complex and so the Cré recommends that Government considers commissioning an appraisal of the composting sector's potential to supply more compost for use in growing media and, preferably, this would be part of a wider assessment that includes the potential for increased use of other non-peat raw materials that could be used.

More needs to be done to reduce the amount of physical contaminants in biodegradable wastes collected for composting (or anaerobic digestion). For example, too many householders are putting non-compostable plastics in their bins for garden wastes, food wastes and, in some areas, garden and food wastes combined.

The growing media industry says it is difficult to remove physical contaminants (e.g. glass, metal and plastic) from composted materials made from waste types that include such contaminants; through on-site process steps the composting industry removes much of the physical contaminants that arrive with the wastes but removal is imperfect and their removal and transport costs and gate fees charged by disposal/other recovery facilities that accept these contaminants make this waste very costly to manage.

Some product status digestates derived from source separated biodegradable wastes that tend to include physical contaminants, e.g. from household sources, may need further processing to remove more physical contaminants before being supplied for use in growing media. Other digestates made exclusively from purpose-grown energy crops would not include physical contaminants and so may be particularly worth exploring for potential use in growing media, e.g. after separating out the solids, maturing and/or partially drying those solids.

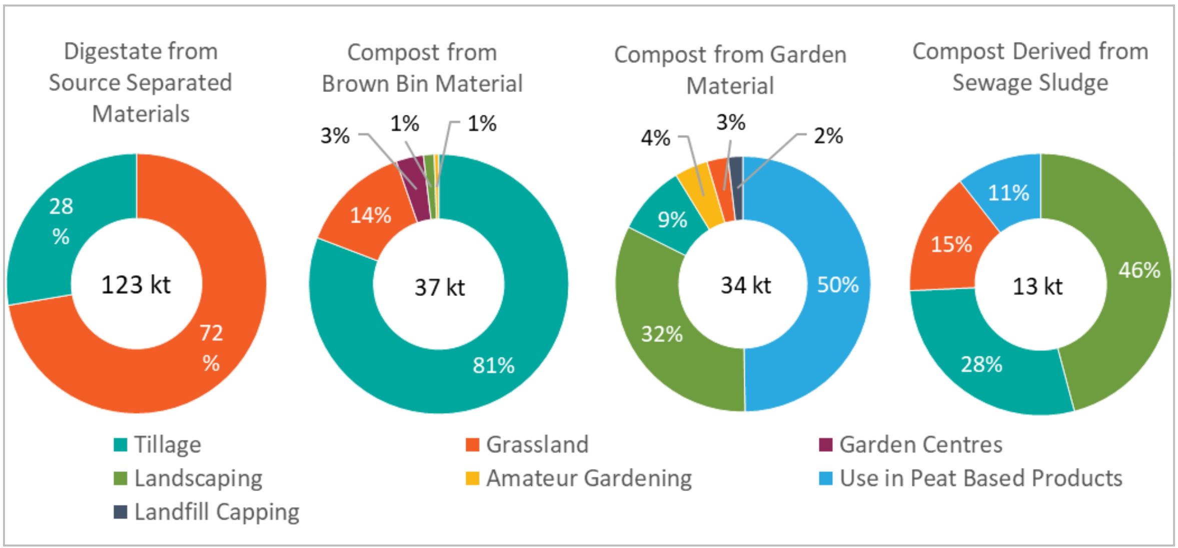
Cré suggests that the Government considers funding a review of research into the use of digestates in growing media for use in amateur and professional horticulture markets. This should include how similar digestates in published research are to Ireland produced dewatered, matured digestated solids. The review should take into account characteristics of waste/material mixtures fed into AD processes.

2. Compost & Digestate Use in Peat Products

Compost

The use of compost in peat products has been happening since around 2006 and has been successful. Reported rate by industry sources is that compost is used up to 30% in certain peat products.

A recent survey was conducted by Cré on markets for compost and digestate in 2018. The results are shown in the charts below.



Climate effect from the use of compost

Boldrin *et al.,* (2010)[1] concluded in a Danish study that using compost instead of peat leads to the reduction of greenhouse gases. It was assumed that compost replaced peat on the basis of volume. Carbon Storage Effects and avoided the use of mineral fertilisers were included in the greenhouse gas inventory.

Use of compost could allow an amount of carbon bound in the soil. This amount will depend on where and how compost is used and is very challenging to quantify.

Digestate

Digestate is a by-product from the biogas production and can be used as fertiliser in liquid form, or it can be dewatered and used as a soil product. Liquid digestate can be used as fertiliser. The dewatered digestate can be composted, but dry digestate can also be used directly as a soil product.

[1] Boldrin, A., Hartling, K.R., Laugen, M. Christensen, T.H. (2010) Environmental inventory modelling of the use of compost and peat in growth media preparation. Resrouce. Conserv. Recycl. 54, 1250 -1260

3. Responses to Consultation Questions

A. What are your views on what more could be done to support and enable the switch to peat free horticulture at professional crop production level and consumer level?

Cré Comment:

Research/development and funding would be needed to ensure the compost and digestate fibre is suitable for professional use.

There needs to be a standard for compost and digestate fibre for incorporation in growing media for professional use so that the compost is fit for purpose.

B. What are your views on alternatives to the use of peat in the Horticultural Industry (from, for example, the perspective of the professional grower or consumer/amateur gardener)?

Cré Comment:
It has been demonstrated successfully in Ireland that compost from green waste only can be incorporated into peat products to reduce the amount of peat required. This should continue but at higher incorporation rates.

This is fine at consumer/amateur level and has been done successfully. However, a standard for compost for incorporation in growing media is vital. Very little green compost has been used in professional growing media and a lot of research and development would be needed in this area.

Dewatered digestate has also the potential to be used. Currently dewatered digestate from a plant in Northern Ireland is used in horticultural products.

The industry acknowledges that the peat industry requires suitable compost and digestate of consistent quality.

C. What are your views on whether Ireland should cut back or cease the export of peat for use outside of Ireland even if this would result in job losses in Ireland?

Cré Comment:
Eventually the use of peat for mass extraction will cease. It's a matter of when. It is better that this happens sooner and plans should be put in place to retrain people employed in the industry for new jobs. Peat that has already drained in Ireland if not processed will degrade and eventually disappear. Only these bogs should be processed for the next short while. No new bogs should be drained and this should be strictly enforced.

D. Do you consider that a working group should be established to advise on how best to overcome the barriers to reducing peat use in professional horticultural crop production and in the amateur horticultural market?

Cré Comment:
Yes and the group should consist of some international peat and compost experts.

E. If you are in favour of the establishment of a working group, which stakeholder groups do you think should be represented on it?

Cré Comment:
Yes Cré would favour the establishment of a working group. Stakeholders should involve, peat alternative producers and suppliers, growers, growing media specialists, research bodies, consultants and other bodies including international bodies who have already been involved in work and research in peat reduction and peat free projects

F. How do you think that those involved in harvesting peat for horticulture could be compensated for any loss arising from a cessation of this activity (for example, on the basis of the profit loss arising or related to the value in ecosystem services retained/provided)?

Cré Comment: No.

G. How do you think that those involved in harvesting peat for horticulture could be guided towards alternative activities, for example, developing an environmentally suitable alternative material that could replace peat in professional horticultural crop production?

Cré Comment:
Yes. It is also likely that the peat/growing media producers will continue to be some of the suppliers of peat reduced and peat free materials and in some cases they have a lot of knowledge on growing media so it is very important that they are included and engaged in this process.

Any funds should be invested in fostering new enterprise and retraining.

H. What do you consider the value of peatlands to be to (please score out of 100):

carbon storage	20
nature conservation	30
the provision of ecosystem services	20
the economy	10
social and cultural needs	20
	100

I. In your opinion should the use of peat within (i) the amateur horticultural market and (ii) the professional horticultural industry be phased out over the next 3, 5, 10, 15 or 20 years and if so, how should this be done bearing in mind the potential job losses and the difficulties with alternative growing media?

Cré Comment:
The use of peat for amateur horticulture market should be phased out over a five year period to allow for R&D of alternative uses. It is generally accepted that peat free growing media in the future will be made up of a number of alternative products and therefore a lot of R&D will be required.

J. Does more need to be done to educate and build consumer awareness of peat free products which are available at retail level?

Cré Comment:
Yes, there needs to be more education on the use and the benefits of the alternatives. Cré would be willing to assist where we can on providing technical knowledge on the use of compost.

Østfoldforskning

Rapport

SUSTAINABLE INNOVATION

Author (s): Lars Gunnar Tellnes, Kari-Anne Lyng, Clara Valente, Ingunn Saur Modahl and Fredrik Moltu Johnsen

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Myrland cabinet in Fjällmossens nature reserve, Sweden. Source: Wikimedia Commons / Glottern

Replacement materials for peat

Mapping of climate and environmental effects

ØSTFOLDFORSKNING AS UTFØRER ANVENDT
FORSKNING INNENFOR OMRÅDENE FOREBYGGENDE MILJØVERN
OG VIRKSOMHETS- OG NÆRINGSUTVIKLING

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Table of Contents

Summary

Peat is widely used as growing medium and soil conditioners. Teague leads to greenhouse gas emissions and affects the habitats of plants and animals. At any phasing of peat, it is important that the use of other materials represent a real environment improvement.

This report was commissioned by the Environment Agency, and examines the climate and environmental effects of various materials as a substitute for the use of peat in growing media and soil conditioners. The program includes materials rockwool, perlite products from coconut production, bark, wood fiber, compost and dewatered digestate, biochar and wool from livestock. The study was conducted by means of a literature review, database searches and some simplified calculations based on figures found in the literature to strive that the results are most relevant for Norwegian conditions.

Since the function of growing media and soil improvers depend on usage, it has been challenging to find a device that provides a proper basis for comparison. The review shows that there are a wide selected options for turf and that the different materials have both advantages and disadvantages in terms of environmental impact compared with peat. All replacement materials have been considered separately, and we have attempted to quantify greenhouse gas emissions over the life cycle per cubic meter of cultivation medium. Since the materials do not have quite the same function, they can not necessarily be compared directly, but must be seen in a wider in a soil mix and to specific applications.

They reviewed studies show that rock wool and perlite have robust data for greenhouse gas emissions and is based on the rich resources available. They require some non-renewable energy production, resulting in greenhouse gas emissions. They are inert and will, therefore, have low environmental impact in use and after use. Wood chips, bark and wood fiber has briefly traveled byproducts low emissions in production. However, it is uncertain how they are performing in use compared with peat or other substitute materials. Coir Dust-product is not considered to have high greenhouse gas emissions even if the transport is long, but the coconut comes rates poorly on overall environmental indicators that influence ecosystems and human health. Compost and biochar have quite varying results depending on the production facilities and conditions for the calculations.

The uncertainties in the analyzes that have been reviewed are mainly related to the environmental impact should be included for waste-based growing media, how the year of greenhouse gas emissions could change the climate effect and the manufacturing technology for the different materials may change over time. In addition, for some of the materials published few studies. These uncertainties are discussed in the report and is important to take into account in interpreting the results. Moreover, direct, site-specific and very specific biological consequences for national and local micro and macro fauna, including for specific red-listed species not considered.

1 Introduction

In Report. St. Ranked # 14 (2015-2016) actualized the use of peat by planting soil often contain large amounts of peat extracted from the marshes. This peat extraction from bogs leads to greenhouse gas emissions, and is destructive to habitats for plants and animals. It is taken on the basis of the need for soil structure and culture media may be based on other renewable resources. It pointed out that the increased use of substitute materials must represent a real environmental improvement and that the government therefore will consider the consequences of a phasing out of peat closer.

Against this background charted Hjellnes Consult (2017), commissioned by the Environment Agency, which peat-free products on the market today that can replace the use of peat. This report is a follow-up of the above work, where environmental and climate effects of seven selected substitutes for peat has been reviewed in the form of a literature study. The result of the literature study is in this report evaluated and collated per material type, while benchmarks and uncertainties are discussed.

1.1 Background growing media and peat

When an average person buys peat in Norway, it is often because he or she planned to buy what we colloquially call 'earth'. Additions to or replacements for 'earth' may generally have more features. For substitute materials for peat mentions Hjellnes Consult (2017) features *cultivation medium* and *soil conditioner.* A culture medium is a product of soil, peat and / or synthetic substances. The main function of a culture medium is to provide structure for the plant roots, and the supplement or replace soil. Culture media have the ability to bind water and nutrients that are useful to the plant. A culture medium may or may not initially even contain nutrients (Culture media, 2014). Rene culturing media can provide structure to the depleted soil (make the soil less compact), thus having a soil-improving action, but helps in some cases little or nothing to the other soil improvers parameters. A soil improvement agent is a substance added to the soil or other growing medium to change the chemical, physical or microbiological properties. The general purpose of a soil improver is to improve the quality of the soil. These make the earth better suited as a habitat for plants, unlike fertilizer, applied to give plants nutrients. Lime, which makes the soil more alkaline, is a typical example of a soil conditioner (Soil improvers, 2015). To maintain a good soil quality is important both to ensure food production and because soil has an important function in distributing nutrients to plants and affects washout.

The advantage of peat growing medium is that it is porous. This allows water flow is good and that the plants have access to water and nutrients. Peat does not contain any particular industry in itself and has a relatively low pH, making the need to fertilize or mix with other materials to get a good result. According to Norwegian Peat and Soil Producers industry federation runs an estimated 15% of their members' turf for construction land, but then as a soil conditioner and not the culture medium (Hjellnes Consult 2017). When one looks at the replacement materials peat, it is therefore natural to primarily examine how materials, like peat, can provide porosity and structure, which are typical characteristics of a culture medium (Schmilewski, 2008).

Peat retrieved from marshes. Peat is distinguished from other forms of biomass in that it does not break down if left untouched. Norwegian peatlands have value as it stands, it is habitat for red-listed species, it helps with carbon storage and acts as a buffer against flooding. In addition, regenerated marsh slowly (Mariussen et al. 2008), and one can therefore not remove significant amounts of peat without resource eventually disappear. Teague fit thus not with the principles circular economy and sustainability, and especially not if the substitute materials are available.

There have been numerous studies looking at the effects of different mixtures in the cultivation medium and soil conditioners, but few studies that systematically addresses the environmental impact of different materials. In addition to individual studies, we have found two main reports dealing with more than one option for replacement of peat. The literature study in this report have been planned on the basis of these studies, and they are therefore briefly summarized here.

Department for Environment Food & Rural Affairs (Defra) in the UK have carried out calculations of the carbon footprint for different materials to the cultivation medium in the report *A preliminary assessment of the greenhouse gases Associated with growing media materials.* They stress that the results are only considered preliminary results due to large uncertainties in the methods (Defra
2009).

Quantis in Switzerland considered various materials for cultivation medium for various applications (greenhouses, nurseries, hobbies, etc.) on behalf of the European trade organization for peat and growing media report *Comparative life cycle assessment of horticultural growing media based on peat and other growing media constituents.* The results showed that for most applications were difficult to establish that some mixtures were better than others. For example, it turned out that for growing medium for fruits with the use of peat, rock wool or coconut shell fiber, then coconut shells by far the lowest climate impact, but the highest impact on the ecosystem quality. The exception was for seedlings in nurseries where a mixture of peat, bark and wood fiber had by far the lowest environmental impact (Quantis 2012).

1.2 Terms of reference

The mission of the Environment Directorate has been to shed light on the potential climate and environmental effects selected substitutes for peat may have. The information was gathered by conducting a literature review of existing studies (project reports and scientific published articles) and search emission databases, in addition to any simplified calculations based on the numbers that are found. An important part of the mission has been to ensure that the results are relevant for Norwegian conditions.

The following types of materials are considered:

- rockwool
- perlite
- byproducts from coconut production
- wood chips (not from wood for recycling)
- compost (from garden and park waste and food waste) and dewatered digestate
- wool (for livestock)

For compost has been a particular focus on finding Norwegian / Nordic literature to get environmental impacts most relevant for Norwegian conditions (temperature and type of composting). The search included the compost of both food waste and digestate, but the main focus was on the garden and park waste.

Climate and environmental impact of peat is also incorporated by reference. Peat has different properties compared to replacement and can thus vary for different applications what environmental impact it will have. At any phasing of peat, it will be necessary to replace the following applications:

- Growing media and soil conditioners for private consumers
- Growing media and soil conditioners for the professional market - horticulture and gardening
- Construction Soil used in parks and green spaces

Against this background, the study attempted to answer the following questions:

- How peat is compared with the alternatives?
- Which climate and other environmental effects have peat and substitute materials?
- How is the climate effects of evaluating different methodological approaches?

2 Lifecycle Methodology

Assessment of climatic and environmental effects are generally selected using cycle assessments (Life Cycle Assessment / LCA). LCA one tries to include the entire supply chain of a product from raw material extraction and production to distribution, use and disposal (cradle to grave). In some studies excluded use phase and waste management (cradle to gate). A common reason for omitting this is that as the producer does not have influence on how the product is used and thrown away, and that it therefore may be irrelevant or difficult to quantify.

LCA studies are to some extent based on generic database figures and calculation factors, which will not enter into a number of issues that can be locally or nationally relevant. The calculations in an LCA study normally takes based on a selection of environmental and climate effects, which happily acidification, global warming, eutrophication and ozone layer degradation is included as a minimum. The advantage of looking at several environmental indicators is that a more comprehensive assessment. Combined with a lifetime reduces the likelihood that a move problems from one place in the value chain to another giving rise to new types of environmental problems when to improve your product or service.

LCA provides a good representation of the entire value chains, but the level of detail in LCA studies should not be considered as high, with the possible exception of special in-depth studies. Product-specific environmental categories are often taken with, where relevant, but this may depend on the scope of the study and the individual developer's knowledge. More direct and site-specific effects are also to a lesser extent with. How and whether the land use and land use changes as well as macro-economic effects are included in the models may vary from study to study. Biological effects that introduction of exotic species and the positive or negative influence of local micro and macro fauna (for example, earthworms, birds, insects) as well as more complex ecosystem impact, is typically maintained outside the system boundaries. Consideration is not given to specific, region-specific red-listed species.

LCA is often divided into four phases: defining the objective of the study, inventory analysis (data collection and systematization of emission figures), the conversion of emission figures to environmental effects and interpretation of results (ISO 2006).

2.1 Functional unit

LCA quantified environmental impacts of various product systems relative to a comparable unit, called a functional unit. In LCA study of various alternatives for peat conducted in the UK by Defra (2009), the environmental impact of the various materials when compared on the basis of one tonne of product. The report points out, however several challenges with this functional unit. An important point in defining the functional unit is to ensure that as compared to providing similar function.

To ensure that the functional unit reflects the function the product provider to the user, it may be useful to define and quantify the function final product performs. This means that the end product is not material turf, but the function turf performs as a culture medium or as a soil improvement product. There is great width in the use of growing media and soil conditioners, and different uses will involve different wishes about function. It is therefore challenging to find a good functional unit when comparing different materials.

Peat is relatively poor in nutrients, and the applications of peat is the primary function to provide structure for the plants, and to bind water and nutrients which are useful for plants. This function in a culture medium will therefore be given most of the focus of this report. Other materials may have additional functions beyond these properties, and any effects of this are discussed in the chapters of the relevant material types.

Quantis (2012) have used 1 m^3 culture medium as functional unit, but is divided between different applications. To define what a $1m^3$ equivalent referred to *EN 12580 Soil improvers and growing media - Quantification.* The different applications that are included are:

- Fruit
- houseplants
- Plants for small plants in tubs (young plant production Using loose-filled trays)
- Nurseries of trees (tree nursery stock)
- hobby market

For each application it was, along with an expert from the principal to the study (European industry organization for peat and culture medium), defined different compositions. Those materials included in the compositions comprises:

- Bark
- Fiber from coconuts
- compost
- Stone wool
- Black peat (mine heterogeneous peat moss)
- White peat (spagnumtorv)
- perlite
- Rice hulls
- wood fiber

Each of these materials is then included in different compositions for each application. White peat is described similarly as spagnumtorv while black peat described accordingly as minerotrophic peat moss. Quantis (2012) includes gain completely peat-free varieties, although it probably is possible for several of the applications. It is only in use as a growth medium for the fruit that a material contained 100% and where one assumes that peat can be replaced 100% with rockwool or coconut fiber. In this comparison has peat highest greenhouse gas emissions, rockwool medium and coconut fibers lowest. For environmental impact of ecosystem services has, however, coconut fibers greatest impact. The use of wool and biochar are not covered by Quantis his study, but the function of biochar has been a major research focus in recent years. Kern et al. (2017) has summarized a workshop on synergies using peat and biochar in growth media. Positive results were here as shown by up to 50% biochar in soil mixtures and focus much on potential additional effects using biochar. For wool from livestock are not as much research but Zhelajzkov et al (2009) for example, has shown how ullavfall from the purification process for wool can be used in potted plants. Referring to the wool can cover large parts of nitrogen, phosphorus and potassium needs of houseplants, so the content of nutrients is a desired option here.

What percentage mixtures of substitute materials for peat which is applicable on the Norwegian market for the relevant uses are not considered in previous studies. An assessment of klimaog environmental effects of alternatives to peat is therefore challenging because the composition of the soil products varies with the application, and that it is usually not disclosed what the various These mixtures on the market consists of. A complete comparison based on function is therefore not possible because of lack of information about the content of peat soil and peat-free alternatives. It is therefore decided to consider the environmental effects of each of the different materials per cubic meter input material to the cultivation medium. The results for each material are considered separately and not in mixtures. It is therefore important to be aware that the functional unit is only partially reflects the function of the product. The different materials are compared have very varying density, as shown in

Table 1.

Table 1: List of densities to substitute materials and peat with references

Material	Bulk dry density [TS kg / m 3] Reference	
Stone wool	70	Quantis (2012)
perlite	105	Quantis (2012)
byproducts from coconut production	70	Quantis (2012)
Wood chips - bark	196	Quantis (2012)
Wood chips - wood fiber	66	Quantis (2012)
Compost (garden waste)	330	Quantis (2012)
biochar	300	Brewer & Levine (2015)
Wool	20	Sheep Wool Insulation Ltd. (2017)
peat	72	Quantis (2012)

2.2 System boundaries in environmental assessments

It is developed general standards for LCA and the ISO 14044 is the most widely used (ISO 2006). This standard is however not sufficiently sharpened that results of different studies can be compared. In conventional LCA of building materials has computational methods has become increasingly standardized and implemented with the European standard EN 15804 (EN, 2012) in recent years. This will therefore here also form the basis for the limits of the summation of life cycle assessment. The results from different studies based on EN 15804 shall initially be comparable as long as it is considered a relevant functional equivalent unit. However, there are aspects of this standard, which makes the results are not entirely relevant to the issues raised in this report. This includes:

- The phasing out of peat change production quantities so that climate impacts per unit for other materials change significantly

- How carbon cycle biomass included in the calculations
- The extent to which space and time for climate and environmental effects are significant
- Criteria for when waste is no longer waste, but is a new product

It is common in LCA to assume that it does not matter if a greenhouse gas emissions takes place in Norway or Indonesia, nor whether it happens this year or in 50 years. Research indicates that this simplification is particularly problematic for biomass, but it lacks consensus alternative methods. This is further discussed in section 2.3.1. At LCA not see the difference between time and place for greenhouse gas emissions is also important to take into account in political decision-making processes, as these tend to have the goal of reducing greenhouse gases in a country until a year, such as the Norwegian greenhouse gas inventory in 2030.

When a product is waste and is recycled, it is conventional LCA necessary to define the system boundaries between the primary and secondary product system wherein ends the life cycle of the product goes to waste and which started the life cycle of the recycled product? Here the EN 15804 based on the criteria for avfallsfasens termination ("end-of-waste criteria"). Criteria for avfallsfasens termination is designed specifically for compost and digestate of sorted waste and provide quality criteria for these to be considered as a new product (Saveyn & Eder, 2013). In a greenhouse gas calculation according to EN 15804 for a culture medium with compost, will initially only release after it has become a new product included. Emissions from the composting process will then be included in the greenhouse gas account for the discarded product being composted. For example, the environmental impact of composting of a Christmas tree included in the accounts to the Christmas tree and not composted Christmas tree as inputs in a ground product. In LCA that do not follow EN 15804, other calculation rules are used, which it is important to take into account in an assembly.

In LCA, there is an alternative to conventional accounting LCA called consistency-LCA. This approach is less standardized, but will mainly take into account that changes in supply and demand will change the environmental impact of products. Common to these methodological aspects is that they can be critical to the performance, but difficult to quantify in a study and impossible in a literature study. These aspects are therefore discussed in the report to the different materials to assess the uncertainty of the results.

This report is the life cycle of each culture medium is considered divided into four phases. These phases are summarized in Figure 1.

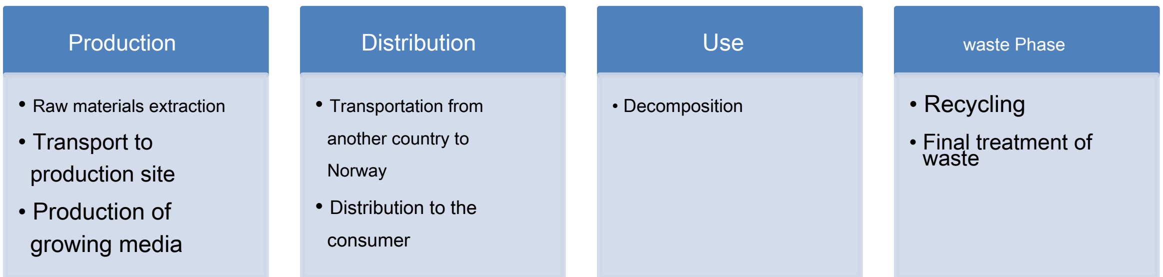

Figure 1: life cycle stages of culture media

Pressures from lifecycle phase production will be affected by whether
soil improvement product / culture medium produced from waste or residual raw materials from other

product systems, or the need for removal of the primary ingredients. Biomass is broken down during use, and greenhouse gases will be discharged. Waste is only relevant in cases where the growth medium or soil product is taken away from the application and sent to a final treatment. For example, with the use of potted plants to private households, which often results in residual waste and treated by incineration with energy recovery. For use in plant soil it may otherwise be assumed that the culture medium is not sent to any formal waste management, but will be partially broken down over time.

2.3 Assessment of environmental and climate effects

Climate and environmental impact of a product or service can be classified into different environmental categories, based on the environmental problems the various emissions could potentially contribute to the cause. Examples of environmental categories are global warming, acidification, depletion of the ozone layer and effects on human health.

2.3.1 Impacts

When greenhouse gas emissions to be converted to potential climate effect, multiply emissions by different characterization factors that reflect how much effect they have on global warming. For climate change, there is great consensus on using the International Panel on Climate Change (IPCC) factors for global warming potential (GWP). All greenhouse gases are given a factor that is relative to CO_2.

For example, 1 kg of methane (CH_4) 30.5 times greater effect on global warming than 1 kg CO_2 hair. Characterization Factor of methane is therefore 30.5. It is normal to employ 100 years as reference time. The factors continuously developed and improved since a gain new knowledge about the emissions that contribute and how much they contribute. In 2013, published IPCC new factors, inter alia involving that methane given a higher factor and nitrous oxide had a lower factor than previously (see Table 2). It is important to be aware of this when comparing studies from different years. In this report, it is attempted to apply IPCC2013 whenever possible, but as a literature study, it is not inevitable that some results may be based on older characterization factors.

Table 2: Characterization Factors

	IPCC 2001	IPCC 2007	IPCC 2013
Carbon dioxide (CO_2)	1	1	1
Methane (CH_4)	23	25	30.5
Nitrous oxide (N_2O)	296	298	265

Calculations of the greenhouse effect is further particularly challenging for carbon cycle of the biomass. This is a complex subject, which nevertheless brief will be reviewed here when specific simplifications and choice of assumptions relating to this will affect the final results.

Carbon admitted through photosynthesis and which binds in biomass, for later in the life cycle completely or partly oxidized, is referred to as biogenic carbon. There is a simplified and a more complete

Method for understanding biogenic carbon. The basic method is mainly used in LCA, and assuming immediate oxidation of biogenic carbon. Set over a lifetime will then record and release of biogenic carbon is considered to have no effect on the climate. However, done it gladly two exceptions. Firstly the emission of biogenic methane adjusted amount of carbon dioxide methane decompose to eventually into the atmosphere. The other exception is when the biogenic carbon is considered not to be released again, it could then be counted as a lasting negative emissions. Examples include CCS by incineration, and biochar in plant soil. A more complete method is to count the admission and discharge directly, which can be called atmospheric flow. In some standards, it is a requirement that emissions are counted in the life cycle module where emissions actually happening,

In recent years there has been extensive research to include timing of greenhouse gas emissions in LCA. In particular, there has been focus on the use of bioenergy from forest, how long Rotation and short life has done that several have questioned whether the assumption of carbon neutrality. For other uses of biomass, such as construction, also has this been appropriate, as products tend to have longevity. The easiest method to take into account the time aspect reduces climate impact of emissions by 1% for each year the spill postponed and called ILCD method, ref. Tellnes et al. (2017). It lacks the consensus for such methods, and ILCD his method is included here as an illustration of the concept. Characterization factors for all approaches are shown in Table 3. In this study, the simplistic approach underlie and emissions over a lifetime would anyway be the same when taking into account the persistent storage. The weakness is that the less shows when emissions actually occurs and that the time is not necessarily irrelevant to the climate effect. Had time adjustment been included would have resulted in different results, this will be further taken up in the discussion of the results.

Table 3: Characterization Factors for simplified and complete beregening of biogenic carbon in LCA

	Simplified IPCC2007	complete IPCC2007	Time-Adjusted (ILCD)
Admission and discharge of carbon dioxide (CO_2)	- / + 1	- / + 1	- / + 1
Admission and discharge biogenic carbon dioxide (CO_2)	0	- / + 1	- / + 1
Circumspectly stock of biogenic carbon dioxide (CO_2) no release until after 100 years	- 1	0	0
Time Adjustment postponed release the first 100 years			-0.01 / year
Methane (CH_4)	+ 25	+ 25	+ 25
Biogenic methane (CH_4)	+ 22.25	+ 25	+ 25
Nitrous oxide (N_2O)	+ 298	+ 298	+ 298

Climate effects may alternatively be measured against the total national greenhouse gas emissions and obligations under international agreements such as the Kyoto and Paris Agreement. A significant difference in this and life cycle assessments are considerations of time and space, where LCA usually is completely independent of where and when the discharge occurs, while national greenhouse gas accounting is direct emissions from a country over a year.

2.3.2 Other environmental effects

For other environmental effects, it is less consensus about which characterization factors to be used in LCA. Both the environmental categories included and the factors used may vary from study to study. As mentioned in the introduction of the chapter is specific and direct biological and toxicological factors typically beyond the level of detail to an LCA study.

In Quantis (2012) is used, for example, LCA indicators of ecosystem quality, resource scarcity and human health. In the method used, called IMPACT 2002+, are not considered contributions from climate change continue to impact on ecosystems and humans (Humbert et al. 2012), an assumption that it is important to notice in order to understand what the calculations are communicating. Climate change would have been an important contributor to the damage to ecosystems and people using other methods, such as Recipes 2008 (Goedkoop et al. 2009), but is thus defined as independent of the category of climate change in the following.

Quantis conducted a sensitivity analysis to check whether the method they use was robust. The results showed that the ranking of various compositions of culture media were modified by using an alternative method. It is therefore uncertain whether the LCA results of such environmental impact categories are robust enough. LCA from such studies nevertheless show where the potential for other environmental impacts are and what contributes to this. Contributions Analyzes of LCA, which shows how the life cycle environmental impact is caused on each category are therefore qualitatively summarized for each material. In addition to the indicators of Quantis (2012) are other significant environmental impact from the production and manufacturing rated and emissions during use of the culture medium. The different environmental impact categories are summarized in Table 4 and explained in more detail below.

Table 4: Other environmental impact categories than climate change that is qualitatively rated

Environmental impact	Explanation	methods
ecosystem Services	Zoning and land use changes, acidification, eutrophication and ecological toxicity	Contributions Analyzes of LCA
resource Scarcity	Use of mineral resources and non-renewable energy	Contributions Analyzes of LCA
human health	Emissions to air, land and water that affects humans.	Contributions Analyzes of LCA
Emissions to air, water and soil during production and distribution	For example, local air pollution, water pollution such as eutrophication and toxicity	Contributions Analyzes from LCA, other literature
Emissions during the use of the culture medium	Contents of nutrients that can be leaked out, the risk from the content of hazardous substances	Contributions Analyzes from LCA, other literature

ecosystem Services

Impact on ecosystem services involves the product's impact on ecosystems in nature. A number of environmental problems will affect the ecosystem. Of these Quantis including ecotoxicity, eutrophication, land use, acidification and water turbines (Humbert et al., 2012). Important ecosystem impacts as land usage changes and climate change are therefore not represented in this category.

resource Scarcity

A shortage of resources is about to map out how much a product helps to "use up" the limited resources. This includes here withdrawal of minerals and use of fossil, non-renewable energy (Humbert et al., 2012).

Example of a limited resource which is relevant when comparing peat with compost is phosphorus. Unless phosphorus managed properly, it can lead to a lack of phosphorus in some areas, which will have a major influence for plant growth and food production. However, it is important to be aware that your plants will make use of the applied phosphorus must be plant available and that in some areas, the excess of phosphorus. Addition of too much phosphorus can cause runoff and cause eutrophication.

human health

Most environmental problems will, directly or indirectly, have an impact on human health. Quantis (2012) have quantified the various materials' impact on human health quantified in DALY (disability Adjusted Life years). This includes the following environmental categories: human toxicity (carcinogenic and not carcinogenic effects), discharge affecting the airways (organic and non-organic) and ozone depletion (Humbert et al., 2012).

3 Stone wool

Stone wool made of volcanic rock and limestone as during high temperature spun into wool. It is widely used for insulation in buildings in Norway, but also to the culture medium in greenhouses including tomatoes. Stone wool has no nutrients, and this must then be added as needed. Application of rock wool is therefore most relevant to professional customers to greenhouses.

3.1 Impacts from rockwool

According Quantis (2012) is climate groove to rock wool approximately 70 kg CO_{2}- ekv./m^{3} for production and about 30 kg CO_{2}- ekv./m^{3} for distribution. 1 m^{3} rockwool weighing 70 kg, and production emissions key is 1 kg CO_{2}-
ekv./kg rockwool. Environmental declaration (EPD) for Rockwool (2013) comprises producing steinullisolasjon from four plants in Norway and Denmark, in which greenhouse gas emissions of 1.18 kg CO_{2}-
ekv./kg rock wool and is then 18% of Quantis their study. This may be because the EPD study more comprehensive data than Quantis. EPD for Paroc steinullisolasjon located at 1.21 kg CO_{2}- ekv./kg rockwool (Paroc, 2014). Since rockwool is already produced in large quantities, it is believed that small change in this by increased utilization in Norway. According Quantis (2012) is environmental load cradle tilport mineral wool mainly from the coke energy production, so replacement of coke with a renewable alternative to production phase could reduce GHG emissions substantially. For Norwegian ratio is further a discharge of 1.2 kg CO_{2}-
ekv./kg rockwool. The production of rock wool cultivation medium assumed occurs mainly in the Netherlands, so the distribution for Norwegian conditions assumed transport to Oslo and a total of 1030 km of the truck and 160 km on the ferry. When using transport calculator LCA.no (2017), then this gives a greenhouse effect of 6.4 kg CO_{2}- ekv./kg rockwool. Disposal is deposition included in EPDs Paroc (2014), and amounts in which 0.18 kg CO_{2}- ekv./kg rockwool. Climate effects of stone wool over a lifetime is summarized in Table 5.

Table 5 Influence of climate throughout life to rock wool (kg CO_{2}- ekv./m^{3} rock wool)

	Production	Distribution	Use	Disposal	Total	Carbon storage
Quantis (2012)	70	30	0	0	100	0
Estimate Norwegian conditions	84	6.4	0	12.6	103	0

3.2 Other environmental effects of stone wool

According Quantis (2012), the impact on human health more for rock wool than for equivalent use of peat and coconut fiber in fruit production. This strain comes mainly from distribution to customers and from the extraction of basalt. The results, however, lower for stone wool than peat for effects on the ecosystem and resource use.

4 Perlite

Perlite is based on volcanic rock which is expanded by high heat. It is used as mixture in the soil to provide air and structure. Perlite does not contain any nutrients, and are available in regular garden stores. The technical features are similar to rock wool, but is also believed suitable for hobby use.

4.1 Impacts from perlite

According Quantis (2012) is the climate impact of perlite about 60 kg CO_2- ekv./m^3 for production and about 40 kg CO_2- ekv./m^3 for distribution. 1 m^3 perlite weighing 120 kg and producing emissions per kg perlite is then 0.5 kg CO_2- eq. Perlite in the Norwegian market are examples from producers in Denmark and the Netherlands, so the starting point is the transport from there in the analysis. Life Cycle Inventory database Ecoinvent v3.3 has data for the production of expanded perlite cradle-to-port. These were adjusted so that they were representative of a production in the Netherlands and Denmark. Climate The track was then approximately 0.55 kg CO_2- ekv./kg and is thus slightly above Quantis (2012) their numbers of 0.5 kg CO_2- ekv./kg. For transportation was carried out an analysis by ferry 160 km and 1030 km on the truck by the use of distance calculation tool for impacts of transport of construction materials available on LCA.no (2017). This resulted in about 11 kg CO_2- ekv./m^3. For waste management, it is believed the same scenario and emissions as rock wool per kg. Since perlite is already used on a large scale, the increased use of perlite instead of peat in Norway probably not change the climate impact per unit of production, and the results are thus presumably safe. Climate effects of stone wool over a lifetime is summarized in Table 6.

Table 6 Influence of climate throughout the life cycle of perlite (kg CO_2- ekv./m^3 perlite)

	Production	Distribution	Use	Disposal	Total	Carbon storage
Quantis (2012)	60	40	0	0	100	0
Estimate Norwegian conditions	66	11	0	22	99	0

4.2 Other environmental effects of perlite

According to the worldwide Perlittinstituttet there is ample supply of raw materials for perlite. Less than 1% of the reserves are used for the last 60 years (Perlite Institute, 2010). In Quantis (2012) shows the LCA study that blasting in the extraction of raw materials contribute most on ecosystem quality, while transport and processing have the greatest impact on human health.

5 By-products from coconut production

Byproducts from coconut production is a peat-free alternative on the market today. Coconut is used mostly for gardening industry, but are in torvfri potting soil for private individuals in Norway. Coconut is a typical product from tropical countries, particularly from Sri Lanka, the Philippines, India, Indonesia, Mexico, Costa Rica and Guinea. For imports of coconut fiber to the Norwegian market, it is Sri Lanka and India are the biggest (ITC, 2016). Byproducts from coconut to replace peat is already on the market in different Norwegian shops (Hjellnes Consult, 2017). Coconuts consists of two parts: the peel and coconut kernel. Coconut core used to produce oil, copra and milk (high-value product). The shell consists of two main parts, coconut dust and fibers. The smallest fraction, coconut dust, i.e. waste quality by elimination of most fibers, for example. Long fibers into ropes and mats, is considered the most stable and most suitable in the cultivation medium, and holds the main potential to replace peat (Fascella, 2015). Coconut dust is extracted from the shell with fibers and accounts for 50-60% of the total weight of the shell (Kumarasinghe et al., 2015). In the coconut industry generated one ton coconut dust per 10,000 shell. After composting get coconut dust is dried to a specified moisture level, and then compressed into balls which are wrapped (Fascella, 2015).

Coconut Dust used alone or mixed with other materials, as an alternative culture medium to peat as substrate for the cultivation of vegetables - such vektshus vegetables such as tomatoes, cucumbers, cabbage etc., ref. such Kumarasinghe et al. (2015) - as well as for cut flowers and potted plants. The physical and chemical properties of coconut dust can vary with the material source, fiber size, moisture content and compression pressure (Fascella, 2015; Kumarasinghe et al., 2015). Therefore, it has some limitations because these properties influence the growth of plants. The bulk density of coconut dust depends on the compression of the final product (from 400 kg / m^3 to 350 kg / m^3) and decompression of the (70 kg / m^3).

5.1 Impacts from coconut

A study by Grodan (2011) looks at LCA of kokossubstrat used to grow tomatoes in greenhouses, compared with rock wool. The functional unit used in this study was the production of culture medium for the cultivation of 1 ha tomatoes in one year in the Netherlands. The system boundary was from cradle to gate. The main contributors to the total impact from cradle to gate was fossil resource use, climate effect (ecosystems and human health), particle formation and land use. For kokossubstrat is transporting the material from the country of manufacture (in this case India) to the Netherlands for further processing and use the dominant source of most environmental categories. Intercontinental transport accounts for more than 60% of particulate emissions and more than 25% of the categories of fossil emissions and climate impact over the life cycle of the culture medium.

In the study of Quantis (2012), the culture medium for horticulture in five different application areas considered: fruity vegetables, potted plants, nurseries for seedlings in tanks and hobby market (study for nurseries for trees is omitted, since there is a potential scenario to replace peat with coconut dust). System boundary is cradle to grave: the cultivation and harvesting of coconut in Sri Lanka, transportation to the Port of Rotterdam, and a waste where it is believed that the culture medium not reusable. The functional unit (FU) is 1 m^3 cultivation medium for various applications. Since extraction and production of coir dust is considered to be in Sri Lanka, refers inputs also to this country, for example, emissions from electricity production in Sri Lanka has been used where relevant in the analysis. The results show climate effect reaches 100% coconut dust and coconut dust compositions are compared to other options such as peat and mineral wool. In this context comes coconut dust out best in environmental category climate. Note that it is assumed production under orderly conditions in Sri Lanka and that it indicated how production in Malaysia and Indonesia can lead to deforestation, which is not included in the calculation of the climate. See detailed results in Table 7 below.

Table 7: Overview on climate coconut dust and soil mixtures with coconut dust. The numbers are only valid for origin Sri Lanka

	Climate effect [kg CO_2 eq / m^3]
100% coconut dust (fruit production)	65
Composition for potted plants (20% coconut dust, 30% of compost, 50% white peat)	150
Composition for nurseries for seedlings (30% coconut dust, 50% white peat, 20% wood fibers)	140
Mixture of nurseries for seedlings (50% of coconut dust, 30% white peat, 20% wood fibers)	130
Compositions for hobby market (10% bark, 30% compost 20% wood fiber, 10% rice hulls, 30% coconut dust)	150

More than half of the greenhouse effect for the production of coir dust caused by transportation to the mixing station. The rest of the effects due to power consumption and the addition of calcium nitrate. It is not found other good LCA studies for the production of coir dust. These results are believed to be heavy on the assumptions in Quantis study, and should be considered unsafe. For the production, distribution and use, it is believed that the results of Quantis (2012) is representative of Norway. For disposal, a scenario with energy where emissions are assumed to be the same as for timber having little importance. This page biogenic carbon is already considered as emissions. Usefulness of energy for production of district heating and electricity is significant but should not be counted as part of the life cycle according to EN 15804.

Table 8: Influence of climate throughout life to coconut dust (kg CO_2- ekv./m^3 coconut dust). The figures are only valid for countries of origin Sri Lanka

	Production	Distribution	Use	Disposal	Total	Carbon storage
Quantis (2012)	45	20	0	0	65	0

5.2 Other environmental effects of coconut

In the study of Quantis (2012), the results are shown as environmental categories of ecosystem quality, resource use and human health, when 100% coconut dust and coconut dust in the mixture is compared with other options such as peat and mineral wool. In this context comes coconut dust out best in terms of resource use, while it comes out worst environmental category Ecosystem quality (due to land use).

For indicator of human health is the greatest environmental impact from the culture broth 100% coconut dust (mainly due to the transport of coconut dust: Shipping from Sri Lanka to Europe and the transport of decompressed coir dust in Europe to mix plant). Thus, the distribution of growth medium to the end customer is a key element for reducing the environmental impact of coconut dust (probably one of the main factors for the import of products from the coconut in Norway). These results are summarized in Table 9.

Table 9: Summary of the environmental impact of coconut dust

	ecosystem Quality [PDF.m2.y / m3]	Resource Use [MJ / m3]	Human health [DALY / m3]
100% coconut dust (fruit production)	92	1000	0.00011
Composition for potted plants (20% coconut dust, 30% compost, 50% white peat)	50	2550	0.00018
Composition for nurseries for seedlings (30% coconut dust, 50% white peat, 20% wood fibers)	50	2300	0.00013
Composition for nurseries for seedlings (50% of coconut dust, 30% white peat, 20% wood fibers)	68	2100	0.00015
Compositions for hobby market (10% bark, 30% compost 20% wood fiber, 10% rice hulls, 30% coconut dust)	60	2000	0.00019

LCA analysis excludes water consumption, because it is believed that the cultivation of coconut come from areas where there is no need for irrigation.

Impact on deforestation is not included because the production of coir dust is a byproduct from coconut production in Sri Lanka, which they consider different from palm oil production, for example. Indonesia and Malaysia. At coconut in the form of for example coconut oil generally are quite significantly different from palm oil, however, seems doubtful. For example, did Saikku et al. (2012) that coconut oil is one of the products with the strongest impact on deforestation in Indonesia. This deforestation is known to be out of control, and is considered by many as one of the planet's environmental problems. Moreover, it will in practice come into indirect causal effects in rainforest via so-called indirect land use changes ("indirect land use change", ILUC), ie virgin land is used because another mark in the area already occupied to coconut production.

LCA studies. Quantis study include, however, the related impact category of land use, and it is this contribution that makes products with coconut dust in their study score worst on ecosystem quality. It is pointed out in the study that this is a simplified modeling assumption (p. 73-74).

In Quantis (2012) was used financial allocation based on the prices of the various products of the annual export statistics. It takes therefore only based on coconut dust originating in Sri Lanka, where conditions are considered relatively superior, and it can be interpreted from Quantisrapporten the results are not transferable to production in countries such as Malaysia and Indonesia, where they point out that deforestation will be a consequence (page 52). Tropical forests are particularly rich in species and tropical rainforest is considered to as the planet's most valuable biotope. When simultaneously observe large-scale deforestation in tropical areas, this aspect should be emphasized. LCA studies of extraction and production in developing countries will also be uncertain when there will be less environmental legislation, which can make common system limits, quantitative assumptions and database data irrelevant.

Specific field studies will therefore be valuable. Bijoy Nandan (1997) reports about massive environmental degradation in Kerala, India caused by steeping ("correction") of coconuts in the production of coconut fibers " *The study revealed That rectification activity has caused large scale organic pollution alongwith the mass destruction of the flora and fauna, converting sizeable sections of the backwaters into virtual cesspools of foul-smelling stagnant waters. High values of hydrogen sulphide, ammonia, BOD5 Associated with anoxic conditions and low community diversity of plankton Benthic fauna, fish, shellfish, wood boring and fouling organisms were the outstanding feature of the rectification zones ".* Suja (2014) examines the same issue somewhat less formally, and also observes that this activity is very polluting. Overall, it seems the coconut production in general to have restrictive effects on the environment, as Quantis study of coconut dust does not necessarily capture.

Quantis report shows that produktblandingene containing coconut dust have the least impact on human health. An interesting problem is also that the analyzes of kokossubstratet contains no assessment of the social aspects of workers. Working conditions in the country of manufacture may be a factor when the more general sustainability of a product produced in developing countries considered. In addition, the population in developing countries have less able to protect themselves against environmental effects. Meanwhile, in some cultures be values different in Norway in what is considered acceptable. There is a risk that the coconut dust is related to child labor, and Future in Our Hands (2016) argues that such a connection exists.

No Norwegian LCA study have been found in the literature where the climate and other environmental impacts are considered, but it is believed that the European findings are relevant for Norwegian conditions.

Coir Dust from Sri Lanka is in the literature considered to have low greenhouse gas emissions, but scores poorly on ecosystems and human health, even when it made a seemingly "good" assumption no tropical deforestation. Coir Dust has thus not as a good alternative to peat, and Future in Our Hands (2016) have come to the same conclusion. As mentioned above, coconut dust from, among other countries such as India, Malaysia and Indonesia also be associated with multiple challenges, and could potentially result in high emissions from deforestation that are not included in the existing studies.

6 Bark

Bark can be taken directly from the timber, but reacted most as byproducts of the forestry industry. Bark's as fresh or composted bark and used for farming, such as industrial raw materials and energy. Fresh bark is currently a byproduct from sawmills and wood processing largely used internally to the energy, but substantial amounts are also sold to bark, and the like. Tellnes et al. (2011) have estimated that approximately 57% of bark from sawmills are used internally energy, while the remainder is sold to sprinkle bark or energy in the second plant. In the production of pulp and paper (fiber and Chemicals) is also used bark in significant quantities. Bark represents 10% of the volume of wood in a log and a total cut of approximately 10 million solid cubic meters of timber measured under bark per year, so the total amounts bark about 1 million solid cubic meters.

In Quantis (2012) it is assumed that the use of fresh bark can be used as an ingredient in various compositions of culture medium. This is based on several plants in Europe practicing mixing in both bark and wood fiber mixtures of culture medium. In Norway, composted bark and garden waste in many cases an ingredient in potting soil. In research literature otherwise Schmilewski (2008) have shown that mixtures of 40% composted organic waste, 30% composted bark and 30% wood fibers have identical air capacity as 100% peat, while the chemical properties are very different.

6.1 Impacts of bark

Production of fresh bark, solid wood chips and wood fibers can now be made of many sawmills scattered throughout the country. Since they are basically waste materials, they will have low greenhouse gas emissions from production. Tellnes et al. (2012) have calculated the greenhouse gas emissions cradle-to-gate of bark and wood chips from sawmills in Norway. The results are presented per solid cubic meters and provides between 14.7 and 20.6 kg CO_{2}- ekv./fm $_{3.}$

The consequence of the increased use of bark to jordproduker may in the short term make that industry uses wood chips for energy instead, while the longer term, increased energy efficiency and switch to return wood as fuel be applicable. It's a challenge to find good uses of byproducts such as wood chips today, and much is sent from afar to be used as energy. For example, it plans to export wood chips to Denmark as energy (Viken Forestry, 2017). Increased use of bark and wood chips as raw material locally could therefore lead to good climate effects resulting from reduced transport needs and prolonged sequestration.

Calculation of climate effects from bark is calculated from a bulk density of 280 kg / m3 and are expected to be half of the density per solid cubic meters. For transport is assumed that 50 km of the truck and using LCA.no (2017) his calculator, this amounts to about 1 kg CO_{2}- ekv./m $_{3.}$ Climate effect for use and disposal is therefore set to zero for coconut and climate effects over a lifetime is summarized in Table 10. It is also assumed that all biogenic carbon is degraded before it has been 100 years and therefore carbon sequestration set to zero. It is uncertain whether composting and degradation of the bark can lead to emissions of methane and nitrous oxide, so the climate effect is therefore considered somewhat uncertain.

Table 10 Influence of climate through the life cycle of the bark (kg CO_{2}- ekv./m $_{3}$ bark)

	Production	Distribution	Use	Disposal	Total	Carbon storage

Norwegian conditions	10	1	0	0	11	0

6.2 Other environmental effects of bark

Bark contains manganese, and must be sufficiently composted to avoid undesirable effects when used as a culture medium. These are the requirements of NS 2890 relating to the declaration of growing media. Norgaard et al (1998) have considered the use of bark in poor soil and working up of new agricultural areas. The reason for the study was that the general had not been recommended by thicker layer bark and need to document any negative environmental impact. The results and experiences from the project showed that the bark should be used up to 1 meter in areas with poor soil without risk of contamination. It will, however, be high concentrations of organic substances, iron and manganese in the leachate directly beneath the bark layer in the first years.

Wood from Norwegian forestry and sawmills are mainly certified as sustainable forestry according to the PEFC and in some cases FSC. Bark is that energy poorer fuel than wood. Bark provides ten times higher ash levels and probably higher local dust emissions from combustion.

7 wood fiber

Wood fiber can be produced by pulpwood from the forest or based on tile that are by-products from the timber industry. It built a new plant for wood fiber in Norway which will be completed in 2018, and potentially also can supply wood fiber without the additives used for insulation. From the production of wood fiber and pulp is also produced trefiberfraksjoner who do not have sufficient quality, but which alternatively could probably have been used in earth products as there is no good economic uses of this today.

In Quantis (2012), the basis is the use of fresh bark and wood fiber that can be used in the cultivation medium in various combinations. This is based on several plants in Europe practicing mixing in both bark and wood fiber mixtures of culture medium. On the Norwegian market it in Hjellnes Consult (2017) found torvfri planting soil for gardening in sacks of composted wood fiber in a mixture of composted bark, garden / park compost and natural fertilizers, but with Swedish origin. It has not been found commercial production utilizing wood fiber in the culture media for greenhouses in Norway, but research shows examples of possible. Muro et al (2005) have tested wood fibers culture medium melon and tomato in Spain compared to perlite and coconut fibers.

7.1 Impacts from wood fibers

Production of wood fiber can now be removed as waste products from several wood processing companies in Norway, and will consequently have low greenhouse gas emissions from production. There are no published climate results from wood fiber produced in Norway, but it is done preliminary analysis of Hunton its production of wood fiber in Gurgaon and due to be completed in spring 2018. The preliminary analysis suggests that the production of wood fiber cradle-to-gate will remain at approximately 30 kg CO_2- ekv./m^3. It's a challenge to find good uses of waste materials such as wood chips today, and much is sent from afar to be used as energy. Increased use of wood chips as raw material locally will have good climate impacts by reducing transport requirements and extend the carbon sequestration.

Calculation of the climate impact of wood fiber based then on an upcoming Norwegian production of wood fiber. For transport is assumed that 200 km of truck and using LCA.no (2017) his calculator, then make up the approximately 2 kg CO_2- ekv./m^3. Climate effect for use and disposal is therefore set to zero for coconut and climate effects over a lifetime is summarized in Table 11. It is also assumed that all biogenic carbon is degraded before it has been 100 years and therefore carbon sequestration set to zero. It is uncertain whether composting and degradation of wood fiber can lead to emissions of methane and nitrous oxide, so the climate effect is therefore considered somewhat uncertain.

Table 11 Influence of climate throughout life to wood fiber (kg CO_2- ekv./m^3 wood fibers)

	Production	Distribution	Use	Disposal	Total	Carbon storage
Norwegian conditions	30	2	0	0	32	0

7.2 Other environmental impacts of wood fiber

Wood from Norwegian forestry and sawmills are mainly certified as sustainable forestry according to the PEFC and in some cases FSC. In Quantis (2012) his comparison of various mixtures of culture medium was generally not found any mixtures that had clearly lower environmental impact on all environmental indicators, except for mixing with peat, bark and wood fiber to nurseries for trees. This is also reflected in the results for each ingredient that bark and wood fiber has a low environmental impact over a lifetime. If wood fiber and bark can provide proper functioning as growing medium, they will have a great potential as ingredients in culture media with low environmental impact.

8 Compost and dewatered digestate

8.1 Properties of compost

Compost is formed by a biological process in which organic material such as food waste, garden waste and manure is converted into nutritious soil and humus. Organisms need a good supply of air provides for the conversion (Pommeresche et al., 2011). Compost properties will depend on the material to be composted. When the food waste is used for composting, there will be the need to add structural material. This may for example be wood chips, bark or garden waste. Structure material function is to provide a more porous structure and introduction of air during the composting process. There are different types of composting plants. In addition, food and garden waste is composted in households.

Many of compost products on the market contain a significant amount of peat. Future in Our Hands has mapped peat content in selling compost products and found that many of compost products on the market containing 70-80% peat (Lindahl, 2015). A generally high peat content of such products was confirmed by Hjellnes Consult (2017). Although compost in many cases, can fill the same function as peat, has compost and peat different characteristics. Therefore, it may be challenging to find a device that provides a proper basis for comparison of environmental performance. While peat is a porous material with low nutrient content, the compost material with higher density and which, in addition to natural bacteria and organisms containing essential nutrients such as nitrogen, potassium and phosphorus. Supply of nutrients can promote plant growth, reduce the need for fertilizer and contribute to the limited resources (such as phosphorus) are returned to the earth again. Simultaneously, the supply of excess nutrients cause these leaks and potentially causing eutrophication (eutrophication). The use of compost also adds carbon to the soil. Boldrin et al. (2010) predicted in its comparison of the environmental properties of compost and peat that a proportion of carbon remaining in the soil after 100 years by the use of compost, while using peat was all the carbon mineralized. Carbon sequestration in soil (addition of organic material) is positive both for the reduction of global warming and in terms of improvement in soil quality. Simultaneously, the supply of excess nutrients cause these leaks and potentially causing eutrophication (eutrophication). The use of compost also adds carbon to the soil. Boldrin et al. (2010) predicted in its comparison of the environmental properties of compost and peat that a proportion of carbon remaining in the soil after 100 years by the use of compost, while using peat was all the carbon mineralized. Carbon sequestration in soil (addition of organic material) is positive both for the reduction of global warming and in terms of improvement in soil quality. Simultaneously, the supply of excess nutrients cause these leaks and potentially causing eutrophication (eutrophication). The use of compost also adds carbon to the soil. Boldrin et al. (2010) predicted in its comparison of the environmental properties of compost and peat that a proportion of carbon remaining in the soil after 100 years by the use of compost, while using peat was all the carbon mineralized. Carbon sequestration in soil (addition of organic material) is positive both for the reduction of global warming and in terms of im

Quantis (2012) used cubic meters (environmental / m^{3}) as a functional unit when compared to turf and other materials, hence compost. Boldrin et al. (2010) also assumed that compost replaced peat on the basis of volume, but also pointed out that it is not always a 1: 1 ratio. Emissions avoided as a result of the use of compost results in reduced use of mineral fertilizers were included in the study. In Raadal et al. (2009) it was assumed that 30% of compost replaces peat, 60% replaces fertilizer and 10% are not used nationwide in Norway. Compost is here assumed to replace the turf on the basis of carbon content.

The environmental impact of the life cycle of a compost product depends on how the system limits are set between the first product waste (e.g. residues from food) and the production of the next product (compost). According to Waste Framework Directive definition of criteria for avfallsfasens termination considered compost and digestate as valuable products (reached avfallsfasens termination) when the product is shipped from the manufacturer to the new owner (Saveyn & Eder 2014). This requires that the compost meets certain quality requirements. Observance of this principle in the life cycle analysis, the environmental impact during the composting process is allocated the primary product sent to recovery and is defined as a waste disposal process for the product to be composted (food waste or yard waste). To avoid double counting should not these emissions are charged compost product. In this literature review, it nevertheless decided to identify emissions from the composting process so that it is possible for the reader to choose between the two different approaches, and so one can see the consequences of the definition of system boundaries.

8.2 digestate from anaerobic the digestion (biogas)

Digestate is a byproduct from the biogas production and can be used as fertilizer in liquid form, or it can be dewatered and used as a soil product. Liquid digestate can be used as fertilizer, and is not part of this review. Dewatered digestate is in many cases composted, but dry digestate can also be used directly as a soil product.

We found no studies that map emissions from composting of digestate specifically, and it therefore requires that any composting process digestate have corresponding emissions for composting of food waste and environmental impact of use of the waste water (and optionally composted) digestate to be correspondingly influences from the use of compost from food waste.

8.3 Impacts of compost and dewatered digestate

Climate effects of the life cycle of compost and dewatered digestate comes from emissions from transportation to place of use, emissions from usage or disposal of the product. If the system limits for avfallsfasens cessation of Waste Framework Directive is used, will not discharge from the composting process are included.

In the report, *Climate accounting for waste (* Raadal et al., 2009) was the climate effect from composting of food waste collected from households in Norway was estimated to be -0.02 kg CO_{2-} ekv./kg waste for composting (ie net saved emissions of greenhouse gas emissions) (0.05 kg CO_{2-} eq. transport, 0.03 is the climate impact of composting (direct emissions and energy use) and -0.10 is the avoided emissions due to carbon storage, replacement of peat and replacement of fertilizer). It is assumed that 30% of the compost replaces peat, 60% replaces fertilizer and 10% are not used. In Quantis (2012) is the greenhouse gas emissions per cubic compost from garden waste (green waste) about 280 kg CO_{2-} ekv./m^3

compost, where the preparation of compost represents about 80, distribution 160 and disposing 40 kg CO_{2-} ekv./m^3. This represents the highest greenhouse gas emissions per cubic meter for cradle-to-port and distribution of all materials included in the study, while emissions in disposal is the third highest after the two turf types. Boldrin et al. (2010) concluded in a Danish study that using compost instead of peat leads to the reduction of greenhouse gases. It was assumed that compost replaced peat on the basis of volume. Carbon Storage Effects and avoided the use of mineral fertilizers were included in the greenhouse gas inventory.

8.3.1 Greenhouse gas emissions from composting

The direct emissions during composting process is greenhouse gases carbon dioxide ($CO_{2)}$ methane ($CH_{4)}$ and nitrous oxide (N_2O). Emissions of CO_2 considered biogenic (coming from biological origin and would be discharged within a reasonable period of time anyway) and are therefore considered not to have a climate effect when using standard life cycle methodology. The direct emissions will depend on a number of factors. If the compost material is very moist, rich in nitrogen, or is not supplied enough air under composting and storage can result in increased emissions of methane and nitrous oxide (Pommeresche et al., 2011). Type compost material, the amount of supplied structural material and how well a composting plant operation will be crucial for the emissions, which uncertainty for estimating emissions from lifecycle compost relatively high.

There have been several studies in which emissions from different types of composting processes and different types of materials are measured, but it is not found any figures from the Norwegian plants. In some studies, the measured concentrations of various gases in the air from the composting plant, but the emissions are not related to the amount of compost produced. These are not examined in detail, since they can not be used to say something about the environmental impact of product compost. Most studies that have found state emissions per amount of waste into the plant, and these are converted to m_3 compost produced in Table 12 below.

Table 12 Direct greenhouse gas emissions from composting

Raw material and type of composting	CO_2 (Biogenic)	CH_4 (Biogenic)	N_2O	Earth (GWP)	Reference
	kg / m3 compost	kg / m3 compost	kg / m3 compost	kg CO2ekv./ m3 compost	
Food waste Ranke Composting		5.14	0.13	69	Andersen (2010) *
Food waste home Composting	166-221 0.38 to 3.94		0,28 - 0.52	151-437 Andersen (2010) *	
Food waste	256	0	0290	77	Boldrin et al. (2010) *
Food waste				120	Raadal et al. (2009) *
Garden waste	415	3.08	0007	87	Boldrin et al. (2010) *
Garden waste				80	Quantis (2012)

* emissions were given in the amount of waste in the unit, but is calculated on the per m_3 compost out of the plant

According Raadal et al. (2009) provides 1 kg waste 0.15 kg compost. Quantis (2012) has provided that the compost has a density of 600 kg / m3. If the figures from the composting process in Raadal et al. (2009) converted from tons of waste into the composting facility cubic compost out of the plant represents the composting process (energy and direct emission) 120 kg CO_{2-} ekv./m_3 compost. This figure, however, contains climate influences both from direct GHG emissions, energy use of composting facility and transport of the structural material to the plant.

Energy consumption by composting provided by Boldrin et al. (2010) to be 0.05 kWh of electricity and 0,004 liters of diesel per ton compost. Andersen (2010) report 0.0002 kWh and 0,003 liters of diesel per kg waste into plants. Using Ecoinvent (2017) and the conversion of units, it is intended that this corresponds to about 10 kg CO_2-ekv./m^3 compost.

There is considerable uncertainty in the estimation of direct emissions from the composting process. This is because the emissions will vary with time and temperature depend on how well the composting process goes (access to air to avoid anaerobic processes). For example, it is likely that emissions reduced by frequent stirring, but the measured emissions increases when the stirring happens because the gases in the air bubbles released. How and when measurements are taken can therefore influence the results. When measurements are to be used as data for calculating the life cycle analysis, they have measured emissions from a plant divided by the amount of waste into / out, which increases the uncertainty further, as the mass in a composting plant is under continuous degradation. There is considerable variation in the rate of degradation in the literature (kg of compost per kg waste in). Andersen (2010) found that 28% of the mass disappeared during windrow composting, and 55 to 73% below the home composting. In Quantis (2012) was provided 72% degradation of garden waste (green waste), while Boldrin et al. (2010) found 57% decomposition of food waste and 32% for garden waste. The density of compost can also vary. Quantis (2012) provided a density of 600 kg / m^3 (compost garden waste), Boldrin et al. (2010) provide 726 kg / m^3

for composting of food waste and 684 kg / m^3 for compost from garden waste.

We found no studies examining the emissions specifically from composting of digestate, and it is assumed that the discharge from composting dewatered digestate equivalent emissions from composting of food waste. When digestate has been treated in biogas plants, the concentration of ammonia will be higher than in normal compost (Modahl et al., 2016). This could potentially lead to higher emissions of nitrous oxide by composting of dewatered digestate compared with composting of food waste, but it is not found any studies that address this. The figures for emissions from the composting process in Table 12 shows that there are large variations in discharge, and that these appear to be more dependent on other factors than type material. It is therefore not possible to separate the greenhouse gas emissions from the composting of different sources (food waste, manure, digestate etc.

8.3.2 Climate effect of the distribution of compost and dewatered digestate

There are over 40 composting plants distributed throughout the country (Waste Norway, 2017). Emissions from the distribution of the compost is calculated from an assumed average distance of 50 km by transport calculator (LCA.no, 2017). Estimated climate impact per cubic meter of compost distributed to user account for 3 kg CO_2- equivalent, which is a relatively small environmental impact compared with the other life cycle phases to compost.

8.3.3 Climate effect from the use of compost and dewatered digestate

Direct Emissions to air during and after the use of compost will depend on compost is stable when it is put on the ground. Boldrin et al. (2010) estimates a nitrous oxide using compost 46 kg CO_2- ekv./m^3 compost from waste and 41 kg CO_2- ekv./m^3 of garden waste.

Use of compost could allow an amount of carbon bound in the soil. This amount will depend on where and how compost is used and is very challenging to quantify. Raadal et al. (2009) required a sequestration effect corresponding to 20% of the carbon content, as calculated constitutes 104 kg CO_2- ekv./m^3 compost. Boldrin et al. (2010) estimated that 14% of the carbon in the compost was stored in the soil 100 years after use, giving a carbon storage effect on 38 kg CO_2- ekv./m^3

compost from food waste, 34 kg CO_2- ekv./m^3 compost from garden waste.

8.3.4 Summary: Impacts through the life cycle of compost

Table 13 summarizes the climate impacts throughout the life cycle of a product. Climate change depends on how to set system boundaries between compost lifecycle and other life cycle. If one follows the end of waste principle described in Saveyn & Eder (2014), shall not emissions from composting charged compost product and compost can represent a net climate savings if one assumes a carbon storage effect. If one includes composting, this represents the largest environmental load throughout the value chain. Highest carbon storage effect of compost is set to -38 kg CO_2- ekv./m^3 which then become part of the results that have the least impact on the climate over a lifetime. For several applications, earth in practice be sent to incineration after short-lived. Therefore, results that give the most effect on the climate over a lifetime no carbon storage effect included.

Table 13 Influence of climate throughout life to compost (kg CO_2- ekv./m^3 compost)

		Production (Composting *)	Distribution	Use	divested ing	Total	Carbon storage
composting outside system limits	My	Not included	3	0	0	3	- 38
	Max	Not included	3	46	0	49	0
Including composting process	My	87	3	0	0	90	- 38
	max	120	3	46	0	169	0

* Includes both direct emissions and energy use. It is understood that large-scale composting plants (not home composting)

8.4 Other environmental effects of compost and dewatered digestate

Compost as growing media and soil conditioner has both advantages and disadvantages compared to the turf when it comes to other environmental impacts than climate. Use of compost can improve the physical, chemical and biological properties of the soil. Prolonged use of compost over time increases the carbon content of the soil (soil organic matter), can reduce the risk of erosion, increase soil's ability to retain water and improve soil pH buffering capacity (Saveyn & Eder, 2014).

Another major advantage of composting is that it can help to ensure that important nutrients are returned to the earth. This can reduce the need for fertilizer and pesticides (Andersen, 2010). Examples of such nutrients are phosphorus, calcium, magnesium, and micronutrients. Use of compost can also lead to environmental challenges, depending on the material is composted and the content of the compost. During composting can be small emissions of ammonia (NH_3), volatile organic compounds (VOCs), bioaerosols and particles. In closed composting plants are often used biofilters to reduce some of these emissions and to prevent odor (Saveyn & Eder, 2014).

Challenges using compost and dewatered digestate can be heavy metals, pollutants, pathogenic microorganisms, residual medicines and pesticides (Pommeresche et al., 2011). Boldrin et al. (2010) made measurements of leaching from growing media from 4 compost samples and 7 peat samples. Compost samples had 3-20 times higher leakage of heavy metals and other substances compared with peat samples. Life cycle analyzes in Boldrin et al. (2010) showed that the compost had the best results in the environmental impact categories greenhouse effect and recycling of nutrients, while peat had better results for some of the toxic categories due to lower heavy metal content. Norwegian komposterings- and biogas plants must follow the fertilizer trade regulations, which have strict requirements for the use of compost products based on heavy metal content.

9 Biochar

Biochar produced by pyrolysis of biomass, and can be used for soil conditioning, reducing agents and energy. Today imported biochar mostly to Norway for use as a reducing agent and charcoal, but there are several plans for national production. Recently, a farm started in Vestfold for making biochar to soil improver in greenhouses. Research is part of the application of biochar, and in Norway it published a number of studies in recent years. An example is the attempt composition of the culture medium for green roofs and then with between 5% and 20% biochar (Hanslin & Saebo, 2015).

Imports of charcoal was in 2016 total of 38 000 tonnes, where 29,000 tons were from Indonesia, 7,200 tons were from Poland, while the rest were distributed among other countries in Europe, South America, Africa and Asia (Statistics Norway, 2017) . The bulk density of biochar tested is 570 kg / m^3 for oak and 280 to 440 kg / m^3 of pine, while the experiences of trade is at 80 to 320 kg / m^3 (Brewer & Levine, 2015). It is further a weight of 300 kg per cubic meter.

9.1 Climate effects of biochar

San Miguel et al. (2017) conducted LCA of various production technologies biochar. The results for the greenhouse effect cradle to the distributor was between 2773 kg CO_2- ekv./tonn and 4714 kg CO_2- ekv./tonn. Contributions analysis showed substantially direct release from the pyrolysis process affect the environment. Assuming a density of 300 kg / m^3, then climate effect lie between 832 kg CO_2- ekv./m^3 and 1414 kg CO_2- ekv./m^3.

Biochar has very little degradation in soil, and experiments in Norway have shown less than 0.6% degradation over two years (O'Toole, 2012), while Hammond et al (2010) assuming 32% degradation over 100 years. The amount of carbon in biochar varies between 58 to 84% (Brewer et al, 2014). Assuming 75% carbon in biochar, the same assumption as Hammond et al (2010), the storage for 100 years, converted to carbon dioxide, be 1.87 kg CO_2- ekv./kg. With these assumptions will the storage of carbon in biochar at best equivalent to approximately the same amount of CO_2 as emissions from production. However, it is uncertain how representative the technologies discussed in San Miguel et al. (2017) is for the imported to Norway today, and that can come from Norwegian production.

Life Cycle Inventory database Ecoinvent version 3.3 has a global representative life cycle inventory for the production of biochar (Jungbluth, 2016), but which is based on European data. Using IPCC 2013 100th characterization factors, as this process provides an air impact of 1.66 kg CO_2- ekv./kg. For Indonesian traditional production, it was found lifecycle inventory as well as information to Smedby et al. (2017). This was calculated by the IPCC in 2013 and 100th characterization factors to be 1.49 kg CO_2- ekv./kg. In both of these studies is that methane emissions from biokullprosessen which has the largest climate contribution. Cornelissen et al (2016) have measured the methane emissions from a new manufacturing process for biochar with emission data from literature for various studies. Uncertainty is great here for the various technologies, but it claims zero emissions from high-tech large-scale facility. Using data from Ecoinvent for production, but assume zero in methane emissions and Norwegian electricity mix, so it provides a discharge of 0.49 kg CO_2- ekv./kg.

Biochar as a soil conditioner may also affect the amount of carbon elsewhere in the earth and emissions of nitrous oxide. Thomassen et al. (2017) has reviewed the research on this and shows that biochar in soil can lead to faster degradation of organic carbon or buildup, but it is suggested that the increased degradation in the short term and accumulation may occur in the long term. For nitrous oxide emissions are also varying results, but studies so far have certainly not shown higher nitrous oxide emissions with biochar.

In the assembly is Norwegian estimates used as a best and worst import figures, but both these figures are uncertain and summarized in Table 14. Distribution of import is considered by boat from Jakarta to Rotterdam and truck to Oslo from there. Using LCA.no its transport calculator, as this represents 44 kg CO_2- eq / m^3. At national production assumed 200 km Truck and providing a discharge of 5 kg CO_2- eq / m^3. Since only 32% of biochar is thought to break down the first 100 years, carbon storage included, but this will not be appropriate for all applications.

Table 14 Influence of climate throughout life to biochar (kg CO_2- ekv./m^3 biochar)

	Production Distribution Use Disposal Total Carbon storage						
Biochar from imports	max 1414		44	0	0	1458 -561	
Biochar from national production	My	147	5	0	0	152	- 561

9.2 Other environmental effects of biochar

San Miguel et al. (2017) conducted LCA of various production technologies biochar. The normalized results showed that the environmental impact was greatest for biochar was local, as photochemical smog, human and terre slave toxicity, as well as global climate effects. Biochar contributes properties that may be useful as a soil. Thomassen et al. (2017) has undergone several studies that have been carried out in Norway and internationally. In the international studies have been several findings on the use of biochar have boosted growth, while studies from Norway has not seen similar benefits. This is explained by the growth conditions have been good enough, and that it therefore has been little change. Thomassen et al. (2017) also show that the cation exchange capacity of biochar indicates ability to prevent leaching of nutrients and thus potentially reduce emissions such as nitrogen and phosphorus. It appears, however, not to experience studies in this area.

Peter et al. (2015) har vurdert miljøpåvirkning av biokull fra sakte pyrolyse til anvendelse i jord mot flere andre alternativer med livsløpsvurdering. Alternativene til bruk i jord var grillkull, bruk i kullkraftverk og til varmeenergi, samt å bruke biomassen direkte til varme uten pyrolyse. Råstoffet kommer her fra poppelplantasjer i sentrale Spania på areal som tidligere har blitt vurdert som å ha et stort potensial for produksjon av energivekster. For bruk av biokull i jord inkluderes også effekter biokull har for økt tilvekst. Utlekking av nitrat og lystgassutslipp er antatt å kun komme fra mineralsk gjødsel og hvor mengden er lik i alle tilfellene, så biokull har i studien kun effekt på tilvekst. Bruk av biokull til kullkraftverk gir det største potensialet til utslippsreduksjon, mens bruk i jord kommer nest best ut. Resultatene er vist med en funksjonell enhet per hektar jordbruksareal, samt med substitusjonseffekter, så er vanskelig å sammenligne med andre studier.

10 Ull fra husdyr

Ull er et mulig erstatningsmateriale for torv (Hjellnes Consult, 2017). Dette kan være spesielt relevant for kvaliteter av ull som regnes å ha lav verdi. Ullkvalitetene C2S, G, V, H2 og H3 har særlig lav kvalitet, og Norilia betalte fra november 2016 null til en kroner per kilo for disse (Norilia
2016). Den lave prisen skyldes delvis at disse kvalitetene nylig har mistet tilskudd, fordi regjeringen ønsker en satsing på ull av høy kvalitet. Det kan dermed tenkes å være behov for nye bruksområder for ull av lav kvalitet. Blant svenske bønder er det andre incentiv- og støtteordninger enn i Norge, og her regnes ull å ha lav eller ingen verdi (Wallman et al. 2011, s. 15). Hanzlíková et al. (2016) skriver: " *Nowadays wool is very often an undesirable waste and thus, new applications have to be looked for",* og mener at det ut fra økonomiske og miljømessige hensyn er hastverk med å få frem forskning på dette feltet.

I sin gjennomgang av dyrkingsmedier og jordforbedringsmidler fant Hjellnes Consult (2017) ingen kommersielle produkter på det norske market der ull inngår. McKinnon (2017) nevner to engelske produkter egnet for oppal og potteplanter. Disse produktene er blandinger av kompostert saueull og bregner/einstape, som produseres på gården Dalefoot i Lake District nasjonalpark i England. McKinnon mener at mediet virker egnet til formålet. Saueull behandlet via hydrolyse ble av Nustorova et al. (2006) funnet å fungere som gjødning, idet det tilfører organisk materiale. Det finnes ellers en del studier som går inn på gjødselseffekten til kompostert ull. For mer informasjon om dette henvises det imidlertid til kompost generelt i kapittel 3.5.

Regarding ukompostert wool cultivation medium, it seems that use little discussed in the scientific literature. An article by Zheljazkov et al. (2009) seem to go in depth of this use of the material. The article is based on growth in larger flower pots, and concludes that ukompostert ullavfall can be used as soil fertilizer as part of the culture medium, as well as a food source. Ullavfall will cover several functions simultaneously if wool fibers contributes to a culture medium function, if the wool chemical properties give it function as a soil conditioner, and if the nutritional content makes wool acts as a fertilizer. This multi-functionality can basically do wool to a particularly promising substitute material for turf compared to other materials that are examined in this report.

10.1 Klimaeffekter fra ull

Det er ikke identifisert studier som undersøker klima- og miljøeffekter av bruk av ukompostert eller kompostert ull spesifikt til dyrkingsmedium. For kompostert ull vises til kapitlet om kompost for generell informasjon. Når det gjelder resirkulering av ull i form av tekstiler, vil dette være i tråd med kaskadeprinsippet og prinsippet om sirkulær økonomi. Det er ikke identifisert studier som gjør en klima-/miljøvurdering ved bruk av ull fra tekstiler til spesifikt bruk som dyrkingsmedium eller jordforbedringsmiddel. Bruk av det som i dag er avfall til å erstatte torv kan som et utgangspunkt antas å være klima- og miljøvennlig, så lenge innsamling, produksjon og bruk skjer uten overdreven transport.

For å lage estimater for klimaeffekten av ull, er det tatt utgangspunkt i at det i beste fall kan komme fra norsk ullavfall, mens det i verste fall importeres som et biprodukt. Som biprodukt vil miljøbelastning fra husdyret også inkluderes og gi en stor innvirkning på resultatene. Tallene blir da basert på en gjennomgang av mange LCA-studier i et review av Henry (2012), hvor noen studier viser resultater så høye som 33,7 kg CO_{2-} ekv./kg. Tallene i rapporten fokuserer primært på Kina, New Zealand og Australia, som står for det meste av verdens ullproduksjon. Wiedemann et al. (2015) gjennomgår hvordan ulike metodiske antakelser i LCA-studiene kan innvirke på resultatene. Her oppnås 76 kg CO_{2-} ekv/kg for ett spesifikt case, som imidlertid inkluderer en såkalt consequential LCA-modellering der nylon antas å være et unngått produkt. Dette holdes utenfor tabell 12, da unngått produkt ikke inngår i de øvrige analysene, og unngått produkt som er relevant for denne rapporten er uansett torv, ikke nylon.

Resultater fra ulike studier varierer sterkt avhengig av om utslipp av lystgass og særlig enterisk metan (fra tarm) er regnet med eller ikke (Henry 2012); når disse utslippene tas med i studien, blir klimagassutslippene langt høyere. Da alle relevante utslipp i prinsippet skal være med i en LCAstudie, vil det i utgangspunktet være riktig at en studie har slike utslipp med. Metan er en potent klimagass, men brytes ned i atmosfæren over tid. Antakelser når det gjelder tidshorisont spiller dermed inn når man omregner fra metanutslipp til CO_{2-} ekvivalenter. Det vanligste i LCA-studier er å bruke IPCCs vanligst brukte antakelse for tidshorisont, men denne kan diskuteres, og metanutslippene gir dermed en usikkerhet i tallene. En annen metodisk detalj som kan spille inn, er allokering, eller hvor stor del av saueholdet ullen skal gis skylden for når den regnes som et biprodukt, ikke et avfallsprodukt. Ved såkalt masseallokering vil total masse ull per total masse av alle produkter fra selve dyret bestemme allokeringen, mens såkalt økonomisk allokering i stedet gir ull "skyld" proporsjonalt med den økonomiske verdien av ullen sammenlignet med verdien av andre produkter.

Data on the density of wool cultivation medium has not been found. Wool insulation, however may be assumed to have similar properties as a growth medium. Korjenic et al. (2015) calculates wool insulation greenhouse gas emissions to 5.4 kg CO_{2-} eq / $m_{3.}$ By this discharge constitutes wool only a very small part, as wool is considered a renewable resource without emissions. The insulation is believed to also contain other materials, which account for most of the emissions. This single outcome seems therefore not very relevant for wool cultivation medium. For wool insulating it declared 20 kg / m_3 Sheep Wool Insulation Ltd. (2017), so when it has been used as the conversion factor table. The figures should be regarded as unsafe, and are summarized in Table 12. The figures for distribution of imported wool will depend on the transport distance. Wool which local residual product is calculated as waste, not as a byproduct of sheep farming, and it is therefore in such a best case case estimated zero emissions from production.

Table 15 Influence of climate throughout life to wool (kg CO_{2}- ekv./m^{3} wool)

	Production Distribution Use Disposal Total Carbon storage						
Wool locally residual product	My	0	0.5	0	0	0.5 0	
Wool imported product	max 674		4	0	0	678	0

10.2 Other environmental effects of wool

En generell observasjon er at bruk av ubehandlet ullavfall fra husdyr som dyrkingsmedium kan være et bidrag til å bruke denne kilden på en mer ressurseffektiv måte enn i dag. Når det gjelder bruk av ull av høy kvalitet som i stedet kunne vært brukt til klesproduksjon til dyrkingsmedium eller jordforbedringsmiddel, vil dette ikke være i tråd med kaskadeprinsippet ("cascading") for mest mulig effektiv bruk av bioressurser, som er en del av sirkulær økonomi-konseptet, jfr. definisjoner i Johnsen og Hanssen (2014). En mulig begrensning er i hvilken grad ubehandlet ull fra husdyr kan gi hygieniske problemstillinger, jfr. Høgåsen et al. (2011). Zheljazkov et al. (2009) nevner også menneskehår som et materiale med lignende egenskaper, jfr. Zheljazkov et al. (2008).

Derimot er avhendede tekstiler eller tekstilrester en mulig kilde til ullavfall. Det er et aktuelt og sterkt ønske om å øke gjenbruk og gjenvinning av tekstiler, da tekstiler som går til forbrenning kan regnes som en uutnyttet ressurs av tilsynelatende høy materialkvalitet. Forbrenning av produkter av relativt høy kvalitet er heller ikke ønskelig fra et kaskade- og sirkulær økonomi-ståsted. Dette prinsippet antyder at makroskopiske egenskaper som struktur og fibre bør utnyttes der de er tilgjengelige, og at full utnyttelse av mer mikroskopiske ressurser i materialet (biologisk, kjemisk og dernest forbrenningsenergi) kan skje i neste gjenvinningsrunde. Fråne et al. (2017) går gjennom problemer og muligheter rundt tekstilavfall. Kjemikalier i avhendede tekstiler kan være et potensielt problem dersom tekstiler skal benyttes som dyrkingsmedium, jfr. Folkehelseinstituttet (2016). Eventuell påvirkning på liv i jorden som f.eks. meitemark er ikke vurdert. Bedre utnyttelse av ull kan påvirke arealbruk ved at større områder benyttes til beite; dette kan ha ulike lokale miljøeffekter, og kan også i sin tur innvirke på klimagassutslipp. Dette vil normalt være inkludert i LCA-studiene, men typisk med generiske, ikke lokale, antakelser. I øvrig litteratur analyserer Wallman et al. (2011) klima- og miljøeffekter av kjøttproduksjon fra sau i en svensk kontekst, men går ikke konkret inn på ull. Totalt sett virker det å være et uutnyttet potensial når det gjelder ull som erstatningsmateriale for torv.

11 Torv fra myr

Torv brukt som strukturmateriale i dyrkingsmedium og som jordforbedringsprodukt har blitt forklart nærmere i introduksjonen.

11.1 Klimaeffekter fra torv

Som en sammenlignende referanse, så er klimaeffekten fra torv inkludert her. I Quantis (2012) er klimaeffekten for torv beregnet for både hvit og sort torv. Beskrivelsen av hvit torv tilsvarer beskrivelsen av hvitmosetorv. Det antas å være størst anvendelse av hvitmosetorv, så derfor er det valgt å anvende resultatene for hvit torv her. Over livsløpet er klimaeffekten cirka 160 kg CO_2-ekv./m^3, hvor halvparten er fra bruk og avhending, mens cirka 45 kg CO_2-ekv. er fra distribusjon og 35 kg CO_2-ekv. er fra produksjonsfasen. Produksjonsfasen er her modellert med utslipp fra arealene under høsting og arealene etter bruk, mens det er trukket fra et referansescenario. Modellen har også inkludert tidsjustering av klimagassutslipp, noen som fører til at utslipp frem i tid har mindre belastning. Det ble også samlet inn data fra produsentene for andre aktiviteter.

Det finnes også data for produksjon av torv til dyrkingsmedier i databasen Ecoinvent v3.3, som er deklarert som globalt representativt, men basert på data fra Quebec. En analyse av dette viser en klimaeffekt fra produksjon på 130 kg CO_2-ekv./m^3, hvor 7 kg CO_2-ekv./m^3 er fra energi og materialer anvendt i produksjonen og 123 kg CO_2-ekv./m^3 er nettoutslippene fra landarealene. For klimagassutslipp fra torv i Norge, så har dette blitt beregnet i Søgaard et al (2017) for Norges klimaregnskap under FNs klimakonvensjon. Rapporteringen her består av to deler, hvor de direkte utslippene fra torvmyrene er basert på drenert areal, mens de indirekte utslippene fra nedbrytning av torven i bruk er basert på omsatt volum. Tetthet i omsatt volum er satt litt høyere enn i Quantis (2012), da det i Norge er regnet med 100 kg tørrstoff/m^3. Årlig produksjonsvolum i 2015 anvendt i statistikken var på cirka 279 039 m^3, som gir 51,16 kt CO_2 utslipp fra bruken av torv. Dette gir 180 kg CO_2/ m^3. Omregning fra arealbaserte utslipp fra torvuttakene til per volum omsatt torv er her gjort basert på gjennomsnittlig uttak for perioden 1990 til 2015 og delt på årlige totale utslipp. Med et gjennomsnittlig uttak på 215 000 m^3 torv per år og 22,36 kt CO_2-ekv. i direkte utslipp årlig fra arealene, blir det et produksjonsutslipp fra arealbruk på 104 kg CO_2-ekv./m^3. I tillegg kommer andre klimagassutslipp i produksjonen og med norsk elektrisitetsmiks er det estimert til 2 kg CO_2-

ekv./m^3.

Utslippene basert på omregning fra Norges klimagassregnskap til per kubikkmeter omsatt torv er en del høyere enn utslippene som er lagt til grunn i den europeiske studien. Dette kan skyldes både beregningsmetode eller geografiske forhold, men dette er ikke undersøkt nærmere da det er utenfor omfanget til rapporten. Den norske studien for klimagassregnskapet er godt dokumentert og gyldig for norske forhold, så det gjør resultatene mer representativ enn Quantis-studien. Metoden for å regne de norske tallene for årlige nasjonale utslipp om til livsløpet til en kubikkmeter torv er dog ikke basert på en komplett LCA-studie, men noen enkle beregninger her. Resultatene fra begge studiene er dermed vurdert som usikre. Resultatene fra begge studiene er oppsummert i Tabell 16. I sammenstillingen blir disse resultatene brukt for å estimere et beste og verste tall, men transporten er flyttet slik at worst case har de høyeste tallene for alle livsløpsfasene. For distribusjon antas det av Quantis transport på skip over lang avstand. For norske forhold antas det samme transport som for trefiber. I oppsummeringen videre vil de norske estimatene for produksjon og bruk anses som verste fall i kombinasjon med transport fra Quantis (2012).

Tabell 16 Klimapåvirkning gjennom livsløpet til torv (kg CO_2-ekv./m^3 torv)

	Produksjon Distribusjon Bruk Avhending				Sum Karbon-	lagring	Sum
Quantis (2012)	35	45	80		160 0		160
Estimat norske forhold	106	2	180		288 0		288

11.2 Andre miljøeffekter fra torv

I Quantis (2012) har torv relativt stor påvirkning på ressursbruk sammenlignet med andre materialer, mens for økosystemkvalitet ligger torv blant de lave alternativene. Imidlertid vil en del effekter falle utenfor vanlige LCA-studier, som nevnt i innledningen av kapittel 2. Særlig er arealbruksendring en kritisk indikator når det gjelder torv, denne har imidlertid Quantis spesifikt tatt hensyn til for torv. Direkte effekter på norske rødlistede arter er heller ikke spesifikt modellert, og slike effekter skal tillegges avgjørende vekt der de er kjent. Quantis-studien bør dermed ikke vurderes å gi et nøyaktig eller godt tilpasset resultat når det gjelder økosystemkvalitet. Torvuttak fra norske myrer medfører imidlertid ikke risiko for å innføre utenlandske arter, som kan tenkes å bli et stort problem ved storskala bruk av noen av erstatningsmaterialene. For menneskers helse ligger resultatene for torv så å si lavest av de vurderte produktene.

12 Sammenstilling av resultater

12.1 Klimaeffekter for torv og erstatningsmaterialer i norske forhold

Klimaeffekt for torv og de ulike erstatningsmaterialene er oppsummert i Tabell 17. Resultatene her kan anvendes videre for spesifikke blandinger av dyrkingsmedium og anleggsjord. Dataene har varierende grad av usikkerhet, og dette er indikert med fargene grønt, gult og rødt. Når data med røde og gule tall blir anvendt videre i en jordblanding i vesentlig mengde, vil klimaeffekten der være tilsvarende usikker.

Tabell 17: Sammenstilling av klimaeffekter for materialene til dyrkingsmedium per kubikkmeter med usikkerheter.

Materiale	Min/ maks	Prod- uksjon	Distri- busjon	Bruk	Avhe- nding	Sum	Karbon- lagring*	Usikkerhet i resultatene
Steinull	-	84	6,4	0	12,6	***103***	0	Ganske sikkert
Perlitt	-	66	11	0	22	***99***	0	Ganske sikkert
Kokosfiber	Min	45	20	0	0	***65***	0	Usikkert
Bark	-	10	1	0	0	***11***	0	Litt usikkert
Trefiber	-	30	2	0	0	***32***	0	Litt usikkert
Kompost	Min	0	3	0	0	***3***	- 38	Usikkert
	Maks	120	3	46	0	***169***	0	Usikkert
Biokull	Min	147	5	0	0	***152***	- 561	Usikkert
	Maks	1414	44	0	0	***1458***	- 561	Usikkert
Ull	Min	0	0,5	0	0	***0,5***	0	Usikkert
	Maks	674	4	0	0	***678***	0	Usikkert
Torv	Min	35	2	80	0	***117***	0	Usikkert
	Maks	106	45	180	0	***331***	0	Usikkert

* Karbonlagring er i utgangspunktet bare aktuelt når et dyrkingsmedium anvendes med en levetid på over 100 år

Dersom en ser på klimaeffekt per kubikkmeter av hvert materiale, gir de fleste materialene et bedre resultat enn torv, med unntak av de høyeste verdiene for kompost og biokull. Det er viktig å være klar over at ulike materialer kan yte ulik funksjon og at sammenligning per kubikkmeter som hovedregel ikke gir et riktig bilde. For eksempel kan komposten tilføre næringsstoffer og bidra til redusert behov for gjødsling, noe som kan redusere klimagassutslipp fra produksjon og bruk av kunstgjødsel. Dersom en antar en god komposteringsprosess med lave utslipp, vil erstatning av torv med kompost representere reduserte klimabelastning per kubikkmeter.

Bruk av perlitt og kokosfiber medfører høyere transportbelastninger enn de andre alternativene, siden produksjonen foregår lenger unna. Det er likevel produksjonen av materialene som representerer den største belastningen.

12.2 Miljøeffekter for torv og erstatningsmaterialer i norske forhold

De ulike andre miljøeffekter som har blitt omtalt i studien er oppsummert i Tabell 18. Resultatene kan ikke brukes til en sammenligning, men gir en indikasjon for videre undersøkelser. Oversikten viser at de ulike materialene har fordeler og ulemper sammenlignet med torv.

Tabell 18: Oppsummering av andre miljøeffekter av torv og erstatningsmaterialer

Materiale	Økosystem	Ressursknapphet	Menneskers helse	Annen miljøpåvirkning under produksjon og distribusjon	Direkte miljøpåvirkning under bruk
Steinull		Rikt tilgjengelig	Transport og sprengning ved ressursuttak		
Perlitt		Rikt tilgjengelig		Lang transportavstand	
Kokosstøv	Arealbruk ved dyrking av kokosnøtter. Forurensing av vann ved bearbeiding av kokos-nøtter. Mulige store negative effekter	Biprodukt	Transport. Arbeidsforhold.	Uoversiktlige miljøeffekter i u-land. Store negative effekter observert i noen land. Lang transportavstand	
Bark	Som regel sertifisert skogbruk	Fornybar ressurs, rikt tilgjengelig		Kan inneholde for mye mangan	
Trefiber	Som bark	Rikt tilgjengelig			
Kompost	Kan gi forbedret jordkvalitet.	Fornybar ressurs. Kan gi gjenvinning av viktige næringsstoffer		Kan gi små utslipp under kompostering (NH_3, VOCs, bioaerosoler, partikler)	Kan gi utslipp av miljøgifter avhengig av kompostmateriale
Biokull	Kan gi forbedret jordkvalitet	Som regel basert på biprodukter	Lokale luftutslipp kan være store		
Ull		Voksende mengde tilgjengelig			
Torv	Uttak er ødeleggende for leveområdene til planter og dyr	Begrenset ressurs			

12.3 Sammenlignbarhet

Torv har liten egenvekt og lite næringsinnhold, og bidrar med struktur ved bruk som dyrkingsmedium og jordforbedringsprodukt. I en vurdering av erstatningsmaterialer for torv, er det viktig å ta hensyn til hvilken funksjon og anvendelse disse har. Alternativer som kokosfiber har ofte blitt beskrevet som å være det materialet som har egenskaper nærmest torv, men noen studier tyder på at trefiber også har tilsvarende funksjoner. Siden det ikke har vært mulig å se hvert av materialene i typiske anvendelser, fokuserer studien på å sammenstille klimaeffekter for hvert materiale per kubikkmeter. Dette kan som en hovedregel ikke brukes til direkte sammenligning, siden det også kan medføre andre innsatsfaktorer og utslipp når det måles etter en konkret funksjon eller anvendelse. Sammenstillingen av resultatene i denne studien kan kun brukes som grunnlag for en videre vurdering og diskusjon, der konkrete blandinger og anvendelser tas med i vurderingen. Selv om ulike blandinger kan ha mange av de samme funksjonene, så kan det være hensiktsmessig å også ta hensyn til levetid og behov for ekstra materialer som gjødsel under bruk, samt eventuell utlaking av stoffer.

12.4 Klima- og miljøeffekter fra materialene

Perlitt og steinull er begge kommersielle produkter som anvendes som dyrkingsmedier. Disse har godt dokumenterte tall på klimaeffekt, som kan regnes som relativt sikre. Disse har lavere klimaeffekter enn torv, men ikke de laveste. Bark, trefiber og kokosfiber har de laveste klimabelastningene. Bark og kokosfiber anvendes allerede på markedet i mange tilfeller, mens trefiber er brukt i noen produkter. Kokos slår imidlertid dårlig ut både for økosystemer og menneskers helse. Dessuten gjøres det for kokos tilsynelatende en best case-antakelse om produksjon under ordnede forhold og uten avskoging i Sri Lanka, og denne antakelsen er ikke riktig ved produksjon i enkelte andre land. De reelle klimagassutslippene kan dermed være høyere enn vist. Økende arealbruk i tropiske områder er også et av klodens største miljøproblemer. For trebasert produkter er det i mange tilfeller vanlig å kreve sertifisert sporing av bærekraftig skogbruk og det er har nylig blitt lovpålagt for bedrifter å loggføre kjøp og salg av trebaserte produkter gjennom EUs tømmerforordning. Slike krav eller slik sertifisering er ikke funnet for kokosstøv, og kan være et tiltak for å sikre at det som kjøpes inn kommer fra bærekraftige kilder.

Klimaeffekter for kompost, biokull, ull og torv har også blitt kvantifisert. Resultatene er her sprikende og dermed vurdert som usikre. Kompost kan ha betydelige utslipp i komposteringen, og disse utslippene vil variere fra anlegg til anlegg. Klimaeffekten for kompost som dyrkingsmedium vil dog ikke inkludere disse utslippene dersom man følger avfallsdirektivets end of waste-prinsipp, da disse allokeres til avfallshåndteringen til produktet som går til kompostering. Bruk av kompost kan medføre forbedret jordkvalitet og redusere behovet for gjødsling, noe som kan gi en positiv klimaeffekt dersom man medregner karbonlagring og unngåtte utslipp fra produksjon og bruk av kunstgjødsel.

Biokull har i mange studier høye utslipp av metan og andre utslipp til luft som har lokal betydning. Dette gjør at biokull kan ha utslipp av klimagass på samme nivå som torv, men ved en satsning på norsk produksjon kan disse bli vesentlig redusert. Biokull kan også bidra med varig karbonlager når anvendelsen har lang levetid. Biokull har i litteraturen også beskrevet en del mulig tilleggseffekter som kan være gunstige i bruksfasen, men det er lite dokumentasjon på erfaringer på det i Norge. Det er ikke funnet litteratur som ser på ull fra husdyr som dyrkingsmedium. Hvis ull er tilgjengelig lokalt som et restprodukt, vil det i utgangspunktet ha en lav miljøbelastning. Nedbrytning i kompostering eller bruk kan dog være en potensiell utslippskilde. Ull inneholder næringsstoffer i tillegg til å være et dyrkingsmedium, noe som kan gi tilleggseffekter. Klimaeffekter fra torv kommer hovedsakelig fra arealbruk av torvuttak og nedbrytning, mens bruk av energi og materialer har liten betydning.

12.5 Forutsetninger for analysene

Vurderingen av de ulike materialene er basert på en rekke forutsetninger som kan ha innvirkning på resultatene. Dette gjelder både metodiske forhold, og data som kan endres over tid eller sted. For metodiske forutsetninger vil karbonlagring og tidsjustering være spesielt relevant for de biobaserte materialene. Dette viste seg spesielt gjeldende for beregningene for torv i Quantis (2012), hvor tidsjustering reduserte utslippene fra nedbrytning av torv betraktelig. Tidsjustering i Quantis (2012) er dog ikke transparent vist betydningen av, men tilsynelatende er det kun inkludert på torv og ikke andre biobaserte materialer. Hadde tidsjustering vært inkludert for alle biobaserte materialer, så kunne resultatene for flere av dem vært negativ klimaeffekt. I de nasjonale klimagassutslippene for uttak av torv blir dette forenklet beregnet, hvor utslipp fra nedbrytning av torv blir beregnet i det året det høstes. Dette har også inntil nylig vært vanlig for alle trebaserte produkter i det nasjonale klimagassregnskapet, men en forenklet metode for å beregne klimagassutslipp i det året det skjer er nå implementert. Denne metoden omfanger dog ikke bruk av treprodukter i jordprodukter, så det kan være nyttig for bedre rapportering og insentiver for tiltak.

For perlitt og steinull er mye av klimabidraget knyttet til bruk av energi i produksjonen og transport. Generelle klimatiltak over tid kan derfor redusere utslipp for disse produktene. Endringer som følge av generelle klimatiltak vil derimot ha liten innvirkning for produksjon av torv, da disse utslippene hovedsakelig ikke kommer fra energibruk og transport, men fra arealbruk. For biokull er det også et stort potensial for utslippsreduksjoner over tid. Teknologien som brukes i en tradisjonell pyrolyseprosess har betydelige metanutslipp som fjernes ved bruk av moderne teknologiske løsninger. Transport har også en betydning, så nasjonal produksjon har et stort potensial. For kokosstøv er det av Quantis brukt en best case-antakelse om produksjon under ordnede forhold i Sri Lanka, som hevdes å ikke føre til avskoging. Denne forutsetningen virker imidlertid grov og lite kritisk. En grundigere studie med et gjennomgående worst case-perspektiv i forutsetninger og datagrunnlag vil kunne gi andre resultater.

Generelt er menneskers helse og økosystemskade generiske samleindikatorer som har betydelig større usikkerhet enn andre LCA-indikatorer. Beregningsmodellene for disse indikatorene er ikke komplette verken i LCA eller i andre sammenhenger, og det er derfor alltid en fare for at noe som i praksis er relevant ikke blir talt med. Detaljene i definisjonene av menneskers helse og økosystemskade nevnt i avsnitt 2.3.2 bør legges merke til. Forutsetningen at kategoriene menneskers helse, økosystemskade og klimaendringer regnes som uavhengige kategorier skyldes heller manglende omregningsfaktorer enn manglende reelle effekter, og bør leses kritisk. I praksis vil klimaendringer samt arealbruksendringer ha særlig stor innvirkning på økosystemer, noe som i sin tur kan ha stor innvirkning på menneskers helse. Beslutningstakere på spørsmålet om torv og torverstatninger bør ha en forståelse av disse kausale sammenhengene. Videre studier kan gå nærmere inn på konkrete mikro- og makrobiologiske virkninger av bruk av bestemte materialer i norsk anleggsjord. Særlig kan effekter på mikro- og makrofauna være av interesse.

13 Konklusjoner

Denne studien har vurdert miljøeffektene av å fase ut torv ved å se på klima- og miljøeffektene fra alternative materialer. Dette har blir gjort ved å gjennomgå litteratur og forsøke å svare på følgende spørsmål:

- Hvordan kan torv sammenlignes med alternativer?
- Hvilke klima- og miljøeffekter har torv og erstatningsmaterialer?
- Hvordan endres klimaeffekter av å inkludere andre metodiske tilnærminger enn de standardiserte?

Torv og flere av de alternative materialene har ulike funksjoner, og kan ikke nødvendigvis sammenlignes per kubikkmeter eller kilo. For anvendelser i veksthus viser en studie at dyrkingsmediet består av kun ett materiale og kan da sammenlignes per kubikkmeter, men det gjelder da bare for torv, kokosstøv og steinull. Til de fleste andre anvendelser må det sammenlignes som en blanding av flere materialer med ulike funksjoner. Torv sin rolle er å være et næringsfattig strukturmateriale og må kombineres med tilsetning av næringsstoffer, mens kompost som inneholder mye næring må tilsettes strukturmateriale for å oppnå ønsket kvalitet.

Alle erstatningsmaterialene har blitt vurdert hver for seg, og det er forsøkt å kvantifisere klimagassutslipp over livsløpet per kubikkmeter. Siden materialene ikke har samme funksjon, må de først sammenlignes i en jordblanding. Steinull og perlitt har robuste data for klimagassutslipp, og er basert på rikt tilgjengelige ressurser. De krever en del ikke-fornybar energi i produksjon, og det gir en del klimagassutslipp. De er inerte, og vil derfor ha liten miljøpåvirkning i bruk og etter bruk. Treflis, bark og trefiber har som kortreiste biprodukter lave utslipp i produksjon. Det er likevel usikkert hvordan de presterer i bruk sammenlignet med torv eller andre erstatningsmaterialer. For kokosstøv virker den ene kvantitative studien som er identifisert å legge et best case til grunn, og kokosstøv kommer likevel dårlig ut totalt sett. Kokosstøv kan ha en del problematiske aspekter avhengig av hvor det kommer fra og som er vanskelig å inkludere i generelle livsløpsvurderinger.

Tidsjustering av klimagassutslipp tilsvarer at biomasse bør prioriteres først som bruk i materialprodukter fremfor energi. Klimaeffekten av å bruke bark og flis ville sannsynligvis bli bedre som jordprodukt enn energi hvis tidseffekten inkluderes. For biokull, så blir det i motsetning større utslipp av metan umiddelbart, og det gir en risiko for at tidsjustering kan være mindre heldig for biokull. Økt etterspørsel etter biokull kan på den andre siden føre til lokal produksjon og med tilstrekkelige utslippskrav gi produksjon med lavere metanutslipp enn ellers.

Diskusjon om hvilke jordblandinger og ingredienser som er mer eller mindre miljøvennlige har mange likheter med diskusjonene om byggematerialer. For byggematerialer har det i økende grad blitt stilt krav til miljødeklarasjoner som gir tredjepartsverifiserte tall for miljøpåvirkning over livsløpet. Slik dokumentasjon vil spesielt være nyttig for ferdigprodukter av jord, og kan stilles som krav i offentlige anskaffelser, samt ved større anleggsprosjekter. De nasjonale metodene for beregning av klimagassutslipp er forenklet på karbonlagring i produkter og bedre metoder her vil gjøre beslutningstaking lettere. Som eksempelet kokosstøv illustrerer, er det imidlertid viktig for beslutningstakere å gå gjennom forutsetningene til kvantitative studier, og å legge til grunn en bred forståelse av alle miljøeffektene til hvert materiale.

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