

# 1 Biocultural approaches to pollinator 2 conservation

3

## 4 Abstract

5 Pollinators underpin sustainable livelihoods that link ecosystems, spiritual and cultural values, and  
6 customary governance systems with indigenous peoples<sup>a</sup> and local communities (IPLC) across the  
7 world. Biocultural diversity is a short-hand term for this great variety of people-nature interlinkages  
8 that have developed over time in specific ecosystems. Biocultural approaches to conservation  
9 explicitly build on the conservation practices inherent in sustaining these livelihoods. We used the  
10 Conceptual Framework of the Intergovernmental Platform on Biodiversity and Ecosystem Services to  
11 analyse the biocultural approaches to pollinator conservation by indigenous peoples and local  
12 communities globally. The analysis identified biocultural approaches to pollinators across all six  
13 elements of the Conceptual Framework, with conservation-related practices occurring in sixty  
14 countries, in all continents except Antarctica. Practices of IPLC that are significant for biocultural  
15 approaches to pollinator conservation can be grouped into three categories: the practice of valuing  
16 diversity and fostering biocultural diversity; landscape management practices; and diversified  
17 farming systems. Particular IPLCs may use some or all of these practices. Policies that recognise  
18 customary tenure over traditional lands, strengthen Indigenous and Community Conserved Areas,  
19 promote heritage listing and support diversified farming within a food sovereignty approach, are  
20 among several identified that strengthen biocultural approaches to pollinator conservation, and  
21 thereby deliver mutual benefits for pollinators and people.

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<sup>a</sup> Here we follow the global norm of using lower case for “indigenous” while recognising the norm in Australia and New Zealand is to use upper case, following Johnson, J.T. et al. (2007) Creating anti-colonial geographies: Embracing indigenous peoples' knowledges and rights. *Geographical Research* 45 (2), 117-120.

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26 Keywords: biocultural diversity, indigenous peoples, local communities, conservation, biodiversity,  
27 governance, cultural values

28

## 29 Introduction

30 Pollinators are integral to a good quality of life for people globally, contributing to sustainable  
31 livelihoods, maintenance of ecosystem health and function, food production, cultural, spiritual and  
32 social values<sup>1</sup>. Inclusive policy for their conservation requires innovative, multiscale assessments that  
33 include evidence from science and other knowledge systems<sup>2</sup>. Yet conservation science has often  
34 neglected societies' values, world views and knowledge systems and ignored culturally-grounded  
35 approaches<sup>3</sup>. In this context, *biocultural approaches to conservation*, which explicitly build on local  
36 cultural perspectives and recognize feedbacks between ecosystems and quality of life, have emerged  
37 as key to the necessary inclusivity<sup>4</sup>. Biocultural approaches are underpinned by the concept of  
38 biocultural diversity, which recognises that culture and biodiversity are linked and may be mutually  
39 constituted<sup>5</sup>. Indigenous peoples and local communities (IPLCs) are integral to the biocultural  
40 diversity that has developed in ecosystems over millennia, including large areas of the globe, many  
41 with high biodiversity, over which IPLCs have management responsibility<sup>6</sup>. The Intergovernmental  
42 Science-Policy Platform on Biodiversity and Ecosystems Services (IPBES) is promoting inclusivity in  
43 assessments through the IPBES Conceptual Framework<sup>5</sup>, their valuation approaches<sup>7</sup>, and by  
44 providing space for context-specific culturally-grounded ways of assessing nature's contributions to  
45 people (NCP)<sup>8</sup>. In this paper, we provide the first global analysis and review of current literature  
46 about biocultural approaches to pollinator conservation, drawing on and augmenting work  
47 undertaken for the first IPBES assessment<sup>9</sup>.

48

49 For the first time in any global environmental assessment, the IPBES global pollination assessment  
50 included indigenous and local knowledge (ILK)<sup>b</sup>. This incorporation of ILK focused on the  
51 contributions of pollination and pollinators to two elements of the IPBES Conceptual Framework—  
52 *good quality of life* and *nature's contributions to people*<sup>10</sup>. For this paper, we analyse biocultural  
53 approaches, based on ILK, according to all six elements of the IPBES Conceptual Framework (CF)<sup>5</sup>  
54 (Figure 1). We focus on the knowledge of IPLCs, both groups identified essentially by their (multi-  
55 scalar) linkages with their traditional territories (see Methods, Box 1). Our analysis demonstrates  
56 that practices of IPLCs that are significant for pollinator conservation can be grouped into three  
57 categories: (1) the practice of valuing diversity and fostering biocultural diversity; (2) landscape  
58 management practices; and (3) diversified farming systems. Particular IPLCs may use some or all of  
59 these practices. Seven policies to strengthen these approaches are presented, followed by  
60 concluding comments about implications for future science and policy. Methods for analysis,  
61 literature review and (self)-identification of IPLCs are presented at the end of the article.

## 62 Results of the Analysis

63 All six elements of the IPBES CF are presented in Figure 1(a); and Figure 1 (b) presents the analysis of  
64 IPLCs' biocultural approaches to pollinator conservation into these elements, which includes

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<sup>b</sup> Indigenous and local knowledge is defined here in accordance with Diaz et al. 2015 as "A cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment. It is also referred to by other terms such as, for example, Indigenous, local or traditional knowledge, traditional ecological/environmental knowledge (TEK), farmers' or fishers' knowledge, ethnoscience, indigenous science, folk science."

65 recognition of drivers of unsustainable practices for pollinators which are evident among some  
66 IPLCs. The arrows between the elements reflect influences and interactions<sup>5</sup> which are not further  
67 described here.

68

69 *Figure 1 (a) IPBES Conceptual Framework<sup>5</sup> and (b) analysis of biocultural approaches to pollinator conservation according to*  
70 *this Conceptual Framework*

71

## 72 Pollinators, pollination and good quality of life

73 Pollinators and plant-pollinator interaction networks make vital contributions to IPLCs' quality of life,  
74 in both subsistence and market economies, as part of socio-cultural heritage, identity, and social  
75 relations<sup>11</sup>. Pollinators, primarily bees, and their products, such as honey and wax, provide a direct  
76 source of income, food and medicines. Beekeeping provides a critical anchor for rural economies  
77 because: (1) minimal investment is required; (2) diverse products can be sold; (3) land ownership or  
78 rental is usually not necessary; (4) nutritional and medicinal benefits derive; (5) timing and location  
79 of activities are flexible; and (6) links to ILK and traditions are usually numerous<sup>12</sup>. Recovery of  
80 stingless beekeeping for rural livelihoods, with diverse species and techniques, is currently underway  
81 globally, particularly in tropical America<sup>13</sup>, India, Africa, Central and South America (Figure 2a)<sup>10</sup>.  
82 Honey hunting makes significant contributions to some IPLCs, providing vital sustenance and deep  
83 connections with quality of life (Figure 2b). Examples of contemporary honey-hunters include: the  
84 forest peoples of Indonesia; Ogiek people in Kenya; and Xingu people in Brazil<sup>11</sup>. The collection of  
85 entire bee colonies means that high protein components such as brood, royal jelly and pollen form  
86 important dietary constituents<sup>14</sup>.

87

88 *Figure 2 Global patterns of the contribution of biocultural approaches for pollinators and pollination*  
89 *to quality of life, from studies/sites identified in the analysis: (a) beekeeping; (b) honey hunting; (c)*  
90 *Intangible Cultural Heritage listed as globally significant; (d) Cultural and Mixed Sites inscribed on the*  
91 *World Heritage List (WHL) with significance for pollinators*

92

93 Pollinators' roles in rituals, dances, myths and legends of IPLCs are recognised as globally significant  
94 through inclusions in the Intangible Cultural Heritage of UNESCO (Figure 2c). Examples of Intangible  
95 Cultural Heritage that rely on pollinator-dependent resources include knotted bag-making by forest  
96 peoples of Papua, and barkcloth-making by the Baganda people in Uganda. World Heritage sites that  
97 celebrate pollinators are numerous. The World Heritage List is divided into sites listed for their  
98 cultural heritage; those listed for their natural heritage; and those that have both cultural and  
99 natural heritage, known as "mixed sites". Virtually all natural sites protect pollinators and many  
100 cultural and mixed sites protect and celebrate biocultural linkages between people and pollinators  
101 (Figure 2d). Examples of sites that recognise biocultural approaches include the *Coffee Cultural*  
102 *Landscape of Colombia*, and the *Osun Sacred Grove* protected by Yoruba peoples near Osogbo,  
103 Nigeria. The *Agave Landscape* in Mexico recognizes biocultural interactions with this bat-pollinated  
104 plant used since at least the 16th century to produce tequila spirit, and for at least 2,000 years to  
105 make other fermented drinks, fibre and cloth.

106

### 107 Anthropogenic assets

108 IPLCs develop and use anthropogenic assets, particularly technologies for honey-hunting and  
109 beekeeping<sup>15</sup> (Figure 1b), that underpin the good quality of their lives. Honey hunters manufacture  
110 ladders in Ethiopia<sup>16</sup> and ropes from lianas in India<sup>17</sup> for tree-climbing. In Nepal, the *Apis dorsata*  
111 *laboriosa* honeycombs on cliffs are collected using handmade rope ladders and long sticks known as  
112 tangos<sup>18</sup>. Diverse techniques among IPLCs for construction of bee hives have been reported across  
113 Europe (e.g. tree-trunk hives<sup>19,20</sup>); in Asia (e.g. clay, cow-dung, bamboo, rafter and log hives<sup>21-23</sup>); and  
114 in west, east and north Africa (e.g. hives made from cane lined with leaves, and woven baskets  
115 covered with mud and dung<sup>24-26</sup>). In Meso-America, indigenous peoples use hollow logs and clay pots  
116 to keep stingless bees<sup>13</sup>.

117 In France and Spain, anthropogenic assets include traditional swarming methods, harvest and honey  
118 extraction techniques, and diverse smokers<sup>19</sup>. Pest management technologies include: use of cow  
119 dung (effective against wax moth, wasp, lizard); polythene sheets to protect against lizards and tree  
120 frogs in Nepal and India<sup>27</sup>; and chestnut tree-trunk hives to repel wood parasites in Europe<sup>19</sup>. In  
121 Morocco, hives are smoked with certain plants that inhibit *Varroa* spp. mite and placed near plants  
122 from which bee-produced propolis has mite-inhibiting effects<sup>26</sup>. Bee wax is a vital asset among many  
123 IPLCs, valued for its adherent and hydrophobic properties and used to create non-slip rope, putty,  
124 glue, waterproofing, and in the construction and repair of objects<sup>28</sup>. Examples include its use for  
125 arrow cement in Bolivia; to soften skins, and make jewelry in Africa; and to make hunting tools,  
126 firesticks (*thumpup*) and didgeridoos, a traditional musical instrument, in Australia<sup>10</sup>.

127

### 128 Biocultural pollinator institutions and governance

129 IPLCs' governance and institutional arrangements are central to biocultural approaches to pollinator  
130 conservation (Figure 1b). Governance systems consist of actors (individuals and organisations),  
131 institutions (formal and informal rules and norms) and multi-level interactions (across scales and  
132 between organisations and institutions)<sup>29</sup>. Actors in biocultural governance systems often include  
133 actual pollinators, as IPLCs attribute authority to many spirits who are pollinators, including birds,  
134 bats, butterflies, bees and other insects<sup>10</sup>.

135

136 Customary institutions that assign rights and tenures, and link people to pollinator resources, are  
137 common in biocultural approaches. Trees that have bees nesting on them are often owned and  
138 rights inherited in Indonesia. Land tenure systems are often multi-layered, for example in the  
139 Philippines people can have tenure rights to communal, corporate and individual lands<sup>30</sup>. These  
140 overlapping rights enable access to pollinators and pollination resources with sets of checks to  
141 ensure conservation.

142

143 However, multilevel interactions highlight risks to these biocultural approaches, arising from lack of  
144 recognition of customary tenure and other rights at the nation-state level. Nevertheless, Ogiek  
145 honey-hunters recently won the case [ACHRP vs Republic of Kenya App. No. 006/2012](#) in the African  
146 Court of Human and Peoples' Rights. The judgement recognised their rights to settle in the Mau  
147 forest, their role in protecting it and their right to reparations from the Kenya government for forced

148 evictions<sup>31</sup>. Nation-state level governance influences how and whether the expansion of agriculture  
149 occurs at the expense of pollinators' habitat and NCP<sup>32</sup>. Often the decline of pollinators and the  
150 decline of IPLCs' knowledge and governance systems that contribute to the diverse multi-functional  
151 agriculture that maintains pollinators occurs simultaneously<sup>33</sup>.

152

### 153 Drivers of change

154 Many IPLCs report pollinator and pollination declines associated with expansion of industrial forestry  
155 and agriculture into their traditional lands, driving habitat loss and degradation, and replacing  
156 biodiverse habitat with monocultures<sup>11</sup>. For example, coffee monoculture results in the destruction  
157 of wintering habitat for migratory birds<sup>34</sup> in South America and the reduction of honey in Ethiopia  
158 (Kechifo people) and India (the Kogadu)<sup>16</sup>. Honey hunters in India and Indonesia also note that forest  
159 fires and forest loss cause declines in the arrival of swarms and the following honey extraction<sup>11,35</sup>.  
160 Furthermore, national laws and development projects focused on agricultural production, rural  
161 development and nature conservation have led to breakdown of traditional tenure systems and  
162 fragmentation of governance arrangements that are vital to shifting agriculture and other practices  
163 that protect pollinators, such as in the Bolivian Amazon and the northern Philippines<sup>30,33</sup>. Traditional  
164 farming systems are undervalued relative to commercial, industrial and trade-oriented resource  
165 exploitation of the same spaces, despite the ecosystem services that traditional farming protects.  
166 Poverty leads to out-migration of farmers searching for opportunities elsewhere and erosion of  
167 traditional farming/ecosystem management practices that co-generate landscapes and sustain  
168 biocultural diversity<sup>36</sup>.

169

170 Pesticides have often been seen as the cause of declines in pollinators. Several indigenous  
171 communities have noted a link between pesticide use and declines of colonies and honey in Burkina  
172 Faso, Korea, parts of Brazil, Paraguay, Uruguay, Argentina and India<sup>10</sup>. Pear producers in Hanyuan  
173 County in China have adopted hand-pollination as insect pollinators have disappeared due to the use  
174 of herbicides and pesticides<sup>37</sup>. Invasive species, such as African and European bees, are recognised  
175 by IPLCs in South and Central America as driving declines in native pollinators and their products,  
176 including stingless bee honey<sup>10</sup>.

177

178 Reviews across Mexico, Costa Rica, Brazil, Africa and Asia indicate that stingless beekeeping is  
179 disappearing in some areas<sup>38-40</sup> while stingless bee breeding is increasing in others as a tool for  
180 development<sup>41</sup>. In the Yucatan, the most important populations of species of stingless bees, like  
181 *Melipona beecheii*, are in the hands of Mayan farmers, as large forest trees have disappeared<sup>42</sup>. Loss  
182 and decline of the stingless bees is linked with a loss of traditional knowledge and practices such as  
183 ethnomedicine (use of honey), cosmogony, and handcraft (using cerumen)<sup>10</sup>. Serious and sudden  
184 loss of language and traditional practices of the Ogiek people (Kenya) has resulted from being  
185 excluded from rock- and ground-nesting bees as their traditional forests have become part of Lake  
186 Nakuru National Park<sup>11</sup>.

187

188 Substantial research on ILK has identified its ongoing loss and decline, as well as resilience, as small-  
189 scale societies became more integrated within nation-states and market economies. Losses extend  
190 to declines in knowledge about pollination-related agricultural and management practices, for

191 example of plants that attract pollinators<sup>43</sup>. Amongst Māori, the movement of people away from  
192 communities during the rural-urban migration of the 1950s contributed to the loss of ILK relevant to  
193 pollination<sup>11</sup>. Regrettably, IPLCs in different parts of the world also frequently suffer lack of access to  
194 food, and extreme poverty, which compromises their relationships with ecosystems, and can drive  
195 rapid changes in ecosystem function<sup>11</sup>. Pollinators can themselves become threatened as IPLCs  
196 experience scarcity of wild food resources. For example, large flying foxes (*Pteropus vampyrus*  
197 *natunae*) in Kalimantan, Indonesia, are threatened by over-hunting for food<sup>44</sup>.

198

### 199 Systems of life

200 Anthropogenic and natural drivers of change in turn influence the systems of life on which IPLCs  
201 depend (Figure 1). Biocultural understandings of systems of life recognise humans and their  
202 languages as critical to both co-creating and understanding biodiversity. Language holds culturally  
203 specific knowledge of local biodiversity, ethnobiological knowledge, as well as knowledge about  
204 traditional resource use, management practices and taxonomy. Thus, ethnoscience for ascribing  
205 names to groups of animals and to individual species is prominent across the world. Morphological,  
206 ecological and behavioural characteristics as well as seasonal occurrence are used by IPLCs to classify  
207 different plant and animal species, resulting in unique understandings of the systems of life<sup>45,46</sup>.

208

209 The ILK of bee pollinators' systems of life is particularly deep. For instance, detailed accounts of  
210 names, nests and anatomy of stingless bees can be found in many cultures<sup>10,11</sup>. Stingless bee honey  
211 and cerumen were used as currency, tribute, medicine and in ceremonies in Mesoamerican  
212 civilizations<sup>38</sup>. The people from the Yucatan have specific names in Mayan language for the  
213 seventeen species of stingless bees found in this region of Mexico and of guardian deities for the  
214 bees<sup>38,47</sup>. Accounts of twenty-three named ethnospecies exist among the Hoti people in Venezuela;  
215 twenty-five among the Tatuyo, Siriano and Bara peoples of Colombia; thirteen among the Guarani-  
216 Mbyá people of Argentina, Brazil and Paraguay; around forty-three among Nukak people of  
217 northwest Amazon in Colombia; forty-eight among the Enawenê-Nawê people; and fifty-six among  
218 the Gorotire-Kayapó in the Brazilian Amazon<sup>46,48-51</sup>. Gorotire-Kayapó, as well as many other  
219 indigenous peoples, understand the nest architecture, development and anatomy of stingless bees  
220 in detail<sup>52</sup> (Fig. 3).

221

222

223

224 *Figure 3 Drawings by J.M.F. Camargo<sup>52</sup>, marked with the Kayapó names of the different anatomical*  
225 *structures of a bee (left) and ontogenetic stages of bee development (right). Reproduced with*  
226 *permission.*

227

### 228 Nature's contributions to people

229 Nature's contributions to people (NCP) include all the contributions, both positive and negative, of  
230 nature (i.e. systems of life) to quality of life for people<sup>8</sup>. NCP are created through interactions  
231 between systems of life, anthropogenic assets, and institutions and governance. The NCP approach  
232 explicitly recognises that a range of views exist about the extent to which 'humans' and 'nature' can

233 be separated<sup>8</sup>, and provides both a generalizing perspective with 18 categories of NCP; and a  
234 context-specific perspective that is more typical of IPLCs' approaches. The context-specific  
235 perspective is recognised as potentially producing bundles or groups that follow from distinct lived  
236 experiences such as farming, or hunting and gathering. Our analysis identified three such bundles or  
237 groups that are considered NCP as part of, and ways to foster, biocultural approaches to pollinator  
238 conservation: (1) the practice of valuing diversity and fostering biocultural diversity; (2) landscape  
239 management practices; and (3) diversified farming systems.

240

241 The practice of valuing diversity in itself is a key aspect of ILK<sup>53</sup>. Many IPLCs favour heterogeneity in  
242 land-use as well as in their gardens, tend to the conservation of nesting trees and flowering  
243 resources for bees, butterflies and other pollinators, name and classify a great range of wild bees,  
244 observe their habitat and food preferences. Through these activities they contribute to maintaining,  
245 fostering and co-creating an abundance and, even more importantly, a wide diversity of bee and  
246 other pollinators and animal pollination-dependent biota<sup>9,10</sup>.

247

248 Seven landscape management practices identified as part of, and ways to foster, NCP occur through  
249 much of the world, and particularly the tropics. These practices include: (1) actions to foster  
250 pollinator nesting resources including in houses, forests and landscapes; (2) mental maps and animal  
251 behaviour knowledge related to pollinators and their resources; (3) totemic and/or spiritual  
252 relationships between people and pollinators, requiring kinship obligations of reciprocity, respect  
253 and care with pollinators and their habitat; (4) taboos and traditions that protect pollinator habitat,  
254 including prohibitions against felling bee-hive trees and forest patches; (5) manipulation of pollinator  
255 resources in landscapes, including through seasonal rotations for prolonged harvests and habitat  
256 patch management; (6) use of biotemporal indicators (observed changes in biological processes over  
257 time) to trigger management of pollinators and pollinator resources, including using birds and  
258 flowering to signal the time for burning vegetation and to harvest honey; and (7) management of  
259 fire to stimulate pollinator resources by increasing floral resources<sup>10</sup> (Figure 4a, b).

260

261

262

263 *Figure 4 Landscape management practices (a and b) and diversified farming systems (c and d),*  
264 *based on Indigenous and Local Knowledge (ILK), that are part of and foster pollinators' roles in*  
265 *Nature's Contributions to People (NCP)*

266

267 Three types of diversified farming systems based on ILK, scattered across the globe, were identified  
268 as part of, and ways to foster NCP (Figure 3 c and d). Evidence is accumulating that commodity  
269 agroforestry, practiced by IPLCs and resulting in a landscape matrix of fragments of high-biodiversity  
270 native vegetation amidst the agricultural crop, both produces food and maintains pollination  
271 services<sup>54</sup>. Home Gardens, capitalised to distinguish those characterised by producing a wide  
272 diversity of foods and medicinal plants, display complexity and multi-functionality, and provide  
273 habitat for a great diversity of pollinators<sup>55</sup>. Shifting cultivation (seasonal rotation of crops, trees,  
274 animals and intercropping) demonstrates diverse interdependencies with pollinators and remains  
275 important in many regions, particularly through the tropical world<sup>56</sup>. The traditional Mayan Milpa



276 shifting cultivation produces a patchy landscape with forests in different stages of succession with a  
277 diverse array of plants, nearly all of which are pollinated by insects, birds and bats<sup>57</sup>. Some of these  
278 relationships between pollinators and IPLCs have been recognized and protected as Globally  
279 Important Agricultural Heritage Systems (GIAHS) (Figure 3d).  
280

## 281 Seven policies to support biocultural approaches to pollinator 282 conservation

283 IPLCs across the globe continue to practice many successful biocultural approaches to pollinator  
284 conservation. Seven policies are identified that will strengthen biocultural approaches *in-situ*, as a  
285 useful adjunct to the “principles of biocultural approaches to conservation” that provide guidance  
286 for conservation *interventions*<sup>4</sup>. These policies are: (1) requiring prior informed consent for  
287 conservation and development; (2) securing customary tenures; (3) strengthening Indigenous and  
288 Community Conserved Areas (ICCAs) and other traditional governance that support pollinators; (4)  
289 supporting knowledge co-production; (5) promoting heritage listing; (6) fostering livelihoods based  
290 on bee-keeping; and (7) promoting food sovereignty.

291  
292 International law supports requiring prior informed consent for conservation and development  
293 projects<sup>58</sup>, and similar requirements in some nation-state legislation have protected pollinators. For  
294 example, the *Forest Rights Act* in India has secured access to forests by honey hunters, and kept  
295 alive their ILK and practices for fostering bees<sup>35</sup>. Indigenous Protected Areas in Australia required  
296 prior informed consent for their creation, and have protected culturally-significant pollination-  
297 dependent fruit, their bird and bat pollinators, and their habitats<sup>10</sup>.

298  
299 Securing customary tenures has proven effective in combating the erosion of traditional  
300 management practices that protect pollinators and their habitats. For example, a study of 80 forest  
301 commons in 10 countries across Asia, Africa, and Latin America showed that larger forest size and  
302 greater rule-making autonomy at the local level produces high carbon storage in trees, thereby  
303 protecting the flowers of those trees for pollinators and presumably also the pollinators<sup>59</sup>.  
304 Nevertheless, legal means of securing customary tenures need to fully respect the local customary  
305 institutions—some legal regimes have imposed a new set of external agents that have been  
306 detrimental to social and cultural values<sup>60</sup>.

307  
308 Strengthening ICCAs is a critical policy agenda that is gaining momentum through the program of  
309 work on protected areas under the *Convention on Biological Diversity*. ICCAs consist of social-  
310 ecological systems voluntarily conserved by IPLCs through customary laws and traditions. Such areas  
311 range in size from <1 ha sacred groves in India to >30,000 km<sup>2</sup> indigenous territories in Brazil, and  
312 are associated with the protection of links between biodiversity and wildlife that ensure  
313 pollination<sup>61</sup>. Governance evaluation provides a means to identify key actions to strengthen the  
314 traditional governance arrangements (councils of elders, clan or tribal chiefs, village assemblies) that  
315 protect pollinators.

316

317 Supporting knowledge co-production activities among farmers, indigenous peoples and scientists  
318 has led to numerous improvements in livelihoods and in turn helped to preserve pollinators. For  
319 example, community ethno-entomological collections empower traditional knowledge of the  
320 difference between insects, and their habitats, of how to foster resources for pollinators, and  
321 thereby build synergies with science and ILK<sup>62</sup>. Participatory evaluation of pollinator-friendly farming  
322 practices has been used by the Food and Agricultural Organisation of the United Nations (FAO) as an  
323 effective framework for co-producing knowledge between scientists and farmers<sup>63</sup>. Biocultural  
324 approaches to monitoring that create space for meaningful local metrics, while supporting cross-  
325 scale linkages with scientific indicators of status and trends in pollinators, are critical to long term  
326 evaluation and adaptive management by IPLCs<sup>2</sup>.

327

328 Promoting heritage listing—using international instruments including the *Convention Concerning the*  
329 *Protection of the World Cultural and Natural Heritage*, the *Convention for the Safeguarding of the*  
330 *Intangible Cultural Heritage*, and the *Globally Important Agricultural Heritage Systems*—can bring  
331 global support for biocultural approaches to pollinator conservation. The *Intangible Cultural*  
332 *Heritage List* promotes understanding of practices which are listed—for example the protection of  
333 traditional knowledge of Totanac people, which includes agroforestry systems that protect  
334 pollinators and stingless beekeeping. World Heritage listing brings international attention to  
335 situations and drivers that threaten the sites listed, and their important natural and cultural  
336 attributes.

337

338 Fostering livelihoods based on beekeeping can overcome many barriers to effective pollinator  
339 protection when they are able to link: (1) customary economies (that require ongoing protection of  
340 pollinators); (2) markets (that give these products economic significance); and (3) investments from  
341 government in accompanying research, market analysis and brokering<sup>11</sup>. Many beekeeping activities  
342 are important in both customary and market economies, and benefit from government investments  
343 in scientific research and brokering, to ensure that negative impacts—such as high densities of hives  
344 resulting in the honeybees outcompeting wild pollinators—are avoided<sup>11</sup>. Certification of organic  
345 production, for example, links beekeepers with customers in developed nations prepared to pay for  
346 high-value product, and has strengthened ILK and improved incomes for beekeepers in Cameroon<sup>64</sup>.

347

348 Promoting food sovereignty helps pollination protection because of its connection with diversified  
349 farming systems and management practices that foster diversity and abundance of pollinators and  
350 pollination resources<sup>65</sup>. Food sovereignty reorients food systems around local production and agro-  
351 ecological principles, mitigating several of the key risks to pollinators such as landscape  
352 homogenisation and the negative impact of agrochemicals, often associated with the expansion of  
353 industrial agriculture<sup>66</sup>. With its emphasis on local food systems, food sovereignty provides an  
354 effective policy framework for strengthening the diversified farming systems that protect pollinators  
355 and pollination (Figure 4).

## 356 Conclusion

357

358 Pollinators and pollination have become worldwide heritage and IPLCs' have ancient and recent  
359 associations with these organisms, creating rich and unique biocultural manifestations. Different  
360 stressors are threatening pollinators and pollination but IPLCs can significantly contribute to  
361 maintain pollinators' biodiversity and the derived NCP. The contributions of IPLCs are therefore  
362 essential to decision-making and actions for the preservation of these key ecological resources. We  
363 consider that the suggested seven policies will strengthen vital ILK while providing ongoing  
364 opportunities for education, development and empowerment of the wellbeing of IPLCs and mutual  
365 benefits with broader societies. Respecting and recognising IPLCs' rights over natural resources are  
366 essential for long term pollinator conservation. Local community-driven conservation initiatives can  
367 be successful and should be encouraged.

368

369 Further efforts are needed to promote and increase the exchange and integration of knowledge on  
370 pollinators and pollination between the scientific world and IPLCs working towards common  
371 conservation goals. We conclude that pollination and pollinators can be better preserved by  
372 acknowledging IPLCs and working together between ILK and science for sustainable ecosystem  
373 governance and management in this time of rapid global change.

## 374 Methods

375 Indigenous and local knowledge (ILK) held by IPLCs is integral to biocultural approaches to  
376 conservation<sup>2,4,5</sup>. Key features for embedding ILK in conservation include IPLCs' customary  
377 institutions and practices, and engagement of ILK actors<sup>67</sup>. While the IPBES global pollination  
378 assessment did not fully succeed in achieving such engagement, as knowledge-holders and their  
379 institutions were not involved in the latter parts of the assessment, several methods, including  
380 global and community dialogues in the early phases and tailored literature analyses, ensured a high-  
381 degree of rigour in our approach to working with ILK<sup>67</sup>.

382

383 An initial review of scientific literature was conducted using a systematic protocol (searching English,  
384 Spanish and French literature) with four subsequent steps to enable incorporation and analysis of  
385 ILK<sup>10</sup>. First, a global call was issued for indigenous and local knowledge holders from IPLCs and  
386 experts who wished to contribute information relevant to pollinators and pollination, to participate  
387 in global and community dialogues. Our work respects the recognition by the United Nations that no  
388 formal definition of whom are indigenous peoples and/or local communities is needed—self-  
389 identification is the key requirement (Box 1). Indigenous peoples and local communities, IPLCs,  
390 display great diversity in their ways of life, including hunter-gathers who practice no recognizable  
391 forms of agriculture (but may intensify the populations of some plants and animals); those who  
392 modify landscapes for example through use of fire; those who rely on farming domesticated plants  
393 and animals; and those who practice diverse combinations of farming, hunting, gathering and  
394 managing their landscapes to provide food resources.

395

### 396 **Box 1: Who are indigenous peoples and local communities (IPLCs)?**

397 Indigenous peoples include communities, tribal groups and nations, who self-identify as  
398 indigenous to the territories they occupy, and whose organisation is based fully or partially  
399 on their own customs, traditions, and laws. Indigenous peoples have historical continuity

400 with societies present at the time of conquest or colonisation by peoples with whom they  
401 now often share their territories. Indigenous peoples consider themselves distinct from other  
402 sectors of the societies now prevailing on all or part of their territories. The United Nations  
403 recognizes that no formal definition of whom are indigenous peoples and/or local  
404 communities is needed—self-identification is the key requirement.

405 Local communities are groups of people living together in a common territory, where they  
406 are likely to have face-to-face encounters and/or mutual influences in their daily lives. These  
407 interactions usually involve aspects of livelihoods—such as managing natural resources held  
408 as ‘commons’, sharing knowledge, practices and culture. Local communities may be settled  
409 together or they may be mobile according to seasons and customary practices. Communities  
410 who come together in urban or peri-urban settings around common interests, such as  
411 beekeeping, are considered here to be “communities of interest” rather than local  
412 communities<sup>10</sup>.

413  
414 The resultant global and community dialogues provided much-needed information and guidance,  
415 and were supplemented by an ILK scoping literature review<sup>11</sup>. Second, an analytical framework was  
416 co-developed between ILK-holders and experts to guide the project. Third, literature was prioritised  
417 where evidence showed a direct role for ILK holders in representing and validating their own  
418 knowledge. A more extensive list of the literature sources can be found online in Chapter 5 of  
419 [Pollinators, pollination and food production: a global assessment](#)  
420 (<https://www.ipbes.net/assessment-reports/pollinators>). Fourth, spatial analysis was undertaken to  
421 locate the various national and regional data syntheses and site-specific examples in relation to the  
422 themes in the analytical framework. The final steps to enable this analysis involved firstly updating  
423 the review with publications since 2015 (the cut-off date for the IPBES pollination report), and  
424 heritage sites and elements listed in 2016-17; and secondly re-analysing the data gathered through  
425 the dialogues<sup>11</sup> and literature to respond to all elements of the IPBES CF.

## 426 Data availability

427 Data for Figures 2 and 4 can be found at <https://doi.org/10.25919/5c3d14a45ec49>. Several files are  
428 available for download, including the spatial data for all the locations on the maps, and the literature  
429 or online sources for each of these locations. Data which link the literature/online sources to the  
430 locations are also available upon request to the corresponding author, with a brief explanation of  
431 why the data is required. These restrictions are in place to protect the privacy of the indigenous  
432 peoples and local communities. Source data for Figures 1 and 3 are shown on the captions.

433

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435 Correspondence and requests for materials should be address to R.H. [ro.hill@csiro.au](mailto:ro.hill@csiro.au)

436

## 437 Acknowledgements

438 We thank the indigenous peoples and local communities globally who provided their knowledge of  
439 practices and philosophies underpinning conservation of pollinators and pollination to the hundreds

440 of publications that we reviewed for this article. Their contributions to the sustainable use and  
441 conservation of biocultural diversity over millennia benefits many peoples globally, and we are  
442 deeply grateful. We particularly thank those IPLCs and their partners who participated directly in  
443 global and community dialogues about pollination for the IPBES assessment of Pollinators and  
444 Pollination in Food Production. Hien Ngo of the IPBES Secretariat and Douglas Nakashima and his  
445 team from UNESCO provided wonderful support to these dialogues. We also acknowledge the fine  
446 efforts of IPBES to work with ILK in their assessments and their commitments to recognise and  
447 respect the roles of IPLCs. We thank IPBES for the opportunity to be involved in the assessment that  
448 enabled our team of co-authors to meet one-another and subsequently progress this paper. Each of  
449 us would also like to acknowledge and thank our organisations which supported our contributions to  
450 this paper. L.V.D. is funded by the Natural Environment Research Council NERC (NE/N014472/1).  
451 R.H. is supported through CSIRO Land and Water's Indigenous Futures initiative. We also thank two  
452 anonymous referees whose helpful comments improved the paper. We would like to thank Giselle  
453 Cristina Aragão of Empresa Brasileira de Pesquisa Agropecuária (Embrapa) and Jacqui Smith of  
454 WhiteSpace Design Studio, for their contributions to Figures 1 and 2, 3, 4 respectively.

## 455 Author Contributions

456 R.H., G.N-P and J.J.G.Q-E coordinated the conceptual design, and together with D.B., G.L., M.M.M.,  
457 drafted the text of the manuscript. P.L.P. undertook the spatial analysis and prepared the maps, with  
458 assistance from R.H. and L.G. in data preparation. All 21 authors contributed to the ideas, evaluation  
459 of the literature, review and finalization of the text.

## 460 Competing Interests

461 The authors declare no competing interests.

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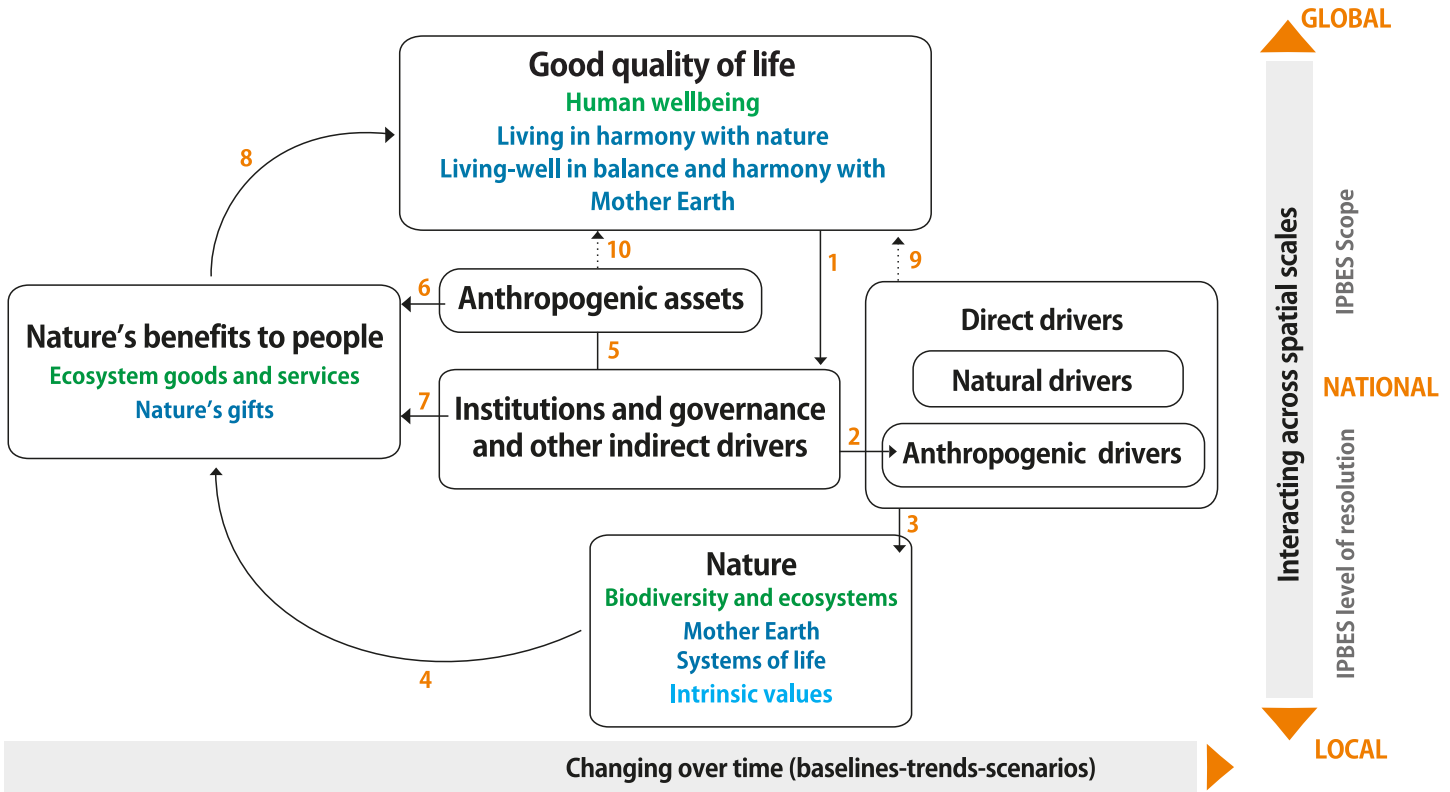
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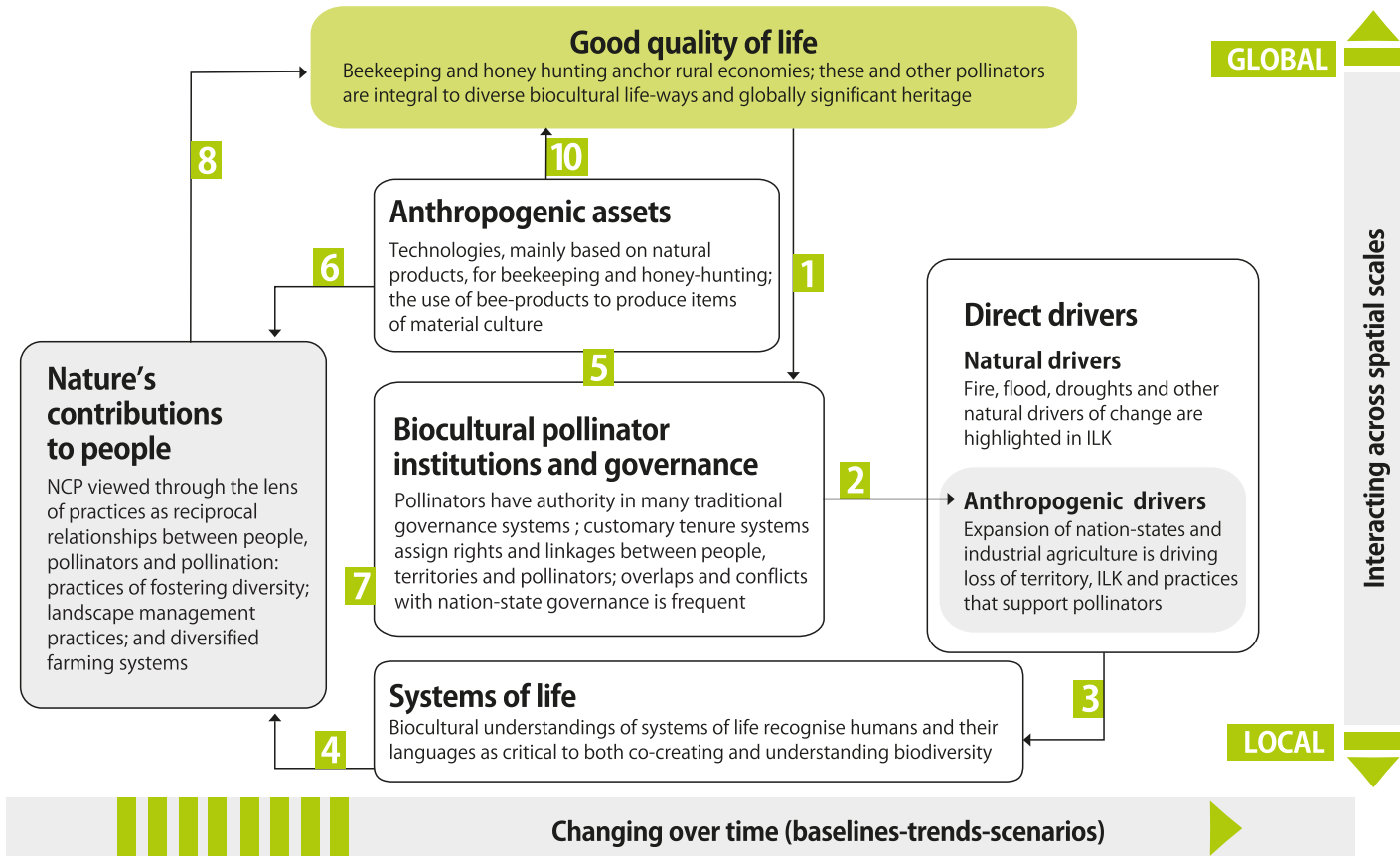


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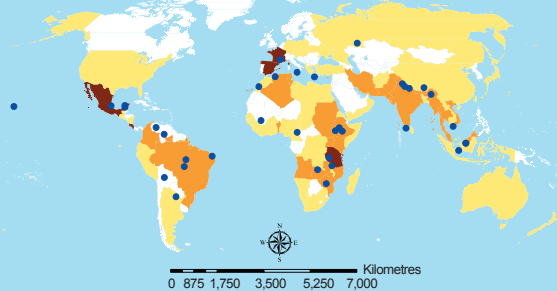
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a



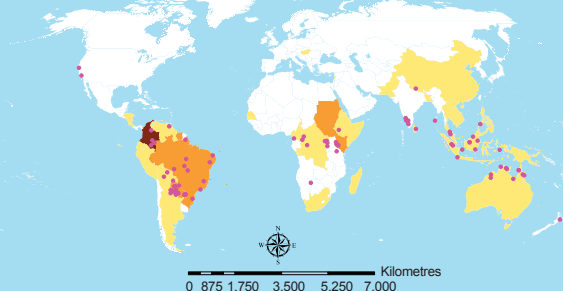
### Beekeeping based on indigenous and/or local knowledge

National compilations of information - number of studies in the analysis

■ 1 ■ 2 ■ 3 or more

● Regional/local information - sites identified in the analysis

b



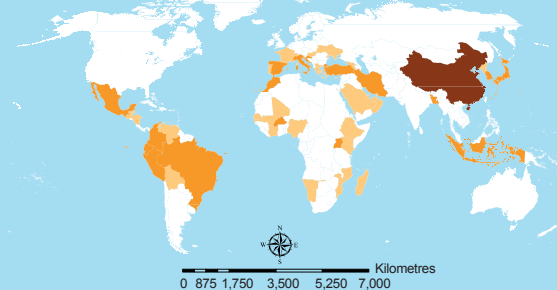
### Honey hunting based on indigenous and/or local knowledge

National compilations of information - number of studies in the analysis

■ 1 ■ 2 ■ 3 or more

● Regional/local information - sites identified in the analysis

c

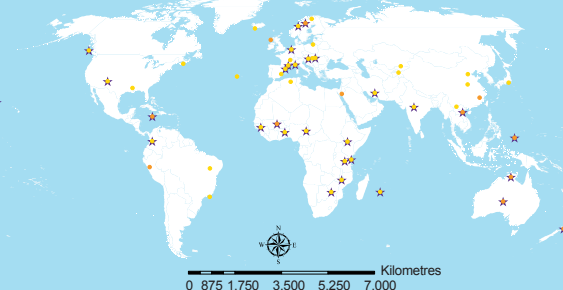


### List of the Intangible Cultural Heritage of Humanity - countries with elements inscribed that celebrate and/or are dependent on pollinators and pollinator products

Number of elements inscribed

■ 1 ■ 2 - 5 ■ 6 or more

d

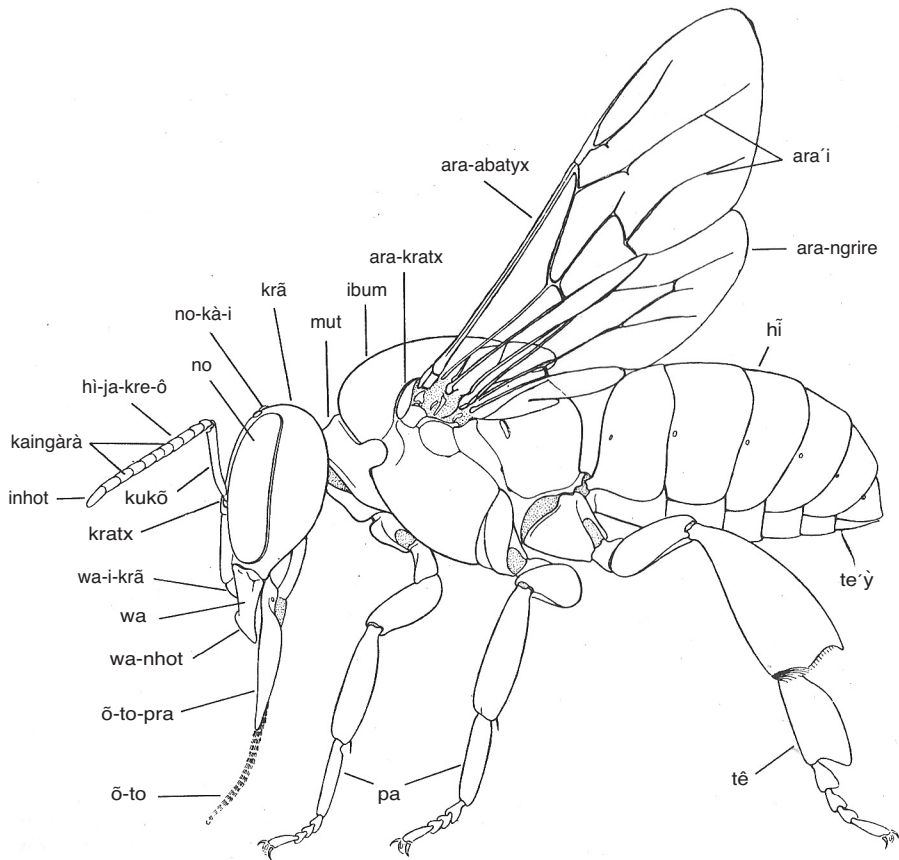


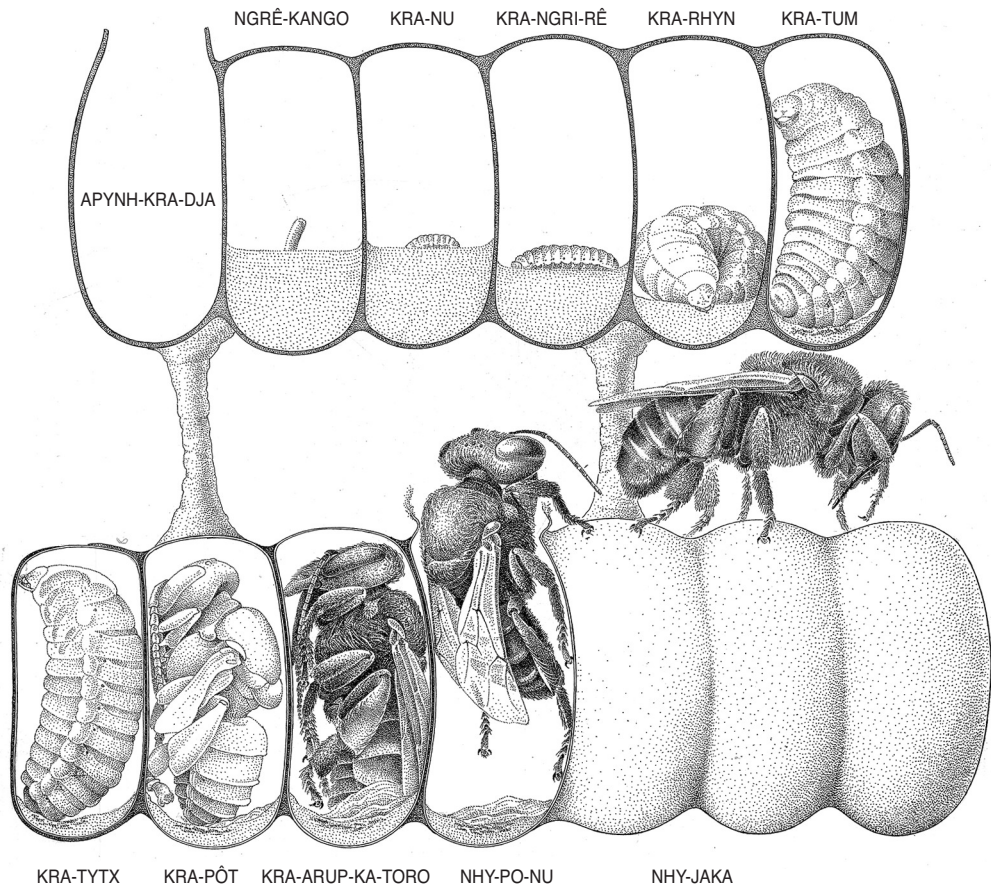
### World Heritage List - sites inscribed that celebrate (through rock art) and/or protect pollinators and pollinator habitat

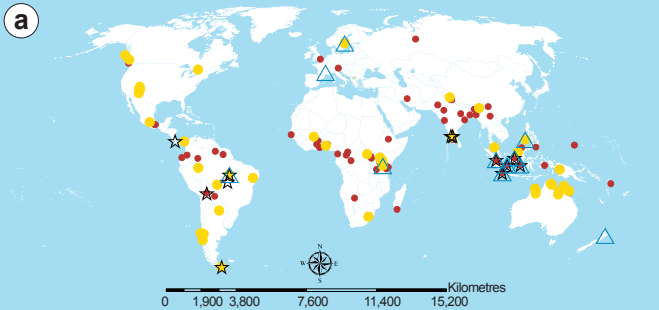
● World Heritage - Mixed Sites

● World Heritage - Cultural Sites

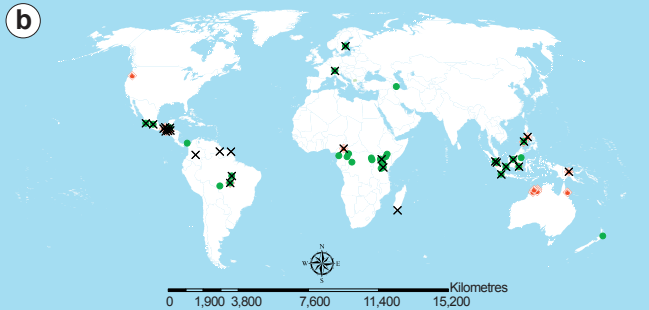
) Recognises the roles of indigenous peoples and/or local communities



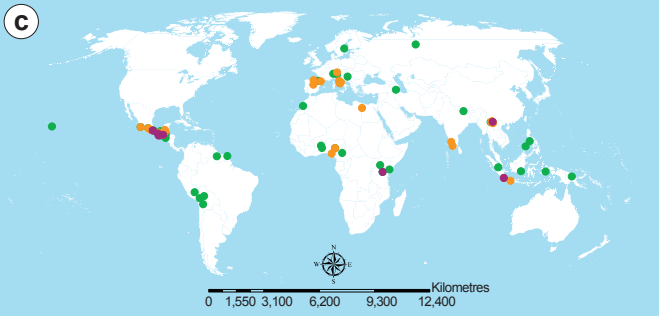




- S Actions to foster pollinator nesting resources
- \* Mental maps of pollinators and pollinator resources
- Totemic and/or spiritual relationships between people and pollinators
- Taboos and traditions that protect pollinator habitat

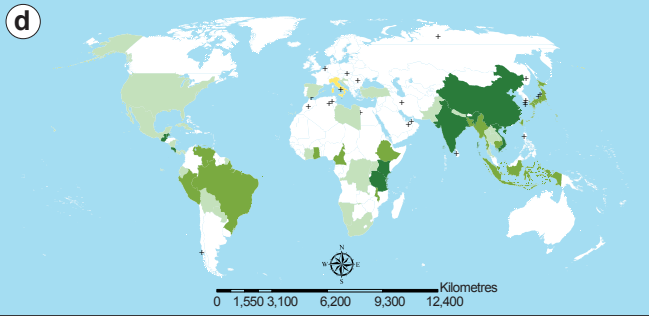


- × Manipulation of pollinator resources in the landscape
- Use of biotemporal indicators to trigger management of pollinators and/or their resources
- ◆ Fire to stimulate pollinator resources



**Sites of diversified farming systems identified in the analysis**

- Commodity agroforestry that fosters pollinators and pollinator resources (e.g. shade coffee)
- Home gardens that foster pollinators and pollinator resources
- Shifting cultivation (seasonal rotation of crops, trees, animals and intercropping) that fosters pollination and pollinator resources



★ Globally Important Agricultural Heritage Systems – listed site of agricultural practices that foster pollinators and pollinator resource

**Diversified farming systems - number of national compilations of evidence identified in the analysis**

- 1
- 2
- 3 or more