

An introduction to the Resilience, Adaptation Pathways and Transformation Assessment (RAPTA) Framework

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1. Rationale

The concept of resilience has captured the attention of the global policy community, and is being translated into aspirational goals that guide policy development. Enabling sustainable development requires us to understand and apply resilience thinking, including the related notions of adaptation and transformation. For example, if a system is not performing well, or is at risk of crossing biophysical or socioeconomic thresholds that would take it into an undesirable state, it may be necessary to adapt or transform the system, before enhancing its resilience. Applying resilience thinking is critical to meeting the Sustainable Development Goals related to food security, land degradation neutrality and climate change adaptation. There are challenges, however, in operationalising resilience concepts. Decision-making to progress resilience goals requires methods to evaluate resilience, and identify needs with respect to adaptation and transformation. Successful implementation of adaptation plans requires systems thinking, stakeholder engagement, and adaptive management. Monitoring progress toward sustainable development goals requires methods for assessment, including relevant indicators. The Resilience, Adaptation Pathways and Transformation Assessment (RAPTA) framework was commissioned by the Scientific and Technical Advisory Panel (STAP) of the Global Environment Facility (GEF) to assist in addressing this need.

RAPTA is intended to be relevant to GEF projects and programs including the program on “Sustainability and Resilience for food security in Sub-Saharan Africa”, the three Rio Conventions¹, and the emerging Sustainable development Goals (SDGs).

2. Developing RAPTA

The GEF-STAP worked with the Commonwealth Scientific Industrial and Research Organisation (CSIRO) to develop a framework to identify indicators to assess resilience of social-ecological systems. Resilience, and related concepts of adaptation (and adaptive capacity) and transformation (and transformability) are not easily quantified – the dynamic concepts upon which they are founded are not congruent with simple biophysical indicators such as land cover, or compound metrics such as gross domestic product. Applying their extensive expertise in this topic, the CSIRO team reviewed relevant indicator sets (eg UNCCD, CBD, UNFCCC), as well as the literature on ‘resilience indicators’ and found that there were no existing approaches that could readily meet STAP’s identified need for a scalable indicator of resilience, suitable for reporting at project- through to national scale. The project did not want to add to the burgeoning list of highly synthesised compound indicators, many of which are applicable only to specific systems and are difficult to apply in support of local or national decisions. Instead, RAPTA guides the user to identify the most relevant indicators from amongst existing indicator sets, and proposes meta-indicators suited to national

¹ The three Rio Conventions: the United Nations Convention to Combat Desertification, UNCCD; the Convention on Biological Diversity, CBD, and the United Nations Framework Convention on Climate Change, UNFCCC.

scale reporting. Importantly, it encourages learning which can guide actions to facilitate adaptation or transformation.

The draft proposal was presented at a workshop in Sydney in November 2014 which aimed to evaluate the framework approach to assessing resilience, adaptation, and transformation, with specific focus on agro-ecosystems. The workshop was designed to elicit suggestions for improvements, and explore potential applications and implementation pathways for the proposed approach. The workshop was attended by 50 experts and staff from GEF, STAP, the Conventions, research institutions and development agencies across the globe. The participants engaged in robust discussion and debate – and ultimately endorsed –the proposed approach. The workshop led to some expansion and change of scope in the framework, and identification of additional elements that have yet to be elaborated. RAPTA requires further co-development and testing with stakeholders in an applied setting before it is ready for implementation.

3. Resilience terminology

Three related terms underpin this framework: **resilience**, **adaptation** and **transformation**. In common usage, such as by governments, business, and development agencies, these terms are invariably framed in a positive light, as desirable attributes, often as aspirational goals (such as ‘enhance the resilience of the agriculture sector’). In this framework, these terms have specific definitions derived from ecological resilience literature. **Resilience** refers to the ability of a system to absorb disturbance and reorganise so as to retain essentially the same function, structure, and feedbacks. Resilience is a neutral property, neither good nor bad. It is sometimes described as coping capacity. Two categories of resilience are distinguished:

- *‘specified’ resilience* – resilience of a system to identified disturbances, with specific thresholds (e.g. capacity of a grazing system to maintain ground cover above 50% during drought)
- *‘general’ resilience* - capacity of the system to cope with all kinds of shocks and disturbances, and so be able to avoid crossing all thresholds, known or unknown, to alternate regimes (features such as ecological diversity, capital reserves, land tenure, education level, gender balance and health status determine general resilience)

Adaptation is a process of change that enables the system to achieve desired goals, including by reducing vulnerability to disturbance or threats such as climate change. **Transformation** refers to the process of moving from one type of system to another that has different controlling variables, outputs, structure, functions, and feedbacks (a different ‘identity’). Adaptation and transformation are seen as a continuum.

A system with high general resilience has the capacity to maintain the same identity, while also having the capacity to adapt, or to intentionally transform to a different identity, if desired. Resilience interacts with sustainability: high resilience contributes to sustainability when it is desirable to maintain a system in its current state, but can work against sustainability when transformation is desirable. When a system is under threat, or assets are being depleted, adaptation is necessary for sustainability.

These terms are discussed further in Annex 1. It is important to note that these terms are defined and used differently by other communities of practice. In the climate change adaptation literature, specified and general resilience are sometimes known as specific and generic adaptive capacity. Adaptation is sometimes seen to include transformation, encompassing both incremental and transformational adaptation. As RAPTA is further developed, broad consultation will be conducted to develop harmonized language to express resilience concepts.

4. Defining agroecosystem resilience

RAPTA is applicable to assessing and managing resilience of any social-ecological system. However, the Sydney workshop focussed on application of RAPTA to agroecosystems. An agroecosystem is a type of social-ecological system, and humans are an integral component. We define agroecosystem as an ecosystem managed for production of food, feed, fibre and/or fuel, whose boundaries include the ecological and human resources required for production, both at and beyond the site of production, including natural systems that support production, and the infrastructure, institutions and people across the supply chain (Cabell and Oloefse,(2012).

Typically, a nation has multiple agroecosystems (e.g. rain-fed annual systems, rain-fed perennial, irrigated, extensive grazing). These operate at multiple nested scales, interlinked at sub-national and national levels, and linked also to urban communities via markets and institutions. It is often helpful to define the systems spatially/bioregionally, while noting there are links between systems operating in different bioregions.

Agroecosystem resilience, in this framework, is defined as *'the ability of an agroecosystem (a type of social-ecological system) to absorb disturbance and reorganize so as to retain essentially the same function, structure, and feedbacks – to have the same identity'*. It is beneficial to build resilience of systems that are in a desirable state, so building agroecosystem resilience equates with enhancing the ability to cope with shocks and continue to maintain the well-being of humans that depend on that system for food and other valued outputs. If an agroecosystem is in an undesirable state, for example, affected by land degradation, poverty and insecure land access, resilience is a disadvantage. In such cases, the appropriate goal is transition, through adaptation or transformation, to a desired state.

RAPTA is applicable to assessing the resilience of agroecosystems, and the need to adapt or transform, in the face of climate change, other slow drivers and shocks, to meet the objectives of maintaining or enhancing food production, livelihoods and/or other ecosystem services.

5. Overview of RAPTA

The RAPTA framework is illustrated in Figure 1. The components with solid outlines in Figure 1 are presented in O'Connell et al. (2015). Those with dotted outlines are elements that require further work to develop and elaborate.

The core of the framework is the RAPTA Procedure (upper left box in Figure 1, expanded in Figure 2), a step by step iterative method for assessment. It is conducted at focal (sub-national) scale, ideally with multi-stakeholder engagement. The RAPTA procedure complements and expands the scope of published guidelines and tools on resilience².

The RAPTA procedure includes four elements:

- Element A: System Description
- Element B: Assessing the System
- Element C: Adaptive governance and management
- Element D: Multi-stakeholder engagement

² "Resilience Practice: Building Capacity to absorb disturbance and maintain function" by B.H. Walker and D. Salt (2012);

The Resilience Alliance Workbook Version 2; and

The Toolkit for the Indicators of Resilience in Socio-Ecological Production Landscapes and Seascapes.

A complete description of these resources is available in O'Connell et al. (2015).

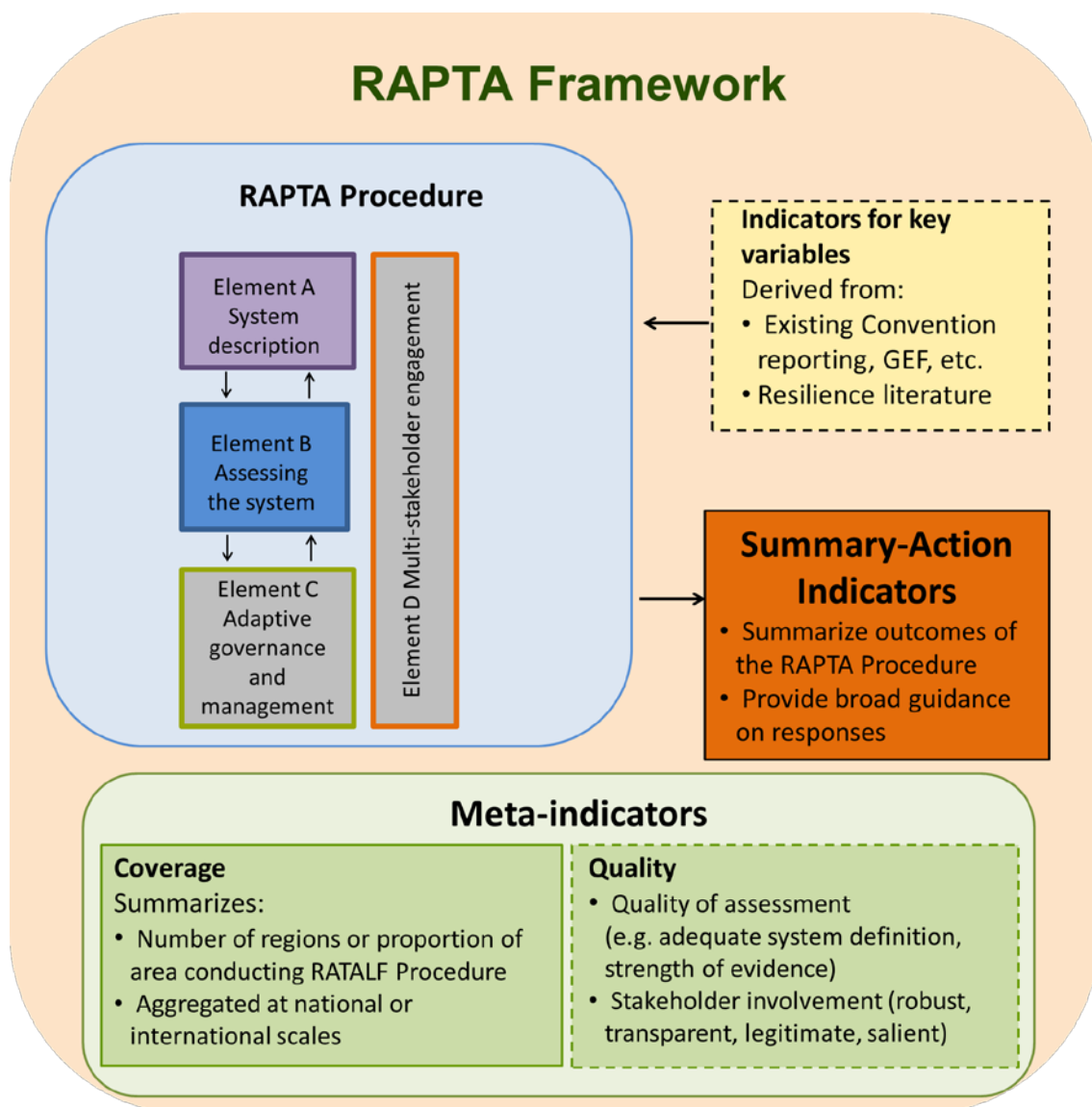


Figure 1 Overview of the Resilience, Adaptation Pathways and Transformation Assessment (RAPTA) framework. The components with solid outlines are presented in O’Connell et al. (2015). Dotted outlines indicate elements that require further work to develop and elaborate.

The outputs of the System Description (Element A) and Assessing the System (Element B) include: 1) a detailed description of the system (defining scale and resilience “of what -to what”, identifying controlling variables and thresholds); and, 2) identifying possible intervention options to adapt or transform.

The Summary - Action Indicators (middle right box, Figure 1) are an output of Element B.5 of the RAPTA procedure.

The steps listed under Adaptive Governance and Management (Element C) require multi-stakeholder and iterative assessment (Element D). This includes engaging stakeholders to identify options and assess their utility in achieving the desired changes to the system. A more detailed description of the elements is provided in Annex 2.

The RAPTA Procedure will help the users understand which are the critical attributes and indicators for their system, so that effort and resources invested in measuring and reporting can be targeted at indicators of those key variables. There may be indicators for these attributes/controlling variables

(upper right box, Figure 1) already reported in the UNCCD, CBD, UNFCCC, GEF tracking tools, or other databases, or in the literature, although some may need to be supplemented or modified. New indicators may need to be developed if they do not exist.

Summary - Action Indicators (middle right box, Figure 1) summarise the result of the RAPTA Procedure, and provide broad guidance on the types of actions or interventions that may be appropriate in response to the results of the assessment, to enhance resilience, or transition to a new regime or new system, if necessary. The result can be scored in terms of specified resilience, general resilience and transformability and this semi-quantitative assessment can be presented as in Figure 3, with interpretation described in Table 1. Please see the technical paper (O'Connell et al., 2015) for complete description, including limitations of this approach to illustrating the results.

There are 2 types of “meta-indicators” to report on the application of RAPTA Procedure (bottom box, Figure 1): a simple Coverage indicator to provide information on how widely the RAPTA Procedure has been applied; and Quality indicator to describe the robustness and replicability of the procedure.

The outcome of the focal scale assessments, the Summary - Action Indicators, could be aggregated to report on the proportion of area that, for example, is classed as “High General Resilience, High Specified Resilience, High transformability” and that which is “Low General Resilience, Low Specified Resilience, High transformability”, etc. (that is, in each corner of the cube – Figure 3), or to report a change in proportion of area in each category. This additional Coverage indicator has not yet been fully developed.

The assessment of resilience, adaptation and transformation can be done in a range of ways and the methods presented here are intended as guidance, rather than prescriptions. The assessment process can be conducted with varying degrees of scientific rigour, ranging from conceptual to detailed quantitative analyses - or analytical models to support the understanding of system processes, controlling variables, thresholds and feedbacks. Assessments should be conducted in an iterative manner with increasingly more detail and effort, according to the purpose of the assessment. For example, rapid assessments could be conducted to trial the approach and provide an initial overview and summary about where further effort in undertaking more detailed analyses could be best invested.

6. Scales of assessment and reporting

The resilience of a system at any scale depends strongly on the connections with the system at scales above and below (i.e. embedded scales). A focal scale for analysis must therefore be defined as part of the analytical process – an agroecosystem in a river basin, for example – as well as the critical scales above (e.g. a nation) and below (e.g. a farm). The definition of the focal scale is contingent on the problem being addressed, and the reason for the assessment. This needs to be considered in an iterative way. For example, the scale of the regions defined for natural resource planning and management by Australian agencies proved too coarse for meaningful resilience assessments, so most regions have focused on scales within catchments or within their regional boundaries; see for example <http://www.wheatbeltnrm.org.au/nrmstrategy> for Western Australia, and <http://weconnect.gbcma.vic.gov.au/> for the Goulburn-Broken region in Victoria where, after an initial attempt focusing on the whole region, they evolved to using six sub-regions which share similar social and landscape characteristics.

In other agroecosystems, the analysis might be stratified by household type based on attributes such as livestock or land ownership, levels of off-farm income, soil type, gender of household head, size of family etc. The Niger and Thailand case studies presented in Grigg et al. (2015) demonstrate the importance of understanding the heterogeneity within an agroecosystem, because levels of resilience and consequent intervention responses will differ between household categories.

The following scales are relevant:

- Focal scale: scale at which the analysis is conducted and indicators gathered, probably sub-national and potentially sub-agroecosystem scale
- Reporting scale: the results or outcomes of the resilience assessments will be reported at the focal scale (sub-national) as well as at the national scale.

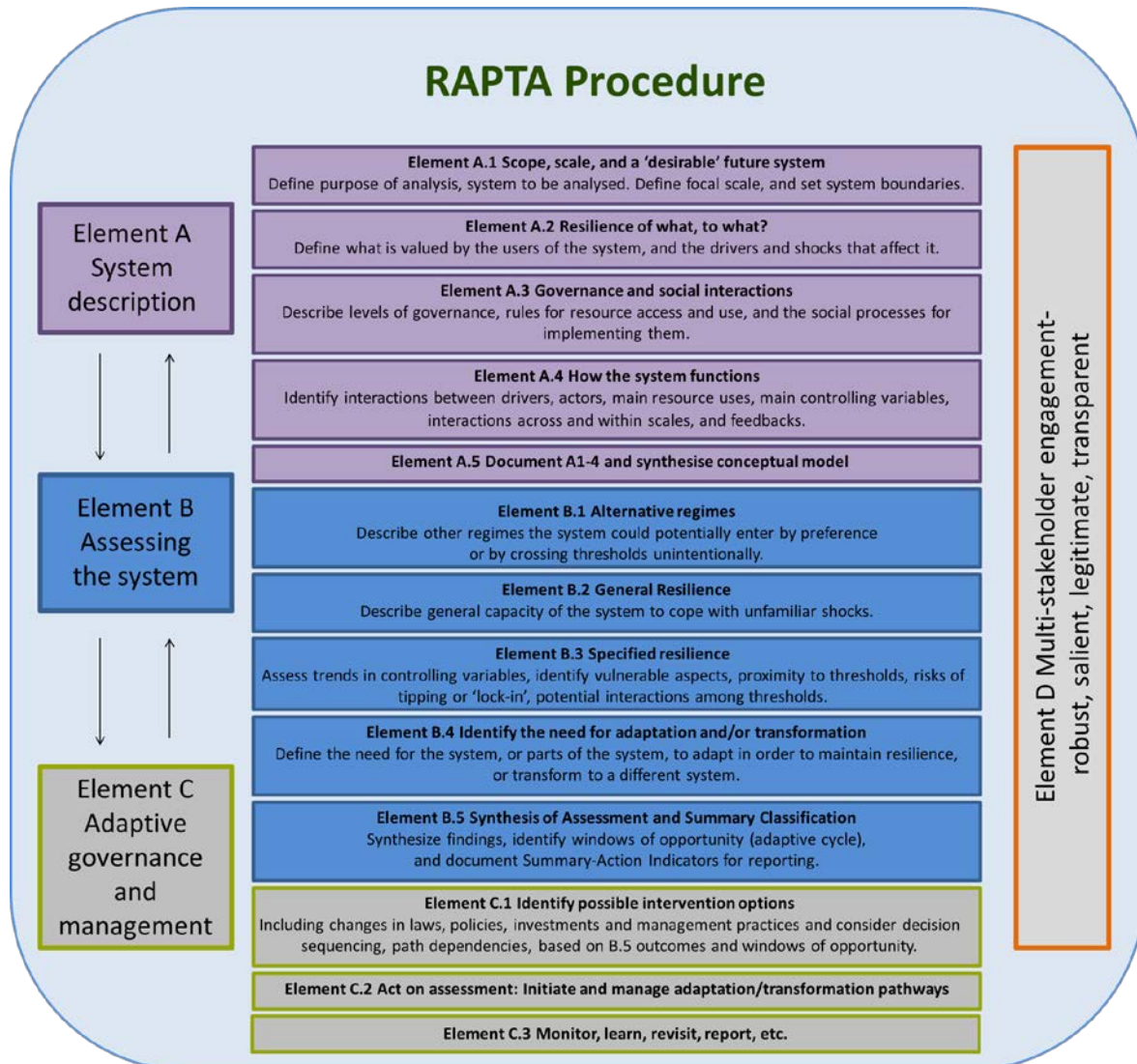


Figure 2 Elements of the Resilience, Adaptation Pathways and Transformation Assessment (RAPTA) procedure.

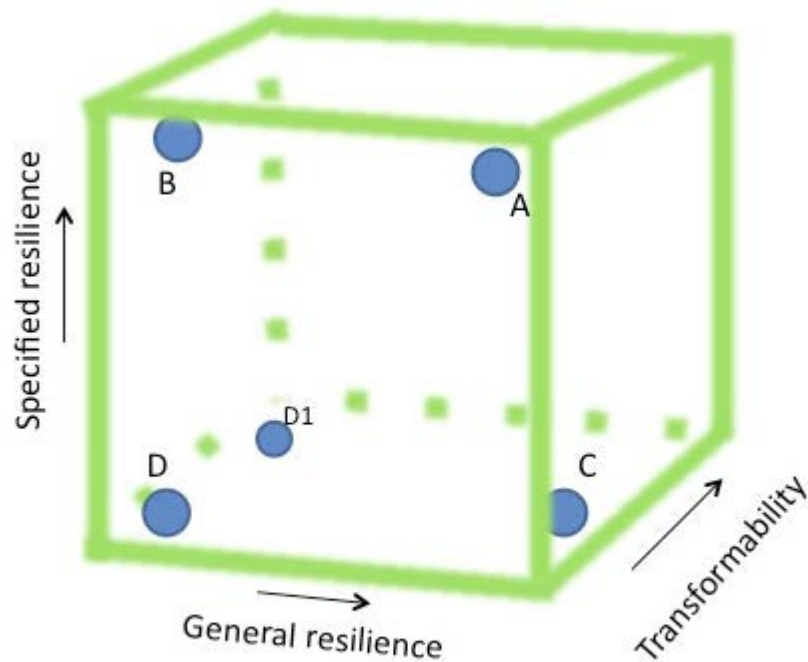


Figure 3 The Summary-Action Indicator: illustrating the general resilience, specified resilience and transformability for a system.

The Summary Action Indicator is an output of Element B.5 of the RAPTA procedure. Each blue ball represents a group of points, reflecting the uncertainty in location within the cube. **Table 1** provides the interpretation for each of the positions shown, for a system that is in a desired regime. Note that although the cube is represented with orthogonal axes, this is not mathematically correct due to correlation between attributes of specified resilience, general resilience and transformability. See O’Connell et al. (2015) for discussion on the limitations of this approach to illustrating the result of assessment.

7. Who would conduct and report the assessment?

RAPTA has many potential applications including:

- by groups of stakeholders at focal scale, to develop meaningful and informed storylines for their planning processes; to derive local meaning and value from the indicators that they measure and report; to strengthen community development.
- individuals or groups of researchers or consultants, utilising their own expert knowledge, and published studies. In such cases, without stakeholder involvement, the assessment should be limited to the System Description (Element A) and Assessing the System (Element B) because the findings are subject to the preconceptions, biases and knowledge limitations of those involved. While this can be a useful preliminary exercise, the assessment process will be more effective if local stakeholders are involved in a robust participatory process, that accesses local and traditional knowledge. The implementation steps (Element C) always require participation by stakeholders.
- national governments, to coordinate actions, including monitoring and reporting to international bodies (UNCCD, CBD, UNFCCC, OECD, FAO, Montreal process, SDGs etc) , and also for domestic policy development, such as climate change adaptation in all sectors,

planning for food and energy security, disaster planning. It can create a basis for coordinating strategic planning and policy development, integrating between disciplines and sectors, to enhance effectiveness of interventions.

- development agencies and donors to help guide support programmes, streamline and focus effort in collating and reporting of indicators most relevant to any given system.

For groups at any scale – household to national – the framework provides an approach to:

- examine and develop shared understanding of the system, and vision for the future;
- determine whether that envisioned future is resilient – and answer the question “Is this a sustainable pathway?”;
- filter and select the most relevant indicators in which to invest resources in monitoring and reporting;
- interpret the results of monitoring and reporting, to deepen understanding of the system and actions required;
- inform decisions intended to improve livelihoods, food security, management of resources, and adapt to climate change.

8. The utility of the proposed approach

The RAPTA approach was proposed for assessing and reporting resilience, adaptation and transformation of agroecosystems at the sub-national and national levels, as relevant to the three Rio Conventions. The following criteria were used to guide the development of the proposed indicators:

- ensure the indicators are fit for the intended purposes
- ensure that the indicators are consistent with the underlying theory and behaviour of the systems in which they are applied
- consider the tractability of implementation, including skill required, repeatability, risk of operator bias.

A self-assessment (see O’Connell et al., 2015) based on feedback from the Sydney workshop and peer-review of the draft report, determined that the RAPTA approach to resilience indicators meets these criteria. Further, this self-assessment identified strengths and weaknesses, and what the next steps should entail.

Table 1 Summary Action Indicators for different combinations of General Resilience (GR), Specified Resilience (SR) and Transformability (T) reflected in the positions A, B, C, D and D1 in Figure 3

	GR low	GR high
Desirable regime		
SR high	<p>B. High SR to shocks that have been assessed therefore little or no motivation to transform. But low GR leaves it exposed to shocks, especially unexpected ones. Likely that actions at higher scale are needed to boost GR to enable maintenance of high SR, and if feasible to boost T.</p> <p>Interventions:</p> <ul style="list-style-type: none"> Invest in general resilience. Higher scale actions may be necessary Urgency = medium Intervention priority = medium to high Scale of intervention = focal scale or above 	<p>A. The system is far from identified thresholds to undesirable regimes and the capacity of the people to manage the system is high, so currently no need to transform. However, if something changes such that communities and government perceive a need to transform, low T will be a challenge.</p> <p>Interventions:</p> <ul style="list-style-type: none"> Monitor and maintain SR and GR Urgency = low Intervention priority = low or zero Scale of intervention = N/A
SR low	<p>D. System is close to thresholds and with low GR the likelihood of an undesired regime shift or transformation is high. It may be in transition (e.g. agroecosystem with increasing land degradation) or transforming to a new system (e.g. agro-urban or mining) in which some households have off-farm incomes. Depending on the levels and options for T, external resources can be used for intentional transformation (move the system towards D1 by increasing the capacity to transform), or it may be driven incrementally and unintentionally from household scale as people find livelihoods outside the system.</p> <p>Interventions:</p> <ul style="list-style-type: none"> Build GR and SR; will likely need higher scale support If the 'low/low' combination makes a shift to 'undesired' inevitable, then build transformability; will need higher scale support Urgency = high Intervention priority = high if feasible Scale of intervention = focal scale, and scales above If above options not feasible, prepare for crises such as famine relief. 	<p>C. Future is precarious despite high GR because it is close to thresholds or approaching them fast. Need to use the high GR (adaptive capacity) to move the state further away from the threshold (increase SR). However, if the likelihood of being able to do this is low (strong drivers taking the system towards the threshold), then intentional regime shift or transformation may be necessary</p> <p>Interventions:</p> <ul style="list-style-type: none"> Use the high adaptive capacity (GR) to manage and build specified resilience If rebuilding SR not feasible, invest in transformability (note that G and T share many attributes) or intentional regime shift If above options fail, prepare for crises such as famine relief Urgency = depends on trend and closeness to thresholds Intervention priority depends on urgency Scale of intervention = mainly focal for building SR, but definitely cross-scale if regime shift or transformation sought
Undesirable regime		
SR high	<p>System is far from the thresholds that separate it from the desirable regime</p> <ul style="list-style-type: none"> Investigate options and feasibility of shifting system back to a desirable regime If this is not possible, look at options for transformation to a different system If an intentional transformation is feasible and desirable, it may be easier if GR is also high If GR low, it will need higher scale support If it is not feasible, investments in emergency measures may be needed Urgency = depends on level of poverty etc. Intervention priority = high if feasible Scale of intervention = focal scale, and scales above 	
SR low	<ul style="list-style-type: none"> If the system is close to thresholds that could take it back into a desired regime...then same as D / D1 above If the system is moving away from these thresholds quickly, with little chance of reversal to a desired regime and a low T (i.e. into a state of high SR 'lock-in' of undesirable state) then investments in emergency measures may be needed If system is close to/moving towards thresholds where T is high and options to transform to another desirable or at least useful system, explore/build adaptive pathways towards that option 	

9. Conclusions

The concept of resilience is an inspiration, and a clearly articulated aspiration, in the global discourse on sustainability and the future of the planet and its people. Despite the valuable body of research that has been conducted on resilience theory and practice, there are still enormous challenges to operationalizing the concept in international and national policy. RAPTA begins to address these challenges. It applies resilience theory as its conceptual basis, and uses a participatory iterative approach to characterise the system, identifying socio-ecological variables and their interactions across scales. By focussing on proximity to thresholds for key controlling variables, it evaluates the adaptive capacity and transformability of the system. Based on the outcomes of this assessment, the procedure identifies the need to adapt within the defined system, or transform to a different system.

RAPTA is flexible, making it applicable in a range of different contexts. It is well able to accommodate the reality that what is vitally important in one system is irrelevant in another. For example, climate change will be an important consideration in some systems, but not all. RAPTA is also readily applicable in situations of high uncertainty, high dispersion of power and highly ambiguous goals. Its flexibility makes it relevant to any social-ecological system.

RAPTA is consistent with existing resilience frameworks and can be used in conjunction with them. It has been informed by existing literature on resilience assessment, and contains key elements common to reviewed approaches: explicit system conceptualisation; multiple scales; and acknowledgment and characterization of context (especially the specification of resilience “of what, to what, and according to whom”).

RAPTA also brings to the fore the value of learning, innovation, experiments and openness to challenging the status quo as important attributes of a self-organised system. RAPTA enables mutual learning, fostering common understanding between stakeholders with different perspectives, interests and visions for their system, and encouraging development of narratives that provide meaningful interpretations of existing knowledge, datasets and indicators. The iterative nature of the framework and its emphasis on learning provides capacity for self-correction and scope for novelty.

RAPTA is applicable at project through to national scale, as it provides scalable indicators that summarise the results of assessment, and report on the coverage and quality of the assessment. It is relevant to planning for climate change adaptation, enhancing sustainability of cities, disaster planning, and many other aspects of the sustainable development agenda. RAPTA is applicable to the projects and programs of the GEF, including the program on “Sustainability and Resilience for food security in Sub-Saharan Africa”. It can be used to inform initiatives to build resilience of desirable social-ecological systems, and thus assist development initiatives to generate sustained positive impacts. Application of RAPTA could assist in integration between the Rio Conventions with respect to planning and implementation of strategies to achieve common objectives, and pursuit of synergies in reporting between the Conventions.

Some challenges identified in applying RAPTA include: need for sound conceptual models describing how the system functions, which are often inadequate especially in relation to socio-economic aspects; a high level of subjectivity in how it is applied (e.g. choice of focal scale and boundary of assessment), which limits the ability to compare across systems; resource intensive and time-consuming, as with any robust multi-stakeholder process; need for further guidance on multi-stakeholder engagement, inclusive adaptive management approaches and meta-indicators of the quality of assessment.

10. Next steps

The proposed approach was developed as part of a small project, and requires further development and testing, through piloting in an operational context, involving stakeholders. Some intermediate steps will be taken to prepare for a pilot or early stage implementation: guidelines on application will be prepared, and the quality indicator will be developed. Further proposed steps including trialling RAPTA in a range of archetypal, contrasting agroecosystems, and other social-ecological systems, in an adaptive learning environment involving local and national stakeholders, and technical experts.

Further information

Technical Report:

O'Connell, D., Walker, B., Abel, N., Grigg, N. (2015) The Resilience, Adaptation and Transformation Assessment Framework: From Theory to Application. CSIRO, Australia.

Accompanying Case Study Report:

Grigg, N., Abel, N., O'Connell, D. & Walker, B. (2015) Resilience assessment case studies in Thailand and Niger: Case studies to accompany a discussion paper for UNCCD STAP workshop 19 - 21 November 2014, Sydney, Australia.

Both available at: <http://www.stagef.org/the-resilience-adaptation-and-transformation-assessment-framework/>

Annex 1: Technical definitions for the key terms resilience, adaptation, transformation and sustainability

Term	Technical usage ¹
Sustainability	<p>Resilience and system dynamics help to explain processes relevant to sustainability. High resilience contributes to sustainability when it is desirable to maintain a system in its current state, but works against sustainability when transformation is desired.</p> <p>Adaptation and adaptive capacity both contribute to (and may be necessary for) sustainability where a system is under threat or is running down crucial assets or system functions.</p> <p>Cross-scale interactions are critical in considering higher level sustainability objectives. For example, in the face of climate change, sustainability of overall human well-being in a large river basin may require some landholders to transform from irrigated to non-irrigated land-use.</p>
Resilience	<p>The ability of a system to absorb disturbance and reorganize so as to retain its 'identity' – the same function, structure, and feedbacks.</p> <p>Resilience can be distinguished into</p> <ul style="list-style-type: none"> • 'specified' resilience – resilience of a system to identified disturbances i.e. potential future occurrence is known or suspected, though their timing and magnitude may be a surprise • 'general' resilience – capacity of the system to cope with all kinds of shocks and disturbances, and so be able to avoid crossing or thresholds, known or unknown, to alternate regimes or systems. It is sometimes referred to as 'coping capacity' and in this approach is used synonymously with 'adaptive capacity'. <p>Resilience is a value-free property: it is neither 'good' nor 'bad'. A system can have a high level of resilience (i.e. able to maintain the same identity despite shocks) whether it is in a desirable state (e.g. healthy, productive, profitable farmland) or an undesirable state (desertified landscape without capacity to produce food or livelihoods).</p>
Adaptation (and adaptive capacity)	<p>This term is used slightly differently in different branches of science.</p> <p>Adaptation can be in response to slow trends or drivers (e.g. climate change), or response to shocks.</p> <p>Adaptation can be intentional (i.e. driven by deliberate actions of people), or autonomous (e.g. natural selection, or forced transitions to another regime or system).</p> <p>Some use a narrower interpretation of adaptation which excludes transformation – for example, restricting it to responses that can maintain prevailing societal objectives, or the current system 'identity'. If these can no longer be achieved then 'limits to adaptation' have been reached, and transformation occurs. Much of the resilience literature separates adaptation and transformation in order to ensure consistency with an early narrow definition of adaptive capacity, namely 'the capacity of actors in a system to influence resilience'.</p> <p>In climate change literature, the term adaptation also encompasses transformation, and is sometimes called transformational adaptation.</p>
Transformation (and transformability)	<p>In resilience literature, transformation is the process of changing from one type of system to another with different controlling variables, outputs, structure, functions, and feedbacks ('identity').</p> <p>Transformation can occur in the biophysical world (e.g. novel ecosystems), or in social systems (e.g. reformed governance arrangements).</p> <p>Transformation can be intentional (i.e. driven by deliberate actions of people), autonomous (e.g. natural selection) or forced (transitions imposed from outside the system).</p>

¹These definitions are based on the social-ecological resilience literature, as used in O'Connell et al, 2015. The terms are defined and used differently by some communities of practice. As RAPTA is further developed, broad consultation will be conducted to develop harmonized language to express resilience concepts.

Annex 2: Description of the RAPTA procedure

System description (Element A)

Element A.1 Scope, scale, envisaging a 'desirable' future system and defining goals

- Define the purpose of the analysis, and the scale(s) at which the resilience assessment is to be used (e.g. local region, with summary indicators perhaps included in reporting to international or national programmes, policies or development projects)
- Determine the focal scale and boundaries of the agroecosystem, including the biophysical and social components (e.g. a catchment, a river basin, a wheat growing region, a mixed farming region, the sorts of households and businesses and livelihoods), as well as the significant, influential scales above and below
- Envisage a future desirable system. Is the system currently in a 'desirable' state? Envisage what a future 'desirable' system (or regime) might be, and compare to the expected future system, based on understanding the current trajectory. This is part of an iterative process, but should be clearly addressed as a first step.
- Define the goals of the assessment on the basis of the above (e.g. if the system currently in a desirable state, 'maintain resilience of ecosystem services, especially food production and rural livelihoods' might be appropriate; whereas if it is in a currently undesirable state, 'transform to a system which has a different source of rural livelihoods' may be a more relevant goal).
- Outline the major issues affecting the system at the focal scale, for example declining water tables, deforestation, growing poverty, the positive or negative impacts of the system beyond the focal scale, and so on.

Element A.2 Resilience of what, to what?

- Identify the values that people expect to get from the system now and in the future (e.g. grain, milk or hides that are marketed or consumed, an unpolluted river and its fish, securely held land on which to raise children) and the drivers that affect or might affect these valued system properties or products. Common drivers are markets and technologies, national and international policies, and (latterly) climate change.
- Identify past or potential 'shocks' that might hit unexpectedly, such as a new crop disease, a sudden collapse in a market, a flood, a drought, a major policy change etc.

Element A.3 Governance and social interactions

- Describe the levels of governance, the extent of decentralization of power, formal and informal rules for resource access and use and the social processes for implementing them.
- Identify conflict resolution processes, and assess levels of public trust in the governance system, its openness to criticism, and the ability to change laws if circumstances require it.

Element A.4 How the agroecosystem functions

- Analyse the social structure of the system, and if necessary stratify into relatively homogeneous groups (e.g. farm household types). Describe their livelihood strategies, their interests and influence, as well as the variables that control the system outputs they value,

such as the cover of grass or dry-season fodder trees, the depth of soil on arable land, or distance to permanent water, social cohesion (iterate with A.2, resilience 'of what' above).

- Describe how these variables interact in producing valued outputs (i.e. the dynamics of the biophysical, social and ecological processes), and how these interactions are mediated by governance and management.
- Describe interactions within and across scales – e.g. between land-use and catchment hydrology; between the focal system and other agroecosystems (e.g. the interaction of pastoralists with crop farmers), and the top-down/ bottom-up interactions of the focal system with systems at national and international scales.

Element A.5 Synthesize conceptual models from Steps A.1 to A.4

- Effective resilience practice is about creating a process where the conceptual models of the system are used to foster shared understanding of the system among the key stakeholders rather than creating one 'right' system description. In order to be implemented effectively, conceptual models should be regularly updated and shared and be used to inform adaptive management and governance.
- Although there is no single right way to develop and document a conceptual model, it needs to contain core elements amenable to resilience assessment. These include:
 - drivers and shocks
 - actors
 - main resource uses
 - valued components and products of the system
 - controlling variables of these values component and products
 - system dynamics (e.g. stabilizing and destabilizing feedback loops, non-linear interactions)
 - cross-scale interactions – connections and feedbacks between the focal scale and the scales above and within the focal scale.

Assessing the system (Element B)

Element B.1 Alternate regimes

- Refer back to the desired future systems explored in Element A1. Describe known and possible alternative regimes the system can potentially be in, either by preference (through a planned transition), or by crossing thresholds unintentionally.
- Determine whether the system as a whole, or particular social groups within it, are in a desired or an undesired system or regime.

Element B.2 General resilience

- Assess the probable effectiveness of the agroecosystem in adapting to expected and unexpected shocks. Dealing with probabilities and likelihoods could be done via a simple ranking method e.g. very effective, effective, somewhat effective, ineffective or very ineffective; or a detailed quantitative analysis, depending on the effort, resources and data with which the assessment is being conducted.

Element B.3 Specified resilience

- Taking the level of general resilience into account, for each social group, or the agroecosystem as a whole if sufficiently uniform, assess trends in controlling variables, proximity to thresholds, and the likelihood of crossing them in the short, medium or longer term (see previous note re: spectrum level as which this could be conducted – simple ranking through to quantitative analysis).
- Considering interactions among controlling variables, their closeness to thresholds and the level of general resilience, assess how likely it is that transgressing one or more thresholds could cause the agroecosystem or a social group to undergo an unwanted regime shift or transformation in the near, medium or longer term (this can be done in a simple way with a ranking systems e.g. very likely, likely, possible, unlikely, very unlikely; through to using analytical models with quantified uncertainties).

Element B.4 Identify the need for adaptation and/or transformation

- Analyse the need for the system as a whole, or of particular components (e.g. social groups) to adapt in order to remain within the existing regime, transition to a different (preferred) regime, or to transform to a different kind of system.
- If the system or social group is in a desired regime, and:
 - the chance of an unwanted regime shift or transformation is judged to be sufficiently low for the chosen time span and goals defined in Element A.1, then investing in the mix of specified and general resilience measures judged to maintain the regime is a prudent strategy; or
 - the chance of an unwanted transformation or regime shift within the chosen timespan is judged to be too high, then an additional option is to invest in intentional regime shift or transformation to a different, desirable more resilient system.
- If the system is locked into an unwanted regime by, for example, land degradation, over-population or land tenure rules, and is unable without external intervention to shift to a preferred regime, then options include seeking external investment in a shift to the desired agricultural regime, for example through land rehabilitation, land tenure changes and the establishment of local industries, or investing in transformation to a new system.
- Describe the adaptive capacity, and the set of options for alternative regimes, and whether the transitions are likely given the trends in drivers and likely shocks identified, and thus whether the situation is resolvable through adaptation. This step may dovetail with other existing tools that may have been used in the past, or available for example social impact assessment.
- Where the situation is not resolvable, assess the transformability of the system and transformation options. Where, and at what scales, is transformation needed? What options exist? What is needed to build transformability? (see C3 below).

Element B.5 Synthesis of assessment B.1–4, and summary classification

- Develop a text summary of the resilience assessment including documenting the steps, and conclusions.
- Use the stages of the adaptive cycle to identify windows of opportunity for intervention.
- Summarize into the Summary Action Indicators.

Adaptive governance and management (Element C)

The steps listed in Elements C and D could not be conducted in the case studies for the technical report, because they are inherently reliant upon multi-stakeholder engagement processes. Further development of these modules to provide more detail will need to be developed in future work, within an implemented context, with stakeholders. Brief summaries of relevant element activities are provided here.

The assessment of the system in elements A and B provides a narrative about the need and potential for the deliberate intervention in order to change system behaviour. This narrative provides the motivation, justification and focus for an adaptation initiative.

Any intervention also needs an underpinning theory of change describing how the adaptation initiative may help enable this change. This involves

- how the social system will adapt to external drivers of change in the absence of intervention and identification of desirable and undesirable system features
- articulation of how an alternative social system response may lead to different, preferable outcomes and how an adaptation initiative enables these
- analysis of feedback processes that maintain this system (e.g. power relationships that entrench some interests and exclude other issues and interests from existing social processes)
- if the societal dynamics preclude short-term controlled change, the narrative also needs to include how this adaptation initiative provides a strategic step towards the desired system (e.g. by establishing resourcing for ongoing adaptation efforts)
- analysis of the inherent limitations of an initiative to influence the societal system forms the basis of the development of a strategy (e.g. limited duration of funding, limited local legitimacy and systems understanding, limited ability to influence the social system at different scales).

The motivating narrative and theory of change needs to be open to critical revision. This is challenging, given their role in motivating and coordinating activities and in structuring in the face of accountability and project reporting requirements.

Element C.1 Identify potential intervention options and their utility in achieving desired futures and articulated goals

- Including changes in laws, policies, investments and management practices and taking into account path dependencies and the need for decision sequencing, according to the resilience assessment and windows of opportunity.
- Use complementary processes for visioning alternative future scenarios, and back-casting through the potential intervention options to test whether the desired futures and articulated goals will have been achieved by taking such actions, or whether taking such actions may reduce the options for adaptive responses in the future, thus taking the system into maladaptive space

Element C.2 Act on assessment: Initiate and manage adaptive or transformation pathways

- The outcome of the resilience assessment can be summarized as shown in the RAPTA procedure, indicating the kinds of options to be pursued under various combinations of the regime the system is in and the levels of its general and specified resilience.

Element C.3 Monitor, learn, revisit, report

- set up a process for RAPTA to be embedded in an adaptive management cycle, in which outcomes of interventions are posed as hypotheses to be tested, and as the outcomes unfold this ensures a learning process of how the agroecosystem functions.

Multi-stakeholder engagement (Element D)

A complete RAPTA procedure requires all four elements A, B, C, D to be implemented. Ideally all elements would be conducted within a multi-stakeholder context; however we understand that there are many situations where some parts of the analysis might be conducted by an individual, or a group of experts/scientists/consultants. Local multi-stakeholder engagement, however, is mandatory if Element C is to be implemented.

The November 2014 workshop in Sydney recommended that further work should be conducted into defining Element D, including:

- a methodological multi-stakeholder systems approach (with tools) that can then feed into evaluation tools and indicators (see section 4.6 Quality-of-assessment indicators) , where best practice is gathered and then fed back for broader learning. The method needs to specifically cover issues; robust, transparent, legitimate and saliency for the application. Some example tools include: critical systems heuristics, systemic interventions.
- a 'Practitioner Guide to Multi-stakeholder engagement for the RAPTA Procedure'. This should be based on best practice in application as well as currently known processes for legitimate, transparent, robust and salient multi-stakeholder engagement. These should draw on existing literature and work, rather than re-invent the wheel.