

1                   What is the main driver of unsustainable natural resource use in the Comoro Islands?

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## 10   **ABSTRACT**

11   The Comoros archipelago is a biodiversity hotspot by virtue of its high level of endemism. However, it suffers  
12   one of the highest rates of forest loss worldwide, mainly due to strong anthropogenic pressures. As Comorian  
13   populations depend on forest resources for subsistence, establishing relevant conservation strategies for their  
14   sustainable management requires the consideration of multiple stakeholders' perspectives toward biodiversity  
15   and habitat conservation. To better understand the relationships between humans and nature; how comorian  
16   people use natural resource and the relevance of a protected area for long-term biodiversity conservation, we  
17   used Q-methodology to assess local people's perceptions regarding biodiversity and conservation actions.  
18   Three discourses are identified during analysis: "Pro-environment discourse", "Keeping things as usual" and  
19   "Social and environmental concerns". According to the results, employed respondents, were favorable to  
20   long-term forest and biodiversity conservation. In contrast, unemployed respondents were in favor of more  
21   immediate benefits while unemployed but educated respondents were in favor to both long-term forest  
22   conservation and immediate benefits from forests. This suggests that the lack of livelihoods for rural people is  
23   the main factor leading them to overharvest natural resources. These results suggest that biodiversity  
24   conservation of the Comoros archipelagos may benefit for plan aiming at (1) developing tourism and  
25   maintaining sustainable production of crops and livestock that could allow enhancing the livelihoods and  
26   well-being of all social groups, (2) developing projects such as local markets that could allow villagers to sell  
27   their agricultural production, (3) setting up awareness campaign for tree-planting and reforestation.  
28   Reforestation could allow re-establishing natural plants and make large trees available for long-term purposes.

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30   Key words: Conservation strategies, Habitat loss, Socio-economic level, Natural resource uses; Q-sor

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58 **1-INTRODUCTION**

59 Biodiversity and natural resources provide many direct as well as indirect services to human society,  
60 including playing a crucial role in sustaining people's well-being (Giannini et al., 2012). As a consequence,  
61 human populations strongly depend on natural ecosystems (Zhu et al., 2016). This is especially true for the  
62 poorest populations of developing countries, who largely rely on wild plants for building materials and for  
63 natural medicines and food, and on wild animals for meat (Ryan et al., 2016). However, on a global scale,  
64 biodiversity and natural resources are being degraded at alarming levels, mainly induced by anthropogenic  
65 pressures (Brook et al., 2008).

66 Over the past two decades, scientists and numerous national and international organizations have argued for  
67 the urgent need to find alternative community-based approaches to protect and manage natural systems in  
68 developing countries (Jantz et al., 2015; King et al., 2021). Until recently, natural resource and habitat  
69 management strategies tended to rely on biological and ecological data based on species ecology, population  
70 genetics or demographics, but have often neglected the human societies that critically depend on natural  
71 ecosystems (Fritz-Vietta, 2016, Gaebel et al., 2020; König et al., 2021). Although some conservation  
72 strategies have been developed in many countries on collaborative governance processes and participatory  
73 protected area management for instance, such strategies are non-existent in different parts of the world  
74 (Krueck et al., 2019; Ghosh-Harihar et al., 2019; Ayivor et al., 2020; Rittelmeyer 2020; O'Brien et al. 2021;  
75 Jin et al., 2021; Arumugam et al., 2021). Communities living in geographic proximity to natural resources and  
76 forests typically have traditional knowledge about as well as emotional bonds with these areas. Ignoring the  
77 needs and practices of local communities in habitat conservation initiatives may result in conflicts between  
78 natural resource managers and these populations if the latter feel they face restrictions in the benefits they  
79 acquire from these areas (Fisher et al., 2020; Gaebel et al. 2020). This can eventually have a negative effect  
80 on both the long-term effectiveness of biodiversity conservation and on the livelihoods of the local population  
81 (Sournia, 1990; Fritz-Vietta, 2016; Debata et al., 2017; Gaebel et al., 2020; Jin et al., 2021). Reconciling the  
82 needs of the local population and natural resource use is now seen as fundamental in developing countries to  
83 implement management plans that ensure livelihoods and well-being in parallel with biodiversity  
84 conservation objectives (Helm Aveliina, 2006; Boron et al., 2016; Jin et al., 2021).

85 The Comoros (an archipelago consisting of the islands of Anjouan, Grande Comore, Mohéli and Mayotte) is a  
86 biodiversity hotspot by virtue of its high level of endemism (Myers et al., 2000). However, on the islands of  
87 the Union of Comoros (Grande Comore, Anjouan and Mohéli), natural habitats are experiencing one of the  
88 highest rates of habitat loss in the world (9.3% each year, FAO, 2010). The Union of Comoros is also one of  
89 the poorest nations in the world (Bourgoin et al., 2017). According to Fisher and Christopher (2007), about  
90 72% of Comorians depend directly on forest resources for subsistence (Fisher and Christopher, 2007;  
91 Bourgoin et al., 2017). Some 60% of Comorians live below the poverty line and 49% are undernourished.  
92 Additionally, the Union of Comoros has a fast-growing population, leading to an acute need of land for  
93 agriculture and wood for building (Elvidge et al., 2009). Many researchers have pointed to intensive land use  
94 as the direct cause of the very high rate of natural habitat loss observed in the archipelago (Ibouroi et al.,  
95 2018a, b). Yet this pressure on natural forests and biodiversity is altering the ecosystem services they provide  
96 for the Comorian people. Effective conservation strategies are crucially needed to ensure the long-term  
97 preservation of biodiversity and natural habitats in the Comoros.

98 On the three islands of the Union of Comoros, some measures have been undertaken by local, national, and  
99 international organizations in the aim of ensuring the long-term conservation of biodiversity (Granek and  
100 Brown, 2005; Poonian et al., 2008; Ibouroi et al., 2018b; Ibouroi et al., 2019). For instance, in 1992,  
101 Mickleburgh et al. proposed a long-term monitoring of the Livingstone's flying fox population and the  
102 establishment of a captive-breeding program for the species (Mickleburgh et al., 1992). The creation of the  
103 Mohéli Marine Park was successful in 2001 (Granek and Brown, 2005). Some of these projects were funded  
104 by the United Nations Development Program (UNDP 1998). In 2016, the national network of marine and  
105 terrestrial protected areas was created in the three islands of the Union of Comoros (see Ibouroi et al., 2019).  
106 However, most of these conservation strategies have been restricted to protecting Livingstone's flying fox  
107 roosts (Ibouroi et al., 2018b), as this is one of the most endangered species on the islands. Strategies to  
108 conserve the islands' biodiversity and habitats need to consider various contentious aspects that currently  
109 involve complex decision-making dilemmas (e.g. forest management, hunting management, representation of  
110 local communities, etc.). Solutions have not yet been clearly defined. For instance, numerous gaps still remain  
111 in understanding stakeholders' perspectives regarding natural resource management and biodiversity  
112 conservation. Local people's subjectivity and viewpoints are important to identify in order to inform

113 conservation strategies and future management practices, to avoid making mistaken decisions in planning  
114 these measures and to increase their chance of being effective (Niedziałkowski et al., 2018).

115 In this study, we conducted a Q-methodology approach to assess the relationships between stakeholders and  
116 their use of natural resources as well as their impact on habitats in the Comoros. Specifically, we assessed (1)  
117 how stakeholders perceive benefits from natural resources, (2) the level of awareness of the impact of their  
118 practices on biodiversity, and (3) their knowledge about, perceptions of and attitudes toward biodiversity and  
119 conservation actions. As social factors such as the level of formal education, employment and geographic  
120 location can affect knowledge and determine attitudes, we assessed what factors were related to positive or  
121 negative perception of forests and biodiversity conservation. This information may help (1) to understand the  
122 local community's representation of biodiversity, and (2) to explore future scenarios, with the objective of  
123 proposing relevant long-term conservation actions and habitat management strategies.

## 124 **2-MATERIALS AND METHODS**

### 125 **2.1. Study area**

126 The Comoros archipelago is located in the Indian Ocean, midway between Madagascar and the eastern coast  
127 of Africa. This archipelago comprises four islands: Grande Comore, Mohéli, Anjouan (the Union of the  
128 Comoros), and Mayotte (an overseas department of France). Without Mayotte, the Comoro Islands cover  
129 1,862 km<sup>2</sup> and represent the third smallest African nation in terms of surface area (Michon, 2016). The islands  
130 are separated from each other by a distance of about 40–80 km. Since their emergence about 7 million years  
131 ago, these islands have never been connected to a continental mainland or to each other (Louette et al., 2004).  
132 Our study focused specifically on the three islands of the Union of the Comoros.

133 In the Union of Comoros, habitat fragmentation and loss differ between islands due to differences in habitats,  
134 ecology and human demographics among islands (Sewall et al., 2007). For example, Anjouan Island  
135 experiences the highest human population density (772.13 inhabitant/km<sup>2</sup> against 180.55 inhabitant/km<sup>2</sup> and  
136 357.78 inhabitant /km<sup>2</sup> for respectively Mohéli and Grande Comoro Islands) within the archipelago, which  
137 has direct consequences on natural habitat disturbance. On this island, between 1972 and 1987, more than  
138 85% of natural habitat was converted into farmland, urban areas and secondary forests (Goodman et al.,  
139 2010). In the Grande Comoro Island, the rate of habitat loss is also high but in certain regions for instance in  
140 the Karthala forest, habitat fragmentation is moderate. In contrast, both habitat loss and fragmentation are

141 relatively limited on Mohéli, probably because of the presence of a protected area (the Mohéli Marine Park)  
142 but also due to the low human population density on this island (180.55 inhabitant/km<sup>2</sup>). The Mohéli Marine  
143 Park was established in 2000 with the goal of protecting 404 km<sup>2</sup> of marine habitats home to many endemic  
144 and threatened taxa, such as the dugong (*Dugong dugon*) and the green sea turtle (*Chelonia mydas*). The  
145 presence of this marine protected area represents an important source of income for local communities –  
146 several members of the community have been hired by the park as regular staff (Granek and Brown, 2005).  
147 Many tourists also come to see the endemic marine taxa and then take the opportunity to discover endangered  
148 terrestrial species such as the Livingstone’s flying fox (*Pteropus livingstonii*) and the mongoose lemur  
149 (*Eulemur mongoz*). This tourist activity generates direct incomes for some local people (for example, who  
150 work as guides or in hotels, etc.). Our study involved different localities on the three islands of Comoros  
151 (Anjouan, Mohéli and Grande Comore, Fig 1).

152 To understand how stakeholders perceive benefits from natural resources, their knowledge, perceptions and  
153 attitudes toward biodiversity and conservation actions, some of the interview questions and Q statements  
154 centered on two native flying fox species: Livingstone’s flying fox (*Pteropus livingstonii*) and the Seychelles  
155 fruit bat (*P.seyhellensis comorensis*), which differ in their feeding and roosting behavior as well as in their  
156 dispersal patterns (Norberg et al., 2000; Ibouroi et al., 2018a). *Pteropus livingstonii* is confined to the  
157 remaining mountain forests on Anjouan and Mohéli and feeds on endemic forest plants, while *P. s.*  
158 *comorensis* is widely distributed over the four islands of Comoros, feeding in both forests and cultivated areas  
159 (Ibouroi et al., 2018b; Trehwella et al., 2001). Both species are important ecosystem service providers, as they  
160 are pollinators and seed dispersers (Ibouroi et al., 2018b). Their differences in habitat use and feeding ecology  
161 ensure different ecosystem services. The two species have a potentially crucial impact on both forest  
162 regeneration and the cultivation of crops, thus are critical for maintaining overall ecosystem dynamics  
163 (Ibouroi et al., 2018b). Because of this contrasted pattern of dispersal, feeding and roosting behavior,  
164 conservation strategies and conflicts between humans and bats are also different between the two species. For  
165 instance *Pteropus livingstonii* populations are the subject of conservation actions, some of which involve local  
166 communities. These conservation actions focus on this species not only because of its low population size but  
167 also the rapid forest loss in the Comoros (Ibouroi et al. 2018b). Regarding *P.seyhellensis comorensis*, as the  
168 species roosts and feeds in overexploited forests, its population is commonly involved in conflicts, as  
169 individuals feed in farmed areas and can damage cultivated plants. Such conflicts are believed to be the

170 primary driver of legal and illegal persecution of this species, as is the case in many countries (Oleksy et al.,  
171 2018). For these reasons, these species are an ideal model to investigate local Comorian perceptions, allowing  
172 their discourses to be mapped regarding the flying fox, biodiversity and social development, followed by an  
173 analysis of the consequences for the long-term conservation of natural habitats.”

## 174 **2.2 Research Design**

175 Q-methodology is a standard method used to reveal people’s subjectivity and explore viewpoints on defined  
176 issues that are often contested (Stephenson, 1935). It specifically aims at identifying underlying patterns  
177 among stakeholders and comparing the key viewpoints, which leads to the identification of shared broad  
178 common points as well as divergences between them (Watts and Stenner 2005, 2012; Bavin et al.,2020;  
179 Arumugam et al., 2021). The approach combines the qualitative study of attitudes with the statistical rigors of  
180 quantitative research techniques (Watts and Stenner, 2005, 2012; Bavin et al.,2020; Arumugam et al., 2021).  
181 It is increasingly applied in different types of environmental research, including environmental management  
182 and policy and social science of conservation (Debata et al., 2017; Kamal and Grodzinska-Jurczak, 2014;  
183 Niedziałkowski et al., 2018; Walder and Kantelhardt, 2018, Rittelmeyer 2020; Fisher et al., 2020; Arumugam  
184 et al., 2021).

185 Q-methodology involves five main steps: (1) collecting a broad sample of statements (**concourse and Q-set**  
186 **design**); (2) Selecting a representative sample of statements (reflecting the diversity of the wider concourse)  
187 to consider as Q-set (**‘Formulating the Q-Set’**); (3) Selection of participants (**‘Identifying the P-Set’**); (4)  
188 Conducting the Q-sorts and Interviews (**‘Q sorting and post-sorting interview’**); (5) Analyzing the data  
189 using factorial analysis (**‘Analyzing the data and development of factor perceptions’**) (Eden et al., 2005;  
190 Kamal and Grodzinska-Jurczak, 2014). The standardized steps of Q methodology are summarized in the  
191 Figure 2.

### 192 **2.2.1 Concourse and Q set design**

193 Q-methodology was conducted in three phases: between August and October 2016, January and April 2018,  
194 and between December 2018 and March 2019. In each field session, the three islands were visited for  
195 collecting data. As a first step, we established a concourse, defined as the full opinion spectrum in relation to

196 the topic of habitat and natural resource uses, biodiversity and habitat conservation. For this concourse  
197 establishment, we used semi-structured interviews with local population during our first field session (August  
198 and October 2016) to gather information regarding the forest and natural resource uses, land uses and  
199 biodiversity conservation. These semi-structured interviews were based on pre-defined interview questions  
200 (Table 1) and all the people interviewed were not preselected but directly asked to participate to the interview  
201 when encountered in villages in the course of their daily activities or during our prospection in forests. Each  
202 discussion and the recording of the collected information took about one hour. All responses were recorded  
203 with a dictaphone. For each person interviewed, their gender, age, place of residence, socio-professional  
204 activity, and level of formal education were recorded. In total, 40 people were asked to participate in the  
205 interviews, of which 13 (1 man and 12 women) declined and 27 agreed. Of the 27 people interviewed, one  
206 respondent was under the age of 18 and was excluded from the analysis. The other 26 respondents were 23  
207 men and 3 women aged between 22 to 65 (average age of 41); 14 lived on the island of Anjouan, 7 on Mohéli,  
208 and 5 on Grande Comore. From the final interview transcripts, a total of 60 statements were extracted to form  
209 the concourse.

### 210 **2.2.2 Formulating the Q-Set**

211 Within the 60 statements selected as concourse (see above), a final set of 33 statements (Figure 2) were  
212 selected as ‘Q-set’ by using a structured filtering process in order to reduce the whole concourse into a  
213 manageable set of statements. Statements expressing the same value or viewpoints were summarized into  
214 one overarching statement. These 33 statements (Q-set or Q-sort, Fig 3) representing the diversity of the  
215 wider concourse cover five main topics:(1) land use, (2) the livelihood activity of the local population, (3) the  
216 importance of the forest and biodiversity for the local population, (4) the importance of flying foxes for both  
217 the forest and the local community, and (5) the relevance of a protected area for long-term biodiversity  
218 conservation and natural habitat management.

### 219 **2.2.3 Identifying the P-Set**

220 Typically, Q methodology involves a relatively small number of respondents, varying from 26 to 46 (Zabala  
221 et al., 2018) although some few studies used large number of respondents beyond 100 individuals (Milcu et  
222 al., 2014; Carmenta et al. 2017; Zabala et al., 2018). Although respondents involved in Q-study have to be



223 diverse, the sample does not have to be representative of the population as the aim is to get the most diverse  
224 range of opinions, regardless of whether they are minority ones (Zabala et al., 2014). In order to represent a  
225 range of opinions from local people, 66 respondents (P-set, 51 men [77%] and 15 women [23%]) who had not  
226 participated in the previous semi-structured interviews were invited to complete the sorting and post-sorting  
227 interview. In contrast to the concourse stage, Q-sort respondents were firstly preselected according to their  
228 level of formal education, whether they were employed or not, and their geographical location. This selection  
229 was firstly based on our knowledge in the Comoros institutions and forest workers, local networks and  
230 collaboration but also based on a snowball sampling approach (i.e. the identification of stakeholders by other  
231 participants). In the field, we get other information regarding villagers working in conservation and  
232 environmental institutions/NGO but also villagers with high/low level of education for each locality. These  
233 villagers are selected as respondents for the Q-Method process.

#### 234 **2.3.4 Q sorting and post-sorting interview'**

235 In the Q-sorting and post-sorting process, a researcher presents the statements (Q-Set) so participants (P-Set)  
236 can rank them according to the predefined Q-sort structure in order to express their level of agreement or  
237 disagreement with. Interviews were conducted on a face-to-face. As for the semi-structured interviews,  
238 discussion and the recording of the collected information took about one hour and interviews were conducted  
239 in local language. For each respondent, the gender, age, place of residence, socio-professional activity, and  
240 level of formal education were also recorded. The researcher had to explain to all participants that the aim of  
241 the Q-sorting process was to obtain their opinions rather than to test for their knowledge. Participants  
242 represented by men and women but also by people from urban vs. non-urban regions (see table 2) were given  
243 the Q-set and were instructed to read the statements carefully. They were asked to sort the 33 statements  
244 according to a nine-point scale of agreement/disagreement (4, 3, 2, 1, 0, -1, -2, -3, -4) presented in a sorting  
245 grid, forcing them to rank statements into a quasi-normal distribution (see Fig s1). Each participant was then  
246 asked to explain their most extreme scores (-4 and +4), and these comments were later used to interpret the  
247 results.

248 During this Q-sort process, some of the difficulties encountered were: (1) The fact that the method is time-  
249 consuming in the preparation, data collection, and analysis phases. For instance: (a) because of the high rate  
250 of poverty in the Comoros, a large number of our potential participants, especially those working in forests,

251 declined to participate unless they were paid. (b) Our semi-structured and Q-sort sampling involved only a  
252 small number of woman's as they tended to decline to be interviewed probably for reasons related to the local  
253 culture. The few interviewed women were mainly employed in NGOs and students. No woman met in  
254 villages agreed to be interviewed. This is probably because the pre-selection of participants from the different  
255 villages were carried out few days before the interviews and no discussion was made with their husbands or  
256 legal parents. (2)Because respondents were often selected few days before the Q-sorting process, some of  
257 them did not have basic knowledge of the questions and often answered haphazardly. This that can impact our  
258 results as the goal of the research is to use a set of relevant people and a sample of opinion statements to draw  
259 conclusions.”

### 260 **2.3.5 Analyzing the data and development of factor perceptions**

261 The data were analyzed using the 'qmethod' package for R (R Development Core Team, 2016; Zabala, 2014)  
262 which groups responses according to their similarity, using PCA and varimax rotation (a common approach in  
263 Q methodology). Different factors were rotated and compared during the multivariate analyses. We choose  
264 three factors based on a combination of total explained variance, minimum correlations between factors and  
265 reduced number of confounders (participants loading on more than one factor). These three factors were  
266 retained as different discourses because they had the minimum of two or more significantly loading  
267 participants (at  $p < 0.01$  level, threshold value =  $2.58 * 1 / \sqrt{\text{number of statements} = 33} = \pm 0.44$ .)”

268 Additionally, we analyzed the dataset with an inter-class Principal Component Analysis (PCA) implemented  
269 in the ade4 R package (Thioulose and Dray, 2007) in order to easily identify contrasted statements between  
270 the different social groups. This method which doesn't require parametric data (it is not based on any  
271 probabilistic model, but only on geometric considerations) rotates the selected PCA axes to maximize  
272 correlation between predefined groups. In a first analysis, we tested the discrimination between (1) the group  
273 of employed people working in NGOs (EmpNGO), (2) the group of employed people not working in NGOs  
274 (Emp), and (3) the group of unemployed people with a low level of formal education (unp). In addition, we  
275 tested the discrimination between (4) people from the three islands of the archipelago, (5) people from urban  
276 vs. non-urban regions, (6) age classes (ages were classified as young [18 to 35 years] and old [36 to 75 years])  
277 and (7) the gender (men and women groups). We tested whether these predefined groups significantly

278 differed from each other in terms of Q-sort scoring using a permutation test based on 1000 permutations. The  
279 tests were considered significant when the p-value was  $< 0.05$ .”

## 280 **3. RESULTS**

### 281 **3.1. Semi-structured interview responses**

282 All 26 people interviewed stated that they receive benefits from forests and use natural resources for everyday  
283 life. All respondents stipulated that they go to the forest to work (for agriculture and cultivation and to collect  
284 wood). In answer to the question “If this forest disappears completely, would that result in changes for you?  
285 What influence does the forest have on your well-being?”, most respondents highlighted that the forest is  
286 essential for fertile soil, and thus necessary for agriculture, and is also important in maintaining the water  
287 source.

288 A large majority of the respondents stated that they know what biodiversity is and its importance for their  
289 subsistence and most of these have a positive perception of wild animals and reported that these are useful for  
290 their well-being. Only a few minority of our respondents stated that some wild animals are harmful. Comorian  
291 attitudes toward bats were mostly positive and only a minority reported that they did not know the usefulness  
292 of fruit bats. Of those with a positive attitude and perception of fruit bats, most reported their importance (1)  
293 as seed dispersers for forest regeneration, (2) as seed dispersers for important cash crops such as cashews and  
294 mangos, (3) as pollinators, or (4) as a source of income from tourism (the case of *P.livingstonii*). Some  
295 respondents mentioned that fruit bats, especially those living in villages (*P.s.comorensis*), generate some  
296 damage in cultivated areas.

297 All the interviewees had some knowledge about the primary forest and its usefulness for the local population.  
298 In answer to the question “Have you noticed any recent changes?” regarding their perception of landscape  
299 changes within the forest, a large majority reported that the forest is overharvested and is decreasing in  
300 surface area. They highlighted that the decline of the forest is having an impact on their livelihood. When  
301 asked “Who exploits the forests in this region?”, they gave contrasting responses. Some respondent reported  
302 that villagers are responsible for forest loss due to the practice of intensive wood collection and only a  
303 minority of respondent claimed that their forests are harvested by foreigners from other cities on the island.

304 Despite these diverging views, all respondents reported the negative impact of forest misuse on their  
305 livelihoods and well-being, and stated that if forests disappear completely, human life will not be possible in  
306 their region.

307 Most respondents reported that rural populations are neglected and lack assistance from the government  
308 and/or NGOs, stating that this is the main cause leading to forest overharvesting. A large majority reported  
309 that they never benefit from any government assistance or help from NGOs and said that the lack of  
310 agricultural equipment and technical assistance are the main factors inciting rural people to harvest the forest.  
311 They mentioned that the lack of assistance from the government and NGOs forces the rural population to be  
312 highly dependent on forests as they do not have any alternative livelihood. On this point, the local population  
313 agreed that forests must be protected or even regenerated and a majority agreed with the creation of protected  
314 areas in their region, and only a minority agreed under certain conditions, notably governmental support of  
315 their livelihoods and for agricultural equipment and technology.

### 316 **3.2. Q sorting and post-sorting results**

317 Among the 66 respondents interviewed during the Q-sort process, five individuals (four men and one woman,  
318 see table 2 for age and demographic repartition) did not agree with any discourse as they had low sorts  
319 loadings on all factors thus were considered non-significant at  $p < 0.01$ .

320 Of the 33 Q statements (see Fig 3), six (18%) were consensual for all respondents (either positive or negative)  
321 and thus did not contribute to discriminations in discourse. Altogether, these discourses explained 55% of  
322 total variance. These three discourses were labeled according to the different statements significantly loaded  
323 to the considered factor (narrative A: “Pro-environment discourse”, narrative B: “Keeping things as usual”,  
324 and narrative C: “Social and environmental concerns”). The results found a low correlation between  
325 narratives A and B ( $r=0.30$ ) and between narratives B and C ( $r=0.30$ ), indicating that they are distinct (Table  
326 s1). The correlation between narratives A and C was higher (0.68), indicating some similarities between them  
327 (Table s1).

#### 328 3.2.1. Consensus statements

329 There was consensus on the need to develop tourism activities on the islands [statement 31], for example, all  
330 respondents agreed that “Tourism is important for Comoros development”. One respondent ranked this on the  
331 extreme end of the scale of agreement (+4) and commented: “We need to develop tourism; this is part of our

332 development program in the Mohéli Marine Park” (see Fig 3). All respondents disagreed with the idea that  
333 animals and fruit bats are not useful [statements 15 and 18]. One respondent who strongly disagreed (-4)  
334 commented that “Animals are very useful; they represent food for local people and are very important for  
335 both forests and plantations”. Many responded in line with the comment, “Fruit bats are useful for ecotourism,  
336 for improving crops and the development of forests”. All respondents were rather neutral concerning the  
337 statement that agriculture and farming are the only possible livelihood activities on the island [statement 19],  
338 and there was general consensus, with slight disagreement, on the fact that people from the village do not cut  
339 trees as logging is prohibited [statement 2].

### 340 3.2.2. Narrative A: Pro-environment discourse

341 Narrative A (factor 1) explained 27% of the total variance (Table s1). For this narrative, 35 of the 66  
342 respondents loaded significantly (12 respondents from Anjouan, 10 respondents from Moheli and 13  
343 respondents from Grande Comoro). These respondents were mainly employed, either in NGOs or in another  
344 sector (EmpNGOs =16 and Emp =15, see Table 2). They agreed with the statement that people will disappear  
345 from the islands if the forest disappears [statement 5; Factor 1 score: +3]. As one respondent commented,  
346 “The forest is our life: when it disappears from the island, we cannot survive.” Another participant who  
347 strongly agreed (+4) stated, “The forest is very valuable to our lives, if it disappears it will be catastrophic and  
348 will be the end of our lives.” Respondents in line with this narrative agreed with the fact that it would be good  
349 to reestablish the forest as before [statement 3; Factor 1 score: +4] and to have protected areas for habitats and  
350 animals [statement 33; Factor 1 score: +4]. For example, one respondent who strongly agreed commented, “It  
351 would be good to reestablish the forest as it was before. There used to be a diversity of foods, many rivers and  
352 it was wetter.” Another strongly agreeing respondent (+4) highlighted that “Dense natural forests are  
353 important; before, the forest brought more benefits than now.” They disagreed with the statement “There is a  
354 need to cultivate more land [statement 22]”. Instead, they agreed that “It is important to develop new  
355 agricultural techniques” [statement 30; Factor 1 score: +3]. As one respondent commented, “We need new  
356 methods and techniques to improve lands for cultivation that will allow us to increase production.” Other  
357 comments included: “We need materials and methods for agriculture that are more ecological.” “Technical  
358 and material aid is important as this will allow us to improve agricultural production.” Those associated with  
359 this narrative disagreed with the fact that Comorians do not eat fruit bats (Table 3). One respondent affirmed,  
360 “Some Comorians eat fruit bats, I can confirm this as I have been present in many cases.”

361 3.2.3. Narrative B: Keeping things as usual

362 Narrative B (factor 2) explained 15% of the total variance (Table s1). For this narrative, only 10 respondents  
363 loaded significantly (9 respondents from Grande Comoro and one respondent from Anjouan). These  
364 respondents were all unemployed (Unp) with a low level of education (Unp = 10 respondents). They  
365 disagreed with the statement, “It is mainly villagers who are cutting trees” [statement 1; Factor 2 score: -3],  
366 though they mostly agreed that people collect wood to sell it [statement 7; Factor 2 score: +2]. They disagreed  
367 that wild animals are decreasing in their area [statement 14]. They also disagreed that their crops may  
368 decrease if wildlife disappears [statement 17; Factor 2 score: -3]. In any case, they consider that hunting  
369 animals is too difficult and so no hunting occurs [statement 11; Factor 2 score: +4]. As one respondent who  
370 strongly disagreed (-4) commented, “It is very difficult to hunt because it requires having a gun.” Another  
371 said, “Although we would like to hunt, it is very difficult and nobody hunts here.” They believe that villagers  
372 should manage forests [statement 8; Factor 2 score: +3]. One who strongly agreed with this statement  
373 commented, “The forest belongs to the villagers and it is up to them to manage it.” Another claimed, “Forests  
374 are for villagers living nearby and who have experience in issues related to them. It is up to them to manage  
375 and to benefit from forests.” They slightly agreed that agriculture is not profitable because of low prices  
376 [statement 23; Factor 2 score: +1] and generally agreed that crops should be mainly developed in plains  
377 [statement 21; Factor 2 score: +2], but they disagreed that rice cultivation should be further developed  
378 [statement 26; Factor 2 score: -2]. They slightly agreed that it is important to preserve traditional agriculture  
379 [statement 27; Factor 2 score: +1]. They agreed that fishing brings them a lot of revenue [statement 32; Factor  
380 2 score: +3, Table 4].

381 3.2.4. Narrative C: Social and environmental concerns

382 Narrative C (factor 3) explained 13% of the total variance. For this factor, 16 respondents loaded significantly  
383 (3 respondents from Anjouan, 6 from Moheli and 7 from Grande Comoro). These respondents were mainly  
384 unemployed with a low level of education (Unp =9), some unemployed but educated respondents (UnpE=5),  
385 while two were employed by NGOs (EmpNGO = 2), explaining the correlation between narratives A and C.  
386 They agreed with the statement that forests are declining on the island [statement 4; Factor 3 score: +3] and  
387 strongly disagreed with continuing deforestation to develop cultivated land [statement 6; Factor 3 score: -4].  
388 As a respondent who strongly disagreed explained, “No, it is not really areas to cultivate that are lacking.”

389 They slightly disagreed that wild animals are destroying their crops [statement 16; Factor 3 score: -1]. They  
390 also disagreed that many outsiders come to their villages to hunt [statement 9; Factor 3 score: -2] and that  
391 only children and teenagers hunt in their village [statement 10; Factor 3 score: -2]. They agreed that it is  
392 prohibited to kill bats [statement 12; Factor 3 score: +2]. They strongly agreed that money from NGO or  
393 government projects never reaches farmers [statement 29; Factor 3 score: +4], and disagreed that the  
394 Comorian government often helps the local population [statement 28; Factor 3 score: -3]. As one respondent  
395 commented, “The Comoros government has never given assistance to local people. If it helped us, we would  
396 not be as poor as we are.” Other comments included: “The Comoros government never helps the people that  
397 is false.” “Unfortunately, NGO money is shared by agencies and does not reach the villagers.” The narrative  
398 C respondents also agreed that there are problems with robbery in cultivated areas [statement 25; Factor 3  
399 score: +3] (Fig 3, Table 4, Table S2).”

### 400 **3.3. Inter-class Principal Component Analysis**

401 Considering the first three principal components, we found a high level of inter-group variation (53.40% of  
402 the total variation) between employed people (EmpNGO and Emp together) and unemployed people (Fig 4).  
403 Axis PC1 clearly differentiated between the two groups EmpNGO/Emp vs Unp, and this discrimination was  
404 significant according to the permutation test (p-value=0.01). Together, the EmpNGO and Emp groups were  
405 agreed with the following statements: “It would be good if the natural forest was reestablished as before”  
406 [statement 3], “Forests are declining on the island” [statement 4], “If the forest disappears from the island,  
407 people will also disappear” [statement 5], “Aid is needed to develop new agricultural techniques” [statement  
408 30], “Tourism activities should be developed on the island” [statement 31], and “There should be some areas  
409 where habitats and animals are protected” [statement 33]. They were disagreed with the following statements:  
410 “We must continue to deforest because we need more land to cultivate” [statement 6], “Comorians do not eat  
411 fruit bats” [statement 13], “In general, animals are not useful” [statement 15], “Fruit bats have no usefulness”  
412 [statement 18], “We need to cultivate more land because the land produces less than before” [statement 22],  
413 and “The Comorian government often helps local populations” [statement 28]. The unemployed group (Unp)  
414 was positively correlated to the statements: “The forest should be managed by villagers” [statement 8], “There  
415 is no hunting here because it is too difficult to hunt” [statement 11], “We need to cultivate more land because  
416 it produces less than before” [statement 22], and “Development project/NGO money never reaches farmers”  
417 [statement 29]. It was negatively correlated to the statements: “It is mainly villagers who are cutting trees”

418 [statement 1], “Wild animals are decreasing in our area” [statement 14], and “Rice cultivation should be  
419 further developed” [statement 26].

420 Considering the influence of the three islands on the first three principal components, we found a high level of  
421 inter-island variation (53.73%). Axis PC1 differentiated the three islands, and this discrimination was  
422 significant according to the permutation test (p-value =0.03). People from Grande Comore were positively  
423 correlated to the following statements: “Crops should be mainly developed in plains” [statement 21], “It is  
424 important to preserve traditional agriculture” [statement 27], and “Fishing brings a lot of revenue for us”  
425 [statement 32]. They were negatively correlated to the statements: “Agriculture and farming are the only  
426 possible livelihood activities here” [statement 19], “If wildlife disappears, our crops will decrease” [statement  
427 17], and “Rice cultivation should be further developed” [statement 26]. People from the island of Mohéli were  
428 positively correlated to the statements: “Agriculture and farming are the only possible livelihood activities  
429 here” [statement 19], “If wildlife disappears, our crops will decrease” [statement 17], and “Rice cultivation  
430 should be further developed” [statement 26]. They were negatively correlated to the statements: “Fishing  
431 brings a lot of revenue for us” [statement 32], “It is important to preserve traditional agriculture” [statement  
432 27], and “There are not enough people who cultivate” [statement 20]. The views of people from Anjouan  
433 were situated between those from the islands of Grande Comore and Mohéli (Fig 4).” Considering the  
434 influence of the gender, people from urban vs. non-urban regions and age classes, the discrimination test was  
435 not significant (p-value > 0.05).

#### 436 **4. DISCUSSION**

##### 437 **4.1. Natural resource use by local people and its relationship to forest loss**

438 According to the information collected in the interviews, Comorian people rely heavily on natural resources  
439 for sustenance. All (100%) of our respondents confirmed that they use the forest for cultivation or to collect  
440 wood – even those with fairly high socio-economic levels, such as administrative, financial or human  
441 resources directors. Most of the respondents have a minimum of formal knowledge about biodiversity and  
442 forests. They stated that they know what biodiversity encompasses, and they generally have a positive attitude  
443 toward wild animals. Our Q-sort sampling involved only a small number of woman’s (23% of all respondents,  
444 see table 2.) thus our interpretation should take into account this sampling bias. The Q-sort results show that,  
445 despite the diversity of viewpoints among stakeholders, all stated the importance of forests and biodiversity,  
446 including flying fox species. However, the findings also highlight the complex links between biodiversity,



447 natural habitats and human needs, which include the economic benefits received from agroforestry systems.  
448 Despite their understanding of the negative impacts of degraded forests on their well-being, some rural  
449 populations have no other solution for subsistence than forests and natural areas. Comorian people know that  
450 the surface area of natural habitats is decreasing in the archipelago and are aware that if the forest disappears,  
451 no human life will be possible on the islands. Most people have accurate ideas of the mechanisms involved:  
452 for instance, they detailed that complete forest loss would generate a decrease in water resources, a low yield  
453 in agriculture, a lack of charcoal and wood for building, and the disappearance of other resources, such as  
454 food, medicinal plants, etc. This indicates that Comorian people are aware of the ongoing process of  
455 degradation and its consequences, but have no alternative livelihood than to harvest in forests.

456 A few respondents had negative perceptions of fruit bats (raised during the interviews but not in the Q-sort  
457 surveys). These are probably due to the fact that *P. s. comorensis* feeds in cultivated areas and in fruit  
458 orchards, resulting in some damage to crops. But some respondents stated that benefits from fruit bats on their  
459 farms clearly outweigh damages. Various studies examining attitudes towards biodiversity and habitat  
460 conservation in developing countries have shown similar positive perceptions of biodiversity: for instance, in  
461 Madagascar (Ratsimbazafy et al., 2012), India (Silori, 2007; Badola et al., 2012) and Uganda (Infield and  
462 Namara, 2001). In our study, positive perceptions of biodiversity were largely driven by the perceived  
463 benefits to the respondents. For example, most positive attitudes toward *P. livingstonii* were due to the fact  
464 that the species attracts many tourists as it is one of the largest bats as well as one of the most threatened  
465 animals in the world, but also because the species plays a crucial role in forest regeneration and in crop  
466 cultivation. The positive attitudes toward *P. s. comorensis* were related to its role as a seed disperser, but also  
467 to the fact that the species represents an important source of food for many rural populations.

468 Our results identified three main discourses, or narratives, one of which (Pro-environment discourse) supports  
469 long-term biodiversity conservation through the creation of protected areas. This narrative recognizes the  
470 consequences of forest loss and supports the development of ecological agricultural methods that allow  
471 forests to be maintained and developed. The second narrative (Keeping things as usual) is more in favor of  
472 immediate benefits from the forest and the protection of local activities and revenues, despite the awareness of  
473 the importance of forests and the effects of natural habitat loss on local livelihoods. The third narrative (Social  
474 and environmental concerns) is in favor of immediate benefits from forests, but equally sees the necessity of

475 preserving natural habitats. These respondents understand the importance of preserving forests and the  
476 negative impact of forest and biodiversity loss, but are forced by poverty to harvest natural resources. Positive  
477 attitudes toward long-term biodiversity conservation (Pro-environment discourse) are held mainly by  
478 employed people, including NGO staff, professors, agricultural engineers and other public officials. This  
479 could be linked to the fact that their employment leads them to be less dependent on forests and natural  
480 resources. Many previous studies have shown a significant relationship between employment, formal  
481 education and perceptions of biodiversity and forest conservation (King and Peralvo, 2010; Cairns et al.,  
482 2013).

483 Our results indicated that respondents with a low level of formal education, who are often unemployed, are  
484 associated with narrative “Keeping things as usual”. Being dependent on forest resources, their main concern  
485 is to protect their livelihoods rather than biodiversity leading them to stress that only local people should  
486 manage forests and natural resources. This highlights that the lack of other means of securing the necessities  
487 of life is the main factor leading rural people to harvest natural resources. While they are aware of the broad  
488 importance of forests, for these people, protecting them is essential mainly for their subsistence or health  
489 rather than for intrinsic or ecological reasons.

490 According to our analysis, the Narrative B appears to represent an attitude associated to Grande Comores  
491 respondents (10 respondents loaded significantly among which 9 respondents from Grande Comoro and one  
492 respondent from Anjouan). The results must be interpreted with caution as may not be broadly applicable  
493 across the three islands of the Union of Comoros.

494 Among unemployed respondents, five were educated (level of university), among which three have just  
495 finished the university studies and two of them are finished education since few years but do not have formal  
496 jobs. These unemployed but educated respondents mainly belonged to the narrative (Social and environmental  
497 concerns, see table 2) indicating that they are aware of the necessity of preserving natural habitats but are also  
498 in favor of immediate benefits from forests because of the level of poverty in these islands. Despite their high  
499 education level and their awareness regarding the importance of forests, biodiversity and natural habitat, these  
500 people are poor and struggle to meet their day-to-day needs and are in favor of any actions that may generate  
501 immediate benefits for their survival. This highlights that although education is crucial for understanding and  
502 awareness regarding the importance of forest and biodiversity conservation, reducing poverty and increasing

503 livelihoods of local people of these islands is the key strategy to allow habitat and biodiversity conservation  
504 actions to be effective.” These rural people claimed that aid money never reaches farmers. In the Comoros,  
505 development project budgets are often managed by people with a high level of education, and local people  
506 believe that this money is always absorbed by these agencies. As aid from development projects and NGOs is  
507 often limited, and thus insufficient to reach all rural people, this leads those who do not benefit to have a  
508 negative perception of NGOs.

509 Our results found that rural people from Grande Comore and Anjouan intensively collect wood to sell it,  
510 resulting in a high harvesting rate of the forests of these islands compared to Mohéli forests (Granek et al.,  
511 2002; Sewall et al., 2011, Ibouroi et al., 2018a). In contrast, respondents from Mohéli are in favor of forest  
512 and biodiversity conservation, including the development of ecological rather than traditional agriculture (the  
513 latter is preferred by respondents from Grande Comore). Respondents from Mohéli feel that wood collection  
514 should be prohibited in their region. On this island, due to the presence of the National Park of Mohéli,  
515 various nature conservation projects, and the high level of tourism linked with local biodiversity (e.g. sea  
516 turtles, Livingstone’s flying fox etc.), biodiversity represents the main source of income for the population  
517 (Granek and Brown, 2005).

518 Our study’s findings highlight the diversity of viewpoints among Comoros stakeholders depending on several  
519 social factors, including formal education level, employment, and geographic location. These results join a  
520 number of other studies that have shown diverse local perceptions of biodiversity and how to manage natural  
521 resources (Watkins and Cruz, 2007; Tapia et al., 2009a; Gall and Rodwell, 2016; Kamal and Grodzinska-  
522 Jurczak, 2014). Understanding the nuances in attitudes and the different weights attributed by stakeholders to  
523 each element of the dilemma may help to find unexpected areas of agreement and to advance new solutions.

#### 524 **4.2. Conservation recommendations**

525 Previous studies in the Comoro Islands have proposed different strategies for limiting intensive forest  
526 exploitation including law enforcement, deployment of the national army in forest, educational initiatives  
527 such as increasing awareness and understanding of conservation issues (Mikuš, 2009; Poonian et al.2008a;  
528 Trehwella et al., 2005). However, all these strategies do not appear as appropriate solutions for effectively  
529 reducing habitat destruction since Comorians’ exploitation of natural resources is a question of survival. As  
530 many stakeholders commented during our interviews, “We use natural resources for our survival. We will

531 continue to exploit forests even if it costs our life.” In the other hand, our results indicate that Comorians  
532 today do not lack awareness concerning the importance of natural habitats and the impact of habitat  
533 disturbance and loss on their livelihood. Rather it appears that the main constraint is poverty, forcing them to  
534 heavily exploit forests. In addition, employing force as a conservation measure is dangerous for villagers,  
535 forest managers and conservationists. Some Mohéli respondents affirmed that marine turtle poachers are often  
536 armed. In an assessment of Comorians’ perception of the Mohéli Marine Park, a Marine Protected Area  
537 (MPA), Poonian et al. (2008b) revealed that the most important factors affecting habitat management in the  
538 protected areas of Comoros are the lack of sustainable alternative livelihoods, inequitable distribution of  
539 benefits and continuing environmental threats. Poonian et al. (2008b) suggested that, to ensure habitat  
540 conservation and the continuity of this protected area, MPA managers should adopt programs that carefully  
541 consider sustainable sources of finance for stakeholders and lower-cost alternatives that reduce poverty.  
542 Hauzer et al. (2008) highlighted that Comorians, especially from Mohéli, were aware of the importance of the  
543 protected area, but felt that their survival was of priority importance. Hauzer et al. (2008) suggested that the  
544 best conservation strategy would be a measure that would “(1) ensure sustainability through effective  
545 financial planning and appropriate management techniques; (2) mobilize local communities to create a truly  
546 co-managed MPA; (3) ensure tangible benefits to local communities through realistic alternative livelihood  
547 options”. In a study of the links between resource dependency and attitude of commercial fishers to coral reef  
548 conservation in the red sea, Marshall et al. (2010) found a direct relationship between conservation attitudes  
549 and aspects of resource dependency. Especially, fishers with higher income were more likely to have a  
550 positive conservation attitude. Sewall et al. (2011) suggested that local Comorians living near forests should  
551 be compensated if agricultural land use within a reserve were restricted. One of the most important  
552 management strategy in protected area is involving local people and habitat users in the management  
553 (Mtwana et al 2014). Freed and Granek (2014) suggested that priority for management actions should be to  
554 include local community members and stakeholders in the decision-making and implementation process for  
555 protecting fragile reef ecosystems in the Comoros. These authors suggested that local communities would  
556 serve as the primary management actor for an effective conservation strategy (see also Freed et al 2016).  
557 Sewall et al. (2011) also suggested that any plans for a reserve should be adopted through a formal process  
558 that includes local community engagement, as without this conservation strategies will not be effective.

559 Our results highlight that employment influence local perceptions and suggest the lack of livelihoods for rural  
560 people as the main factor leading local people to overharvest natural resources. Although these rural people  
561 cultivate more, most of them apply traditional methods especially by using slash-and-burn making lands  
562 unproductive few years later and increasing the need of more lands.

563 The first key recommendation we propose for the preservation natural habitats is developing and maintaining  
564 sustainable production of crops for local human benefit. New methods and materials to develop ecological  
565 agriculture must be made available to local communities. Roccliffe et al. (2014) highlighted that  
566 underdevelopment of legal structures supportive of local communities was one strong constraints for formal  
567 local protected areas in many developing countries of the Western Indian Ocean islands including the  
568 Comoros archipelago. Projects such as these could allow local populations to improve yield with the same  
569 surface area, thus reducing the conversion of forest into farmland.

570 The lack of market to sell cultivated products is the second factor leading to overexploitation of natural  
571 habitats as highlighted by many respondents. As a second key recommendation we propose to develop  
572 projects of local markets that that could allow the creation of new jobs for local people.

573 According to our results (semi-structured interviews), all interviewed respondents are using forests and  
574 natural resource for subsistence. Fisher and Christopher (2007) highlighted that, about 72% of Comorians  
575 depend directly on forest resources. This strong dependence on natural resources is due to the fact that many  
576 development sectors such as tourism are not yet developed in the Union of Comoros (Granek and Brown,  
577 2005). The third key recommendation we propose is to develop eco-touristic project, including the  
578 construction of bungalows in strategic villages as well as tourist sites for observing emblematic species such  
579 as the endemic flying foxes, lemurs, scops owl, etc. Villagers and local communities could manage these  
580 infrastructures.

581 As the lack of governmental assistance is claimed to be the main cause leading to the overharvesting of  
582 forests, the fourth key recommendation we propose here is that government aids and support should made  
583 available for rural people that could reassure them of the government good intentions to contribute to local  
584 development.

585 The fifth key strategy allowing ensuring the preservation of Comoros forests and natural habitats in mid-term  
586 and long-term purposes will be to set up awareness campaign for replantation and reforestation. As Comorian  
587 people do not lack awareness regarding the necessity to preserve forests and natural habitats but overexploit

588 forest for their everyday needs, forest managers must ensure the improvement of living conditions of local  
589 population before any replantation project otherwise community will exploit the forests before replanted trees  
590 grow. Replantation can play an important role in sustaining native biodiversity and makes an important  
591 contribution to the conservation of native biodiversity (Rocliffe et al. 2014). Their re-establishment involves  
592 the replacement of native natural plants but also makes large trees available for mid and long-term purposes  
593 which are crucial for human wellbeing (Brockerhoff et al. 2008).

## 594 **5. CONCLUSION**

595 In conclusion, habitat loss and the vulnerability of biodiversity in the Comoros are the results of the  
596 unsustainable overexploitation of natural resources. Yet to maintain the ecological balance necessary for daily  
597 human needs and for future generations (clean water, productive agricultural land, ecosystem services from  
598 biodiversity and forests), it is vital to conserve the natural habitats on these islands.

599 As the exploitation of natural resources by local people is a question of survival, a program allowing to reduce  
600 poverty for instance by developing tourism and maintaining sustainable production of crops, livestock and  
601 setting up awareness campaign for tree planting and reforestation projects are necessary for the Union of  
602 Comoros.

603 On the three islands of the Union of Comoros, a project to create national marine and terrestrial protected  
604 areas – including national parks funded by the Global Environmental Finance (GEF) and put in place since  
605 2016 by the United Nation Development Program (UNDP) – has been agreed by the Comorian government.  
606 The project is now managed by an independent institution (The National Network of Protected Areas or  
607 *Réseau National d'Aires Protégées RNAP*). Based on our interviews with local people, most rural  
608 communities agree with the creation of protected areas if they can gain direct benefits from the project and are  
609 involved in the conservation actions. Constructive engagement with local residents (such as providing  
610 employment as local guides or park rangers, for example) would contribute to supporting long-term  
611 conservation success.

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616

617 Figure 1: Sampling localities in the Union **References**

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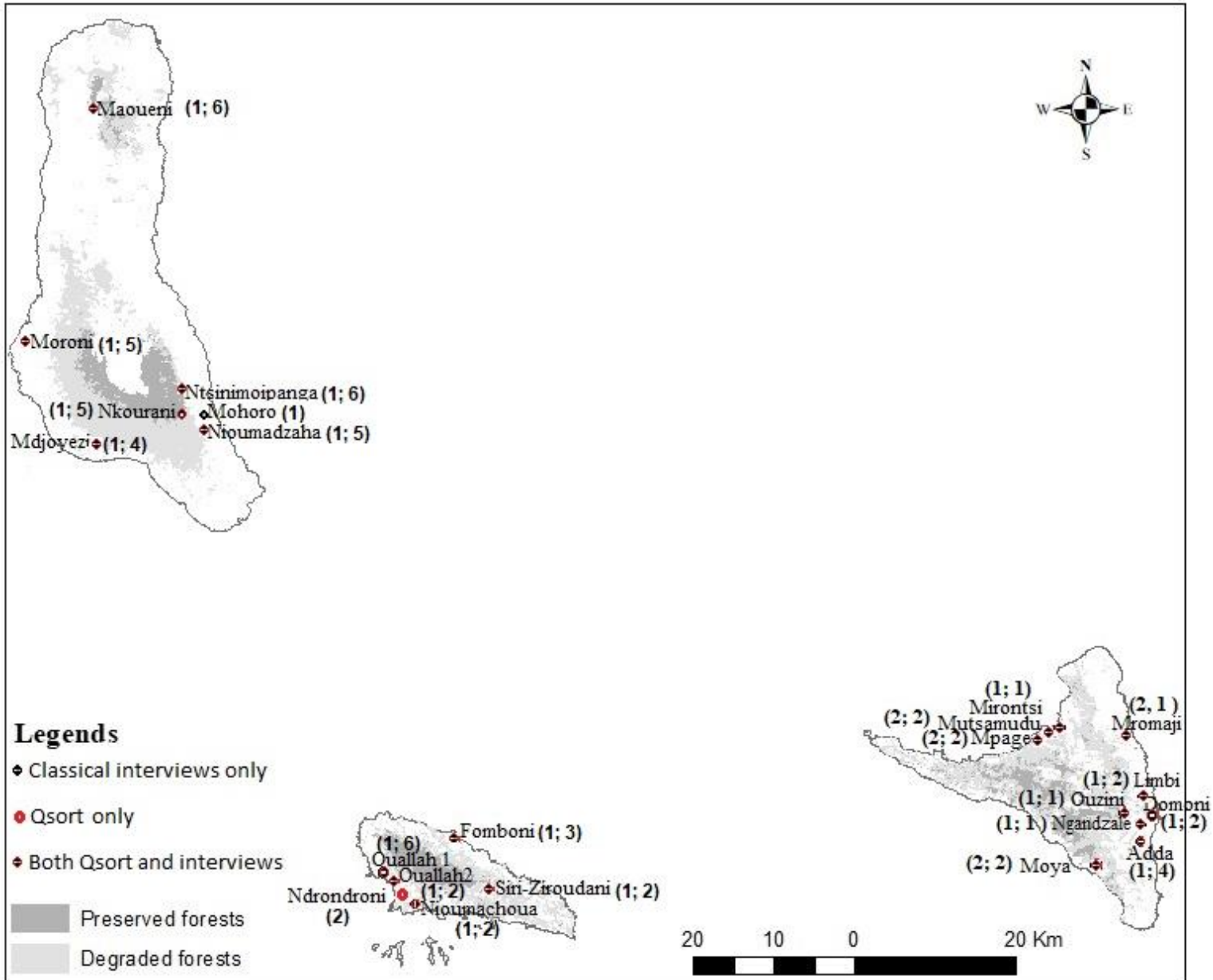
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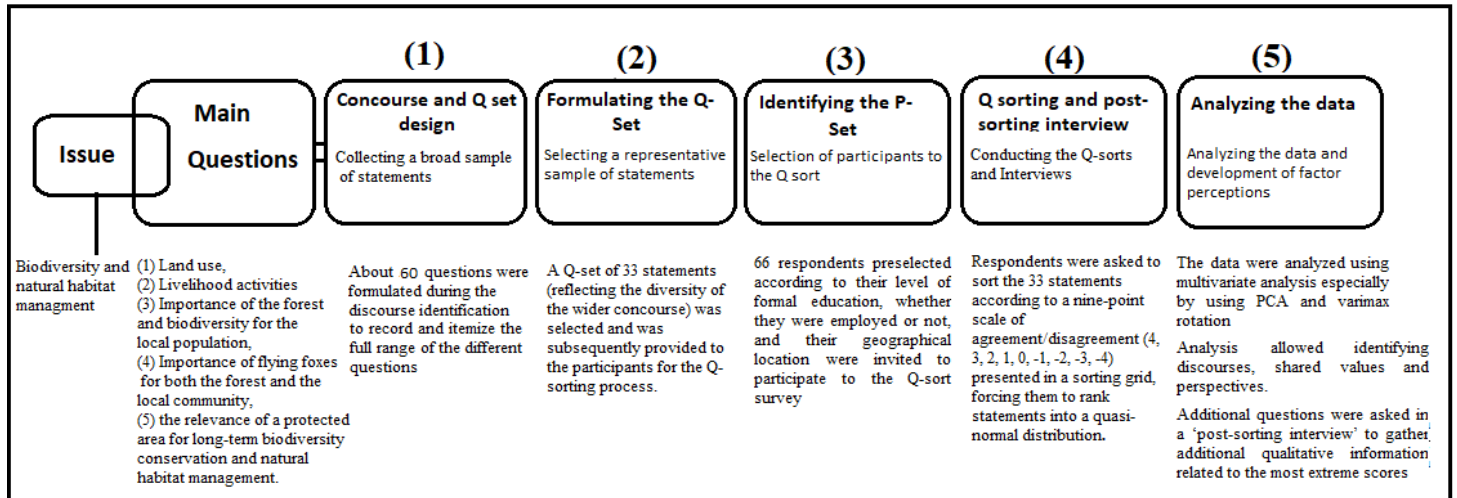
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- 827
- 828 of Comoros: Grande Comore (top left), Anjouan (bottom right), Mohéli (bottom left), indicating main villages  
829 and preserved (dark grey) and degraded (light grey) forests; Numbers of interviewed people are presented  
830 between brackets for each locality; when both classical interviews and Qsort methods are realized in the same  
831 locality, the first number on the parentheses represents the number of interviewed people for classical  
832 interviews and the second represents the number for Qsort.

833



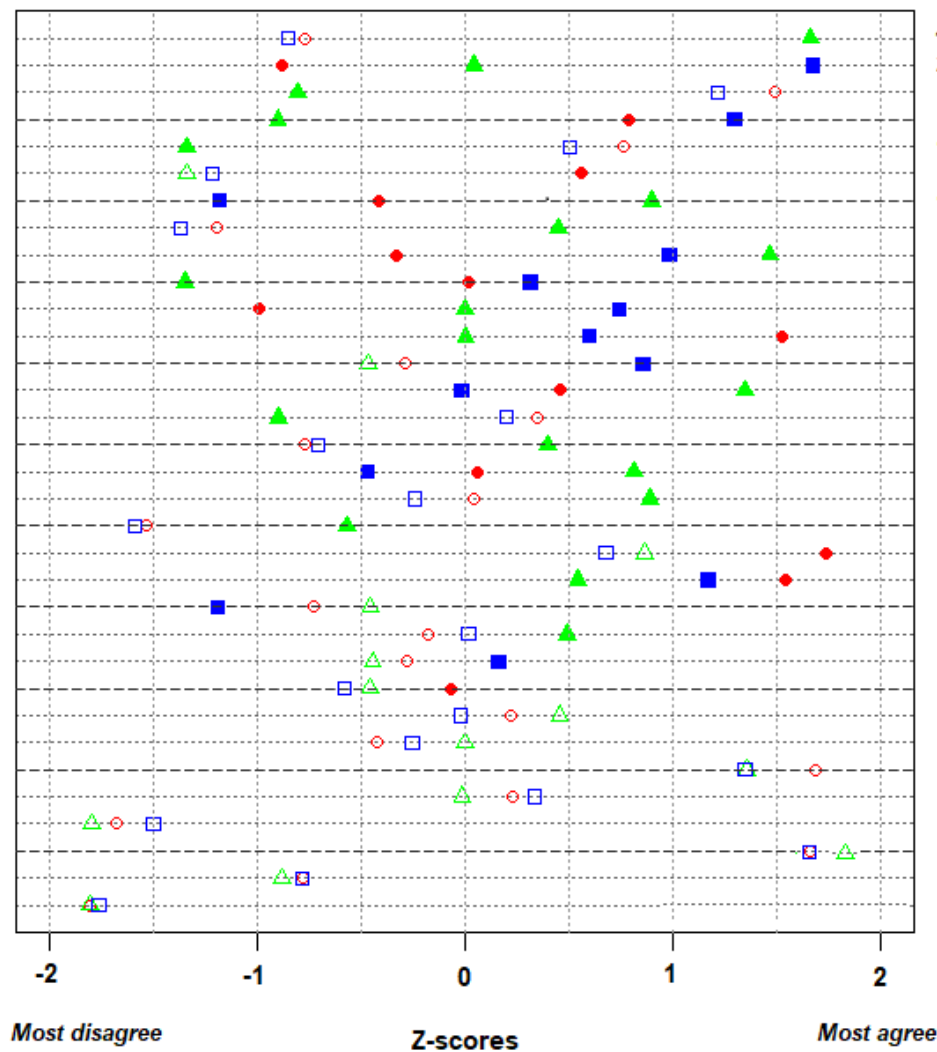


841

842 Figure 2. Q methodology steps conducted for the current study.

843 Figure 3: Statements selected for Q sorting, ordered from most distinctive (top) to consensus (down, in bold and italic), based  
844 on Z-score differences; A statement is considered distinctive when comparing all pair of factors and at least one factor is  
845 significantly different to the others for this statement at p-value < .01 (e.g. statement 11); if all the comparisons between each  
846 pair of factors are significantly different at p-value < .01, the statement is considered as “distinctive all” (e.g. statement 29); a  
847 statement is considered as consensus when none of the comparisons are significantly different at p-value < .01(e.g. statement  
848 15); if a statement is distinctive for a factor (at  $p < 0.01$ ), the symbol is filled and if a statements is not distinctive for a given  
849 factor, the symbol is empty.

850 .

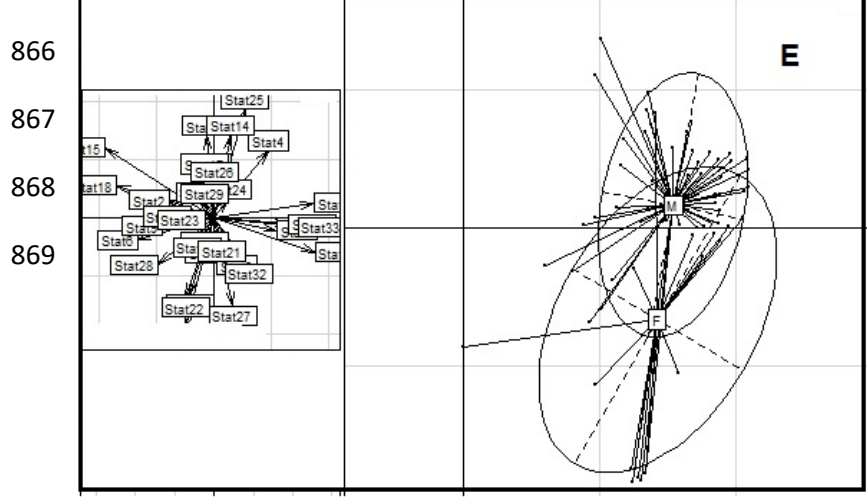
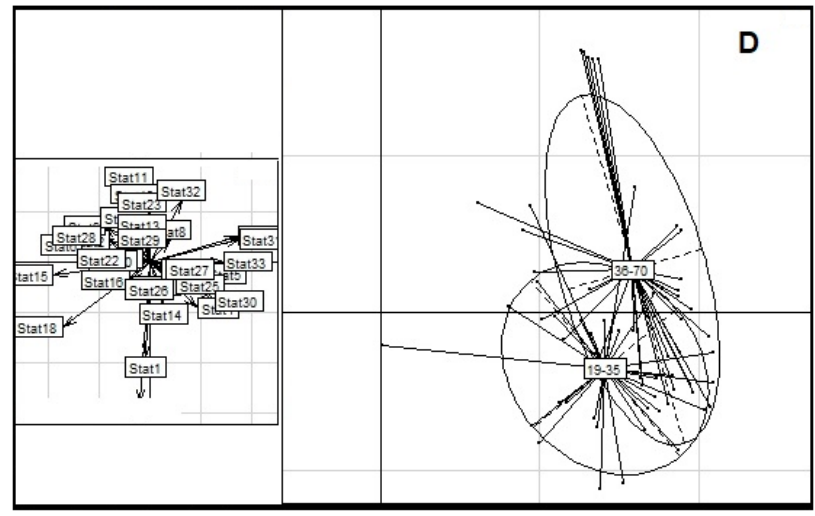
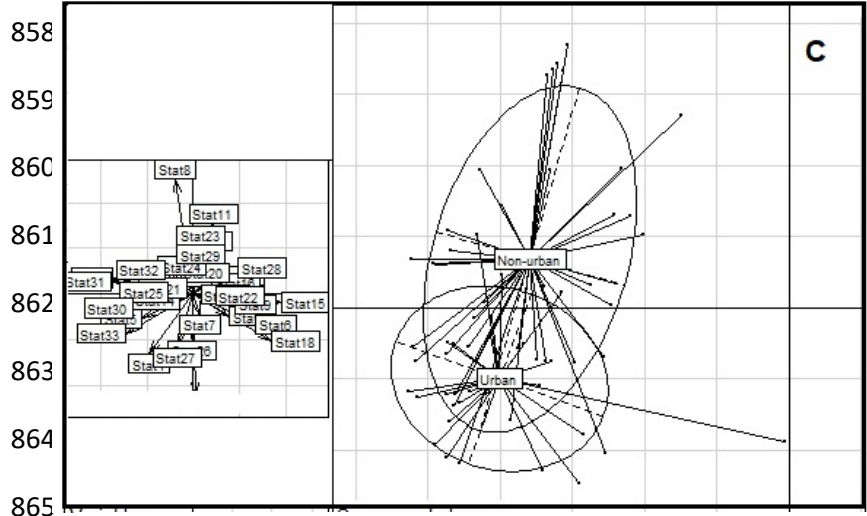
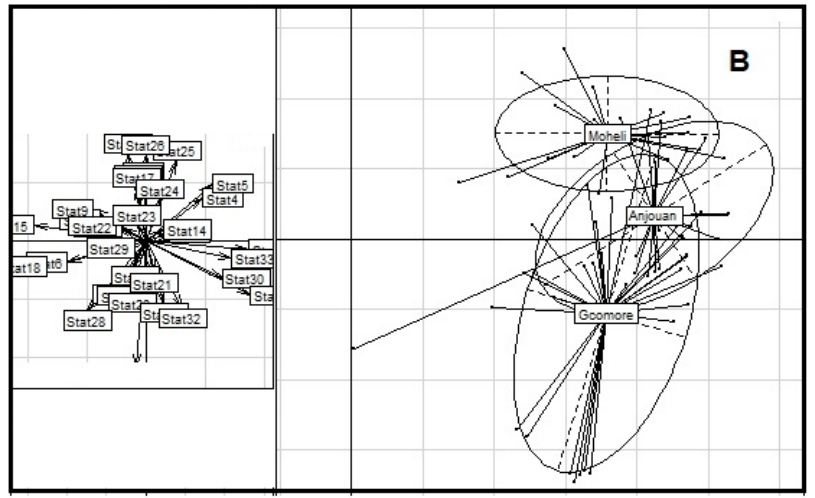
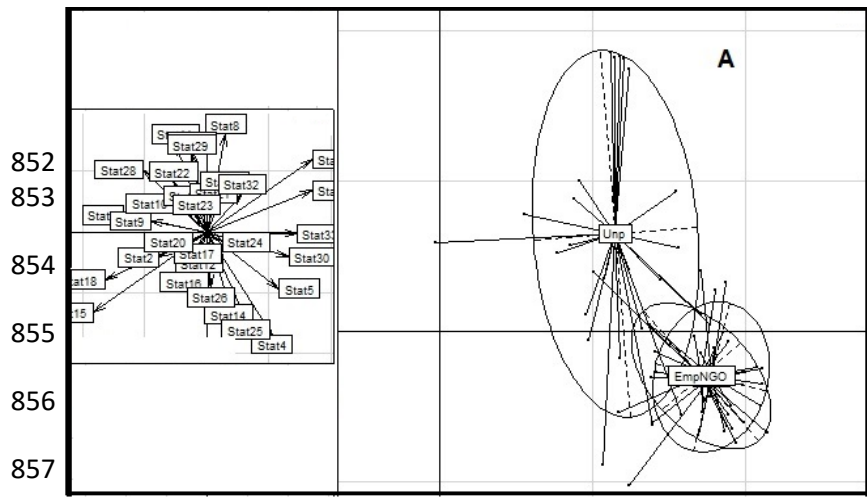


**Statements**

- 11 There is no hunting here because it's too difficult to hunt
- 29 Development project/NGO money never reaches farmers
- 4 The forest is declining on the island
- 25 There are many problems with robbery from farms
- 14 Wild animals are decreasing in our region
- 1 It is mainly villagers who are cutting trees
- 10 Only children and teenagers hunt in our village
- 28 The Comorian government often helps local populations
- 8 The forest should be managed by villagers
- 17 If wildlife disappears, our crops will decrease
- 13 Comorians do not eat fruit bats
- 5 If the forest disappears from the island, people will also disappear
- 12 It is prohibited to kill bats
- 32 Fishing brings a lot of revenue for us
- 26 Rice cultivation should be further developed
- 22 We need to cultivate more land because land produces less than before
- 7 If people collect wood, it is mainly to sell it
- 21 Crops should be mainly developed in plains
- 6 We must continue to deforest because we need more land to cultivate
- 33 There should be some protected areas for natural habitats and animals
- 30 Aid is needed to develop new agricultural techniques
- 9 There are many outsiders coming to the village to hunt
- 23 Agriculture is not profitable because prices are too low
- 20 There are not enough people who cultivate
- 16 Some wild animals destroy our crops
- 27 It is important to preserve traditional agriculture
- 3 It would be good if the natural forest is reestablished as before
- 19 *Agriculture and farming are the only possible living activities*
- 24 *Crops do not produce enough because there are many diseases*
- 18 *Fruit bats are not useful*
- 31 *Tourism activities should be developed on the island*
- 2 *People from this village do not cut trees, logging is prohibited*
- 15 *In general, animals are not useful*

- 1. Pro-environment discourse
- ▲ 2. Keeping things as usual
- 3. Social and environmental concerns





870 Figure 4: Principal component analysis (inter-class analysis). A= Discrimination between stakeholders in different social  
871 groups (EmpNGO = employed in an NGO or other; Unp = unemployed); B= Discrimination between stakeholders from the  
872 three different islands of the archipelago (Comore, Anjouan, Mohéli); C= Discrimination between stakeholders from urban  
873 and non-urban regions; D= Discrimination between Ages (from 19 to 35 years and from 36 to 70 years) of the different  
874 stakeholders; E= Discrimination between stakeholder's gender (M= male, F=female); The different statements are presented in  
875 left and the different groups are shown in right; the different point for each group represent the individuals; the arrows oriented  
876 to statement indicate which group the statement is more correlated on; arrows pointing up indicate that the corresponding  
877 statements are more correlated to the group at the top and arrows pointing down indicate that the corresponding statements are  
878 more correlated to the group at the bottom.

879 Table 1. Guidelines for the initial semi-structured interviews with rural Comorians

880

N°	Statement	881
1	What activities do you use forests for?	882
2	What relationship do you have with the forest?	883
3	Who exploits the forests in this region?	884
4	Do you have any knowledge regarding the history of this forest?	885
5	Have you seen any recent changes?	886
6	What do you want this forest to be like in the future?	887
7	If this forest disappeared completely, would it have any implications for you?	888
8	What wildlife are you familiar with in this forest?	889
9	Do you have any relationships with these animals? What do these animals represent for you?	890 891
10	Are any of these wild animals hunted? If so, for what purpose?	892
11	Who hunts in this region?	893
12	Which hunting technique is most used in this region and is most effective?	894
13	Have you seen an increase or a decrease (in number) in these animals?	895
14	Do you know about fruit bats?	896
15	What type of fruit bats have you encountered in your life?	897
16	Where do these bats live?	898
17	Where do these bats feed?	899
18	What do you think of these bats?	900
19	What activities do you do to make a living?	901
20	What do you cultivate?	902
21	In which area do you prefer to cultivate?	903
22	What type of foods do you grow?	904
23	Based on your knowledge of the soil in the past, have you noticed any changes compared to before?	905 906 907
24	What are the difficulties you face in developing your livelihood?	908
25	Do you receive any assistance from the government?	909
26	Do you receive any assistance from an NGO?	910
27	What would you like to do to improve your livelihood activities?	911
28	Do you know about protected areas?	912
29	Would you agree to the creation of a protected area in this forest?	913
30	Which possible areas would you propose for a protected area?	914 915 916 917

918 Table 2: Factor matrix based on Q methodology (\* indicates that the corresponding respondent loaded to a narrative), Emp=  
 919 Employed outside NGOs; EmpNGO= Employed in an NGO; G.Comoro= Grande Comore; Educ= educated; Non-educ= non-  
 920 educated; the 5 respondents that didn't fit any of the 3 narratives are shown in bold; M=Male; F= Female

Island	Gender	Age	Urban/non-urban	Education	Social group	Narrative A	Narrative B	Narrative C
G.Comoro	F	26	Non-urban	Educ	Unp	0.19	* 0.40	0.13
Mohéli	M	19	Non-urban	Non-educ	Unp	0.22	-0.14	* 0.54
Mohéli	M	20	Non-urban	Non-educ	Unp	* 0.36	0.33	0.03
Mohéli	M	45	Non-urban	Educ	Emp	* 0.63	0.27	0.21
Mohéli	M	45	Non-urban	Non-educ	Unp	-0.08	0.31	* 0.37
Mohéli	M	65	Non-urban	Educ	Emp	0.54	0.14	* 0.64
Mohéli	M	26	Non-urban	Educ	Emp	* 0.58	0.04	0.14
Mohéli	M	36	Non-urban	Non-educ	Unp	0.04	0.23	* 0.46
Mohéli	M	41	Non-urban	Educ	Emp	* 0.60	0.14	0.47
<b>Mohéli</b>	<b>F</b>	<b>56</b>	<b>Non-urban</b>	<b>Educ</b>	<b>Emp</b>	<b>0.41</b>	<b>0.42</b>	<b>0.38</b>
Mohéli	M	33	Non-urban	Educ	Unp	0.42	-0.06	* 0.51
Mohéli	M	26	Non-urban	Educ	Emp	* 0.62	0.13	0.34
Mohéli	M	37	Non-urban	Educ	Emp	* 0.76	0.16	0.34
Mohéli	M	29	Non-urban	Educ	Emp	* 0.54	-0.14	0.24
Mohéli	M	46	Non-urban	Educ	Emp	* 0.57	-0.15	0.29

G.Comore	M	58	Non-urban	Educ	Emp	* 0.72	-0.01	0.35
Anjouan	M	53	Non-urban	Educ	Emp	* 0.56	0.10	0.39
Anjouan	M	42	Non-urban	Educ	Emp	* 0.58	0.11	0.53
Anjouan	M	52	Urban	Educ	Emp	0.36	0.25	* 0.60
Anjouan	M	37	Urban	Educ	Emp	* 0.58	-0.05	0.46
Anjouan	M	31	Non-urban	Educ	Emp	* 0.69	0.28	0.39
Anjouan	M	27	Non-urban	Educ	Emp	* 0.71	0.08	0.21
Anjouan	M	45	Non-urban	Educ	Emp	* 0.69	0.14	0.40
Anjouan	M	38	Non-urban	Non-educ	Unp	0.32	0.33	* 0.51
<b>Anjouan</b>	<b>M</b>	<b>25</b>	<b>Non-urban</b>	<b>Educ</b>	<b>Unp</b>	<b>0.39</b>	<b>0.38</b>	<b>0.39</b>
G.Comore	M	47	Non-urban	Educ	Emp	* 0.80	0.21	0.25
G.Comore	M	23	Non-urban	Educ	Unp	0.05	0.20	* 0.39
G.Comore	M	33	Non-urban	Non-educ	Unp	* 0.66	-0.07	0.25
G.Comore	M	35	Non-urban	Non-educ	Unp	0.18	0.08	* 0.75
G.Comore	M	36	Non-urban	Non-educ	Unp	0.20	0.12	* 0.35
Anjouan	F	25	Urban	Educ	EmpNGO	* 0.71	0.10	0.15
Anjouan	F	24	Urban	Non-educ	Unp	0.14	0.16	* -0.42
Anjouan	M	27	Non-urban	Educ	EmpNGO	* 0.54	0.25	0.16
G.Comore	M	40	Non-urban	Non-educ	Unp	0.12	* 0.96	0.12

Anjouan	F	26	Urban	Educ	EmpNGO	* 0.81	0.24	0.18
Anjouan	F	22	Urban	Non-educ	Unp	0.50	* 0.60	-0.01
<b>Anjouan</b>	<b>M</b>	<b>38</b>	<b>Urban</b>	<b>Educ</b>	<b>EmpNGO</b>	<b>0.42</b>	<b>0.20</b>	<b>0.43</b>
Mohéli	F	28	Urban	Non-educ	Unp	* 0.63	0.16	0.28
Mohéli	F	35	Urban	Non-educ	Unp	0.23	0.17	* 0.52
Mohéli	M	42	Urban	Non-educ	Unp	* 0.52	-0.04	0.12
G.Comore	M	38	Non-urban	Non-educ	Unp	0.08	* 0.98	0.09
G.Comore	F	42	Non-urban	Non-educ	Unp	0.12	* 0.96	0.12
G.Comore	F	26	Non-urban	Educ	EmpNGO	0.25	0.08	* 0.70
G.Comore	M	35	Urban	Educ	EmpNGO	* 0.65	-0.06	0.39
G.Comore	M	44	Non-urban	Educ	EmpNGO	* 0.52	0.33	-0.31
G.Comore	M	29	Non-urban	Non-educ	Unp	0.15	* 0.55	0.05
<b>G.Comore</b>	<b>M</b>	<b>35</b>	<b>Non-urban</b>	<b>Non-educ</b>	<b>Unp</b>	<b>0.40</b>	<b>-0.36</b>	<b>0.48</b>
G.Comore	M	26	Urban	Educ	EmpNGO	* 0.74	0.14	0.24
G.Comore	F	37	Non-urban	Non-educ	Unp	0.08	* 0.98	0.12
G.Comore	M	36	Urban	Educ	EmpNGO	* 0.44	0.28	0.13
G.Comore	M	29	Urban	Educ	EmpNGO	* 0.66	0.12	-0.24
G.Comore	M	61	Urban	Educ	EmpNGO	0.52	0.16	* 0.57
G.Comore	M	42	Urban	Educ	EmpNGO	* 0.77	0.19	0.14

Anjouan	M	38	Urban	Educ	EmpNGO	* 0.78	0.18	0.16
G.Comore	F	40	Non-urban	Non-educ	Unp	0.03	* 0.96	0.17
Anjouan	M	42	Urban	Educ	EmpNGO	* 0.73	0.28	0.12
G.Comore	M	32	Urban	Educ	Emp	0.40	-0.03	* 0.48
G.Comore	M	35	Urban	Educ	EmpNGO	* 0.57	0.13	0.07
Anjouan	M	37	Urban	Educ	EmpNGO	* 0.85	0.14	0.24
<b>G.Comore</b>	<b>M</b>	<b>42</b>	<b>Urban</b>	<b>Educ</b>	<b>EmpNGO</b>	<b>0.41</b>	<b>0.25</b>	<b>0.42</b>
G.Comore	F	39	Non-urban	Non-educ	Unp	0.08	* 0.98	0.09
G.Comore	M	38	Non-urban	Educ	EmpNGO	* 0.55	0.15	0.49
G.Comore	M	30	Urban	Educ	Unp	0.35	0.19	* 0.45
G.Comore	F	42	Urban	Educ	EmpNGO	* 0.83	0.13	0.16
G.Comore7	F	32	Non-urban	Educ	EmpNGO	* 0.77	0.17	0.15
G.Comore	M	37	Non-urban	Non-educ	Unp	0.10	* 0.98	0.10

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Table 3: Different statements for each narrative ordered according to z-scores, beginning from the highest ranked statements in “*Agreement*” and the lowest ranked statements in “*Disagreement*”. Asterisks show statements that are distinct between narrative at  $P < 0.01$ , DisA-B=distinction between the narrative A and B; Dis A-C=distinction between the narrative A and C; Dis B-C=distinction between the narrative B and C; Sign= significantly.



N°	Statements	DisA-B	DisA-B-Sign	DisA-C	DisA-C-Sign	DisB-C	DisB-C-Sign
<b>Consensus statements</b>							
<i>Agreement</i>							
31	Tourism activities should be developed on the island.	-0.175		-0.002		0.17	
24	Crops do not produce enough because there are many diseases.	0.240		-0.109		-0.35	
<i>Disagreement</i>							
15	In general, animals are not useful.	0.002		-0.043		-0.04	
18	Fruit bats are not useful.	0.117		-0.180		-0.30	
2	(2) People from this village do not cut trees, logging is prohibited.	0.098		0.005		-0.09	
19	Agriculture and farming are the only possible livelihood activities here.	-0.313		-0.167		0.26	
<b>Narrative A: Pro-environment discourse</b>							
<i>Agreement</i>							
3	It would be good if the natural forest was reestablished as before.	0.329		0.441	*	0.01	
33	There should be some areas where natural habitats and animals are protected.	0.876	****	1.062	****	0.19	
5	If the forest disappears from the island, people will also disappear.	1.521	****	0.926	****	-0.60	**
30	Aid is needed to develop new agricultural techniques.	1.001	****	0.471	*	-0.63	**
<i>Disagreement</i>							
13	Comorians do not eat fruit bats.	-0.996	****	-1.734	****	-0.74	***
22	We need to cultivate more land because land produces less than before.	-1.169	****	-0.064		1.10	****
<b>Narrative B: Keeping things as usual</b>							
<i>Agreement</i>							
11	There is no hunting here because it's too difficult to hunt.	-2.434	****	0.083		2.52	****
32	Fishing brings a lot of revenue for us.	-0.887	****	0.475	**	1.36	****
8	The forest should be managed by villagers.	-1.800	****	-1.315	****	0.49	*
7	If people collect wood, it is mainly to sell it.	-0.754	***	0.532	**	1.29	****
21	Crops should be mainly developed in plains.	-0.844	****	0.290		1.13	****
23	Agriculture is not profitable because prices are too low.	-0.669	***	-0.194		0.48	*
27	It is important to preserve traditional agriculture.	-0.234		0.238		0.47	*

<i>Disagreement</i>						
1	It is mainly villagers who are cutting trees.	1.895	****	1.777	****	-0.12
14	Wild animals are decreasing in our region.	2.098	****	0.257		-1.84 ****
17	If wildlife disappears, our crops will decrease.	1.362	****	-0.498	*	-1.66 ****
26	Rice cultivation should be further developed.	1.244	****	0.148		-1.10 ****
20	There are not enough people who cultivate.	0.168		-0.537	**	-0.61 **
<b>Narrative C: Social and environmental concerns</b>						
<i>Agreement</i>						
29	Project development/NGO money never reaches farmers.	-0.922	****	-2.557	****	-1.63 ****
25	There are many problems with robbery in plantations.	1.694	****	-0.505	***	-2.20 ****
4	The forest is declining on the island.	2.293	****	0.270		-2.02 ****
12	It is prohibited to kill bats.	0.178		-1.144	****	-1.32 ****
<i>Disagreement</i>						
6	We must continue to deforest because we need more land to cultivate.	-0.967	****	0.058		1.03 ****
28	The Comorian government often helps local populations.	-1.643	****	0.172		1.82 ****
9	There are many outsiders coming to the village to hunt.	-0.275		0.464	**	0.74 ***
10	Only children and teenagers hunt in our village.	-1.310	****	0.768	****	2.08 ****
16	Some wild animals destroy our crops.	0.486	*	0.511	**	0.13

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Statements (Stat)	Stat No	Factor 1 (F1)		Factor 3 (F2)		Factor 3 (F3)	
		QS	ZSC	QS	ZSC	QS	ZSC
<b><i>Consensus statements</i></b>							
People from this village do not cut trees, wood logging is prohibited	2	-2	-0.78	-2	-0.88	-2	-0.78
In general, animals are not useful	15	-4	-1.80	-4	-1.81	-4	-1.76
Fruit bats have no usefulness	18	-4	-1.68	-4	-1.80	-3	-1.50
Agriculture and farming are the only possible living activities here	19	-1	-0.42	0	0.00	-1	-0.25
Cultures do not produce enough because there are many diseases	24	1	0.23	0	-0.01	1	0.34
Tourism activities should be developed on the island	31	3	1.63	4	1.80	4	1.63
<b><i>Narrative A: Pro-environment discourse</i></b>							
It would be good if the natural forest is reestablished as before	3	4	1.69	3	1.36	3	1.35
If the forest disappears from the island, people will also disappear	5	3	1.53	0	0.00	1	0.60
Comorians do not eat fruit bats	13	-3	-0.99	0	0.00	2	0.74
We need to cultivate more land because land produces less than before	22	-2	-0.77	1	0.40	-1	-0.71
Aid is needed to develop new agricultural techniques	30	3	1.54	1	0.54	2	1.17
There should be some areas where environment and animals could be protected	33	4	1.74	2	0.86	1	0.68
<b><i>Narrative B: Keeping things as usual</i></b>							
It is mainly villagers who are cutting trees	1	2	0.56	-3	-1.34	-3	-1.22
If people collect wood, it is mainly to sell it	7	1	0.06	2	0.81	-1	-0.47
The forest should be managed by villagers	8	-1	-0.33	3	1.47	2	0.98
There is no hunting here because it's too difficult to hunt	11	-2	-0.77	4	1.67	-2	-0.85
Wild animals are decreasing in our regions	14	2	0.76	-3	-1.34	1	0.50
If wildlife disappear, our plantation will decrease	17	0	0.02	-3	-1.34	1	0.31

There are not enough people who cultivate	20	0	-0.27	-1	-0.45	0	0.16
Cultures should be mainly developed in plains	21	0	0.05	2	0.89	-1	-0.24
Agriculture is not profitable because prices are too low	23	0	-0.18	1	0.49	0	0.02
Rice cultivation should be further developed	26	1	0.35	-2	-0.90	0	0.20
It is important to preserve traditional agriculture	27	1	0.22	1	0.45	0	-0.02
Fishing brings a lot of revenue for us	32	1	0.46	3	1.35	0	-0.02
<b><i>Narrative C: Social and environmental concerns</i></b>							
Forest is declining on the island	4	2	1.49	-2	-0.80	3	1.22
We must continue to deforest because we need more land to cultivate	6	-3	-1.53	-1	-0.56	-4	-1.59
There are many outsiders coming to the village to hunt	9	-1	-0.73	-1	-0.45	-2	-1.19
Only children and teenagers hunt in our village	10	-1	-0.41	2	0.90	-2	-1.18
It is prohibited to kill bats	12	-1	-0.29	-1	-0.47	2	0.86
Some wild animals destroy our plantations	16	0	-0.07	-1	-0.46	-1	-0.58
There are many problems with robbery in plantations	25	2	0.79	-2	-0.90	3	1.30
The Comorian government often helps local populations	28	-3	-1.20	1	0.45	-3	-1.37
Project / NGO money never reaches farmers	29	-2	-0.88	0	0.04	4	1.68

943 Table 4: Z-scores (ZSC) and idealized Q-sort scores (QS) for the different factors or Narrative.

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