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# A systems approach to liveability and sustainability: Defining terms and mapping relationships to link desires with ecological opportunities and constraints

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## Abstract

I offer a protocol for assessing the sustainability of liveability. This protocol draws on a framework developed to assess vulnerability, and offers two key pertinent features. These are (a) a capacity to incorporate multiple and shifting stakeholder values, and (b) a means of moving from expressions of liveability to underlying ecological attributes that deliver or constrain system change. The applicability of these features to both assessing the sustainability of liveability, and a reappraisal given system change are illustrated using data from a study site in the French Alps. The central place of values intrudes into liveability and sustainability so as to complicate the situation. Even so, the protocol presented here is able to ground the abstractions and equivocation in a transparent and explicit set of announcements. Laying the steps out in the open allows for consistency in comparison and replication without artificially removing the labile flexibility embedded in liveability and sustainability.

# 1. Introduction

There has been increasing interest in examining relationships between the concepts of liveability and sustainability, primarily in the context of advancing the fields of urban development and environmental quality (e.g. Newman, 1999; Shafer et al., 2000; Van Kamp, et al. 2003; Godschalk, 2004; Newton, 2007; Howley, et al, 2009; Lewis & MacDonald, 2009). A recent review by Van Kamp et al. (2003) found a diverse set of definitions of liveability and sustainability in the literature. They concluded that while a consensus on definitions is important to advance thinking, no single conceptual framework could be formulated on the basis of their review. In this paper I offer both definitions and a protocol, though perhaps in a different spirit that focuses on multiple perspectives and flexibility in the face of specific circumstances.

A number of scholars have highlighted the role values play in defining concepts that describe and evaluate ecosystem change (e.g. Adger, 2006; Eakin and Leurs, 2006; Carolan, 2006; Nelson et al. 2007; de Chazal et al. 2008). Even so, these concepts are often used as if they were value free, carrying a single, universal meaning. Liveability and sustainability as commonly used are taken as self-evident and so are often not defined. Value judgements are therefore implicitly embedded in descriptions and assessments of relationships between people and environment.

Allen (2010, this volume) identifies that values change, particularly with regard to liveability. This paper offers a protocol for making values and any changes in values explicit. de Chazal et al. (2008) laid the ground work by proposing a framework for vulnerability assessment (the Vulnerability of Ecosystem Services to Land-use Change in Traditional Landscapes (VISTA) project) and illustrated it using findings from two study sites in France and Portugal. Several key features distinguished this work from others. One was the capacity to incorporate multiple and shifting stakeholder values. Another was to incorporate these values via services that the ecological system offers, services embodying something appreciated by humans in that setting. Specific ecosystem services will be defined later in the paper. These services concretize attitudes that are intangible and map them onto underlying ecological attributes that deliver or constrain those services. Moving beyond the intangible is helpful given system change. The capacity of the framework to assess change deemed external to the system was explored in de Chazal et al. (2008) however the capacity to assess internal change was not. Here I use the same study to illustrate both these capacities in relation to assessing the sustainability of liveability.

As was the case with findings reported in de Chazal et al. (2008), the findings are illustrative only. They not intended to represent conclusive statements regarding the desires of the selected stakeholders or the sustainability of the region presented. I direct this protocol at systems thinkers, researchers and/or policymakers engaged in assessing or implementing responses to environmental change.

## 2. Systems thinking

Allen and Hoekstra (1992) emphasize the observer driven nature of thinking about ecology. The ideas in this paper represent a contribution from a relative newcomer to the area of systems thinking, although they are not new ideas in themselves to this author. If I am typical then the ideas of systems thinking are all around but not in a formal self-conscious way.

## 3. Seeking single definitions and frameworks

The call for consensus on definitions for liveability and sustainability, and agreement as to a single conceptual framework describing their relationship invite the mistake of reifying definitions as somehow true definitions, locking them into relationships that are universal. Van Kamp et al. (2003) appeal to the idea of such concepts 'developing' over time where they start off with a 'vaguely circumscribed meaning' to be later 'clarified and specified by more research and reflection' (Szalai, 1980 cited in Van Kamp, et al. 2003). Others echo this view (e.g. Camagni, et al. 1998; Portney, 2005). This call arises in other fields, for example, ecosystem health (de Chazal, 2003; Carolan, 2006), vulnerability (Eakin & Leurs, 2006; de Chazal et al., 2008). Post-normal science in the systems field also recommends a process of iteration when dealing with that which cannot be defined (Funtowicz & Ravetz, 1991; 1993). Iteration can lead to improvement through quality in the process of assessment itself, not in finding some external verity. There is no true nature as the particular meaning assigned to liveability and sustainability is predicated on differing and indeed shifting values. We are faced with an undefinable, but must work past that anyway. I offer a protocol for doing just that.

## 4. Definitions and the role of values

Proposed definitions are given in Table 1. I distinguish liveability and sustainability primarily in terms of scale. Allen (this volume) offers a much more nuanced distinction, separating them in terms of logical type; The definitions raised in the present study reflect my thinking on the subject as applied the framework that follows. We do need working definitions applicable to specific circumstances.

In the simplest sense, liveability can be seen as a pure expression of values or desires. I see sustainability, whilst also involving values, implying an ecological constraint on the realisation of those desires. I elaborate below on the various ways values underpin both of these two concepts.

### *Whose and what desires?*

Depending upon the scale under consideration, liveability may be viewed at scales from the perspective of a single individual through to scales of the perspective of collective individuals at the global level. Desire as a concept is scale independent. From any given perspective a range of desires may be considered important with regard to liveability. Van Kamp et al. (2003) provides examples that they call 'domains' ranging from desires relating to the physical environment (food, water shelter) though to desires relating to personal and community development (recreation, leisure, social networks). The 'determinants and constituents of well-being' represents an example drawn from the global environmental change literature (Millennium Ecosystem Assessment, 2003).

The selection and ranking of desires will inevitably vary from individual to individual. Criteria for selection or ranking may be influenced by a range of factors, including how essential the desire is considered for survival (i.e. distinguishing needs from wants), or in terms of the impact of a selected desire on other desires. Often these criteria are framed in terms of selecting desires that are considered sustainable. Sustainable is often understood in terms of 'treading lightly' or being purposefully austere to minimise undesired ecosystem change (e.g. http://www.sustainablelivingdirectory.com/index.php*)*. In this way a link is made between what are deemed appropriate desires and any undesired ecological consequences in the realisation of those desires.

### *Time frame*

A time frame must be articulated for sustainability that specifies for how long those desires will be delivered. The selected timeframe may be short-term through to longer-term (e.g. WCED, 1987), however whatever time frame is selected, value judgements are involved concerning what is deemed desirable and appropriate.

### *Characterising the system*

Different sets of desires can dictate different characterisations of the system at hand, where different ecological attributes are implicated in the delivery of the respective services. Moreover, different observers may characterise the system differently, in relation to the same or different desires. For example, in the VISTA work, we made a distinction between system characterisations derived by stakeholders or by ecologists. We noted that stakeholder derived characterisations may not be the same as those developed by ecologists. We also noted that different stakeholders who hold the same desires may focus on different attributes of the system. For instance farmers focused on more detailed aspects of grasslands in contrast to hikers. Choice of desires and who is observing the system necessarily dictate how the system will be characterised, along with the value judgements that come with them.

### *Assessing sustainability*

The statement 'apart from basic ecological limits, sustainability is negotiated' (Murray et al. 1999) has always intrigued me. The statement is suggestive of a core set of human needs that underpins sustainability. There are a number of formulations on what might constitute fundamental human needs (e.g. Alderfer 1972; Max-Neef 1992; Alkire, 2002), with propositions made that these needs are fixed across cultures and through time (e.g. Max-Neef 1992). There are also formulations on what constitutes basic ecological limits (e.g. Rockström, 2009). I disagree with all these formulations, and instead, along with others (e.g. Allen, Tainter and Hoesktra, 2003; Allen, this volume) propose that sustainability will always be negotiated. What constitutes sets of desires together with sufficient delivery (both quality and quantity) of those needs is dictated by values and as such is not an absolute. Allen and Hoekstra (1999); Allen, Tainter and Hoekstra (2003) and Giampetro (2005) all offer methods for estimating these limits given a particular context of purpose.

There are also scientific uncertainties associated with estimations of sustainability. These uncertainties are particularly amplified when estimating the sustainability of liveability at the global scale, such as climate change (Pielke, 2007; Hulme 2009). We can expect science to better address these uncertainties over time, though post-normal science (Funtowicz and Ravetz, 1991) notes that in many practical matters there is an intrinsic and large uncertainty with which scientists must simply live. Even so, there is a present need to account for information uncertainties in estimating ecological constraints. Technological innovations (e.g. sources of energy, efficiency in manipulating energy, methods of disposing of waste) may increase the capacity of the system to meet desires. Technologies of the future are unknown and many upon which we may speculate may not come to pass. This too adds an extra dimension of uncertainty.

## 5. Assessing the sustainability of liveability using the VISTA framework

The VISTA project assessed the vulnerability of stakeholders to projected land use change in 2030 in relation to a study site in France and one in Portugal (de Chazal, et al. 2008). Figure 1 provides an overview of the assessment framework developed. The framework uses five matrices to move from projected ecosystem changes under several scenarios of land-use change through to judgements about changes in ecosystem services (see Table 2 for definitions). Matrices were filled with Likert scores (Likert 1934) drawn from ecological field studies, land-use and land-cover modelling, and social surveys. There is a touch of meta-analysis here, a tried technique combined with scenarios.

We then assessed vulnerability via the 'acceptability' or otherwise of ecosystem change to each stakeholder group under each scenario. Summary measures of acceptability were then calculated in order to assess vulnerability (described below). Vulnerability in the VISTA context represents the inverse of acceptability across all scenarios, where greater vulnerability equals less acceptability.

The framework can be applied to assess the sustainability of liveability via the same mapping sequence as described above. Ecosystem services, acceptability and vulnerability can be respectively substituted for liveability desires and sustainability as they can be used to characterise the system in similar ways. Ecosystem services therefore represent liveability desires and ecosystem attributes represent the capacity or otherwise for the delivery of these desires over time. Capacity here is used to encompass the set of system resources, their characteristics and ecological relationships. Composite measures of acceptability across all scenarios (vulnerability) become sustainability. Being less vulnerable equals greater sustainability, representing a measure of whether stakeholder desires can continue to be met (see below for an example).

A sub-set of the findings drawn from de Chazal et al. (2008) are used to describe the framework below. Findings from the French site (Lautaret) are reported only, to provide an inter-site comparison, sufficient to illustrate the points I wish to convey.

The Lautaret study site is located in the central French Alps. The main activities in the area include animal husbandry, nature conservation, and recreation. The study focused on a mosaic of grasslands with varying past and present land uses. Further details are described in Quetier et al. (2007a,b).

### *Linking desires to capacity for delivery*

The first matrix (Fig. 2a) represents how selected stakeholders value (desire) the set of identified ecosystem services using a 3 point Likert scale (+ for desired, 0 for not important and - for undesired). Note that all stakeholders assign a value to all ecosystem services, even when they are not their own.

The second and third matrix (Fig. 2b-c) links these ecosystem services to underlying ecological attributes that contribute to their delivery. The VISTA project distinguished several types of ecological attributes (see Table 2). Only ‘descriptors’ and ‘ecosystem attributes’ are presented here. Scores represent a positive (+), neutral (0) or negative (-) relationship with delivery.

### *Estimating change in capacity for delivery*

Two scenarios of prospective land-use change for 2030 were developed by Quétier (2006) drawing on ecological field studies (Quétier (2007; Castro et al. unpublished manuscript). These were applied to estimate projected changes in ecosystem services relative to the present (Fig. 3a). The first scenario ('staying tame') represented a renewal of the currently declining agricultural practices, with the second representing a continuation of current trends of intensification and agricultural land abandonment ('going wild'). These trends were drawn from possible effects of changes in agricultural policy in Western Europe as described by Baldcock et al. (2002). In the VISTA study we distinguished two spatial scales that these scenarios were applied, a within site 'land-use' scale and a composite 'site' level. Only the site level scores are presented here. Scores represent an increase (+), no change (0) or a decrease (-) in the projected delivery of the service.

### *Assessing the sustainability of liveability*

The 'acceptability' of each land-use change scenario to each stakeholder relative to their desires (Fig. 3b) is estimated by multiplying the change in the delivery of each service (Fig. 3a) by the assigned stakeholder desire (Fig 2a). We determine 'acceptable' as representing either a positive or neutral score (+ or 0), and unacceptable as a negative score (-). These acceptability scores then provide the input information to calculate changes in sustainability. We can apply a weighting scheme to both stakeholder groups and ecosystem services. Different weighting schemes will produce different results, the selection of the scheme depending on the context of assessment (e.g. Quétier et al. 2009). We assigned equal weights to all services and stakeholder groups for ease of illustration in de Chazal et al. (2008) and I do the same here. Acceptability scores can be considered collectively or grouped by sets of stakeholders or sets of services. The VISTA study described two examples of calculating summary measures for acceptability, the simplest measure is presented here. This score was calculated by summing up the scores relating to selected services for a set of stakeholders for a given scenario and taking the sign of the score (termed 'acceptability score') (Fig. 3c).  A positive (+) or neutral (0) score represents an overall acceptable assessment of changes (more sustainable), while a negative score represents an overall assessment of "unacceptable' with regard to changes (less sustainable).

## 6. Increasing the sustainability of liveability

The previous section describes how the VISTA framework can be applied to assess the sustainability of liveability. A path was traced from stakeholder's desires to those ecological attributes that contribute to the delivery of those desires.  Then, given a change in those ecological attributes, the path is retraced to assess the sustainability or otherwise of continued delivery of those desires to stakeholders, according to their perspective.

Increasing the sustainability of a given liveability, if deemed aspirational, can be achieved in two ways.  Leaving aside debates concerned with how these may or may not be achieved (e.g. McDornough & Braungart 2003), they are:

1. Modify desires to use less, e.g. reduce population, and adjust concepts of wealth and wealth distribution.

2. Modify the ecosystem to produce more through technical innovation, e.g. agricultural developments, shifting to different energy sources.

The VISTA framework treated drivers of change as external to the system of interest. Equally however change could arise as the result of internal system feedbacks applied to the two pathways of change described above. An example of how the framework can address each of these pathways is given below.

### ***Modifying desires: examining conflicts and concordances between farmers and hikers***

Conflicts can exist both in the delivery of a service (i.e. different perspectives on whether it is desired or otherwise) as well as on the delivery of different services (where the delivery of one service conflicts with another).  In the case of the latter, the same stakeholder may hold conflicting desires. In the example given in the previous section farmer positively desire ‘hay for winter fodder’ and negatively desire ‘wild beauty of the landscape’ (Fig. 2a). In contrast hikers positively desire wild beauty of the landscape and assign no importance to hay for winter fodder.  ‘Habitat for fauna’ is not a desire of farmers or hikers.

Exploring the successive matrices reveals that ‘variety of flower colours’ and an open landscape contribute positively to the delivery of wild beauty of the landscape, while ‘visual cues of agricultural activities’ contributes negatively. ‘Grassland productivity’, ‘abundance of legumes’, visual cues of agricultural activities and an ‘open landscape’ all contribute positively to hay for winter fodder, while ‘abundance of unpalatable plants’ contributes negatively’.

Following on, ‘flowering diversity index’ and ‘abundance of Festuca’, ‘manuring’ and ‘flock size’ can be traced back to competing desires of farmers and hikers. The properties of ‘phosphorus’ and ‘grass productivity’ are pertinent to farmers alone.

The difference in desire for wild beauty of the landscape between hikers and farmers is therefore reduced to a difference in desire for flowering diversity index, abundance of Festuca, manuring and flock size. In addition, manuring and flock size contribute differently to the hiker’s positive desire for wild beauty (which farmers considered undesirable) and the farmers’ desire for hay for winter fodder.

These are somewhat obvious associations in the case considered but they work here to explain the procedure that may apply to less intuitive circumstances. Such a method illustrates how the framework can examine relationships between desires. Relationships mapped out in this way might then assist in decisions regarding the selection and ranking of appropriate desires in the context of sustainability. For example, both compatible and conflicting desires can be identified. Characterised ecological relationships determining their compatibility are revealed. The attributes and capacity to deliver these desires is identified. Selection and ranking of desires can therefore be made in the context of respective capacity for delivery, and potential conflicts between desires.

### *Reassessing the sustainability of liveability*

The framework also enables a reassessment of the sustainability of liveability. This reassessment may be the result of a change in desires, management in relation to the delivery of that desire, or the introduction of an innovation that changes the relationship between desires and the ecological attributes. de Chazal et al. (2008)

suggested future research incorporating stakeholder learning and reflection so as to facilitate reassignment of such relationships.

Some examples of hypothetical changes in relation to hikers and farmers are given below. Quétier et al. (2009) provides a more sophisticated example in relation to an extended set of scenarios and stakeholders, in particular exploring changes by applying different weightings to ecosystem services. Different weightings enabled prospective stakeholder adaptations to future scenarios to be explored. For example we examined projected shifts in farmer's preferences in Lautaret from assigning importance to forage quality to reassigning this to forage quantity given a new production context (Quétier et al. 2009).

Under the prospective land use scenarios presented the acceptability of both scenarios was negative for hikers and positive for farmers (Fig 3c). The scenarios represented an increased sustainability for farmers, however a reduced sustainability for hikers.

The outcome of a hypothetical forum enabling stakeholder learning and reflection might offer a collective greater appreciation of the multiple functions the landscape performs, catering for pastoral as well as recreational interests. In this spirit, farmers might modify viewing wild beauty of the landscape from undesirable to neutral (Fig. 4a). Similarly, hikers may learn that an open landscape, rather than being natural is maintained by pastoral activities such as mowing for hay and grazing by stock. Desire for hay to winter fodder would then change from neutral to positive (Fig. 4a). The relationship between wild beauty and visual cues for agricultural activities in the descriptor matrix was also modified from negative to positive (Fig 4b). Additionally, discussion might be held on how the ecological attributes that deliver wild beauty and hay for winter fodder might be made more compatible. A forum participant might suggest that by mowing at a slightly later time of year, the variety of flower colours could be enhanced, thus changing the relationship between grass productivity and variety of flower colours from neutral to positive (Fig 4c). The relationship between wild beauty and grassland productivity would be similarly modified from neutral to positive (Fig 4b).

These hypothetical changes modify the acceptability of both scenarios to both hikers and farmers (Fig 5b-c). Although the overall acceptability across stakeholders and scenarios didn't change (Fig 5c), the acceptability of both hikers and farmers of individual services under individual scenarios come more into line. There is an overall improvement in the acceptability of changes by hikers (Fig 5c). For example, hikers' acceptability score changes from negative to positive for wild beauty, and from neutral to positive for hay for winter fodder under the staying tame scenario (Fig 5b). There is a decrease in overall acceptability by farmers (Fig 5c), where for example, farmers acceptability score changes from positive to neutral for wild beauty under both scenarios.

In this way, we might reassess the sustainability of these selected liveability desires. Although in this example overall sustainability did not increase, the initially quite different desires of hikers and farmers become more compatible through modification. Changes were of both farmers and hikers desires as well as some underlying relationships with ecological attributes. We see a potential for greater congruence between different stakeholder perspectives. It becomes easier to meet both the desires of both hikers and farmers through a single trajectory of system change.

## 7. Summary and conclusions

Sustainability and particularly liveability both challenge definition, because they are always morphing and changing. Not only do they remain undefined, despite an extensive literature that goes further to seek a single definition, liveability and sustainability are undefinable. McCormick, Zellmer and Allen (2004) have developed a rather abstract way for dealing with the undefinable. They see cycles of model building locked together with cycles of realization. For them the essence that realizes the observed structures is the intangible that keeps changing through processes such as evolution in biology or perhaps elections in political systems. They say that we all know what the US Presidency is, but we cannot define it because it is always changing (e.g. the election of Obama). McCormick and his colleagues use iteration of discrete defined models (lists of past presidents or collections of animal in a class) as the anchor to address the essence even if it is undefinable. The paper addresses the same dilemma of how to deal with what cannot be defined but is presented in much more down to earth terms, well rooted in observations of liveability and sustainability in action.

The flawed search for single, universal definitions of such concepts belies a crucial misapprehension as to the necessary role that values play in the characterisation and management of environments. This error pervades ecology and wider research on global environmental change. I am hardly alone in making these statements, but even so liveability and sustainability are bandied about carelessly. The discussion appears to have little traction, and I think it is precisely because of muddled thinking that makes them both chimeras.

The framework presented here offers a method of quantifying abstract concepts and identifying the necessarily multiple relationships between them. This provides a means of making these concepts more accessible to landscape managers and decision-makers, where currently they are not. The framework enables assessments to be made that are particular to the context; addressing the critical questions of: for whom, for how long, at what costs, and of what? (Allen, Tainter and Hoekstra, 2003). Moreover the assessment can be repeated, given system change. In the context of assessing sustainability, this flexibility permits a range of different liveability scenarios to be examined to determine how relationships and the system state might change. This capacity to deliberate and play with multiple prospective futures is key to negotiating what it is that is and isn't sustainable over time, particularly in the medium term.. Probably the most important feature of the scheme presented here is the way it shows that messy, labile values with material outcomes can still be treated in an organized fashion. We do have the means to variously and shiftingly set what are deemed as appropriate visions for our passage into the future.

## 8. Acknowledgements

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VISTA framework and underwrote a number of the themes explored here. Additionally, I thank Fabien Quétier for his expertise and inputs into the development of the presented hypothetical example.

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# Tables

Table 1 Definitions of the concepts liveability and sustainability

| Term | Definition |
|---|---|
| Liveability | A statement of desires related to the contentment with life in a particular location of an individual or set of individuals. |
| Sustainability | Capacity to deliver those desires to an individual or set of individuals through time. |

Table 2. Definitions of key concepts used in the VISTA framework (adapted from de Chazal et al. 2008). For the purposes of this paper, ecosystem properties, land-use attributes and descriptors are grouped together as ‘ecosystem attributes’.

| Term | Definition |
|---|---|
| Ecosystem services | Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth (Millennium Ecosystem Assessment, 2003, p 49). |
| Ecosystem properties | Structural or functional characteristics of ecosystems. They include plant functional traits such as plant height or specific leaf area, other structural properties such as species richness or vegetation structural diversity, and processes such as aboveground net primary production or litter decomposition. |
| Land-use attributes | Descriptions of management practices (including intensity of management) that characterise the land-use(s) for a given ecosystem. Examples include manure input, presence of features of agricultural activity (fences, irrigation equipment), grazing intensity or hay cutting. |
| Descriptors | Stakeholder derived descriptions of observable characteristics of ecosystems. Descriptors include ‘natural’ or less human modified elements such as trees, wildflowers, and wild animals through to more human modified elements such as fences, farm machinery, and livestock. Descriptors linked to the ecosystem properties are termed biophysical descriptors. Descriptors linked to land-use attributes are termed land-use descriptors. A descriptor may also be the same as an ecosystem property or a land-use attribute. |
| Stakeholders | Individuals, a set of individuals, and/or a community or an agency with identified preferences for a single, or set of ecosystem services. |
| Acceptability | Stakeholders’ judgements about changes in identified ecosystem services as a response to ecosystem change |
| Vulnerability | The comparison of acceptability of change in ecosystem services, as a response to ecosystem change for all selected scenarios. |

# Figures

Figure 1 Schematic giving an overview of the VISTA framework (from de Chazal et al. 2008, Fig.1).

Exposure, sensitivity and adaptive capacity represent three commonly used components of ‘vulnerability’. For the purposes here, exposure represents systems change characterised in terms of ecological attributes, sensitivity represent changes in the delivery of ecosystem services, and adaptive capacity and vulnerability represent acceptability of changes with respect to stakeholders’ desires.

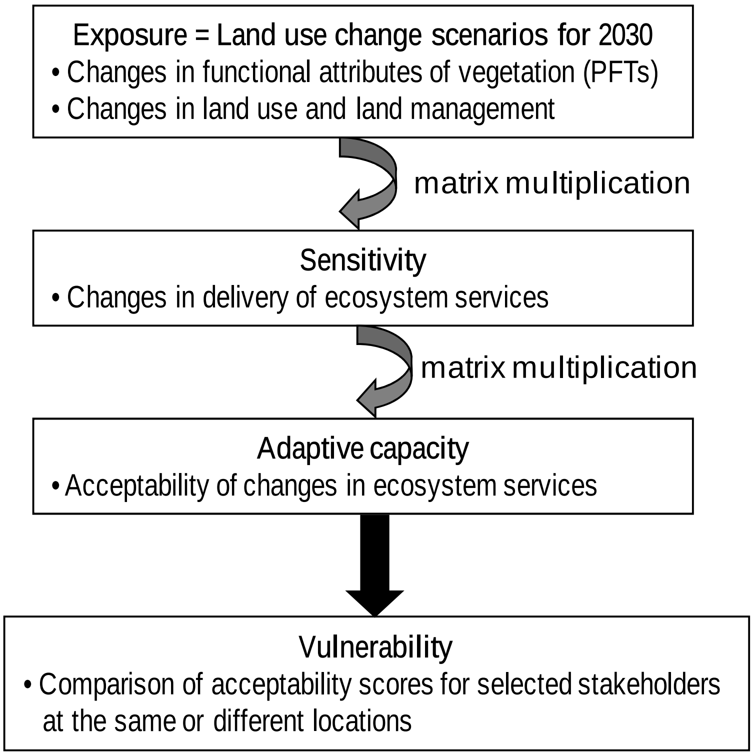

Figure 2a-c (modified from de Chazal et al. 2008, Fig 2a.c, 3a-b). (a) Ecosystem services matrix for Lautaret (b) Descriptors matrix for Lauraret (c) Ecosystem attributes matrix for Lautaret (grey areas represent non-applicable relationships, this table representing a combination of two tables as originally presented). Relationships linked to 'habitat for fauna' are omitted from successive matrices (Fig. b-c) as they do not feature in the example presented.

a.

| ***Ecosystem Service matrix (Lautaret)*** | | Ecosystem Services | | |
|---|---|---|---|---|
| | | Wild beauty of the landscape | Hay for winter fodder | Habitat for fauna |
| Stakeholders | Hikers | + | 0 | 0 |
| | Farmers | - | + | 0 |

b.

| ***Descriptor matrix (Lautaret)*** | | Stakeholder descriptors | | | | | |
|---|---|---|---|---|---|---|---|
| | | Variety of flower colours | Grassland productivity | Abundance of legumes | Abundance of unpalatable plants | Visual cues of agricultur al | Open landscape |
| Ecosystem Services | Wild beauty of the landscape | + | 0 | 0 | 0 | - | + |
| | Hay for winter fodder | 0 | + | + | - | + | + |

c.

| ***Ecosystem Attributes matrix (Lautaret)*** | | Ecosystem Attributes | | | | | |
|---|---|---|---|---|---|---|---|
| | | Phosphorus availability for plant growth | Flowering Diversity Index | Grass productivity ($kg.m^{-2}$) | Abundance of *Festuca paniculata* (%) | Organic Fertilization | Flock size |
| Stakeholder Descriptors | Variety of flower colours | 0 | + | 0 | - | | |
| | Grassland productivity | + | 0 | + | 0 | | |
| | Abundance of legumes | + | 0 | 0 | - | | |
| | Abundance of unpalatable plants | - | 0 | 0 | + | | |
| | Visual cues of agricultural activities | | | | | + | + |
| | Open landscape | | | | | 0 | + |

Figure 3 a-c. (modified de Chazal et al. 2008, Fig. 5c., 6a, c). (a) Site level sensitivity (changes in the delivery of ecosystem services) for Lauraret (b) Acceptability of changes in ecosystem services for stakeholders at Lautaret (c) Acceptability scores for stakeholders at Lautaret.

a.

| Site level sensitivity | | Scenarios | |
|---|---|---|---|
| | | *Staying Tame* | *Going Wild* |
| Ecosystem services | Wild beauty of the landscape | - | - |
| | Hay for winter fodder | + | - |

b.

| Acceptability (Lautaret) | Scenarios | |
|---|---|---|
| | *Staying Tame* | *Going Wild* |
| **Hikers** | | |
| Wild beauty of the landscape | - | - |
| Hay for winter fodder | 0 | 0 |
| **Farmers** | | |
| Wild beauty of | + | + |
| Hay for winter fodder | + | - |

c.

| Acceptability score (Lautaret) | Scenarios | | *Across Scenarios* |
|---|---|---|---|
| | *Staying Tame* | *Going Wild* | |
| Hikers | - | - | - |
| Farmers | + | 0 | + |
| *All stakeholders* | 0 | - | 0 |

Figure 4a-c Hypothetical changes in the ecosystem services matrix for Lautaret (b) Hypothetical changes in the descriptors matrix for Lauraret (c) Hypothetical changes in the ecosystem attributes matrix for Lautaret (grey areas represent those relationships that were modified).

a.

| ***Ecosystem Service matrix (Lautaret)*** | | Ecosystem Services | | |
|---|---|---|---|---|
| | | Wild beauty of the landscape | Hay for winter fodder | Habitat for fauna |
| Stakeholders | Hikers | + | + | 0 |
| | Farmers | 0 | + | 0 |

b.

| ***Descriptor matrix (Lautaret)*** | | Stakeholder descriptors | | | | | |
|---|---|---|---|---|---|---|---|
| | | Variety of flower colours | Grassland productivity | Abundance of legumes | Abundance of unpalatable plants | Visual cues of agricultural activities | Open landscape |
| Ecosystem Services | Wild beauty of the landscape | + | + | 0 | 0 | + | + |
| | Hay for winter fodder | 0 | + | + | - | + | + |

c.

| ***Ecosystem Attributes matrix (Lautaret)*** | | Ecosystem Attributes | | | | | |
|---|---|---|---|---|---|---|---|
| | | Phosphorus availability for plant growth | Flowering Diversity Index | Grass productivity ($kg.m^{-2}$) | Abundance of *Festuca paniculata* (%) | Organic Fertilization | Flock size |
| Stakeholder Descriptors | Variety of flower colours | 0 | + | + | - | | |
| | Grassland productivity | + | 0 | + | 0 | | |
| | Abundance of legumes | + | 0 | 0 | - | | |
| | Abundance of unpalatable plants | - | 0 | 0 | + | | |
| | Visual cues of agricultural activities | | | | | + | + |
| | Open landscape | | | | | 0 | + |

Figure 5 a-c. (a) Hypothetical changes in site level sensitivity (changes in the delivery of ecosystem services) for Lauraret (b) Hypothetical changes in acceptability of changes in ecosystem services for stakeholders at Lautaret (c) Hypothetical changes in acceptability scores for stakeholders at Lautaret (grey areas represent those relationships that were modified).

a.

| Site level sensitivity | | Scenarios | |
|---|---|---|---|
| | | *Staying Tame* | *Going Wild* |
| Ecosystem services | Wild beauty of the landscape | + | - |
| | Hay for winter fodder | + | - |

b.

| Acceptability (Lautaret) | Scenarios | |
|---|---|---|
| | *Staying Tame* | *Going Wild* |
| **Hikers** | | |
| Wild beauty of the landscape | + | - |
| Hay for winter fodder | + | - |
| **Farmers** | | |
| Wild beauty of the landscape | 0 | 0 |
| Hay for winter fodder | + | - |

c.

| Acceptability score (Lautaret) | Scenarios | | *Across Scenarios* |
|---|---|---|---|
| | *Staying Tame* | *Going Wild* | |
| Hikers | + | - | 0 |
| Farmers | + | - | 0 |
| *All stakeholders* | + | - | 0 |