INTERNATIONAL UNION FOR CONSERVATION OF NATURE

BUSINESS AND BIODIVERSITY PROGRAMME

Rio Doce Panel

Issue Paper No. 4

A framework for assessing environmental and social impacts of disasters

Ensuring effective mitigation after the Fundão Dam failure

In November 2015, the failure of the Fundão tailings dam at the Samarco´s iron ore mining site in the State of Minas Gerais, Brazil, resulted in 19 deaths and severe environmental, economic and social damage. The tailings spill ran 670 km through the Rio Doce to the Atlantic Ocean. It is referred to as one of the worst environmental disasters in Brazil's history.

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Figure 1. View of Fundão Dam site. On the right, a permanent dam referred to as S1, is being constructed to contain the tailings remaining on site. This dam is part of the actions determined by government agencies to address tailings management (October 2018).

Source: © Luis E. Sánchez

What is the issue?

Disasters disrupt communities and often result in severe environmental harm. Following the collapse of the Fundão Dam, short- and long-term impact mitigation programmes were designed over a four-month period as part of an out-of-court settlement.[1] Although a rapid assessment of damages was conducted prior to the settlement, a comprehensive and in-depth assessment of the environmental and social impacts of the dam's failure has not been completed so far, although a number of initiatives started early and are underway.

The first recommendation of Rio Doce Panel's Thematic Report No. 1 urges Renova Foundation[2] to undertake such an assessment (Sánchez et al., 2018). The current Issue Paper thus aims to present a systematic approach, which would facilitate the collection and analysis of key data and information required to carry out an impact assessment and to evaluate the effectiveness of mitigation programmes.

Why is it important?

A complete assessment of the actual consequences of the dam collapse is necessary to identify cumulative effects from past and present human actions in the watershed and in the coastal zone. As such, it will contribute to addressing the potential threats to the effective delivery of mitigation programmes, which is also one of the recommendations of Rio Doce Panel's first thematic report.[3]

A comprehensive ex-post[4] assessment also provides an opportunity to communicate information and interact with the local population, community and political leaders, and other stakeholders interested in the outcomes of the actions that are being undertaken to restore, remediate and compensate for the harmful impacts of the dam failure.[5]

Current approaches to ex-ante[6] environmental and social impact assessment (ESIA) can be adapted to perform an ex-post assessment of the cumulative effects of the dam failure.[7] In this regard, guidance is deemed necessary to help Renova Foundation implement the Panel's recommendation.

It is expected that the framework presented here will also be useful for practitioners, decision-makers and scientists involved in identifying, assessing and mitigating impacts of other disasters with severe environmental consequences.

What can be done?

One possible approach when preparing a comprehensive assessment is to start by mapping all impacts and their key characteristics into a synoptic table or chart that can be used as a tool to guide the assessment. While other approaches are possible, provided that key information is clearly shown, a synoptic table can foster a shared understanding among stakeholders about the scope of the impacts of the Fundão Dam's failure. However, it cannot substitute for a detailed and focused assessment of each impact that is fundamental to setting a solid foundation for decision-making about mitigation, and to identifying information and knowledge gaps.

Mapping 'all' impacts means identifying all relevant impacts related to the dam failure at appropriate spatial and temporal scales. Expert judgement, public participation, and tailor-made approaches suited to the context of each impact are indispensable for that purpose.

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[1] For further information, please visit: www.samarco.com/en/plano-de-recuperacao-macro/

[2] Renova Foundation is an entity created by Samarco and its parent companies to restore the affected environment and compensate for damages, following guidance jointly issued by several government agencies.

[3] For further information, please visit: https://portals.iucn.org/library/node/47833

[4] Evaluation *after* an event or an intervention has been completed.

[5] For an overview of such actions, please visit: www.fundacaorenova.org/en/

[6] Evaluation *before* the implementation of an intervention, usually conducted in support of decision-making.

[7] In this paper and in line with the Panel's publications, the term 'impact assessment' refers to the process of identifying any change, positive or adverse, in the environment or any of its biophysical or social components, resulting from a past, present or intended future human action. Impact assessment is used for supporting decision-making about human actions that can affect the environment, including the mitigation of the consequences of disasters. Terms, such as 'damage assessment', are sometimes used specifically to assess harmful effects of past events; however, such terminology is not used in this paper.

In order to facilitate the application of the proposed approach, this paper provides a template in the form of a synoptic table (see Table 1) using examples and applying key concepts of cumulative impact assessment (CIA), with a view to organizing information and analysis.[8]

A CIA usually starts by scoping the key issues through the selection of valued environmental and social components (IFC, 2013) or simply valued components (VCs) (IAIA, 2017). VCs are defined as "environmental and social attributes that are considered to be important in assessing [impacts and] risks" (IFC, 2013, p. 21).[9] In comparison with an ESIA, where a new project usually starts by identifying the major actions that can cause the impacts, CIA starts by choosing VCs that can be affected by an action and takes into consideration several stressors that could affect them.

Public participation is considered essential in the selection of VCs (IAIA, 2017). Even though a CIA is usually conducted for a limited set of VCs (Canter, 2015; Canter and Ross, 2010), for the purpose of the assessment recommended by the Rio Doce Panel, it is advisable to draw up a list of components that is as complete as possible. The scoping phase is critically important in a CIA and should be conducted with the purpose of ensuring a comprehensive assessment of all significant impacts. In addition to selecting VCs for analysis, defining the scope requires setting geographic and time boundaries to the assessment.

The proposed framework illustrated in Table 1, which describes the impacts on VCs spread over 19 columns, features categories of information and interpretation. Since mitigation is a long-term endeavour that should transcend staff turnover, political transition and be adaptable to changing priorities, it is important to remember that interpretation must be grounded on appropriate analyses and traceable to relevant sources of information. Traceability also helps minimise a possible bias that could result from exercising professional judgement when assessing certain impacts.

Cumulative impacts to be considered are those to which the dam failure contributed. The VCs, which should be included in the assessment, are those that are recognised to have been affected and for which pathways can be established on reasonable grounds.

Rather than a one-off exercise, the table is meant to be a living tool which can and must be continuously improved. The process is similar to the implementation of ISO 14001[10] standard environmental management systems, where the identification and analyses of environmental aspects and impacts are first conducted, then periodically updated. In this regard, critical analyses and recommendations from regular internal audits and external reviews could be fed back into the table along with supporting documents and information systems. This would benefit from the fact that Renova Foundation's programmes and actions are regularly audited both internally and externally.

The examples of impacts provided in Table 1 are intended to illustrate how the approach can be applied immediately, offering a variety of situations which are likely to be observed when applying the framework. The list represents a fraction of the impacts of the Fundão Dam failure; the final table will likely feature several more impacts. For this reason, Renova Foundation may have an interest in developing information technology-based versions of the table that can be linked to existing internal management systems.

The following are general guidelines on how to implement the tool:

1. Establish a core team of assessors and programme managers who will take the responsibility of preparing the first version and subsequent updates;

2. Consult and involve specialists in each VC – their inputs will be valuable in determining the appropriate terms to describe the components and impacts;

[8] The expanding literature on CIA provides valuable information and additional guidance. For further readings, please see: Broderick et al. (2018); Dibo et al. (2018); Hegmann et al. (1999); IFC (2013). Cumulative impact assessment, or CIA, is also referred to as cumulative effects assessment.

[9] Valued components are also known as 'valued ecosystem components', or VECs, in practice and in the literature about cumulative impact (or effects) assessment, due to the origins of the concept, that results from critical reviews of the approach used to assess ecological impacts in early environmental impact assessments.

[10] For further information, please visit: https://www.iso.org/iso-14001-environmental-management.html

Figure 2. **Mud covers a local church, a symbol of the community, in the rural district of Gesteira (Barra Longa, November 2015).**

Source: © Cai Santo, https://www.flickr.com, licensed under Creative Commons (CC BY-NC-SA 2.0)

3. Use accurate terms to describe the impacts, clearly stating the consequences which can be reasonably linked to the source event (in this case, the dam failure);

4. Maintain a record of the main sources of information (documents must be fully referenced, with page numbers, spreadsheets, databases, maps, shapefiles and others) in support of the analyses; and

5. Insert additional columns, where necessary, to correspond to the needs of the organisation applying the framework; these could include internal documents and responsibilities, key information gaps, actions to address the gaps, key performance indicators and the like.

Specific recommendations are explained in the notes to Table 1 (pp. 8–9).

Table 1. A synoptic table for cumulative impact assessment and management, including examples of impacts on valued environmental and social components (1) (2)

VALUED COMPONENT		IMPACT		PATHWAY	CHARACTERISTICS OF IMPACTS			
1	2	3	4	5	6	7	8	9
Component	Type	Description of impact	Category of impact	Impact pathway or affected process	Affected area	Temporal scale	Indicator of impact magnitude	Level of uncertainty in the determination of magnitude
Tangible heritage	Built heritage	Destruction of São Bento church	Total loss	Collapsed due to the tailings wave	Bento Rodrigues	Permanent	NA*	Certain
	Movable heritage	Loss and decontextualization of artifacts stored in São Bento church	Partial loss	Deterioration due to contact with wet tailings; dispersion due to the mud wave	Bento Rodrigues	Permanent	NA	Certain
			Decontextualization			Permanent	NA	Certain
Intangible heritage	Celebrations	Interruption of the annual procession São Bento-Mercês churches	Interruption	Destruction of São Bento church, and most houses and temporary relocation in Mariana	Bento Rodrigues	Temporary	NA	Certain
Riverine ecosystems	River margins, banks and channels	Alteration in profile	Changing characteristics	Erosion of margins and bottom; deposition of tailings	Santarém creek, Gualaxo do Norte and Carmo Rivers	Long term (10^2-10^3 years)	TBD**	Medium
	Water quality	Increased turbidity, sediment load and concentration of metals	Degradation	Tailings dispersion; erosion of river banks and bottom; remobilization of sediments	All stretches of Rio Doce downstream of the dam site and sectors of tributaries where the tailings rebounded upstream	Unknown	Levels of suspended solids; dissolved oxygen, nitrogen, phosphorus and other water quality indicators	Low
							Presence/ absence of indicator organisms	Low
	Native fish	Fish mortality	Partial loss	The flow of tailings	The entire Rio Doce watershed	Unknown	TBD	High

***NA** Not applicable ****TBD** To be determined

(1) See explanatory notes next page.
(2) Examples in this table are provided only to facilitate its possible application. They do not necessarily represent advice from the Rio Doce Panel or IUCN about a specific course of action or an evaluation of current performance.

Table 1. (continued)

CUMULATIVE PROCESSES		MITIGATION							REFERENCES
10	11	12	13	14	15	16	17	18	19
Are there persistent effects of past or present actions affecting the valued component?	Other past or present actions affecting the valued component	Mitigation implemented, being implemented or required to be implemented	Type of mitigation	Indicator of mitigation success	Main threats to effectiveness of mitigation	Level of confidence in the expected effectiveness of mitigation	Adverse environmental and social aspects, or impacts, of mitigation	Is additional mitigation necessary or is there a need for current mitigation to be modified?	Key references
No	NA*	NA	Not mitigable	NA	NA	NA	NA	NA	Please cite documents (include pages), websites and any other source with their respective dates
No	NA	Artifacts were gathered, transported to a safe place, hygienized, catalogued and stored	Compensation	TBD**	Low acceptance of mitigation by the community	Moderate	None	No	
			Compensation	TBD				No	
No	NA	Construction of two churches in the Lavoura resettlement situated at equivalent distance	Compensation (substitution)	TBD	Low acceptance of mitigation by the community; long-term transformation of the Lavoura resettlement	Unknown	None	TBD	
Yes	Deforestation; iron mining (from 1960s); gold mining (18th–19th centuries)	Stabilization of margins and planting of tree seedlings	Remediation	TBD	Cattle invasion in recuperation areas; dissemination of exotic grasses	Moderate	Loss of pastureland	TBD	
Yes	Deforestation; discharge of untreated sewage; residues from past mining activities; discharge of industrial effluents	Retention of tailings upstream by constructing dams Axis 1 (permanent), S3 and S4 (temporary)	Remediation	TBD	No significant threats were identified	High	Emissions of particulates and gases; GHG emissions; consumption of fuel and raw materials; increased traffic in public roads and others	Yes	
		Dredging of tailings in Candonga		TBD	Instabilization of retention structures; need of long-term care; unknown decommis-sioning approach	Low		Yes	
		Stabilization of margins		TBD	Cattle invasion in recuperation areas; dissemination of exotic grasses	Moderate		Yes	
Yes	Introduction of exotic species; construction of dams; deforestation, fishing	Retention of tailings upstream; stabilization of margins and planting of tree seedlings; fishing ban	Remediation	TBD	Widespread and growing presence of exotic fish in the watershed	Low	None identified so far	Yes	

***NA** Not applicable ****TBD** To be determined

(1) See explanatory notes next page.
(2) Examples in this table are provided only to facilitate its possible application. They do not necessarily represent advice from the Rio Doce Panel or IUCN about a specific course of action or an evaluation of current performance.

Notes and keys to Table 1:[11]

(1) **Component –** Different approaches can be used to organize the information in this column.[12]

(2) **Types –** If necessary, a component can be divided into two or more types. Components are broad categories, while types are parts of a valued component. Such a division should only be used to the extent that it can be useful to describe an impact with appropriate detail, which means that some components will not be disaggregated.

(3) **Description of impact –** All direct and indirect impacts resulting from the dam failure should be listed. As the final list will be considerably large, it is advisable that impacts of a similar nature be aggregated, as appropriate. Impacts on a number of valued components may be unknown, either because the baseline is insufficient to support a conclusion or because an impact may be delayed or for any other reason. In those cases, the corresponding cell in the table can be marked as 'unknown'. It is possible that some impacts will only be detected after monitoring.

(4) **Category of impact –** Refers to a further description of an impact.

(5) **Impact pathway or affected process –** A summarized information about the linkages between the event and the described impacts should be provided.

(6) **Affected area –** Should preferably be located in a GIS-based map. A column or a code could be added to link each cell in the synoptic table to one or more maps. It is advisable to note that the area of impact may change over time and the impact magnitude can vary over that area (i.e. being more intense in certain places than in others across the affected area). However, the table is intended to provide a synoptic view of the impacts before any mitigation.

(7) **Temporal scale –** Different descriptors can be used for this column, such as short- or long-term, temporary or permanent, seasonal, chronic or others. It is important to define clearly the meaning of the descriptors.

(8) **Indicator of impact magnitude –** An indicator should have reliable metrics. Both quantitative and qualitative indicators can be used or a combination of both, such as, for example, '128 hectares of degraded forest land'. The source should be entered in column 19 (key references). Indicators should inform about the impact before mitigation. It is possible to add columns to show relevant indicators after or during mitigation, but the Panel recommends that other tools, including other tables, would be preferable to follow-up on the outcomes of the mitigation measures.

(9) **Uncertainty in the determination of magnitude –** The magnitude of an impact is a description of its intensity. Such description, where appropriate, should as much as possible be quantitative or semi-quantitative. However, the uncertainty in determining impact magnitude is inherent to both ex-ante and ex-post assessments. One important source of uncertainty is an inadequate baseline. The following qualitative scale can be used to describe the level of uncertainty:

Low Baseline is considered well-known and the impacts have been estimated on the basis of field measurements or observations, remote sensing, statistical analysis or other established technique.

Medium Baseline is not well-known and the estimation of magnitude is based on professional judgement or any other qualitative approach, including local knowledge.

High Baseline is not well-known and there exists contradictory information about the magnitude of impacts.

If there is negligible uncertainty about the magnitude of an impact, write 'not applicable' (i.e. this category is not applicable to that particular impact). If the impact is known to its full extent, write 'certain'.

(10) **Persistent effects of past or present actions affecting the valued component –** The responses to this column require careful consideration; the documented sources are expected to substantiate judgement.

(11) **Other past or present actions affecting the valued component –** Listing the actions requires context-specific expert evaluation. Current remediation actions should not be considered in this column.

(12) **Mitigation implemented, being implemented or required to be implemented –** Should be summarized in this column and referred to in an existing or scheduled programme.

(13) **Types of mitigation –** The following types can be used:

Remediation – Actions aiming at reducing impacts and risks derived from the post-disaster situation, such as stabilizing an affected component or removal of risk factors.

Restoration – Actions aiming at restoring the component to a pre-disaster situation. A specific concept can be developed for particular valued components, e.g. to restore the attributes or functions of agroecosystems.

Compensation – Actions aiming at substituting the affected component or the benefits provided by that component.

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[11] The numbering corresponds to the column number. For further help and guidance, please see the references on cumulative impact assessment.

[12] IFC (2013) defines valued environmental and social component as "environmental and social attributes that are considered to be important in assessing risks" (p. 21), while Hegmann et al. (1999), for the purpose of assessing cumulative effects, conceptualized those components as "any part of the environment that is considered important (...) on the basis of cultural values or scientific concern" (p. A4). The careful selection and description of valued components are of paramount importance to the effective application of this tool.

Compensation can be in-kind (the same type of benefit) or out-of-kind (i.e. monetary indemnification).

Enhancement – Actions aiming at improving the state or conditions of a component to a better state or situation in relation to the pre-disaster condition.

Impacts that cannot be mitigated, such as impacts on irreplaceable valued components should be marked as 'Not mitigable'.

(14) **Indicators of mitigation success –** Should be developed and should consider, where applicable, the following aspects: legal requirements, guidance provided by authorities, the perspective of stakeholders (i.e. what constitutes 'success' under the point of view of affected and interested parties).

(15) **Threats to effectiveness of mitigation –** Should be prospected and listed.

(16) **Confidence in the expected effectiveness of mitigation –** The level of confidence is expressed as a combination of how widespread is the adoption in similar situations and the level of threats to effective delivery, as shown in Table 2 below.

Table 2. Level of confidence in the expected effectiveness of mitigation

	Levels of threats		
Levels of dissemination of a particular mitigation measure	**Threats are well understood and under control[1] of the organisation[2]**	**Threats are well understood and under influence[1] of the organisation[2]**	**Threats are insufficiently understood or beyond influence[1] of the organisation[2]**
Widely used, generally considered as good practice	High	High	Moderate
Other applications are known, but practice is not widespread	High	Moderate	Low
An innovation or there is limited practical experience	Moderate	Low	Low

Notes:
(1) 'Control' and 'Influence' of the organisation are to be understood in the usual meaning of management systems.
(2) In this application, the 'organisation' referred to is Renova Foundation.

Source: Rio Doce Panel.

The estimation of the level of confidence should preferably be made by an expert group, using consensus-building techniques such as Delphi.[13] The rationale for estimation should be recorded. It is important to keep track of the sources of information that are considered for making professional judgements. This should not be an arbitrary classification made by one person, but be grounded on the professional experience of a group and on information assembled for the assessment. New information could change the judgement.

(17) **Adverse environmental and social aspects or impacts of mitigation –** Any such related aspects or impacts should be listed. It is possible to cross reference these impacts by listing them in column 3 ('Impacts').

(18) **Additional mitigation necessary or a need for current mitigation to be modified –** The question reflects current understanding of the assessment team as informed by monitoring and evaluation of existing programmes.

(19) **Key references –** In order to minimise the effect of both excess and contradictory information, the column should mention only the most important documents used to substantiate the analysis presented in the table. Sources other than documents can also be referred to, such as documented interviews and focus groups.

After performing this comprehensive assessment, results should be critically reviewed. One possible (or expected) outcome is to propose improvements or rearrangements in the current mitigation programmes, or additional mitigation, if necessary. If gaps and/or overlaps between existing programmes are detected and documented, the assessment would provide substantiated argument to improve prescribed mitigation.

The proposed approach is structured on the basis of valued components, but the interactions between components are hardly addressed by this tool. To advance the analysis, once the synoptic table is completed, the next step would be to identify the possible additive, countervailing or synergistic effects. Another supplementary action would be to analyse the impacts of mitigation on those valued components, whether they are positive or adverse.

Information and knowledge gaps should be acknowledged and registered. Cells marked as 'not applicable' or 'to be determined' require follow-up action.

[13] Delphi is a technique to collect and aggregate expert judgement about issues that are qualitative in nature, hard to quantify or require interpretation of evidence. Successive rounds of iteration are conducted to reach a shared understanding among a small group of invited experts. For further reading: Hsu and Sandford (2007).

Recommendations

The Rio Doce Panel suggests that Renova Foundation undertake the following actions:

1 **Adopt a structured and systematic approach for a comprehensive assessment of the environmental and social impacts of the Fundão Dam failure, taking into account the following advice:**

- Impacts should be identified, described and characterized in detail, including information on affected area, estimated temporal scale and an appropriate indicator of impact magnitude, acknowledging uncertainties.
- The assessment should consider the cumulative effects of other past and present actions that could affect each valued component.
- The selection of valued components for analysis should be conducted by engaging with relevant stakeholders.
- For each impact, the following steps should be undertaken: describe ongoing or planned mitigation actions; identify threats to effectiveness; and explain any adverse environmental or social impact of mitigation.
- This assessment is not meant to be a one-off exercise, but a living tool to be continuously updated and improved.

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The Rio Doce Panel is an IUCN-led Independent, Scientific and Technical Advisory Panel, which has the critical objective of advising on recovery efforts following the breakdown of the Fundão Dam in November 2015 and leveraging long-term landscape-scale positive impact. Comprised of national and international experts, the Rio Doce Panel is convened and managed by IUCN, which acts in impartial coordination, and technical and administrative support, in respect of the principles of independence, transparency, responsibility and commitment.

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Cover photo: Aerial view of the Fundão Dam failure (July 2016). Courtesy of Felipe Werneck/Ibama

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