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Informing investments in land degradation neutrality efforts: A triage approach to decision making

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ABSTRACT

Sustainable Development Goal (SDG) target 15.3 commits countries to strive towards land degradation neutrality (LDN) by 2030. LDN requires reductions in land quality to be balanced by efforts to restore or rehabilitate degraded areas. However, decisions need to be made as to where to invest given limited budgets and the impossibility of targeting all degraded land. Any prioritisation process is likely to be controversial and needs to be underpinned by transparent, justifiable, repeatable decision processes. In this paper, we develop a triage approach for LDN, drawing on experiences from biodiversity conservation. In conservation, triage refers to prioritisation where for a given budget, threatened species, habitats or ecosystems receive management if they contribute more to the achievement of particular objectives (e.g. maintaining ecosystem function, ensuring the survival of a species) and the management actions are more likely to be successful. Conservation triage has proved both effective in allocating scarce resources, and controversial, as it requires acceptance that it is not possible to save everything. We present a decision framework 'the Decision Dahlia' that transposes triage principles to the LDN decision context, recognising that not all land can be improved. First, we consider countries' reporting needs on SDG 15.3 and set out a decision process to support progress towards three biophysical global indicators agreed by the United Nations. Second, we take a more people-centred approach, recognising the imperative for social justice and good governance, matching LDN investment decisions more closely with societal needs in an integrated social-ecological systems approach. We then reflect on the remaining risks, such as the potential for vulnerable areas to miss out on investments due to the scale of decision making and challenges of leakage. While we acknowledge the controversial nature of the approach, we argue that a decision framework grounded in triage principles, offers a transparent, justifiable and repeatable process for deciding where to invest in efforts to achieve LDN. This can lower financial costs and help to reduce risks so that 'striving towards LDN' does not exacerbate existing drivers of land loss and worsen poverty.

1. Introduction

Tackling land degradation is an urgent challenge affecting both human development and the environment. The problem is extensive, covering an estimated 23% of the Earth's terrestrial area (Stavi and Lal, 2015), affecting billions of people globally, particularly the poor (UNDP-UNCCD, 2011). Land degradation also comes at considerable economic cost (ELD Initiative, 2015). The Sustainable Development Goals (SDGs) set out a new approach to tackling land degradation, building on proposals tabled at the United Nations' Rio + 20 meeting that recognised the need to move towards 'no net land degradation' (Grainger, 2015). For the first time, the world has a land degradation management target to work towards by 2030, enshrined in SDG target 15.3: "to combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world" (UNGA, 2015). While inclusion of land degradation neutrality (LDN) in SDG 15 ('life on land') represents notable progress in recognising the global severity of the degradation issue, routes to its attainment remain poorly developed. It is vital that the concept receives further clarification, both to avoid its misinterpretation, as has occurred in relation to the term desertification (Juntti and Wilson, 2005), and to reduce the environmental, social and economic risks associated with LDN investments. In some circumstances, restoration of degraded land might prove either impossible or extremely costly, particularly under climate change (Akhtar-Schuster et al., 2017), so rehabilitation may be more appropriate. A process is required through which LDN investment decisions can be achieved in a transparent, justifiable and repeatable way,

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informing both restoration and rehabilitation.

The United Nations Convention to Combat Desertification (UNCCD) defines LDN as "a state whereby the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security remain stable or increase within specified temporal and spatial scales and ecosystems" (UNCCD, 2016: 8). Achieving LDN therefore requires any reduction in land quality to be balanced by efforts to restore or rehabilitate already degraded areas (Barkemeyer et al., 2015). Countries can choose to participate in the UNCCD's voluntary target setting programme, elaborating national LDN targets. These can be complemented with sub-national targets that might not necessarily achieve neutrality but which can contribute towards avoiding, reducing and reversing land degradation. For countries to be able to set and work towards their targets requires clarity on the scientific basis and requirements for LDN.

The UNCCD's Science Policy Interface (SPI) developed a conceptual framework to inform the pursuit of LDN across all land types (Orr et al., 2017; Cowie et al., 2018). The framework presents the response hierarchy: avoid > reduce > reverse, recognising that the further through the hierarchy, in general, the more expensive it is to act (ELD Initiative, 2015). It highlights the need to consider food security and human wellbeing outcomes, and notes the importance of managing LDN at the landscape scale, balancing losses with gains within the same land type (Orr et al., 2017; Cowie et al., 2018). Although emphasis is placed on the global biophysical indicator set agreed by the UN to monitor progress (which incorporates land cover (land cover change), land productivity (Net Primary Production; NPP) and carbon stocks (soil organic carbon; SOC), it encourages use of complementary indicators, as relevant to specific country contexts.

While the LDN framework can inform development of approaches that enable progress towards LDN, countries and other stakeholders involved in tackling land degradation face persistent challenges associated with limited financing (Bauer and Stringer, 2009; Akhtar-Schuster et al., 2011). LDN is not yet supported by the necessary resources for substantial progress to be made. FAO and Global Mechanism of the UNCCD (2015) report that up to 90% of annual investments targeting land degradation issues come from public funding sources, and underscore that it is far from sufficient. Although a new LDN Fund has been launched that pools resources from public and private investors in an attempt to garner additional resources and engage private sector capital (Mirova, 2017), the challenge remains. This means that tough decisions need to be made regarding which areas of land should be prioritised for investment. Such prioritisation processes are not well developed within the land sector. However, there are opportunities to look more widely to other arenas to identify processes through which prioritisation takes place in the context of limited resources.

In this paper we present a decision tool that complements the LDN framework and helps to support LDN decision making so those responsible for delivering on SDG 15.3 can make more informed investment decisions. We explore the utility of ideas around the concept of 'triage' to help decision makers prioritise which areas receive investment. Triage has been associated with battlefield medicine since the 1800s, at which time important decisions had to be made regarding which of the injured soldiers should receive treatment given limited resources (Nakao et al., 2017). It has since been adapted and applied in conservation science and restoration ecology. Despite its controversies (outlined in later sections), we argue that lessons from triage approaches can be useful in informing a transparent, justifiable and repeatable approach towards LDN investment decision making, in the context of limited resources. We first examine the application of triage in the context of conservation decision-making. Next, we present a decision support tool that builds from experiences of triage in conservation science and guides achievement of different objectives for both environment and society in line with local stakeholders' objectives. We discuss important outstanding issues in the LDN decision context and highlight the need for the real world testing of our tool, in settings with various degrees of complexity.

2. Triage and its application in conservation

Decision makers charged with delivering biodiversity conservation commonly encounter resourcing dilemmas (Bottrill et al., 2008; Margules and Pressey, 2000). Given limited budgets, those tasked with managing biodiversity have to make decisions on what to save, how and when. Despite the desire to make significant advances towards SDG targets under goal 15 'life on land' and goal 14 'life below water', and save all species from extinction, there is not enough money to do so. For instance, the cost of reducing the extinction risk of all globally threatened bird species alone is estimated at up to US$1.23 billion a year for the next decade, yet only 12% of this amount is funded (McCarthy et al., 2012). Despite some successes, populations continue to go extinct, and large tracts of habitat are lost or declining in condition (Millennium Ecosystem Assessment, 2005; Butchart et al., 2010). Without a formal decision making and prioritisation process, limited budgets are unlikely to be spent efficiently, not least because decision makers can have little idea of the opportunity costs associated with their choices, potentially resulting in greater levels of habitat and species loss. Limited understanding of opportunity costs can lead to decisions based largely on subjective grounds, with the inevitable consequence of expensive failures (Manning et al., 2006; Hobbs, 2007). In an attempt to address this problem, a prioritisation decision making process, conservation triage, has been developed. In conservation, 'triage' refers to the process of allocating scarce resources to maximise the effectiveness of conservation actions by explicitly considering the costs, benefits and chances of success of different investment options (Bottrill et al., 2008).

Triage, as a process of prioritisation, developed rapidly into (systematic) conservation planning: "a discipline focused on providing decision support around the allocation of resources for biodiversity conservation" (McIntosh et al., 2017; 677). Underpinned by ecological principles, such as complementarity, representativeness, persistence and connectivity, systematic conservation planning is considered one of the most rigorous approaches in making decisions regarding the location and implementation of conservation actions. It has been applied globally (McIntosh et al., 2017). Well known examples of its implementation (rather than its advancement as an academic discipline) include the expansion of the Great Barrier Reef network of protected areas (Day, 2016). Here the identification of specific quantifiable objectives during the planning process is credited with having provided sufficient structure for political and social discussions to be held regarding the future of conservation in the Marine Park (Day, 2016). Further examples applying the approach include protected area designations in South Africa (Knight et al., 2006), Malaysia (Jumin et al., 2017) and planning strategies of large NGOs (Kareiva et al., 2014). When decision makers are made aware of costs (including opportunity costs) of investments in particular actions, this can lead to greater returns (Naidoo et al., 2006). For example, in New Zealand a prioritisation process based on triage and considering costs, benefits and probabilities of success and costs, meant that for a given budget, more species could be managed compared to processes based on threat status alone (Joseph et al., 2009). The importance of incidental benefits, such as improved social, human and financial capitals, or changed expectations among stakeholders regarding the need for conservation action as a result of going through the process of systematic decision making, has also been recognised (Pressey and Bottrill, 2009; Bottrill et al., 2012; McIntosh et al., 2017).

2.1. Conservation triage concerns and complexities

"There are no hopeless cases, only people without hope and expensive ones" (Soule, 1987; p. 181).

Not all conservationists view triage approaches positively (Marris, 2007). It remains controversial, as it requires acceptance that it is unviable to save all species in all places. This potentially undermines one of the key tenets of conservation itself, whereby all species (and by extension, their habitats) have the fundamental right to exist and it is a human moral imperative to conserve them (Soule, 1987). Some argue that as a triage approach justifies or allows declines and extinctions to continue, a danger is that losses that are rationalised through triage processes after careful consideration by conservationists, open a door to extinctions being normalised for other reasons, such as profit or resource extraction (Jachowski and Kesler, 2009). Allowing species or habitats to be lost when resources are scarce could lead to wholesale abandonment of conservation in certain regions. For instance when considering large spatial scales, an overall net conservation gain could be achieved by spending resources only in particular areas, leaving others without investment (e.g. Kark et al., 2009, Moilanen and Arponen, 2011). Further, one of the central tenets of triage is the concept of limited resources, but marketing campaigns regularly raise the amount of money available for biodiversity conservation (Veríssimo et al., 2017). Large conservation NGOs also recognise that increasing their income through pursuing philanthropic donations to support their programmes is critical, even though seeking these donations can constrain and determine what activities are undertaken (e.g. Larson et al., 2016; Fovargue et al., 2018). Support for triage processes might also be lower among stakeholders who are less concerned with scientific and decision making processes, and more focussed on local or group-specific priorities (e.g. Wheeler et al., 2016). Nevertheless, triage, as a basis for decision making in conservation, can draw out the values of different stakeholders, and help examine spatial and temporal dynamics, scale issues and trade-offs.

There many ways to prioritise, for example, focusing on those species contributing most to ecosystem function, those most likely to persist, phylogenetic distinctiveness, specific ecosystem service provision (Favretto et al., 2016; Willemen et al., 2017), disturbed site remediation (Raymond and Snape, 2017) or landscape restoration (Hobbs and Kristjanson, 2003). Indeed, there is no universal agreement on the 'value' of species, functional diversity, phylogenetic distinctiveness, ecosystem function or service, or any of the other metrics that can be prioritised through a triage process (Vucetich et al., 2017). This suggests that a triage process focussing on more than one metric will likely have greater validity.

The recovery of species, or the restoration of habitats, is complicated by spatial and temporal dynamics. Identifying appropriate conservation actions requires an acknowledgement of historical contexts and the spatial dependencies that exist within landscapes (Rappaport et al., 2015). Temporal issues are further exacerbated by climate change and likely species range shifts as the world warms (e.g. Johnson et al., 2015) which necessarily alter long-term implications of what to conserve and where. The scale at which prioritisation processes are undertaken is particularly influential in determining which habitats or landscapes receive management interventions. Carrying out assessments at larger scales by coordinating across a biogeographical region covering many different countries (e.g. Kark et al., 2009) usually results in a larger overall conservation gain. However, habitats or landscapes that are prioritised for protection in some countries at some scales might be left unprotected if decisions are taken at larger scales. Conservation decision making and prioritization is carried out against a complex background of multiple environmental and social objectives. Trade-offs and associated ethical dilemmas are, therefore, almost inevitable (e.g. Howe et al., 2014; Jax et al., 2013; Wilson and Law, 2016), and vary according to the stakeholder groups involved, their values and perspectives. Conservation prioritisation processes have increasingly acknowledged the complexity of decision-making and spatial planning. Elements such as the attitudes and the propensity of land managers to engage in a given scheme (Knight et al., 2011), uncertain financial costs (Carwardine et al., 2010) or the views of local communities and context specific political acceptability of protected area networks (Bicknell et al., 2017) can therefore be taken into account. One issue that has been poorly dealt with thus far in conservation triage is equity (Law et al., 2018), but addressing it effectively is acknowledged to be particularly important (as well as a moral imperative) if conservation goals are to be delivered (Ward et al., 2018). Broader challenges include the difficulty of estimating the costs of conservation actions, the resource and data intensiveness of following a rigorous decision and monitoring process and the time interval that can exist between carrying out a prioritisation process and its successful implementation (Pressey and Bottrill, 2009).

Conservation triage has formed the basis of a decision-making process that can be used to prioritize the allocation of scarce resources in a constructive, transparent, rational and repeatable fashion. This has enabled decision makers to understand and further investigate the inevitable trade-offs which result from taking particular courses of action (Bottrill et al., 2008), or highlight the current funding short-falls associated with biodiversity conservation (McCarthy et al., 2008). Though not without controversy and with challenges that still need to be addressed, conservation triage can be applied at any spatial, temporal or operational scale and is grounded in traditional rational economic approaches and decision theory. These approaches recognise the requirement to incorporate the realities of limited budgets when deciding among actions or interventions that are intended to maximise some kind of societal gain (Johnson et al., 2015). The next section examines the possibility of applying triage principles in decision processes regarding investments in actions supporting LDN.

3. Triage principles and LDN

Although we might assume that land is more fungible than species, applying triage to LDN is not straightforward. Many challenges, such as values, dynamics, scales and trade-offs, that have faced conservation planning and decision making will resonate if a parallel process is applied to LDN. As land degradation is often concentrated in drylands, directly affects people's livelihoods, and frequently co-occurs with poverty and marginalization (Stringer et al., 2017), triage based solely on the state of the land could exacerbate poverty and marginalization with issues surrounding equity, trade-offs and value systems becoming even more contentious. Applying triage in an LDN context requires careful evaluation of experiences and lessons learned from its application in the conservation arena, as well as additional considerations that extend beyond achievement of the three global indicators required by the international community in LDN reporting.

Fig. 1 shows two sets of decision processes presented in the form of a 'Decision Dahlia'. The inner circle of steps outlines a process to follow if the focus is purely on achieving environmental aspects of LDN, as reflected in the global indicators and SDG target 15.3. The outer circle tackles socio-economic elements, bringing in a dimension that is paramount if LDN is to be achieved in such a way that does not adversely affect human wellbeing or exacerbate poverty. Several authors have written about the links between land and people, and the importance of treating humans as part of nature/the environment rather than external to it (e.g. Torday and Miller, 2015). It is not useful to view people as drivers of change that operate outside of the environment if we want to create interventions that can better manage real world dynamics and complexity (Raymond et al., 2013). This provides a strong justification for the two circles.

Before embarking on any decision process, it is assumed that the decision maker is aware of their budget, the time frame over which it is to be spent, and the time frame over which monitoring, evaluation and reporting are to be undertaken. In general the process is intended for situations in which decision makers need to decide between a range of possible investments.

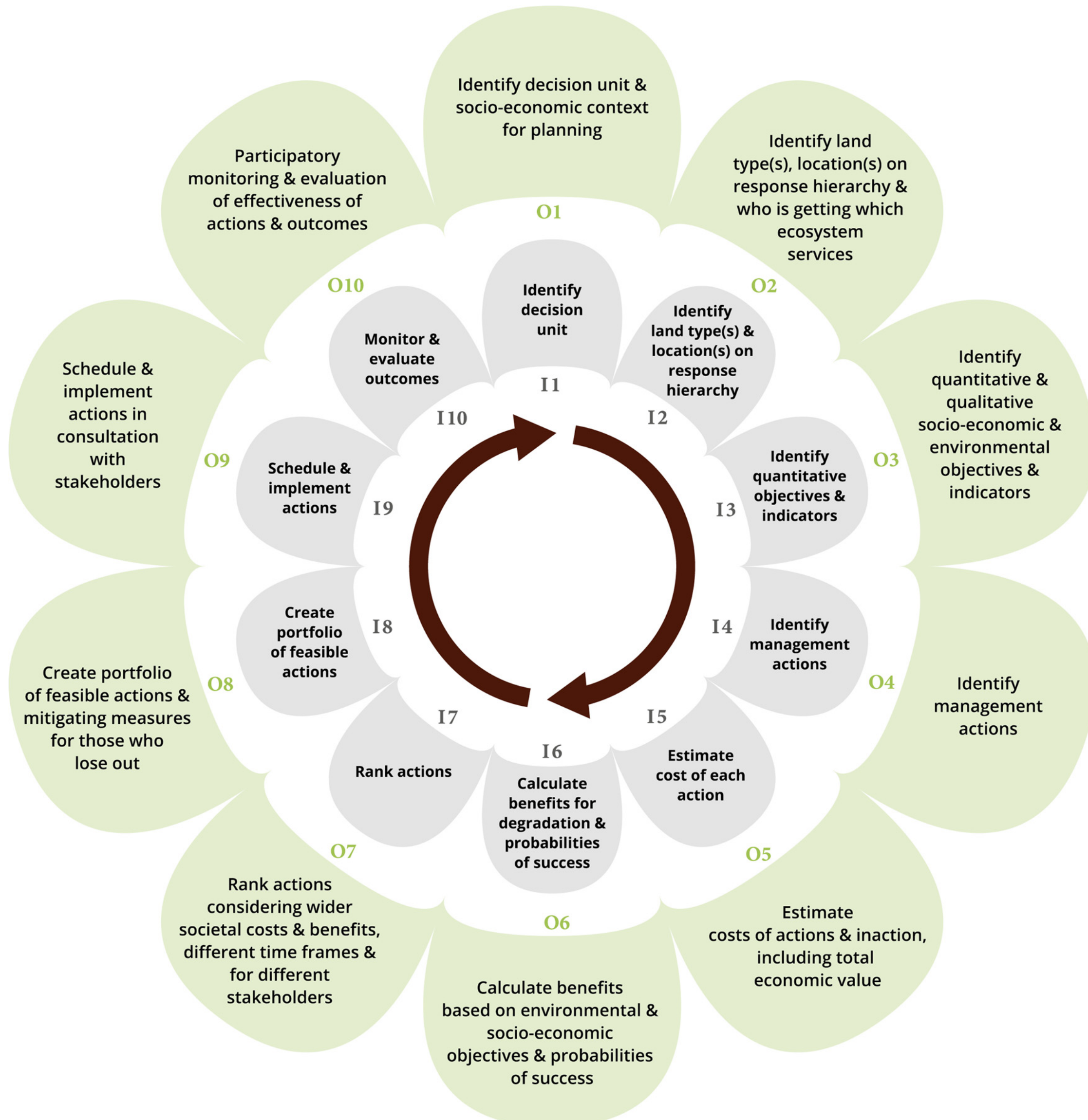

Fig. 1. Decision Dahlia: a decision support tool drawing on triage principles to inform investment choices and actions in progressing towards LDN targets. The inner circle places the three global indicators linked to SDG target 15.3 as the quantitative objectives to be achieved, while the outer circle takes a more holistic and participatory approach that considers socio-economic as well as environmental goals.

3.1. *The inner circle: biophysical goals*

Step I1 requires identification of the spatial boundary and governance jurisdictions of the whole area over which decisions could be made (the decision unit). The decision unit can cover any scale (i.e. catchments or landscapes at sub-national, national or supra-national scale). Scale choices made will affect the outcomes of the process not least because it is important to match the biophysical and administrative boundaries (Dallimer and Strange, 2015; Guerrero et al., 2015) given well known challenges of fit, interplay and scale between the environment and the institutions that govern them (Young, 2008).

Second, within the decision unit, the type(s) of land to be considered should be identified (I2). The decision unit will also contain land parcels at different stages on the response hierarchy. This includes land that is currently degraded and in need of restoration/rehabilitation; land that is on a degradation trajectory; land that is not degraded but that may become so in future; and land that is not degraded and is unlikely to become so in future. Existing data sources and land cover maps/remote sensed imagery can help assess degradation status/risk and land types respectively.

Third (I3), quantitative objectives need to be set. In the case of LDN, these relate to the three global indicators that countries use to report their progress towards SDG target 15.3 at a national scale: land cover change, net primary production and soil organic carbon. Neutrality is achieved when losses equal gains within each land type, and across land types. Orr et al. (2017) note that a “one out, all out” approach is taken, so countries need to be progressing in the right direction or remaining static across all indicators to achieve LDN. Further quantitative objectives can also be set in line with sub-national targets. These may not seek neutrality but can instead centre on avoiding, reducing or reversing degradation.

Fourth (I4), within the decision unit, possible management actions for land at each location on response hierarchy need to be identified. Existing data sources such as WOCAT (2007) or the online WOCAT global database (available at: https://www.wocat.net/global-slm-database) could provide useful options. Fifth (I5), the implementation costs associated with each action (e.g. materials, labour, maintenance costs) are calculated. Land management actions generally fall under four categories: i) agronomic; ii) vegetative; iii) structural; and iv) management. However, costs of these are not spatially uniform, almost regardless of the type of intervention undertaken (e.g. implementing agroforestry in different land parcels will cost different amounts even if the same species are grown e.g. Dallimer et al., 2018) and the scale considered (Naidoo et al., 2006). It is possible to evaluate options more fully in this step by considering maintenance and upfront costs for multiple land management options within a given land parcel.

Sixth (I6), calculate the expected benefits of avoiding, reducing or reversing degradation considering the probability of success over the time frame considered. This can be done quantitatively or qualitatively depending on available data and accessible lessons/experiences from similar environmental, social and economic contexts. Each action undertaken is likely to have a different probability of the objectives being achieved, even within land parcels of the same degradation status, depending on biophysical variables (e.g. aspect, slope, soil type) and socio-economic variables (e.g. population, infrastructure, accessibility). Even where qualitative or subjective evaluations of success are used (e.g. as reported in the literature), these can be converted into probabilities of objectives being achieved under conditions similar to those in the decision unit where an action is likely to offset the greatest amount of land degradation per unit cost.

Seventh (I7) is the ranking of actions based on the benefits calculated in I6. From this ranking, in I8 the decision is made regarding where to invest first, working down the ranked list until the budget is exhausted and a feasible portfolio of actions has been developed. I8 would also be the time at which to use the process to go to lobby for more funds, with the knowledge that with an additional $X more land could receive investment.

Ninth (I9) comes implementation, when the chosen actions take place. Implementation processes may or may not involve stakeholders, depending on the context and considerations such as land tenure, land use etc. The timing of implementation may need to be considered in relation to context-specific windows of opportunity (e.g. particular weather events, seasonal dynamics etc – see Sietz et al., 2017) as these can help to boost the effectiveness of actions and alter the probabilities of success. Tenth (I10), monitoring and evaluation need to take place using the indicators identified in I3. Progress needs to be considered in relation to the objectives set, with monitoring taking place in line with the timeframe decided upon before application of the decision process.

The decision process we have outlined in the inner circle is transparent, justifiable and repeatable. It would allow prioritisation of interventions intending to support achievement of LDN, using the necessary biophysical indicators for SDG progress reporting. However, it ignores the links between land and people (see Okpara et al., 2018 this issue). If applied it could result in unintended consequences (e.g. mass migration or exacerbated poverty and food insecurity, particularly in vulnerable dryland areas (Stringer et al., 2017)). Indeed, where land is not prioritised for action, such as when it is on a worsening degradation trajectory, the degradation can act as a risk multiplier, increasing overall vulnerability and even supporting conditions for conflict (Busby et al., 2014). It could also cause the degradation to extend over a larger area (e.g. when land left unmanaged is abandoned and human populations move to nearby land parcels exerting increasing pressure and resulting in further land degradation and abandonment). Although the LDN conceptual framework notes that decision makers should include additional indicators depending on their need and context, listing 19 guiding principles (Orr et al., 2017; Cowie et al., 2018), any additional indicators are not mandatory for SDG reporting. We argue that this is a risk to the whole LDN concept, as it does not require assessment of the direct impacts of LDN on socio-economic aspects nor specific attribution of socio-economic gains and losses to LDN efforts. Instead, a decision process is needed which objectively and transparently considers and monitors likely socio-economic impacts resulting from LDN investment decisions, particularly for vulnerable and marginalised groups. Monitoring would need to consider: i) land rights; ii) the role of each land unit in livelihood systems; iii) the ecosystem services stemming from each land unit (and the scale at which they are delivered); iv) the distribution of costs and benefits across different stakeholder groups and different scales; v) total economic values; vi) returns over different time frames; and vii) their implications in relation to trade-offs. The outer circle (Fig. 1) extends each step to include such wider societal and economic considerations.

3.2. The outer circle: bringing societal needs into the decision making process

O1 takes into account the human population within the decision unit. By characterising the livelihood and human-environment systems, key relationships and driving variables can be incorporated, demonstrating how many people could directly and indirectly benefit from any investment actions. O2 extends land type identification and the location of land parcels on the response hierarchy to cover land rights, ecosystem service stocks and flows (both actual and potential), as well as beneficiaries of flows, including those not physically present within the decision unit. O3 involves setting the objectives and indicators that could be used for monitoring. These could be quantitative and/or qualitative and cover both biophysical and socio-economic elements identified in O1 and O2. Identification of context-relevant indicators could involve stakeholder participation too (see Reed et al., 2008). The globally agreed LDN indicators can still be used but are supplemented with socio-economic indicators to ensure their achievement does not result in unintended (negative) consequences for other SDGs, harm livelihoods, exacerbate poverty, act as a risk multiplier driving migration and conflict, or cause further environmental degradation elsewhere. O4 mirrors I4 and sees development of a menu of possible actions for each land type and degradation status identified in O2. The costs associated with each possible action need to be calculated in O5. Taking a more comprehensive approach than I5, O5 considers the costs of the actions themselves, opportunity costs (including the costs of inaction), costs of socio-economic impact mitigation measures and wider societal costs. The latter is likely to differ according to the societal groups and time periods considered but proves vital in identifying the possible trade-offs that can occur as a result of the decision taken. It is therefore important that relevant groups and mitigation time frames are defined by the stakeholders involved in the decision process and considered in conjunction with reporting needs.

O6 focuses on expected benefits considering the probability of success of each possible action identified in O4, as evaluated against all of the biophysical and socio-economic objectives identified in O3. Again, different time frames and societal groups can be considered here, as well as through O7 and O8. O7 provides the ranking of actions relative to costs, benefits and probability of success, allowing identification of ‘quick wins’ and investments that will take longer to deliver benefits, and highlighting where mitigation measures may be needed to minimise negative outcomes and trade-offs for those societal groups who lose out. O8 then provides the decisions on where to invest using the ranking under the previous step, also considering any mitigating measures, until all the budget is assigned.

O9 remains focused on scheduling and implementing the decisions and O10 considers their monitoring and evaluation. Again, these steps may specifically include stakeholder engagement within the process if it is appropriate to the context. Stakeholder engagement can be integrated from the very beginning of O1 if appropriate, and can be desirable given research that identifies that participatory interventions often deliver more beneficial environmental and social outcomes (de Vente et al., 2016). Involving stakeholders can foster a sense of ownership over interventions while outcomes from decision-making processes perceived as fair and legitimate are more likely to be accepted by stakeholders (Young et al., 2013). Participatory approaches can therefore help to strengthen the overall decision process, not least, the probabilities of success.

4. Discussion

Triage principles that have been applied in biodiversity conservation (e.g. Knight et al., 2006; Kareiva et al., 2014; Jumin et al., 2017) have been used to fill an important gap in current LDN decision making. A triage approach targets the need for LDN investment decisions to be made in a transparent, justifiable and repeatable way in the context of limited resources (Bottrill et al., 2008). We have outlined the considerations specific to LDN and have tied it to the LDN conceptual framework (Orr et al., 2017; Cowie et al., 2018). This has resulted in a process that can guide decision makers towards investments that can aid their LDN progress, in line with both national targets and targets at sub-national and smaller scales. The inner circle of the Decision Dahlia centres on achieving progress measured against the three global indicators. The outer circle offers a more comprehensive approach that draws attention to trade-offs and reduces risks of unintended consequences that could have damaging socio-economic impacts, thus encompassing considerations relevant to multiple SDGs.

The Decision Dahlia, and the triage processes which underpin it, face a number of challenges, not all of which can be easily mitigated in the outer circle. For example, the governance scales at which decisions are made often do not match ecosystem scales, representing a problem of 'fit' between the environment and the institutions designed to govern it (Young, 2008). Enacting successful actions where multiple jurisdictions are spanned can become increasingly difficult. However, if carried out, one outcome can be that although overall gains across the large spatial scale improve, at smaller scales some regions can be left with fewer resources (e.g. Kark et al., 2009). For land, this could trigger migration and/or conflict as populations and livelihoods become increasingly vulnerable (Okpara et al., 2016), having social and political implications.

To reach neutrality, the LDN conceptual framework requires 'equivalence': to balance degradation with restoration of land of the same type and to consider all land types. However, under the UNCCD target setting programme, in addition to national neutrality targets, sub-national targets are also valuable in tackling the land degradation problem. Sub-national targets do not necessarily seek to achieve neutrality but can help to avoid, reduce and reverse degradation in particular systems. A concern in this case is that drylands could lose out in any prioritisation process linked to sub-national targets. This is a particular risk in countries that have large land areas and span multiple climatic and agro-ecological zones because dryland areas are often more degraded and the costs of rehabilitation and restoration are likely to be higher than in other environments that have seen greater investment in infrastructure and which are better connected to markets (Middleton et al., 2011). It is vital to ensure processes are in place so that dryland areas are not marginalised further through the investment decision process, particularly if efforts to avoid and reduce degradation as well as reverse degraded areas end up being more expensive in drylands. The Decision Dahlia goes some way towards making such decisions more transparent but it cannot fully mitigate this risk.

Another concern, leakage, has been seen in efforts to stem deforestation and forest degradation through programmes such as REDD+ (Harrison and Paoli, 2012). LDN investment in one area could cause leakage in the form of increased degradation elsewhere, as people and their degrading activities relocate. Feedbacks and unintended consequences need further exploration in the LDN context. This could be done by initially focusing on past decision outcomes, applying the Decision Dahlia retrospectively to see what other actions could have been possible in an attempt to understand how and why unintended consequences came about. Information from these analyses can then feed into future decision process.

The outer circle in Fig. 1 explicitly incorporates temporal considerations, with, for example, cost benefit analyses and mitigation measures considering different time frames. In contrast, the inner circle focuses more on the single time frame over which resources are to be allocated and monitoring and evaluation are to take place. Incorporating temporal considerations is not necessarily easy to manage as stakeholders will have different time frames they wish decision processes to operate over. Agreement will therefore be required, something that is particularly important given environmental benefits can occur over long periods in relation to when some sustainable land management and restoration practices are implemented (see e.g. Dallimer et al., 2018). While it is inevitable that those responsible for delivering on LDN will want to demonstrate quick wins given the 2030 reporting deadline, it is paramount that these do not come at the expense of future environmental quality and human wellbeing.

Whether funding to improve land quality and achieve LDN will continue to be limited, or can be expanded with marketing and success stories, is yet to be explored. Experiences from conservation suggest that resourcing may not be as fixed as it may initially appear. By concentrating on particular species through, for example marketing campaigns, conservation budgets can be been increased (Veríssimo et al., 2017). However, decision makers cannot guarantee such increases. There are also well known species, such as the Mauritius kestrel (*Falco punctatus*) which would likely have been allowed to go extinct if triage principles had been applied. With a population of just four in the late 1970s, many thought "We might abandon the Mauritius kestrel to its all-but inevitable fate, and utilize the funds to proffer stronger support for any of the hundreds of threatened bird species that are more likely to survive" (Myers, 1979; 43). The management actions which led to the recovery of the kestrel have acted as a focal point for long-term conservation investments throughout the island. Similarly, research efforts on restricted range species of conservation concern can often catalyse further research in particular regions (e.g. de Lima et al., 2011). It will be important to assess whether similar effects are experienced for initiatives targeting LDN.

We acknowledge that trade-offs can occur between different environmental objectives, between environmental and socio-economic aspects, and between different stakeholders. Processes of dialogue and stakeholder engagement will be vital and context specific as these aspects are negotiated. One approach could be to introduce greater levels of detail, with possible examples given in Table 1.

5. Conclusion

This paper has demonstrated how triage principles, similar to those used under limited resourcing in biodiversity conservation decision making, could be applied to LDN. In doing so, it offers the chance to deliver a transparent, repeatable decision process when investing in actions addressing land degradation issues. It has highlighted some important risks of decision approaches that focus only on biophysical outcomes linked to the three global indicators. It has also provided ways forward to incorporate socio-economic considerations in an attempt to deliver an approach to LDN that is better underpinned by social justice concerns. Risks and complications nevertheless remain. There is no guarantee that neutrality will be reached by employing triage principles as this depends on the overall 'balance sheet' of the decision makers, taking into account where the land units sit within the response hierarchy, considerations of land type, 'like for like' and so on. Nonetheless, it provides a route to delivering a greater 'bang for buck' from investments intending to contribute towards LDN and efforts at smaller scales that aim to prevent, reduce and reverse degradation. It also helps to address an important gap by providing a decision support process for efforts to achieve SDG 15.3. The next step will be to apply the Decision Dahlia in a range of real-world degradation, socio-economic and political contexts, both retrospectively and to guide future decisions. During this application it will be important to test and adapt the process taking into account different levels of complexity. At the same time, further analyses are required to better understand the outstanding risks and to identify ways in which they can be addressed.

Table 1
Further considerations that could help provide information that can resolve trade-offs.

Consideration	Explanation
Include multiple ecosystem services	Research often focuses on provisioning services while cultural services are considered harder to assess. Consideration of multiple ecosystem services allows a broader picture of environmental trade-offs to be attained
Include climate change effects linked to feasibility of restoration/rehabilitation options	Some actions may be feasible now but not under future climates. Rankings of actions could consider e.g. how well adapted tree species are to drought in agroforestry actions.
Assess uncertainty in all estimates of costs, benefits, values	This would further increase transparency in the approach
Use different probabilities of success for different indicators	This would make the probability calculations more extensive and could act as a useful basis for sensitivity analyses
Include multiple weighting factors e.g. for population, livelihoods, foods security, migration risk, conflict risk, indicators of wellbeing and options for future use	This could be a useful addition if investments are explicitly seeking to build social-ecological resilience through LDN investments and not just achieve environmental benefits, allowing consideration of sustainable development more broadly
Allow benefits to accrue over different timescales	This would allow more realistic assessments of returns on investments and would provide information that identifies where mitigation measures might be needed to address resulting inequalities
Carry out case-specific calculations for several sectors of society, e.g. marginalised groups, smallholder farmers, commercial farmers, urban residents reliant on food supplies from rural areas, future generations, those outside of the decision unit etc.	This would help to identify trade-offs between different stakeholder groups and can be used to draw attention to who the winners and losers might be in light of particular investment decisions
Do not assume land is fungible by, for example, building in place attachment and cultural values for land, and/or addressing issues of tenure	Although LDN allows land to degrade in one area and be restored in another, this assumes that land has the same value throughout. However, specific locations hold particular, irreplaceable, meanings for communities. Including these values in the decision making frameworks will be important if cultural values are not to be lost
Place a floor on how badly degraded land parcels are allowed to become before action is prioritised	This would alter the ranking of parcels but could reduce the risk of negative social and economic impacts resulting from degradation
Incorporate threat reduction (rather than land management actions) within each of avoid, reduce and reverse in the response hierarchy	Land management actions which reduce the threat of degradation in the future, especially under climate change, could be a cost effective approach to minimising degradation in areas where it is currently not present. It could, therefore, be important to include these options within any decision making process

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