

Article

Sustainable Urban Drainage Systems: Themes of Public Perception—A Case Study

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Abstract: Climate adaptation measures address the challenges that densification and climate change impose on the urban environment. Sustainable urban drainage system (SUDS) constructs include the introduction of natural elements, such as riparian buffers, vegetative filters, rain beds, water spills, watermark filters, retainers and dams, and are an integral part of these climate adaptation measures. SUDS are commonly undertaken at a municipal level in Norway but, unfortunately, the implementation of SUDS projects has lagged behind expectation. Norway is a normative and egalitarian society, where public resistance to local projects is a factor in the delayed adoption of SUDS. That is why a greater understanding of public perceptions and priorities is needed to build consensus and support for these climate adaptation measures. This research looked at the Blaklibekken SUDS case study in Trondheim, Norway. A cross-section of interviews with the municipality and users was undertaken to establish themes within local perceptions of the project. Themes of environmental benefit, child-related activities, maintenance of the site and funding were established to provide a better understanding of public expectations and what aspects of the project correlated with public acceptance or resistance. This work provides a starting point for further research to establish public ‘themes of interest’ that can provide decision makers greater insight into public priorities.



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Keywords: stormwater management; nature-based solutions; SUDS; climate change; public perception; climate adaptation

1. Introduction

1.1. Climate Change and Urban Flooding

The Nordic countries are projected to be disproportionately affected by climate change. These changes will be marked by an increase in temperature, precipitation, and intensity and frequency of rain events [1–3]. Norway currently has an average annual rate of precipitation that is 20% higher than it was 100 years ago, with an additional increase of 20% expected by the end of this century [1,3]. For Norway, the increase and effects of torrential rain on the built environment are considered the greatest technical challenge of climate change, and its impacts are already evident in urban areas [4–8]. Traditional closed systems, such as underground pipelines, have limited capacity and little ability to detain collected surface water [9]. The intensified loads brought on by climate change will add further strain on surface water drainage, burdening the existing systems, thus increasing risks to buildings and infrastructure [6,7]. Compounding these challenges, aging outmoded infrastructure within Norway’s existing urban environments is already beyond capacity [6,10]. The burden on these existing systems is also exacerbated by the continued densification of cities and loss of pervious surfaces, increasing the risk of flooding in localized events [10,11].

In response to these challenges, Norway has adopted policies and regulations nationally for the management of water within the urban environment. The Norwegian Water

Directive is drawn from the European Union (EU) Water Framework Directive, which is intended to improve and protect the environmental status of all ground and surface waters within the EU and Norway [12–14]. The policy stipulates that bodies of water should, as far as possible, be maintained or returned to their natural state to maximize their ecological potential [13]. Within the Norwegian Water Directive these guidelines direct Norwegian municipalities to employ the use of sustainable urban drainage systems (SUDS) [7].

1.2. Sustainable Urban Drainage Systems (SUDS)

Within the field of landscape architecture and urban planning, the concept of sustainable urban drainage infrastructure is loosely defined. The European Commission emphasizes the importance of “spatial structures of natural and semi-natural areas and environmental features, which enable citizens to benefit from its multiple services” [13]. Berg et al. (2013) outlined (soil–water–plant systems) infrastructure as being within the contextual interactions between buildings, urban activity and the climatic environment [15]. Within this paper, the term SUDS, are constructs that include the introduction of natural elements, such as riparian buffers, vegetative filters, rain beds, water spills, watermark filters, retainers and dams, rather than active mechanical installations [16,17]. The terminology of urban drainage is complex and more thoroughly discussed by Fletcher et al. (2015) [3].

Norway’s water management policies and regulations have prioritized the application of passive SUDS [16]. This approach to managing stormwater and urban floods is called the ‘three-step strategy’ [18]. First, a SUDS intercepts and infiltrates small storm events; second, it delays and detains medium events; and, finally, it establishes safe flood paths for larger events [10,19]. This three-step strategy is also used by Copenhagen Municipality in its stormwater management plan, where it is termed ‘blue-green infrastructure’ [20]. The three steps are illustrated in Figure 1.

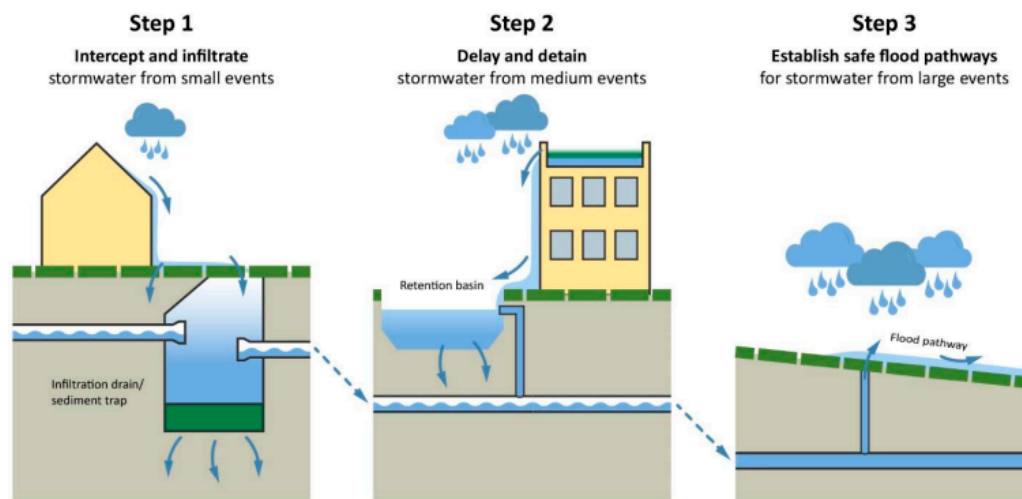


Figure 1. Norwegian three-step strategy for stormwater management. Illustration: Klima 2050/SINTEF [21].

SUDS have been promoted at the political and bureaucratic level as providing affordable cost-effective solutions for municipalities, while also creating added values beyond managing stormwater, such as experiential qualities, recreation values, biodiversity and purification [15,20]. The European Commission Environmental report has said, ‘Contrary to single-purpose, traditional grey infrastructure, green spaces can perform a variety of very useful functions, often simultaneously and at a fraction of the cost. One of the key attractions of green infrastructure is this multi-functionality’ [14]. They have also been promoted as ‘important arenas for learning, local identity and understanding of nature’ [22].

1.3. Climate Adaptation within Norway: Implementation and Preception

Within the Norwegian Water Directive, there is a requirement for a coordinated planning process across various authorities and with the active participation of all types of users. The water regional authority is responsible at the county municipal level in each water region, with the work being led by a water area committee. This committee is meant to provide local knowledge and generates local proposals for environmental measures [23]. While these structures have been set forth and put into place within the framework of the Norwegian Water Directive, an evaluation report has stated that ‘there is a great need for more knowledge and support processes by follow-up commissions’ [22].

While, the measures within the Norwegian Water Directive should be adequate to safeguard climate adaptation within Norway, at the municipal level, implementation often fails [24] and the adoption of SUDS projects has lagged behind expectation [22]. Klaussen et al. (2015) found that in urban planning, climate adaptation occurs randomly, and this is typically due to longstanding, conventional routines, policies, or strategies [25]. Identified challenges to implementation have included: conventional attitudes to planning, resistance to change, lack of knowledge and competence, unequal access and engagement with support networks, and a short supply in the recruitment of highly qualified personnel [24]. Additional studies showed that municipalities lack the right kind of competence and expertise to succeed with climate adaptation [26,27]. Næss et al. (2011) confirmed that in many municipalities the recruitment of highly qualified personnel was problematic and impeded the application of climate initiatives [28]. It is also recommended that within Norway, ‘climate adaptation guidelines and other tools are necessary to support planning and other decision-making processes. Effective climate adaptation consequently depends as much on structures and processes as on technical concepts and solutions’ [29].

At the municipal level, the SUDS projects proposed and undertaken have at times received strong public resistance [30–32]. To address these challenges, initiatives like ‘climate adaptation networks’ comprised of governmental, academic and industry partnerships were undertaken at the national level to increase awareness at the municipal level of how cities might manage climate challenges [33,34]. The municipalities engaged in these networks undertook far more adaptive planning and executed more measures than municipalities unaffiliated with such networks [8]. Research also called for greater interdisciplinary competence in strategy, planning and project management [35]. A focus on the translation of research evidence into practical advice for the landscaping profession is also a priority, especially in the face of climate change [36].

Landscape aesthetics provides a critical linkage between humans and ecological processes, where Gobster et al. 2007 argues that this ‘ecological aesthetic’ affects landscape planning, design and management. ‘Understanding how people perceive and experience landscapes is central to achieving public support of, and compliance with, ecologically motivated landscape change’ [37]. Wetland landscapes, especially bogs or swamps, are an often-cited example of landscapes that are extremely important ecologically but are not perceived to be scenically attractive [37].

Gaining community support for SUDS requires a greater understanding of public perceptions because, in contrast to hidden grey infrastructure, SUDS often changes the visible urban environment, involving shifts in what flood risk management and water treatment involve and look like. Consequently, agendas and funds for their installation and maintenance are often subject to greater residential scrutiny [38]. Hoyle et al. 2001 argued that actions can be devised to create landscapes in the future that are ecologically beneficial and simultaneously aesthetically pleasant. Landscape planning, design and management that address these aesthetic concerns can be powerful ways to protect and enhance ecological goals [39]. Ecological aesthetics is more thoroughly discussed by Hoyle et al. 2017 [39] and Gobster et al. [37].

1.4. Objective and Scope

Within the context of this research, we reviewed the Blaklibekken SUDS case study in Trondheim, Norway. A thorough review of public documentation and published discourse regarding the site spans from 2010 to 2021 and semi-structured interviews with various actors and site users were collected, categorized, and coded. This was undertaken to identify and provide an understanding of the local users' perceptions and what aspects of the project, design, maintenance, and ways the municipality engaged the public informed the users' perceptions of the site. Further, we sought to create themes of public interest to better understand acceptance or resistance to these projects. The following research questions were outlined:

1. What were the perceived benefits or drawbacks of a SUDS?
2. What themes emerged from the perceived benefits or drawbacks of the SUDS?
3. How can themes drawn from the users' perspectives of a SUDS project inform the front-end of project planning?

This research was conducted within the methodological model of grounded theory. This method of analysis begins with the formulation of a theory around a single data case. Therefore, the theory and, in this case, themes were 'grounded' in actual data. Additional cases should be examined to confirm and develop the original theory. These findings were aimed at public policymakers and municipal administrations within the Norwegian and the European context. The general conclusions are also relevant for other egalitarian countries with similar climate challenges. The study's ethics was approved by the Norwegian Center for Research Data.

2. Case Study: Blaklibekken, Trondheim, Norway

Location and Scope

Approximately half of the Trondheim municipal drainage network, which manages both sewage and overflow, is currently piped [31]. This aging infrastructure within the urban environment was already shown to be beyond functioning capacity [40]. These piped areas were often once naturally occurring drainage tributaries that spilled into Trondheim's main river the Nidelven and Trondheim fjord. Not unique to Trondheim, increased stormwater runoff due to urban development and climate changes have further compromised the integrity of these stormwater systems [31,40]. During rapid snowmelt and intense rainfall, the current system regime no longer has the capacity to adequately manage the water [31,40]. To respond to these challenges and meet the call of the European Water Directive and Norwegian Water Management Standards, Trondheim municipality is working to incorporate the adoption of SUDS into the planning process.

The Blaklibekken site is located at the southern end of Trondheim municipality (63°23'24" N, 10°26'09" E) in an area that was previously farmland but has been developed as a mixed-use residential area since 2005, with the construction of residential multi-family apartment blocks continuing adjacent to the site at the time of this article's publication. At the north end of the site is a large facility owned by a commercial organization and a transformer station, and to the south of the site, a public sports hall is located. Residential development adjacent to the site is a mix of occupant-owned apartment blocks to the east and townhouses to the west. A children's daycare abuts the northwestern section of the site (see Figure 2).



Figure 2. Aerial view of the Blaklibekken site (Maxar Technologies, map data © 2022).

The Blaklibekken site is a green corridor over 400 m in length and was proposed as a multi-functional combination of a SUDS project and public recreation space. The site was designed as a diversion facility for surface water discharged from the surrounding areas with retention and detention ponds, as the piped system downstream had limited capacity. The project was first completed with three ponds to manage water runoff, with two ponds close to the kindergarten and one further south. It was later found that the capacity of the first most northerly pond was poorly functioning and was converted into a stream in 2015 [17]. The site was meant to be landscaped for both wet and dry weather. A footpath followed the length of the site north to south. A bridge was added that traverses the north pond and docks jut out over both ponds. Numerous fixed and loose play fixtures were included in the original design and dispersed across the site. The site was managed for the first 3 years by the neighborhood developer that contracted the larger development and then management was taken over by the Trondheim municipality. Corrections were made to the smaller pond in 2012 [17]. Figure 3, which shows the photographic timeline of Blaklibekken, illustrates the environmental conditions, patterns of vegetative growth and changes in water quality from project completion in 2010 through 2021.



Figure 3. Photographic timeline of Blaklibekken site. 2010/2012 Photo: [30]. 2016 Photo: [22]. 2020 Photo: Author.

Within 2 years of the project's completion, the municipality started to receive numerous complaints regarding the site. These complaints were sent directly to the municipal offices, articles in local newspapers covered public dissatisfaction with the site, complaints were lodged with the city's political board and local community groups published scathing condemnations of the site when protesting the introduction of proposed SUDSs in other various neighborhoods [17,22,30,32].

The Blaklibekken site was evaluated in 2016 as part of a feasibility study on stormwater management called 'Overvann som Ressurs' and funded by The Research Council of Norway [22]. The assessment was based on four criteria of project performance: hydrology, ecology, operation and phenomenological performance. Phenomenological performance

within this evaluation included visual impression, phenomenology and social spaces. The report found that the main challenges identified were attributed to ‘poor execution that now presents operational challenges’, where recommendations included: reduce the algae growth/clean ponds annually (sludge suction/flushing), mow twice a year and budget to implement measures. During this evaluation, there were semi-structured interviews and discussions with industry professionals and operational personnel on site and afterward. Meetings with representatives from the municipalities of Trondheim and interviews were conducted with key professionals from the municipality. Yet, public perceptions and perspectives were not included in the evaluation process [22].

3. Methodology

Grounded theory is the methodological approach that has been applied to the qualitative research in this study and has followed the prescriptions of Martin (1986), Strauss and Corbin (1994) and Faggiolani (2011) [41–43]. Following this methodology, hypotheses and theories are constructed through the collection and analysis of data. Ideas and concepts emerged as data was collected. These ideas and concepts were drawn from a preliminary literature review, which informed theory development. These concepts and theory development were then further informed by open-ended, semi-structured interviews with the municipality. The results of the preliminary literature review and interview with municipal actors informed the interview approach and focused on local site users. Data were then collected in each phase of the research, where ideas and concepts were developed into higher-level concepts and then into categorized themes through the application of inductive reasoning [44]. These themes then provided the basis of our new hypotheses presented in the discussion section.

3.1. Literature Review

An overview of existing documentation informed the analysis of public perceptions by providing the historical background of the site and existing assessments of its performance. This overview included a review of all available project documentation, public records, site evaluations and newspaper articles. All statements regarding public perceptions of the site were cataloged and coded to inform the development of the themes. The reviewed texts were:

- One consultancy evaluation;
- Nine NTNU University engineering evaluations;
- Seven municipal planning commission summaries;
- Six newspaper articles;
- One regional SUDS feasibility study;
- One national review evaluation;
- One municipal plan.

3.2. Interviews

In the qualitative interviews, an open-ended approach was taken to provide participants the freedom and flexibility of describing their own experience and understanding of the Blaklibekken site. These interviews were semi-structured, following the prescriptions of Yin (2009) and Brinkman and Kvale (2014) [45,46]. The intention was to assess people’s impressions of the space, satisfaction with the project’s outcome and whether they felt that the outcomes had met the expected results set forth by the Trondheim municipal planning office. Most importantly, the interviews were conducted to recount the residents’ and users’ impressions and personal opinions of the project’s value and necessity. This was done to determine whether there were common perceptions among the public that influenced the acceptance and satisfaction of the project. The interviews were not undertaken to gauge the public’s actual understanding of the project’s engineering and scientific principles or the policy/regulatory legitimacy.

3.2.1. Semi-Structured Interviews with the Municipality

An interview with the municipality was conducted to record what commonalities and variants in opinion there were between the municipality and users' interview responses. The Blaklibekken project leader and municipal representative from Kommunal Teknikk VA were interviewed. The interview was conducted on 27 June 2020 by phone and notes were taken to document the participant's responses. The municipality was asked to give the context in which the project was undertaken, an overview of the project's history and a summary of the current challenges to the site as identified by the municipality. Additionally, the municipality was given the opportunity to respond to local newspaper reports about the project. Quotes taken from these interviews were incorporated into the discussion section to illustrate the convergences and divergences of perspective between the municipality and the public. Identities were withheld to protect their privacy. The results of the municipal interviews were used to inform and provide context for the analysis of the users' responses. These interviews provided a foundation with which concepts and theories were developed. Statements from the municipal interviews were included in the discussion to provide greater context to illustrate the convergences and divergences of perspectives.

3.2.2. Semi-Structured Interviews with Area Users

One hundred residents or local users were interviewed onsite at Blaklibekken and the surrounding adjacent neighborhood. The interviews were semi-structured, short interviews, which were conducted over a weeklong period between the 30 June and the 6 July 2020. The day of the week, time of day and place were noted. Weather at the time of interviews and weather period prior to the interview was also documented.

The recruitment of participants was done both onsite and in the adjacent neighborhood; participation was unincited. The onsite interviews were collected along a pathway for foot traffic that people use to go to work, the local sports hall and the daycare, as well as use for exercise. The requirements to participate in the interviews were: to be a resident whose property abuts the sites and/or locals who use the public spaces on a regular basis (once per week).

The demographic characteristics of participants were also included to inform the users' qualitative responses by contextualizing the opinions of respondents. These demographic considerations included: gender, age, user frequency and how long a user had been familiar with the area (Table 1). Open-ended questions allowed the participants the opportunity to share observations, opinions and recommendations. The interviewee's provided responses to the following questions:

1. What are your general opinions of the area?
2. Do you enjoy using the area?
3. Is it well maintained?
4. Do you think this improves the natural environment and quality of the water?
5. Should projects like Blaklibekken be implemented in other areas of Trondheim?
6. Do you have any suggestions to improve future projects like these?

The responses of participants were transcribed. While quotes pertaining to the impression of the residents and locals were included, their identities were withheld to protect their privacy.

3.3. Quantitative Thematic Analysis

All data was logged and managed in MS Excel. The quantifiable data of gender, age, residency, frequency of use, and how long a user had been familiar with the area are cataloged in Table 1. For questions 2–5, the semi-structured interview responses were sorted and categorized by topic, as shown in Table 2, regarding site impressions and enjoyment. These results were then cross-referenced by combining the quantitative demographic data with the qualitative, semi-structured interview responses from which additional correlations were inferred. Whenever possible, an effort was made to compare

data between the residents from various demographic subgroups to see how attitudes and perceptions might vary.

Table 1. Sample characteristics.

Variable		Total
N	100	100
Gender	Male	45.8%
	Female	54.2%
Age	10–20	0.0%
	20–30	12.5%
	30–40	32.3%
	40–50	25.0%
	50–60	5.2%
	60–70	12.5%
	70 plus	12.5%
Are you a resident of or a frequent user of the Blaklibekken area?	Resident	71.7%
	Frequent user (once a week)	28.3%
How long have you been a (resident/frequent user of the area)?	1–5 years	57.6%
	5–10 years	21.2%
	More than 10 years	21.2%
Were you familiar with the area before the project was undertaken?	Yes	17.0%
	No	83.0%

Table 2. Responses regarding site impressions and enjoyment.

Question	Response	Total
Do you enjoy using the area?	0 (not at all)	4.3%
	1	2.2%
	2	3.3%
	3	23.9%
	4	22.8%
	5 (very much)	43.5%
Does this project add value to the area	Yes	64.9%
	Somewhat	23.7%
	No	11.3%
Is the project site well maintained?	Yes	3.1%
	Somewhat	17.5%
	No	79.4%
Do you think this improves the natural environment and quality of the water?	Yes	73.2%
	Somewhat	14.4%
	No	12.4%
Should projects like Blaklibekken be implemented in other areas of Trondheim?	Yes	83.5%
	No opinion	11.3%
	No	5.2%

3.4. Reflexive Thematic Analysis

Reflexive thematic analysis (TA) is a commonly used inductive (data-driven) approach. This approach is reliant on familiarization through intense immersion with the data, while coding is understood to be an organic and subjective, inductive process [47]. This approach allows for the work to be undertaken by one coder [47]. The findings are drawn from an inductive review of the data results. The analysis starts with observations while theories are proposed toward the end of the research process as the result of observational development [48]. Patterns, resemblances and regularities in experience are organized in order to reach conclusions or to generate a theory [49]. In reflexive TA, there is flexibility and

variability. The conclusions are drawn from the findings of one coder and while reflecting the values of a qualitative paradigm, must be classified as subjective and interpretive [50]. While the work is that of one coder, the process goes through several iterations and is subject to the review of additional experts.

The goal of thematic analysis is to identify themes, i.e., patterns that can provide valuable insight based on the data [47]. This method is not merely a summarization and organization of the data but an analyzed interpretation of it. Here we follow the prescriptions of Braun and Clarke's (2006) six-step framework; this approach offers a clear and usable framework for doing thematic analysis [47,51]. Replication of this method can be achieved following Braun and Clarke's (2013) recommendations, and the practical step-by-step guidelines laid out by Maguire and Delahunt [51,52]. The six-step framework is not necessarily linear and the researcher may move between steps many times. Braun and Clarke's six-phase framework for doing a thematic analysis involves:

Step 1: Become familiar with the data;

Step 2: Generate initial codes;

Step 3: Search for themes;

Step 4: Review themes;

Step 5: Define themes;

Step 6: Write-up.

Themes of public interest were established to inform where obstacles to social acceptance of SUDS were occurring, thus giving greater context to the public's views and what effects and implications these perspectives have on the general acceptance of SUDS. The research involved transcribing and coding quotes from all documentation and interviews to identify factors that affected the perceptions of the residents. The demographic considerations of Table 1 were also triangulated with the participants' responses to questions 1–6 and were categorized into: enjoyment of the area, what elements provided user satisfaction or dissatisfaction and recommendations for improvements (Table 3). An analysis was performed of the free text generated from the interviews and was also coded; from this work, phenomenological themes emerged and were developed.

Table 3. Positive responses, negative responses and potential improvements in free text.

Free Text	Aggregated Response	Total
Positive responses (N = 98)	Has been nice	31.6%
	Pretty area	18.4%
	Nature	15.3%
	Ducks	12.2%
	Improvement	7.1%
	Provides good feelings and well being	5.1%
	Happy with green areas	4.1%
	Better for environment	4.1%
	Pleasant walking area	1.0%
	Docks	1.0%
Negative responses (N = 258)	Not maintained	31.0%
	Overgrown	15.1%
	Cloudy water/algae	12.4%
	Dangerous/not safe for children	9.7%
	Ugly	8.1%
	Dirty/muddy water	7.0%
	Garbage	5.8%
	Water smells bad	3.5%
	Ducks left	2.7%
	Polluted water	2.8%
Features have been removed or stolen	1.2%	
No child activities	0.8%	

Table 3. Cont.

Free Text	Aggregated Response	Total
Areas of improvement (N = 213)	Better maintenance	36.2%
	Child activities	13.1%
	Benches	9.9%
	More activities	4.2%
	Improved safety for children	8.5%
	Plan for funding	8.0%
	Clean water	8.0%
	Make more natural	4.7%
	More landscaping	2.8%
	More plants	2.8%
	Gathering spaces	1.9%

4. Results

TA Summary: The Area Users' Perspective

The demographics of the participants were collected, including: gender, age, residential location, period of residency and historical familiarity. Table 1 is a summary of the documented demographics. A total of 52 women and 44 men reported gender on the onsite survey, with 4 surveys not identifying gender. All respondents were aged 20 or older, with the largest cohort of respondents between the ages of 30 and 40 (32%) and the next largest cohort of respondents was between 40 and 50 (25%). A total of 70% of area users were between 20 and 50 and most of the people in the survey (71%) were residents of the area. The majority (79%) of respondents had lived in the area for less than 10 years: 58% between 1–5 years, 21% between 5–10 years and 21% over 10 years. The majority of people (83%) were unfamiliar with the area before the project was undertaken (see Table 1).

As seen in Table 2, approximately 66% of respondents reported a high enjoyment of the area, rating the site a 4 or 5 on a five-point scale, while only 6% of respondents reported a low enjoyment (0–1) of the area. Two-thirds (65%) of people felt that the project added value, while 24% of respondents felt the project 'somewhat' added value to the area. Only 11% of respondents felt the project did not provide any added value to the area.

The responses from the users during on-site interviews were transcribed as free text, cataloged, aggregated and presented in Table 3. Three primary groupings were established: positive responses (N = 98), negative responses (N = 258) and recommendations for areas of improvement (N = 213). Criticism of the site heavily outweighed positive responses; users were 72% more likely to voice these criticisms. Of the negative responses, the most common criticism made was that the site was not maintained (31%). When these statements were made with greater specificity, they fell into three categories: issues of landscaping (29%), water quality (28%) and child-related issues (12%). Issues of landscaping included: overgrowth (15%), ugly presentation (8%) and garbage (6%). The quality of the water was also discussed at length, with complaints made regarding cloudy water and algae (12%), dirty or muddy water (7%), water smelling bad (4%), polluted water (3%) and a proxy-issue was noted that wild ducks had frequented the pond but no longer visit the area (3%). The child-related concerns centered around safety for children (10%), play features had been removed or stolen (1%) and no child activities (1%).

Of the 98 positive comments cataloged from the user interviews the most commonly stated response was that the site 'has been nice' (32%), which, while placed in the category of positive responses, is a conflicting statement, as it is used in the past tense. A total of 18% of positive statements from these respondents stated that they still considered the area pretty and 7% thought it was an improvement, with 4% considering it better for the environment. The natural aspects of the site were 63% of the collected positive statements. The natural environment (15%), ducks (12%) and enjoyment of the green spaces (4%) were a combined 32% of the responses collected. The impact of the site on health and wellness was also discussed, with (5%) of positive responses referencing that the site provided 'good

feelings of wellbeing'. Meanwhile, only 1% commented on the pleasantness of the area to walk.

There were 213 suggestions for areas of improvement, with 36% of comments pertaining to better maintenance and 8% of comments specifying improving the water quality. Increased child-related activities (13%) were suggested, with 4% of respondents suggesting more activities in general, as were more gathering spaces (2%) and benches (10%). Requests for improved safety for children (9%) and a plan for funding (8%) were also suggested.

Figure 4 shows that even though 66% of users reported positive experiences, these same users also reported a significant amount of negative responses and areas of improvement. However, in general, they were also more likely to find positive elements of the project.

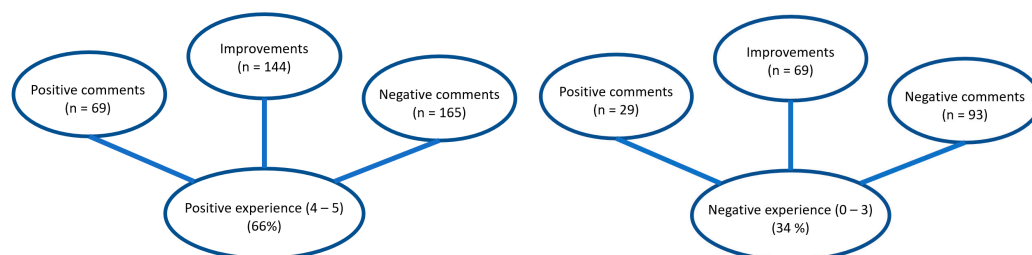


Figure 4. A graphic illustration of public response distributions between positive and neutral or negative experience groups, subdivided into sub-categorized comments by percentages of positive comments, improvement recommendations and negative comments.

5. Discussion

The research acted as an instrument of evaluation through the collection, cataloging and coding of data to deliver hypotheses and grounded theories. The themes drawn from this work provide greater insight into the engagement and relationship between the municipal planning office and the public of the Trondheim commune. Themes were generated and occur at the intersection of the data and interpretation. The researcher's role was one of personal involvement and empathetic understanding. It should be noted that in reflexive TA, there is flexibility and variability. The conclusions were drawn from the findings of one coder and while reflecting the values of a qualitative paradigm, must be classified as subjective and interpretive.

The research focused its findings on the results and analysis of the public's perspective, which was informed through a literature review and preliminary interview with relevant municipal actors. Where appropriate, quotes were taken from the literature and the municipal interviews were included to provide context to the users' responses. The origin and number in the series of included quotes are denoted after the statement: (user interview), (municipal interview) or (article) with the citation succeeding the statement.

The findings of this research are discussed according to each research question in the paragraphs below.

5.1. What Were the Perceived Benefits or Drawbacks of the SUDS?

While, the measures within the Norwegian Water Directive should be adequate to safeguard climate adaptation within Norway, at the municipal level, implementation often fails and implementation of SUDS projects has lagged behind expectation [22,24]. This work sought to better understand 'What were the perceived benefits or drawbacks of a SUDS?' In answering this research question, there seemed to be a discrepancy between expected technical performance and public expectations. Water quality as defined by the EU and as experienced by area users are two completely different things. This site fulfilled the criteria of the Norwegian Water Directive but showed that the current criteria within these standards were not designed to fulfill public expectations for recreation. The purpose of the site was vague in the minds of respondents, where the layout of the site; the design, natural and architectural elements; as well as children's play equipment created confusion.

The stated drawbacks of the site outweighed the stated benefits given by users. As shown in Table 3, users were 72% more likely to voice these criticisms. The most common criticism made was that the site was not maintained (31%). When these statements were made with greater specificity, they fell into three categories: issues of landscaping (29%), water quality (28%) and child-related issues (12%). The most commonly stated positive feedback was the ambivalent statement that the site ‘has been nice’ (32%). Of the 28% of responses that were categorized as positive statements, 18% of these respondents still considered the area pretty and 7% thought it was an improvement, with 4% considering it better for the environment.

5.2. What Themes Emerged from the Perceived Benefits or Drawbacks of the SUDS?

The second objective of this work was to establish ‘What themes emerged from the perceived benefits or drawbacks of the SUDS?’ Themes were developed and categorized into: environmental benefit, child-related activity, maintenance of the site and funding. These themes emerged from the triangulation, cataloging and coding of the demographic considerations shown in Tables 1 and 2, with the open responses cataloged in Table 3. This work was further informed by the cataloging and coding of the municipal interviews and additional preexisting site documentation. An overview of the themes and their context is given; quotes from the interviews are also included to further illustrate the findings.

5.2.1. Environmental Benefit

Residents generally appreciated having a natural space and had vague assumptions that the area would generally improve the environment without a clear understanding of the specific benefits the site provided and almost no technical understanding of the water management processes. In the case of Blaklibekken, ‘It is important that residents understand the solution,’ (municipal interview #2). Yet, ‘It seems like all these natural processes do not meet the expectations of the residents.’ (municipal interview #2).

Of the users who elaborated on the positive aspects of the site (Table 3), those respondents reported that the area provided good feelings, that they enjoyed the natural environment and that they like the green areas. Users considered that the site had improved the area and that proximity to nature was the most appreciated aspect of the site noted (15%); specifically, 12% of respondents noted that the ducks were what they liked most. In particular, respondents within the 30–40 and 60+ age groups requested that there be more benches in the area to enjoy the natural environment and take advantage of the space. There was general confusion as to whether the site was to be maintained as a formal park area or kept natural.

A majority of respondents (71%) stated that the project improved the natural environment and water quality. Respondents in the 30–40 and 70+ age groups were the most favorable of the project in this regard. Respondents between 50 and 70 were the category who found the least benefit; however, even this category were between 58% and 60% positive.

5.2.2. Child-Related Activities

Since the environmental processes of the site are not clear to the public the recommendations of respondents tended heavily toward public use. A quarter of the respondents recommended more child-related activities, with the majority of these respondents falling within the age groups of 30–40 and 60+, often referencing their children or grandchildren. The ‘child-friendly’ considerations that were included in the planning of the site drew notable criticism. Local users assumed that since playground elements were originally placed on site and that few remained (others having been stolen), the site’s primary function was as a playground. This assumption was reinforced by the proximity of a daycare adjacent to the site. If the site was intended as a play area for children, respondents did not think enough activities had been provided and the ones that had been installed were in disuse or had been stolen. The site was perceived to be overgrown, particularly in and around the more formal playground elements. The playground elements were seen as dilapidated

and the grounds around them were neglected, conveying the general sense that the area was derelict.

While creating more child-related activities was the most common recommendation made, the current safety of Blaklibekken concerned the users and residents. Child safety was of particular concern to users, with 10% of the respondents reporting that the area was not safe for children and 18% of respondents suggesting more measures be taken to increase the safety of the site. Respondents considered the site dangerous for children: access to the water concerned residents; two docks that jutted into the water were perceived to be unstable; and the water was described as muddy, dirty and polluted. A mother interviewed said, 'I do not let my kids out the front door, because I'm afraid that they will go to the water to play' (user interview #42), while another mother was quoted, 'I am terrified that a serious accident will happen' (user interview #73).

5.2.3. Maintenance of Site

Responsibility for maintenance is an issue that is often at the heart of many conflicts within the management of a SUDS. Specifically, within distributed systems that often also have distributed management, conflict may arise due to a lack of clarity of where the responsibility for the various aspects of maintenance lie. Residents often voiced frustration that the site was not well maintained (31%). Approximately 31% of respondents had referenced that the site had 'originally been nice' when it was first completed, while only 19% of respondents reported that they considered the site to be a 'nice/pretty area'. A majority of residential users (34%) recommended that the site needed to be better maintained by improving water quality, clearing trash and debris, and providing waste bins. As shown in Table 3, 15% of respondents reported that the area was overgrown; 13% reported that the water was dirty, polluted and smelled; and 12% complained about the cloudy water and algae. Beyond improving the quality of the water and cleaning the area of garbage, respondents also thought that the children's play equipment should be better maintained and improved.

There was a mix of responses regarding how the 'overgrown areas' should be maintained as respondents could be categorized into those who thought the site should be formally landscaped and those that thought the site should be brought to a more natural condition and left to 'go wild'. Despite these differing views of whether the site should be maintained in a formal or natural condition, users of both opinions recommended the addition of more plants. Whatever the personal preferences of respondents, there was confusion over the intention of the site's design, with one respondent observing, 'I just wonder what the municipality's plan is? How do they really want it to be here?' (user interview #16). Meanwhile, another respondent stated, 'I wish they could have cleaned up here. Mowed the grass and cleaned up the drain. It is actually an incredibly nice area, but not as it is now.' (user interview #3). The municipality also acknowledged, 'It is probably different from what people expected and what they got.' (municipal interview #2). 'When the area is planned, landscape architects have drawn how it should look upon completion, but as natural processes happen it will look different than planned.' (municipal interview #1). 'Calls have been made to the municipality for a management plan and clear allocation of responsibility' and residents stated that they 'have worked for several years to get the area cleaned up but without discussions or guidance by the municipality they did not feel confident to act on their own' (article) [32].

5.2.4. Funding

SUDSs have been promoted as affordable cost-effective solutions for local municipalities, creating added values beyond managing stormwater [15,20]. The European Commission Environmental Report has said, 'Contrary to single-purpose, traditional grey infrastructure, green spaces can perform a variety of very useful functions, often simultaneously and at a fraction of the cost' [14]. Yet, the responsibility for maintenance needs to be clarified and the municipality must plan for the perpetual management and care of the site.

Clearly allocated or increased funding was suggested by 8% of respondents. 'There should be a plan for the funding of maintenance before starting on a project' (user interview #99). 'There should be minimum requirements for how to follow up the site and money set aside for either the municipality or the local residents to maintain the site' (user interview #52). Public action resistance groups within Trondheim cited a lack of funding for maintenance at Blaklibekken as a primary concern in the implementation of future projects. 'This appears to be a horrifying example of the municipality's eagerness to spend taxpayers' money on new construction, then not to set aside funds for annual maintenance' (article) [30].

5.3. How Can Themes Drawn from the User's Perspective of a SUDS Project Inform the Front End of Project Planning?

Within the Nordic countries, positive public perception is integral to the timely acceptance and adoption of SUDS climate adaptation measures; therefore, it is necessary for greater comprehension of what the actual understanding, expectations and perceptions of the public are and what factors are influencing local users and area residents.

The acceptance and adoption of innovation take time and SUDS solutions are still considered a niche technology that has not been entirely accepted as an integral part of the existing water management regime. The Blaklibekken case illustrated the ongoing challenges that a municipality can face when implementing new niche technologies and are poorly understood by users within the local landscape. Community outreach at the beginning of decision-making processes and continued public education regarding the function of these sites were lacking in this case study. Gaining community support for SUDS requires a greater understanding of public perceptions because, in contrast to hidden grey infrastructure, a SUDS often changes the visible urban environment, involving shifts in what flood risk management and water treatment involve and look like. Furthermore, agendas and funds for their installation and maintenance are often also subject to greater residential scrutiny. The establishment of themes of user perception can place these challenges within a localized context. Providing this context can inform municipalities in the decision-making processes at the front end of project planning. Recommendations drawn from these themes are summarized in the following paragraphs.

5.3.1. Environmental Benefit

It is important to acknowledge that SUDS solutions are area intensive in densely populated areas. This creates a substantial challenge for the site to address the demands of all stakeholders: municipality, developers and residents. Within denser development where space is at a premium, holistic solutions that protect against flooding, while, at the same time, improving the city microclimate, promoting biodiversity and creating new green space and recreational areas for the public may not be feasible. Landscape management practices that effectively conserve water quality and provide important ecosystem services may not be seen as aesthetically pleasing. People tend to interpret their aesthetic experience of landscape as providing information about its ecological quality [37]. The relationship between aesthetics and ecology has important implications for the public acceptance of SUDS, and a greater understanding of this relationship provides insight into the causes and consequences of landscape change [37].

Solutions must prioritize the hydrological and ecological impact of the site in accordance with the Norwegian Water Directive. While active public use can only be considered when the scale of the site, feasibility and clear public understanding of environmental prioritization and use is established. Conflicts may be resolved by education campaigns to encourage an ecological aesthetic that better aligns with environmental goals, helping to raise public awareness and spur action [37].

Residents generally appreciated having a natural space and had vague assumptions that the area would generally improve the environment without a clear understanding of the specific benefits the site provided and almost no technical understanding of the water management processes. Despite the promoted aspirational benefits of SUDS 'as green

spaces (which) can perform a variety of very useful functions, often simultaneously and at a fraction of the cost', the aspirations of the site and designs may benefit by being less ambitious [15,20].

- Prioritization of the Norwegian Water Directive, hydrological and ecological performance.
- Improve community outreach and education of SUDS functions.
- An ecological aesthetic should be advocated as a normative aesthetic.
- Lower design ambitions and public expectations for the multi-functional uses of the site. Planting moderately and naturally in urban spaces was perceived as significantly more restorative than more formal spaces, suggesting that people may be more accepting of an 'ecological aesthetic' in urban planning [39].

5.3.2. Maintenance

These sites need to be better maintained by improving water quality, clearing trash and debris, and providing waste bins. Management responsibility must be established and clarified in the planning stages and operational responsibilities that are drawn up. Respondents were mixed as to how overgrown areas should be maintained between those who thought the site should be formally landscaped and those that thought the site should be left naturally. Sites are best served by clearly delineating formally kept and natural spaces. These determinations should be made in the pre-planning of a project and should be clearly presented to the public during the planning stages. These project presentations need to clearly and accurately represent what the finished character of the site will be to set realistic expectations.

- Pre-project designation of maintenance responsibility;
- Design in assurances of trash collection and water quality;
- Clarify formal and natural areas;
- Accurately depict the finished site's appearance in promotional materials.

5.3.3. Child-Related Activities

There must be greater consideration for child-related concerns during the planning stages of SUDS projects. The introduction of child-related activities has the greatest perceived impact on and strongly influences the local perception of the site. The introduction of play equipment increases public expectations of the formal maintenance of the site, equipment, landscaping and increased safety precautions. Unfortunately, the findings suggest that the inclusion of child-related activities increased users' expectations of site maintenance and the funding associated with it. In the planning stages of a project, the introduction of child-related activities should be critically assessed to evaluate whether the municipality has the funding and resources to properly execute and manage their inclusion in the SUDS. If children will be encouraged to engage with a site, the public expects greater safety precautions to be implemented and decreased access to the water.

- Child-related activities should be kept in formalized spaces;
- Decrease child access to water.

5.3.4. Funding

Funding must be adapted to these new stormwater management solutions and this funding must be considered similarly to the funding of other traditional spaces, such as public parks, if that is their intended use. The value of partnerships working across sectors must be recognized, potentially as a source of innovative funding opportunities [53]. A clear budget and maintenance plan that includes 'identified responsible persons', will better inform the design process and planning of a site. A clear budget and maintenance plan that includes 'identified responsible persons' will better inform the design process and planning of a site. This will ensure greater compatibility of site ambitions with feasible investment in a long-term maintenance plan.

- Clarification of responsibility and budgets;

- Increased budgets;
- Organized shared expenses with local homeowner associations into perpetuity.

Further research is necessary to build upon these findings, including the continued collection of data to validate or refute the themes identified in line with the methodological approach of grounded theory. Broadening this work will allow researchers to determine whether these themes can reliably be applied in a broader and more general context.

6. Conclusions

The intent of this research was to better inform decision makers about the consequences of their plans and actions from the public's perspective, as well as to inform research that seeks better practices of public engagement and consensus-building. Each SUDS project is unique and largely dependent on the specific needs and parameters of a site. For the best results, the correct level of ambition for a project must be defined by the specific perimeters set forth by the environment, location, financial restrictions, public expectation and acceptance. The level of ambition in each project must be defined at an early stage and be agreed upon by all participants in the project, while operational responsibility and funding for these sites have to be clarified. While interdisciplinary cooperation is essential, this approach has not been able to account for all the requirements of success. The themes that were drawn from this research, namely, environmental benefit, child-related activity, maintenance of site and funding, are meant to inform these processes. It is essential that politicians, planning authorities, building officers, project owners, designers, contractors and operations personnel are made aware of the experiential challenges addressed within these themes.

This research showed that local residential/user stakeholders should be heard and systematically documented, providing critical insight into local expectations and the acceptance or resistance to these projects. In this kind of realignment lies the possibility of creating nature-based SUDS that would sustainably manage water and be accepted by the public for their perceived social benefits.

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