Integrated cross-realm planning: a decision-makers' perspective

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What is cross-realm planning?

We define integrated cross-realm planning as a process to guide the spatial allocation of management actions and land/water uses to achieve explicit environmental and socioeconomic objectives across multiple realms. General goals of cross-realm planning include maintaining key ecological processes connecting realms, limiting cross-realm threats that compromise conservation or socioeconomic objectives, and balancing the benefits and trade-offs resulting from management decisions. The concept is founded on the general principles of systematic conservation planning, including complementarity between priority management areas and actions, cost-effective solutions to achieving objectives, and transparent and repeatable methods for prioritising management areas/actions or allocating uses (Kukkala and Moilanen 2013). Cross-realm planning also calls for integrating conservation prioritisations with established processes for water and land-use planning, traditionally undertaken independently (Pierce et al. 2005). Effectively, this means integrating multiple objectives (e.g. biodiversity, ecosystems services, agriculture) and assessing the potential co-benefits and trade-offs between them under alternative development scenarios (Moilanen et al. 2011); this in turn requires a multidisciplinary approach to planning and new decision-support frameworks to guide and facilitate this transition (Reyers et al. 2010). Our definition includes approaches with the same broad goals, including 'integrated land-sea conservation planning' (Álvarez-Romero et al. 2011), 'ridges-to-reef planning' (Lipsett-Moore et al. 2010) and 'catchment-to-coast planning' (Smith et al. 2011), but is wider in scope and aims to capture the full complexity of planning for multiple interconnected realms.

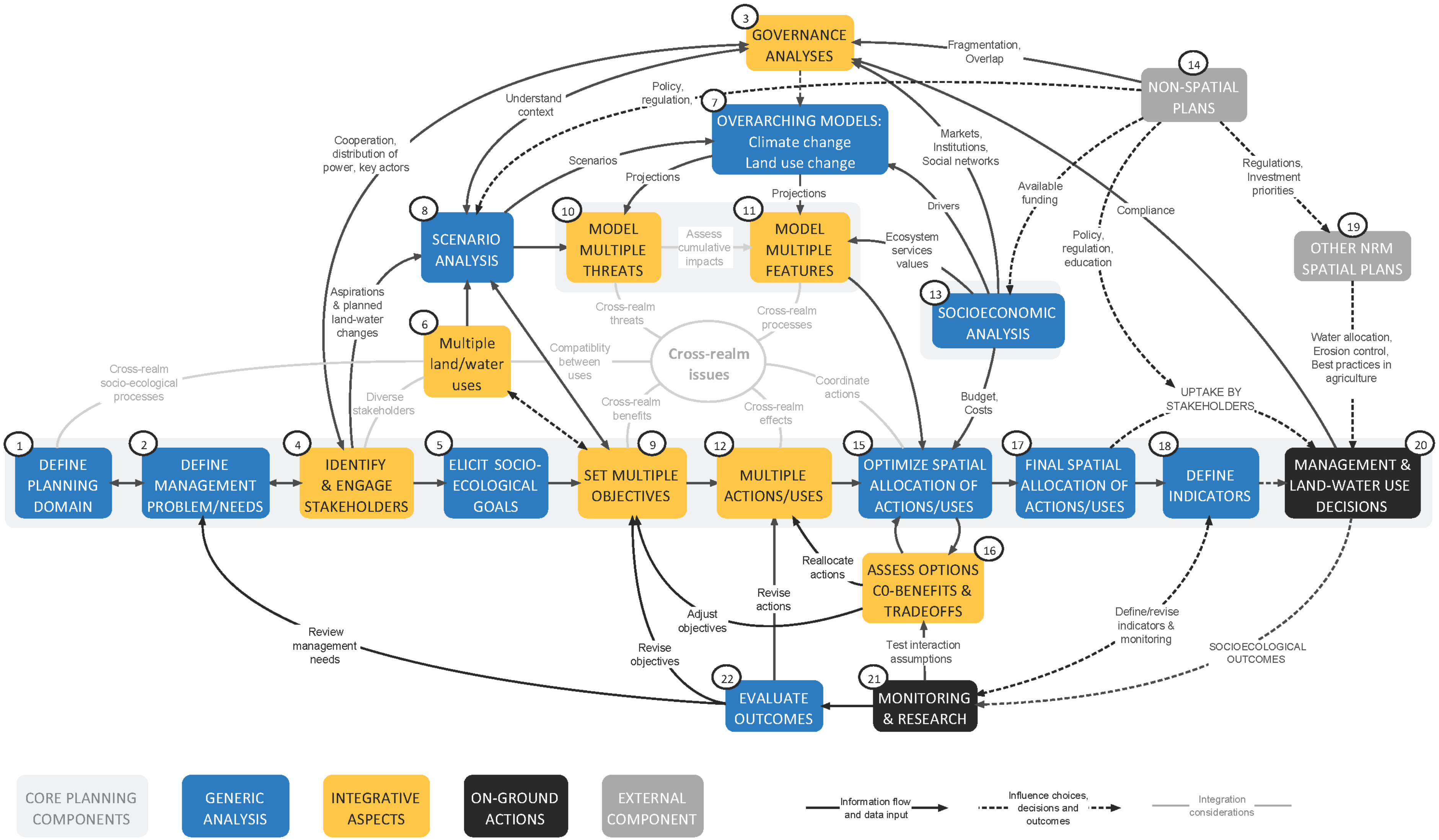
Why a new planning framework?

While there have been important advances in theoretical approaches to cross-realm planning (Adams et al. 2014a; Álvarez-Romero et al. 2011), practical advice on their application for decision-makers is generally lacking. Importantly, existing conceptual and operational frameworks are generally developed in academic settings without the participation of decision-makers responsible for implementing plans. To address this limitation, we assembled a group of applied researchers and decision-makers to discuss the requirements and challenges of integrated cross-realm planning. Together, we developed a new operational framework based on current theory, but reflecting the structure and detail required to facilitate its accessibility, application, and potential for adaptation to different contexts.

An operational framework for applied cross-realm planning

We propose a novel operational framework that incorporates considerations relevant to achieve full integration of planning across realms and offers practical guidance to decision-makers (**Figure 1**). Our framework was broadly based upon leading systematic conservation planning frameworks (Groves et al. 2002; Lehtomäki and Moilanen 2013; Pressey and Bottrill 2009), particularly those relevant to cross-realm integration (Adams et al. 2014a; Álvarez-Romero et al. 2011; Klein et al. 2010), while considering key operational aspects conducive to implementation (Knight et al. 2006). The framework reflects key considerations that decision-makers and the academic literature identified as fundamental components of cross-realm planning, but provides an in-depth and sequential conceptualisation of the information and analyses required to move from single- to cross-realm planning. It recognises the types of analyses available, such as scenario planning and cumulative impact assessments, and the appropriate points in the planning process to consider these analyses. The core planning components (from defining the problem through to implementation) reflects activities that most decision-makers currently undertake for single-realm planning. Expanding to planning across realms requires enlarging core components to include integrative analyses, as well as undertaking additional components. **Table 1** provides a description of each planning component and its application in the Daly River catchment.

Figure 1. An operational framework to guide integrated cross-realm planning (see high-resolution figure)



Some components are common to single-realm planning exercises (blue), while others were identified as critical integrative components (yellow) that will require significant changes to current planning. External components (grey), such as strategic NRM plans, legislation, and current best-practice guidelines, will influence planning through policies, regulations and funding opportunities enabling or constraining management, but can also be the starting point of planning (e.g. policy mandate). Numbers suggest a sequence of planning components, but the order in which these are undertaken (and their inclusion/exclusion) can change with planning aims, context and resources. Feedback arrows indicate where later stages can generate information that will allow revising, adjusting and/or reviewing analyses and decisions, which will lead to refining plans. This reflects the adaptive management approach identified by decision-makers and the literature as critical to cope with limited knowledge about social-ecological systems (e.g. regarding cross-realm processes), ongoing attrition of assets, and emerging management opportunities or constraints. Designing adequate indicators and monitoring programs is thus essential to assessing the social-ecological outcomes of management interventions required to adjust plans.

Table 1. Application of the cross-realm planning operational framework in the Daly Catchment planning process

To demonstrate how the framework can be adapted to real-world planning, we describe its application to a planning process in the Daly River catchment, Northern Territory, Australia. Over the course of the past two and a half years of collaboration with decisionmakers we developed and refined the framework, while adapting it to the current development and conservation planning process in the Daly catchment. The Daly catchment covers approximately 5.2 million hectares. The Daly River (including its main tributaries) is itself an important conservation asset, being one of northern Australia's largest rivers, with unusually consistent year-round flow (Kennard et al., 2010). Riparian strips contain some of the most extensive gallery (rainforest) vegetation in the region. The catchment is a high priority for development, with particular interest for its horticultural potential. Consequently, the government identified the need for a plan that integrated priorities for development and conservation, leading to the Daly River Management Advisory Committee (DRMAC) commissioning an integrated planning process.

Stage and analyses	Daly Catchment planning
1. Define planning domain: Define the region or area across which management areas are assessed and compared for investment in actions (e.g. protection, fire management, erosion control, weeding) to achieve explicit objectives (e.g. species conservation, livelihoods, development). This can be defined based on biophysical features (e.g. catchments, bioregions), political or management boundaries (e.g. districts, shires, NRM regions) or a combination of these depending on the planning goals.	The planning region was defined as the Daly catchment (including terrestrial and freshwater systems) given this is the region which DRMAC is tasked with providing advice for resource management decisions.
2. Define management problem/needs: Identify and describe the key conservation and/or natural resource management issues in the region (e.g. weeds, feral animals, bush fires, erosion, water quality and quantity, pollution, vegetation clearing) that can be addressed by actions identified in the plan, these include threats to the natural and socioeconomic assets of interest (e.g. species, wetlands, productive soils, cultural sites)	The Daly catchment is high priority for both development and conservation. In order to navigate these potentially opposed activities and ensure that decisions are made with best available information DRMAC agreed that an appropriate solution was to design a strategic spatial plan for development and conservation in the catchment. The plan explicitly considers development options including irrigated agriculture, rain-fed crops and improved pastures, grazing, and alternative economies such as carbon offsets. The plan also explicitly considers further establishment of protected areas for conservation. It is intended that the final land use scenario will support the ongoing adaptive planning and management of nature resource decisions, in particular land and water allocations for development and conservation. **For details see Adams et al. (2014b).**
3. Governance analysis: The governance context, defined by existing institutional, political, and socioeconomic decision systems, will influence management and decisions about uses of land and water across realms, and will dictate which types of funding and actions are feasible. This stage aims to understand the current or potential overlap, gaps and coordination between institutions with jurisdictions over the region (including across terrestrial, freshwater and marine realms) and how these interactions can affect management decisions and prioritisation of actions when planning.	A governance analysis was conducted to understand the overall context for the plan, and to identify strengths and weaknesses in natural resource management governance in the catchment that should be taken into account in the planning process. This informed the overall implementation strategy and methods of engagement. **For details see Dale et al. (2014).**

4. Identify and engage stakeholders: Identify organisations and/or people (e.g. agencies, resource users, NGOs, residents, scientists) who will affect or be affected by management actions or contribute to the planning process, including implementation and monitoring of actions. This stage is critical to consider the diversity of views and preferences of stakeholders when developing the plan, to maximise uptake, promote ownership, and develop feasible and cost-effective actions to achieve planning objectives.	The stakeholder engagement process with DRMAC was aimed at raising catchment residents' awareness of the plan and eliciting their preferences for different values in the catchment to inform the plan objectives. DRMAC requested a broad process of community engagement, in addition to engagement with key representatives of stakeholders. DRMAC, as the commissioning body for the plan, agreed to manage the process of setting objectives, but wanted to ensure that the objectives reflected people's ties to and expectations about the catchment. An engagement strategy was therefore designed to include community forums, focus groups, and a survey sent to all residents of the catchment, with scope for feedback from stakeholders to refine objectives and direct subsequent stages of planning. The survey was designed to elicit four types of data to feed into the plan: 1) frequency of recreational activities in the catchment and any areas of importance for recreation or protection, 2) well-being factor importance and satisfaction, 3) satisfaction with hypothetical changes to land uses in the catchment, and 4) socio-demographic background. The final well-being factors included in the survey contained 19 factors grouped into four domains based on information from the focus groups. **For details see Adams et al. (2014b).**
5. Elicit social-ecological goals: Identify the collective visions of aspirations, such as representation and persistence of biodiversity, improved livelihoods, and maintenance of ecosystem services. This broad statements of what the plans aim to achieve then need to be translated into - preferably quantitative - objectives (e.g. SMART) that will guide the allocation and prioritisation of actions and monitoring of progress.	DRMAC identified qualitative goals with a series of internal objective-setting sessions. Examples include "Protect biodiversity", "maintain water quality", "Increase development and diversification of land uses and industries". **For details see Adams et al. (2014b).**
6. Multiple land and water uses: Associated with diverse stakeholders are multiple uses of land and water with varying levels of compatibility, which requires understanding the benefits and costs of potential uses across stakeholders, sometimes geographically distant (e.g. farmers and fishers). This stage mainly consists in mapping the main land/water uses across the planning region and exploring the potential links between stakeholders with interests or jurisdiction over terrestrial, freshwater and marine realms. This will be the basis of later analysis to identify and assess the co-benefits and trade-offs resulting from land/water management decisions.	Based on the stated goals, all available data on relevant spatially discrete features was compiled from government and scientific experts. These include terrestrial features such as vegetation types, freshwater features such as species distributions for fish and turtles, and inputs into land production such as soil suitability for agriculture.
7. Overarching models: Of special concern are the effects of climate change on ecological processes and threats, including changes in species distributions (including invasive species), fish migration, rainfall (linked to sediment and nutrient runoff, flooding, droughts), and sea level rise (linked to coastal salinization). Future land (and water) uses will be constrained by these changes and threats can be accentuated (at least in some regions) or mitigated through appropriates land/water uses. Therefore, it is necessary to understand and compile available and appropriate models of climate and land use change that can influence land use/management decisions.	**Climate change was not considered in this analysis.** Potential changes in land use were considered explicitly by planning for the development of suitable land. This was achieved through the inclusion of data on land capability rather than models.

8. Scenario analysis: Cross-realm planning calls for integrating conservation prioritisations with established processes for water and land-use planning, traditionally undertaken independently. Effectively, this means identifying and integrating multiple objectives (e.g. biodiversity, ecosystems services, agriculture) and assessing the potential co-benefits and trade-offs between them under alternative development scenarios. Scenario planning can allow for the envisioning of multiple futures that include different impacts of threats on assets and actions on threats, and thereby inform achievement of objectives by feasible actions/uses.	The planning process designed in collaboration with DRMAC is based upon a scenario approach. The process includes the development and testing of different land-use scenarios before selecting a final scenario for the plan. Land-use scenarios have been designed using Marxan with zones to optimally plan for multiple land uses while meeting objectives. The land-use scenarios will be coupled with water-use profiles for agricultural land and assessed using an existing tool for evaluation of management scenarios developed for the Daly. The final plan will involve the land-use scenario, or a variation thereof, which meets the stated objectives and is best aligned with stakeholders' preferences
9. Set multiple objectives: Cross-realm planning requires integrating multiple objectives for conservation and development (e.g. biodiversity, ecosystems services, agriculture). Conservation objectives for single realms are well described (e.g. maintain species populations, represent habitats, increase production), but objectives for multiple realms are less common (e.g. protect representative marine and terrestrial habitats while also reducing land-based threats to the marine environment). Likewise, cross-realm socioeconomic objectives are generally missing (e.g. achieve land development and coastal fisheries goals through catchment management and land/water use that minimise downstream impacts). This stage entails translating broad goals into, preferably quantitative (SMART) objectives. These include realm-specific (terrestrial, freshwater, marine) and cross-realm objectives that will influence the allocation of actions across realms based on understanding cross-realm threats and ecological processes, and the costs and benefits of different land/water uses to stakeholders.	Based on the stated goals, all available data on relevant spatially discrete features was compiled from government and scientific experts. These data sets were then presented to DRMAC and a final session identified quantitative spatial objectives (e.g., protect 17% of all vegetation types, protect 17% of predicted species occurrences for freshwater species) based on qualitative goals and spatial data. The objectives reflect existing policy, such as government protection targets to meet international commitments, relevant legislation and plans that inform land and water uses (e.g., clearing guidelines), or the views of experts and other stakeholders. In addition the stakeholder engagement highlighted potential ranges for several objectives (namely land clearing levels and associated impacts on water). Therefore, scenarios were developed based on sets of objectives that reflect two different clearing levels (10% and 20% of the catchment) and constraining development spatially to precincts. **For a comprehensive list of objectives set for freshwater and terrestrial systems see Adams et al. (2014b).**
10. Model multiple threats: When planning for resource management it is important to consider multiple threats to the social-ecological systems. Threats can be associated with current land/water uses, such as modified water flow or vegetation clearing, but can derive from past or distant uses (e.g. feral animals, altered fire regimes and water flows). Managing some threats, such as feral pigs, will benefit production and conservation across multiple realms through mitigating local (e.g. soil erosion) and downstream (e.g. water quality) problems. There are likely to be varied interactions between threats and assets/uses of management interest. The potential interactions between threats (e.g. additive, synergistic, antagonistic) call for assessing, quantifying and/or modelling cumulative impacts, as well as co-benefits or trade-offs between management actions to mitigate threats.	**Threats were not explicitly incorporated into the plan.** Instead the planning approach was designed to guide different land uses to the most optimal spatial locations to reduce trade-offs. The threats of land use to freshwater values will be considered through post-hoc analysis of the plan using the water allocation MSE.
11. Model multiple features: Multiple threats will influence multiple assets in various ways. Identifying the sources of threats and the assets they influence across realms therefore underpins decisions about where, when and how to act. Assets of interest in a region include ecosystems and species with different conservation significance, but will also include, for example, areas with high suitability for agriculture or grazing and sites of cultural or recreational importance. This stage requires planners to identify the assets that are the main focus of the management plan, and may require compilation of data from historical records, monitoring programs, modelling exercises, stakeholders-based mapping, etc. This requires discussing with stakeholders which are these features and available data.	**The plan used only existing data, no new models for features were developed.** Available data included in the plan covered features across terrestrial and freshwater realms and also reflected stakeholder values (e.g. development of suitable regions for agriculture).

12. Multiple actions and uses: Threats will affect assets in different ways and can propagate across realms, thus decision-makers will likely need to employ a portfolio of management actions that will suit the requirements of different assets and mitigate local and cross-realm threats cost-efficiently. Along with prescribed actions, decisions about land and water uses should reflect the desired balance between socioeconomic opportunities and conservation needs. An integrated plan thus needs to identify, prioritise and coordinate the locations and types of actions and uses. Prioritisation of multiple actions and uses across space and time allows plans to meet objectives for multiple outcomes, which take into account the benefits and costs across diverse stakeholders and realms.	The land actions considered in the plan were different types of land uses as opposed to different types of management. These were included in the plan through explicit targets for each land use and optimal placement of these land uses with Marxan with zones. **For a summary of the final land use scenarios based on the Marxan with zones analysis see Adams (2014).**
13. Socioeconomic analysis: The socioeconomic context of the region will dictate the type of actions that are feasible to implement and inform the assumptions of overarching models (e.g. land use change, ecosystem services). There are a number of potential analysis that can inform planning at this stage, including social network analysis (stakeholders' collaboration and power dynamics), market (drivers of change), ecosystem services (values), spatial variation of management costs (inform priorities). These studies will be informed by non-spatial plans (e.g. available funding).	This step was not formally undertaken but was achieved informally through sessions with DRMAC in which they discussed the types of land uses they would like to plan for in the catchment and how this reflects their constituents desires for the catchment (e.g. carbon offsets, agriculture, conservation).
14. Non-spatial plans: External components, such as strategic NRM plans, legislation, and current best-practice guidelines, will influence planning through policies, regulations and funding opportunities enabling or constraining management. This will constrain and influence the uptake of planning recommendations by stakeholders, dictate research and planning priorities (e.g. based on current budgetary allocations, funding streams), inform other spatial planning processes (e.g. water and land use allocation) through investment priorities and regulations. Planners need to be aware of these non-spatial plans and work within the opportunities and limitations that these may impose directly or indirectly on the plan.	The plan took into consideration non-spatial regulations for the catchment including clearing guidelines which state allowed levels of clearing, water allocation plans which limit groundwater extraction and national commitments to conservation such as the CBD targets. These plans were taken into consideration in the objectives and quantitative targets set for the Daly plan. **For details of consideration of non-spatial clearing guidelines and implications for the plan see Adams and Pressey (2014).**
15. Optimize spatial allocation of actions and uses: Planning with objectives across multiple realms is uncommon and generally based on concurrent and/or sequential optimisation in terrestrial, freshwater and/or marine realms. This stage consists in integrating information derived from previous stages and optimising the allocation of actions and land uses across realms (e.g. using Marxan, Marzone, C-Plan, Zonation). Outputs of this stage are maps depicting cost-effective allocation of actions and land uses that balance social and ecological objectives across multiple realms. Rather than static and unique "optimal" solutions, these maps are likely to be alternative maps under different climatic/land use change scenarios and/or different budgetary or policy constraints. Available tools allow to consider some cross-realm threats (e.g. downstream impacts on aquatic ecosystems), but further research and tools are needed to optimize actions across multiple realms.	Land-use scenarios have been designed using Marxan with zones to optimally plan for multiple land uses while meeting objectives. **For a summary of the final land use scenarios based on the Marxan with zones analysis see Adams (2014).**

16. Assess cobenefits and tradeoffs: Managing one realm can affect ecosystems in linked realms, which can result in co-benefits, if management achieves objectives in two or three realms more efficiently, or trade-offs, if management in one realm compromises the achievement of objectives in another. To quantify co-benefits and trade-offs, it is necessary to have an understanding of how assets respond to potential actions and how actions applied in one realm can propagate to others. Response curves (e.g. persistence of species and ecosystems across realms under different levels of threats) can be incorporated into optimization algorithms to allocate multiple actions to mitigate threats across realms. When possible, the outputs of optimization tools should be assessed (or ideally integrated) to other tools to assess ecological (e.g. effects of water extraction on aquatic species) and economic (e.g. production) outcomes to assess proposed management and land use alternatives.	Scoping analysis was used to informally explore trade-offs across a range of clearing levels. The formalised assessment explored multiple scenarios and used an existing water evaluation tool to identify potential impacts on the freshwater realm across the land use scenarios.
17. Final spatial allocation of actions and uses: Based on alternative maps depicting the allocation of land use and management actions, managers – in consultation with stakeholders – can select a configuration that balances socioeconomic and environmental goals across realms. Depending on the expected output of planning, this map can be in the form of a catchment management and/or land use plan.	The final plan will involve the land-use scenario, or a variation thereof, which meets the stated objectives and is best-aligned with stakeholders' preferences. This stage has not yet been completed.
18. Define indicators: Once the management plan has been determined, the planning team should determine the social, economic and/or ecological indicators that will be used to assess the achievement of plan objectives and adjust management actions (including the overall plan) accordingly. This process should include an explicit procedure to revise and update (if necessary) the plan. Preferably, indicators should be conceptualized early in the planning process to ensure objectives are clear and can be measured using readily-available data (e.g. remotely-sensed) or can be obtained using existing or new monitoring programs (e.g. led by researchers, users and/or agencies). Indicators can be refined based on research and monitoring.	The monitoring and evaluation strategy for the plan was not discussed or designed as part of the plan. As such no indicators have been defined to date. However, some indicators are implicit such as % of vegetation cleared or amount of water extracted and are kept track of by DRMAC and associated government departments as part of the adaptive management process of approving new developments (i.e. requests for clearing and water extraction permits).
19. Other NRM spatial plans: Planners should be aware of existing spatially-explicit plans that inform uses of land and water. These plans will constrain and/or serve as the legal mechanism to implement the plans. Examples of such plans are water allocation, erosion control, weeding plans, prioritization of farms to implement best farming practices. These plans will influence uptake of the plan and should be considered when optimizing the allocation of actions and land uses, but not necessarily constrain this process.	No other spatial plans were identified for the region.
20. Management and land-water use decisions: Depending on the nature of the planning outputs (e.g. guidelines, statutory), the proposed plan will then guide the on-ground allocation of land/water uses and management actions in the planning region by the relevant stakeholders (i.e. uptake) and determine the allocation of available funding.	Selection of the final land-use scenario and implementation of the plan was to be guided by DRMAC through adaptive planning, including refinement of objectives, updating of the plan, and evaluation of ongoing resource-use decisions. However, in 2013, the government chose to discontinue support of DRMAC. Therefore, the final phase of planning has instead shifted feedback from DRMAC to the Government and relevant stakeholders – those who were members of DRMAC as well as the broader public within the catchment. Implementation of the plan is uncertain but the plan's outcomes will be provided to both appropriate NT Government departments and a newly formed Territory-wide catchment advisory committee (NTCAC).

21. Monitoring & research: Plans should include a monitoring program to periodically assess the progress and achievement of plan objectives using identified indicators. Monitoring should consider using existing research (e.g. long-term monitoring) and land/water assessment programs (e.g. land condition assessments), as well as available tools and data (e.g. remotely-sensed indices, water quality) to facilitate assessment and – if needed – adjustment of the plan. Participation of users (e.g. on-farm monitoring of biodiversity and land/water condition) can improve long-term effectiveness and promote stakeholder uptake and ownership. Monitoring will serve to test assumptions about responses of assets to threats and the effectiveness of prescribed actions. Consequently, actions/uses can be reallocated in updated plans.	The monitoring and evaluation component of the plan was not explicitly designed. DRMAC used an adaptive management approach to their decision making and intended to apply a similar approach to the plan implementation. In the absence of DRMAC it is unclear how monitoring and evaluation would proceed.
22. Evaluate outcomes: Using the information derived from monitoring programs and assessment of effectiveness of actions, plans can be revisited to redefine and/or reallocate management actions and uses. This information can also serve to assess and – if necessary – adjust objectives, either because they are inadequate or are not providing information that will allow managers to assess the health of the system. This information ultimately can serve to revisit the broad management problems/needs and assess the relevance of the planning goals under new circumstances.	The monitoring and evaluation component of the plan was not explicitly designed. DRMAC used an adaptive management approach to their decision making and intended to apply a similar approach to the plan implementation. In the absence of DRMAC it is unclear how monitoring and evaluation would proceed.

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