Net Environmental Benefit in Urban Centres

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A theoretical model is proposed to assess whether activities associated with urban development create net positive environmental benefits. The rationale is that the application of *no net loss and preferably a net gain* goals for biodiversity values associated with offsetting development impacts requires a shift away from the usual regulatory pursuit of minimising harm toward requiring benefit. A catchment-based decision-making framework is used to demonstrate the process. Limitations include outcome uncertainty and deciding on baselines related to cumulative effects, and dealing with transaction costs.

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Managing ecosystem impacts from urbanisation requires avoidance, remediation or mitigation (Resource Management Act 1991, section 5(2)(c)) and, commonly, ecological compensation (Brown et al, 2013). Ecological benefits may result from these actions, though this is not required (Knight-Lenihan, 2013; 2014).

This minimising harm and making occasional gains is inadequate, evidenced by continuing ecological decline globally (eg, WWF, 2016) and locally (eg, Gluckman, 2017; PCE, 2017). This has led to an argument that all human activity, including urban development, needs to contribute to a *net ecological benefit* (Birkeland and Knight-Lenihan, 2016; Knight-Lenihan, 2015).

This paper proposes an assessment framework as a step towards operationalising the concept of net benefit. A net gain needs to be demonstrated at the place where urban development occurs (such as creating a subdivision) as well as net gains or losses across supply chains supporting urban systems. Assessments include various environmental dimensions, such as atmospheric carbon emissions, water quality and waste, as well as ecosystem functioning, leading to the adoption of the term *net environmental benefit*.

The first part of this paper describes the concept and application of net gain. The challenge of auditing is then discussed, with possible approaches suggested for further research. A catchment-based decision-making framework is proposed. The difficulty of establishing baselines against which to measure progress, and where transaction costs fall, is also discussed.

Net environmental gain assessment framework

The prospect of *net ecological benefit* evolved with the use of ecological compensation and biodiversity offsets as applied in New Zealand (Brown et al, 2013; New Zealand Government, 2014) and internationally (BBoP, 2012b; Pilgrim et al, 2013). Offsets are measurable conservation outcomes compensating for significant residual adverse biodiversity impacts occurring from development,

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after appropriate prevention and mitigation measures have been taken (Brown et al, 2013; New Zealand Government, 2014).

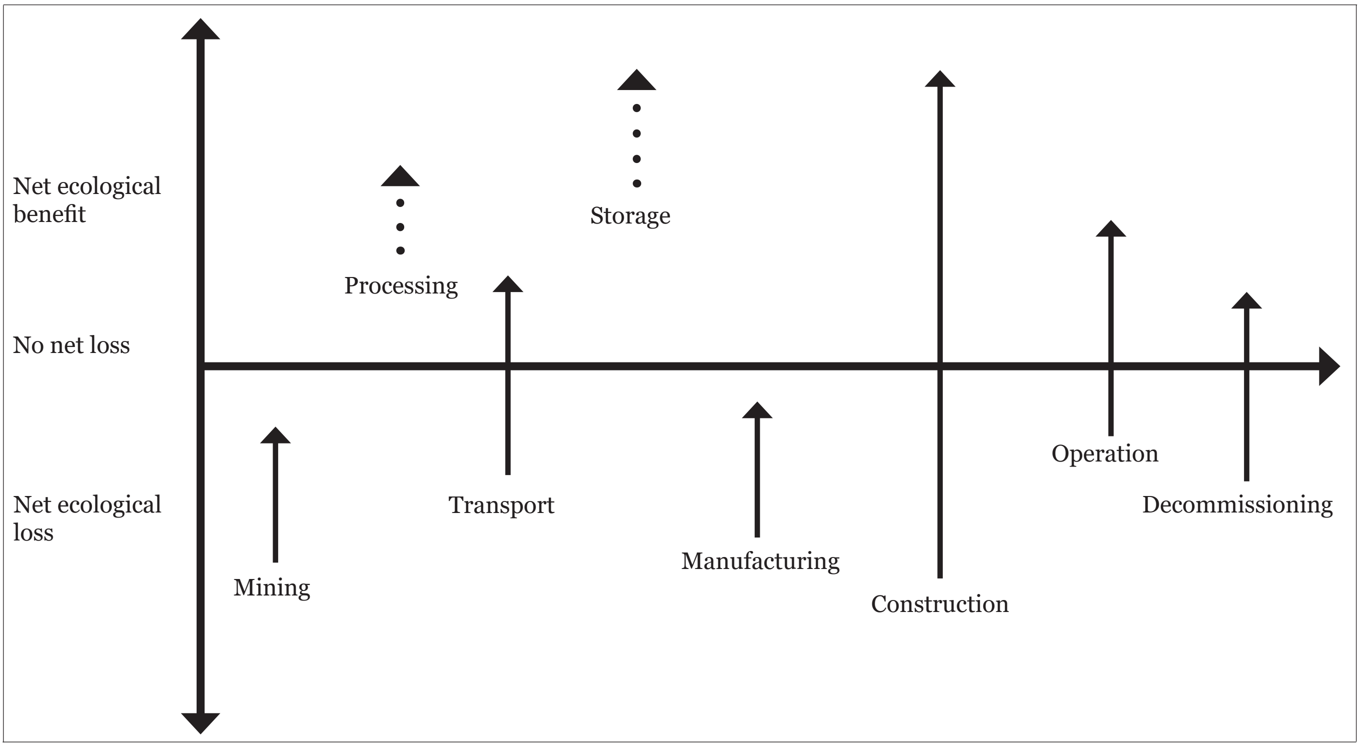
Offsets promote a *no net loss (NNL)* and *preferably a net gain* in biodiversity.[1] This, in effect, creates a preference for a net ecological benefit, given that biodiversity is a measure of, and helps define, ecosystem functionality.

Net benefit goals may help reverse cumulative ecological losses over time and space associated with economic development. The normalisation of ecological losses associated with development (Knight-Lenihan, 2015; Pitcher, 2001) – for example, freshwater degradation seen as a price paid for economic development (Gluckman, 2017) – means economies evolve on the explicit or implicit assumption of continuing ecological decline. To be sustainable, development must address cumulative losses by enhancing ecological health and integrity (sensu Park, 2000) and social and natural capital (Birkeland, 2008; Birkeland and Knight-Lenihan, 2016). This places net gain as the preferred outcome rather than one to be pursued after prevention and mitigation.

Assessing a particular system's ability to work within local biophysical limits should also include assessing the impact such systems have elsewhere. This is because the 'elsewheres' also need to work within their own biophysical limits.

The concept of NNL in biodiversity (ecosystem) values, and preferably a net gain, is used to illustrate the model (see figure 1). There is a sliding scale from negative (net ecological loss) to remedial (eg, removing pest species) to net positive (increasing ecological values by, for example, increasing the number of species, and the number of individuals in particular targeted species, in a given habitat; and/or improving habitat condition). A position below or above the line indicates the extent to which an activity is or is not achieving net benefit (NB). Solid lines indicate the potential improvement due to current planned activities. Dotted lines indicate any existing 'credit' level of an activity, proportional to the distance above the NNL axis.

Figure 1: Framework for assessing the biodiversity and ecosystem net losses and net benefits of activities associated with urban development



Applying the concept of net gain

Figure 1 represents an imaginary example of an urban brownfields (ex-industrial) site being converted to a residential subdivision. Towards the bottom of the *y*-axis is where an increasing net ecological loss occurs. Ecological loss includes the loss of biodiversity and ecosystem functioning, such as declines in soil condition or contributions to maintaining water quality. The *x*-axis, half-way up the diagram, indicates the point where no net ecological loss occurs. Above the line is where an activity has resulted in a net improvement in ecosystem values: that is, improvements that exceed impacts and that would not have happened had the activity not occurred.

The *x*-axis is also the timeline where moving left to right indicates the stage of securing and formulating the materials required to build the infrastructure and housing associated with the subdivision. These raw materials are processed, transported, stored and manufactured into products used for construction.

Impacts occur at each of these stages. Some are unavoidable and will always require compensation: for example, a quarry removes top soils, sub soils and habitat. Other impacts can be avoided, remedied or mitigated to a point where they have little or no significant effect: for example, storage systems in energy-neutral buildings using solar power.

The model can be broadened to consider various environmental impacts to be compensated for. At each stage, an independent audit would be made assessing the extent to which net environmental losses occur and what (if any) steps have been made to compensate for them. Therefore, it would be possible to create versions of figure 1 relating to various environmental dimensions, such as biodiversity and ecosystems, energy, atmospheric carbon emissions, water quality or waste. Each dimension could be assessed independently, and the dimensions would be identified by a strategic environmental assessment prioritising issues to be addressed.

The *NNL* and *net ecological benefit* terms would be modified accordingly. For carbon emissions, it would be the point where reducing emissions and/or offsetting emissions reaches and exceeds a carbon neutral point. For waste, it is the point where no waste is landfilled, and above the line is where material is repurposed for other uses. Water is more problematic, but the 'NNL' point could be where the activity no longer pollutes or abstracts water, with above the line being where actions contribute to improving water quality and/or help in recovering natural flow regimes.

Using the ecological benefit example in figure 1, the audit generates an estimate of the extent to which net ecological loss has been compensated for. The objective is to achieve NNL and preferably an NB. Aiming for NB in effect ensures at least NNL is achieved, given the high degree of uncertainty in estimating unwanted ecological impacts and compensation actions. Compensation is for cumulative losses over time and space, creating baseline and assessment challenges, as discussed below.

At some points along the *x*-axis, activities will have a net environmental benefit. For example, a mined materials processing plant might use co-generated electricity and heat from waste incineration, thereby diverting waste from landfill and reducing demand for electricity from coal-fired plants. This reduces atmospheric carbon emissions. In a separate assessment, the owners of the plant also contributed to a biodiversity offset during construction that has resulted in an ecological benefit in addition to what would have happened had the plant not existed.

Similarly, the storage facility is designed for passive lighting and heating, and uses solar power. Excess power is stored in batteries and used by the electricity supply utility to contribute to morning and evening peak demand from domestic consumers, at a time when the storage facility demand is low. This reduces the need to use a stand-by coal-fired electricity plant to meet growing peak demand, thereby contributing to avoided emissions.

In addition, when applying for its resource consent in this hypothetical example, the storage facility agreed to contribute to a biodiversity offset brokering scheme being run in the water catchment it is operating in. As with the processing plant, this is anticipated to have a benefit in addition to what would have occurred if the storage facility did not exist. The benefit can only be potential because offset success can only be confirmed over time.

Taking these actions into account, the independent auditors assess the processing and storage facilities as having existing and potential net environmental benefits in dimensions relating to carbon emission, ecosystem values and waste. Other prioritised dimensions would be similarly assessed. Therefore, for some environmental dimensions, credits would be generated (indicated by the dotted lines) proportional to the estimated NB. An NB is represented by the distance each facility is above the NNL line, in terms of biodiversity values, or a similar neutral line for each of the other dimensions.

The distance above or below the line is expressed proportionally. For example, an assessment could rate an activity as having achieved 20 per cent of the required action for emissions neutrality and 50 per cent towards the ecological compensation goal. Thus, while mining may have a far greater real environmental impact across various dimensions than say construction, both can be compared in terms of the distance they are from their own neutral and NB goals.

Incentives for achieving an NB would be from generating credits that could be used to earn developer rights elsewhere, or for trading. This, of course, relies on there being markets, which may exist for carbon emissions (see, for example, the New Zealand Emissions Trading Scheme)[2] and nutrient management for reducing impacts on waterways (Duhon et al, 2015), but are problematic for biodiversity and ecosystem values. This is discussed further below.

As noted, the solid lines in figure 1 indicate the potential benefit of current and planned actions by each of the components in a net ecological loss situation. Some may not achieve NB or even NNL, due to financial and technical limitations.

It is important to note that the assessment of progress combines quantitative and qualitative measures. This is because the complexity of achieving environmental 'progress' requires professional opinion as well as measurement.

In summary, the idea is that activities along a supply chain can be rated according to:

- whether they are audited
- the extent to which the auditing can be verified as independent and effective

- the results of the audit in terms of percentage progress towards, or the degree to which it exceeds, NNL or the equivalent, and whether this can be estimated
- the clarity of the methodology used and its reliability.

This includes the extent to which the urban development project itself is addressing on-site cumulative ecological impacts.

The focus (at least initially) would be on large-scale projects and large-scale suppliers. In some circumstances, it may not be useful to estimate percentage achievements due to technical issues associated with evolving methodologies. Instead, it may only be possible to note whether and how an activity is addressing an identified issue. The caveat of methodological limits would have to be attached to the estimate.

Given jurisdictional limits, it is not always possible to directly influence suppliers. However, ratings will contribute to behaviour change. This is partly because suppliers already reducing their ecological impacts, or creating positive benefits, gain profile and possibly market share from promoting this fact. Those currently not doing so may be motivated to start. Those further up the supply chain can then refer to components of their product or service as contributing to ecological value, in addition to any action they may be taking.

It is tempting to allow those up the supply chain to incorporate credits from suppliers to offset their own impacts. This would not be advisable, however, given the likely scope for manipulating data and avoiding taking action locally. Equally, making users liable for supplier ecological debts would be an administrative burden that would outweigh any benefit in terms of encouraging behaviour change.

All of this rests ultimately on consumers and regulators responding to evidence of environmental impacts. That is, consumers in their desire to favour developers demonstrating both supply chain and local net environmental benefit efforts, and regulators in terms of putting in systems rewarding such action. Underpinning this is having confidence in the auditing process and a decision-making framework. These ideas are explored in the following sections.

Auditing

Auditing the movement toward or away from NNL or its equivalent is the biggest challenge of this proposal. Research in this area is incomplete. Existing assessment systems do exist, however, that in part address this need. Three are looked at below:

- ecological footprints
- built environment material and resource flow assessments
- expanded product verification systems.

None of the above has been subjected to rigorous analysis for this paper. The objective is to outline three mechanisms that could be developed for an auditing process.

Ecological footprints

The premise behind ecological footprinting is calculating the biophysical carrying capacity required to support a given human population. It accounts for the ability to use international trade to "relieve local ecological constraints" (Rees and Wackernagel, 1994, p 363), addressing a need to calculate impacts on distant ecosystems to complement estimates of local impacts. It includes resource consumption and waste production and has evolved into a tool claiming to measure the natural environment's capacity to support human activity.[3]

This is a rather narrower goal than that discussed for this paper. That is, essentially, it draws attention to the value of ecosystem services for human welfare (Shackleton et al, 2017), which, while potentially allowing for the broadening out of natural capital measures (see, for example, Guerry et al, 2015), is not the same as measuring total ecological health and integrity. It does, however, set up a database that can be both contributed to and interrogated independently,[4] a valuable attribute for auditing.

Also contributing to the evolution of ecological footprints is restoration ecology, which may broaden the scope of what is included when valuing ecosystem services, and, hence, payment for those services (Bullock et al, 2011). For example, the contribution of New Zealand urban ecosystems to biodiversity goals (Clarkson and Kirby, 2016) extends observations that incorporating 'working environments' (that is, economically developed landscapes not in the conservation estate) is vital to achieving net improvements in biodiversity values (Green and Clarkson, 2006). This requires measuring progress towards protecting and enhancing indigenous biodiversity, which could be included in an ecosystem footprint account.

Built environment material and resource flow assessments

Initiatives such as the Leadership in Energy and Environmental Design credit system demonstrate it is technically possible to assess on- and off-site impacts of (and associated compensation by) buildings and precincts or city blocks.[5] Compliance can be regulated for, or incentivised by, preferential investment in rated buildings and policy evolved to (for example) reduce the environmental impact of buildings (Nejat et al, 2015). Commercial and residential neighbourhoods can also be assessed.

Models are also being developed to calculate and characterise present and future energy use, carbon emissions and associated costs for the built environment, including transport (Webster et al, 2011). Such modelling could form the basis for the energy component of the auditing required to calculate existing and future impacts of the built environment.

However, code compliance aims to mitigate impacts (Nejat et al, 2015) rather than result in an NB (Birkeland, 2014, Birkeland and Knight-Lenihan, 2016). Alternative code requirements would be needed to create buildings that, for example, absorb more carbon than they emit over their lifetime through integrating vegetation and micro-ecosystems, renewable energy and passive solar design (Renger et al, 2015). Such 'green scaffolding' also supports functions such as heating, cooling, on-site water treatment, food production and ecosystem functioning (Birkeland, 2014).

Attaching these initiatives to such things as attempts to increase urban biodiversity (Ignatieva et al, 2011) and ecosystem functioning (Clarkson and Kirby, 2016) would generate credits according to the extent to which a development (in this case, a building) contributed to ecological restoration and carbon sequestration and storage goals.

Product verification systems

Another issue is the need to verify the assessment of progress against the priority impacts. Results would answer the following.

- Is it clear what the priorities are? Has there been an assessment against broader national, regional and local medium- to long-term goals? Gaps in such a process need to be noted.
- How has progress towards goals been measured and reported? Any independent audit would need to generate an estimate of the reliability of the data, as well as establishing what progress has been made towards individual goals.

The technical challenges are significant, particularly when considering how to generate ‘credits’. Using the example of biodiversity offsets, issues occur over how to assess the condition of a particular habitat, whether and how to compare different types of habitat and/or species for offsetting and whether there can be a valid acceptable ‘currency’ for doing so, challenges over how to measure additionality (that is, whether there is an additional benefit over what would have occurred anyway), the difference between applying an offsetting process and the time it takes to prove it worked, and the overall ethics of trading in biodiversity and estimating the risk of poor outcomes.[6]

Another issue is transaction costs. Requirements to comply with auditing of impacts will add costs at each stage, resulting in resistance from those in the supply chain. However, this problem already exists for any region or country attempting to address environmental externalities. It is accepted that, in some situations, the legal and regulatory systems will not be adequate to ensure externalities are accounted for, while in contrast some companies may well respond to consumer pressure to improve the environmental management despite the regulatory regime.

An additional cost comes from capturing information for those further up the chain. So, for an urban subdivision, a developer addressing the two bullet points above will need collated data from suppliers. This would add a transaction cost for the developer and suppliers. The drivers would be consumer pressure to demonstrate knowledge about the environmental status of suppliers, and any regulatory requirement to do so.

As a result, taxpayers or ratepayers should meet a share of the costs. This is because developers and suppliers make investment decisions within an economic system that not only allows for but incentivises ecological capital cross-subsidising. All of society benefits from this drawing down of natural capital, and all of society should be equally responsible for repaying the debt.

Of course, other ways exist of pursuing positive outcomes, community support for ecological restoration being an obvious one (Clarkson and Kirby, 2016).

The point of this paper, however, is to address a need to generate net gains in environmental values by helping to embed changes in the economic system and go beyond relying on voluntary action.

The product verification system could be similar in structure to the auditing done by organisations such as Trade Aid. For example, all components of coffee sold under the Trade Aid banner have to be individually audited and confirmed at source.[7] This then generates a compliance assessment.

The overall objective is to estimate the extent to which urban activities are achieving net environmental gains locally and to which goods (such as raw materials) and services (such as energy generation) in the supply chain are achieving their own goals. This would be incorporated into a rating for parts of the built environment. The following section shows how this might evolve within the New Zealand planning system.

Decision-making framework

For each criterion at each stage of the lifecycle analysis, it is necessary to have a goal-setting process. This will of course vary, depending on in which country and region the lifecycle stage occurs. For the urban development stage, the 2014 New Zealand National Policy Statement for Freshwater Management (NPS-FM) shows how this process might work.

The NPS-FM sets objectives and limits for freshwater quality and quantity standards to be achieved by managing land use at a catchment level through freshwater management units. The NPS-FM sets environmental bottom lines that regional councils and unitary authorities must comply with but have the discretion to go beyond. This is where the potential for both net positive ecological benefits and broader environmental benefits arises.

New Zealand has examples where biophysical improvements can be achieved by setting limits on such things as total anthropogenic nitrogen catchment loads or water allocation within a catchment, and allowing permit holders to trade within the cap (see, for example, Duhon et al, 2015). The overall cap is then reduced (or, if it were applied to biodiversity, increased) to help achieve collective goals. This establishes a condition for achieving net ecological benefit.

Hence, the country does have a catchment-based freshwater unit capable of including NB goals, if desired. Three questions then arise. What is an acceptable level of net benefit; what is the baseline; and can this relate more broadly to issues beyond water quality? The third question has been answered. Initiatives generating co-benefits relating to water quality, flood control, biodiversity, sediment control and atmospheric carbon sequestration already exist (Clarkson and Kirby, 2016; Ignatieva et al, 2011). The former two questions are addressed by looking at the example of managing Auckland's coastal wetlands.

Globally, coastal wetlands are known to reduce the risk of climate change (CC) through carbon sequestration and storage (CS&S) (which reduces the probability of CC happening), as well as providing coastal protection (which reduces the scale of CC impacts).[8] A lot of uncertainty exists around, in particular, CS&S estimates. However, by using climate zone delineation, species and habitat comparability, and making conservative estimates of the past and current extent of Auckland's coastal wetlands, inferences can be drawn (Khodabakhshi, 2017).

Using a social cost of carbon[9] estimate of US$220 per tonne (around NZ$300) (Moore and Diaz, 2015), Khodabakhshi (2017) concludes CS&S services of mangrove forests and saltmarshes in the Auckland region are worth about US$9.6 million (around NZ$13.2 million) per year. Equally, recent losses in the aerial extent of Auckland wetlands are worth about US$4.4 million (around NZ$6.0 million) per year. Consequently, per hectare CS&S benefits associated with individual parts of the Auckland coastline could be calculated. Notably, this would not include any co-benefits of adaptation, such as to coastal and marine biodiversity or water quality; these values could be assessed separately.

The benefits of wetlands for coastal protection are highly site specific. Wetland restoration may require removing coastal development, with associated direct costs, or, alternatively, rule out certain development, with associated opportunity costs. The value of protection will depend on the value of existing infrastructure.

If a development in a particular catchment could demonstrate benefits to coastal wetland protection or enhancement through either avoided reclamation or direct protection, this could contribute to compensating for emission impacts of the development. CS&S benefits could be calculated relative to the whole of the Auckland coastline, while protection (adaptation) benefits would be linked to the specific infrastructure being protected.

These actions could be done within the freshwater management units generated as part of the NPS-FM. The legal impetus comes from councils needing to give effect to an NPS (Resource Management Act 1991, section 55(2)), which includes having regard to the connection between freshwater bodies and coastal water (NPS-FM, Policy A1(iii)). Coastal wetland protection and enhancement help address this connection while generating co-benefit improvements in CC security.

Baselines

The example above raises an important point about baselines. For emissions, exceeding the 'carbon neutral' point earns credits that can either be used by the developer elsewhere or sold to another developer. Contributing to adaptation capability does not require passing through a neutral point, because all additions are beneficial. In this case, all developer contributions are positive and earn credits.

Estimating ecological baselines (in this case as a co-benefit) is far more problematic given arguments over how far back to go to reach an 'un-impacted' level. This may be unnecessary for coastal wetland protection and rehabilitation, however, given the benefits accrue immediately and the debate is not over returning the coast to what it was originally but, instead, creating new ecosystems that have climate, biodiversity and recreational values. What remains is the difficulty in estimating the scale of improvements and deciding what is fair and reasonable. These issues are not resolved here.

However, while technical difficulties are substantial, ultimately, the objective is to clearly connect urban development to prioritised catchment-level ecosystem protection and rehabilitation projects. If this is not done, net ecological decline will continue.

Conclusion

A net environmental benefit concept has been developed in this paper. A lifecycle analysis approach has been taken, arguing that assessments of every stage of the securing and formulating of materials, and provision of energy, should be audited against various prioritised environmental issues. Estimates of progress would translate to proportions: so a mining company might be assessed as offsetting its ecological impacts by 50 per cent while offsetting its atmospheric carbon emissions by 20 per cent. The objective is to ensure all activities associated with development generate a net environmental benefit.

A decision-making framework based on the National Policy Statement provisions of the Resource Management Act 1991 demonstrates how the process might be implemented. Baselines are a major challenge. That is, what determines a point of no net loss (NNL) for such things as biodiversity or ecosystem values? This was not resolved in the paper. It was proposed that creating a credit trading system might help incentivise developers to keep adding benefits beyond the point of NNL, that is, beyond a baseline.

Transaction costs already occur at each stage of the supply chain, depending on the regulatory environment in place. Additional transaction costs occur in collating and providing information to those further up the supply chain. Given the socialised benefits, consideration will have to be given to taxpayer or ratepayer payment for some or all of the transaction costs. What is fair and reasonable will be set locally, resulting from negotiations between communities and regulatory authorities.

Two further aspects of pursuing net environmental benefit arise: is there a process in place to measure it? And could it work?

The first aspect requires an independent auditing system to be established, and one acceptable both within the region and country where the activity occurs and to those receiving the goods and services. The second aspect asks whether and how it is possible to assess if it works. A fundamental challenge with environmental compensation is being able to wait long enough to see whether what is established in fact delivers.

Neither challenge has been resolved in this theoretical paper. However, these challenges are not new. Difficulties in audit reliability have always existed, and outcomes related to biophysical phenomena are by definition uncertain. Equally, these challenges are already being addressed. The added dimension argued in this paper is to apply process improvements to the goal of requiring development activity to demonstrate net environmental benefits. While the example provided is urban, the principle applies to any development initiative.

There is also a question of the complexity of process. If a process is too complex, it will not be implemented. The proposal here is to compartmentalise parts of the life cycle so different regions and countries may pursue net benefit at their own pace. It will be consumer pressure that generates work towards resolving the technical and management issues, and incentivises progress toward achieving net environmental benefits.

NOTES

1 Based on the Business and Biodiversity Offsets Programme definition (BBoP, 2012a; 2012b and http://bbop.forest-trends.org; accessed October 2016).

2 See www.mfe.govt.nz/climate-change/reducing-greenhouse-gas-emissions/new-zealand-emissions-trading-scheme; accessed June 2017.

3 See, for example, the Global Footprint Network www.footprintnetwork.org/our-work/ecological-footprint; accessed November 2016.

4 See http://data.footprintnetwork.org/#; accessed May 2017.

5 See www.usgbc.org/credits; accessed November 2016.

6 See, for example, BBoP, 2012a; 2012b; Birkeland and Knight-Lenihan 2016; Curran et al, 2014; Gardner et al, 2013; Knight-Lenihan, 2013; 2014; May et al, 2017; Overton et al, 2013; Pilgrim et al, 2013; Quétier and Lavorel, 2011; Walker et al, 2009.

7 See www.tradeaid.org.nz/our-story/made-fair; accessed November 2016.

8 Material in this section is summarised from a submitted doctoral thesis (Khodabakhshi, 2017).

9 The social cost of carbon is the estimated price of the economic or social costs or damages caused by each additional tonne of carbon dioxide emitted and has been commonly used to assess the benefits of CC mitigation policies (Nordhaus, 2014).

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