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4 **The emergence of the social-ecological restoration concept**
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13

14 **Author contributions**

15 JFM conceived and designed the study; AGB contributed the study case with Amazonian
16 Ecuador communities; JFM, AGB, SR wrote and edited manuscript.
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18

19 **Abstract**

20 Many ecosystems in the world are the result of a close interaction between local people and their
21 environment, which are currently recognized as social-ecological systems (**SoES**). Natural
22 catastrophes or longstanding social and political turmoil can degrade these **SoES** to a point where
23 human societies are no longer autonomous and their supporting ecosystems are highly degraded.
24 Here we focus on the special case of the restoration of **SoES** that we call social-ecological
25 restoration (**SoER**), which is characterized as a restoration process that cannot avoid
26 simultaneously dealing with ecological and social issues. In practice, **SoER** is analogous in many
27 ways to the general principles of ecological restoration, but it differs in three key aspects: 1) the
28 first actions may be initially intended for human groups that need to recover minimum living
29 standards; 2) the **SoER** process would often be part of a healing process for local people; and 3)
30 there is a strong dependency on external economic inputs, as the people belonging to the **SoES**
31 may be incapable of reorganizing themselves on their own and supporting ecosystems can no
32 longer self-recover. Although it might not be desirable or necessary to call all restoration projects
33 with a social component a **SoER**, the use of this concept may help in defining early restoration
34 targets that may prevent conflicts among users in the long term. From the perspective of other
35 disciplines and humanitarian institutions, **SoER** would be more appropriately perceived as
36 programs of ‘social-ecological recovery’ or ‘social-ecological development’.

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38 **Key words:** ecosystem restoration, humanitarian crisis, natural catastrophes

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Implications for Practice

- Social-ecological restoration (**SoER**) cycles may involve several very difficult decisions between human well-being and ecosystem recovery for which many managers may feel overwhelmed. Hence, managers should reach for extended collaboration beyond their usual disciplines and institutions.
- Natural catastrophes may set ecosystems in trajectories for which people dependent on them may not be able to cope with. Open minds and a dynamic view of ecosystems are therefore needed for a successful **SoER**
- Resources need to be wisely allocated in **SoER** as social dynamics can be very fast while ecosystem dynamics may be beyond human generation times

Introduction

Reconciling ecological restoration goals with human well-being objectives is a restoration approach that needs no further presentation in the ecological sciences. The link between the two has been actively tackled through the ecosystem services concept, with various review articles suggesting the links between restored diversity and ecosystem function on the one hand, and the availability of ecosystem services on the other (Benayas et al. 2009; Alexander et al. 2016). The underlying hypothesis is that if restoration re-enables ecosystems services while maintaining and promoting biodiversity, human needs are met in a “win-win” scenario and may even help to alleviate poverty (Cao et al. 2009; Aronson et al. 2010 and references therein; Cao 2011; Yin & Zhao 2012). A related approach used to address the relation between ecological and social issues in restoration has been to include traditional knowledge in restoration programs (e.g., Uprety et al. 2012). However, an ecosystem service-centered approach to restoration and conservation goals has been also criticized on the grounds that it can lead to a loss of biodiversity and ecosystem functions in the long term without really solving the social issues they were supposed to (Blignaut & Aronson 2008; Vira & Adams 2009; Schroter et al. 2014; Batavia and Nelson 2017). Hence, there is a need to maintain a diversity of views regarding the relation between people and ecosystems when social and economic concerns are pressing.

Here we argue that under certain circumstances, a common goal of social and ecological reparative measures can be explicitly named ‘social-ecological restoration’ provided that the goal is to restore a ‘social-ecological system’. By social-ecological system, we understand a complex system that has emerged through a series of people’s close interactions with their supporting ecosystems and species, creating structures and processes that would otherwise not exist. Only until recently has the scientific literature begun to explicitly address the concept of social-

ecological restoration as both a practice and a conceptual field in itself. To the best of our knowledge, the term was coined recently by Takeuchi and collaborators in an article addressing the need for a comprehensive approach to reconstruct the areas devastated by the 2011 earthquake, ensuing tsunami, and radioactive pollution in northeastern Japan (Takeuchi et al. 2014).

In contrast to the ecological sciences, the social sciences and organizations that deal with humanitarian crises do not use the word restoration. Instead, the term ‘recovery’ is more commonly used, but mostly as part of a ‘recovery plan’ for countries torn down by war or natural catastrophes (UNDG 2007). The expression ‘social restoration’ is not used in the social sciences, because it would be a controversial concept for obvious reasons, including undesirable political interpretations. Societies and cultures are not restored as no one would intend to return exactly to past cultural values or practices. It is well accepted that cultures change and that each epoch has its own set of shared values that will evolve over time. Nevertheless, the expression ‘social restoration’ has been used sporadically by urban planners in the context of how ecological restoration should be socially acceptable and not lead to conflicts with users (Eden & Tunstall 2006; Nagendra & Ostrom 2014). Thus, it would appear that Takeuchi and colleagues’ use of social-ecological restoration is the first attempt to clearly interlink social and ecological goals in the reconstruction of societies and their supporting ecosystems.

Here we propose that social-ecological restoration (**SoER**) is a problem-solving approach in which the main goal is to *jointly* restore the interdependent social and ecological processes in a social-ecological system (**SoES**). We believe that this concept and practice are probably more adapted to areas in which the historically strong presence of humans has shaped the terrestrial landscapes, wetlands, and coastal areas and in which present-day human populations struggle to have a sustainable society. We discuss throughout the text how this approach differs from

ecosystem-service centered restoration and present some practical issues related to the emergence of the **SoER** concept by presenting a parallel with humanitarian crises and a case study from the Shuar communities in Ecuador.

Do we need a new concept?

The short answer, in our opinion, is yes. Many readers will argue that they have already been working in social-ecological restoration and that the lack of a term has not prevented them from using both ecological and social approaches to deal with specific restoration cases, which we agree with. Yet the need to use a specific term, as with Takeuchi and collaborators, stems from at least three key points: 1) it permits an up-front dismantling of any animosity or ambiguity in a restoration program by setting clear goals from the onset that are well accepted by a majority of people; 2) it helps to identify quickly objects and processes that link the natural system and human societies at the proper geographical and temporal scales; and, most importantly, 3) it is a concept appropriate for societies that have suffered from natural disasters or long-term armed conflicts in which people have lost everything and supporting ecosystems are presently fragile.

Conflicts and animosity against restoration programs is not new, and it is one of the most recurrent issues (Geist & Galatowitsch 1999; Buckley & Crone 2008; Palamar 2010; Halme et al. 2013; Winkel 2014; Druschke & Hychka 2015; Fox et al. 2016; Alves-Pinto et al. 2017). As stated previously by Geist and Galatowitsch (1999), there is a need to show and implement reciprocity in restoration programs so that people's contributions to the restoration of ecosystems are inversely compensated by the contributions of ecological restoration to people, which proves extremely challenging. In areas where there are close links between human societies and plant or animal populations, which represent the main resources of livelihood, programs framed as **SoER**

may be better accepted by stakeholders. Humanitarian, post-conflict or post-catastrophe management agencies and organizations will be obliged to look into ecosystem recovery, something that is frequently overlooked because of the dimensions of the crisis (Abrahams 2014). Evidently, the open use of the social-ecological restoration concept does not prevent all conflicts, as unforeseen tensions may emerge at any time.

The **SoER** approach helps to identify early keystone objects and processes that would otherwise be pondered differently or in later steps if only ecological or social analysis were conducted. After a crisis, chances are that the affected society will very quickly point out what essential components of the ecosystem are lacking and what processes have been disrupted that they deem necessary to return back to their normal lives. In the case of the post-tsunami actions in Japan, coastal forests (object 1) were identified as natural way to stabilize dunes (process 1) in stark opposition to concrete barriers which would destroy the landscape. Likewise, inner riparian broadleaf forests (object 2) were identified as a means to maintain good-quality water (process 2) for oyster culture in the sea, which is an essential part of the human activities in the area (Takeuchi et al. 2014), and so forth. This object-process based approach will also help to identify the disciplines and expertise required to tackle problems at the social-ecological level in an interdisciplinary way as this cannot be anticipated in advance. Whether forestry, aquaculture, agronomical and even mining expertise is needed during the implementation of a humanitarian program depends much of how people see themselves after crises (see next).

In our view, the use of **SoER** as a driving concept can prove particularly useful after natural or human-induced disasters, because almost all natural and social processes and structures have been disrupted. Moreover, as shown by Takeuchi and collaborators (2014) and in the example of the recovery after Hurricane Katrina in the southeastern United States (for a review see Day et al.

2007), reconstructing the links between people and natural processes can help in the healing processes for the human populations. For instance, reconstructing the natural structure of the Mississippi Delta will require new paradigms of development if the same catastrophes are to be avoided in the future, and if a human environment that is culturally identified with living within the wetlands is to be maintained. However, the **SoER** concept may be useful not only for regions affected by large natural catastrophes, but also in places where longstanding conflicts and social turmoil have erased people's capacity to manage and conserve their ecosystems (see example with Amazonian communities in the last section). For example, international organizations have been increasingly working with the restoration of degraded ecosystems due to overpopulation, poverty, and war (see <http://www.unep.org/disastersandconflicts/what-we-do/recovery/environmental-cooperation-peacebuilding> and UNEP 2016). While the expression of **SoER** has not been used in these programs, the arguments are similar to what we propose here. In fact, the subjacent idea that the good governance of resources is an essential way to prevent conflicts strengthens the concept of **SoER**.

What is the scale of social-ecological restoration?

If the research or restoration object of **SoER** is the social-ecological system, then its spatial and temporal scale corresponds to the **SoES**. As seen above, the general definition of **SoES** is open to discussion regarding the relevant spatial scale, because it is difficult to trace limits in a globalized economy. One response from institutional economics can help us to limit the scope of **SoER**. In particular, the works of Elinor Ostrom and colleagues define the scale (or **SoES** itself) as the scale at which people self-organize to use a given resource (Ostrom 2009). In the context of Ostrom's works, 'resource' refers to provisioning ecosystem services such as irrigation water, timber,

fisheries, and so on. This approach baffles the majority of ecologists who, for obvious reasons, would argue that the spatial scale of the supporting ecosystem as the scale to consider. Hence, **SoER** would need explicitly a step of negotiation between ecologists and social workers and between the ecologists and funding agencies for the need to include a larger geographical area for the implementation of restorative ecosystem measures. Again, this was clearly shown by Takeuchi and collaborators when they addressed the need to work together on the mountain-plane interface (*satoyama*) and on the shore-sea interface (*satoumi*) as integrated units that represent essential components of their cultural heritage.

People recovery, reference systems, and external inputs

Solving humanitarian crises (EuropeAid 2004) and ecological restoration (McDonald et al. 2016) share management principles of cycles of diagnostics, implementation and evaluation (Fig. 1, Supporting Information Appendix S1). Restoration cycles, either ecological or humanitarian, are necessarily sequential, incremental and each step has a duration that cannot be predicted. Humanitarian aid is highly coded by international institutions and are defined at the scale of a country even if the actions are local. Nevertheless, despite overall similarities between restoration cycles and humanitarian aid cycles, key differences exist between ecological restoration and **SoER** (Table S1). The first main difference is that in **SoER** the majority of resources would be used in the initial stages of the restoration process to recover the minimum living standards for the people concerned. This can be viewed as a social bias in the restoration process, but aside from the humanitarian reasons, it actually may be a useful thing to relieve the pressures placed on the supporting ecosystems before a complete **SoER** plan is being designed.

Although the cultural values of ecosystems is of primary importance because **SoER** is frequently part of a healing process, it is difficult to anticipate how much of the previous ecosystem will be desired by the people. The second and perhaps greatest challenge in **SoER**, at least from the perspective of the ecological sciences, is agreeing on the reference system to be used for restoration. In countries in the recent aftermath of civil wars or natural catastrophes, people who may have lost everything may simply ask for ways to escape the traps of poverty and violence. Whatever comes first with the promise of a better future will quickly be accepted by people, even if it entails new ways of interacting with the natural systems. At this point, conservative views of what restoration is will collide with what people are demanding. For instance, illicit grow of coca (*Erythroxylon coca*) in South America for the last 40 years has caused degradation of many areas of tropical rain forest in Bolivia, Peru and Colombia, creating social conflicts and violence among peasants that have reduced their quality of life. Because of the difficult climatic conditions and low fertility of tropical forests, agroforestry propositions to replace illegal coca monoculture plantations with a handful of useful native plants are often proposed as an alternative (Corradi et al. 2013). However, local tree diversity can easily exceed 100 tree species per hectare in the western Amazon (Ter Steege et al. 2003), a species richness that will never be attained with agroforestry programs. According to SER standards, this type of restoration would be considered closer to rehabilitation than to ecological restoration (McDonald et al. 2016). Still, using a handful of legal tree crop species may be better than a single, highly polluting crop as coca plants. If the idea of **SoER** helps local people and external organizations to co-construct a viable future in a respectful manner for both people and natural systems, it may be worthwhile using the concept early in the recovery programs as better biodiversity and social objectives may be attained in the long term.

The third and probably most striking difference with more ecologically centered restoration programs is the level of external inputs, especially economic inputs (Table S1). Current approaches in ecological restoration seek to assist the recovery process of the relevant ecosystem by allowing for the internal reorganization and adjustments of the system (McDonald et al. 2016). By contrast, highly degraded ecosystems and societies that are a consequence of long-term conflicts or natural catastrophes require immense amounts of external economic input, sometimes for decades. In this regard, the budget allocated to most restoration programs is insignificant compared to the resources committed for recreating stable and self-sustainable human populations. Hence, joining inextricably both social and ecological restoration process, albeit more difficult and costly, may help in the achievement of long-term goals, and hopefully in many cases to ensure sooner the sustainability of human groups in a respectful manner with their environments.

A second external input that may be needed disproportionately in **SoER** is expertise to recover the traditional ecological knowledge [that is knowledge people have of their environment] that may be endangered or even lost. Community leaders or vulnerable population categories may have fled, lost their leadership or died in areas where social turmoil has been chronic. In this regard, universities, museums and scholars may go along with local communities and participate in **SoER** programs for recovering disappearing local knowledge.

SoER restoration efforts do not need to start from scratch but can learn from experiences developed and accumulated in programs of community restoration and conservation development. For instance, if the key biodiversity object for restoration identified in the first steps of the **SoER** cycle is a ‘commons’ (i.e., resources accessible to everyone and clearly affected by the subtractions of units like trees in a forest or fishes in waterbodies), there is a clear need to acknowledge the complexity associated with governing the commons and avoid top-down out of the box solutions

(Frey & Berkes 2014; Ostrom 2009). As with community-based conservation principles (Berkes 2004), **SoER** would benefit of building the capacity to deal with multiple objectives and use of deliberative processes (concertation) to allow for a multilayered governance for the various institutions that would get involved in humanitarian crisis and ecosystem restoration (Berkes 2007; Frey and Berkes 2014). This means that contrary to the impression that Figure 1 may give about discrete steps of concertation **SoER**, deliberation processes to account for the multiple layers of governance and actors will probably be almost permanent.

Social-ecological restoration after long term ecological and social degradation

As stated earlier, not all **SoER** programs would be intended for the aftermath of disasters. Until recently, the hunter and horticulturist Shuar people from southern Amazonian Ecuador and northern Peru were a semi-nomadic population. Since the late nineteenth century, Christianization led them to become sedentary, drastically changing their social and political organization as well as their economic life. At present, a large part of their traditional territory is cleared of the original highland Amazonian forest vegetation because of cattle breeding or timber trade, which they adopted to secure titles to their ancestral land to comply with government requirements in the 1960's.

Some Shuar communities have initiated family-level restoration programs based on their traditional agroforestry system, the *aja* (Fig. 2) with a focus on native trees as key stone restoration species (sensu Garibaldi & Turner 2004). The goal of the *aja* is to reproduce the high biodiversity of the forest, viewed as the domesticated garden of the master spirit *Nunkui* were women have the leading role (Descola 1994). Present-day *ajas* are less diverse than their traditional counterparts and increasingly include *Theobroma* spp. and *Herrania* spp. (domesticated and wild cocoa)

because of pressures by exporters looking for rare organic cacao beans that they buy at very low price. This fragile context makes it very easy for some communities to allow mining into their lands or tree felling to make charcoal, as the cash flow is greater and steadier than the difficult market of organic produce for international markets for which they are not prepared. Sadly, the Shuar ignore that cacao trees were certainly domesticated there 5500 years BP (Valdez et al. 2013) and have no means to increase their produce value despite of its importance.

Even a superficial needs and assessment analysis (first step of the **SoER** cycle in Fig. 1) would promptly identify that their rich ecosystem has been degraded to a point where natural regeneration will hardly bring back the biological diversity associated with extirpated late successional trees without external intervention. It is also obvious, that living standards are low and that local knowledge is disappearing fast. People live precariously without running water or sewage and have no one trained at the university level in agronomy or marketing to deal with external markets that appear as the only source of income. Our hypothesis is that engaging the Shuar in a **SoER** restoration cycle would increase ecosystem health and the Shuar's well-being. For instance, a careful zoning to intermix organic cacao plantations, regeneration plots for late successional tree species and enriched *aja* gardens for their medicinal and food needs could be a viable option to discuss with them. Such actions would require leadership and local community commitment that is currently wanting, making the dependence on external aid unavoidable. Unfortunately, examples like the Shuar abound worldwide in developing countries and it is difficult to imagine a successful ecological restoration without restoring the links between people and their surrounding nature, even if they include new ways of human-nature interactions.

Conclusions

In sum, we define the emergent concept of Social-Ecological restoration *as cycles of reparative processes in which restoring ecosystem function is inextricably linked to repairing basic needs of human populations that depend on a local ecosystem*. In general, **SoER** would be placed in a gradient where humanitarian crises are strong, the dependence on key processes or species within an ecosystem is essential for the local communities, and flexibility regarding the reference ecosystem systems is possible but not mandatory (Fig. 3). In fact, one clear difference between ecosystem service-centered restoration and **SoER** is that the latter is envisioned as part of a healing process for local populations. In this sense, cultural values associated with ecosystems and the biodiversity contained in them can be as important, or more, than simple recovering plant and animal populations to be exploited by a community in need of income. In fact, communities after a crisis might be living from external input for many years or decades, so that the ecosystem of concern might not be usable for long time. Hence, it is the cultural value and identity they provide that will help people to get afloat again.

We do not argue here in this short essay that all restoration ecology projects should be envisioned as a social-ecological restoration process. In fact, speaking of **SoER** might even be counter-productive in cases where the links between human welfare and biodiversity are not straight forward. Ecologists and wildlife managers may be frustrated because their roles – and budgets – in **SoER** may be quite small compared to what is invested in people's recovery, but more ambitious goals may be reached in the long term. The **SoER** concept can constitute an alternative path in the debate that traditionally opposes the development of human populations and ecological conservation, especially in developing countries where substandard conditions of life are the norm.

As explained earlier, it will be very unlikely that the term ‘restoration’ would be used outside of fields related to the ecological sciences because it is awkward when applied to social issues. More general terms, including short and long term reparative actions for both social and ecological components, could be ‘social-ecological recovery’ and ‘social-ecological development’, respectively. It is impossible to anticipate which expression will generalize, but any of them could help raising awareness within the humanitarian aid community for calling early the expertise of ecologists and ecosystem managers when handling humanitarian crises.

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411 **Supporting Information**

412 The following information may be found in the online version of this article:

413 **Appendix S1.** Additional details on the humanitarian cycle programs and ecological restoration
414 standards.

415 **Table S1.** Synopsis of humanitarian cycle programs and their similarities with restoration ecology
416 programs.

Table 1. Main differences between ecological restoration and social-ecological restoration based on six principles of ecological restoration (McDonald et al., 2016).

<i>Key concept</i>	<i>Ecological restoration</i>	<i>Social-ecological restoration (SoER)</i>
1	Practice is based on an appropriate local native reference ecosystem, taking environmental change into account.	The target system can be a highly reinterpreted reference system; the new system typically builds resilience to floods, fires, etc. and could be seen as rehabilitation or even as ecological engineering. External market opportunities may cause local people to switch to new ways of interacting with their ecosystems and the species that they collect or gather.
2	Identifying the target ecosystem's key attributes (threats, physical conditions, species composition, structural diversity, and ecosystem functions and flows with other ecosystems) is required prior to developing longer-term goals and shorter-term objectives.	In addition to identifying the ecosystem's attributes, SoER programs may need to address the level of people's vulnerability and their access to food, shelter, and basic goods, as well as security, political participation, and the end of violence, among others.
3	The most reliable way to achieve recovery is to assist natural recovery processes, while supplementing them to the extent that natural recovery potential is impaired.	In contrast to letting the system self-organize, massive external economic inputs may influence the trajectory of the system in very short periods of time, which is common in humanitarian crises.

- 4 Restoration seeks the “highest and best effort” Full recovery is rarely known for **SoER** in
towards full recovery; the recovery can be countries with civil wars, as they may be
quantified for each of the key attributes (see recurrent crisis because of poverty and violence
principle 2). traps.
- 5 Successful restoration draws on all relevant Relevant knowledge may have been lost if key
knowledge. actors have died or fled from the target regions.
- 6 The early, genuine, and active engagement with Long periods of time may be needed until all
all stakeholders underpins long-term restoration actors are actively engaged, thus making the
success. **SoER** process probably longer than equivalent
ecological restoration programs.

420

421 **Table S1.** Synopsis of humanitarian cycle programs and their similarities with restoration
422 ecology programs as currently conceptualized by leading institutions in the area. Humanitarian
423 aid is highly coded regarding steps and mandatory documents to comply with international
424 funding agencies and governments. Synthesis steps from both fields are outlined as a set of
425 simple questions in the Social-Ecological restoration cycle proposed in **Figure 1** in the main text.
426

Stage	Humanitarian program cycle ¹	Standard practices for planning and implementing ecological restoration projects ²
1	Needs, assessment & analysis In humanitarian contexts, two main assessments are produced, a Humanitarian Needs Overview (HNO) to gather the necessary evidence, and a severity ranking of the different threats that are summarized in a Humanitarian Dashboard , which is a simple to	1.1 Stakeholder engagement 1.2 External context assessment 1.3 Ecosystem baseline inventory 1.4 Reference ecosystem identification

understand document that can be shared with all levels of authorities

2	Strategic response planning	1.5 Targets, goals and objectives
	Humanitarian response plans (HRPs) are required for any humanitarian crisis requiring the support of more than one agency, and are prepared by country level teams based on the humanitarian needs overview (HNO) from the previous step.	1.6 Restoration treatment prescription
	The HRPs consist of: 1. a country strategy consisting of a narrative, strategic objectives and indicators, and, 2. cluster plans consisting of objectives, activities and accompanying projects, which detail implementation and costing of the strategy.	1.7 Assessing security of site tenure and of post treatment maintenance scheduling
3	Resource mobilization	1.8 Analyzing logistics
	It is recommended that humanitarian aid implement a Financial Tracking Service (FTS) to provide data aggregation and curation service for funding and a unique, open data platform for visibility and transparency. It is a special branch of the United Nations Office for the Coordination of Human Affairs (OCHA). Funds are pooled at the global or at the country level	1.9 Review process scheduling

4	Implementation, monitoring	2.1-2.6 Implementation
	Response monitoring is a continuous process that tracks the humanitarian assistance delivered to affected populations compared to targets set out in the humanitarian response plan (HRP). Response monitoring seeks to achieve two main goals: a) to identify shortcomings in the delivery of humanitarian aid as planned in the HRP , and b) to improve accountability to affected populations and other stakeholders. It does not redefine goals. Monitoring plans and codify these in a humanitarian response monitoring framework document. In turn, the monitoring data is made publicly available for use in public reports and forms the basis of the periodic monitoring report (PMR). The PMR is complementary to the Humanitarian Dashboard .	3.1 Monitoring 3.2 Adequate records of treatments are maintained
5	Operation peer review & evaluation	3.3 Evaluation 3.4 Reporting 4. Post-implementation maintenance
	Operational Peer Reviews (OPRs) are an internal, inter-agency management tool, which serve as a course corrector and to identify areas for immediate corrective action. They are designed to help coordinators and country teams determine whether adjustments or improvements are necessary, focusing on: a) leadership arrangements; b) implementation of the other phases of the Humanitarian Program Cycle; c) coordination, and mechanisms for accountability to affected people.	

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428 ¹ Text adapted from <https://www.humanitarianresponse.info/en/programme-cycle/space>

429 ² Text adapted from SER standards 2016

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