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Cluster analysis reveals latent structure in stakeholder interests relevant to the management of Blueskin Bay estuary, Otago, Aotearoa New Zealand

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ABSTRACT

Community participation is increasingly embedded into environmental policy with the aim of accelerating transformative change towards sustainable management. A common approach to engage with communities is through key stakeholders who are still often selected *ad hoc* based on their activities. We tested an analytical approach for identifying distinct groups of community preferences as part of a case study to develop a community-led management plan for Blueskin Bay estuary and its catchment. We interviewed 36 community members to elicit their preferences for predefined management objectives following a standardized protocol. Using an agglomerative hierarchical analysis, we determined value-preference clusters for high-level management objectives and for more specific sub-objectives. At both levels combined, preference clusters were attributed to some of the commercial interests, such as cockle harvesting, forestry, or tourism, which we also identified *ad hoc* based on their activities in the Blueskin Bay area. However, in addition cluster analyses revealed five additional preference types, which we termed Urbanization Development Advocates, Cultural Environmentalists, Economic Environmentalists, Integrative Thinkers and those with Diverse Interests. We conclude that cluster analysis more objectively and specifically maps community preferences and, consequently, increases the robustness of collaborative environmental management processes such as the one underway for Blueskin Bay estuary.

Key words: Blueskin Bay; ecological quality; estuary; hierarchical cluster analysis; integrative management; multi-attribute value theory; multi-criteria analysis; National Policy Statement for Freshwater Management; public participation; stakeholder engagement

Introduction

Estuaries are unique ecosystems between land and sea that represent hotspots of biodiversity, biogeochemical processes, and biological production (Douglas, Lohrer, & Pilditch, 2019; Kennish, 2002). They are also sites of diverse social, cultural, and economic significance which makes them among the most valuable, yet also among the most threatened and degraded ecosystems on earth (Barbier et al., 2011; Costanza et al., 2014). A reason for that is that estuaries accumulate both proximal, direct effects of human activities localised in and around the estuary in addition to more distal, indirect effects resulting from catchment-based activities (Keneley, O'Toole, Coffey, & MacGarvey, 2013). In Aotearoa New Zealand (hereafter 'NZ'), for example, estuaries face local and catchment-wide issues including excessive nutrient loads and associated estuarine algal blooms, excessive sediment loads leading to enhanced sedimentation, chemical and waste pollution, pathogens, fish and shellfish harvesting, and the disturbance of estuary beds and margins (New Zealand Parliamentary Commissioner for the Environment, 2020). Accordingly, effective, catchment-scale estuary management is a pressing issue, not only in NZ but worldwide (Lotze et al., 2006). However, decisions about how to manage (i.e. restore, conserve and use estuaries) are highly complex and including local communities in the decision making process is invaluable (Keneley et al., 2013).

Community participation in environmental decision-making has been increasingly embedded into national and international policy, as embracing the diversity of knowledge and values is thought to result in flexible and transparent decision-making for complex issues (Innes & Booher, 2018; Nissen, 2014; Reed, 2008; Sinner, Newton, & Duncan, 2015). When performed effectively (Biddle, 2017; Durham, Baker, Smith, Moore, & Morgan, 2014), community participation integrates local and scientific knowledge and, therewith, provides a more comprehensive understanding of the relevant complex and dynamic social, ecological, cultural, and economic processes indicative of a particular system (Gray, Chan, Clark, & Jordan, 2012). In turn, when the decision-making process considers people's interests, values, and concerns, the likelihood that the project will successfully meet local needs and priorities is increased (Dougill et al., 2006). In addition, giving people a voice leads to decision-making processes that educate the public, are more resilient to local vested interests, and can change attitudes of participants towards more robust and longer term outcomes (Biddle & Koontz, 2014; M. S. Reed, 2008; Sterling et al., 2017). In effect, collaborative decision-making processes facilitate the implementation and sustainability of management actions (Webler & Tuler, 2021).

Over the past two decades, community participation has also become an integral part of water governance and resource management (Carr, Bloschl, & Loucks, 2012), progressing from earlier directives which encouraged stakeholder collaboration, e.g. the European Union Water

Framework Directive (European Commission, 2000, 2003) or the Clean Water Act (United States, 1972) to more recent regulations mandating community engagement (e.g. (Australian Government, 2018; New Zealand Ministry for the Environment, 2020). For example, Sections 3.3, 3.4 and 3.7 of the New Zealand National Policy Statement for Freshwater Management (which also encompasses estuaries) mandate engagement and active involvement with stakeholders and *tangata whenua* (Māori) in the development of long term visions for freshwater management, for locally relevant implementation of policy, for the setting of environmental limits, and for agreeing on appropriate monitoring strategies (New Zealand Ministry for the Environment, 2020). A common way of facilitating community participation in catchment management is through engagement with key stakeholders (i.e. people who hold a "stake", i.e. an interest in the matter of the decision-making process), whose opinions inform the decision-making process and shape outcomes. Key stakeholders in catchment management processes are typically selected based on whether they either hold an economic interest located within the river catchment (e.g. forestry, infrastructure development, or hydropower production etc.), use the waterways for social activities (e.g. fishing, swimming, customary use etc.), or represent (governmental or non-governmental) environmental organisations and agencies (Barbosa et al., 2019; De Stefano, 2010; Junker, Buchecker, & Mueller-Boeker, 2007; Morrison, 2003; Nissen, 2014). The status of participating indigenous rights holders can differ among and within countries. In NZ, *tangata whenua* (indigenous *iwi* (tribes) which have *mana whenua* (customary authority) over a particular area) must be actively involved by the local authority in freshwater management to the extent they wish to be involved (New Zealand Ministry for the Environment, 2020) and, therefore, collaborate outside of a stakeholder definition (also see Memon & Kirk, 2012).

Theory and practical experiences indicate that collaborative processes lead to more sustainable and effective solutions when the full range of stakeholders, who are representative of the value-preference landscape for a particular decision-making process, are involved (Junker et al., 2007; Reed, 2008; but see Tadaki, Sinner, Stahlmann-Brown, & Greenhalgh, 2020, who found that community confidence in the legitimacy, fairness and effectiveness of water management institutions has not improved despite major investments in collaborative decision making in three regions in the North Island of NZ). This is especially true if stakes greatly differ, which is a common situation in water management where a variety of human interests can be at odds with maintaining ecological health (Falkenmark, 2003). While engaging only with like-minded people can be expedient, participatory processes that engage with relevant stakeholders are expected to be more efficient and effective in the long-run (Irvin & Stansbury, 2004; Konisky & Beirele, 2001). In catchment management processes, main reasons for this are fewer delays in the implementation of management plans due to interventions by overlooked (or intentionally excluded) interests (Luyet, 2005), and buy-in from the whole community which fosters long-term sustainability of management plans (Duram & Brown, 1999; Junker et al., 2007) among others, such as fostering and developing social learning and improving project design using local knowledge (Luyet, Schlaepfer, Parlange, & Buttler, 2012).

Although stakeholder selection is a vital first step in collaborative processes, it is still often done *ad hoc* (Nissen, 2014; Mark S. Reed et al., 2009), based on the assumption that their values align with their visible interests/activities and that each representative promotes the interests of a stakeholder group that they are deemed to reflect. However, it is likely that the value preferences of people are more complex than that of a single interest group. This was shown for a river restoration project in Switzerland where, for the most controversial issues including naturalness, forestry, recreation, and agricultural use of land, the public's preferences did not match those of the stakeholder groups which are commonly involved in such projects (i.e. land owners, fishing and hunting groups, NGOs, farmers union, tourism (Junker et al., 2007)).

Here we hypothesised that a values-based analytical approach would reveal a broader and more complex spectrum of key stakeholder types compared to an a priori selection of stakeholder group representatives. We tested the approach in the context of a real-world participatory process that is underway to develop a community management plan for Blueskin Bay estuary and its catchment in Otago, NZ.

Material and Methods

Case study area: The Blueskin estuary and catchment

Blueskin estuary is Otago's largest intertidal estuarine environment, rich in birds, shellfish, fish and other forms of life (Fig. 1A, B). It is as a shallow intertidal-dominated estuary characterized by a heterogenous mosaic composed of saltmarshes, estuarine sand and mudflats, estuarine seagrass beds, tidal estuarine channels, and sheltered shallow sand (New Zealand Department of Conservation, 2016). These habitats support a diverse flora and fauna which provide for cultural and customary uses such as cockle/tuaki (*Austrovenus stutchburyi*) and flounder/patiki (*Rhombosolea* spp.) harvesting, picnicking and generally enjoying the estuary and its ocean beach (Fig. 1C, D). Blueskin estuary is a regionally and nationally outstanding cockle habitat providing large quantities of shellfish to both recreational and commercial harvesters. The significance of the estuary is acknowledged by being encompassed in the East Otago Taiāpure Management Area – a fishery management arrangement with Ngāi Tahu which limits recreational takes and highlights both the food gathering value of the region and the importance of protecting the aquatic resources of the area for future generations (East Otago Taiapure, 2008). In addition, the estuary is a designated coastal protection area in the Otago Regional Council's Regional Plan (Otago Regional

Council, 2012), due to its special characteristics and the vulnerability of its biota and habitats to human pressures.

Recent observations by locals regarding the blooms of sea lettuce (*Ulva sp.*) in the estuary and reductions in cockle distributions within the estuary raised concerns within the community that the health of the estuary is deteriorating. Cumulative contaminant flows arise from residential areas (including sewage, septic tanks, and stormwater), which will increase with the current and planned residential developments. Forestry is also prevalent in the Blueskin Bay catchment and anecdotal evidence suggests that soil erosion has deleterious effects on water quality and estuarine ecology in Blueskin estuary. While farming in the catchment is low intensity, current land plans allow intensification, which could put the estuary at risk from increasing fertilizer, sediment, and faecal runoff.

Relevant environmental policies for estuary management in New Zealand

The New Zealand Coastal Policy Statement (CPS; New Zealand Department of Conservation, 2010) and the National Policy Statement of Freshwater Management (NPS-FM; New Zealand Ministry for the Environment, 2020) are the two key policies to consider when developing estuary management plans in NZ. While the CPS identifies estuaries as important ecosystems to manage as their own entity, the NPS-FM emphasises the management of estuaries as part of an integrated catchment management approach, recognising the connection between land, water and human health. The recently released report by the New Zealand Parliament Commissioner for the Environment (2020) similarly urges for estuaries to be included in freshwater management units (as set out in the NPS-FM; New Zealand Ministry for the Environment, 2020) to facilitate integrated management from the mountains to the sea.

Development of a catchment-estuary management plan for Blueskin Bay

With support from Blueskin Bay Watch – a local conservation-oriented community group founded to represent the views of people on environmental and development issues in and around Blueskin estuary – we initiated the process of developing a catchment and estuary management plan in 2019. A series of four workshops were held in which 1) the Multi-Criteria Decision Analysis-framework (see below) we agreed to follow was explained, 2) key community values related to the Blueskin estuary and the catchment were identified, 3) objectives (i.e. suggested by the authors based on the previously identified values) were arranged hierarchically from high-level (abstract) to more specific (measurable) objectives, and 4) measurable system properties (i.e. indicators) were identified (Fig. 2). Participation was open to the public and each of the workshops was attended by 40 to 60 people.

A framework for collaborative catchment management planning

Multi-Criteria Decision Analysis (MCDA) is an umbrella term for a collection of formal methods that support complex decision situations with multiple objectives (Eisenführ, Weber, & Langer, 2010; Gregory et al., 2012; Gregory & Keeney, 2002). Currently, MCDA gains new momentum due to its ability to integrate social objectives and stakeholder engagement in environmental decision applications that involve coupled human-natural systems (Estevez, Walshe, & Burgman, 2013). Examples of MCDA-based catchment management and restoration planning are described in Kuemmerlen, Reichert, Siber, & Schuwirth (2019), Langhans & Lienert (2016), Langhans, Lienert, Schuwirth, & Reichert (2013), Langhans, Schuwirth, & Reichert (2014), Paillex et al. (2017) and Reichert, Langhans, Lienert, & Schuwirth (2015). Recently, an MCDA-framework was used in Otago, NZ, to contribute to a community-based catchment management plan for Lake Wanaka and its upper catchment and provides a thorough description and review of the MCDA-framework for a NZ-specific context (Langhans & Schallenberg, 2022).

A defining characteristic of the MCDA-framework is that it describes an inclusive, transparent, collaborative step-by-step process, whereby multiple local interest groups (stakeholders) have equal opportunity for input into the process (see Langhans, Jähnig, & Schallenberg, 2019; Langhans & Schallenberg, 2022 for a discussion of how Māori might want to collaborate on, or use the framework). The subjective value preferences of said stakeholders and objective expert knowledge ('expert knowledge' as discussed in Burgman et al. (2011)) are clearly separated throughout the process, but are ultimately combined to identify the management actions that have the most buy-in from all stakeholders. The first step of the MCDA-framework is to identify key stakeholders (Langhans et al., 2019; Langhans & Schallenberg, 2022). Key stakeholder groups which would be identified with an *ad hoc* a priori-approach based on visible activities in the Blueskin catchment and estuary include forestry, commercial cockle harvest, housing development, tourism, and recreational/customary bivalve harvest.

Development of the management objectives hierarchy

During the four workshops, the Blueskin Bay community defined the main objective as "[the establishment of] a collaborative catchment-estuary management plan (including estuary restoration and conservation) that recommends priority actions to maintain and/or restore the chemical, physical, and biological integrity of the estuary and its catchment while allowing for sustainable use of its ecosystem services". The main objective was separated into five first-level objectives (Fig. 2A): (1) effect excellent catchment and estuary health, (2) maintain sense of place in a changing and dynamic environment, (3) maintain local culture, (4) allow for sustainable economic activities, and

(5) adaptability to climate change. Each of the first-level objectives was divided into more specific second-level objectives including: (1.1) effect excellent estuary health and (1.2) effect excellent catchment health (both under the first-level objective 'catchment and estuary health'); (2.1) maintain or restore native water-bound bird populations, (2.2) no invasive species, (2.3) maintain or restore functioning and native estuary riparian vegetation, and (2.4) maintain protective spit vegetation (under 'sense of place'); (3.1) preserve indigenous knowledge, (3.2) ensure satisfactory experience harvesting mahinga kai, and (3.3) ensure satisfactory experience with recreational activities (under 'local culture') (Fig. 2B); (4.1) establish or maintain sustainable cockle harvest, (4.2) sustainable agriculture, (4.3) sustainable forestry, (4.4) sustainable tourism, and (4.5) sustainable urbanization (under 'economic activities') and, finally, (5.1) implement cost-effective monitoring and (5.2) cost-effective management action (under 'cost-effective management plan') (Fig. 2C). The second-level objectives were further refined into third and fourth level objectives (Fig. 2A-C).

Identifying the community's weight preferences for various management objectives

Instead of interviewing one or only a few representative(s) of each a priori-defined key stakeholder group (as it is usually done in collaborative management; Harris-Lovett, Lienert, & Sredlak, 2019; Langhans & Schallenberg, 2022; Marttunen, Weber, Aberg, & Lienert, 2019), we interviewed 36 adults who are working or living in proximity to the Blueskin Bay estuary to elicit individuals' weights for different management objectives. We aimed at interviewing people working in, or having links to, all the industries present in the Blueskin Bay catchment including cockle harvest, forestry, and construction/housing developers as well as community members not depending on economic activity directly related to Blueskin estuary. To cover all the industries, we actively approached potential participants. Additional community participants were gathered through word of mouth and an interview sign-up sheet provided in the local public library. Everybody who was interested in participating was interviewed.

Interviews were performed during October 2020, face-to-face with each participant individually, following a standardised protocol to minimise biases due to framing, availability and social context (Burgman et al., 2011). Standardised interview protocols also minimised interviewer error and ensured participants were asked identically worded questions without unscripted commentary that could bias the answers (Fowler & Mangione, 1990). A template of the interview questions used is provided on zenodo https://doi.org/10.5281/zenodo.6821332.

Interviews were based on a method which is commonly used to elicit weight preferences called the Swing-method (Eisenführ et al., 2010). With the Swing-method one asks interviewees to assign points from 0 to 100 to hypothetical management scenarios, each of which results in the complete restoration of one of the pre-defined management objectives, while all the other objectives in the same branch remain in an unfulfilled condition. The points are assigned relatively to a worst-case scenario (with all objectives in the same branch being in the unfulfilled condition; receiving zero points) and to a best-case scenario in which the interviewee's most important objective is restored to the best condition (receiving 100 points). For example, in our case when eliciting community weights for the first-level objectives (Fig. 2A), the worst-case scenario for a collaborative catchment-estuary management plan for Blueskin Bay estuary (Fig. 2A, main goal) was that all five first-level objectives remain unfulfilled. This scenario always received zero points for all interviewees. The interviewer then asked the interviewee to name their most important first-level objective. Let's assume for interviewee x this was "effect excellent catchment and estuary health". Hence, a hypothetical management scenario that improves the objective on 'catchment and estuary health' to the best condition, while all other first-level objectives remain unfulfilled, received 100 points for interviewee x. Then, interviewee x identified their second most important first-level objective and assigned points between 0 and 100 to a management scenario that improves said second most important first-level objective to the best condition, while all other first-level objectives remain unfulfilled. This process included the third, fourth and least important first-level objective with the interviewee, and was repeated for all second-level objectives (https://doi.org/10.5281/zenodo.6821332.).

The points given by the interviewees were then transferred into weights according to equation 1 (Eisenführ et al., 2010):

(1) $$w_r = \frac{t_r}{\sum_{i=1}^{m} t_i}$$

where

w_r = weight of objective X_r

t_r = points given to objective X_r

m = number of objectives.

For the purpose of defining weights for decision-making in the environmental sector, Lienert et al. (2011) adapted the Swing-method to a reverse version, which they found was more intuitive for interviewees to follow. However, when we trialed the interview protocol in the Blueskin Bay area, the Reverse Swing-method was assessed as less intuitive, and we switched back to working with the original method.

Identifying value-preferences groups for management objectives

To identify groups of similar value preferences among the 36 interviewed community members, we applied cluster analysis (Hastie, Tibshirani, & Friedman, 2009) – a statistical method which is part of the pattern recognition/ unsupervised machine learning family. We performed agglomerative hierarchical clustering with two separate analyses, one based on the stated preferences for the first-level management objectives and another one for the second-level objectives using the software R (R Core Team, 2020) and the package ‘cluster’ (Maechler et al., 2016). Similarity between participants’ preferences was determined by Ward’s agglomerative clustering algorithm (Ward.D2 = Ward’s minimum variance method; Ward, 1963). This algorithm is based on a classical sum-of-squares criterion producing groups that minimize within-group dispersion at each point where two groups merge and looks for clusters in a multivariate two-dimensional space (Murtagh & Legendre, 2014). A weaknesses of Ward’s method is that the algorithm is constrained by previous choices.

As identifying the “correct” number of clusters has been shown to be difficult in real-world applications (Dash, Liu, Scheuermann, & Tan, 2003), we applied a two-step approach: First, we plotted separate dendrograms for the stated preferences for the first- and second-level objectives and identified the number of clusters visually based on the dendrograms’ hierarchical structure. For each pair of dendrograms produced, we selected a distance along the dendrograms' y-axis where the distance between clusters was greatest. Then to validate the selection, we ran NbClust which uses 30 different indices for determining the number of clusters (Charrad, Ghazzali, Boiteau, & Niknafs, 2015).

Results

Descriptives of interviewed community members

The 36 interviewed community members comprised 19 women and 17 men between the ages of 29 and 76. For cultural heritage, three of the 36 people identified as Māori, one as Indigenous Canadian and 32 people identified as NZ European.

Participants value-preference clusters of first-level objectives

Based on the preferences elicited for the first-level objectives, the agglomerative hierarchical cluster analysis grouped the 36 community members into four distinct clusters of different sizes: cluster 1.1 had seven individuals, cluster 1.2 had one individual, cluster 1.3 had six individuals, cluster 1.4 had 22 individuals (Fig. 3). Through a visual analysis of each cluster’s preferences and comparisons to those of the other clusters (Table 1A), cluster 1.1 exhibited high weightings for the objective ‘catchment and estuary health’ paired with low weights for the objectives ‘sustainable economic activities’ and ‘cost-effective catchment management plan’ (and consequently higher weightings for ‘local culture’). Cluster 1.2 exhibited a high weighting for the objective ‘sustainable economic activities', cluster 1.3 high weightings for the objective 'catchment and estuary health' paired with low weightings for the objective 'local culture', and cluster 1.4 exhibited relatively evenly distributed weightings for all five first-level objectives. Based on the weightings apparent for the identified clusters, the stakeholder types identified by the cluster analysis were termed Cultural Environmentalists, Industry stakeholder (Forestry), Economic Environmentalists and Diverse Interests stakeholders, respectively for clusters 1.1 to 1.4.

Value-preference clusters of second-level objectives

Based on the stakeholders' preferences elicited for the second-level objectives, the cluster analysis grouped participants into five distinct clusters with three clusters consisting of one individual each (clusters 2.1, 2.2 and 2.4), cluster 2.3 with 25 individuals and cluster 2.5 consisting of eight individuals (Fig. 4). The three Clusters with one member were characterized by: cluster 2.1 - a full weighting given to the objective 'sustainable tourism' (i.e., zero weighting given to the three other second-level objectives in the 'sustainable economic activities' branch), cluster 2.2 - a high weighting for 'sustainable urbanization' paired with a low weighting for 'no invasive species' and no weighting given to 'cost-effective management plan' and, cluster 2.4 - a high weighting for 'sustainable cockle harvest' and zero weighting for 'protective spit vegetation'. Cluster 2.3 was characterized by evenly distributed weightings across the second-level objectives and cluster 2.5 by particularly high weightings for 'indigenous knowledge preservation' and higher weightings for 'catchment health' than for 'estuary health' (Table 1B). Based on the weightings, the stakeholder types in the clusters were termed Industry stakeholder (Tourism), Urban Development Advocates, Diverse Interests stakeholders, Industry stakeholder (Commercial Cockle Harvest) and Integrative Thinkers, respectively for clusters 2.1 to 2.5.

Comparison of clusters' composition at the two levels of management objectives

We performed a simple network analysis to compare the composition of clusters between the two levels of management objectives (Fig. 5). Representatives of the Cultural and Economic Environmentalists were distributed between four and three different stakeholder types on the second level of objectives, respectively, while only a small fraction of the Divers Interests stakeholders were attributed to a new type (to the Integrative Thinkers; 4 out of 22 individuals) at the second level. The representative of the Industry stakeholder type chose similar weights for all objectives at the second level and, consequently, grouped with the Divers Interests stakeholders.

Discussion

Public participation, including the collaboration of researchers, local experts, decision makers, and the general public, is becoming a standard feature of environmental decision making. This trend is mirrored in 21st century legislation as well as large research programs (e.g. Horizon Europe; http://ec.europa.eu/horizon-europe), which mandate public engagement as an element in environmental management research projects and actions. Despite best practice handbooks emphasizing the importance of stakeholder selection (Durham et al., 2014; European Commission, 2003), identifying relevant stakeholder groups is still often done a priori or *ad hoc* when selected key stakeholders are not available for participation. This is surprising, since recent evidence suggests that the particular participants in collaborative catchment management processes can considerably influence their outcomes (Baudoin & Gittins, 2021; Koontz & Johnson, 2004). Consequently, acquiring a good understanding of the value preferences-landscape is key to ensure representatives of all value preferences-groups that are locally and thematically relevant are included in a collaborative management process.

We tested a hierarchical cluster analysis approach in the Blueskin Bay area specifically for the community's weightings of management objectives that they had previously identified as being of relevance for the management of Blueskin Bay catchment and estuary. We found preference clusters reflecting the following stakeholder types: those showing commercial interests (e.g., cockle harvesting, tourism and forestry; the Industry Stakeholders), Sustainable Urban Development Advocates, Cultural Environmentalists, Economic Environmentalists, Integrative Thinkers and stakeholders with Diverse Interests. While community members with local economic interests were primarily (but not only) concerned with objectives directly related to their industries, the cluster analyses revealed additional groups with distinct, non-economic interests in the area. A similar result was found by Pascoe et al. (2009) who elicited stakeholder preferences for objectives of marine fisheries management in Australia. They found that while stakeholder preferences generally corresponded with their expected preference set, there was low coherence within stakeholder groups. Interestingly, in our study not all representatives of the Industry stakeholder type had a direct link to one of the local businesses. This result showcases that people's preferences are not necessarily motivated by personal economic benefits, even when advocating for sustainable economic activities.

At both levels of management objectives, we found a small cluster representing commercial interests (Industry Stakeholders) as well as a large cluster of participants who weighted all objectives at the respective level similarly (Diverse Interests Stakeholders). These common clusters were supplemented by two small clusters identified at each level of objectives (Fig. 5): At the first level, the two additional stakeholder types were clustered based on strong preferences for environmental management objectives, with one focusing on cultural objectives and the other one on economic objectives; preference clusters at the second level of objectives revealed an additional stakeholder type that advocates for sustainable urban development and one with strong preferences for approaching estuary management in an integrative way regarding the spatial scale (catchment) and the information sources that are used (indigenous knowledge). This pattern, composed of one large value preference cluster and multiple smaller ones, was also found for a river restoration study in Germany, in which the majority of people who use the river environment for recreational activities had contrasting value preferences compared to smaller user groups (Symmank, Profeta, & Niens, 2021). In our case study, a possible explanation for the large diverse interests clusters might have been social learning (Luyet et al., 2012), whereby community members developed a better understanding and therewith empathy towards the whole range of objectives due to their previous participation in the workshop series.

Comparing all of the above stakeholder types with the activities which we had identified a priori to be relevant for the main goal of 'establishing a collaborative catchment-estuary management plan' (i.e. forestry, commercial cockle harvest, housing development, tourism and recreational/customary bivalve harvest), clearly illustrated a more complex value preferences-landscape that transcended pre-conceptions of a priori stakeholder interests based on visible activities in the case study area. Consequently, the use of an analytical hierarchical cluster analysis approach, as we have tested here, shows merit to become a promising addition to the currently used methods, such as focus groups, snowball-sampling, interest-influence matrices, stakeholder-led stakeholder categorization or Q methodology (see in-depth discussion of these methods in Reed, 2009) and, therewith, to help towards alleviating the problem of under-representing marginalized or powerless groups in environmental management decision-making processes. By identifying community preferences, not only for the broad first-level management objectives but also for the more specific objectives at the second-level, we revealed additional preference clusters. Future research will have to investigate how much new knowledge on a community's value preferences-landscape can be gained by analyzing more specific levels of objectives (e.g. in our case 3rd and 4th; Fig. 2).

We acknowledge some weaknesses of this study, including the total number of participants, their ethnical diversity, their age distribution as well as their personal attitude and interest towards environmental issues in the area. The local population size is approximately 1000 people (Statistics New Zealand, 2020) of which we interviewed 36. This is a relatively small number despite the intensive recruitment effort we made. One potential reason for the low participation is the covid-19 pandemic, which was shown to lead to a decrease in pro-environmental behavior during periods of lockdown restrictions (Kesenheimer & Greitemeyer, 2021) and has likely decreased willingness to contribute to pro-environmental activities in the case study area as well. Along the same lines, the study would have benefitted from the participation of more younger community members and people of Māori heritage. Finally, one of the *a priori* identified stakeholders, the housing developers, were not interested in participating in the study. Hence, we missed aspects of the value-preferences landscape which would have contributed to our analysis. Accordingly, we recommend accounting for the possibility that recruitment of some community groups will take extra resources, especially for those groups which are unfamiliar with, or are not interested in environmental management.

In future applications of the approach, it has to be taken into account that when interviews are performed face-to-face, the analytical cluster analysis-approach is more time-consuming and resource-intense compared to interviewing a limited set of *a priori* identified stakeholders. To resolve this issue, interviews could be conducted face-to-face over a streaming platform or with online questionnaires, which could be filled out by participants in their own time. Driven by NZ's covid-19 response, we trialled both approaches in the Blueskin Bay area but without success. Consequently, from our experience, choosing an interview set-up which is adapted to local circumstances, people's comfort zones and their tech-related abilities is essential to collecting robust values-preference data.

Conclusions

We found that using hierarchical cluster analyses provides the means to analytically disclose value-preference groups that do not strictly align with assumed stakeholder value preferences in the context of water management decision-making. Consequently, cluster analysis clearly helps identify more nuanced perspectives which are likely missed when selecting stakeholders in the usual *a priori* manner and, therewith, increases the robustness of collaborative restoration and management processes such as the one underway for Blueskin Bay's catchment and estuary. The weight preferences identified for the different clusters can be fed back into the MCDA-framework (Langhans et al., 2019; Langhans & Schallenberg, 2022) where they, paired with predicted consequences of potential management actions, build the basis for optimising a management plan that includes the values landscape of the whole Blueskin Bay community and, therefore, will be truly collaborative. Future research needs to test the analytical cluster analysis-approach for different community sizes, locations with different cultural backgrounds and for environmental planning processes dedicated to different problem framings, to get a more nuanced picture of the main drivers of community values landscapes.

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Written informed consent for publication of the participants' preferences was obtained from the participants. The interviews were conducted according to the requirements of ethics and integrity in Article 34 of the H2020 Programme Multi-Beneficiary Model Grant Agreement (i.e. ethic's approval to interview the participants was granted by the Human Ethics Committee of the University of Otago). The authors would like to thank everyone who attended the community workshops and who contributed their time, values, and expertise. The authors also appreciate the valuable comments from Jim Sinner and an anonymous reviewer, which considerably improved the manuscript.

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Data Availability Statement

The interview protocol for the elicitation of community preferences that support the findings of this study are openly available in zenodo at https://doi.org/10.5281/zenodo.6821332.

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FIGURE CAPTIONS

Figure 1. Map of the study area. A) The Blueskin Bay estuary and its catchment located on the east coast of Otago in the South Island of Aotearoa/New Zealand; B) bird's-eye view of the estuary at high tide with enhanced coloring to show differing water levels; C and D) collection of shellfish (cockles – *Austrovenus stutchburyi*) at low tide; and E) extensive growth of the sea lettuce (*Ulva* sp).

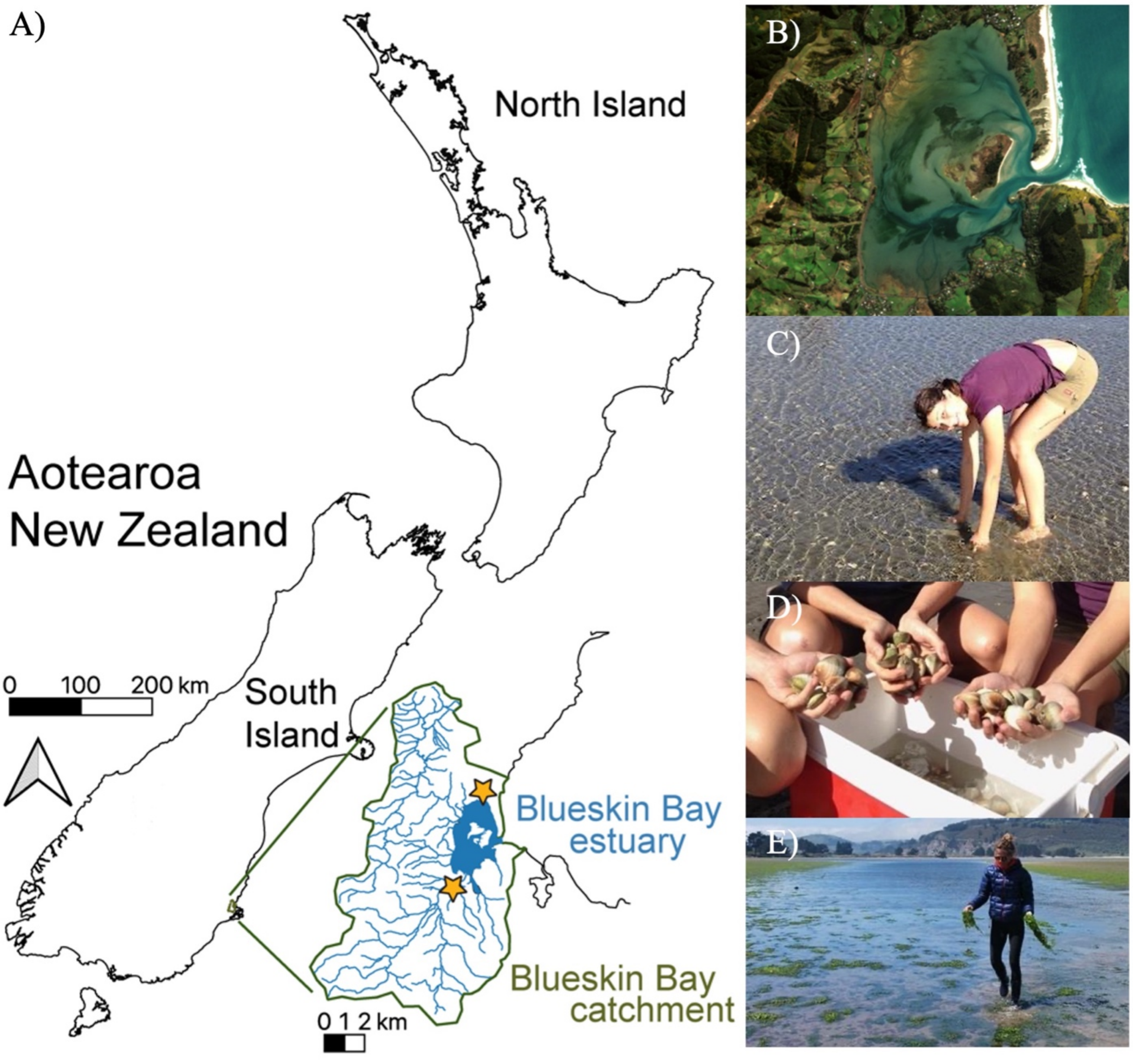
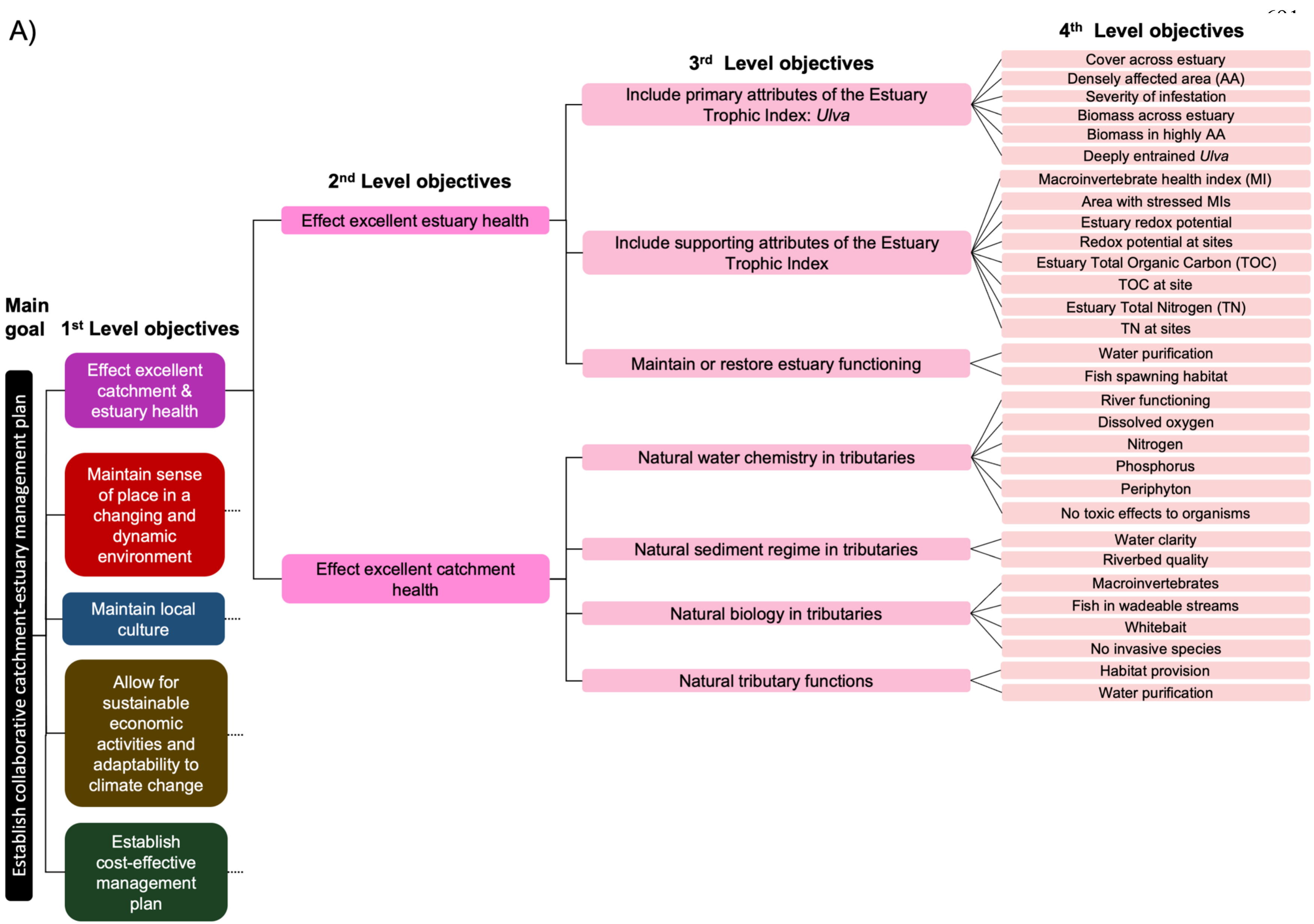
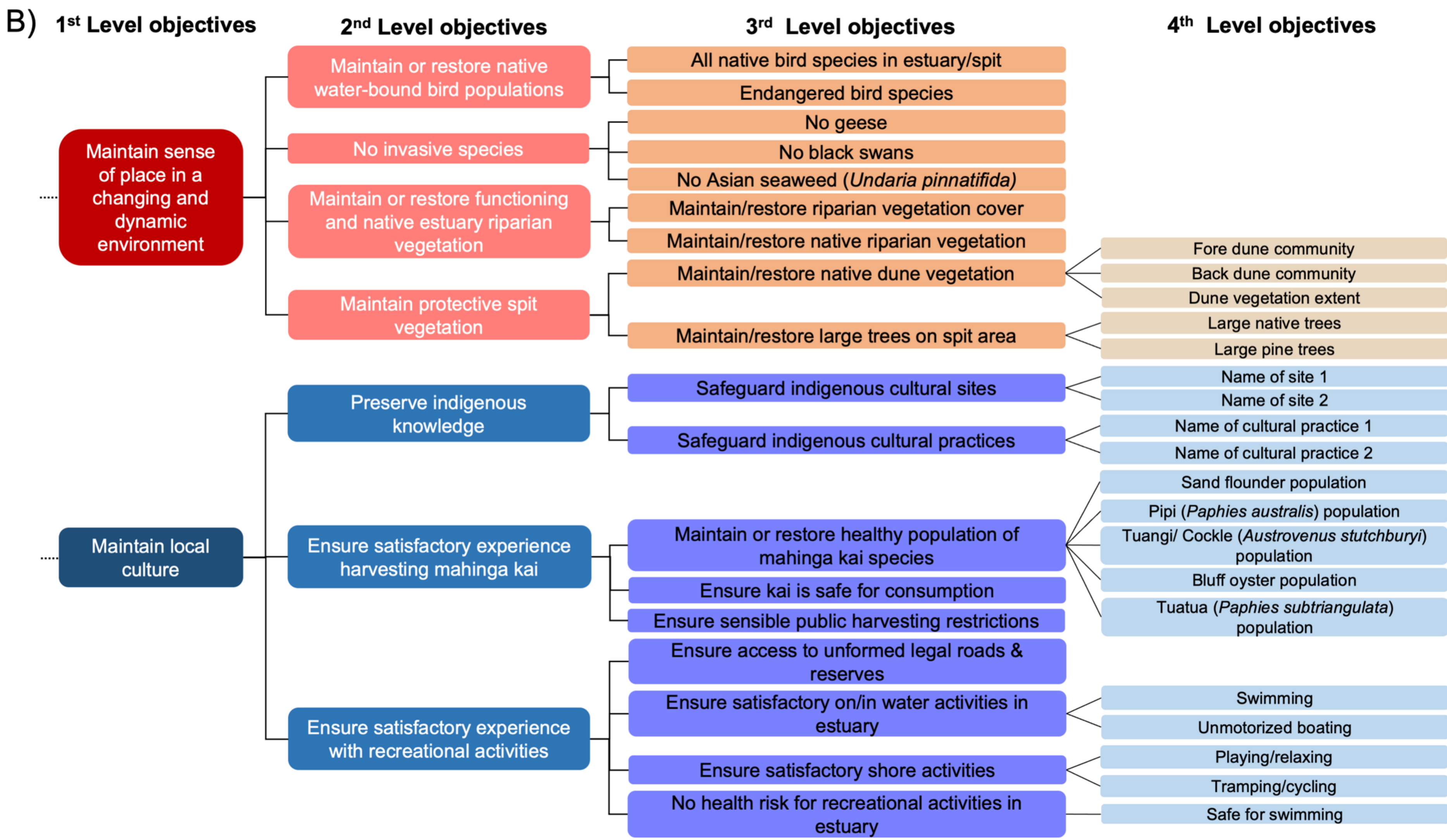


Figure 2. Hierarchy of management objectives for the Blueskin Bay estuary and its upper catchment. A) Overall objective, all first level objectives and sub-objectives for *effecting excellent catchment and estuary health*; B) sub-objectives for *maintaining sense of place in a changing and dynamic environment* and *maintaining local culture*; and C) sub-objectives for *allowing for sustainable economic activities and adaptability to climate change* and *establishing cost-effective management plan*. The objectives hierarchy was elicited from local residents during four consecutive facilitated workshops that took place throughout 2019. All workshops had 40 to 60 participants.

A)



Main goal
Establish collaborative catchment-estuary management plan
1st Level objectives
Effect excellent catchment & estuary health
Maintain sense of place in a changing and dynamic environment
Maintain local culture
Allow for sustainable economic activities and adaptability to climate change
Establish cost-effective management plan
2nd Level objectives
Effect excellent estuary health
Effect excellent catchment health
3rd Level objectives
Include primary attributes of the Estuary Trophic Index: Ulva
Include supporting attributes of the Estuary Trophic Index
Maintain or restore estuary functioning
Natural water chemistry in tributaries
Natural sediment regime in tributaries
Natural biology in tributaries
Natural tributary functions
4th Level objectives
Cover across estuary
Densely affected area (AA)
Severity of infestation
Biomass across estuary
Biomass in highly AA
Deeply entrained Ulva
Macroinvertebrate health index (MI)
Area with stressed MIs
Estuary redox potential
Redox potential at sites
Estuary Total Organic Carbon (TOC)
TOC at site
Estuary Total Nitrogen (TN)
TN at sites
Water purification
Fish spawning habitat
River functioning
Dissolved oxygen
Nitrogen
Phosphorus
Periphyton
No toxic effects to organisms
Water clarity
Riverbed quality
Macroinvertebrates
Fish in wadeable streams
Whitebait
No invasive species
Habitat provision
Water purification


B)
1st Level objectives
2nd Level objectives
3rd Level objectives
4th Level objectives
Maintain sense of place in a changing and dynamic environment
Maintain or restore native water-bound bird populations
All native bird species in estuary/spit
Endangered bird species
No invasive species
No geese
No black swans
No Asian seaweed (*Undaria pinnatifida*)
Maintain or restore functioning and native estuary riparian vegetation
Maintain/restore riparian vegetation cover
Maintain/restore native riparian vegetation
Maintain protective spit vegetation
Maintain/restore native dune vegetation
Fore dune community
Back dune community
Dune vegetation extent
Maintain/restore large trees on spit area
Large native trees
Large pine trees
Maintain local culture
Preserve indigenous knowledge
Safeguard indigenous cultural sites
Name of site 1
Name of site 2
Safeguard indigenous cultural practices
Name of cultural practice 1
Name of cultural practice 2
Ensure satisfactory experience harvesting mahinga kai
Maintain or restore healthy population of mahinga kai species
Sand flounder population
Pipi (*Paphies australis*) population
Tuangi/ Cockle (*Austrovenus stutchburyi*) population
Bluff oyster population
Tuatua (*Paphies subtriangulata*) population
Ensure kai is safe for consumption
Ensure sensible public harvesting restrictions
Ensure satisfactory experience with recreational activities
Ensure access to unformed legal roads & reserves
Ensure satisfactory on/in water activities in estuary
Swimming
Unmotorized boating
Ensure satisfactory shore activities
Playing/relaxing
Tramping/cycling
No health risk for recreational activities in estuary
Safe for swimming

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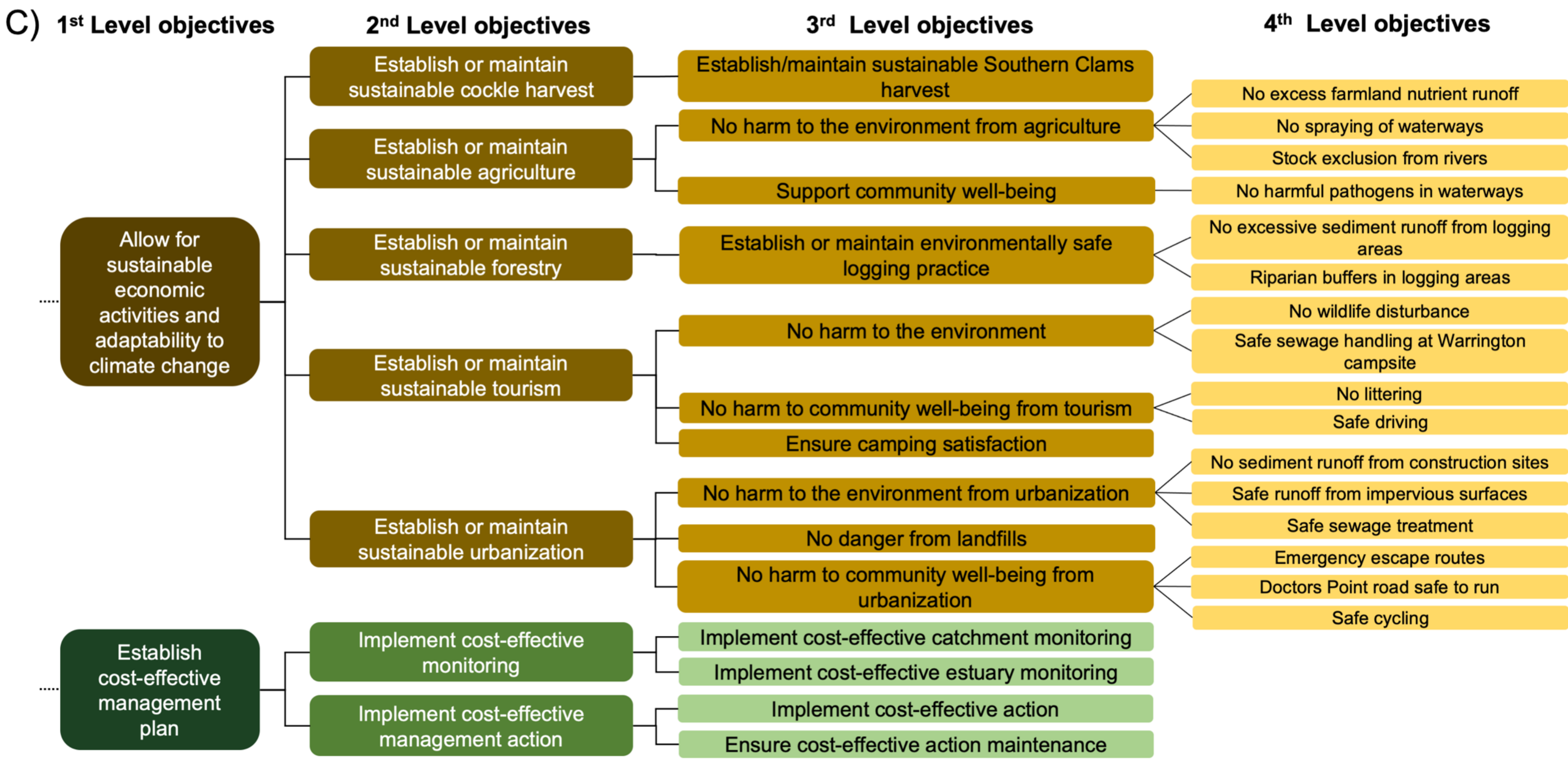

C)
1st Level objectives
2nd Level objectives
3rd Level objectives
4th Level objectives
Allow for sustainable economic activities and adaptability to climate change
Establish or maintain sustainable cockle harvest
Establish/maintain sustainable Southern Clams harvest
Establish or maintain sustainable agriculture
No harm to the environment from agriculture
No excess farmland nutrient runoff
No spraying of waterways
Stock exclusion from rivers
Support community well-being
No harmful pathogens in waterways
Establish or maintain sustainable forestry
Establish or maintain environmentally safe logging practice
No excessive sediment runoff from logging areas
Riparian buffers in logging areas
Establish or maintain sustainable tourism
No harm to the environment
No wildlife disturbance
Safe sewage handling at Warrington campsite
No harm to community well-being from tourism
No littering
Safe driving
Ensure camping satisfaction
Establish or maintain sustainable urbanization
No harm to the environment from urbanization
No sediment runoff from construction sites
Safe runoff from impervious surfaces
Safe sewage treatment
No danger from landfills
No harm to community well-being from urbanization
Emergency escape routes
Doctors Point road safe to run
Safe cycling
Establish cost-effective management plan
Implement cost-effective monitoring
Implement cost-effective catchment monitoring
Implement cost-effective estuary monitoring
Implement cost-effective management action
Implement cost-effective action
Ensure cost-effective action maintenance

Figure 3. Dendrogram for the 1st-level management objectives. The dendrogram represents the clusters generated by the Ward.D2 agglomerative clustering algorithm based on the interviewees' (1 to 36 on the x-axis) preferences of the first-level objectives identified to be relevant for the management of Blueskin Bay estuary and its upper catchment. Each cluster represents a stakeholder type. A dendrogram is a two dimensional diagram that depicts how the agglomeration is done at the different stages of the cluster analysis. The Y-axis depicts the distance among the ratings while the X-axis lists the participants. Clusters with the same color represent the same stakeholder types as in Fig. 4.

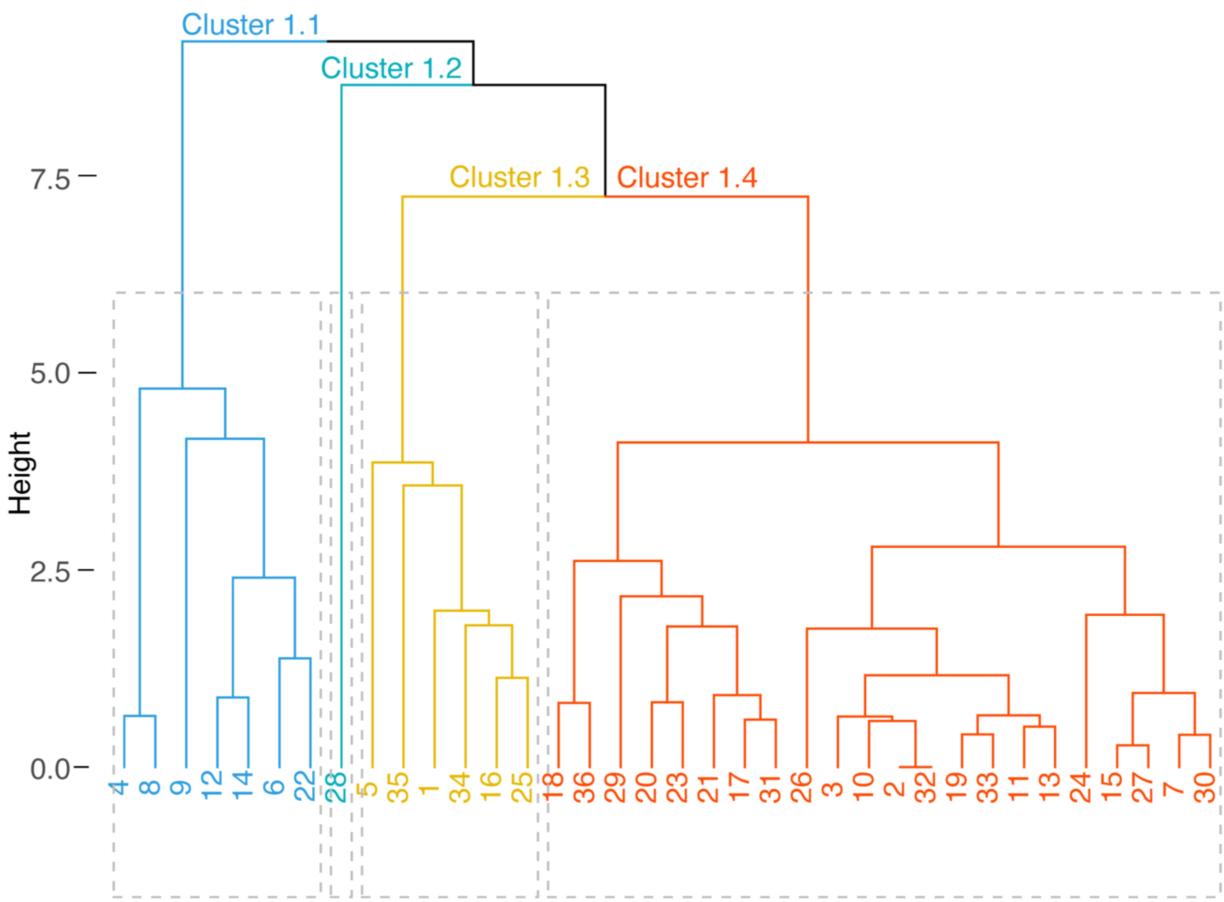


Figure 4. Dendrogram for the 2nd-level management objectives. The dendrogram represents the clusters generated by the Ward.D2 agglomerative clustering algorithm based on the interviewees' preferences (1 to 36 on the x-axis) of the second-level objectives identified to be relevant for the management of Blueskin Bay estuary and its upper catchment. Clusters with the same color represent the same stakeholder type, also when compared to Fig. 3.

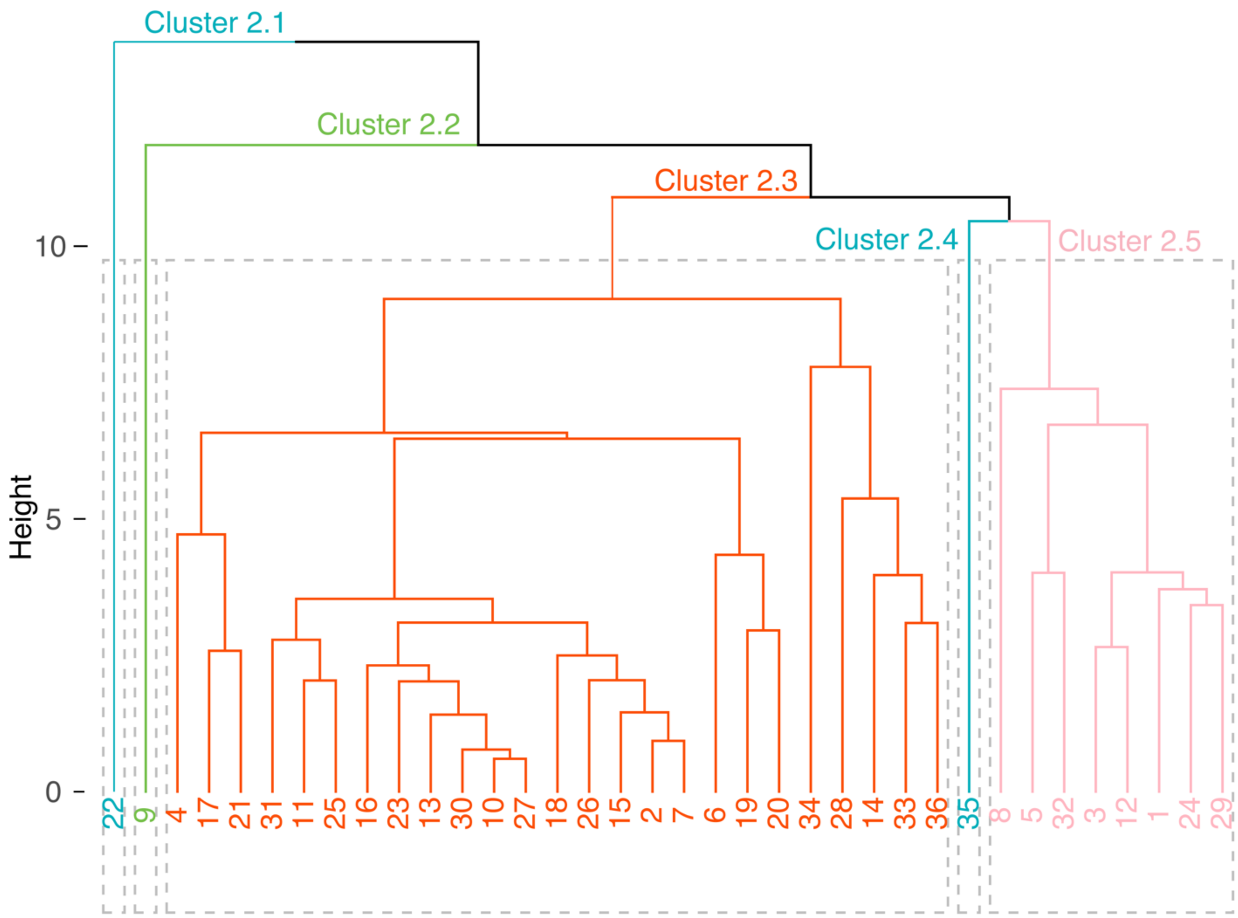
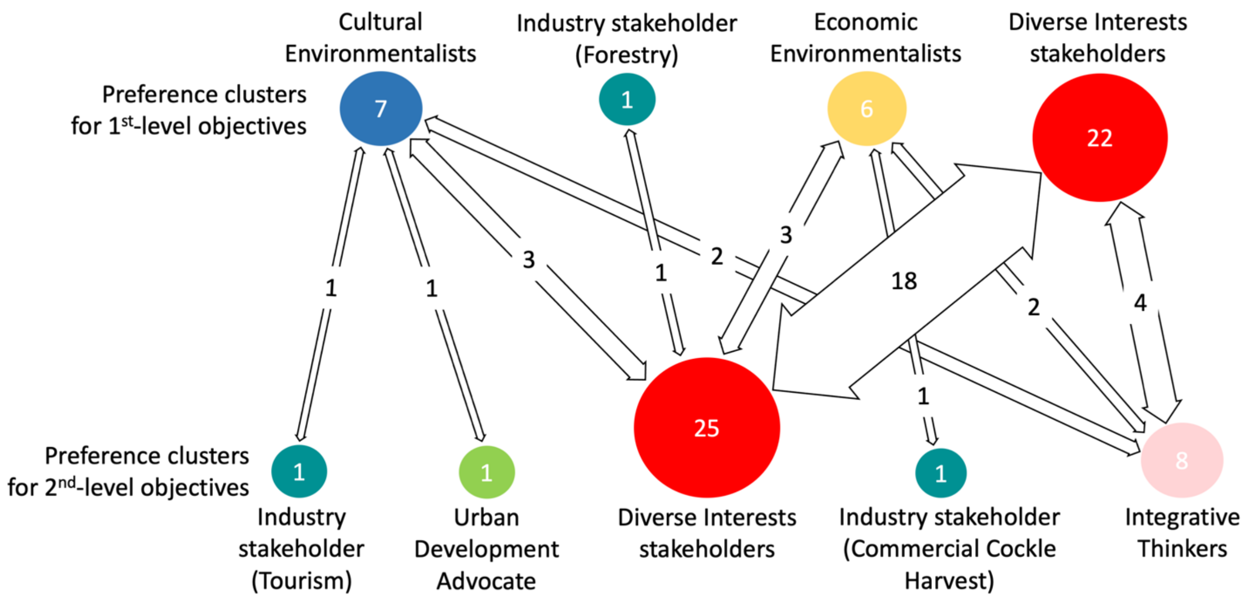


Figure 5. Comparison of clusters' composition at the two levels of management objectives. Circles represent clusters and stakeholder types identified through cluster analyses, with colors corresponding to dendrograms in Figs. 3 and 4. Numbers within circles indicate numbers of interviewees comprising a cluster. Numbers within arrows indicate how many interviewees share preferences for the connected clusters.



TABLES

Table 1. Weight preferences for pre-defined management objectives. A) First-level objectives; B) second-level objectives**.** Weights were elicited with the Swing-method from the 36 interviewed community members. Weights sum up to 100. ID = identification number of the interviewee; CEH = catchment and estuary health; SOP = sense of place; LC = local culture; SEA = sustainable economic activities; CEM = cost-effective management plan; Est = estuary health; Catch = catchment health; Birds = water birds; Inv spec = no invasive species, Rp veg = estuary riparian vegetation, Spit veg = protective spit vegetation, IK pres = indigenous knowledge preservation; Mah kai = harvesting mahinga kai; Rec act = recreational activities; Cockle = sustainable cockle harvest; Agr = sustainable agriculture; For = sustainable forestry; Tour = sustainable tourism; Urb = sustainable urbanization; Mon = cost-effective monitoring; Act = cost-effective management action. Ordering of the IDs and color coding correspond to clusters and colors in Figures 3 and 4.

A)

ID	Catchment & estuary health	Sense of place	Local culture	Sustainable economic activities	Cost-effective management
4	27.8	19.4	22.2	27.8	2.8
8	27	21.6	21.6	27	2.7
9	33.4	30.1	33.1	3.3	0
12	33.3	23.3	23.3	10	10
14	29.9	23.9	23.9	13.4	9
6	28.6	28.6	17.1	11.4	14.3
22	31.3	25	18.8	6.3	18.8
28	28.6	2.9	8.6	57.1	2.9
5	25	25	5	20	25
35	26.7	6.7	6.7	33.3	26.7

741	1	32.3	12.9	9.7	19.4	25.8
742	34	29.9	17.9	11.9	22.4	17.9
743	16	25.6	15.4	19.2	19.2	20.5
744	25	27	13.5	13.5	21.6	24.3
745	18	24.7	17.3	24.7	12.3	21
746	36	26.3	18.4	21.1	13.2	21.1
747	29	25.7	20	28.6	17.1	8.6
748	20	19.5	24.4	24.4	17.1	14.6
749	23	22.7	22.7	22.7	18.2	13.6
750	21	25.6	23.1	20.5	15.4	15.4
751	17	25	20	22.5	17.5	15
752	31	25	20	20	20	15
753	26	18.2	20.5	15.9	22.7	22.7
754	3	22.2	22.2	20	17.8	17.8
755	10	21.7	19.6	21.7	17.4	19.6
756	2	21.7	19.6	19.6	19.6	19.6
757	32	21.7	19.6	19.6	19.6	19.6
758	19	20.2	20	20	20	20
759	33	19.1	21.3	19.1	21.3	19.1
760	11	19.9	21.6	20.6	18.4	19.5
761	13	20	20	22.2	20	17.8
762	24	24.2	15.2	15.2	30.3	15.2
763	15	24.7	18.5	18.5	19.8	18.5

27	23.8	19	19	19	19
7	22.2	17.8	17.8	22.2	20
30	22.7	18.2	18.2	22.7	18.2

B)

ID	Est	Catch	Birds	Inv spec	Rip veg	Spit veg	IK pres	Mah kai	Rec act	Cockle	Agr	For	Tour	Urb	Mon	Act
22	44.4	55.6	10	40	20	30	31.6	52.6	15.8	0	0	0	100	0	50	50
9	47.4	52.6	22.2	3.7	37	37	33.3	33.3	33.3	13.6	13.6	13.6	13.6	45.5	0	0
4	55.6	44.4	26.3	23.7	23.7	26.3	33.3	33.3	33.3	30.3	3	6.1	30.3	30.3	33.3	66.7
17	54.1	45.9	21.4	28.6	21.4	28.6	32.3	35.8	31.9	26.3	22.4	13.2	15.8	22.2	50	50
21	52.6	47.4	25	25	25	25	33.3	33.3	33.3	21.9	31.3	15.6	12.5	18.8	37.5	62.5
31	49.7	50.3	25	18.8	31.3	25	30.8	30.8	38.5	20	25	15	20	20	50	50
11	49.7	50.3	29.2	15.4	30.8	24.6	34.9	35.2	29.9	22.4	22.2	20.6	13.5	21.3	50	50
25	50	50	24.2	21.2	30.3	24.2	32.1	35.7	32.1	29.4	26.5	23.5	8.8	11.8	50	50
16	50	50	23.5	23.5	29.4	23.5	34	37.7	28.3	14.3	20	17.1	28.6	20	52.6	47.4
23	50	50	25	25	25	25	33.3	33.3	33.3	20	20	20	20	20	62.5	37.5
13	50	50	29.4	20.6	23.5	26.5	33.3	33.3	33.3	21.3	21.3	19.1	19.1	19.1	52.6	47.4
30	50	50	25	25	25	25	33.3	33.3	33.3	19.6	21.7	19.6	19.6	19.6	50	50
10	50	50	25	25	25	25	34.5	34.5	31	20.4	19.4	1.4	20.4	20.4	51.3	48.7
27	50	50	25	25	25	25	35.7	32.1	32.1	22.2	17.8	20	20	20	50	50
18	48.7	51.3	25.1	25.4	24.9	24.6	35.2	34.9	29.9	28.6	11.4	14.3	25.7	20	47.4	52.6
26	47.4	52.6	25.7	28.6	22.9	22.9	40	28	32	19.6	19.6	19.6	19.6	21.7	52.6	47.4
15	47.4	52.6	25.4	25.4	28.2	21.1	37	29.6	33.3	24.1	19.3	19.3	18.1	19.3	47.4	52.6

787	2	47.4	52.6	25	22.2	27.8	25	32.1	32.1	35.7	20.5	18.2	18.2	22.7	20.5	50	50
788	7	48.7	51.3	23.3	24.7	27.4	24.7	34.5	31	34.5	20.4	18.3	19.4	20.4	21.5	48.7	51.3
789	6	50	50	32.3	22.6	22.6	22.6	30.8	30.8	38.5	47.6	23.8	14.3	14.3	0	55.6	44.4
790	19	49.7	50.3	26.8	21.7	27.1	24.2	34.6	34.3	31.1	33.7	34	8.5	6.8	17	49.7	50.3
791	20	47.4	52.6	24.3	24.3	27	24.3	35.7	35.7	28.6	31	27.6	3.4	34.5	3.4	50	50
792	34	58.8	41.2	25.9	11.1	37	25.9	15.8	52.6	31.6	23.8	15.9	12.7	31.7	15.9	41.2	58.8
793	28	47.4	52.6	21.7	13	43.5	21.7	22.7	45.5	31.8	14.7	20.6	29.4	11.8	23.5	44.4	55.6
794	14	50	50	24.6	23.1	30.8	21.5	25.9	37	37	0	24.6	26.2	16.4	32.8	33.3	66.7
795	33	50	50	25	25	25	25	32.8	34.5	32.8	3.1	31.3	25	25	15.6	44.4	55.6
796	36	50	50	35.7	17.9	17.9	28.6	30.8	38.5	30.8	11.4	22.9	28.6	17.1	20	41.2	58.8
797	35	47.4	52.6	48.8	2.4	48.8	0	33.3	33.3	33.3	27	13.5	21.6	16.2	21.6	50	50
798	8	50	50	32.3	16.1	25.8	25.8	50	25	25	8.3	41.7	8.3	8.3	33.3	66.7	33.3
799	5	44.4	55.6	28.6	35.7	21.4	14.3	45.5	18.2	36.4	33.3	26.7	20	13.3	6.7	50	50
800	32	47.4	52.6	32.3	32.3	19.4	16.1	45.5	27.3	27.3	12.5	25	25	18.8	18.8	50	50
801	3	44.4	55.6	29.2	23.4	23.3	24	41.7	33.3	25	15	15	20	25	25	50	50
802	12	44.4	55.6	21.4	21.4	28.6	28.6	40	28	32	15.8	15.8	15.8	26.3	26.3	50	50
803	1	41.2	58.8	24.2	21.2	30.3	24.2	41.7	33.3	25	25.8	32.3	9.7	16.1	16.1	44.4	55.6
804	24	44.4	55.6	29.4	23.5	23.5	23.5	37	33.3	29.6	26.3	26.3	26.3	10.5	10.5	50	50
805	29	44.4	55.6	20.3	16.9	28.8	33.9	37	37	25.9	32.3	19.4	19.4	9.7	19.4	52.6	47.4