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Variation in perception about blue-green infrastructures at NMBU campus, Ås.

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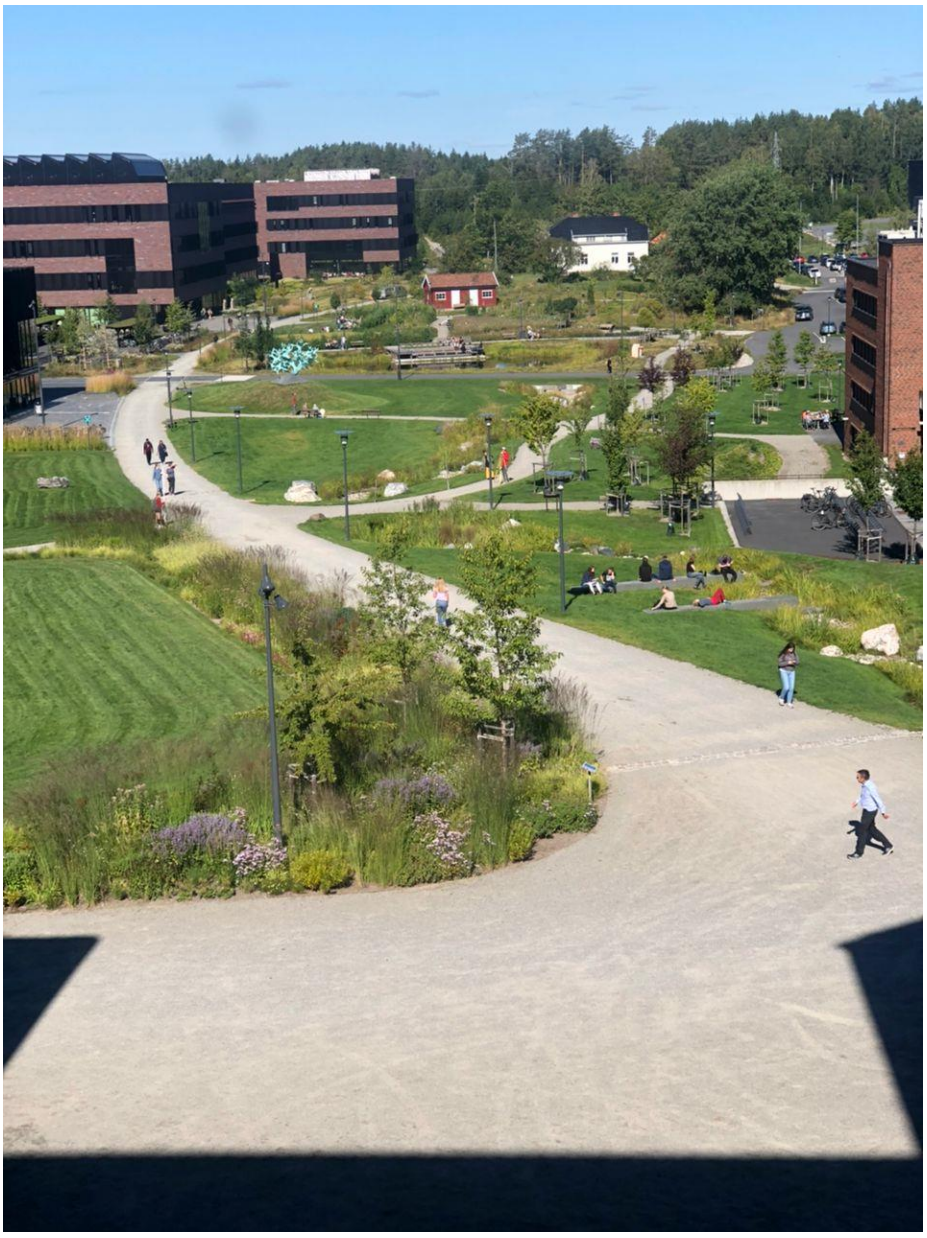
Master in International Environmental Studies

VARIATION IN PERCEPTION AMONG STAKEHOLDERS OF BLUE-GREEN INFRASTRUCTURE AT NMBU, ÅS



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Preface

This master's thesis was written for the Institute of Landscape Architecture at the Norwegian University of Life Sciences and marks the completion of my master's degree in landscape architecture. The thesis is weighed 30 credits (ECTS).

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Declaration

I, Rosemary Ebosetale Aghedo, declare that this thesis is a result of my research, investigation, and findings. Sources of information that are not my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for an award of any type of degree.

Rosemary Ebosetale Aghedo

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ABSTRACT

Blue-green infrastructures have been widely adopted as a climate mitigation strategy and provide multiple ecosystem benefits. An evaluation of the perception of blue-green infrastructure among the public can be useful for policy development and spatial planning. Since blue-green infrastructures are considered to enhance the aesthetic quality of a landscape, it is important to know how different categories of users feel about such landscape elements. The case study area is in the campus of the Norwegian University of Life Sciences. Using a mixed-methods approach, a total of 131 responses were collected from students, municipality residents and other individuals who utilize the infrastructure in any way. The findings revealed a general similarity in aesthetic preferences and ecosystem benefits enjoyed, among the different stakeholders. Although slightly significant differences were recorded when socio-demographic factors were included alongside individual responses. The responses indicate that gender, distance to the infrastructure, nationality and environmental consciousness of individuals play a significant role in the perception of blue-green infrastructures among stakeholders. This is linked to the fact that the respondents live at various distances from the infrastructure, those who attend school or work may tend to live closer to the infrastructure thus enjoy most of the benefits than others. The group of students had a total of 23 nationalities which infers that their preferences may vary based on what they are accustomed to in their home country. Among the 11 benefits of blue-green infrastructure listed in the survey, most respondents preferred habitat for plants and animals, water storage to prevent flood and clean water for the environment but were also concerned about ease of maintenance.

Keywords: blue-green infrastructure, ecosystem services, perception.

Contents

1.INTRODUCTION

Climate change, urban densification and population increase have caused increased global mean temperature and have led to increasing flood risks globally (Drosou et al., 2019; O'Donnell et al., 2021; Venter et al., 2023). Present statistics reveal that approximately 25% of the world's population is susceptible to flood incidence (Tellman et al., 2021). Such documented trends threaten livelihoods and have led to the need for more sustainable ways of climate adaptation particularly in dense residential areas (Everett et al., 2018). In Norway, a rapid temperature increase of about 4.5 degrees is expected at the end of the century with proposed increase in rainfall intensity (Hanssen-Bauer et al., 2015). Many major cities, also in Norway have adapted infrastructures and approaches to help mitigate the effect of climate change (Udas-Mankikar and Driver, 2021).

Landscape planners and Architects are continuously trying to respond to this challenge by incorporating blue-green infrastructures in their designs (Ahern, 2013). The term 'blue-green infrastructure' emerged around 2005 as a sustainable mitigation method, 'blue' refers to water bodies like wetlands, ponds, lakes while 'green' refers to the land components such as gardens, parks, forest (Gledhill and James, 2008; Demuzere et. al., 2014). Blue-green infrastructure is a strategically planned network of natural and designed landscape components aimed at abating environment degradation and increasing climate resilience (EEA, 2019). They are multifunctional, man-made structures which aim to integrate natural elements to solve climate issues, particularly stormwater management and enhance environmental quality as well as maintain natural diversity (Jose et al., 2015). These infrastructures can provide several ecosystem services, and their functioning depends on sound design, quality of maintenance and attitude of the users (Muthanna et al., 2018; Lamond and Everett, 2019).

The concept of ecosystem service is a compound term used to describe benefits by humans from ecosystems, both natural and man-made (MEA, 2005). The services could be regulating, provisioning, or cultural; ranging from habitat for plants and animals, clean water for nature or people, air quality, water storage to prevent flooding, recreation, general experience of health, amenity and aesthetics, educational or research opportunities, provision of jobs, improved sense of place and, reducing urban heat (MEA, 2005; Liu et al., 2014, Schroeter et al., 2014; Aronson et al., 2017; Imerzeel et al., 2021). The ecosystem services derived from BGI are enjoyed on different scales by different individuals, thus their perception varies.

Perception in this context refers to the way or manner an entity is understood or regarded. The perceived amenity and aesthetics of blue-green infrastructures can contribute to the positive well-being and experienced health among visitors and nearby inhabitants and thus be

considered a cultural service (Boyd and Banzhaf, 2007). However, perception may vary among categories of people, therefore obtaining and evaluating their perception is important. It may also help to possibly provide more optimal solutions that are equitable and inclusive based on the local context rather than a homogenous top-down approach (Tompkins et al., 2008; Broto et al., 2015). User inquiries may also elicit other views on the case under study that may have roots in different world views or forms of knowledge (Martín-López et al., 2012). This non-economic valuation of blue-green infrastructure offers ways to identify intrinsic values of stakeholders that may be hindered by monetary incentives (Martín-López et al., 2012).

The perception of blue-green infrastructures may be influenced by perceived effectiveness against flooding, public knowledge on the importance of these structures, how and where they are located, and visual appeal (Lamond and Everett, 2015). The level of education, risk perception and environmental mindedness also influences the public's perception of blue-green infrastructure. This can affect implementation and alter their longevity (Tompkins et al., 2008; Mallette et al., 2021). With an overall continuous process of urbanization, which often involves more compact, denser and sealed urban spaces, there is need to integrate precautionary measures and including flooding and water quality management in urban planning becomes increasingly paramount (Drosou et al., 2019).

In a bid intensify efforts towards implementation of blue-green infrastructure, The Norwegian Environmental Agency in conjunction with The Norwegian Nature Inspectorate (SNO) was commissioned with the task of identifying and developing more nature-based solutions for climate adaptation and mitigation in 2016 (Sefo et al., 2021). In 2018, the Norwegian parliament authorized that nature-based solutions should be used in resolving climate change issues unless in exceptional cases (Muthanna et al., 2018). In Norway, blue-green infrastructure was traditionally envisioned to tackle only flood risks, however addressing other socio-cultural services became relevant with increasing climate change (Amorim et al., 2021). Concurrently, some municipalities in Norway have made it mandatory to incorporate blue-green infrastructure in their urban infrastructural plans (Oslo kommune, 2014). Some notable examples of blue-green infrastructures have been implemented such as the ‘Moellendalselven River park’ in Bergen. The project is composed of a restored river and green space which help improve habitat for plants and animals and reduce flooding. The project's outcome is to also increase citizen engagement through public interaction and water quality for trout production to encourage recreational fishing (ERDF, 2020). In Oslo, a substantial number of blue-green infrastructures have been provided in public spaces and residential areas such as the ‘Tullinløkka park,’ ‘Bjørvika waterfront development and Hovinbekken (Ødegård, 2016). Moreover, there is increasing awareness on issues related to environmental justice and equity pertaining access to blue-green infrastructures (Venter et al., 2023).

This thesis will first give a comprehensive literature review describing previous studies while highlighting strengths and limitations. The case study is then introduced followed by a detailed description of the method used to collect and analyze data. Results are presented and used to elaborate the discussion about perception among different stakeholder groups. The study will discuss how to overcome implementation barriers by having better interactions with users and intensifying education on the importance of blue-green infrastructure.

1.1. Purpose of this research

The purpose of this study is to reveal if there are similarities or differences between the perception, aesthetic quality and benefits of blue-green infrastructure enjoyed by the different groups of respondents. The study will also discuss how to assess different stakeholders' knowledge on blue-green infrastructures, their needs, the benefits they accrue, their opinion on how effective these structures are in adapting to climate change and how environmentally conscious they are in general. Although, there is increasing research about blue-green infrastructures in Norway, this thesis addresses the fact that more can be done to ensure that the stakeholders' needs are taken into consideration when designing mitigation strategies. It provides a distinct perspective on how environmental consciousness of individuals determines what ecosystem services they view as most important and how the perception of blue-green infrastructures varies among different types of users. The outcome of this study can also be utilized by urban landscape planners and decision makers to help address priorities, achieve strategic objectives, and support replication in other parts of Norway (Mallette et al., 2021).

1.2. Research questions

1. How do different user categories perceive the blue-green infrastructure located at the campus of NMBU?
2. How do these users appreciate the aesthetic quality of the blue-green infrastructure?
3. How do these users appreciate the different ecosystem services potentially provided by the blue-green infrastructures and what factors explain the difference in perception?

2. LITERATURE REVIEW

Several studies on perception of blue-green infrastructures from different parts of the world have been described in scientific reports. However, not much has been documented in Norway (Chamberlain, 2020). This section will examine the importance of blue-green infrastructures and reveal the most important ecosystem services enjoyed by respondents as seen in various studies. It will also state why it is necessary to acknowledge users' perception.

Besides stormwater management, which is its key function blue-green infrastructures have numerous benefits which cannot be overemphasized (Persson et al., 2018, O'Donnell et al., 2020). Habitat for plants and animals is a benefit which has been recorded as most important in several studies (Williams et al., 2019, Tan and Ng., 2015). It functions to increase biodiversity, reduce genetic erosion and foster inter and intra-specific relationships between plants and animals. Tan and Ng (2015) during their review of scientific literature between 1980 to 2015 revealed that 'habitat for plants and animals' was a major factor that led to the increased population of flora and fauna within certain locations. A recent study conducted in the UK examined public perception of blue-green infrastructures in six different cities located in the South-east and East midlands of England. It revealed that most people chose wildlife and open spaces as the most preferred services but disliked aspects of leaf litter and pests that surrounded the waterbodies (Williams et al.,2019).

Only a few studies rated aesthetics as the most important benefit of blue-green infrastructures. A study conducted by Dushkova et al., (2021), in two major cities Perth and Moscow located in Australia and Russia respectively, revealed that respondents mostly selected 'aesthetics and enjoying the scenic view' as the highest benefit closely followed by 'mental health benefit'. In addition, Baptiste et al., (2015) identified aesthetics value as a major factor which improved the acceptance of blue-green infrastructures during a survey in Syracuse, New York.

Climate change induces environmental, economic, and social stress and blue-green infrastructures aid to alleviate these impacts. A survey by Zhang et al., (2020) in Guangzhou, revealed that respondents had an overall positive perception of blue-green infrastructures. The most important blue-green infrastructures service to the respondents was air purification and they were willing to pay more to keep enjoying this regulating service. The World Health Organization has suggested that individuals who reside in urban areas should have access to public green spaces within 300m of residence as it would help increase their overall wellbeing (WHO, 2017). This was also confirmed in a study by Dushkova (2021), where it was recorded that blue-green infrastructures helped to improve the mental health of residents during the covid-19 pandemic. Different services may be considered most important in different places. Thus, the perception and degree of importance placed on blue-green infrastructures by stakeholders depends on the needs of the individuals within the community, and it can be assessed in different ways.

A study by Tompkins et al., (2008), utilized the 'Scenario-based stakeholder engagement' to reveal to what extent stakeholders are willing to support integration of blue-green infrastructures. This approach provides an opportunity for stakeholders to discuss alternative options and encourage centralized decision making. The study revealed that residents wanted to actively participate in making decisions so pragmatic solutions are realized. Lamond and Everett (2019), in their findings revealed that acknowledging the ecosystem services enjoyed by users and trying to enhance them will encourage user-interaction thus increasing longevity of blue-green infrastructures. A huge disadvantage of not recognizing these services is that it may lead to conflicts between different stakeholders (Kati and Jari, 2016). This was the case in a study conducted by Kati and Jari (2016), which explored the attitudes of residents towards blue-green infrastructures in Finland. The article stated that lack of optimizing the multiple services provided by the infrastructures was a major cause of the Kumpulanpuro storm-water management conflict. A major limitation to this study revealed that different benefits are enjoyed in different seasons, and this should be clearly delineated from the start. This literature review shows that perception of blue-green infrastructures has been well studied, but significant knowledge gaps still exist in Norway. Studies integrating stakeholders' viewpoints at the local level are particularly needed.

3. METHODOLOGY

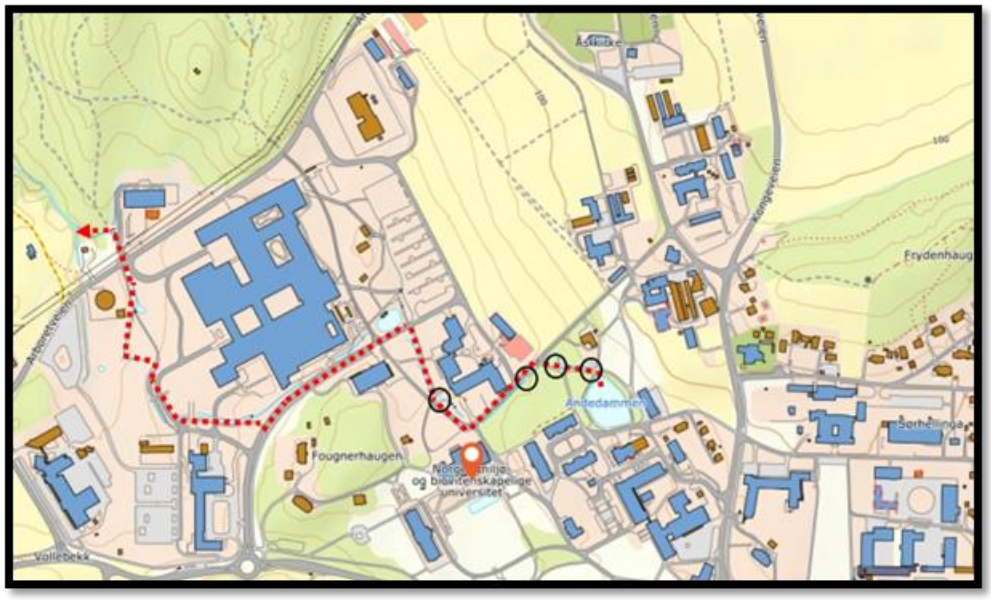
3.1. Study area

The blue-green infrastructure at the Norwegian University of Life Sciences (NMBU) was selected as a case study because it is a novel project with potential that could be an example for other public institutions. The university has principles which are in line with achieving the sustainability goals, including goal 11"Making cities and communities inclusive, safe, resilient, and sustainable" (UN, 2022a). As a result, it is sometimes assumed that the university's values may influence the environmental consciousness of its staff and students. The blue-green infrastructure is thought to contribute to enjoyment of walking, running, cycling, reading or relaxing, observing wildlife and plants, photography, socializing or meeting, and learning experiences for all users including kids (SPARE, 2021).

The Norwegian University of Life Sciences is located in Ås, Southeastern Norway. It is one of the most beautiful campuses in Norway and is quite known for its greenery. These green areas and ponds are multifunctional and various categories of use exist. Ås (59°39'37" N 10°47'1" E) is peri-urban and has a population 20,652 (Statistics Norway, 2021). NMBU students make up a significant part of the population. Traditionally, the region is an important farming area in Norway.

The blue-green infrastructure at NMBU consists of a small brook with gravel stones lining the sides, some rainbeds, bank vegetation and a larger pond with benches for relaxation. The pond's purpose is to temporarily store water and reduce runoff through infiltration (Jose et al., 2015). The brook is landscaped to form a series of subsequent ponds, enhancing sedimentation and flood retardation. This pond runs into Lake Arungen (see in Figure 1) and there is a need to prioritize stormwater management to prevent overflow.

Figure 1**:** The study location is at NMBU campus. The Map shows the location of pools along the blue-green infrastructure indicated with black circles and displays the direction of water flow into the main lake.



3.2. Survey design

The survey was developed using a standard approach where the first draft was written and assessed by a focus group (Brooks et al., 2014, Dillman et al., 2014). Then the questions were reevaluated, and a final version was produced. Each question was formulated to address the research questions and carefully worded for easy understanding by the respondents. The survey was written in English and translated to Norwegian.

The questionnaire consisted of both quantitative and qualitative questions. Besides demographic information, Likert scale-based questions (strongly agree – strongly disagree) were utilized to facilitate completion by the respondents and allow for comparative analyses across questions. The standard New Ecological Paradigm (NEP) scale questions were included to get a standardized record of the environmental mindedness and worldview of the respondents (Dunlap and Van Liere, 2000). The distance of participants' homes to the infrastructure site and various activities usually done were requested. Pictures of specific sites along the structure were included to gauge aesthetic preferences and perception among survey participants. The pictures were also put in place so respondents could connect their knowledge on blue-green infrastructure with the study site (Jose et al., 2015). The English version of the questionnaire is included in Appendix 1.

The survey lasted from mid-August 2022 till the end of September 2022. General Data Protection Regulation (GDPR) guidelines were adhered to by registering the collection of

personal data with the Norsk Senter for Forskningsdata (Norwegian Center for Research Data).

3.3. Sampling respondents

Purposive sampling was used to select survey participants. It was distributed both physically and online with NMBUs digital nettskjema form. The questionnaire was shared on social media platforms LinkedIn and NMBU-group chats on Facebook.

Personal mail was sent to students from different faculties to ensure that responses were gotten from students who do not study environmental courses. Experts with professional knowledge of BGI outside NMBU were also sent mails and contact was sought with a major research institute on campus, NIBIO, as well as Ås municipality. Physical questionnaires were handed out to Ås residents. The survey was answered by 131 respondents in total: 53 NMBU students, 35 NMBU staff, 14 NMBU non-academic staff, 21 Ås residents, 3 non-NMBU research institute on-campus, 3 visitors and 2 others. Random and non-structured qualitative interviews were also conducted with gardeners who maintain the blue-green infrastructure and kindergarten teachers who often bring kids around the campus. The responses from both groups are included in the discussion section.

3.4. Data analysis

The respondents were categorized into three main groups for easier data analysis namely: ‘NMBU students’, ‘Ås residents’ and ‘Others’. The category ‘Others’ consisted of the subgroup, NMBU non-academic staff, Non-NMBU researchers, visitors and others.

The data were coded into the Statistical Package for the Social Sciences (SPSS) and analyzed. Univariate General linear Model (GLM) analysis was used to identify variation between fixed factor (user category), random factors (nationality, gender), and covariates (age, distance from the infrastructure and frequency of visits to the infrastructure) when compared with the dependent variable. While significant differences in the evaluation of blue-green infrastructure benefits among the three groups were identified using Kruskal-Wallis test, the results are adjusted for ties. Simple regression was also carried out to compare the number of visits against the categories of respondents.

4. RESULTS

4.1. Characteristics of respondents

The median age group of NMBU students was 25 which is significantly different from Ås residents and others whose median age was 50.5 and 42 respectively (Table 1). Women were highly represented across all categories. Bicycles were noted as the most frequent mode of transportation often used to access campus with a total of 35% as opposed to public transport which was the least used transport form with 11%. There was a median of 20 visits per month, but Ås residents had a significantly lower median of 4 visits per month. The number of people who lived in urban areas while growing up was significantly different from those who currently reside in urban areas. 85% of the respondents have attained higher education and a significant 66% are employed. Among the Ås residents, respondents were mainly Norwegian, and a similar trend was observed in the category 'others'. However, a significant difference was observed in the nationality of NMBU students in the survey. A total of 23 nationalities were among the respondents. NEP-scores range from 1 to 5 with low numbers indicating anthropocentric and high number ecocentric worldviews (Thiemer et al., 2023). The mean NEP score across the three groups revealed no significant difference with values 3.17,3.05 and 3.11 for NMBU students, Ås residents and others respectively ($p = 0.89$). Nonetheless, a significant difference was observed when the NEP score was analyzed based on gender with females being more ecocentric.

Table 1: Socio-demographic profile of respondents represented as percentage and number of respondents per category. Median and standard deviation (S.D) of age and number of visits is indicated. The total number of respondents who recorded their response is denoted by the letter N. The last column gives the level of significance of Kruskal-Wallis test comparing the three categories of respondents. Bold fonts represent significant values. Frequency distribution of the NEP score is also represented with Likert scale numbers and p-value is < 0.05.

Variable	Category	N	NMBU students	Ås residents	Others	P- value
Age	Median ± S.D	126	25±4.6	50.5±11.6	42±21.6	**<0.001**
Number of visits	Median ± S.D	130	20±13.7	20±7.5	4±13.0	**<0.001**
Gender	Male	131	25% (13)	38% (8)	47% (27)	0.44
	Female		66% (35)	62% (13)	51% (29)	
	Others		3% (2)	-	2% (1)	
	Prefer not to say		6% (3)	-	-	
Education	Secondary	131	9% (5)	-	-	0.21
	Vocational		6% (3)	10% (2)	5% (3)	
	Higher		77% (41)	90% (19)	90% (51)	
	Others		8% (4)	-	5% (3)	
Previous living status	Urban	131	60% (32)	29% (6)	46% (26)	**0.04**
	Rural		40% (21)	71% (15)	54% (31)	
Current living status	Urban	131	47% (25)	10% (2)	40% (23)	**0.01**
	Rural		53% (28)	90% (19)	60% (34)	
Nationality	Norwegian	131	23% (18)	10% (8)	67% (52)	**<0.001**
	Others		66% (35)	25% (13)	9% (5)	
Employment status	Student	130	74% (39)	5% (1)	4% (2)	**<0.001**
	Employed		26% (14)	86% (18)	95% (54)	
	Unemployed		-	5% (1)	-	
	Others		-	4% (1)	1% (1)	
NEP score	2	131	4% (2)	10% (2)	11% (6)	0.64
	3		75% (40)	76% (16)	68% (39)	
	4		21% (11)	14% (3)	21% (12)	

4.2. Perception of blue-green infrastructures

Respondents reported varying views about the influence of blue-green infrastructures on their recreational possibilities with a significant difference between the groups. In total, 65% of NMBU students responded with “I don’t know” when asked if the blue-green infrastructure led to an increase in recreational possibilities. While only 22% of Ås residents signified that the recreational possibilities were much improved after construction. The reported ease of accessibility disclosed that 48 respondents 37% in total recorded that it was very easy to access the infrastructure whilst only 5 respondents 4% indicated that it was very hard. The contribution of blue-green infrastructures to the enjoyment of observing wildlife and plants was significantly higher than running as seen in median Likert score in (Table 2).

Table 2: Activities carried out around the BGI are indicated in the table below with frequency of response per category (denoted by letter N). The overall median Likert score per category is recorded together with individual scores per respondent group. The numbers in brackets indicate the frequency of response per respondent group. P- value is result of the Kruskal-wallis test difference among the three groups. Bold fonts represent significant values.

Activities around the BGI	N	Overall Median	NMBU students	Ås residents	Others	P
Walking	124	4	4 (50)	4 (20)	5 (54)	0.26
Running	61	3	3 (24)	3 (12)	3 (25)	0.08
Cycling	72	4	5 (33)	4 (13)	4 (26)	0.85
Relaxing or reading	96	4	5 (45)	4 (17)	4 (34)	**0.04**
Observing wildlife and plants	106	5	5 (42)	5 (18)	5 (46)	0.39
Photographing wildlife and plants	82	4	4 (29)	4 (16)	5 (37)	**0.03**
Socializing or meeting	112	4	5 (48)	4 (18)	4 (46)	**0.04**
Others	60	3	3 (21)	3 (7)	3 (32)	0.09

4.3. Aesthetics of blue-green infrastructure

Many of the respondents described the general aesthetics of the blue-green infrastructure as good (47%) as opposed to 8% who indicated that it looked bad. Respondents rated ‘Picture E’ (see Figure 2) consisting of a clear retention lake with seating area as the most beautiful, closely followed by ‘Picture C’ made up of a pond and trees. The reason stated for the former is its picturesque and aesthetics features and the latter with 40 respondents viewed it as the ‘most beautiful’ with reasons being linked to habitat for plants and animals. Preference of

Picture C may suggest a high desire for natural looking systems which is similar to the study by Williams et al., (2019).

Some notable comments from respondents about the pictures include ‘Picture E - you can sit by the water while enjoying a beautiful view of the lawn and surrounding’ 17#, ‘Picture E – exciting for kids’, ‘Picture C - most diverse, authentic and supports many ecosystems’4#, ‘Picture C - the natural appearance of the pond is remarkable’ 35#. Although ‘Picture B’ was the lowest ranked with 33 respondents, a respondent commented ‘Picture B - I like it the most because of the variation of plant species grown’.

Figure 2: Pictures from different sites on the blue-green infrastructure (from top left to right). (a) Site with pool of water and different variety of plants with a plank constructed across to aid accessibility (b) Site without pool of water and different variety of plants (c) Pool with vegetation along its path and a lot of leaves on the surface (d) Site with fine stones and gravel lined with vegetation (e) Large pool of water with fine stones underneath and a sitting area along the water bank.

4.4. Ecosystem services provided by the blue-green infrastructure

“Habitat for plant and animal”, “Water storage to prevent flood” and “Clean water for the environment” were consistently rated as the main ecosystem services provided by blue-green infrastructures. There were however significant differences in the rating of other benefits across the three groups, these are explored in Table 3.

Table 3: Benefits of the blue-green infrastructures are indicated in the table below with frequency of response per category (denoted by letter N). The overall median Likert score per category is recorded together with individual scores per respondent group. The numbers in brackets indicate the frequency of response per respondent group. P- value is result of the Kruskal-wallis test difference among the three groups. Bold fonts represent significant values. ($p<0.05$).

Benefit of BGI	N	Overall Median	NMBU students	Ås residents	Others	P value
Habitat for plants and animals	124	5	5 (52)	5 (17)	5 (55)	0.34
Clean water for nature	123	5	5 (49)	5 (19)	5 (55)	**0.03**
Air quality and improvement	124	5	5 (50)	4 (19)	4 (55)	**0.02**
Water storage to prevent flood	125	5	5 (50)	5 (18)	5 (57)	0.29
Recreation	125	4	4 (49)	4 (20)	4 (56)	0.24
General experience of health	128	4	4 (50)	4 (19)	4 (59)	0.63
Amenity and aesthetics	128	4	4 (52)	4 (19)	4 (57)	0.63
Education	118	4	4 (48)	5 (18)	4 (52)	**0.006**
Provision of jobs	121	4	4 (50)	3 (18)	4 (53)	0.34
Improved sense of place	118	4	4 (49)	5 (19)	4 (50)	0.46
Reducing urban heat	113	4	5 (48)	4 (17)	4 (48)	**0.01**

4.5. Factors that explain the difference in perception

General Linear Model analysis was done to analyze all the survey questions. Analysis was done between dependent variables and fixed factor (user category), random factors (nationality, gender), and covariates (age, distance from the infrastructure and frequency of visits to the infrastructure). A lot of results were generated but only general linear model variables with significant p-values are presented in Table 4 below. The factors which explain difference in perception include distance to the blue-green infrastructure, user category, frequency of visits to the infrastructure, age, gender, and nationality.

Simple regression was carried out to compare the number of visits against the categories of respondents. This was done to measure if any relationship exists between the variables (ref). The explanatory variables included to run this test includes age, distance from NMBU and NEP score. A significance of 0.03 (p-value) was realized. In addition, regression analysis was

carried out to find if other socio-demographic factors influence aesthetic appreciation of the infrastructure. The factors included in this test were previous and current living status and covariates (age and days per month). No significant effects were reported.

Table 4: Overall comparison of the results from the GLM with user category (NMBU, Ås residents and Others) as fixed factor, nationality and gender as random factors, and lastly, age, distance from the infrastructure and frequency of visits to the infrastructure as covariates. ($p<0.05$).

Dependent variable	GLM explanatory variables	GLM significance
Walking	User category*gender	0.02
Running	User category*nationality	0.004
	User category*gender	0.04
Relaxing or reading	User category*nationality	0.04
Observing wildlife and plants	Distance from NMBU	0.01
Photographing wildlife and plants	Distance from NMBU	0.002
Socializing or meeting	Distance from NMBU	0.02
Mode of transportation	Age	0.04
	Distance from NMBU	0.02
Easy accessibility to BGI	Frequency of visits to the BGI	0.02
Habitat for plants and animals	Distance from NMBU	<0.001
Clean water for nature	Distance from NMBU	0.006
	Nationality*gender	0.05
Air quality	Distance from NMBU	0.003
Water storage to prevent flood	Distance from NMBU	<0.001
General experience of health	Distance from NMBU	0.006
Amenity and aesthetics	Frequency of visits to the BGI	0.006
Improved sense of place	User category*nationality*gender	0.05
General perception of BGI	Frequency of visits to the BGI	0.04
Picture E	Frequency of visits to the BGI	0.03
Previous living status	User category*nationality	0.01
Current living status	Distance from NMBU	0.002

5. DISCUSSION

Overall, the number of respondents is a sufficiently large subsample of the total population. The results obtained demonstrate that the different categories of users have a positive perception towards blue-green infrastructure in general but statistically different perspectives on aesthetics and ecosystem services provided.

5.1. Perception of blue-green infrastructures

Respondents in general did not know if there was a difference in their activities after construction of the blue-green infrastructure which suggests that they may not have had prior knowledge of blue-green infrastructure. Also, there is a possibility that most of the respondents have not been around the campus long enough to know about the situation before the blue-green infrastructure was constructed. This was also confirmed during the process of handing out the paper questionnaires where most of the respondents admitted that they had not heard the term 'blue-green infrastructure' previously. Likewise, a respondent mentioned that they would like to know more about the ecological impact of the infrastructure. From this observation it can concluded, in line with Renata and Kinga (2023) that increasing public awareness on the benefits of blue-green infrastructures would be helpful.

Perception of blue-green infrastructure was obtained from individual responses to the question about activities usually carried out around the infrastructure. The answers revealed that most respondents participated in more than one activity. When rated on a Likert scale, 'socializing' and 'relaxing' were the two major activities carried out, which infers that the infrastructure makes the activity more enjoyable and fulfilling. There was a correlation between socializing and distance from NMBU with a significant p-value of 0.02 (Table 4). This is quite logical as individuals who live closer to the infrastructure will most likely use the infrastructure frequently for social interaction. Whereas the perception of how the infrastructure contributes to observation of wildlife and plants was quite low and may be increased by introducing a more diverse variety of ornamental plants. This may also increase the photography of wildlife and plants.

With regards to accessibility, many of the respondents indicated that it was very easy to access the blue-green infrastructure. Similar comment was made by the kindergarten teachers who stated that they enjoy bringing the kids to play around the blue-green infrastructures on campus because it is easy to access and safe. This reveals that easy accessibility may increase the frequency of activities such as cycling or running.

Interestingly, the observed mean NEP score was 3.1±0.4 was lower than that found in other studies in Norway. Thiemer et al., (2023) had a mean of 3.4, Immerzeel et al., (2022) also had a slightly higher mean of 3.5 and Bjerke et al., (2006) also had a significantly high mean of

3.8. This indicates a downward trend of the perceived environmental mindedness of individuals overtime.

5.2. Aesthetics of blue-green infrastructure

However, many respondents described the general aesthetic of the blue-green infrastructure as good which implies that even if they do not know all the functions, they find it aesthetically appealing. In addition, Amenity and aesthetics had a median of 4 and 53 respondents (Table 3), particularly Ås residents and others rated it as highly important. Most respondents rated the scenic landscape 'Picture E' as the most beautiful and further commented on how the aesthetic quality increases their overall enjoyment and wellbeing. Preference was particularly high for the landscape with clear water free from aquatic weeds and debris as opposed to 'Picture B'. Hence, such apparent neatness points to maintenance as an issue to be taken into consideration in the design of these infrastructures. Although, this choice may have been influenced by the photo's framing and weather conditions.

The issue of maintenance was also brought up by the gardeners who maintain the blue-green infrastructure during a non-structured interview. They commented that "the debris in the pond is much more than the previous year" which makes the water look muddy and makes the cleanup process more time consuming. Another respondent stated that although C is the most natural looking there is fear that algae build up will occur making the water look unappealing - 36#.

Also, 43 respondents indicated that the landscape lined with pebble stones was very beautiful. When asked respondents suggested 'Picture D - they look very natural and calming- 43#', 'the stones look very aesthetic and complement the lawn in the background 46#'. Although, concern was expressed that this may lead to poor infiltration.

5.3. Ecosystem services provided by the blue-green infrastructure

Furthermore, respondents ranked Habitat for plants and animals, water storage to prevent flooding and clean water for nature as the three most important benefits. This also reveals that the individuals believe that blue-green infrastructures can sufficiently help adapt to climate events. However, this is opposed to the study by Jose et al., (2015).

Respondents with higher NEP score had a very strong preference for habitat for plants and animals and were mainly Norwegians between the ages of 21-35. This also reveals that age may play a role in influencing the type of activities carried out around the blue-green infrastructures.

Overall, there is a high appreciation of other ecosystem services provided which is reflected in the fact that respondents commented that they engage in activities such as playing

Pokémon, dog walking, work meetings and seminar, confirmation events, and excursion. These extra activities were mostly reported by Ås residents and others which indicates that more people may be willing optimally enjoy the benefits of blue-green infrastructures. This implies that easy accessibility and close distance to residential areas may influence how often it is being used. When asked about visual landscape preference, 40 respondents chose 'Picture C' which is a natural looking pond that supports the habitat of small life forms. This trend was also observed in the studies by Derkzen et al., (2015), Hayden et al., (2015), and Williams et al., (2019). This means that while many respondents appreciate aesthetics, they are similarly concerned about other components which contribute to ecosystem function.

5.4. Factors that explain the difference in perception

As observed in Table 4, the major factor which explains the difference in perception in this survey is the distance between residence of the respondents and the blue-green infrastructures on campus. This prominent factor influences habitat for plants and animals, observing wildlife and plants, socializing and meeting, mode of transportation, reducing urban heat and so on. This reveals that closer people live to the infrastructure, the likelihood of them frequently utilizing the benefits. Other factors which explain difference in perception include user category, frequency of visits to the infrastructure, age, gender, and nationality. NEP score was significantly different when categorized based on gender. This is similar to the findings of Drosou et al., (2019).

The age of respondents had an influence on mode of transportation. This is because older respondents may be able to afford cars while younger respondents who are mostly students may not earn much and thus make use of cheaper modes of transportation. In addition, nationality was observed to influence sense of place which suggests that Norwegians or respondents who have lived here for long.

The results show that from a stakeholder's perspective it is highly relevant to know the benefits of blue-green infrastructures because knowledge has a huge influence on individuals' perception. This is further proved by Renata and Kinga (2023) that showed students who study biology related courses understood the importance of blue-green infrastructures in sustenance of ecological status compared to other students.

5.6. Methodological limitations and data gaps of the study

Firstly, the sample size may not have been fully representative of the total population. This is because the total population of Ås residents, students, and staffs at NMBU sums up to 10,950 (Statistics Norway, 2021) and similar studies on stakeholder's perception of blue-green

infrastructure had 282 responses (Jarvie et al., 2017) and 442 responses (Williams et al., 2019).

The questionnaire should have asked if respondents have heard about blue-green infrastructures before and how they heard about it. This will help in giving urban landscape designers a baseline on how to disseminate information about blue-green infrastructure. In addition, words used to phrase the different ecosystem services and benefits could have been discussed more thoroughly to ensure that there was little overlap as possible. An example is the ‘aesthetics and amenity’ stated as one of the benefits, this should have been rephrased because the word ‘amenity’ has several meanings.

Further research could be carried out in the future, to compare if answers of respondents vary in different seasons. This may help to identify other underlying services provided by the blue-green infrastructure at different times of the year. This implies that the data collection should be carried out over a longer period of time as this survey was only carried out in the autumn.

6. CONCLUSION AND LESSONS LEARNT

The results from this study show that different user categories have a generally similar perception of the blue-green infrastructure. About 65% of the NMBU students do not have a recollection of the situation before the blue-green infrastructure came into place. This is similar to respondents in the category 'Others' with 62% who indicated that their recreational possibilities have 'neither increased nor reduced' since the blue-green infrastructure was established. Nevertheless, when asked further questions respondents indicated a positive perception of aesthetics and ecosystem services provided by the blue-green infrastructure.

The different categories of users appreciate the aesthetic quality of the blue-green infrastructures in a similar way with only slight variation when asked to select their favorite picture view. NMBU students mostly preferred the natural looking pond with plants while Ås residents and respondents in the category 'others' responded that the large pond with sitting area was their favorite. The most frequently mentioned benefit to respondents is habitat for plants and animals whereas clean water for nature and water storage to prevent flooding are also often mentioned. Although a similar trend was observed between respondent groups, different groups of respondents' slight variations occurred in their appreciation of the different functions, this is the case for Ås residents who have a higher appreciation for sense of place, while NMBU students indicate that the blue-green infrastructures contribute more to their activity of relaxing and reading. On the other hand, the respondents in the category 'Others' indicated that they enjoy socializing and meeting around the infrastructure.

Climate change has necessitated nature-based solutions, thus more should be done to educate the public on numerous importance of blue-green infrastructures.
Lessons learnt from this survey is that awareness about blue-green infrastructure is limited and outcome of this study could be used to improve strategic planning and inclusion of model blue-green infrastructure in urban and landscape design, as a conscious effort in mitigating climate impacts which may enhance scenic beauty.

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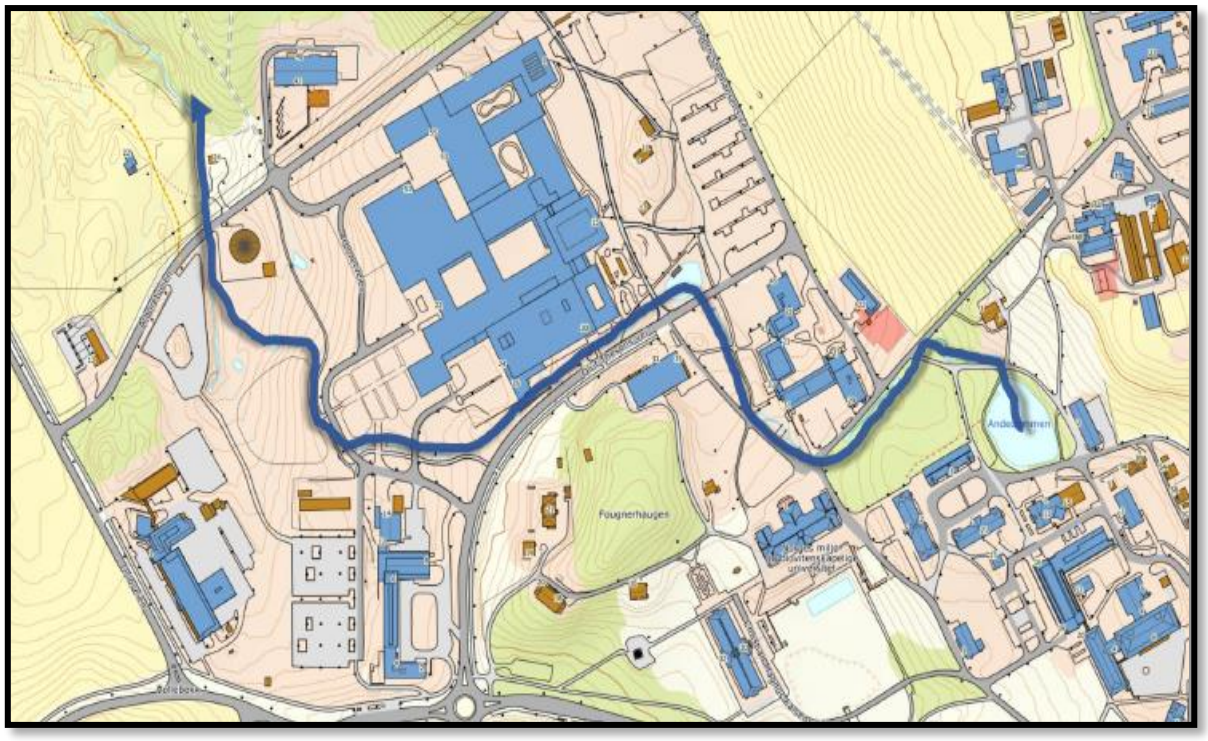
APPENDIX 1

Survey questionnaire

Questionnaire:

Perceptions of the bluegreen infrastructure on NMBU's campus in Ås



Location of the blue green infrastructure on the campus of NMBU. Basemap: Norgeskat

ABOUT THIS SURVEY

Climate change is predicted to lead to an increased intensity and frequency of heavy rain events. This is likely to lead to increased flooding particularly in urban areas, parks, and along natural drainage structures. Blue-green infrastructure is a strategically planned network of natural and designed landscape components aimed at abating environment degradation and increase climate resilience.

We are interested in your views on the recently completed blue-green infrastructure on the campus. It consists of a stream channel and its surrounding vegetation, as well as connected ponds and vegetated rain beds. The photo shows part of the infrastructure during a recent rain event. In addition to increased biodiversity in and around the new streams, it also provides an area where people may like to recreate.

Your answers will help in determining the effects of developments regarding blue-green infrastructure on individuals and society. All answers are important – it is not necessary that you have specific knowledge of blue green infrastructure, water management or ecology. Thank you for your willingness to

participate in this survey.

Completing the survey takes about 15 minutes. Your responses will be kept confidential and individual responses cannot be identified from the data or traced back to you. If you have any questions concerning the study, please contact rosemary.aghedo@nmbu.no

QUESTIONS

1) Select the user category that best describes your position

a)	NMBU student	☐
b)	NMBU academic staff	☐
c)	NMBU non-academic staff	☐
d)	Ås resident	☐
e)	Visitor	☐
f)	Non-NMBU Researcher or environmental authority	☐
g)	Other	☐

2) How often do you visit the campus in a month?

…… days

3) What activities do you usually carry out within the campus? Multiple answers are possible.

a)	Walking	☐
b)	Running	☐
c)	Cycling	☐
d)	Relaxing or reading	☐
e)	Observing wildlife and plants	☐
f)	Photographing wildlife and plants	☐
g)	Socializing or meeting	☐
h)	Others: …….	☐

4) To what extent does the blue-green infrastructure on campus contribute to your enjoyment of the following activities?

		Very little	Little	Indifferent	Much	Very much	I don't know
a)	Walking	☐	☐	☐	☐	☐	☐
b)	Running	☐	☐	☐	☐	☐	☐
c)	Cycling	☐	☐	☐	☐	☐	☐
d)	Relaxing or Reading	☐	☐	☐	☐	☐	☐
e)	Observing wildlife and plants	☐	☐	☐	☐	☐	☐
f)	Photographing wildlife and plants	☐	☐	☐	☐	☐	☐
g)	Others	☐	☐	☐	☐	☐	☐

5) How far away do you live from NMBU? (Kindly write your answers in km)

…… km

6) What mode of transportation do you use to access the campus? Please mark only one option

a)	Car	☐
b)	Bicycle	☐
c)	Public transport	☐
d)	Walking	☐
e)	Others……	☐

7) How easy is it to access the blue-green infrastructure on campus for recreational or aesthetic purpose?

a)	Very hard	☐
b)	Hard	☐
c)	Neutral	☐
d)	Easy	☐
e)	Very Easy	☐
f)	I don’t know	☐

8) If the surrounding lawn around the pond was not accessible due to poor maintenance or flooding, would you seek an alternative area outside of campus buildings? If so, would you go to:

a)	In front of Ur building	☐
b)	In front of Tower building	☐
c)	In front of Sørhellinga	☐
d)	Jordfags geologihage	☐
e)	Others: …….	☐

9) The blue-green infrastructure generates benefits for society. Please indicate how important the following benefits are for your own well-being.

		Highly Unimportant	Unimportant	Neither Important nor Unimportant	Important	Highly Important	I don't know
a)	Habitats for plants and animals	☐	☐	☐	☐	☐	☐
b)	Clean water for nature	☐	☐	☐	☐	☐	☐
c)	Air quality improvement	☐	☐	☐	☐	☐	☐

d)	Water storage to prevent flood	☐	☐	☐	☐	☐	☐
e)	Recreation	☐	☐	☐	☐	☐	☐
f)	General experience of Health	☐	☐	☐	☐	☐	☐
g)	Amenity and aesthetics	☐	☐	☐	☐	☐	☐
h)	Educational or research opportunities	☐	☐	☐	☐	☐	☐
I)	Provision of jobs e.g., for gardeners and maintenance	☐	☐	☐	☐	☐	☐
j)	Improved sense of place	☐	☐	☐	☐	☐	☐
k)	Reducing urban heat	☐	☐	☐	☐	☐	☐

10) Please indicate your top 3 most important benefits from the list above. Write down the letter from the first column related to the benefits.

1.	
2.	
3.	

11) How would you describe the aesthetic view of this blue-green infrastructure indicated on the map on page 1 in general?

Bad	Moderate	Good	I don't know
☐	☐	☐	☐

12) On a scale of 1-5 with 5 being the highest, how would you rate the aesthetic view of different parts of the blue-green infrastructure. Note that these pictures have been taken on different occasions.

		Very Ugly	Ugly	Neutral	Beautiful	Very Beautiful	I don't know

a)		☐	☐	☐	☐	☐	☐
b)		☐	☐	☐	☐	☐	☐

c)		☐	☐	☐	☐	☐	☐
d)		☐	☐	☐	☐	☐	☐

e)		☐	☐	☐	☐	☐	☐

13) Please indicate with a letter which of the pictures above is most beautiful in your opinion and briefly describe what makes it most attractive.

14) If you have been in Ås for about two years or more, Do you think your recreational possibilities have increased over the last two years, after the construction of the infrastructure in 2021?

No	A little	Yes	I don't know	I have been here for less than two years
☐	☐	☐	☐	☐

Background Information

16) What is your age?

a)	Age in years….	☐
b)	Prefer not to say	☐

17) What is your gender?

a)	Male	☐
b)	Female	☐
c)	Other…..	☐
d)	Prefer not to say	☐

18) What is your nationality?

a)	Norwegian	☐
b)	Other…	☐

19) In what kind of neighbourhood did you grow up?

a)	Rural area or village	☐

b)	City or town	☐

20) In what kind of neighbourhood do you currently live?

a)	Rural area or village	☐
b)	City or town	☐

21) What is the highest level of education you have received? Please choose only one answer.

a)	Primary school	☐
b)	Secondary school	☐
c)	Vocationary education	☐
d)	Higher education	☐
e)	Other education: …....	☐

22) Are you currently employed? Please choose only one answer.

a)	Yes, I am employed	☐
b)	I am unemployed	☐
c)	I am retired	☐

d)	I am a student	☐
e)	I manage the household	☐
f)	No, other reason: ……...	☐

23) In which sector do you work (pensioners and unemployed: past work)? Please only choose one answer.

		Public	Private
a)	Agriculture	☐	☐
b)	Forestry	☐	☐
c)	Building and construction	☐	☐
d)	Manufacturing industry	☐	☐
e)	Energy and mining	☐	☐
f)	Fishery	☐	☐
g)	Healthcare	☐	☐
h)	Education	☐	☐
i)	Student	☐	☐
j)	Other services	☐	☐
k)	Others: ……...	☐	☐

24) Please indicate to what extent you agree or disagree with the following general statements.

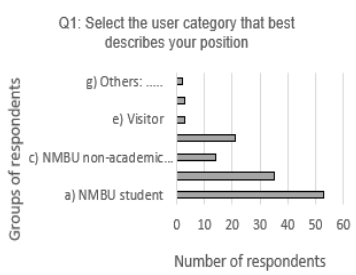
		Strongly Disagree	Disagree	Neither agree nor disagree	Strongly Agree	I don't know
a)	We are approaching the limit of the number of people the Earth can support.	☐	☐	☐	☐	☐
b)	Humans have the right to modify the natural environment to suit their needs.	☐	☐	☐	☐	☐
c)	When humans interfere with nature it often produces disastrous consequences.	☐	☐	☐	☐	☐
d)	Human ingenuity will ensure that we do not make the Earth unlivable.	☐	☐	☐	☐	☐
e)	Humans are seriously abusing the environment.	☐	☐	☐	☐	☐
f)	Earth has plenty of natural resources if we just learn how to develop them.	☐	☐	☐	☐	☐
g)	Plants and animals have as much right as humans to exist.	☐	☐	☐	☐	☐

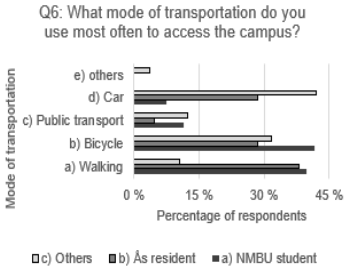
h)	The balance of nature is strong enough to cope with the impacts of modern industrial nations.	☐	☐	☐	☐	☐
i)	Despite our special abilities, humans are still subject to the laws of nature.	☐	☐	☐	☐	☐
j)	The so-called “ecological crisis” facing humankind has been greatly exaggerated.	☐	☐	☐	☐	☐
k)	The Earth is like a spaceship with very limited room and resources.	☐	☐	☐	☐	☐
l)	Humans were meant to rule over the rest of nature.	☐	☐	☐	☐	☐
m)	The balance of nature is very delicate and easily upset.	☐	☐	☐	☐	☐
n)	If things continue their present course, we will soon experience a major.	☐	☐	☐	☐	☐
o)	If things continue their present course, we will soon experience a major ecological catastrophe.	☐	☐	☐	☐	☐

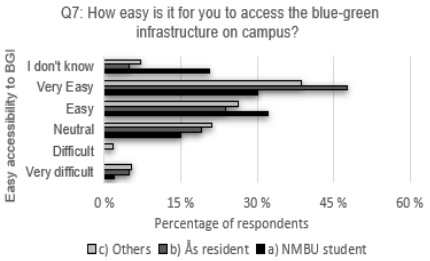
Thank you very much for taking the time to fill in this questionnaire. Below there is some room for additional comments.

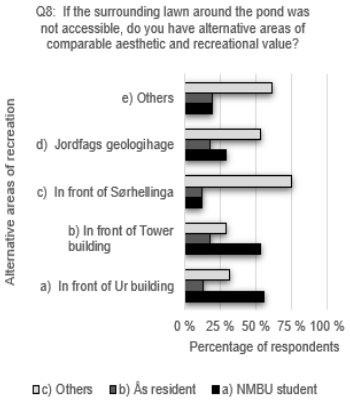
APPENDIX 2

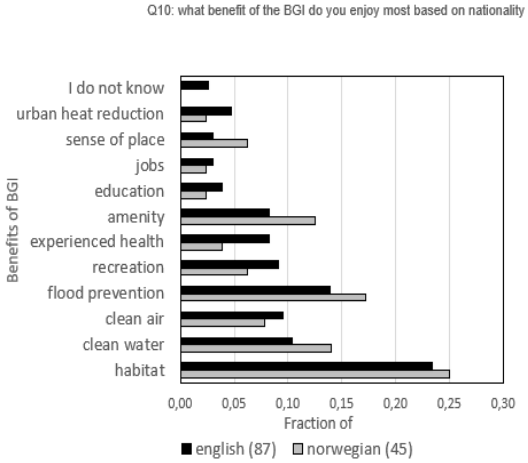
The figures below show the responses of respondents to the survey questions. Only quantitative questions with visible differences are presented in the bar graphs below. The respondent groups are divided into three main groups; NMBU students, Ås residents and Others (combination of NMBU non-academic staff, Non-NMBU researchers, visitors and others).

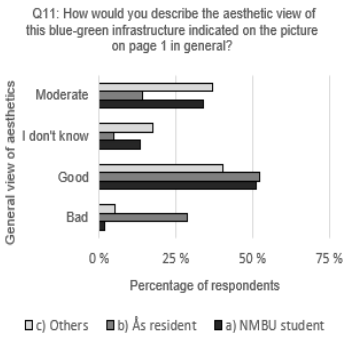


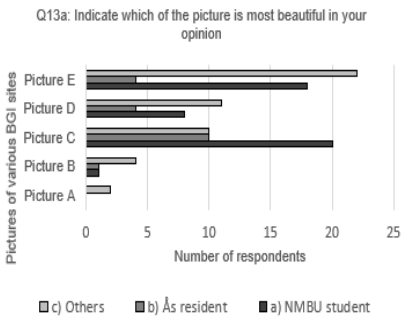


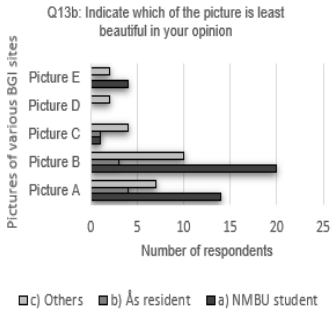


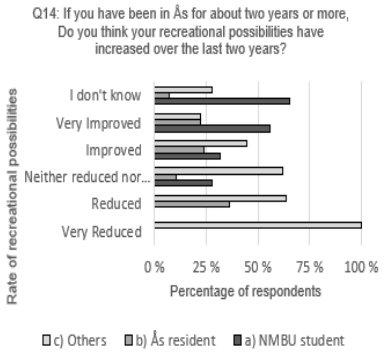


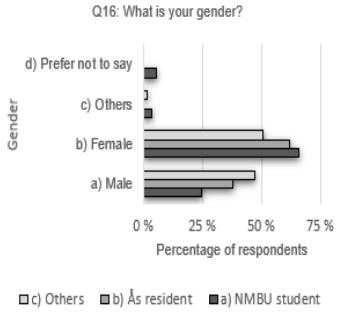


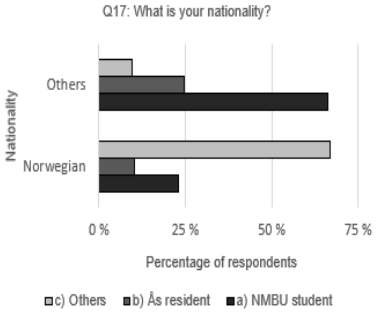


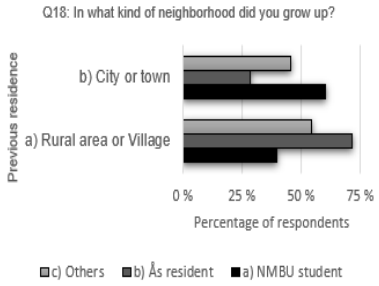

Q13a: Indicate which of the picture is most beautiful in your opinion
Pictures of various BGI sites
Picture E
Picture D
Picture C
Picture B
Picture A
0
5
10
15
20
25
Number of respondents
c) Others
b) Ås resident
a) NMBU student

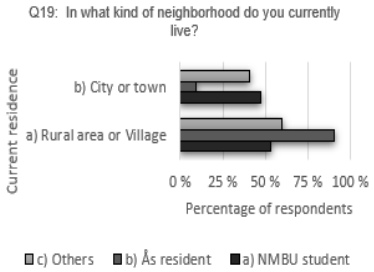

Q13b: Indicate which of the picture is least beautiful in your opinion
Pictures of various BGI sites
Picture E
Picture D
Picture C
Picture B
Picture A
0
5
10
15
20
25
Number of respondents
c) Others
b) Ås resident
a) NMBU student

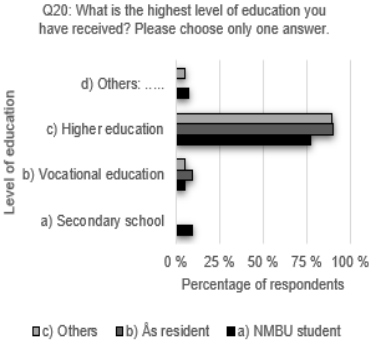

Q14: If you have been in Ås for about two years or more, Do you think your recreational possibilities have increased over the last two years?
Rate of recreational possibilities
I don't know
Very Improved
Improved
Neither reduced nor...
Reduced
Very Reduced
0 %
25 %
50 %
75 %
100 %
Percentage of respondents
c) Others
b) Ås resident
a) NMBU student

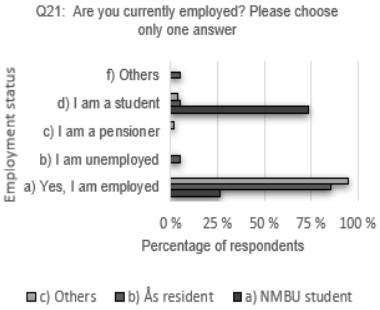

Q16: What is your gender?
Gender
d) Prefer not to say
c) Others
b) Female
a) Male
0 %
25 %
50 %
75 %
Percentage of respondents
c) Others
b) Ås resident
a) NMBU student

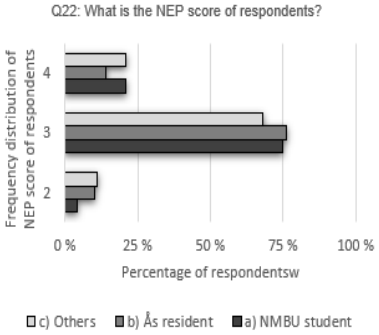

Q17: What is your nationality?
Nationality
Others
Norwegian
0 %
25 %
50 %
75 %
Percentage of respondents
c) Others
b) Ås resident
a) NMBU student

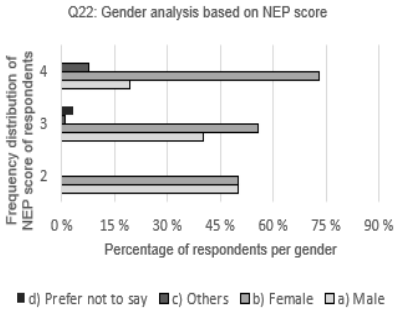

Q18: In what kind of neighborhood did you grow up?
Previous residence
b) City or town
a) Rural area or Village
0 %
25 %
50 %
75 %
Percentage of respondents
c) Others
b) Ås resident
a) NMBU student


Q19: In what kind of neighborhood do you currently live?
Current residence
b) City or town
a) Rural area or Village
0 % 25 % 50 % 75 % 100 %
Percentage of respondents
c) Others
b) Ås resident
a) NMBU student


Q20: What is the highest level of education you have received? Please choose only one answer.
Level of education
d) Others: .....
c) Higher education
b) Vocational education
a) Secondary school
0 % 25 % 50 % 75 % 100 %
Percentage of respondents
c) Others
b) Ås resident
a) NMBU student


Q21: Are you currently employed? Please choose only one answer
Employment status
f) Others
d) I am a student
c) I am a pensioner
b) I am unemployed
a) Yes, I am employed
0 % 25 % 50 % 75 % 100 %
Percentage of respondents
c) Others
b) Ås resident
a) NMBU student


Q22: What is the NEP score of respondents?
Frequency distribution of NEP score of respondents
4
3
2
0 % 25 % 50 % 75 % 100 %
Percentage of respondentsw
c) Others
b) Ås resident
a) NMBU student


Q22: Gender analysis based on NEP score
Frequency distribution of NEP score of respondents
4
3
2
0 % 15 % 30 % 45 % 60 % 75 % 90 %
Percentage of respondents per gender
d) Prefer not to say
c) Others
b) Female
a) Male

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