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DAPSET - Concept for Characterising Socio-Economic Drivers of and Pressures on Biodiversity

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Concept for Characterising Socio-Economic Drivers of and Pressures on Biodiversity

ABSTRACT

This article develops eleven criteria focusing on the relative importance and strength of different, especially socio-economic drivers of and pressures on biodiversity. These refer to the syndrome concept designed to assess global environmental risks and the DPSIR framework developed to guide integrative assessment of links between human activities and degradation of the natural environment. The aim is (a) coordinating interdisciplinary research on distinguishing characteristics of drivers and pressures, (b) structuring interdisciplinary discussions on scale and cross-scale dynamics in assessment of biodiversity change as well as (c) setting priorities in policy making and implementation of response actions.

Key words:

Biodiversity change, assessment criteria, setting priorities in driver-pressure management

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I. Introduction

There is a broad consensus among the scientific community that anthropogenic factors relating to unsustainable production and consumption are the primary causes that lead to biodiversity loss, depletion of the foundation for ecosystem resources and services provisioning as well as cause deterioration in human well-being (e.g. MEA, 2005; EEA, 2006). This agreement is also reflected in the global, regional and national political will to act with the aim of halting the loss of biodiversity by 2010, as e.g. stated at the World Summit in Johannesburg, 2002, in the EU's 6th environmental action programme issued in 2002 and included in the national biodiversity strategies of several countries (EEA, 2006; 2007). There are methodological advances that systematically link human activities and degradation of the natural environment such as the DPSIR (Drivers – Pressures – State – Impacts – Responses) framework (EEA, 2003). However, such frameworks fall short of providing clear analytical insights required to achieve common understanding of threats to biodiversity, particularly which drivers or pressures to counteract first and also by which measures, at the same time taking into account institutional matters such as governance at different geographical scales.

In the literature key, drivers and pressures of biodiversity change are often identified and discussed either without naming any criteria for weighing their relative importance or their linkages to management priorities or by applying a diverse set of criteria. For example, a recent paper by Spangenberg (2007) provides two tables of relevant drivers and pressures behind biodiversity loss. The first table lists all pressures in Europe regarding the frequency with which they are mentioned in national sustainability and environment reports (p. 152-153). The second table lists the main driving (physical, primary) forces regarding their importance in current politics and to stakeholder perceptions (p. 155). In addition, the European Environmental Agency (EEA) report on the Millennium Ecosystem Assessment identifies main drivers and pressures regarding "growing demands for food, fresh water, timber, fibre and fuel" (EEA, 2006, p. 11). Moreover, Sala et al. (2000), in reporting results of a scenario analysis, point out that among five major drivers of change in terrestrial ecosystems (i.e. land-use change, climate change, nitrogen deposition, biotic exchange and elevated carbon dioxide concen-

tration) “Land-use change is the most severe driver of changes in biodiversity…” (p. 1771).

However, it is not clear why mentioning a driver or pressure frequently in the literature can be taken as an adequate measure for its relative importance. Research may, for example, be driven by the resources at hand (e.g. expertise and/or money; Vadineanu/Palarie, 2004) and thus deliver a distorted picture of the relative importance of certain drivers and pressures. Secondly, there are some inconsistencies in ways of using drivers and pressures in research on biodiversity change. Sala et al. (2000) identified climate change as a driver, but Spangenberg (2007) categorizes climate change as a pressure. Furthermore, land-use change, the most severe driver according to Sala et al., is classified by Spangenberg as pressures on biodiversity in terms of habitat fragmentation and habitat size reduction. These differences in viewpoint call for developing a common assessment framework for the importance of drivers and pressures which allow integrated cross-scale analysis to provide policy and decision makers with information for setting priorities in biodiversity management. Therefore, this paper aims to provide a set of eleven criteria to identify and distinguish between important characteristics of socio-economic drivers and pressures that cause biodiversity change. These criteria were developed on the basis of the syndrome concept introduced for assessing global environmental risks (WBGU, 2000) and serve as a first step in the process of developing science-management, science-policy and management-policy interfaces.

The paper is structured as follows: Section II provides a review of frameworks for assessing biodiversity-relevant drivers and pressures and points out why it is necessary to go beyond existing frameworks. It additionally describes a set of criteria for assessing the importance and strengths of drivers and pressures as tools for prioritizing research and decision making. Section III introduces the set of assessment criteria and presents results from an explorative study designed to evaluate the acceptance of the assessment criteria within a group of experts in the field of biodiversity research. Finally, we draw conclusions and present an outlook in section IV.

II. Review of frameworks for assessing drivers and pressures

Biodiversity and its changes are subject to numerous anthropogenic drivers and pressures. Anthropogenic drivers include social, cultural and economic forces that create various pressures on nature (Nelson et al. 2006). For example, economic and population growth are the underlying causes of agricultural intensification and urbanisation (EEA

2004, 2005, Lambin et al., 2003). Since the early 1960s, there has been a considerable amount of research to improve our understanding of the implications of the profound changes of the environment and all their devastating effects on the socio-ecological global system. However, there still remain gaps in our knowledge of the likely impact of the different forces, particularly those of the underlying causes of biodiversity change. These are often disconnected from priority setting for biodiversity management. When the first alarming signals towards resource depletion and environmental damage came to light in the 1960s, systems of environmental statistics were created in order to assist in formulating and evaluating different sectoral and integrative policies. Four major approaches have been used at the international level:

1. *The media approach*, based on considering the major environmental components air, land, water and human-made environment;
2. *The stress-response approach*, focused on human impact and subsequent transformation;
3. *The resource-accounting approach,* which traces the flow of natural resources from extraction until their return to the environment;
4. *The ecological approach*, based on using models, monitoring techniques and ecological indices. This approach, with regard to data organization, draws on the notion of pressures, state, and response (PSR), but applies these concepts only to ecological zones within the country (GIS uses the ecological approach, for example; Shah, 2000).

Different combinations of these approaches have been used on all scales of the environmental statistics (local, regional, national). As a result, several major frameworks have been created. Among the frameworks, the most relevant for worldwide diffusion and applicability are:

- FDES – A Framework for the Development of Environmental Statistics – developed and published in 1984 by the United Nations Statistical Office;
- PSR – Pressure-State-Response framework – developed by the Organization for Economic Cooperation and Development (OECD);
- DSR – Driving forces-State-Response framework – from the Commission of Sustainable Development;

- DPSIR – Driving forces-Pressure-State-Impact-Response framework – used by European Environment Agency (EEA) and the Statistical Office of the European Communities (Eurostat).

These frameworks have served to different degrees to assess biodiversity drivers and pressures, but the DPSIR framework generates the most complete approach, by specifically referring to biodiversity loss and by separating drivers from pressures.[1] All the other frameworks include either biodiversity under different umbrella information categories such as social and economic activities, natural events (FDES) or environment (DSR), or refer only to drivers or pressures like PSR and DSR. The most complete framework is thus DPSIR, which deals with biodiversity-relevant drivers and pressures separately and was adopted by ALTER-Net to explicitly support the identification of sources that cause biodiversity change.

III. Assessing Drivers and Pressures within the DPSIR framework

As biodiversity loss is no longer a problem of "flagship" species and ecosystems, but of global concern, there is a need for understanding and action towards reducing biodiversity loss rate as well as controlling changes. One way of assisting the decision-making process for this purpose is using environmental statistics that can provide valuable information with the help of important frameworks such as DPSIR. However, although the DPSIR framework is a useful guide to complex issues, it may not fully represent all aspects of cross-scale dynamic environmental phenomena, particularly when there is a need to approach particular contexts by applying more detailed quantitative and qualitative models. More specifically, it does not distinguish between the relative importance of different drivers and pressures. To make progress in this type of assessment, we propose a set of eleven criteria that deliver information on the severity of drivers and pressures at different time and spatial scales. This information will facilitate the groundwork for identifying the most effective policy measures, their adequate timing and the most

[1] Another framework focusing only on water issues is GIWA. GIWA also uses the stress-response approach for analysing the causal chains between perceived problems and their societal roots. The five major problems analysed by GIWA are freshwater shortage, pollution, habitat and community modification, unsustainable exploitation of fisheries and other living resources and global change.

suitable governance level at which these measures should be implemented and socio-ecological monitoring should take place.

1. The set of assessment criteria

Various data sources in recent years indicate that human intervention in nature has assumed dimensions as never before; disturbances to socio-ecological systems have not only increased in magnitude, but their effects on the vulnerability of well-being have also become increasingly unpredictable. This has caused concerns regarding the appropriateness of applied conservation and management strategies. Consequently, this issue presents a new methodological challenge to applying science in the development of new approaches and strategies: (i) to consider the interplay between humans and nature; (ii) to incorporate knowledge on regulatory functions of ecosystems and their components into the scheme of nature management; (iii) to discover components which are able to accept and deal with a level of uncertainty and unpredictability. These enable identifying priority areas for action, avoiding activities that have harmful and irreversible effects on performance of both natural and human systems, and dealing with drivers and pressures in the way that diminish their negative consequences. In order to contribute constructively to an effective and efficient management of drivers and pressures on biodiversity, we have adopted the syndrome concept for assessing global environmental risks developed by the German Advisory Council on Global Change (WBGU) in 1998 (WBGU 2000). This concept provides taxonomy of globally relevant risks and highlights links between risk classes and management strategies. The aim was to depart from the principle of 'trial and error' that dominates in empirical methods because errors with global consequences can lead to unacceptable and irreversible damages. The characteristics used for classification include: uncertainty regarding the probability distribution of damage, catastrophic potential, a probability of occurrence, the associated magnitude of damage, persistency and ubiquity (scope in time and space), reversibility of potential damage, and potential for social conflict and mobilization.

This concept has been used as a starting point for the development of **DAPSET - D**rivers **a**nd **P**ressures – **S**trength **E**valuation **T**ool – presented in this paper. The purpose of this exercise is to fill the gap in the current knowledge about the need for such a concept (science-policy interface), its communication with the process of political decision making (science-management interface), and application with respect to the protection of biodiversity (management-policy interface). The proposed set of assessment criteria in-

tegrates knowledge in the fields of social and natural sciences to inform and guide policy-making processes and draws attention to the most crucial areas of socio-ecological monitoring. The set of criteria identified and analysed in this study focuses on drivers and pressures with respect to:

a. The potential to create impact on biodiversity: *Damage potential*, *Probability*, *Irreversibility* (criterion 1 to 3),
b. Vulnerability in terms of geographical scale and targets: *Spatial scale*, *Connectedness* (criterion 4 and 5)
c. Dependency in terms of time: *Acceleration*, *Persistence* and *Time delay* (criteria 6 to 8) and
d. Public awareness: *Invisibility*, *Information Unavailability* and *Public mobilization* (criterion 9 to 11).

Criteria are most directly concerned with the first two elements of the DPSIR framework, but their assessment also refers to the other DPSIR components – *state*: present as existing expert knowledge on potentials, *impact*: part of assessment procedure and *response:* linked to reactions and decisions as a result of the information gathered with the help of DAPSET.

Criteria 1-5 have been pre-defined as those of the first order, as they are critical in guiding the management options. Criteria 6-11 deliver additional information regarding the timing and support of policy measures. Before assessing a driver or pressure in terms of all criteria, we also propose to pre-determine a) the spatial area of assessment which could either be the regional scale (here, EU level), the national scale (country level) or the local scale (site level) and b) the time period of assessment which may either reflect a short-run focus (0-5 years, i.e., driver or pressure is already at work or will be at work within the next 5 years), a medium- (5-10 years) or long-term focus (more than 10 years). Predetermining the spatial area of assessment should allow comparing characteristics of a driver or a pressure at different scales of assessment (local versus national versus regional) because the assessment of one driver or pressure at different scales may lead to distinct results. And pre-selection of the time frame touches upon dissimilarities in the appearance of drivers and pressures because some drivers or pressures are already evident (like implemented national policies and standards), whereas others (like technological developments or further increase in global temperature) are not apparent but expected. When the general frame of assessment has been set, the characteristics of a driver or pressure are determined regarding:

a) The potential to create impact

Criterion 1: Damage Potential

The first criterion refers to a possible loss of or damage to biodiversity and ecosystem goods and services. The loss should be measured or estimated in monetary terms by using different economic valuation methods, for example, the *market price* of goods and services provided by the ecosystem, the *willingness to pay* for protecting specific species and ecosystems, the *travel costs* as an expression of the benefits of recreation in nature and *option* or *non-use values* for specifying aesthetic or nature-immanent qualities. Due to scarce financial resources, quantifying the damage potential of different drivers and pressures is not only fundamental for setting management priorities in policy making; it also delivers transparency regarding possible benefits that can be gained by costly policy interventions. The importance of such an assessment was currently highlighted at COP9 in Bonn 2006 (EC 2008).

Criterion 2: Probability

The assessment of probability relates to the occurrence of a Driver or Pressure and depends on the availability of data and knowledge regarding the likelihood of potential events and underlying mechanisms of the system under consideration. In some cases objective data sets may be available; in the others only subjective expectations which nevertheless allow a constructive way of assessing uncertainty by reflecting an "educated guess" by the researcher or the practitioner. Assessing the probability of Driver or Pressure occurrence helps to reflect the severity of the damage potential and possible irreversibility as assessed by the following criterion.

Criterion 3: Irreversibility

This criterion focuses on the time required to reverse a Pressure or mitigate a Driver. Although, from a thermodynamic perspective, all natural processes are irreversible, system theory still points out that there is an adaptive capacity of complex systems (living organisms, species, ecosystems). According to Holling (2000) this capacity is governed by panarchy, a term which describes the evolving nature of complex adaptive systems and encapsulates how novelty and change coexist in a context of persistence and stabil-

ity. From this point of view, all events to which the self-organizing capacities of the systems can adapt (e.g. to minor damages or changes in the physical environment) are reversible. Here, a critical question is to know within which time period the effect of the damage can be reversed. The answer to this would provide some hints as to how long society has to cope with a change and how long restoration measures need to be applied to achieve an acceptable ecological potential.[2]

b) Vulnerability in terms of geographical scale and targets

Criterion 4: Spatial Scale

Criterion 4 addresses the question of *political responsibility* by considering the number of administrative units that are affected by a Driver or Pressure. The aim of this assessment is to deliver first hints regarding which governance scale (here: local, national or regional level) is best suited to implement a policy measure – e.g., whether it is necessary or useful to communicate and co-operate among different administrative units. This criterion also indirectly informs about the system-inherent resilience within the affected area when large scale impact lowers their self-regulatory potential or, for example, may slow down or prevent succession and thus ecological recovery of the area.

Criterion 5: Connectedness

Connectedness refers to the number of targets that are hit by a Driver or Pressure. It is related, among other things, to sectors in the economy, aspects of human life: health, aesthetics and ecosystem properties. It informs about the extent of vulnerability by assessing whether one specific sector/property or focus group is affected, a few of them or the whole society. Thus it helps to gain insight into the number of affected policy areas and the degree of linkages among socio-economic and ecological issues involved. The assessment aids decision making and policy co-ordination, e.g. whether or not co-ordination of health and agrarian policy is required.

[2] This criterion shows a close link to the set of criteria focusing on the vulnerability of biodiversity in time. Nevertheless, we consider this criterion in the group of criteria focusing on the potential of drivers/pressures to creat impact. In our opinion, the reason is that irreversibility does not primarily focus on aspects of time but rather on a qualification of the severity of potential impact.

c) Vulnerability in terms of time

Criterion 6: Acceleration

Acceleration focuses on the expected intensification of a process, i.e., whether the speed at which a Driver or a Pressure is at work declines, stays constant, or speeds up slowly or quickly. This assessment may, for example, focus on the reproduction rates of animals, growth rates of plants or the time horizon of decision makers. It helps to decide on which point in time the policy measure is best taken and may indicate a need to intensify the action or redefine the management goal (e.g., a pollution standard or a catch quota).

Criterion 7: Persistence

Persistence refers to how long a Driver or Pressure remains in effect over time. To support the process of political decision making, the time scale for assessment may consider the election periods of political parties. In this case, attention is drawn to whether a problem can be dealt with in one election period (implying that different parties may be involved in solving the problem). Moreover, since there is more than one Driver or Pressure at work, the assessment provides a clue to the possibility and the duration of Driver and Pressure inter-actions.

Criterion 8: Time delay

The focus here is on the time span between the occurrence of a Driver or Pressure on the one hand and the impact on the biodiversity and ecosystem functions on the other hand (e.g. no delay, delay in days/month or years). This kind of assessment also refers to the timing of the policy measures, especially to the time span policy makers may have for taking a set of preventive measures as well as the time lag between their implementation and first results.

d) Public Awareness

Criterion 9: Invisibility

A Driver or Pressure might be fully visible (like urbanization and oil spills), easily visible by monitoring and observation activities (e.g. temperature), by specific observation technologies (e.g. satellite data to identify land cover changes), or may not be visible at all (e.g., due to time lag and/or knowledge gained from artificial settings such as experiments in the laboratory or by using a modelling approach). Depending on the assessment, there may be the need to advise the policy makers to support monitoring activities – e.g., for showing stakeholders what is going on below ground – or to design specific educational and training measures – e.g., training the scientific community in interpreting remote sensing data or teaching school staff about the links between biodiversity loss and people's attitudes and lifestyles.

Criterion 10: Information Unavailability

Here the focus is on access to information, whether information is available free of charge (for example, within the AIDS campaign), at low cost (e.g. by reading newspapers or watching TV), at high cost (e.g., the study of large data sets, specific literature or reports) or whether information is not available at all (e.g. for reasons of national safety). This assessment should allow the design of effective communication strategies that help to enhance public awareness of a Driver or Pressure. Moreover, simultaneously taking the assessment of criterion 9 into account helps to determine the urgency and necessity of information policies to mobilize public support or involvement. On the other hand, it can be a warning message to decision makers that they themselves may not be aware of some aspects or consequences of existing drivers.

Criterion 11: Public Mobilization

Public mobilization refers to public interest and awareness as well as to the occurrence of conflicts. There may be no public interest, low or high involvement of the public, or involvement of specific and less influential or important stakeholders. The assessment thus gives insight into public support of policy measures, e.g., on how much encouragement a policy maker will have when implementing a management plan or how much the policy maker is pushed to do so as a result of advocacy by different interest groups.

Moreover, additionally considering the assessment of criteria 9 and 10 helps to shed light on possible reasons for the lack of involvement if information is not available and/or driver/pressure is not visible.

This set of criteria was designed to structure knowledge on distinguishing features of drivers and pressures and to provide such knowledge in a comprehensive way to policy makers and the broader public. However, to check the validity of DAPSET, we first introduced the set of criteria to a group of experts in the field of biodiversity research.

2. Testing and acceptance of DAPSET

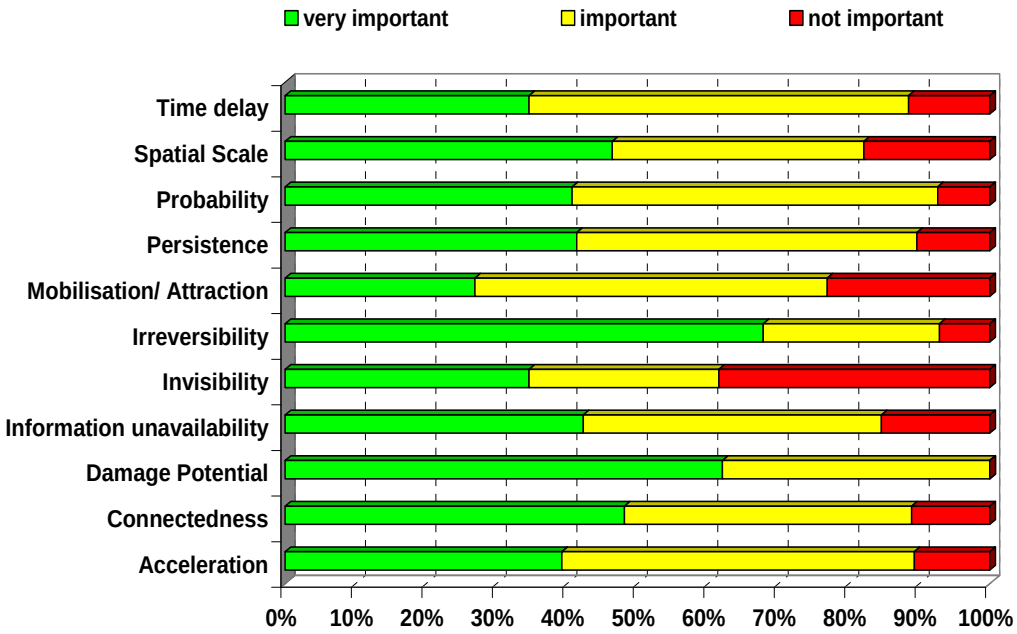
The initial version of DAPSET was presented to biodiversity experts recruited from "A Long-Term Biodiversity, Ecosystem and Awareness Research Network of Excellence" (AlterNet NoE), a consortium of 24 organisations from 17 European countries, funded by the EU's 6th Framework Programme. Members of the partner organisations contribute to a variety of tasks in different work packages, expanding their background expertise into social, ecological and economic aspects. To obtain feedback on the relevance of the presented assessment criteria and the assessment procedure from this group, the authors presented DAPSET at several meetings of the AlterNet where they received common consent. Above all, the authors conducted an online questionnaire to explore the relevance and acceptance of the assessment criteria under the pledge of anonymity. The results of this questionnaire are reported below.

In sum, 31 experts provided complete feedback. The participant group consisted of 15 female and 18 male experts from 13 countries. So as not to distort the data analysis, we did *not* consider the experts' additional answers during the pre-test phase.

In a first step, participants were asked whether they considered each criterion important for driver/pressure assessment. The aim was to eliminate from the provided list those criteria which are not relevant with respect to broader use of DAPSET. For criteria assessed as important, the second step was to decide between two options – important and very important. The hypothesis behind this exercise was to test whether criteria 1 to 5 ("first order" criteria), considered as more important for driver/pressure assessment than the other 6, are similarly perceived by the audience. After going through all presented criteria, the participants had the opportunity of inserting further criteria they thought were either important or very important for driver/pressure assessment.

The results indicated that all criteria were accepted at minimum approval rate of 60%. If *Invisibility* is excluded from the analysis the remaining criteria are accepted as important/very important by more than 75% of participants (Figure 1).

Figure 1: Importance of assessment criteria



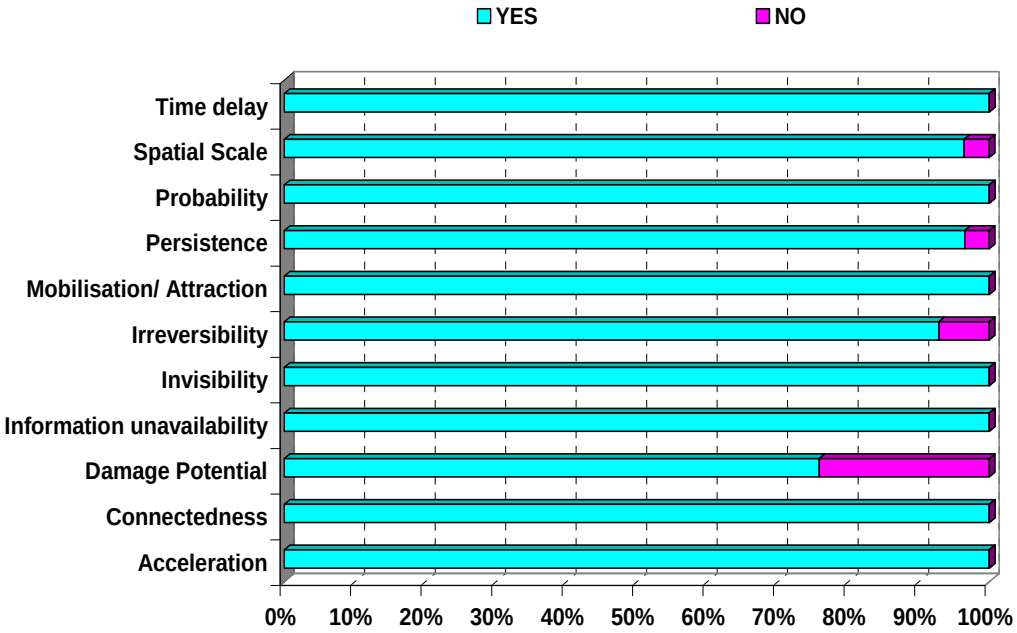
The outcome of the study also supports a division of criteria into two sets: the first order criteria (very important) and the second order criteria (important). Proposed first order criteria are *Irreversibility, Damage Potential, Connectedness, Spatial Scale* and *Probability*. These criteria are not only judged as important by at least 80% of participants, but they were also qualified as very important by more than 40% of the participants. The second order criterion *Persistence* also reaches this threshold value. However, compared with the results of *Probability,* the percentage of people who judged this criterion as not important is higher.

Regarding the proposal of new criteria, only one respondent expanded the set with "Specificity". Since, however, neither a definition nor an assessment scale could be provided, that criterion had not been included in the proposed set of assessment criteria.

The second part of the online questionnaire presented a proposal for an assessment scale (see Appendix 1) and was devoted to collecting comments and suggestions regarding relevance of a scale and a measure. For each of the criteria the participants could either

accept or reject the measurement scale or provide an alternative measurement. Figure 2 shows that roughly 75% of participants agreed with the proposed measurement. If we exclude the measurement for *Damage Potential* the measurement scales were accepted by more than 90% of the participants.

Table 2: Agreement on measurement for criteria assessment



The alternative proposals for measurement included happiness instead of percentage of GDP for assessing Damage Potential. It has also been pointed out that measurement in monetary terms may not be feasible; at any rate, a proposal for an alternative was not provided. Another suggestion was to consider local income instead of GDP for small (site-like) scales. Moreover, the term 'generation' used for measuring Irreversibility was recommended to be defined in a more precise way (time span in years).

IV. Conclusions and Outlook

Achievement of the global aim to slow down or stop biodiversity loss and prevent decline in ecosystem services delivery is still far from reality. Some of the reasons to mention are inappropriateness of the existing monitoring infrastructure (EEA 2001), lack of harmonized research covering adequate time and spatial scales (Dirnböck, et al. submitted), and lack of synthesis of available data and research outcomes (EEA, 2001; WWF, 2006). All of these result from an unclear definition of priority themes for biodiversity

research and management, which can be defined only on a basis of recognition of key drivers and pressures. Thus it is equally important to distinguish characteristics of drivers and pressures i) that would establish a common denominator for importance appraisal, ii) that would be translatable into a set of management measures and, iii) in this way, support communication with stakeholders.

The presented set of eleven criteria adds to the development of a common theoretical basis and research agenda for driver and pressure assessment within the DPSIR (Drivers – Pressures – State – Impacts – Responses) framework. Its design is inspired by the syndrome concept developed for assessing global environmental risks and serves as a first step in the process of developing science-management, science-policy and management-policy interfaces which are employed by world-wide ecosystem assessment initiatives (e.g., GEO-4 2007, WWF 2006, MEA 2004, HFA 2005). These initiatives in particular identified a need for *first*, development of methods and approaches considering economic, social and cultural context of environmental changes; *second*, institutional development following recognition of a critical role of decision makers in environmental and social impact assessments, *third*, and finally, implementation of tools facilitating decision making through incorporation of multi-sectoral and interdisciplinary knowledge. The methodology provided in this paper supports these tasks by framing the multi-dimensional character of factors inducing environmental change: strictly defined parameters enable comparison of the impact of pressures and drivers at a number of scales; assessment guided by clearly defined criteria contributes to building awareness of important distinguishing features of drivers and pressures. This promotes long-term studies on aspects of management and making the most of scarce financial resources as well as scaling up or down solutions and best practices. We thus believe that despite the potential for serving as a support for decision making, the criteria open doors for continuous dialogue and cooperation among researchers, response agencies, technical and scientific specialists, planners and other stakeholders. However, further efforts are needed to transform the criteria set into an applicable tool that shows important characteristics of biodiversity change in terms of driver-/pressure-specific risk profiles. Case study testing is essential to check the completeness, operability, and usefulness of policy planning and management as well as to compare its potential with reality. Consequently, the goal is now to test and redefine the set of criteria in the field, especially in the geographical boundaries of the newly founded LTSER – *Long-Term Socio-Ecological Research* – sites all over Europe (e.g. Ohl/Krauze/Grünbühel 2007).

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Appendix 1: Assessment Criteria and related Measurement Scales (First order criteria)

Criterion (first order)	Measure	Boundaries			
		LOW	**MEDIUM- LOW**	**MEDIUM- HIGH**	**HIGH**
Damage Potential	Percentage of GDP	Less than 1%	Up to 2 %	Up to 5 %	Above 5%
Probability	Subjective probability (P)	$P \leq 0.25$	$0.25 < P \leq 0.5$	$0.5 < P \leq 0.75$	$P > 0.75$
Irreversibility	Time required for reversing pressure/ mitigating driver	Reversible within one year	Reversible within 5 years	Reversible within one generation	Irreversible even for future generations
Spatial Scale	Number of administrative units at considered level (local, national, EU-level)	One administrative Unit	Several Administrative units	Most of the Administrative units	Whole area considered is affected
Connectedness	Number of "targets" hit by considered driver/pressure (e.g. sectors in economy, aspects of human life: health, aesthetics, ecosystem properties	One specific sector/ property/ group of people	Few sectors/ properties/ groups of people	A large number of sectors/properties/ groups of people	Whole economy/ society is affected

Appendix 1: Assessment Criteria and related Measurement Scales (Second order criteria)

Criterion (second order)	Measure	Boundaries			
		LOW	**MEDIUM- LOW**	**MEDIUM- HIGH**	**HIGH**
Acceleration	Expected intensification of the process, assessment focuses on current state, time scale to adjust dependent on the context	Speed declines	Stays constant	Slowly speeds up	Quickly speeds up
Persistence	Existence of driver/pressure over time, with time scale referring to election periods of politicians	Less than one year	1 to 5 years	5-10 years	More than 10 years
Time delay	Time span between occurrence of driver/ pressure and their impact	No delay	Days/month(s)	1-10 years	More than 10 years

Invisibility	Visibility of considered driver/ pressure	Fully visible	Visibility easily provided by monitoring/ observation	Visibility provided by specific observation technologies/ expert knowledge	Not visible at all
Information unavailability	Access to information about considered driver/pressure	Information is accessible free of charge	Information is accessible at low cost (e.g. public media)	Information access at high cost (study of large data sets, specific reports etc.)	Information is not provided to the public
Mobilisation/ Attraction	Public interest/awareness	No public interest	Attracts specific and less influential stakeholders / small group of people	Attracts important stakeholders/large group of people	All kinds of people, most of/the entire public