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Why cultural ecosystem services matter most: Exploring the pathways 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



**Kathmandu,
Nepal**

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

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

Abstract

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

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
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- 34 • Cultural ecosystem services play larger role for mental health than presumed
- 35 • Increasing access to greenspaces may address current health inequalities in LMICs

1. Introduction

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

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

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

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

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

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

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

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

2. Methods

2.1. Setting

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

Kathmandu



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

2.2. Study design

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

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

2.3. Participatory video

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

for study site and participant selection in the Supplementary material section 2. The participatory video workshops were facilitated by one male and one female Nepali researcher in Nepali language. The researchers were well-oriented in the project and experienced in facilitating participatory video workshops.

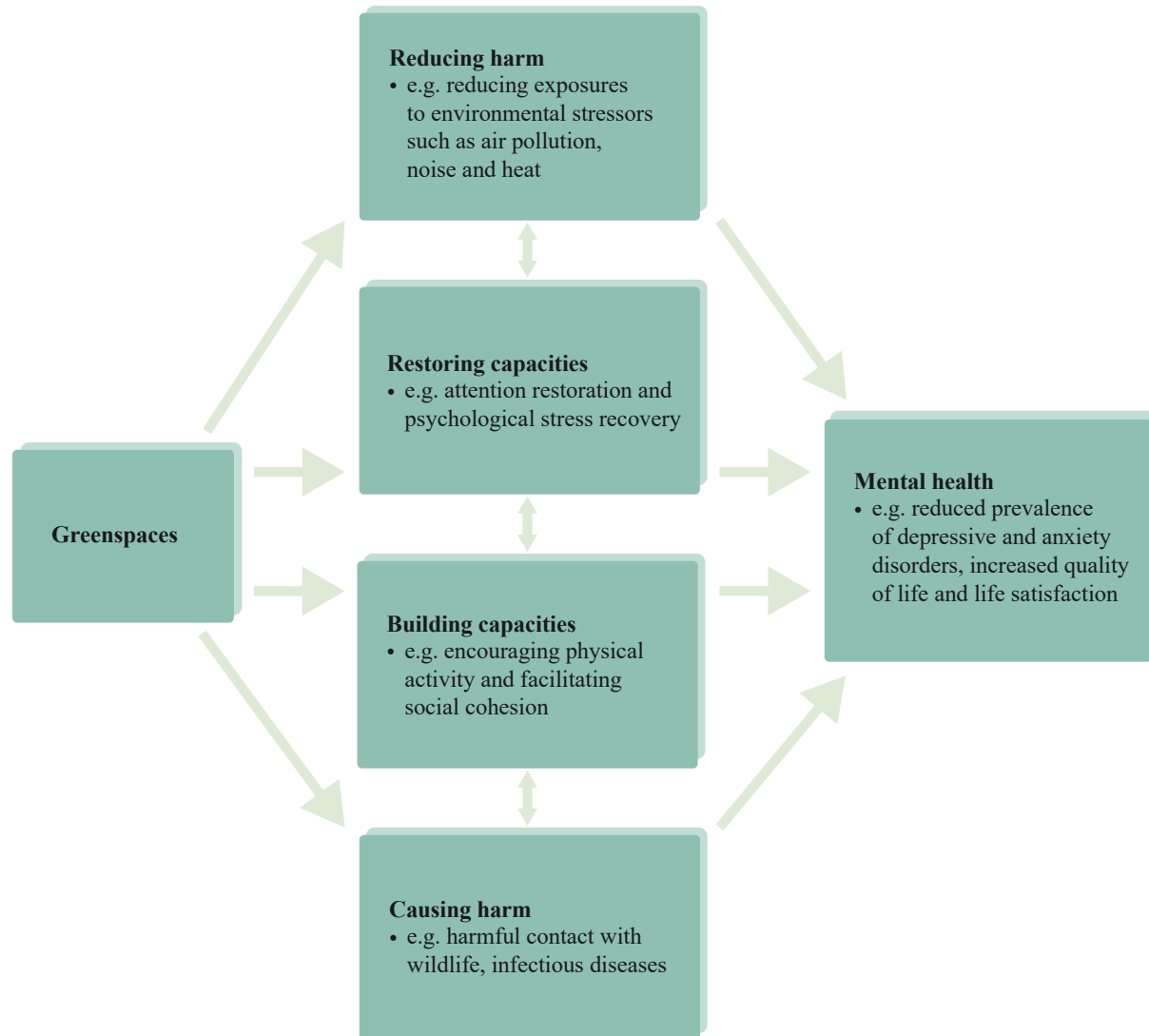


Figure 2: Domains of pathways linking greenspace to positive health outcomes, adapted from Markevych et al. (2017) and Marselle et al. (2020). The arrows represent hypothetical patterns of influence, with specific pathways in each domain potentially influencing one or more specific pathways in the other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

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

workshops in the Supplementary material section 3. Written and informed consent was obtained from all study participants. Verbal informed consent was obtained from all persons photographed or recorded. The consent included permission to use all media for publication, online and offline dissemination.

2.4. Photovoice and focus groups

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

For the second focus group, we showed to the participants pictures of provisioning (n=9), regulating (n=9) and cultural ecosystem services (n=11) covering all sections and divisions of the CICES ecosystem services framework (Haines-Young and Potschin, 2018) to stimulate discussions (Table S1; Supplementary material B). For the third focus group, the participants discussed their perceptions of various parts and types of urban greenspaces in Kathmandu. We aimed to include pictures of parts and types of ecosystems which are commonly found in greenspaces in Kathmandu (Botzat et al., 2016), are likely to be encountered by urban residents (Marselle et al., 2018) and displayed a variety of utilitarian traits (e.g. provision of shade, food, medicine) and phenotypic traits (e.g. colours, sounds, smells). Following these criteria, we included pictures of a selection of mammals (n=10), amphibians/reptiles (n=4), birds (n=7), invertebrates (n=10) and plants (n=17) (Table S2; Supplementary material B). Further details of

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

2.5. Q-methodology

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

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

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

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

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

2.6. Data analysis

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

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

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

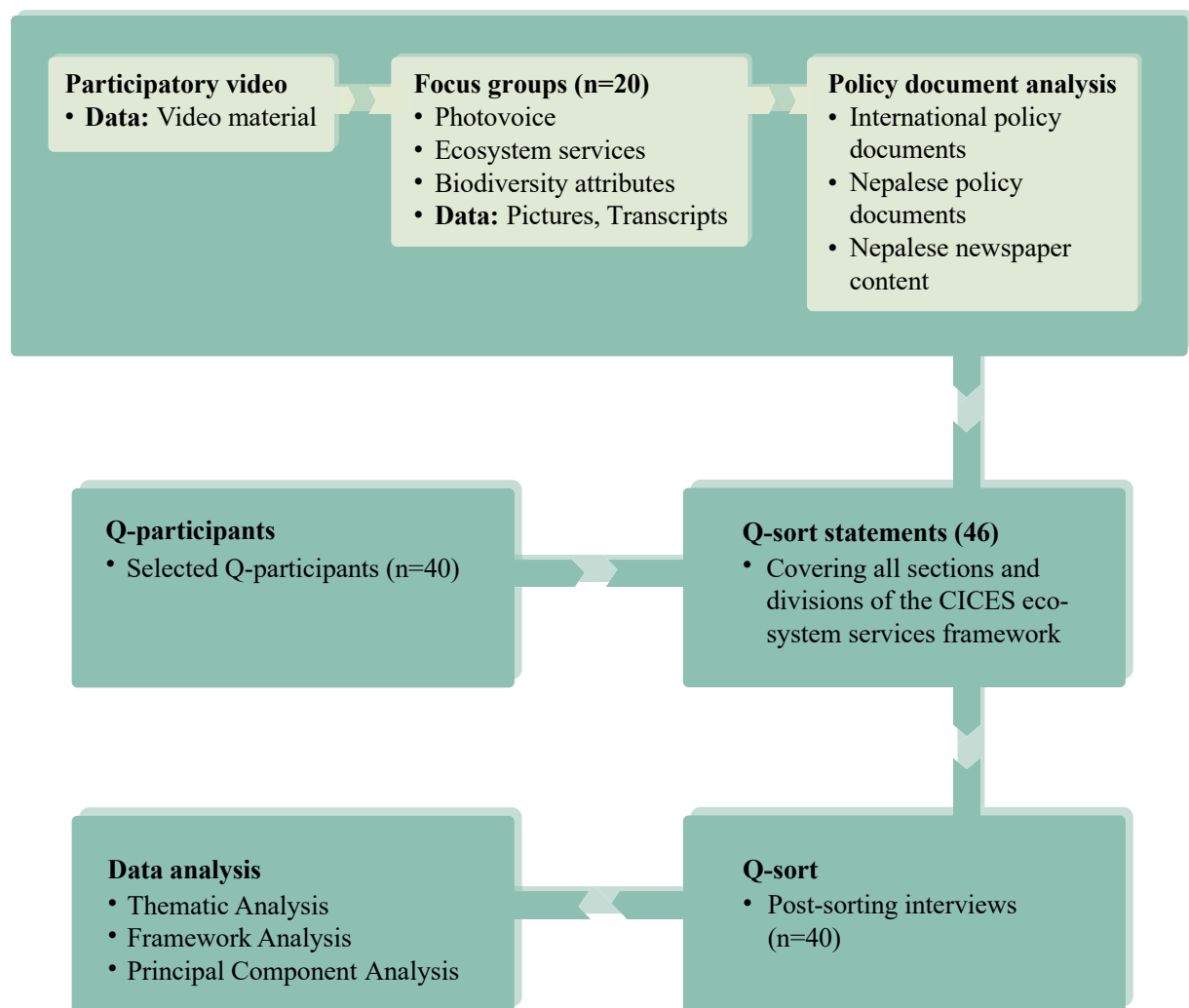


Fig. 3: Infographic of the study design.

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

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

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

2.7. Ethical considerations

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

3. Results

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

ecosystem services. Participants in these stakeholder groups were also more likely to have tertiary education compared to stakeholders who directly benefit from or are negatively affected by ecosystem services.

3.1. Pathways linking greenspaces to mental health

3.1.1. Reducing harm

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

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

3.1.2. Restoring capacities

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

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

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

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

3.1.3. Building capacities

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

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

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

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

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

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

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

3.1.4. Causing harm

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

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

3.2. Q-methodology

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

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

Statement	Viewpoint 1	Viewpoint 2	Viewpoint 3	Viewpoint 4	Viewpoint 5	Viewpoint 6
Trees in the city are an important source of firewood.	-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

3.2.1. Viewpoint 1: Reducing risks for ill-health

Participants in this group were predominantly male and highly educated. They thought that greenspaces can influence health mainly through reducing risks for ill-health. Reducing the level of air and noise pollution was believed to be the most important function of greenspaces: “if we had many places like this [urban parks], we would have less pollution” A3: 36-year-old woman, Pashuputinath. Participants in this group were worried that urban agriculture such as keeping livestock has detrimental effects on human health: “I think the city is not a suitable place to raise cattle, because [...] unwanted smell will come through their manure [...]” D4: 36-year-old man, Babar Mahal. Adding to this, participants in this group did not believe that interactions with urban wildlife contribute to restoring capacities such as stress recovery and

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

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

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

3.2.3. Viewpoint 3: Reducing risks for ill-health through environmental regulation

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

3.2.4. Viewpoint 4: Securing health benefits for future generations

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

3.2.5. Viewpoint 5: Building capacities for good health

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

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

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

4. Discussion

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

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

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

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

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

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

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

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

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

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

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

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

This study aims to provide the basis for future research on the links between greenspaces and mental health in LMICs. We argue that the analysis of mediating and moderating factors is of particular importance in the LMIC context. Thus, we encourage future studies to take into account locally relevant moderating and mediating factors. We acknowledge that pathways are likely intertwined. However, there are analytical tools available for assessing the relative contributions of multiple mediators using standard regression approaches (Markevych et al., 2017), which we recommend for further research. Future research should also explore how socioeconomic and demographic factors impact on the perception of different parts and types of greenspaces. This would aid understanding how some parts of greenspaces have beneficial mental health effects on some population groups while others have not. Our findings highlight that future research should take into account gender norms. Men and women use and experience greenspaces differently, which can lead to mental health benefits being spread unequally between genders (Fortnam et al., 2019). Age and ethnicity are other factors that may impact on the link between greenspaces and mental health. We found that cultural norms affect how people use and experience greenspaces, and to which parts and types of greenspaces they respond to. Hence, future studies should take into account local cultural norms, and animal and plant species with particular relevance in the local culture, when assessing the links between greenspaces and mental health.

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

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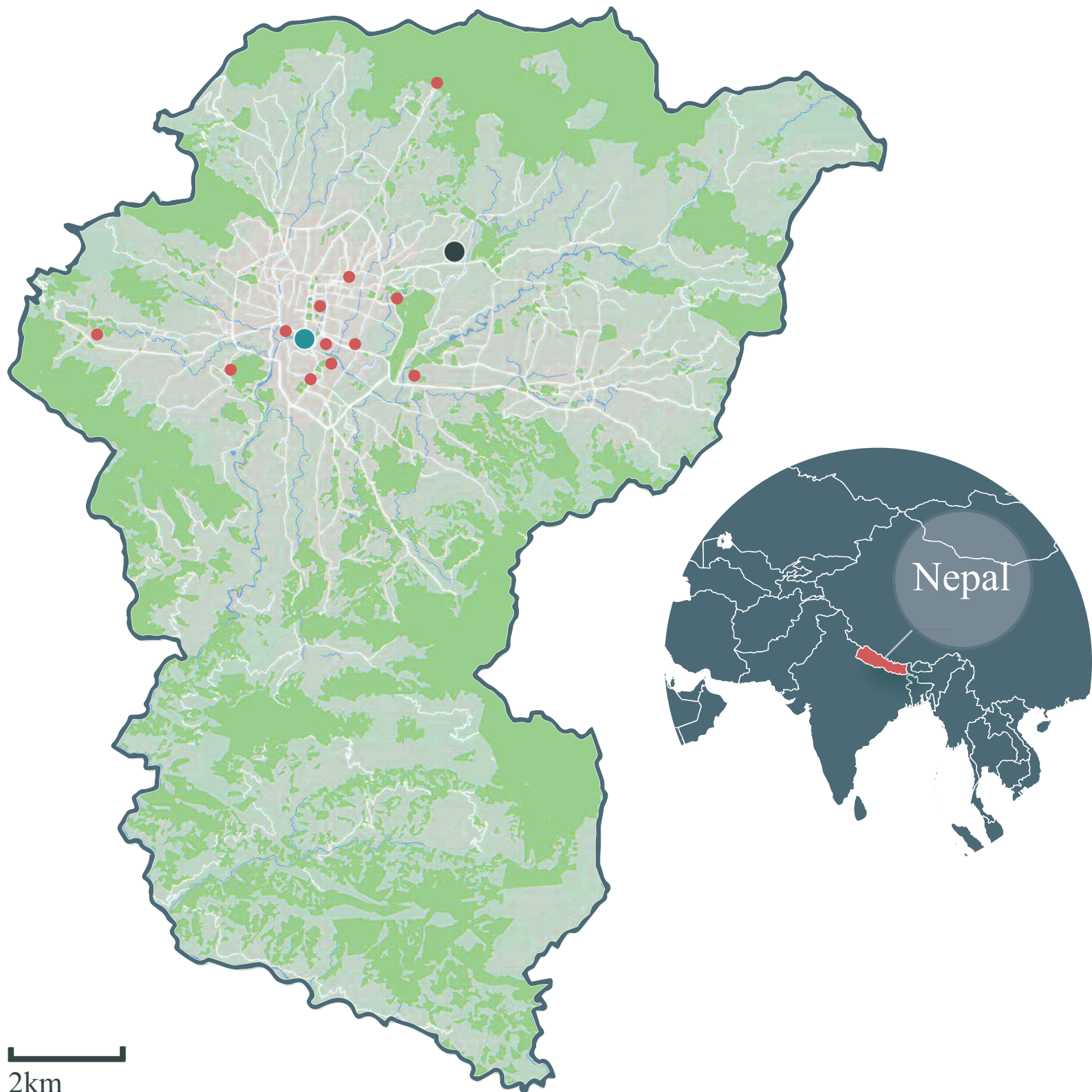
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Kathmandu



Legend

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

