Landscape Institute Technical Information Note

Carbon and Landscapes

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Contents

This Note provides information about Carbon and Climate Change, and whilst not constituting guidance, may encourage a change in the way in which landscape interventions are perceived and thereby facilitate the creation of more sustainable, resilient environments.

1. Introduction

In the era of globalisation and environmental instability the 'landscape' is often perceived as a medium of little importance compared to the global challenges we face. The aim of this Technical Note is to illustrate the impact spatial strategies could have in climate issues as well as to introduce some of the carbon challenges which landscape professionals can address, leading to improved environments.

Supporting the notion that landscape is 'an area as perceived by people whose character is the result of the action and interaction of natural and/or human factors' (Council of Europe, 2000) as proposed by the European Landscape Convention (ELC), the Note covers carbon concepts and ways in which the landscape professions can change public opinion on Climate Change.

The concepts of carbon and low carbon are not easy to define and are often perceived as merely a method for the reduction of Greenhouse Gases (GHG) and carbon dioxide (CO_2) emissions (Yuan et al., 2011) as well as ways to minimise energy and transport gas emissions. Although carbon reduction is a legitimate aim, it begs various questions related to how to achieve a low carbon lifestyle, and how such concepts can be evaluated based only on the numerical models and mathematical equations on which carbon is being assessed. Is the low carbon way of living only defined by carbon footprint and the carbon cycle process? Or are these terms lacking a broader interpretation as Wiedmann and Minx (2008) argue? Concepts related to carbon cycle are presented and discussed showing the main characteristics and also engaging with a new way of thinking between the landscape professions and climate change.

2. Carbon in the atmosphere and the environment

NASA reveals that CO_2 levels surpassed 400 parts per million (ppm) for the first time in recorded history in 2013 (NASA Climate, 2017). This is twice the level reached during the last Ice Age (200 ppm) and significantly higher than during the warmer interglacial periods (approximately 280 ppm). The Intergovernmental Panel on Climate Change (IPCC) shows projections that CO_2 concentrations could continue to rise to as much as 500–1000 ppm by the year 2100 (IPCC, 2007), impacting not only on the atmosphere, but also to the environment and our daily life.

CO_2 is a naturally occurring gas, but according to the IPCC it is also 'the principal anthropogenic gas that is thought to affect the Earth's radiative balance' (IPCC, 2007). NASA adds that this significant rise in CO_2 shows a relationship with fossil-fuel burning that remains in the air (NASA Earth Observatory, 2017), however this can also result from land-use changes and industrial processes. CO_2 is therefore also a result of various anthropogenic activities and, as Hoffman et al. (2009) explain, even the rise in population is often related to the rise of atmospheric CO_2 that could lead to a total atmospheric level of about 430 ppm in the next 30 years.

One of the immediate impacts of excessive atmospheric CO_2 is related to the increase of temperature that can lead to the rising of sea levels (Florides and Christodoulides, 2009), enhancing the effect of extreme weather events (such as storms, hurricanes etc), impacts on the amount of participation and changing agricultural processes, yields, plant processes and species lifecycles. While it seems true that the increase of atmospheric CO_2 is not just anthropogenic and that CO_2 contributes less to the overall greenhouse effect, for example water vapour, NASA data suggest that CO_2 is *the* gas that sets the temperature and is, therefore, very significant to climate related issues (NASA Earth Observatory, 2017). Specifically, CO_2 causes about 20 per cent of the Earth's greenhouse effect, water vapor about 50 per cent and clouds account for another 25 per cent, leaving the remaining 5 per cent to minor greenhouse gases (GHG) such as methane and aerosols (NASA Earth Observatory, 2017). However, 'CO_2 controls the amount of water vapour in the atmosphere and thus the size of the greenhouse effect' (NASA Earth Observatory, 2017), creating concerns for continuing temperature increases and the effect on the planet.

A significant part of the carbon cycle is also the carbon stored in soil, known as Soil Organic Carbon (SOC). Organic material is embodied into the soil by soil fauna, leading to organic material transformation and therefore incorporates carbon inputs into the soil. The soil carbon pool is not static and can be lost or gained through soil erosion or deposition leading to changes of soil Carbon at the landscape, regional or local scale. Data extracted from the Food and Agriculture Organisation of the United Nations (FAO, 2017) suggest that in the first meter of soil it is stored an estimated 1.500 PgC (Petagrams of Carbon), a number bigger than the carbon that is contained in the atmosphere and terrestrial vegetation combined. CO_2 that is found in soil can also be emitted back into the atmosphere when soil organic matter (SOM) is decomposed (or mineralized) by microorganisms and also by root exudates which liberate organic compounds (FAO, 2017). Another form of carbon, known as dissolved organic carbon (DOC) can also be exported from soils to rivers and oceans.

The changes in the amount of atmospheric or dissolved CO_2 can also relate to effects in the broader environment. Oceans absorb CO_2 resulting in a decrease of their pH as this is dissolved in the water producing carbonic acid. Ocean acidification negatively affects calcifying organisms such as oysters, clams and more but can benefit the growth of seagrass and algae. Plants can also change some of their processes, either stimulating their growth or not, depending on their species and the land is also affected either by the absorption of CO_2 by terrestrial plants or by the different climate conditions.

3. Greenhouse effect and the landscape

The greenhouse effect is often perceived as dangerous for the earth and living species, however it needs to be clarified that the effect itself is a natural process. It is the *excess* of this effect resulting from multiple gas emissions that is a problem for the environment. As Florides and Christodoulides (2009) explain, the greenhouse effect is 'the phenomenon where water vapour, carbon dioxide (CO_2), methane (CH_4) and other atmospheric gases absorb outgoing infrared radiation resulting in the raising of the temperature'. Atmospheric gases trap heat, allowing the earth to retain solar heat and be 'liveable' as a planet. Without this effect, therefore, life would not be possible as the temperature would be too low for most forms of life (Land Trust Alliance, 2017). However, CO_2 is the main anthropogenic GHG and therefore immediately related to the greenhouse effect (IPCC, 2007) as the gas emissions stay in the atmosphere for long periods, resulting in increased surface air temperatures and warming the planet. Land use, agriculture and every land activity results in emissions that are often way beyond what the earth can sustain (Fig.1). Smith et al. (2014) reveal that during the years 2000-2010 the GHG emissions from agriculture were estimated at 5.0-5.8 giga-tonnes CO_2 equivalent per year, while land use and land-use change activities accounted for approximately 4.3 – 5.5 giga-tonnes CO_2 equivalent per year.

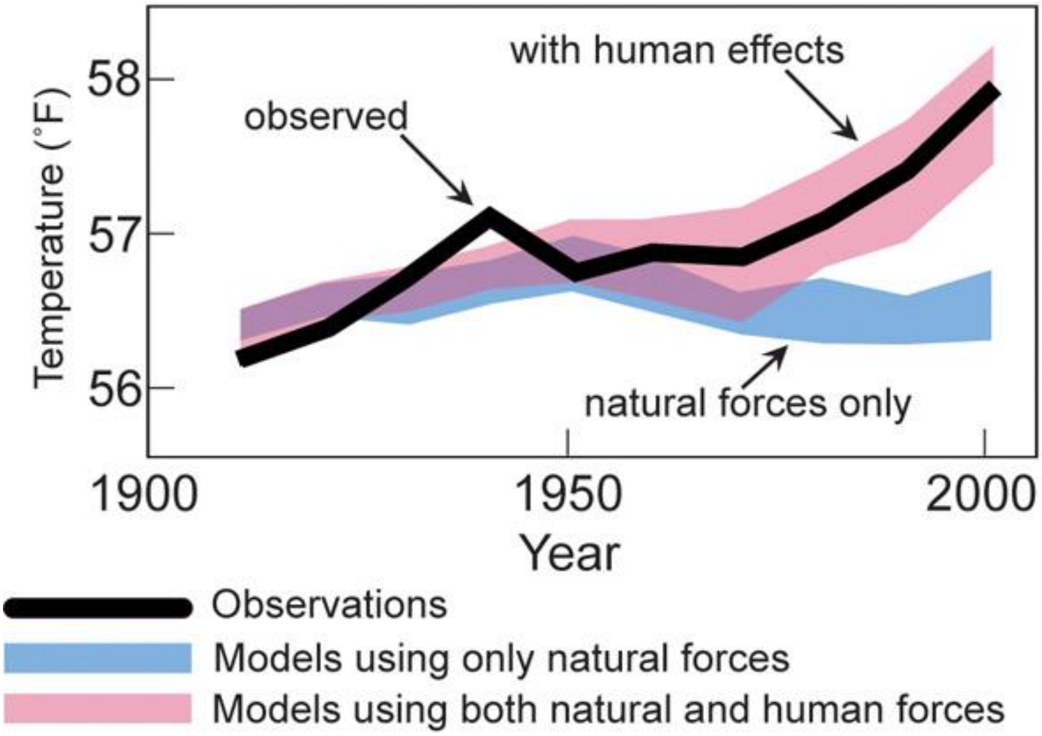

Figure 1. Temperature levels over the years considering anthropogenic activities and natural forces. Source: US Environmental Protection Agency.

Oceans are able to store heat, however they do not have an immediate response to higher GHG concentrations, resulting in warmer temperatures, rising sea levels, more frequent droughts and floods, typhoons, anomalies in climatic conditions, earthquakes, volcanic activity and other effects. As Rood (2014) explains, such extreme climatic effects will continue to have an impact on the planet for centuries and, even if CO_2 emissions were stopped immediately, the earth's temperature would rise by another 0.6^{o}C. Therefore, immediate action is crucial to give time to our ecosystems to partly recover and partly adapt to the new climate conditions. As Smith et al. (2014) suggest, mitigation methods available nowadays may not work in the future depending on the current ecosystem and its response to climate change.

It can be argued that all these extreme events are inseparable from the landscape and so the role of the landscape architecture and the landscape designer is important for the future of the planet. The current impacts of climate change all relate to the land and so would be the future challenges. GHG emissions can be mitigated by reducing waste, providing alternative more sustainable ways of living and through experiential learning. Landscape professionals play a major role in the ways in which such issues are understood, communicated, visualised and hopefully addressed. And it will not be with regard to extremes, but for a 'new normal' that the professions will be involved in mitigation. There is no other way than by putting landscape at the core of development and creating a sustainable vision for the future; but for this to be achieved the profession needs to lead the way towards a low-carbon lifestyle.

4. A low-carbon landscape

There is much discussion around the topics of low carbon, sustainability and CO_2 emissions in relation to climate change and yet their relationship to the spatial context challenges both professionals and the public. As stated above, low carbon is often treated as a gas emission indicator or a new technological approach related to climate change. But what does low carbon mean for the landscape?

During the last two decades, sustainable communities and infrastructure have begun to receive attention in the planning literature and therefore ‘plans’ are now considered either as a ‘product of the process or as a guide for promoting a sustainable community’ (Conroy and Berke, 2004). It is encouraging that such terms are starting to be linked with strategic schemes and planning, however at the moment low carbon is interpreted in relation to spatial development with a variety of different approaches. Examples such as ‘acceptable landscape locations for wind farms’ (Cowell, 2010), ‘solar energy in landscape’ (Pokorný, 2001), ‘photovoltaic systems in urban and rural environments’(Redweik et al., 2013), ‘ecological landscape’ (Makhzoumi and Pungetti, 2003) and the focus on energy, transport and fossil fuels (Harto et al., 2010) show that we are still trapped in the single sided view that the spatial interpretation of ‘low carbon’ is just about technological projects or the decision on the best possible location for renewable activities.

Figure 2. Drawing analysis developed by Nikologianni exploring the potential of a low-carbon landscape and the impact of water and green strategy in the city. The drawing was based on the Stoke Harbour garden city proposal submitted by Shelter & PRP Architects, during the Wolfson Economics Prize 2014.

Nikologianni (2017) explains that the term low carbon can be symbolic to behavioural change and a new lifestyle that promotes, environmental, cultural, social, historic and economical sustainability through exploration and understanding of the land. The landscape designer can create a vision and interpret low carbon elements in ways that engage the visitor and promote a healthy and environmental way of living (Fig.2). Therefore it can be argued there is a moral, ethical and professional responsibility for landscape professionals and any relevant discipline to embrace and promote such ideas.

5. Impact of climate change to our planet and the landscape

One way to improve the understanding of what low carbon means for the landscape is to examine how climate change impacts on it and the whole planet. Not only are the warmer temperatures, rising sea levels, extreme climatic effects, more frequent droughts and harder rainfalls going to affect the planet for centuries, but they all become concerns when designing, planning and managing. The changing air and water temperatures create more challenging heatwaves, that have an impact both on spatial design and the selection of plants and materials used. The varying precipitation and snow patterns alter water regimes as well as the ocean systems and strengthen flooding and storms that impact on the available quantity and quality of surface (Land Trust Alliance, 2017). Studying these phenomena makes it easier to understand the inseparable link between the importance of a climate resilience strategy and landscape planning. As the Land Trust Alliance (2017) explains, by learning, planning and adapting to the challenges presented by a changing climate, it is possible to protect the landscape and assist in land conservation.

The recent extreme events of hurricanes Irma, Maria and others are an example of how climate change increases the strength and impact of such phenomena, threatening the land and its inhabitants.

Some of the carbon sources whose impact on the landscape is easier to identify are fossil fuels, agricultural processing, transportation, fertiliser production, mining, industrial activity, ethanol production, cement plants, iron and steel industries, oil and gas processing, petrochemical industry, waste and electricity (NETL, 2017; CCC, 2017). Most of these processes are related to our daily life, either producing food or covering some of the extremely wide range of our 'needs', even though this might not be apparent all the time. Assisting in the mitigation of the carbon sources, or creating designs that provide a balance between the real needs and the environmental challenges is definitely related to strategic design. However, through the designs/plans and the exploitation of carbon sinks[1] in the best possible way, landscape professionals have a significant chance to play a key role in the way in which carbon affects the land. The fact that carbon sinks can be natural or man-made, allows the professions working on these issues to protect and rejuvenate the natural carbon sinks, but also to improve the conditions of man-made carbon sinks. Some of the most common natural sinks are acknowledged as oceans, plants, forests, agricultural land, grasslands, coastal ecosystems and wetlands (Reay et al., 2008; Rinkesh, 2017). Artificial carbon sinks also exist, with the most common being landfill sites (Rinkesh, 2017), however other methods such as storage of CO_2 in the oceans or underground have been tried. As challenging as it sounds to be able to improve such efforts, environmental and planning related professions can both explore possibilities of creating a better environment around landfills, but they can also have a greater involvement in the preservation of natural sinks.

[1] A carbon sink is anything that absorbs more carbon than it releases as carbon dioxide.

The already known methods of reforestation and afforestation can be very beneficial to the support of carbon sinks (Rinkesh, 2017) and being part of a holistic plan that includes open space protection, forest conservation and wetlands preservation and restoration can demonstrate the relevance of a well thought-out, and well-designed landscape and the impact this has on the environment, health and the future of this planet.

6. A role for the landscape professional

How could contemporary landscape interventions deal with a major issue, such as the air pollution and the greenhouse effect?

Landscape professionals can help reduce excess carbon emissions, based on knowledgeable and holistic consideration of the environmental issues and not just relying on enhancing the natural sources. It is relevant that plants and trees, the ocean and land can absorb CO_2 (NASA Earth Observatory, 2017), but the goal for practitioners would be to create interventions that not only reduce CO_2 emissions, but also support the natural sinks.

Figure 3. Citadel bridge, Nijmegen - Lent, designed by NEXT architects as part of the climate adaptation project, Room for the River, Netherlands. On high water the bridge floods allowing the visitor to cross using the steps, while the same time spreads awareness on the effects of climate change. Source: city of Nijmegen.

The reality is that we cannot afford to design anything without considering the environmental and climate challenges, but for these designs to be successful they need to integrate cultural, social and historic elements that will engage the visitor and create positive memories. Places need to create a bond with the user generating behavioural change. Once this strategic vision has been created, elements such as open spaces, parks, tree avenues, interaction with water, woodlands and grasslands, can be brought in to increase the absorption of the greenhouse gas emissions and 'defend the effect'. But the practitioners' real strength is not just providing this corner of green space that will have beneficial outcomes to counter any unsustainable behaviour. Our real strength is to educate, design, and spread awareness about such concepts through the daily routine and assist in the mitigation as well as adaptation of the climate challenges (Fig.3). Taking the example of innovative landscape designs as the one shown in Figure 3, practitioners can create a vision for every strategic scheme, while their design addresses the environmental challenges and promotes a different more sustainable way of living.

7. How landscape planning and management can influence environmental carbon at a large-scale

Through the exploration and evaluation of landscape schemes that deal with climate adaptation and mitigation on a regional scale, Nikologianni et al. (2017) suggest that such concepts can be addressed in a strategic level and that successful examples have begun emerging across Europe: showing that much can be learned from practice, however an in-depth understanding of project processes and strong communication is important. Innovative strategic landscape schemes that follow a sophisticated and holistic project process are able to enhance sustainability and spatial quality in landscape infrastructure. The development of a process suitable to shape the vision of the project as well as the early integration of low carbon and environmental concepts benefits its delivery. The goal for the landscape professionals could not only be the creation of an interesting and visually valuable scheme, but also to spread awareness about the landscape as much as deal with the preservation, regeneration and climate adaptation or mitigation in existing or newly-designed schemes.

Especially for large-scale developments, the significance of the political dimension of a regional scheme has emerged, opening discussions about the way we conceptualise low carbon landscape and the region (Nikologianni, 2017). The need for a supportive alternative framework undoubtedly benefits the implementation of the strategic landscape schemes and ensures integration of concepts related to sustainability, environmental design, low carbon, resilience and future proofing. The variability demonstrated between large-scale projects across Europe (Nikologianni et.al, 2016) shows that the principle of the environmental mentality at the strategic scale is feasible, and that visuals can affect the way in which a project evolves and decisions are being made. Such landscape projects have managed to develop unique ways of delivery that suit their needs, integrating policies, legislation and various processes of project development, considering the physical, natural, cultural and social characteristics of the area, with a significant impact on low-carbon management in large-scale landscape developments.

The role of the designer and planner often relies upon the influence of decision makers, and this is much more important when it comes to climate challenges at a strategic level. Smith et al. (2014) highlight that national and international development goals and priorities, policies and commitments play an important role when decisions are taken at a higher administrative level such as regional or national authorities and administration. Nikologianni (2017) also explains that policies and legislation impact on the decision making of a potential landscape development and, therefore, they need to support the early integration and early engagement of the low carbon and spatial quality ideas from the beginning of a landscape development: but, for this to happen, such concepts would need to be thoroughly integrated at the vision and project framework of each scheme. Environmental and quality ideas can be easily overlooked and what the landscape designer can do for this is to visualise what a sustainable scheme would look like, highlight the importance of such issues and the benefits of their integration in the large-scale landscape policy and design. It is argued that the challenge of spatial scale is 'to provide landscape governance that responds to societal needs as well as biophysical capacity at different spatial scales' (Smith, 2014), while considering social interactions. The undeniable global climate challenges and the significance for the development of holistic landscape-based strategies are becoming an ethical and social responsibility of our times. Low carbon has also a social and moral significance that relates to the landscape, and it needs to be seen in a different perspective than just the technocratic and technological innovations that have dominated practice in recent years. It needs to be a responsibility of anyone who is dealing with the landscape, no matter what the scale.

Dealing with environmental and sustainable design has also a multidisciplinary impact involving artistic and scientific disciplines, as well as policy, legislation and administration across the globe. The way in which landscape design is being addressed, practiced and taught needs to consider carbon management, create a sustainable vision and educate the current and next generations. It is time for practice to form theory and impact on decision and policy-making for the future.

8. Landscape Planning Local Scale – Parks

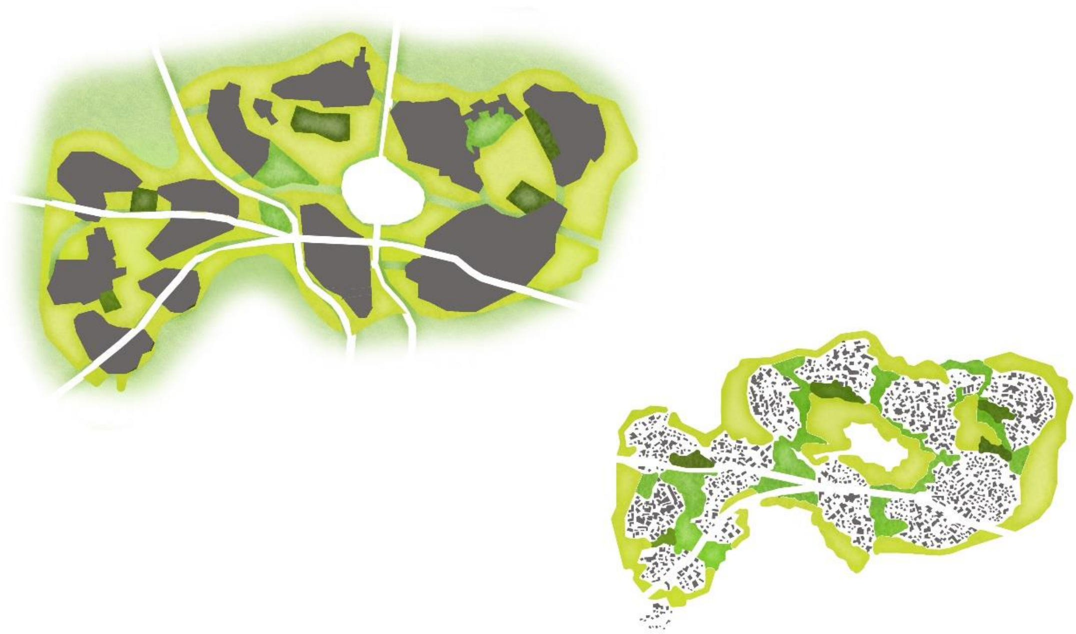

Figure 4. Drawing analysis developed by Nikologianni exploring the open spaces, parks and agricultural areas between several garden villages that form a city. The drawing analysis was based on the 'String of pearls' garden city proposal submitted by Barton Willmore, during the Wolfson Economics Prize 2014.

Influencing low carbon at a spatial scale requires a strong structure and vision, that embeds key concepts across all stages of the landscape project, from the conceptual to the implementation phase and from a strategic scheme to individual city parks and open spaces. It is necessary to recognise any space with which we work as valuable infrastructure for our communities and as important as transport projects, highways, bridges and so on. Parks, urban areas, open spaces and, social community areas are all places that can attract visitors, businesses and locals. If their designs are based on a greater urban or regional plan (Fig.4), they can be part of a major scheme boosting the economy, health and environmental resilience while improving, daily life, spreading awareness, supporting behavioural change and even engaging in climate mitigation or adaptation of the area.

Landscape design, planning and management can improve the response to a resilient environment, reintroduce the community feeling and educate about health, cultural and ecological aspects no matter the scale. But for this to happen, practitioners need to introduce such ideas through their proposals and request that they be established through policy and legislation. Function can be sustainable and beautiful, and the landscape professions are well equipped to make this happen.

9. Embodied carbon in landscape design

The landscape profession can promote itself as one of the pro-environmental disciplines, however - as happens in most activities - there is also embodied carbon in landscape design. Whilst the focus on reducing carbon emissions from the built environment is often related to the design characteristics (lighting, ventilation) materials used (sun reflection, recycled materials) and the way in which the users will interact with the space (awareness, education, maintenance), there is also carbon in various stages prior to the project's delivery, from operational, manufacture, construction and maintenance carbon.

The UK Green Building Council explains that 'embodied carbon is calculated by finding the quantity of all materials needed for the project's lifetime and multiplying this by the carbon factor (expressed in kg CO_2e per kg of material/product) for each material to produce the embodied carbon figure' (UKGBC, 2015). However there are various other sources of carbon in a landscape project and the difficulty arises from the fact that not all carbon factors consider the carbon associated with the same boundaries of life cycle. Even though the UK aligns to specific regulations for environmental management and Life Cycle Assessment (LCA) such as BS EN ISO 14040 or tools such as Breeam, BRE Green Guide and modelling tools (e.g. BIM) the task of measuring embodied carbon in a landscape project remains ill-defined.

Pocock (2007) suggests that the embodied carbon for a landscape design starts at the office carbon footprint and continues throughout the life span of a project. Some of the main stages where carbon is generated during a project process are: office carbon footprint, footprint of a design programme, design and specifications, materials selected, implementation/construction carbon, reduction of machinery (less fuels, less pollution), less machinery (less site damaged), recycling thought the process, and selection of plants in alignment with climate and maintenance (Pocock, 2007). Even though carbon generation is not easy to avoid, the landscape architect can help to minimise the carbon emissions of a project and to reduce the embodied carbon. Therefore the designer needs to constantly be aligning with the environmental goals of the scheme and asking challenging questions, such as; what is its role/use, is it all needed, what is it made of, how is it made, is there a more sustainable alternative, where do these plants/materials come from, can this design recycle itself in the future?

It is argued that transparent and comparable data are difficult to acquire, and the lack of policy drivers to measure embodied emissions is not helpful; however development of tools has begun (e.g. Impact modelling, BRE LINA) aiming to help the designers in this area (CIBSE, 2017).

10 Conclusion

The landscape profession can play a major role in decision making of large-scale schemes, by improving the understanding of environmental and life quality aspects. The visualisation of low carbon and resilient ideas that occurs through the landscape practice can improve their implementation and form policy aiming towards the integration of such concepts in legislation.

By introducing a holistic plan of low-carbon design and management there is a great potential to strengthen the processes and procedures followed, creating opportunities where the landscape idea can be embraced, providing a social, cultural and environmental identity. Through innovative projects envisioning sustainable and quality places, landscape professionals can engage higher-level political decision makers to increase their awareness of global challenges and the importance of the landscape-scale design. The prospect for this new way of thinking to influence the development of professional attitudes can also potentially impact on political views and future legislation.

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