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1 **Why cultural ecosystem services matter most: Exploring the pathways**
2 **linking greenspaces and mental health in a low-income country**
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AIM

What are the pathways linking greenspaces to mental health in urban low-income settings?

METHODS

Participatory video
Focus groups (n=20)
Policy document analysis



Q-methodology (n=40)
• Q-sort, informed by PV and focus groups

SETTING



Greenspaces

RESULTS

Pathways

Mental health



- Reducing exposure to air pollution and heat
- Attention restoration and stress reduction
- Encouraging physical activity, facilitating social cohesion and child development
- Human - wildlife conflict, gender discrimination



CONCLUSIONS

Greenspaces can reduce the burden of mental ill-health in low-income settings through a variety of pathways and the provision of cultural ecosystem services

Highlights

- Entirely novel, interdisciplinary approach to capture the views of urban residents
- Greenspaces are linked to mental health through a variety of pathways in LMICs
- Cultural ecosystem services are pivotal for reducing the burden of mental ill-health
- Cultural ecosystem services play larger role for mental health than presumed
- Increasing access to greenspaces may address current health inequalities in LMICs

1 **Why cultural ecosystem services matter most: Exploring the pathways**

2 **linking greenspaces and mental health in a low-income country**

3

4 **Abstract**

5 Exposure to urban greenspaces promotes a variety of mental health benefits. However, much
6 of the evidence for these benefits is biased towards high-income countries. In contrast, urban
7 areas in low-income settings that have the highest rates of urbanisation remain understudied.
8 Given the increasing burden of mental ill-health associated with urbanisation in low- and mid-
9 dle-income countries (LMICs), there is a clear need to better understand the role urban green-
10 spaces play in mitigating mental ill-health. Here we use a novel combination of research meth-
11 ods (participatory video, focus groups and the Q-methodology) in a rapidly urbanising low-
12 income city (Kathmandu, Nepal). We explored residents' perspectives on ecosystem services,
13 and the pathways linking greenspaces to mental health. Residents indicated that greenspaces
14 are linked to mental health through pathways such as reducing harm (exposure to air pollution
15 and heat), restoring capacities (attention restoration and stress reduction), building capacities
16 (encouraging physical activity, fostering social cohesion and child development) and causing
17 harm (human – wildlife conflicts, gender discrimination). It is likely that a combination of such
18 pathways triggers mental health impacts. Of all ecosystem services, cultural services were val-
19 ued most strongly. Contact with urban greenspaces and the cultural ecosystem services they
20 provide are a fundamental basic need which all people, including low-income residents, depend
21 on to participate meaningfully in their society. Greenspaces can therefore play a pivotal role in
22 reducing the burden of mental ill-health for low-income residents in LMICs through a variety
23 of pathways, as well as through the provision of cultural ecosystem services. Greater efforts to
24 increase the quantity, quality and access to greenspaces in urban low-income settings may
25 therefore help addressing current health inequalities in LMICs.

26

27 **Keywords**

28 Global South, mental disorders, biodiversity, natural environment, participatory video, Q-
29 methodology

30 **Highlights**

- 31 • Entirely novel, interdisciplinary approach to capture the views of urban residents
- 32 • Greenspaces are linked to mental health through a variety of pathways in LMICs
- 33 • Cultural ecosystem services are pivotal for reducing the burden of mental ill-health
- 34 • Cultural ecosystem services play larger role for mental health than presumed
- 35 • Increasing access to greenspaces may address current health inequalities in LMICs

36 **1. Introduction**

37 Globally, mental health problems pose a serious threat to public health. The proportion of the
38 global burden of disease attributable to mental disorders is rising and has been estimated to
39 account for 32% of disability-adjusted life years (Vigo et al., 2016). Affecting more than one
40 billion people globally (Rehm and Shield, 2019), the burden of mental ill-health is increasing
41 particularly in rapidly urbanising cities in low- and middle-income countries (LMICs), where
42 lifestyle changes associated with urban living increase risks for mental ill-health (Rathod et al.,
43 2017).

44 The transition to urban living in LMICs is profoundly transforming the way people live, with
45 potentially serious consequences for their mental health (Cox et al., 2018). Cities promote men-
46 tal health through providing access to employment, education and health services (Dye, 2008).
47 However, several risk factors for mental ill-health are associated with urban living including
48 reduced levels of physical activity (Sallis et al., 2016), high levels of social stressors such as
49 social isolation, violence, and poverty (Vlahov and Galea, 2002) and characteristics of the ur-
50 ban environment such as crowding, air and noise pollution and other stressful urban conditions
51 (Hartig et al., 2014). Mental health is affected by a variety of factors including social, eco-
52 nomic, psychological, physiological, behavioural, genetic, cultural and environmental factors
53 (Meyer-Lindenberg, 2014). Given that 66% of the global population is predicted to live in cities
54 by 2050 (United Nations, 2014), there is a pressing need to understand the determinants of
55 mental health of urban populations.

56 Due to urbanisation, urban populations in LMICs are spending less time exposed to natural
57 environments such as greenspaces (Pearson and Craig, 2014). This may be problematic, be-
58 cause research has demonstrated that greenspaces play an important role for the mental health
59 of urban populations (Lovell and Maxwell, 2018). For instance, greenspaces may reduce the
60 prevalence of depressive disorders (Roberts et al., 2019) and anxiety disorders (Gascon et al.,
61 2018), and improve indicators of positive mental health such as increased quality of life
62 (Stigsdotter et al., 2010) and life satisfaction (White et al., 2013). Adding to this, four out of
63 five people with severe mental illness in LMICs do not receive effective treatment (Luitel et
64 al., 2015), and the prevalence and costs associated with treating poor mental health are expand-
65 ing worldwide (WHO, 2014).

66

67 While the mental health benefits provided by urban greenspaces are increasingly well under-
68 stood (Lovell and Maxwell, 2018), much of the evidence is biased towards temperate, high-
69 income countries (HICs) (Nawrath et al., 2020). Although there is evidence to suggest that
70 greenspaces can support mental health outcomes in upper-middle-income countries, the urban
71 areas with the highest rates of urbanisation remain critically understudied (Nawrath et al.,
72 2020). It cannot be assumed that findings from HICs appropriately represent the diversity of
73 urban living conditions in rapidly urbanising cities in LMICs (United Nations, 2015). Associ-
74 ations in low-income cities may differ for several reasons.

75

76 Many cities in LMICs are characterised by informal settlements and slums (United Nations,
77 2014), which therefore are a dominant type of settlement in many cities in these areas (United
78 Nations, 2015). The importance of understanding how greenspaces can promote the mental
79 health of residents in informal settlements and slums is underlined by the fact that by 2050, up
80 to three billion people may be living in such environments (Nagendra, 2018). To date, the few
81 studies with focus on informal settlements and slums showed inconsistent or even negative
82 links between greenspaces and mental health (Nawrath et al., 2020).

83

84 Adding to this, much uncertainty remains about the importance of the specific pathways and
85 their relative contributions to mental health (Marselle et al., 2020). This is particularly true in
86 urbanising low-income settings, where locally relevant environmental and cultural settings are
87 often markedly different from cities in HICs, where most of the evidence originates from. For
88 instance, how people interact with greenspaces depends on local cultural norms, which arise
89 and reflect a society's relationship with the natural environment (Selin, 2003). What's more,
90 emotions and life satisfaction are correlated stronger in individualistic societies such as in
91 Western Europe or North America, as opposed to more collectivistic societies such as in many
92 LMICs (Suh et al., 1998). This could mean that positive emotions elicited by greenspaces may
93 impact on mental health differently in many LMICs. Adding to this, psychological and social
94 processes exist in changing historical and cultural contexts (Bratman et al., 2019). This indi-
95 cates that taking into account cultural norms is crucial when assessing the relationship between
96 greenspaces and mental health, especially since there is a dearth of research exploring the path-
97 ways linking greenspaces and mental health in LMICs.

98

99 The benefits of greenspaces may be valued differently across individuals due to socioeconomic
100 factors including gender, age, occupation and personality traits or neighbourhood characteris-
101 tics including residential location (Astell-Burt et al., 2013). We acknowledge that the strength
102 and direction of associations, and the composition of pathways linking greenspaces to mental
103 health, may depend on these factors (Marselle et al., 2020). For instance, gender differences in
104 the mental health effects of greenspaces have been observed (Richardson and Mitchell, 2010).
105 Adding to this, there is evidence from HICs to suggest that the health benefits of urban green-
106 spaces are strongest for deprived communities (McEachan et al., 2016). Furthermore, low-in-
107 come residents in informal settlements and slums may experience barriers to greenspaces use,
108 thereby exacerbating health inequalities (Cronin-de-Chavez et al., 2019).

109

110 Thus far, there is a lack of understanding of the links between greenspaces and mental health
111 in low-income country settings. To explore the perceptions of the pathways linking green-
112 spaces to mental health in a rapidly low-income city, we used a novel combination of research
113 methods including participatory video, focus groups and the Q-methodology. In particular, we
114 address the following questions: (1) what are the perceptions residents of a low-income city
115 hold on the pathways linking greenspaces and mental health; (2) what are the contrasting view-
116 points on ecosystem services and disservices provided by urban greenspaces held by residents
117 of a low-income city?

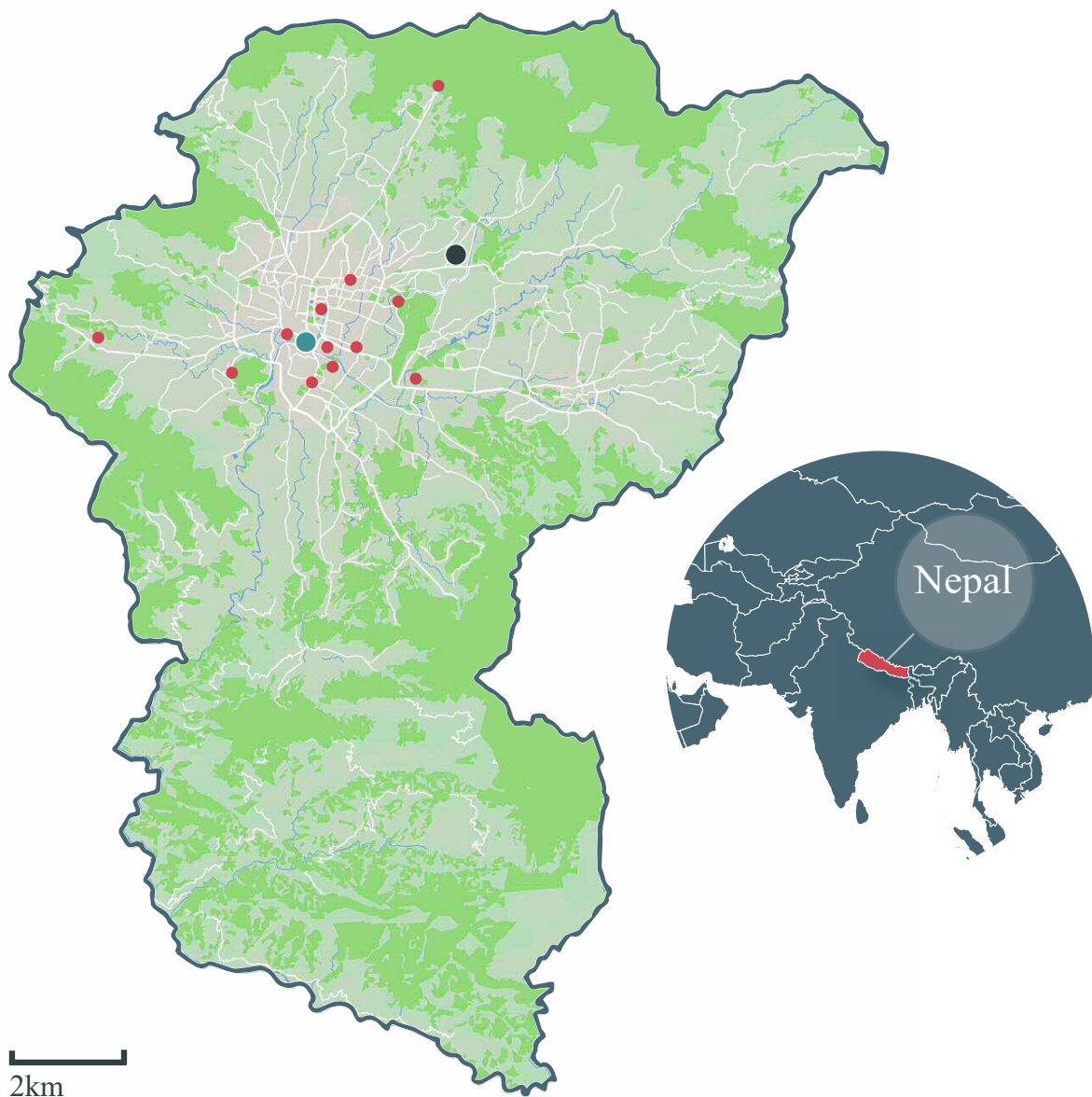
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119 2. Methods

120 2.1. Setting

121 Data was collected in Kathmandu, Nepal, which is a low-income country with the highest urban
122 growth rate in South Asia at around 6.5% annually (Lamichhane and Thapa, 2012). However,
123 the majority (83%) of the population still lives in rural areas (Kohrt et al., 2016). Kathmandu
124 has experienced significant growth and land use and land cover change over the last 30 years,
125 and its population of around one million in 2011 (Central Bureau of Statistics Nepal, 2011) is
126 predicted to double by 2030 (Ishtiaque et al., 2017). This trend has created unprecedented pres-
127 sure on Kathmandu spurring various environmental problems such as high levels of air and
128 noise pollution, and loss of urban greenspace (Haack, 2009; Thapa and Murayama, 2009). Most
129 of the in-migrant populations live in slums located in the core city, primarily on the banks of
130 the Bagmati and Bishnumati rivers (CARE Nepal, 2008). Such settlements are characterised
131 by a lack of security of tenure, and inadequate access to basic services and city infrastructure
132 (United Nations, 2015). Informal settlements and slums are often situated in geographically
133 and environmentally hazardous areas (Subbaraman et al., 2014). Slum dwellers' living condi-
134 tions are poor, with little or no access to basic services, and suffer from poorer mental health
135 than their affluent counterparts (CARE Nepal, 2008). Around 81 percent of the Nepalese pop-
136 ulation reported their religion as Hindu, while Buddhism and a few other local faiths play an
137 important role as well (Bennet et al., 2008). Independent from the religion people adhere to, all
138 Nepalis are socially defined by the cast system, which is a major determinant of their identity,
139 social status and life chances (Bennet et al., 2008). Nepal can be characterised as a collectivistic
140 society. High cultural value is assigned to family and familial relationships are typically
141 marked by high levels of responsibility and obligations (Amiya et al., 2014). The level of gen-
142 der inequality is high in Nepal. Women face discrimination on multiple levels by virtue of their
143 sex, caste, and ethnicity (Lundgren et al., 2013). Data were collected in August and September
144 2019 in a variety of locations in Kathmandu (Fig. 1).

Kathmandu



Legend

- Participatory video group Bansighat
- Q-sort interview sites
- Participatory video group Jorpati
- Greenspace
- Built-up area

145 Fig.1: Study sites of participatory video and Q-sort interviews in Kathmandu, Nepal. The map shows
146 the administrative boundaries of the Kathmandu agglomeration including Kathmandu, Lalitpur and
147 Bhaktapur districts.
148

149 **2.2. Study design**

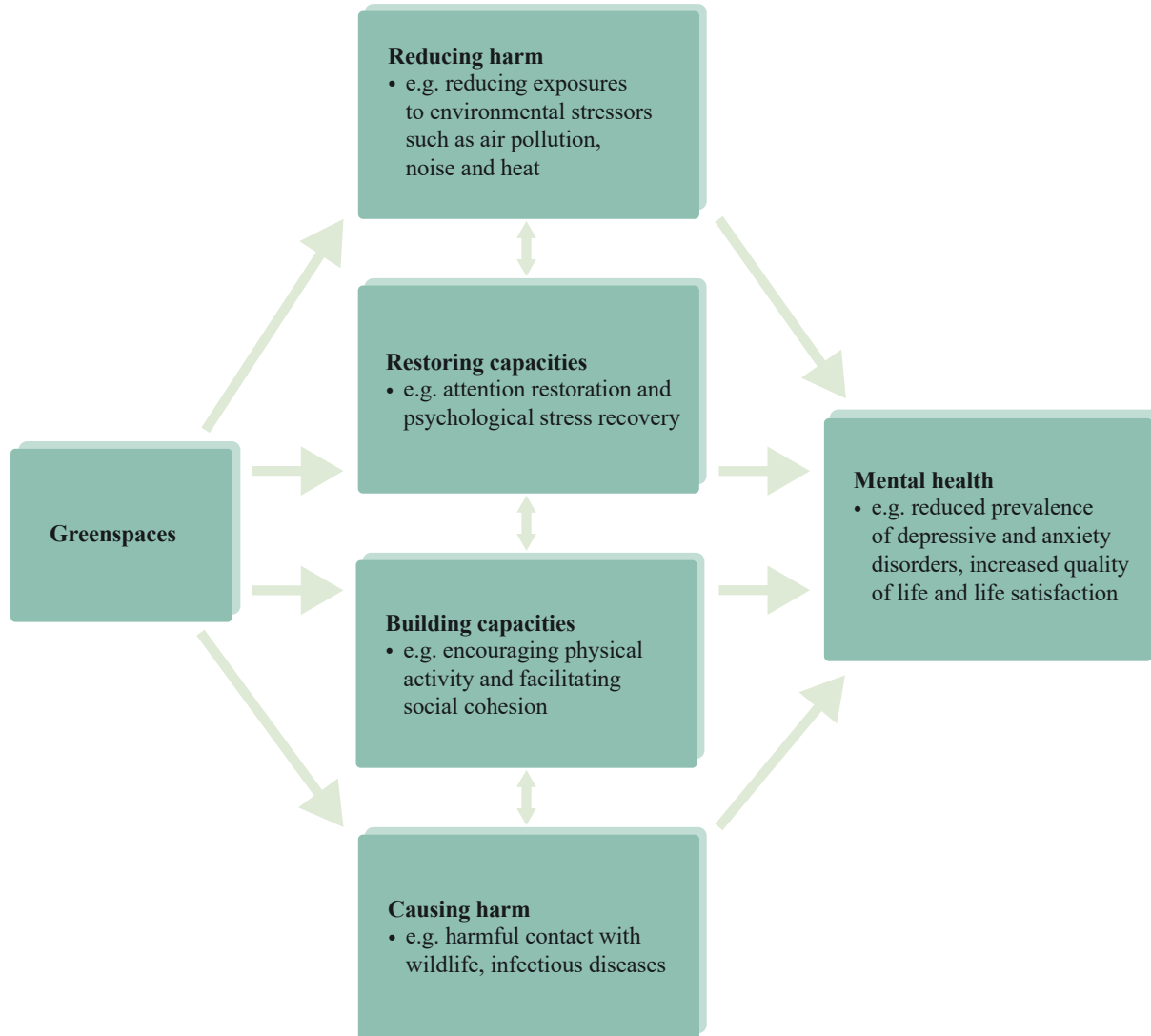
150 We used a sequential mixed-methods study design to explore the issue in depth and to enable
151 triangulation between the different methods (Fig. 3). In a novel combination of research meth-
152 ods, we used participatory video, photovoice, focus groups and the Q-methodology to gain
153 insights into perspectives on the pathways linking greenspaces to mental health and on con-
154 trasting viewpoints on ecosystem services. We used this bottom-up approach to enable the
155 participants to voice their views on their relationship with greenspaces without imposing ideas
156 and perspectives derived from urban ecological or public health theories. This reduced the in-
157 fluence of the research team over the data. Aiming to explore the issues from multiple perspec-
158 tives across participants, methods and theories, and to increase the credibility of the results, we
159 applied different theoretical frameworks to analyse the data.

160
161 We used the Common International Classification of Ecosystem Services (CICES) framework
162 (Haines-Young and Potschin, 2018) and the domains of pathways linking greenspaces and
163 health framework (Markevych et al., 2017) as analytical frameworks (Figure 2). Ecosystem
164 services are defined as the contributions that urban ecosystems make to human well-being and
165 can be divided into three main categories: provisioning services such as food and water, regu-
166 lating services such as reducing exposure to air pollution, noise and heat and cultural services
167 such as fostering social cohesion and encouraging physical activity (Haines-Young & Potschin,
168 2018). Mental health outcomes are affected through the pathways reducing harm (e.g. reducing
169 exposure to air pollution, noise and heat), restoring capacities (e.g. fostering attention restora-
170 tion and stress reduction), building capacities (e.g. encouraging physical activity and fostering
171 social cohesion) and causing harm (e.g. infectious diseases, human – wildlife conflicts)
172 (Markevych et al., 2017).

173 **2.3. Participatory video**

174 We used participatory video to untangle which aspects of urban greenspaces and their associ-
175 ated ecosystem services residents of Kathmandu relate to. In collaboration with a local NGO,
176 the Health Research and Social Development Forum (HERD International), we recruited 10
177 participants from a slum settlement (Bansighat) and 10 participants from an affluent area
178 (Jorpati), to form two participatory video groups, aiming to include a variety of perspectives in
179 terms of socio-economic and demographic backgrounds (Table S5). We describe the criteria

180 for study site and participant selection in the Supplementary material section 2. The participa-
 181 tory video workshops were facilitated by one male and one female Nepali researcher in Nepali
 182 language. The researchers were well-oriented in the project and experienced in facilitating par-
 183 ticipatory video workshops.



184
 185 Figure 2: Domains of pathways linking greenspace to positive health outcomes, adapted from
 186 Markevych et al. (2017) and Marselle et al. (2020). The arrows represent hypothetical patterns of influ-
 187 ence, with specific pathways in each domain potentially influencing one or more specific pathways in
 188 the other domains.

189
 190 With each of the two participatory video groups, we conducted community-based digital sto-
 191 rytelling activities which were designed based on published guidelines (Gubrium, 2009; Lunch
 192 and Lunch, 2006) and a participatory video workshop manual developed by the University of
 193 Leeds ‘Community Arts against Antibiotic Resistance in Nepal’ project in collaboration with
 194 HERD International (Cooke et al., 2019). We describe the steps of the participatory video

195 workshops in the Supplementary material section 3. Written and informed consent was ob-
196 tained from all study participants. Verbal informed consent was obtained from all persons pho-
197 tographed or recorded. The consent included permission to use all media for publication, online
198 and offline dissemination.

199 **2.4. Photovoice and focus groups**

200 We conducted three focus group discussions in the slum settlement and the affluent area. These
201 were facilitated by one male and one female Nepali researcher who had extensive training and
202 experience in qualitative research methods. We explored the perceptions of urban greenspaces
203 with focus on photovoice pictures, biodiversity attributes of greenspaces and ecosystem ser-
204 vices. Photovoice is a qualitative participatory research technique that has study participants
205 use photography, and stories about their pictures, to identify and represent issues of importance
206 for them (Nykiforuk and Vallianatos, 2018). The pictures then serve as a basis for focus group
207 discussions. We supplied the participants with cameras, asking them to take pictures consider-
208 ing the question “What do urban greenspaces mean to you?” We defined urban greenspaces as
209 all forms of ‘living nature’ of flora and fauna in cities, together with still and running water
210 (Hartig et al., 2014), including maintained and unmaintained environmental areas such as na-
211 ture reserves, wilderness environments, urban parks (Barton and Rogerson, 2017) as well as
212 urban wildlife. The participants had two days to take pictures. They captured pictures repre-
213 senting perceptions of greenspaces, and these pictures identified central themes inductively.
214 The researchers then used these to stimulate discussions around urban greenspaces in the first
215 focus group. With the participants’ informed consent, all pictures were used for data analysis.

216

217 For the second focus group, we showed to the participants pictures of provisioning (n=9), reg-
218 ulating (n=9) and cultural ecosystem services (n=11) covering all sections and divisions of the
219 CICES ecosystem services framework (Haines-Young and Potschin, 2018) to stimulate discus-
220 sions (Table S1; Supplementary material B). For the third focus group, the participants dis-
221 cussed their perceptions of various parts and types of urban greenspaces in Kathmandu. We
222 aimed to include pictures of parts and types of ecosystems which are commonly found in green-
223 spaces in Kathmandu (Botzat et al., 2016), are likely to be encountered by urban residents
224 (Marselle et al., 2018) and displayed a variety of utilitarian traits (e.g. provision of shade, food,
225 medicine) and phenotypic traits (e.g. colours, sounds, smells). Following these criteria, we in-
226 cluded pictures of a selection of mammals (n=10), amphibians/reptiles (n=4), birds (n=7), in-
227 vertebrates (n=10) and plants (n=17) (Table S2; Supplementary material B). Further details of

228 the approach we took for conducting the focus groups are provided in the Supplementary ma-
229 terial section 4. The process of all focus groups was piloted with two Nepali researchers, but
230 no changes were implemented as a result. Focus groups took place in community centres in a
231 slum settlement (Bansighat) and an affluent area (Jorpati).

232 **2.5. Q-methodology**

233 We used the Q-methodology to examine the outcomes of participatory video and focus groups
234 and to investigate the viewpoints on ecosystem services and disservices held by residents of
235 Kathmandu. The Q-methodology involves the rank-ordering, by the participants, of a set of 40-
236 60 statements into a near-normal distribution, ranging from the least to the most agreed (ten
237 Klooster et al., 2008). To better understand sorting decisions, we complemented the sorting
238 task with in-depth interviews focusing on the statements on the far ends of the distribution
239 (Table 1).

240
241 We included statements on provisioning (10), regulating (17), and cultural ecosystem services
242 (19), covering all sections and divisions of the CICES ecosystem services classification
243 (Haines-Young and Potschin, 2018). Of the 46 statements, 40 were framed as ecosystem ser-
244 vices and six as disservices (Table 1). Statements were developed based on data from partici-
245 patory video and focus groups with residents from two communities in Kathmandu (see section
246 2.3), international policy document analysis (e.g. The 2030 Agenda for Sustainable Develop-
247 ment, TEEB Manual for Cities: Ecosystem Services in Urban Management), Nepalese policy
248 document analysis (e.g. Sustainable Development Agenda for Nepal.), scientific evidence (e.g.
249 WHO urban green spaces and health - review of the evidence) and online searches of Nepalese
250 newspaper content (e.g. the Himalayan Times, Kathmandu Tribune) (Table S3, S4). Statements
251 were generated in English and double translated to Nepali (i.e., translated to Nepali, then back
252 to English by another person, with consistency of meaning verified by comparing the two ver-
253 sions by the researcher). Statements derived from participatory video and focus groups, how-
254 ever, were double translated from Nepali to English. Participants could choose to conduct the
255 interview in Nepali or English. Statements were read aloud for illiterate participants.

256
257 Participants were recruited through contacting gatekeepers within the local communities
258 through HERD International, following pre-defined criteria. We conducted 40 interviews with
259 participants from across Kathmandu district (Table S6). These were not the same participants
260 taking part in participatory video and photovoice. To ensure that all potential viewpoints on

261 ecosystem services were covered, we strategically sampled participants from six stakeholder
262 groups, who relate, in different ways, to greenspaces and their ecosystem services (Hauck et
263 al., 2016) (Table 1). stakeholders who directly benefit from ecosystem services (e.g. urban
264 farmers, park users), stakeholders who are negatively affected from ecosystem services (e.g.
265 flood or pest affected), stakeholders who directly influence ecosystem services (e.g. land own-
266 ers, resource managers) and stakeholders who indirectly influence ecosystem services (e.g.
267 government employees, researchers, civil society organisations). Aiming to further increase
268 the diversity of viewpoints, we conducted interviews with slum dwellers in Bansighat and with
269 residents of Manohara, an affluent area. More information about the stakeholder groups and
270 participant selection process is included in Supplementary material section 5.

271
272 Interviews took place at the homes or offices of the participants. During the interviews, partic-
273 ipants were presented with a set of 46 statements to be sorted into a near-normal distribution,
274 from the least to the most agreed, resulting in a Q-sort. They were first asked to sort the state-
275 ments into three piles, according to their level of agreement (agree most, agree least, neutral).
276 The participants were then asked to further the classification by arranging them from the most
277 agreed to the least agreed on a grid representing a quasi-normal distribution of ten steps (Fig.
278 S5). This resulted in a “Q-sort” of the different statements for each participant. The sorting task
279 was followed by a post-sort interview about the reasons behind the sorting decisions made by
280 focusing on the three most agreed and three least agreed statements as well as details of their
281 socioeconomic background. The participants could decide to do the Q-sort and interview in
282 English or Nepali. Interviews in English (14) were facilitated by a male researcher (MN) and
283 interviews in Nepali (26) by a female Nepali researcher. Interviews were recorded and tran-
284 scribed for analysis. Interviews in Nepali language were first transcribed and then translated to
285 English.

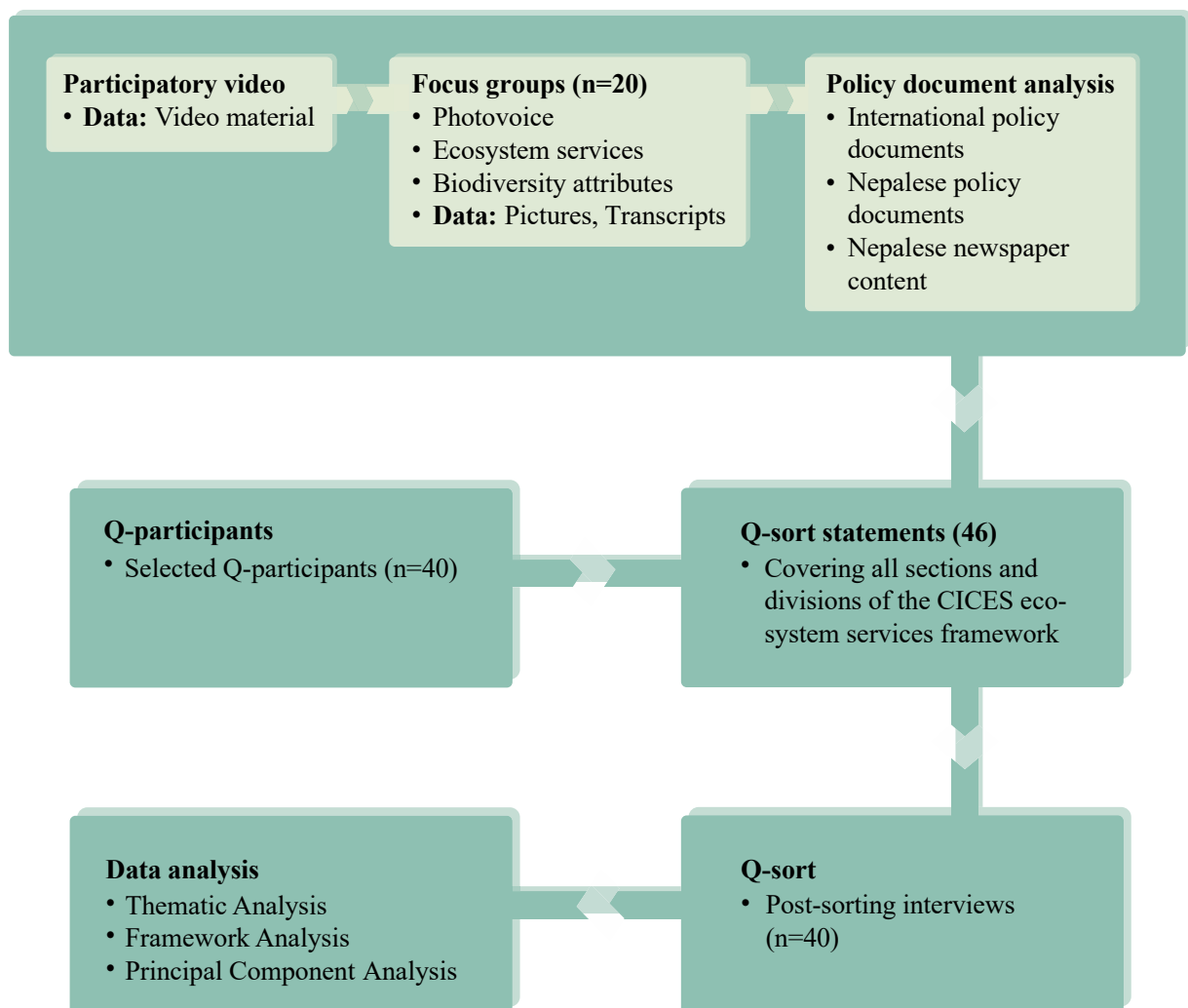
286 **2.6. Data analysis**

287 First, data from participatory video (video material), photovoice (pictures), focus groups (tran-
288 scripts) and Q-interviews (transcripts) were analysed inductively by one researcher (MN) using
289 thematic analysis, without trying to fit it into a pre-existing coding frame or theory (Braun and
290 Clarke, 2006). This was done to discover novel links between greenspaces and mental health.
291 The analysis was conducted using a constructionist perspective, from which meaning and ex-
292 perience are socially produced and reproduced (Burr, 2015). We followed Braun and Clarke's

293 (2006) six steps of conducting thematic analysis. Data were read carefully to identify mean-
 294 ingful patterns and themes. Then, units of text dealing with similar issues were grouped in
 295 analytical categories. Data were reviewed systematically to ensure that each category was sup-
 296 ported sufficiently. Data analysis was done by one of the researchers (MN).

297

298 As a second step, data were analysed deductively by using framework analysis along with
 299 content analysis. We did this to test two theoretical frameworks. We used the CICES ecosystem
 300 services framework (Haines-Young and Potschin, 2018) and the domains of pathways frame-
 301 work linking greenspaces and health framework (Markevych et al., 2017) as analytical frame-
 302 works. We followed Gale et al.'s (2013) seven steps of conducting framework analysis. After
 303 familiarising with the data, we used the categories from both analytical frameworks for coding.



304 Fig. 3: Infographic of the study design.

305 Data from participatory video, focus groups and policy document analysis informed the devel-
306 opment of the 46 Q-sort statements covering all sections and divisions of the CICES ecosystem
307 services framework (Haines-Young and Potschin, 2018). The Q-sort statements were analysed
308 by applying a principal component analysis (PCA) and a varimax rotation within the R package
309 “qmethod” (Zabala, 2014). The PCA shows similarities between participants’ sorting of the
310 statements, and participants with a similar ranking of statements load significantly on the same
311 viewpoint, revealing patterns of statements that express their subjective views (Coogan and
312 Herrington, 2011). The scores of the Q-sorts assigned to a viewpoint were used to reconstruct
313 a hypothetical Q-sort for each viewpoint, through calculating the factor scores of each state-
314 ment (Guenat et al., 2019).

315

316 The number of viewpoints for the PCA was determined by having at least two participants and
317 at least one distinguishing statement per viewpoint (Coogan and Herrington, 2011). Besides,
318 we aimed to minimise the number of “confounders” (participants who load on multiple view-
319 points) and “non-loaders” (participants who do not load on any viewpoint) (Webler et al.,
320 2009). All Q-sorts were combined in one analysis.

321

322 The viewpoints were interpreted by examining the factor scores for each statement and view-
323 point, by paying attention to the distribution of the distinguishing statements within each hy-
324 pothetical Q-sort (Table S9), and by examining the statement z-scores, which indicate how far
325 a statement lies from the middle of the distribution (Webler et al., 2009) (Table S8). Interviews
326 assigned to a participant and viewpoint supported understanding the underlying rationale for
327 each viewpoint.

328 **2.7. Ethical considerations**

329 The study protocol was approved by the University of Leeds Social Sciences, Environment and
330 LUBS Faculty Research Ethics Committee (AREA 18-133) and the Nepal Health Research
331 Council (Reg. no. 419/2019).

332 **3. Results**

333 The participants’ age ranged from 17 to 65 years, with a median age of 33 years. The partici-
334 patory video and focus group participants were split evenly between genders (Table S5). How-
335 ever, more men than women participated in the Q-method (58%; Table S6). This was due to
336 the high proportion of men in the group of stakeholders who directly and indirectly impact on

337 ecosystem services. Participants in these stakeholder groups were also more likely to have ter-
338 tiary education compared to stakeholders who directly benefit from or are negatively affected
339 by ecosystem services.

340 **3.1. Pathways linking greenspaces to mental health**

341 **3.1.1. Reducing harm**

342 Nearly all participants felt that greenspaces play a crucial role for improving air quality in
343 Kathmandu. Participants emphasised that trees provide *"fresh air to breathe in"* P_B2: 52-
344 *year-old man, Janjati, Bansighat*, and that they help control pollution through filtering partic-
345 ulate matter. They thought that if there were more greenspaces, there would be less air pollu-
346 tion. Others worried that the loss of greenspace associated with urbanisation may increase the
347 level of air pollution. Greenspaces were perceived as being places free of pollution: *"In an*
348 *open greenspace [...] you feel like admiring the beauty of it rather than if you are in a very*
349 *congested, polluted, dusty environment"* C1: 29-year-old man, Thapathali. Participants high-
350 lighted that the good air quality in greenspaces contributes to relaxation. Tree species with
351 cultural importance were believed to contribute more to improving air quality: *"We get more*
352 *oxygen from the Sacred Fig than from other trees"* P_J3: 36-year-old woman, Janjati, affluent
353 *area (Jorpati)*. The participants did not discuss much the potential of greenspaces to reduce the
354 level of noise pollution.

355
356 Another priority benefit identified by the participants was the provision of shade by urban trees.
357 Linked to this, they highlighted the provision of cool air and the reduction of air temperatures.
358 Adding to this, urban greenspaces were regarded as being increasingly important since tem-
359 peratures are rising due to climate change: *"I think greenspaces are important to mitigate the*
360 *negative effects of climate change because greenery would help a lot [...] providing better air*
361 *quality [...] and decreasing the temperature."* C6: 27-year-old woman, Babar Mahal.

362 **3.1.2. Restoring capacities**

363 A dominating perception was that greenspaces play an important role for attention restoration
364 and stress reduction, mainly through offering a place to relax and to have a peaceful time: *"In*
365 *[the] park we see greenery all around, which gives a sense of relaxation, we feel peaceful"* B4:
366 *20-year-old man, Pashuputinath*. The participants observed links to mental health: *"if there is*

367 *greenspace near you, you'll just get relaxed and so [health] might improve" C2: 31-year-old*
368 *man, Thapathali.*

369 Various parts and types of urban greenspaces were seen as contributing to attention restoration
370 and stress reduction. The parts and types of greenspaces which were valued most by the par-
371 ticipants were those with sacred or religious significance. The Sacred Fig (*Ficus religiosa*), for
372 instance, was seen as important because it is used as a multifunctional place for religious wor-
373 ship, fostering social interaction, providing shade and reducing exposure to air pollution. View-
374 ing flowers, in particular, was perceived as stress reducing: "*Whenever we see flower, we forget*
375 *our tension, we feel very peaceful." P_J3: 36-year-old woman, Janjati, affluent area (Jorpati).*
376 This was mainly through eliciting positive emotions such as feeling "*positive vibes*" and
377 "*changing negative to positive mind*".

378 Adding to this, the participants emphasised that wildlife viewing such as watching birds helped
379 them "*to relax and enjoy the moment*": "*Especially during mornings while feeding and being*
380 *surrounded by birds makes my mood better, it brings mental peace as well." B2: 35-year-old*
381 *woman.* Participants also mentioned that they found a variety of birds, bats and butterflies aes-
382 thetically pleasing: "*It is good to have a city if it has chirping birds and bats, of course, it gives*
383 *a kind of flavour, they are the ornaments [of the city]" C3: 35-year-old man, Shivapuri.* The
384 participants expressed that they were worried about the lack of large greenspaces in Kath-
385 mandu. For instance, "*[name of local park] it's not big, it's small, very small, and then the*
386 *crowd is very big. You don't feel relaxed or tension free in the parks of Kathmandu, I'm sure."*
387 *C3: 35-year-old man, Shivapuri.* Talking about a national park bordering the city area to the
388 north, one participant mentioned that it is large enough for people to feel relaxed, compared to
389 the crowded parks in the city centre. Moreover, Kathmandu is an earthquake prone area, which
390 manifested in the 2015 earthquake which caused widespread destruction and loss of life
391 (Okamura et al., 2015). Urban greenspaces were seen as an important refuge in the case of
392 earthquakes and thus, living close to greenspaces may have beneficial mental health effects
393 through decreasing anxiety related to earthquakes.

394 **3.1.3. Building capacities**

395 Many participants believed that urban greenspaces are important for encouraging physical ac-
396 tivity. This was not necessarily because urban residents preferred to be active in green envi-

397 ronments rather than in built-up environments, but mostly because greenspaces were high-
398 lighted as the only spaces where air quality was sufficiently good to allow for being physically
399 active. Furthermore, the participants suggested that due to urbanisation and the associated loss
400 of greenspace in Kathmandu, there is a lack of space for people to be physically active. They
401 emphasised that being physically active contributed to their mental health, for instance through
402 fostering feelings of relaxation and reducing levels of stress.

403

404 Urban greenspaces were perceived as being a crucial component for the physical and mental
405 development of children: *"If you have space, they can run"* C3: 35-year-old man, Shivapuri.
406 The participants argued that greenspaces allow children to be physically active. One priority
407 concern identified by the participants was the lack of urban greenspaces in Kathmandu and the
408 negative consequences for child development: *"Nowadays there are no greenspaces in Kath-*
409 *mandu. I really worry about it because my children, where do they go to play?"* C3: 35-year-
410 *old man, Shivapuri.* This was perceived to be problematic because the lack of greenspaces was
411 thought to contribute to sedentary behaviour involving screens and the internet: *"because of*
412 *lack of [...] proper park [...] they are locked up in the house which is the main reason they are*
413 *being addicted toward gadget, which is making them isolated and mentally ill"* B2: 35-year-
414 *old-woman.*

415

416 The participants thought that strengthening social cohesion is one of the main functions of
417 urban greenspaces in Kathmandu: *"Parks are the only places where people come together to*
418 *talk"* A6: 20-year-old man, Pashuputinath. Urban greenspaces were believed to provide these
419 benefits through promoting a range of social activities, including the provision of space to play
420 for children, meeting friends and family and for holding cultural events. In contrast, partici-
421 pants reported that greenspaces allowed them to escape from family responsibilities and obli-
422 gations, which are typically on a high level in Asia (Amiya et al., 2014). Adding to this, green-
423 spaces were thought to offer an opportunity to escape the crowded city centre. Both meeting
424 others and spending time away from family responsibilities was perceived as contributing to
425 mental health.

426

427 Greenspaces were perceived as being important for child development through developing so-
428 cial skills: *"if you have space [...] then they can hang, they can laugh [...] it gives you a kind*
429 *of environment for development."* C3: 35-year-old man, Shivapuri. What's more, the partici-

430 pants highlighted safety issues linked with letting children play outdoors. They expressed con-
431 cerns that the lack of available greenspace led to these safety issues: "*Playing in the streets is*
432 *very [...] risky, they can get injured [...] we need to have proper greenspaces for our children*
433 *to play [...]*" D3: 30-year-old man, Sano Gaucharan. Moreover, greenspaces were perceived
434 as being important for developing a sense of place in neighbourhoods. One participant ex-
435 pressed his concerns: "*let me say that, if we don't have open greenspaces, my children will not*
436 *know who is there in the next house. That's a big issue here.*" C3: 35-year-old man, Shivapuri.
437

438 Nearly all participants were worried about the loss of greenspace in Kathmandu over the last
439 decades: "*Nowadays, urban dwellers [...] if they plan to go somewhere, and then have a good*
440 *time with their friends or maybe just hang around, there is no place to go.*" C5: 30-year-old
441 *man, Pulchowk.* They emphasised that this development leads to increased social isolation:
442 "*Most of the time we just need to rely on [...] surfing internet and those kinds of things, but if*
443 *there would be any parks or more greenspaces, then we'll definitely come up with the idea of*
444 *meeting our friends in the park*" C6: 27-year-old woman, Babar Mahal.

445 **3.1.4. Causing harm**

446 Some participants thought critically about some types of urban wildlife, mostly because they
447 feared being attacked by large mammals such as leopards or wild boars: "*if we have wild ani-*
448 *mals in the city, they will bite*" A3: 36-year-old female, Pashuputinath. Participants also related
449 negatively to animals such as rats, mosquitoes, cockroaches and wild boars because of their
450 potential of transmitting diseases to humans. Mosquitoes, in particular, were seen negatively,
451 because participants thought that they are the main transmitter of Dengue fever. The partici-
452 pants related negatively as well to a range of mammals, insects and birds because they were
453 perceived as pests threatening harvests of small farmers or nuisances destroying food or clothes
454 or make homes dirty. Frequently discussed was how Rhesus macaques (*Macaca mullata*),
455 which are common in Kathmandu's greenspaces, snatch food and attack people: "*animals be-*
456 *come lazy if they see [...] easy food around [...] so of course, they snatch your food.*" C3: 35-
457 *year-old-man, Shivapuri.* However, when pointed out that urban wildlife can also include ani-
458 mals such as birds, most participants modified their assessments and expressed more positive
459 attitudes towards wildlife encounters in the city.

460

461 The participants reported only few problems with crime and fear of crime in greenspaces such
 462 as parks. Thus, nearly all participants, both male and female, felt safe in greenspaces. Well
 463 maintained greenspaces were perceived as being particularly safe. It was noted that the high
 464 number of greenspace users in Kathmandu acts as social control against crime and uncivil be-
 465 haviour. However, visiting parks was perceived as having potentially negative consequences
 466 for women. A female participant explained: “*When I am here [in the park] with my husband,*
 467 *people might think that I have come here with my boyfriend [...] if any relative will see me in*
 468 *the park they will gossip about me [...] saying that I was with some other guy in the park.*
 469 *People always judge in a negative way.*” B5: 24-year-old woman, United Nations Park. Thus,
 470 gender issues might pose a barrier to greenspace use in Kathmandu.

471 3.2. Q-methodology

472 The analysis of the Q-sorts revealed that the participants valued cultural services the most
 473 (mean factor score: 0.95), followed by regulating services (mean factor score: -0.41), while
 474 provisioning services (mean factor score: -1.10) were valued least. Statements falling into the
 475 ‘building capacities’ domain (mean factor score: 1.14) and ‘restoring capacity’ domain (mean
 476 factor score: 0.75) were most important for the participants, whereas statements falling into the
 477 ‘reducing harm’ category were valued less (mean factor score: -0.21). As anticipated, state-
 478 ments falling into the ‘causing harm’ domain were valued least (-2.8). In the following, we
 479 discuss six contrasting viewpoints on ecosystem services held by different stakeholder groups
 480 (Table S7).

481
 482 Table 1: Factor scores for each Q-sort statement, ranging from -4 (least agreed) to 4 (most agreed).
 483 Each of the viewpoints represents a hypothetical Q-sort that has been constructed from the factor scores.
 484 Asterisks indicate distinguishing statements for the respective viewpoint and double asterisks indicate
 485 consensus statements.

Statement	Viewpoint 1	Viewpoint 2	Viewpoint 3	Viewpoint 4	Viewpoint 5	Viewpoint 6
Trees in the city are an important source of fire-wood.	-4	-3	-4	-2	2*	-3
Manure from livestock is an important source of biogas.	-1	0	0	2	0	2
Urban agriculture promotes dietary diversity and improves our nutrition and food security.	0	1	0	0	0	1
Small kitchen gardens are helpful to satisfy our daily need for vegetables.	1	2*	0	0	-1	0
Stray cows on Kathmandu's roads are dangerous, because they can cause road accidents.	0	-2	2	3	-1	0

Urban greenspaces can create job opportunities and can be a regular source of income for the city by stimulating economic activity, attracting high-calibre professionals and businesses, and increasing real-estate value.	0	-2	-2	-1	-4	-4
Keeping livestock in the city is an important source of income.	-3	-2	-3	-3	0	2
Livestock in the city is important because it provides manure to improve soil fertility.	-2	0	-2	0	2	-2
Forest products are used as medicines, dyes, food, cosmetics, fibre and crafts and contribute to the economic security of people, especially the poor.	0	0	0	0	2	0
Shivapuri National Park is crucial for the provision of drinking water for Kathmandu.	1*	-2	3*	-2	-3	-3
Urban greenspaces are important because they purify wastewater and help providing us with drinking water.	0	0	-1	0	3	3
Vegetation cover in the city holds together the soil and prevents erosion.	-2*	0	3	1	2	-3*
Rapid depletion of green open spaces in the city can increase people's vulnerability to landslides and flooding.	-1	-1	1	-3*	2	0
Insects (and some birds and bats) and wind pollinate plants, which is essential for the development of fruits, vegetables and seeds.	0	-3	4*	-2	0	-2
Greenspaces are an important habitat for wildlife in the city.	-3*	0	1	1	0	2
It is good to have birds, bats, flies, wasps, frogs, snakes and fungi in the city, because they act as natural control of pests and diseases.	-2	1	-1	-2	-2	0
Urban greenspaces are important to mitigate the negative effects of climate change.	2	0*	-2	2	3	-2
Trees help saving energy used for heating.	0*	4*	-3	1	-1	1
Trees in the city provide shelter from sunlight and the heat in summer.	1	1	0	-1	2	3
Greenspaces can harbour breeding ground for mosquitoes, thereby increasing the risk of Dengue infections.	-3*	-2	0	0	0	0
I don't like wild animals in the city because they are spreading disease, make our homes dirty, destroy our food and clothes.	-2	-3*	-2	1*	-2	-1
Wild animals in the city are dangerous.	-1	-4*	1	0	-2	0
I don't like having monkeys in the city, because they snatch our food.	-2	-4*	-1	-1	0	1
Trees in the city shield homes from nearby roads and industrial areas.	-1	-1	3*	-2	0	0
Urban greenspaces increase carbon storage and uptake, thereby helping to protect the global climate.	2	2	2	-1	0	-4*
Trees and green areas in the city soak up rain and river water, thereby protecting us from the impact of flooding.	0	1*	-1	3*	-1	-2
We need more greenspaces to reduce the level of air and noise pollution in the city.	4	-1	1	3	1	0
Greenspaces make the city attractive to tourists.	1	3	2	1	-2*	0

Greenspaces improve the physical, social and psychological health of urban dwellers.	3	2	0	0	4*	0
When I visit a city park, I feel relaxed and tension free.	1	2	0	-3*	1	-1
I enjoy watching wildlife in the city.	-1	0	-3	-1	0	2*
Feeding birds makes me happy.	1	2	-4*	0	1	-1
Urban greenspaces are important for holding social and cultural programmes.	0	1	1	0	1	0
Urban greenspaces are important for people to meet and learn, to share knowledge and to rest.	0	1	0	0	0	0
Urban gardens act as a classroom for children and teenagers to learn how fruits and vegetables are grown.	0	0	0	2	-3*	-1
Greenspaces provide an opportunity for young people to come together and implement their education, skills and innovation.	0**	0**	0**	0**	0**	0**
We need greenspaces as safe playing spaces for our children.	0	3	4	2	-4*	2
Greenspaces make our city more beautiful.	3*	4*	0	2	0	1
Open greenspaces are an important refuge in the case of disasters such as earthquakes.	4	0	-1	-4*	1	4
Urban parks are places of pollution, crime and drug consumption.	-4*	-1	-1	-4*	-2	-2
Greenspaces such as Tudikhel or Ratna Park are an important part of our city's heritage.	2	3	2	0	-3*	0
Greenspaces in the city maintain a harmonious relationship between humans and nature.	2	0	-2	-1	1	4
Biodiversity, ecosystems and natural landscapes have been the source of inspiration for much of our art and culture.	0	0	0	1	4*	-1
Nature is sacred and must be worshipped and protected.	2	0	0	4*	0	1
Flowers are an integral part of many religious rituals.	-1	-1	2*	0	-1	-1
It is important to conserve our natural resources for the next generations.	3	-1	1	4*	-1	3

486

487

3.2.1. Viewpoint 1: Reducing risks for ill-health

488

Participants in this group were predominantly male and highly educated. They thought that

489

greenspaces can influence health mainly through reducing risks for ill-health. Reducing the

490

level of air and noise pollution was believed to be the most important function of greenspaces:

491

“if we had many places like this [urban parks], we would have less pollution” A3: 36-year-old

492

woman, Pashuputinath. Participants in this group were worried that urban agriculture such as

493

keeping livestock has detrimental effects on human health: *“I think the city is not a suitable*

494

place to raise cattle, because [...] unwanted smell will come through their manure [...] D4:

495

36-year-old man, Babar Mahal. Adding to this, participants in this group did not believe that

496

interactions with urban wildlife contribute to restoring capacities such as stress recovery and

497 attention restoration. Indeed, they emphasised on the danger urban wildlife may pose to health
498 and were worried that the presence of wildlife is a barrier to greenspace use: *“I think green-*
499 *spaces are important for people, not for wildlife [...] there will be some kind of danger in the*
500 *greenspaces and people would not go there. We don’t need wildlife in the city, I guess” B3:*
501 *26-year-old man, Pashuputinath.*

502 **3.2.2. Viewpoint 2: Restoring capacities to support health through interactions** 503 **with urban wildlife**

504 This group of participants had a low level of education and was mixed in terms of gender. What
505 differentiated this group was their emphasis on the potential of experiencing urban wildlife to
506 restore capacities through stress recovery and attention restoration: *“I enjoy watching monkeys*
507 *around me, because I think their behaviour is good” B4: 20-year-old male, Pashuputinath.*
508 They were not concerned about the potential of wildlife encounters to cause harm to humans:
509 *I think they [the monkeys] are not dangerous [...] all animals will not harm us until we harm*
510 *them” B4: 20-year-old male, Pashuputinath.* Participants sharing this viewpoint were also op-
511 posed to the idea that wildlife in the city is harmful through spreading disease, making homes
512 dirty or destroying food and clothes.

513 **3.2.3. Viewpoint 3: Reducing risks for ill-health through environmental regula-** 514 **tion**

515 This group consisted of highly educated men who benefit, but also impact on the provision of
516 ecosystem services. Participants of this group strongly supported the view that greenspaces
517 reduce risks for ill-health through environmental regulation. For instance, they believed that
518 greenspaces play an important role for water filtration and the provision of clean water: *“If*
519 *there are no trees, then there will be a scarcity of water” A9: 30-year-old male, Chandragiri,*
520 *farmer.* Moreover, this group valued the role vegetation plays for erosion control in Kath-
521 mandu: *“Vegetation [...] binds the soil together, it prevents erosion, there are a lot of inclined*
522 *places around Kathmandu Valley.” D3: 30-year-old male, Sano Gaucharan.* Adding to this,
523 pollination by insects, birds and bats was highlighted as being essential for the development of
524 fruits, vegetables and seeds, thereby contributing to good nutrition and food security.

525 **3.2.4. Viewpoint 4: Securing health benefits for future generations**

526 This group was dominated by women with moderate education level who directly benefit and
527 who were negatively affected by ecosystem services. What set this group of participants apart
528 was the future oriented worldview they held. They feared the effects of greenspace loss asso-
529 ciated with urbanisation and population growth in Kathmandu. This group believed that it was
530 their religious duty to protect greenspaces, so that future generations will have the opportunity
531 to experience the health benefits provided by greenspaces: *“if the population goes on increas-
532 ing day by day, then the next generation will not see enough trees because we are destroying
533 [...] greenspaces for making buildings.” B5: 24-year-old female, United Nations Park.* They
534 argued that greenspaces are sacred and must be protected, because of their innate religious and
535 spiritual significance.

536 **3.2.5. Viewpoint 5: Building capacities for good health**

537 This group was dominated by women with low education level from an affluent area and a
538 slum settlement. Participants with this viewpoint valued greenspaces for improving the physi-
539 cal, social and psychological health of urban residents through building capacities: *“Green-
540 spaces will maintain our healthy life” P_QB8: 65-year-old man, Janjati, slum dweller (Ban-
541 sighat).* They also appreciated that greenspaces support building capacities by offering oppor-
542 tunities for social interaction. For instance, greenspaces were seen as a source of inspiration
543 for art and culture, or as a place where culture is taking place: *“They [greenspaces] are our
544 cultural heritage and many people come to see them, so we should conserve them [...] we can
545 also use them for entertainment, as many programs will happen in these places” P_QP7: 42-
546 year-old woman, Chettri, slum dweller (Bansighat).*

547 **3.2.6. Viewpoint 6: Reducing risks for ill-health through providing refuge in case**
548 **of disasters**

549 Participants sharing this viewpoint were dominated by men with low education level from an
550 affluent area and a slum settlement. A view that was strongly supported by this group was that
551 greenspaces reduce risk for ill-health through being available as refuge in case of disasters such
552 as earthquakes: *“We need Tudikhel [large greenspace in central Kathmandu] during natural
553 disasters like earthquakes. People need open spaces at such times, so these should be pro-
554 tected” P_QB2: 27-year-old man, Brahmin, slum dweller (Bansighat).*

555 4. Discussion

556 The large contribution of mental ill-health to the global burden of disease exemplifies the press-
557 ing need to better understand the determinants of mental health of urban populations. Here, we
558 present novel evidence on the pathways linking greenspaces and mental health in a rapidly
559 urbanising low-income city. Our findings indicate that cultural ecosystem services provided by
560 urban greenspaces can play a pivotal role in reducing the burden of mental ill-health for low-
561 income residents for cities with similar characteristics around the world.

562

563 It has been argued that cultural ecosystem services play only a secondary role for residents in
564 low-income settings. In fact, provisioning services such as food provision and regulating ser-
565 vices such as air pollution reduction are often described as more important to meet people's
566 basic needs, while cultural services are considered less relevant (Adegun, 2017). Our findings
567 contrast markedly with this notion. The framework analysis revealed that the participants per-
568 ceived provisioning and regulating services as highly relevant. However, when the participants
569 were asked to rank the importance of specific ecosystem services through the Q-sorts, a very
570 different picture emerged. The participants then systematically ranked cultural ecosystem ser-
571 vices highest. This contradicts current paradigms and demonstrates that cultural ecosystem ser-
572 vices provided by urban greenspaces are vital components for living a healthy life. We argue
573 that contact with urban greenspaces and the cultural ecosystem services they provide are a
574 fundamental basic need which all people, including low-income residents, depend on to par-
575 ticipate meaningfully in their society. Transitions from direct reliance on local provisioning
576 and regulating services to greater appreciation of cultural ecosystem services has been reported
577 in other rapidly urbanising settings, however in a HIC context at later stages of urbanisation
578 (Richards et al., 2020). Our findings indicate that cultural ecosystem services could play a
579 much larger role for the mental health of urban residents in less urbanised low-income settings
580 than previously assumed.

581

582 While the participants displayed a high level of consensus regarding cultural services, view-
583 points on other ecosystem services contrasted. Viewpoints on urban wildlife, for instance, dif-
584 fered considerably. While some groups of participants preferred having wildlife in the city,
585 others did not. This suggests that socio-economic factors are important for the acceptance of
586 urban wildlife. Exposure to wildlife in the city could provide mental health benefits for specific
587 population groups while for others, it could have detrimental effects. While there was high

588 consensus that greenspaces provide mental health benefits, viewpoints contrasted as to which
589 particular parts and types of greenspaces trigger these benefits.

590

591 While we found evidence for the link between greenspaces and mental health through the path-
592 ways reducing harm, restoring capacities and building capacities, our findings indicate that
593 likely a combination of pathways triggers mental health effects. For instance, the participants
594 emphasised that being physically active fostered attention restoration and stress reduction. This
595 has been reported before, however in the HIC context (De Vries et al., 2013; Markevych et al.,
596 2017).

597

598 The important role the participants ascribed to greenspaces in reducing exposure to air pollu-
599 tion, noise and heat suggests that this is a pivotal pathway linking greenspaces and mental
600 health in low-income settings. This is not surprising, given that similar to many other low-
601 income cities, Kathmandu is characterised by very poor air quality (Mahapatra et al., 2019)
602 and hot and humid summer climate. Research has shown that this is an important pathway in
603 the high-income country context (Bowler et al., 2010). Our findings indicate, however, that
604 reductions in air pollution may be of particular importance in low-income cities that are char-
605 acterised by poor air quality, since there is a higher perceived potential for greenspaces to re-
606 duce harmful exposures.

607

608 The participants' perception that urban greenspaces play an important role for attention resto-
609 ration and stress reduction suggests that these are critical pathways linking greenspaces and
610 mental health in low-income settings. This supports findings from studies that have used me-
611 diation analysis to investigate these pathways in other low-income settings (Nawrath et al.,
612 2020). We found that cultural norms affect how people use and experience greenspaces, and to
613 which parts and types of greenspaces they respond to. The participants emphasised on specific
614 parts and types of greenspaces with religious and sacred significance when describing attention
615 restoration and stress reduction effects. For instance, the participants described the Sacred Fig
616 in particular as a multifunctional place for religious worship, fostering social interaction,
617 providing shade and reducing exposure to air pollution. This indicates that the cultural meaning
618 attached to specific animal or plant species could modify mental health effects. This is an im-
619 portant finding, because it demonstrates that the same part or type of greenspaces could have
620 contrasting mental health effects on different people, depending on their cultural backgrounds.

621 This implicates that a society's values around biodiversity impact on the mental health effects
622 of greenspaces.

623

624 Encouraging physical activity and fostering social cohesion were perceived as priority func-
625 tions of greenspaces. Evidence from rapidly urbanising regions suggests that continued urban
626 growth will result in reduced physical activity of urban residents (Muthuri et al., 2014). Hence,
627 while physical activity levels in many low-income settings remain high mainly due to occupa-
628 tional physical activity, maintaining these levels may be challenging due to the decreasing
629 availability of greenspaces associated with urban growth (Pedisic et al., 2019). Our findings
630 highlight the importance of greenspaces for supporting child development through encouraging
631 physical activity and social cohesion. Indeed, research from HICs has shown that contact with
632 greenspaces can play a defining role in children's brain development and that physical activity
633 and social cohesion are major pathways (Dadvand et al., 2019). While there is a lack of evi-
634 dence for this link from LMICs, our findings indicate a similar association between green-
635 spaces and child development in low-income settings. Continued urban growth and a reduction
636 of the availability of greenspaces may contribute to children being less physically active and
637 engaging in more sedentary behaviours (Muthuri et al., 2014), with potentially far-reaching
638 detrimental effects on child development in LMICs. In many low-income settings, family
639 members are often highly dependent on each other (Amiya et al., 2014). This suggests that
640 greenspace as a place for learning social skills could be a pathway of particular importance for
641 mental health in low-income settings. Further, greenspaces could be especially important for
642 people in that they offer a place of retreat from family responsibilities and obligations, which
643 has been found in LMICs before (Byrne and Wolch, 2009).

644

645 Greenspaces can be harmful for mental health (Marselle et al., 2020). For instance, some par-
646 ticipants feared attacks of large mammalian predators such as leopards. Due to urbanisation,
647 urban areas in many low-income cities are increasingly becoming conflict hotspots between
648 wildlife and humans (Acharya et al., 2016). Although few people are directly affected, this
649 phenomenon could contribute to negative attitudes towards urban wildlife in urbanising areas.
650 While some types of urban wildlife were perceived negatively, most people felt decidedly pos-
651 itive about birds. This supports the evidence from HICs, which indicates that the perceived
652 diversity of birds can improve mental well-being (Dallimer et al., 2012). In contrast to previous
653 findings from low-income settings, which reported that perceived safety was a substantial con-
654 cern, and resulted in mixed attitudes towards the mental health benefits of greenspaces (Fisher

655 et al., 2020; Shackleton et al., 2015), we found that safety concerns linked to greenspaces were
656 not perceived as a serious concern for residents in Kathmandu. This somewhat surprising find-
657 ing could be explained through the comparatively low levels of crime in Nepal (Braithwaite,
658 2014). This implies that safety concerns might be a weak moderator of the link between green-
659 spaces and mental health in low-income cities with low crime levels.

660

661 We found that gender issues could pose barriers for greenspace use and thus, the mental health
662 benefits provided by greenspaces in many low-income settings may be biased towards men.
663 This was manifested in negative attitudes towards women visiting greenspaces such as parks.
664 Indeed, women in many low-income settings are required to practise restrictions that perpetuate
665 gender discrimination and inhibit their full participation in public life (Lundgren et al., 2013).
666 This suggests that gender discrimination could be an important moderator of the link between
667 greenspaces and mental health. In fact, gendered behavioural expectations and access to green-
668 spaces have been reported in other low-income settings before (Fortnam et al., 2019).

669

670 This study aims to provide the basis for future research on the links between greenspaces and
671 mental health in LMICs. We argue that the analysis of mediating and moderating factors is of
672 particular importance in the LMIC context. Thus, we encourage future studies to take into ac-
673 count locally relevant moderating and mediating factors. We acknowledge that pathways are
674 likely intertwined. However, there are analytical tools available for assessing the relative con-
675 tributions of multiple mediators using standard regression approaches (Markevych et al., 2017),
676 which we recommend for further research. Future research should also explore how socio-
677 economic and demographic factors impact on the perception of different parts and types of
678 greenspaces. This would aid understanding how some parts of greenspaces have beneficial
679 mental health effects on some population groups while others have not. Our findings highlight
680 that future research should take into account gender norms. Men and women use and experi-
681 ence greenspaces differently, which can lead to mental health benefits being spread unequally
682 between genders (Fortnam et al., 2019). Age and ethnicity are other factors that may impact on
683 the link between greenspaces and mental health. We found that cultural norms affect how peo-
684 ple use and experience greenspaces, and to which parts and types of greenspaces they respond
685 to. Hence, future studies should take into account local cultural norms, and animal and plant
686 species with particular relevance in the local culture, when assessing the links between green-
687 spaces and mental health.

688

689 The findings of this study call for shifting our approach of how to provide for residents in low-
690 income settings in LMICs. Greenspaces present a powerful tool to reduce the burden of mental
691 ill-health in these settings through a variety of pathways and the provision of cultural ecosystem
692 services. This implies that greater efforts should be made to increase access to greenspaces in
693 urban low-income settings and to protect current greenspaces from the rapid development seen
694 in urban areas in LMICs. This may address current health inequalities that residents of low-
695 income cities experience.

696

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706

707 5. References

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907

Kathmandu



Legend

-  Participatory video group Bansighat
-  Q-sort interview sites
-  Participatory video group Jorpati
-  Greenspace
-  Built-up area

