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ClimateCafé: An Interdisciplinary Educational Tool for Sustainable Climate Adaptation and Lessons Learned

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Abstract: ClimateCafé is a field education concept involving different fields of science and practice for capacity building in climate change adaptation. This concept is applied on the eco-city of Augustenborg in Malmö, Sweden, where Nature-Based Solutions (NBS) were implemented in 1998. ClimateCafé Malmö evaluated these NBS with 20 young professionals from nine nationalities and seven disciplines with a variety of practical tools. In two days, 175 NBS were mapped and categorised in Malmö. Results show that the selected green infrastructure have a satisfactory infiltration capacity and low values of potential toxic element pollutants after 20 years in operation. The question "Is capacity building achieved by interdisciplinary field experience related to climate change adaptation?" was answered by interviews, collecting data of water quality, pollution, NBS and heat stress mapping, and measuring infiltration rates, followed by discussion. The interdisciplinary workshops with practical tools provide a tangible value to the participants and are needed to advance sustainability efforts. Long term lessons learnt from Augustenborg will help stormwater managers within planning of NBS. Lessons learned from this ClimateCafé will improve capacity building on climate change adaptation in the future. This paper offers a method and results to prove the German philosopher Friedrich Hegel wrong when he opined that "we learn from history that we do not learn from history."

Keywords: climate adaptation; education; capacity building; Nature-Based Solutions; water management; field experience; ClimateCafe

1. Introduction

Cities are becoming increasingly vulnerable to climate change. Increased flooding due to an increase in cloud bursts, or drought, forces action to be taken within already heavily urbanized areas where there is a competing demand for different land usage [1]. To address these challenges there is a clear demand for collaborative knowledge-sharing on sustainable climate adaptation [2]. Interaction with social, natural, and technical sciences is necessary to make resilient changes [3–7].

Climate adaptation is a field that requires interdisciplinary collaboration, due to the multiple tasks that are involved to achieve sustainability and robustness [8]. Nesshöver et al. (2017) stated that for Nature-Based Solutions (NBS) to achieve their full potential as a climate change adaptation measure, experience and knowledge must be included as well as stakeholder engagement [8]. NBS is a concept that can be defined as: "a transdisciplinary umbrella that encompasses experience from existing concepts such as 'blue-green infrastructure' in engineering, 'natural capital' and 'ecosystem services' in economics, and 'landscape functions' in environmental planning" [8]. NBS aim to use ecological functions in order to mitigate the negative impacts of climate change on the urban environment whilst improving well-being. An example of this can be the positive effects of urban greening on rainwater infiltration, urban heat, productivity, liveability, and health [9–12]. The aim of ClimateCafé Malmö was to exchange knowledge in the field and raise awareness on climate adaptation in an urban area where NBS have been implemented. Field education in fields such as geoscience provides a sense of scale, introduces concepts of earth processes, assists in developing the ability to integrate fragmentary information, and gives practice in gathering and evaluating the quality of data [13]. ClimateCafé Malmö used a "learning by doing" approach [14] as an incentive to target young professionals that would then work together where public, academic, private parties, and citizens collaborated [15]. The reason for choosing this quadruple helix approach is that in the urban environment the resources that need adapting are spread over a large number of disciplines, making stakeholder collaboration and communication a key challenge in successful adaptation to climate change [16]. Despite this emphasis, the extent to which these principles are applied in planning practice is limited [16]. Research on the concept of collaboration has shown that the governance approach required for spatial transformations must be both top-down and bottom-up [15,17]. Specific forms of adaptation governance that involve city administrations and citizens can help creating a foundation for more sustainable climate adaptation and transformation by holistically addressing existing adaptation dilemmas [18].

Leal (2009) and Leal et al. (2018) pointed out the importance of communication for climate change [19,20]. ClimateCafés focus on the education of young professionals and can thus be seen as a bridge between bottom-up and top-down. This multidisciplinary approach highlights obstacles from several perspectives for a collective understanding of the challenges. These include areal planning, management, (lack of) regulations, technical design, (lack of) maintenance, pollution, water quantity and quality, ecosystem services, biodiversity, sustainability, and the improvement of life quality by implementing NBS in urbanized areas. By teaching young professionals to gather local knowledge and data within several disciplines connected to climate adaptation they become aware of multiple challenges that need to be addressed. As demonstrated by Hoffmann & Muttarak (2017), education is an effective tool to increase preparedness for climate-related hazards [21]. To promote sustainable development and resilience, relating education to the UN Sustainable Development Goals (SDGs) is essential [22]. The topics discussed, and work executed are linked to the UN SDGs, bringing awareness to measures that achieve greater goals. Strengthening resilience to climate-related hazards is an urgent target of Goal 13 of the SDGs [22]. According to one of the targets set for reaching the SDG 4 on "inclusive and equitable quality education and promote lifelong learning opportunities for all", education shall activate sustainable lifestyles. Education plays an essential role in achieving the sustainable goals [22–24]. The goals related to the different activities executed in this work are listed in Table 1.

The objective of ClimateCafé is to approach the challenge from different fields of science and practice to answer the main research question "Is capacity building achieved by interdisciplinary field experience related to climate change adaptation?" No discipline can give the full solution on its own. This work aims to demonstrate the necessity of multidisciplinary collaboration for assessing and implementing sustainable climate adaptation solutions, as well as capacity building among young professionals. To achieve the aims of ClimateCafés, both the social and natural science approaches to a common challenge are considered. The content of each ClimateCafé is not fixed, which allows each event to adapt to any setting depending upon the location and stakeholders with local challenges or threats in terms of climate adaptation. This paper describes the concept ClimateCafé, as well as the topics and (novel) methods used during the Malmö event and the relevant results as examples of the different disciplines undertaken that can be applied to evaluate NBS.

ClimateCafé Malmö took place on the 11th and 12th of June 2019, with the participation of 20 young professionals, which included PhD students, Masters students, Bachelors students, and employed professionals (national, regional, and local governments as well as companies and NGOs). It should be noted that 50% of the participants were women (SDG 5). The participants had different backgrounds, including spatial planning, urban design, architecture, water management, civil engineering, geoscience, and natural sciences. The group was highly international, with participants from China, Indonesia, Sweden, Latvia, The Netherlands, Romania, Belgium, Sri Lanka. and Czech Republic. The workshops were guided by international experts from The Netherlands, Brazil, Norway, and Portugal.

Young professionals from disciplines such as urban planning, water management, and education are the future stakeholders for climate change adaptation. With this interdisciplinary approach we hope to encourage implementation of Nature-Based Solutions, with the holistic knowledge of its functions, challenges, and possibilities. Over 20 ClimateCafés have already been carried out around the globe (Africa, Asia, Europe), where different tools and methods have been demonstrated. Figure 1 shows the locations where ClimateCafés took place in the time period 2014–2020, with the 25th edition of ClimateCafé organized in Malmö, Sweden, in June 2019.

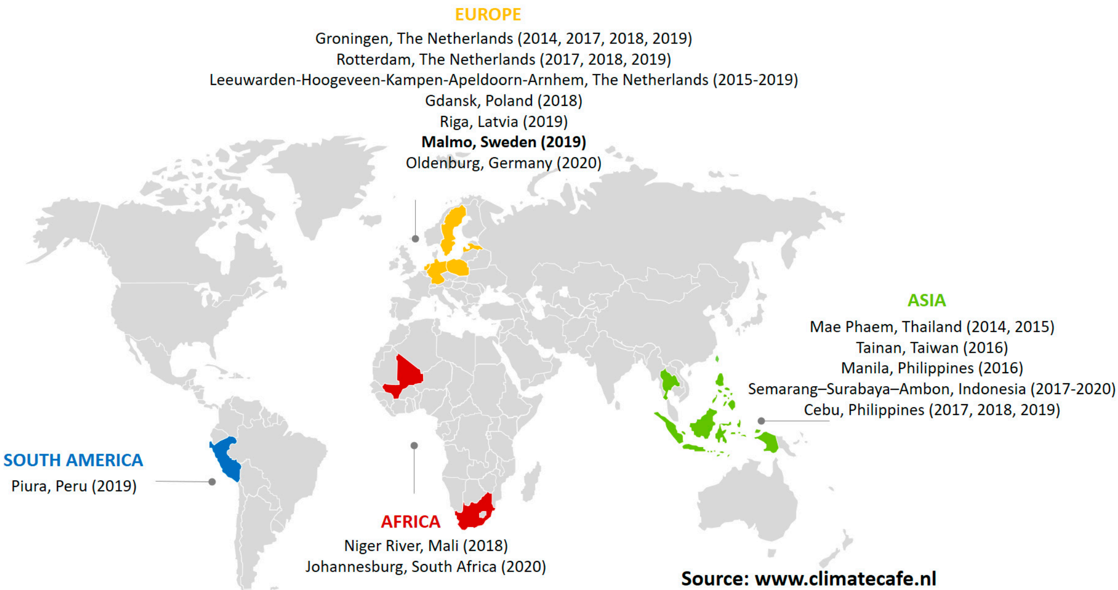


Figure 1. ClimateCafés arranged worldwide in the period of 2012–2020. Study area.

Malmö is well known within the field of urban hydrology, as the city was a pioneer in the area of integrated water management [25]. In 1998 the Augustenborg neighbourhood was refurbished due to its reoccurring problems with flooding and damage caused by water [25,26]. The project "Ekostaden" (eco-city) included many initiatives implementing NBS, such as swales and rain gardens for infiltrating surface (storm) water into the ground [27,28] (Figure 2). Stakeholders question if these NBS still function satisfactorily after 20 years and if we can adopt the strategy to other parts of the world. To quote the German philosopher Georg Wilhelm Friedrich Hegel, "we learn from history that we do not learn from history."

Therefore, Augustenborg is an ideal location to demonstrate the sustainability of NBS, test the functionality for infiltration of surface water in swales, map the build-up of potential toxic elements, (PTE) and test the water quality after 20 years operation. The results from the different methods demonstrated in the ClimateCafé Malmö are described below.

Figure 2. Map of Augustenborg eco-city showing all the different Nature-Based Solutions (NBS) that have been implemented. The different workshops used different locations in the eco-city.

2. Materials and Methods

During this two-day workshop, all participants joined a field trip at the Scandinavian Green Roof Institute [27] and the Augustenborg eco-city to discuss adaptive strategies implemented. The workshops included storytelling conducted through interviews, climate adaptation mapping by the use of ClimateScan (www.climatescan.org), soil quality mapping with a portable X-ray fluorescence (pXRF) instrument, water quality measurements using water drones (ROVs: remote-operated vehicles), hydraulic efficiency by a full-scale flooding test of a swale and heat stress mapping with the use of sensors on bikes (Figure 2 and Table 1). ClimateCafé Malmö consisted of six workshops intending to assess the long-term efficiency of sustainable climate adaptation (Figure 3 and Table 1). The aim of each workshop followed by the method used and results are described in Table 1 and below.

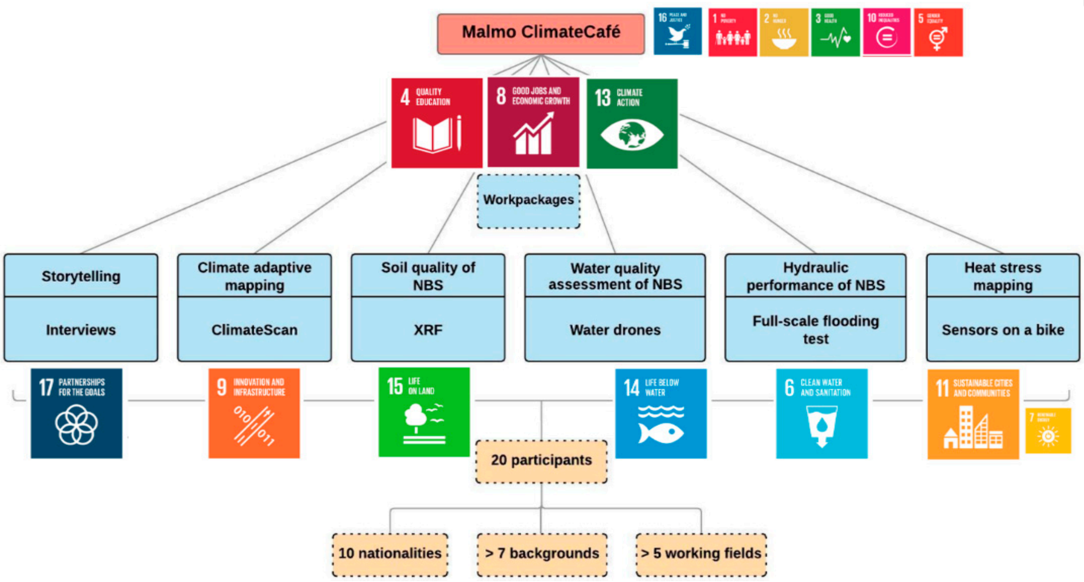
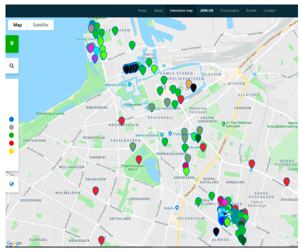
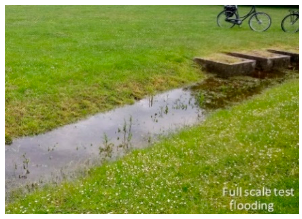


Figure 3. Flowchart of workshops included in ClimateCafé Malmö, which are related to the UN's Sustainable Development Goals (SDGs) [21].

Taking part in data collection within all workshops provides insight, creates awareness, and builds capacity within multidisciplinary fields of climate adaptation. All the measurements were conducted by the participants, supervised by experts in those particular fields, therefore assuring that beyond the gathering of data, discussions about climate adaptation and tools took place in the various workshops (Table 1). The six workshops will be described in the next paragraphs.

Table 1. Methods of the ClimateCafé Malmö workshops.

	Workshops	Workshop aim	Method	
1	Storytelling	To enhance discussions regarding climate adaptation UN SDG #17: partnership for the goals, #4: quality education, #11: sustainable cities and communities	Interviews with participants of ClimateCafé and additional with different stakeholders (government, industry, academia, and civil participants) brought multidisciplinary viewpoints together and created new shared values that benefit Augustenborg to optimize the ecosystem services.	
2	Mapping climate adaptation on ClimateScan	To give first impressions of urban resilience projects and examples of existing sustainable climate adaptation. UN SDG #13: climate action, #11 and #9: innovation and infrastructure.	Climate adaptations were mapped on the open-source tool www.climatescan.org	
3	Soil quality of NBS	To assess the built-up of potential toxic elements in the NBS in the study area UN SDG #6: clean water and sanitation, and #15: life on land.	A portable X-ray fluorescence (pXRF) instrument was used to measure the build-up of potential toxic elements (PTE) in the topsoil of rain gardens and swales after 20 years. A new method for cost-effective insights into the environmental performance of NBS.	
4	Water quality assessment of NBS	To scan water quality in this neighborhood, and gain insights into the spatial variability of water quality between different ponds. UN SDG #14: life below water and #6.	The (surface) water quality of all ponds in Augustenborg was measured by underwater drones with cameras and sensors.	
5	Hydraulic performance of NBS	To gain more insight into the hydrological performance of NBS in the study area. UN SDG #6 and #13	Full-scale testing of swales was conducted using sensors, resulting in detailed measurements of the infiltration capacity of these nature-based solutions	
6	Heat stress mapping	To gain more insight into heat stress and the effects of NBS on urban cooling inside and outside of the Augustenborg area. UN SDG #11 and #7: renewable energy	Heat sensors on bikes gave detailed information on 'hotspots' in Malmö where nature-based solutions could be implemented to mitigate high temperatures	

2.1. Storytelling and the Impact of Malmö ClimateCafé

As pointed out by Moezzi et al. (2017) [29] and Sovacool et al. (2015) [4], research on climate change has been dominated by well-established methods within natural sciences. To achieve resilient change the human aspect must be included [3–6,29]. Wamsler and Raggers (2018) demonstrated the need for a holistic approach to achieve sustainable climate adaptation and transformation by developing principles, where practices and interactions are in focus [18]. Storytelling, where methods within social sciences are included, such as interviews, is a relatively new way of collecting data from all participants as well as citizens. This creates engagement at a local level for topics such as climate adaptation [29].

The storytelling workshop was composed of a discussion with the participants concerning their knowledge about climate adaptation and how ClimateCafé may help them raise their awareness. Storytelling has already been proven as an effective tool to discuss and build capacity among climate change [29,30]. Every participant was interviewed and recorded regarding the different topics in the workshops. The footage was analyzed and cross-checked with post questionnaires sent online to the same participants to check how ClimateCafé is helping to build capacity related to climate adaptation. Table 2 summarizes the origin and background of participants in ClimateCafé Malmö, as well as the questions asked during the interviews.

Table 2. Participants of the Malmö ClimateCafé, background and questions asked during the event for storytelling. A total of 50% of the participants were women.

<table>
<tr><th>Countries</th><th>Background</th><th>Field</th><th>What Are Your Thoughts about Climate Adaptation?</th><th>How did ClimateCafé Improve Skills about Climate Adaptation?</th></tr>
<tr><td rowspan="8">Sweden (7)
Sri Lanka (1)
Indonesia (1)
Czech Republic (1)
Romania (2)
Latvia (6)
China (1)
Belgium (1)</td><td rowspan="8">PhD students (5)
Masters students (7)
Bachelors students (1)
Professionals (7)</td><td rowspan="8">Stormwater quality
Civil engineering
Water resources engineering
Environmental engineering
Landscape architecture
Groundwater engineering
Urban drainage system
Water management</td><td>Need to educate people</td><td>More knowledge about climate adaptation (discussions)</td></tr>
<tr><td>Need more studies, more knowledge</td><td>More knowledge about climate adaptation (new techniques)</td></tr>
<tr><td>Important due to climate change (e.g., disasters)</td><td rowspan="2">Networking (people from different backgrounds/countries)</td></tr>
<tr><td>It's a challenge</td></tr>
<tr><td>Ongoing field with a lot already happening</td><td>Spread the knowledge known to hometowns</td></tr>
<tr><td>Important topic to spread to other stakeholders, e.g., municipalities</td><td>Experience theory on field (by measurements)</td></tr>
<tr><td>Do not have a strict opinion, need more time to verify if climate is changing</td><td rowspan="2">Inspiration for future studies by solutions already applied on field</td></tr>
<tr><td>Necessity of more resilient cities</td></tr>
</table>

2.2. Mapping of Climate Adaptation Measures with the ClimateScan Tool

To collect, distribute, and share knowledge, the open access, web-based ClimateScan adaptation tool www.climatescan.org was used [31]. This tool helps policymakers and practitioners to gather valuable data for a rapid appraisal at the neighborhood level, mapping specific climate adaption measures at specific locations with information. ClimateScan is a citizen science tool giving the exact location, website links, free photo, and film material on measures regarding climate mitigation and adaptation. NBS related to stormwater infiltration, such as swales, rain gardens, water squares, green roofs, and permeable pavement are some that improve the liveability in cities [32,33].

2.3. Quick Scan Mapping of Pollutants with the Use of Portable XRF

Surface runoff and stormwater have been identified as important pathways for pollutants that enter receiving water bodies [34]. NBS are constructed to receive, store, and infiltrate surface water to restore the groundwater balance and to remove pollutants [10,35]. It is important for stormwater managers to know the characteristics of the pollutants in stormwater so that vital knowledge can be incorporated into management and maintenance. With an increased pollutant load in urban stormwater that degrades the water quality, the mapping of pollutants such as potential toxic elements (PTE) is essential [36]. After 20 years of operation, build-up of pollutants is expected [37]. Therefore, the mapping of potential toxic elements in several NBS at Augustenborg was carried out. Examples and results from the large swale behind Augustenborg school are shown in this paper (see Figure 2 for the location of profiles).

The portable XRF (X-ray fluorescence) was used to map PTE (Figure 4). pXRF is an instrument that analyzes the content of elements from Magnesium (Mg, 12) to Uranium (U, 92) in the periodic table [38]. For a systematic mapping of the dispersion of PTE in swales, measurements at a predetermined interval along profiles were conducted. Since the profiles were relatively short (max. 2 meters), the measuring intervals were from 0.2 to 0.5 meters. Each point was measured for 60 seconds, and the values displayed on the screen as well as stored for a later download from the instrument. For a more detailed description of the methodology see Venvik and Boogaard (2020), [39]. As stormwater is the transporting media of the pollutants the profiles of measurements must cover the inlet(s), the deepest part, and if possible, the outlet(s) of the swale to map the distribution.

Figure 4. Quick scan mapping with portable XRF (X-ray fluorescence) measuring content of potential toxic elements in the topsoil of a swale. Here students are demonstrating measurements along a profile across the swale. Profiles are collected in the swale (**A**), covering the inlets (**B**), the deepest part (**C**), and the outlet of the swale. (**D**) shows the swale filled with rainwater and infiltration of surface water into the ground.

2.4. Water Quality

There are multiple ponds located within the district of Augustenborg, which collect and store rainwater. Literature often argues that the implemented measures reduce water quality degradation and that they have inclusively contributed to the improvement of the surface water quality [36,40]. However, little is known about the water quality conditions of these small water bodies, as only a few studies have addressed water quality directly, and they mostly focus on the discussion of runoff water quality from green roofs in the area [40].

Figure 2 shows a map with all the ponds of the Augustenborg. Multiple water quality sensors were deployed in every pond to collect data about water quality parameters. The sensors included a multi-parameter sonde (In-Situ Troll 9500) [41], a dissolved oxygen logger (PME MiniDOT) [42], Conductivity Temperature CTD Diver [43] and an Algae/Chlorophyll sensor [44]. The measurements took place on June 11th, 2019, after scattered rain events.

In order to map the spatial distribution of water quality parameters in the ponds, the same sensors were equipped to an aquatic drone [45] (Figure 5), which was then piloted across the ponds, and guided towards water sprinklers/fountains where there was aeration of the water, and upstream/downstream of existing (gray) wastewater outlets. This procedure was only possible in the larger ponds, as the smaller ponds had limited depth and/or dense vegetation that inhibited the use of the drone. A global positioning system GPS logger was also installed on the drone to record the coordinates of each measurement.

Figure 5. Illustration of the water quality measurement campaign: participants of ClimateCafé workshop (**left**), an impression of a pond and aquatic drone (**center**), and pond with sprinkler for aeration (**right**).

2.5. Hydraulic Efficiency of Swales

Bioretention swales are one type of NBS that has been used for decades globally to provide stormwater conveyance and water quality treatment [34]. Swales are a landscape surface-drainage system planted with vegetation that collect rainwater and allow surface runoff to be detained, filtered, and infiltrate into the ground to reduce peak flow, collect and retain water pollution, and improve groundwater recharge [34,35]. However, one common issue is that swales can be subject to clogging [46–49].

After mapping multiple swales in Augustenborg data were collected on the hydraulic conductivity and infiltration capacity using wireless, self-logging, pressure transducer loggers [46] as the primary method of measuring and recording the reduction in water levels over time. Two loggers were installed at the lowest points of the swale. The transducers continuously monitored the static water pressure at those locations, logging the data in internal memory. Three different measurement methods were used in conjunction with the pressure transducers to calibrate and verify the transducer readings. The three methods were: hand measurements, underwater camera, and time-lapse photography (Figure 6).

Figure 6. Discussion during monitoring in the swale in Augustenborg (**left**). Dataloggers were placed at several locations in the water (**right**) and time-lapse photography recorded the infiltration proces.

2.6. Heat Stress Mapping with Sensors on a Bike

Urban heat islands (UHI) are zones within cities that are warmer than surrounding areas and may have impacts on health, productivity, and liveability on a local scale [50]. In the urban environment, these urban heat islands can be related to design, green-blue structures, and building patterns [51–54]. In this workshop heat sensors were attached to a bicycle to collect air-temperature data in Augustenborg and Malmö city centre. The measuring unit contained multiple sensors that collected information about parameters and indicators needed to calculate the physiological equivalent of temperature (PET) values. To calculate the PET value a combination of (1) air temperature, (2) humidity, (3) light intensity, and (4) wind speeds was used [54]. The sensors are described in Table 3. The data were collected in cross-sections through Malmö city and the data were further analyzed using Geographical Information System (GIS).

Table 3. Specifications of sensors used for heat stress mapping in ClimateCafé Malmö.

Sensor	Variables Collected	Output	Precision
BME280	Air temperature, humidity	Temperature in Degrees Celsius, Humidity in 5	± 3%
MLX90615	Infrared temperature, air temperature	Temperature in Degrees Celsius	± 3%
BH1750FVI	Light intensity	Lux	± 2%
Velleman Anemometer WS1080	Windspeed	Wind speed in km/h	±0.5 km/h
GY-NEO6MV2	GPS	Lat/long	Depending on satellite connections

3. Results

3.1. Storytelling and the Impact of Malmö ClimateCafé

The storytelling was conducted alongside the other workshops. The participants were interviewed and filmed in order to understand their previous knowledge regarding climate adaptation and their perception on how ClimateCafé could help them develop their skills. All interviews were compiled together with pictures and descriptions of the activities developed into a video (https://climatecafe.nl/2019/01/city-climatescan-Malmö-will-be-held-10-14-june-2019). The participants and coordinators were engaged in discussing possible solutions and challenges within different settings as well as obstacles that may occur. The ClimateCafé contributed to forming a network on climate adaptation for the young professionals, which is fundamental for further knowledge exchange. Storytelling is a method to capture perceptions, experiences, and stories from the community and bring experiences to the attention of decision-makers.

The analysis of the storytelling shows the importance of discussions, the sharing of experiences and knowledge regarding climate adaptation, as assembled in Table 4. The results especially highlight the areas where ClimateCafé has had an impact in the development of capacity building among these topics, as shown in Table 4.

By storytelling, we verified that young professionals are a group of people mainly formed by students (Masters or Bachelors), PhDs, and professionals (Table 2). The field of work can be divided among civil engineers, architects, and environmental engineers, with the water sector as the main focus. When confronted about their thoughts about climate adaptation, most of the participants related it to climate change and the more extreme events and disasters that are happening around the globe. In the analysis of the interviews, particular attention was given to participants that did not have a strict opinion about the topic and the necessity to have more resilient cities. ClimateCafé helped these participants to gain awareness of sustainable solutions for climate adaptation. When confronted at the end with the question of how the ClimateCafé helped this group of participants improve their skills and awareness, three main answers were given: (i) the need for more knowledge about the topic (by discussions and learning about new techniques), (ii) networking with people from different backgrounds and countries, (iii) inspiration for new studies and to bring it to their hometowns. Lastly, participants were asked whether they were familiar with the Sustainable Development Goals and which of these goals were part of the ClimateCafé. Most participants were unfamiliar with the SDGs, resulting in this question not being answered in most of the interviews. At the end of the event a questionnaire was distributed to all the participants in order to verify the importance of the different workshops and tools presented, as well as the capacity building of ClimateCafé Malmö (Table 4).

Table 4. All participants answered a questionnaire with the following results.

Participants Have Learned How to Use the Proposed Tools during Malmö ClimateCafé						
	Strongly disagree	Neutral to strongly disagree	Neutral	Strongly agree to neutral	Strongly agree	Sum
SDGs	20%	10%	20%	30%	20%	100%
FullScale	0%	10%	20%	40%	30%	100%
Water drones	0%	0%	20%	40%	40%	100%
pXRF	0%	0%	10%	20%	70%	100%
ClimateScan	0%	0%	0%	10%	90%	100%
Participants can explain the proposed tools during Malmö ClimateCafé to colleagues / fellow students after attending it						
	Strongly disagree	Neutral to strongly disagree	Neutral	Strongly agree to neutral	Strongly agree	Sum
SDGs	0%	0%	50%	30%	20%	100%
FullScale	0%	10%	20%	50%	20%	100%
Water drones	0%	0%	20%	40%	40%	100%
pXRF	0%	0%	10%	30%	60%	100%
ClimateScan	0%	0%	0%	20%	80%	100%
The proposed tools are of value to the participants' work/study and he/she is inclined to use it in the future.						
	Strongly disagree	Neutral to strongly disagree	Neutral	Strongly agree to neutral	Strongly agree	Sum
SDGs	0%	0%	10%	30%	60%	100%
FullScale	0%	0%	20%	50%	30%	100%
Water drones	0%	0%	20%	40%	40%	100%
pXRF	0%	0%	0%	20%	80%	100%
ClimateScan	0%	0%	20%	30%	50%	100%

3.2. Mapping of Climate Adaptation Measures with the ClimateScan Tool

During the two days over 175 NBS were mapped on www.climatescan.org (Figure 7) by the participants through uploading with the ClimateScan App in the field. The mapping included a short description, the location (GPS), category of NBS, and pictures. For some locations, additional information, documents, and websites for further information were added later using a computer.

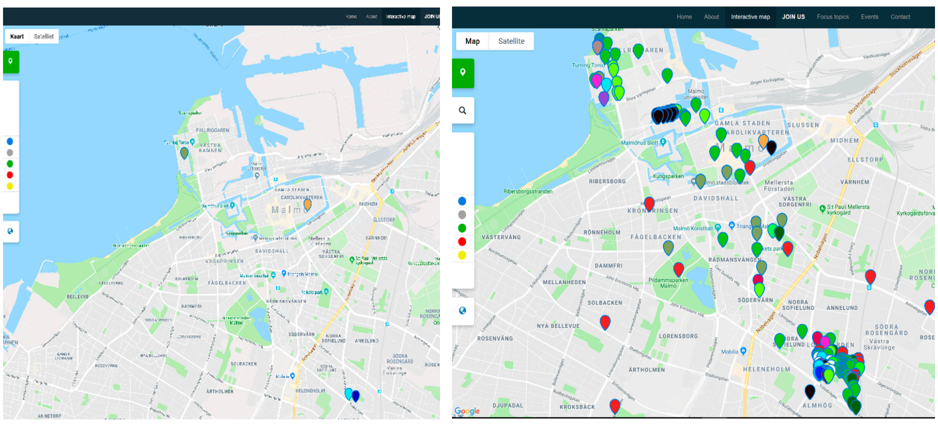


Figure 7. ClimateScan for Malmö city centre before ClimateCafé (**left**) and after (**right**): more than 175 NBS mapped on the open-source nature-based solution platform www.climatescan.org [31]. For more detailed info: https://climatecafe.nl/2019/01/city-climatescan-Malmö-will-be-held-10-14-june-2019 [19].

Figure 8 shows the results of the NBS mapping during the ClimateCafé in Malmö. The 175 mapped climate adaptation solutions were distributed in 19 categories, with the majority within the green roofs and walls category (25.7%). The following categories were bio filters (13.7%), rain gardens (12%), and ponds (8.6%), as shown in Figure 8.

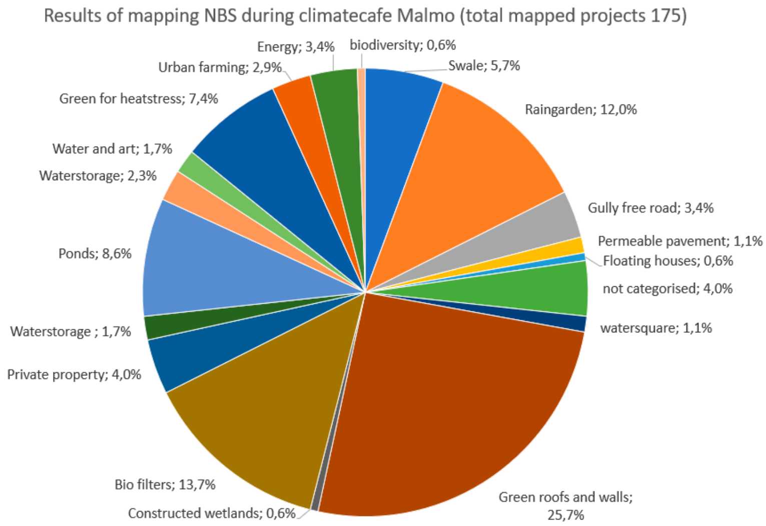


Figure 8. Results from mapping of climate adaptation measures with the ClimateScan tool [31] with categorization of NBS.

3.3. Quick scan Mapping of Pollutants with the Use of Portable XRF

Results from the mapping of the PTE lead (Pb), zinc (Zn), and copper (Cu) in the large swale behind Augustenborg school by pXRF are shown in Figure 9. The profile shows that the highest concentration of PTE was at the inlets and the deepest part of the swale. This is as expected since these are the areas in the swale most exposed to surface water in frequency and duration. All measurements were well below the Swedish thresholds for lead (80 ppm (mg/kg)), zinc (350 ppm), and copper (100 ppm) [55] and are thereby not polluted. After 21 years in operation, the NBS at Augustenborg shows a little build-up of PTE. This is most likely due to the absence of polluting source(s), such as no or little traffic, separate drainage system from the surrounding areas, thereby no drainage from major roads, industrial areas, or brownfields. This has not been the case in other residential areas after 20 years of operation, where PTE in the topsoil exceeded quality guidelines [37,39,49,50,55].

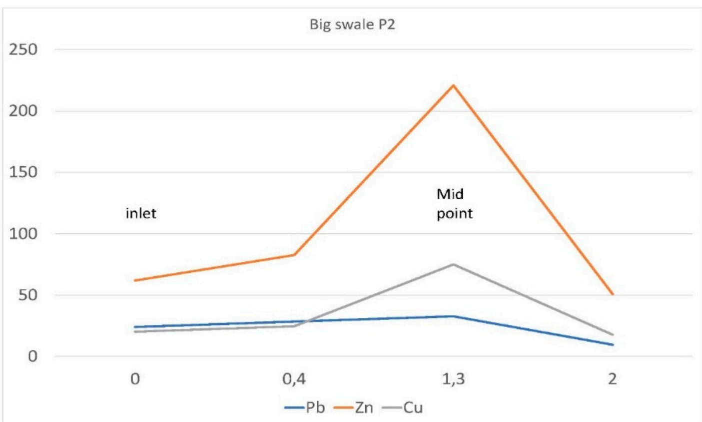


Figure 9. Results from mapped profile 2 across the big swale, where the concentrations (ppm) of lead (Pb), zinc (Zn), and copper (Cu) are shown.

3.4. Water Quality

Figure 10 shows an average of the measured values of different water quality parameters in the ponds in the district. Some ponds were clearly less turbid than others, as confirmed in the data collected. In most ponds, dissolved oxygen concentrations were above the minimum values required to sustain aquatic life (5 mg/L). In three ponds dissolved oxygen reached values under this threshold. The lowest value recorded corresponded to a location where a wastewater outlet was present (discharges water from washing machines after passing by a small water treatment unit) and was measured in a small channel before it gets diluted in a pond. The electrical conductivity of the water in the ponds varied throughout the district. The ponds store different volumes of rainwater, which dilutes the salts/ions unevenly. Chlorophyll-a and Phycocyanin (cyanobacteria/blue-green algae) reached very high concentrations in a few ponds, which could become a threat to local populations. Results of turbidity measurements are in accordance with the other parameters measurement: when water is more turbid, algae concentrations and electrical conductivity are also higher.

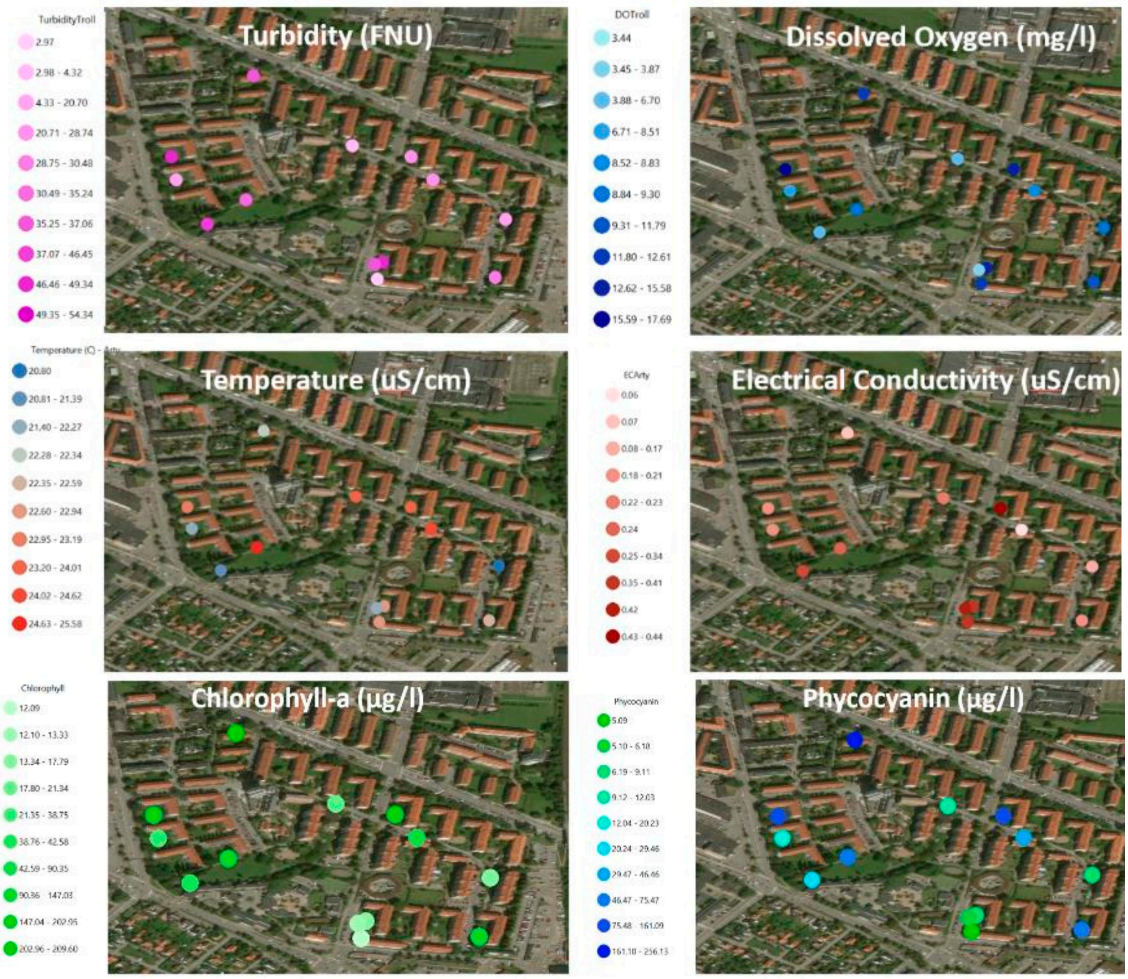
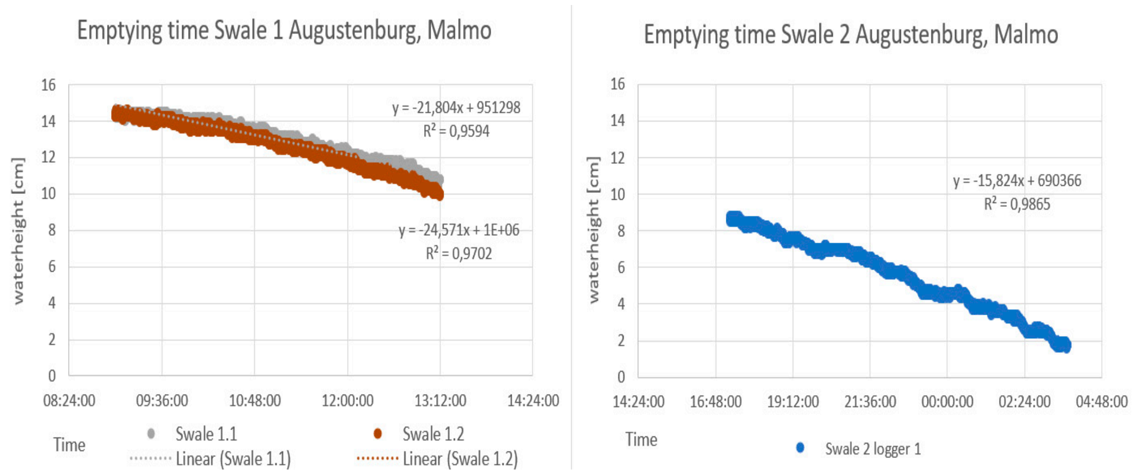


Figure 10. Color scale with average values of multiple parameters in the ponds in Augustenborg district.

3.5. Hydraulic Efficiency of Swales

The test on the hydraulic performance of swales was performed after 20 years of operation. The results showed that all three swales are able to empty their water storage volume within 48 hours (Figure 11). The saturated infiltration capacity is thereby in the order of 0.15 m/d (swale 2, Figure 11a, Table 5) and 0.2 m/d (swale 1, Figure 11b, Table 4).



(a) (b)

Figure 11. (**a**) Emptying curve monitored swales in Augustenborg swale 1. (**b**) Emptying curve swale 2.

Table 5. Hydraulic performance of two swales after 20 years.

	Logger	**Slope**	**R2**	**k (cm/min)**	**k (m/d)**
Swale 1	Logger 1	−21.804	0.9594	0.0174	0.23
Swale 1	Logger 2	−24.571	0.9702	0.0155	0.20
Swale 2	Logger 1	−15.824	0.9865	0.0112	0.15

These values are comparable to values found on the infiltration capacity of Dutch and German swales monitored after 10 to 20 years [46–48]. Ingvertsen et al. (2011) found infiltration capacities between 0.01 and 3.1 m/day using the open-end infiltration test on German swales [49]. The results show that these swales are considered sustainable after 20 years, with sufficient infiltration rate to infiltrate the stormwater in Augustenborg without any other maintenance than mowing the grass.

3.6. Heat Stress Mapping

Figure 12 displays the results of the air temperature differences in Malmö. The data collected during the ClimateCafé did not contain data on wind speeds and light intensity due to technical failure. The map shows the relative cooling effect of urban green-blue infrastructures in the parks in the middle, and the lower temperatures closer to the ocean, indicated in blue colors (Figure 12).

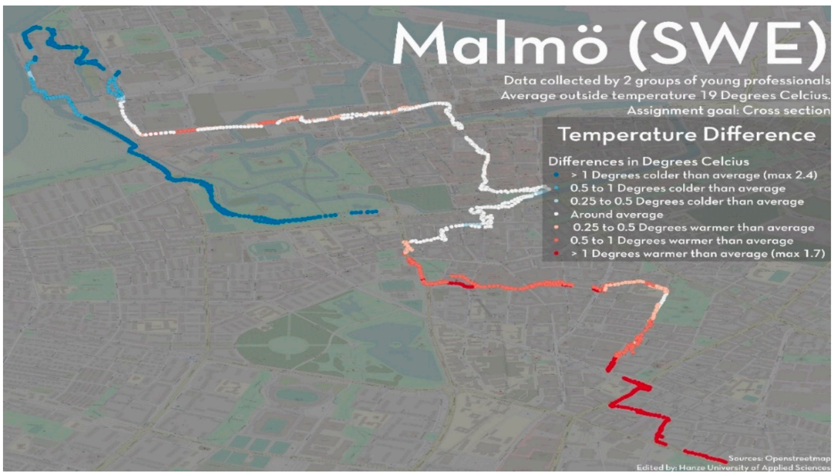


Figure 12. Results of heat stress mapping with sensors on a bike in Malmö, Sweden. Red colour indicates higher temperatures than average, blue lower than average, and white around average temperature.

4. Discussion

4.1. The Interdiciplinary Approach for Climate Adaptation

ClimateCafé is an example of bridging the gap between theory and practice for NBS and water management. Traditional education has focused on the theoretical aspects of design and criteria of NBS, but with little focus on the long-term maintenance. This gap may be because, within a municipality, there are different departments responsible for design/building and maintenance. Experience shows that lack of maintenance is one of the major challenges when it comes to the functionality of NBS [46,56,57]. To achieve sustained climate change adaptation, transformative knowledge has to be included in education, as demonstrated in the study of Urmetzer et al. (2020) [7].

As pointed out by Hoffmann and Muttarak (2017) [21] education enhances resilience to climate-related hazards. Even though the goal of this study was disaster preparedness, it shows that it is through education that fundamental change is possible. Similarly, this is the primary aim of ClimateCafés, where the goals are to raise awareness of climate change adaptation and show the complexity involved in such challenge.

4.2. The Impact of the Different Diciplines on the Participants

The ClimateCafé is a "learning-by-doing" approach [14] that focuses on young professionals through learning multiple tools and gathering valuable data in a short period of time in order to assess the level of resilience at street or district level. Through fieldwork and group discussion, the participants identify practical solutions and possible measures by producing tangible results, such as a map of NBS, or hydraulic and environmental assessment of NBS. A "quadruple helix" approach to the complexity of climate adaptation is necessary [15], but this still raises several challenges. To achieve sustainable and resilient solutions for climate change adaptation, knowledge exchange, capacity building, and collaboration across disciplines and sectors is essential [8,18]. To highlight sustainability issues, the UN SDGs [22] have been addressed, with particular SDGs being referenced within the different workshops. The SDGs were unfamiliar for most participants, making them aware of the importance of the work related to clean water (#6) and climate adaptation (#13) for sustainable (and resilient) cities and communities (#11). Results from the questionnaire show which parts of the ClimateCafé achieved their aim and which require improvement. Figure 13 shows that for the use of the ClimateScan, the XRF, the water drones, and the full-scale flooding test, more than 80% of the participants considered that they learned those tools during the ClimateCafé.

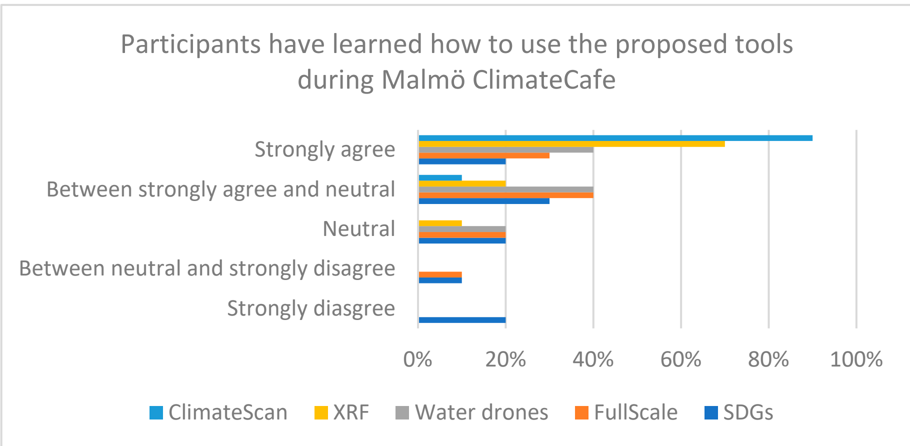


Figure 13. Success in practical use of the tools demonstrated.

As emphasized by UN agencies UNISDR and UNESCO, the role of education is essential for promoting sustainable development and resilience [23,24]. The results from the participant questionnaire show a small but still relevant share is seen in terms of the SDGs, in which 20% of the participants considered that it was not sufficiently addressed (Figure 13).

The process of understanding the use of the tools presented is reaffirmed in Figure 14, when the participants were asked if they would be able to explain the use of the tools to colleagues. Again, 80% or more of the participants felt capacity on explaining the use of the ClimateScan, the XRF, the water drones, and the full-scale flooding test, with an exception for the SDGs, in which 50% considered themselves to be neutral in terms of this concept (Figure 14).

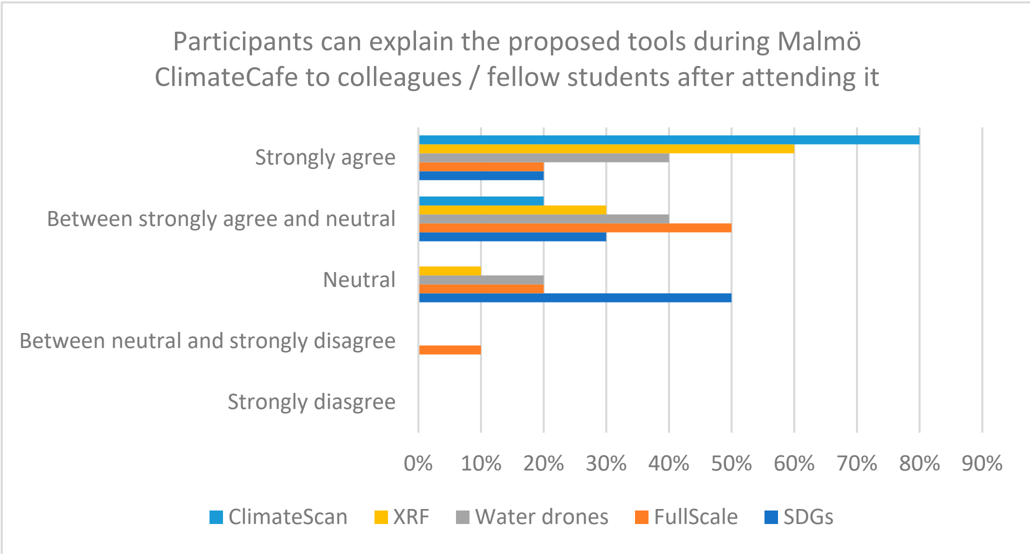


Figure 14. The participants' ability to explain the tools' use to others.

To finish, 80% or more of the participants believed that the tools demonstrated during this event are of importance for their work or study activities, including the SDGs (Figure 15). The combination of those results show that the ClimateCafé methodology is efficient in terms of teaching in a short time the use of such tools, as well as for capacity building within their own discipline.

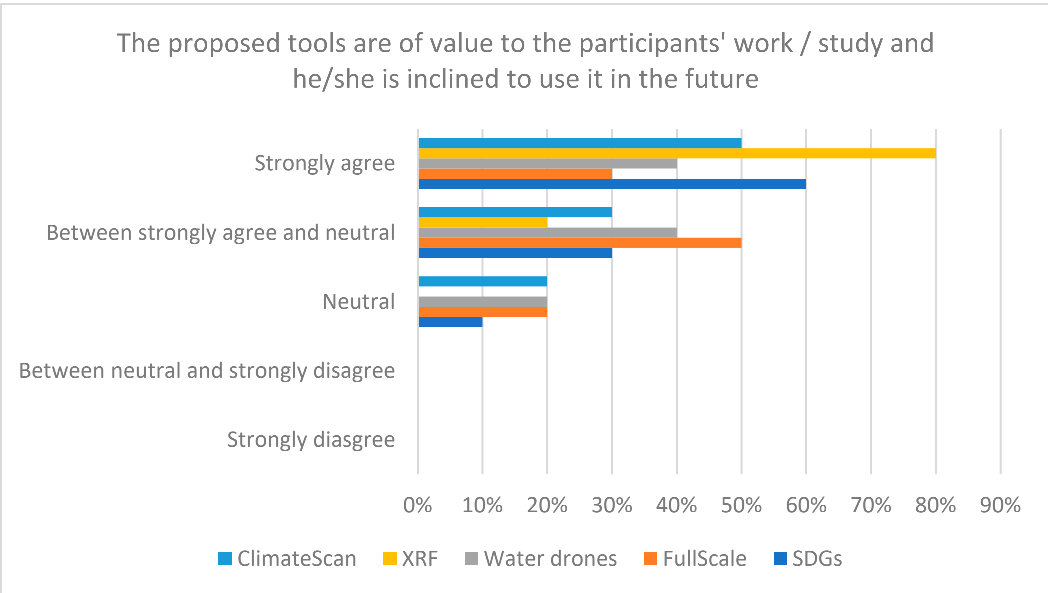


Figure 15. Results of the participants future perspective.

Sovacool et al. (2015) concluded that future research, innovation, and development lies in the interaction of disciplines [4]. ClimateCafé targets the young professionals because they are the next generation of stakeholders. As pointed out by Nesshöver et al. (2017), Nature-Based Solutions are an umbrella concept that requires an interdisciplinary approach [8]. By bringing together different experts from different fields of science to address multiple challenges regarding NBS and collectively discuss solutions, we introduced an interactive way of learning with tools that were appreciated by participants, as shown in Figure 15. Experience is collected by the participants, but also by the experts. One major area of improvement is to better implement the UN SDGs in the work. This is clearly stated in the results from the questionnaire.

5. Conclusions

ClimateCafé is still being developed, but the outcome of the ClimateCafé in Malmö gives a clear direction for further development of this concept for capacity building, knowledge exchange, and bridging the gap between disciplines within climate change adaptation. The results of the different workshops show that valuable multidisciplinary data can be gathered in a short period of time, which can be used by local stakeholders to improve, maintain, or evaluate the effectiveness of Nature-Based Solutions in their local context.

ClimateCafés, like the Malmö event, can aid young professionals with different backgrounds, such as urban planners, water management, and landscape architects, designers, and many more in managing sustainable climate change adaptation for resilient cities. In a ClimateCafé this is demonstrated through (i) a multidisciplinary approach of Nature-Based Solutions (NBS), and (ii) demonstrating tools and methods to evaluate the quality and sustainability of NBS. The data collected in Augustenborg show that the green infrastructure is functioning particularly well, with an infiltration capacity in the order of 0.15–0.23 m/d and very low values of potential toxic element pollutants after 20 years in operation. In contrast, the study has shown that the blue infrastructure in Augustenborg requires further research and monitoring, as in some ponds the algae (blue-green algae) and dissolved oxygen concentrations revealed undesired values, which could have negative implications for inhabitants and animals when they come in contact with the water. Mapping with sensors on bikes showed that the air-temperature varies through the city. Green-blue infrastructure in parks has a cooling effect, and the temperatures are lower closer to the ocean. This may be a useful tool for planning where Nature-Based solutions will be most effective in reducing heat stress in urban areas. The results of this study regarding quick scan mapping of pollutants and hydraulic test of Nature-Based Solutions could help (storm) water managers with planning, modelling, testing, and scheduling of maintenance requirements for swales and raingardens with more confidence so that they will continue to perform satisfactorily over their intended design lifespan.

In addition to enhancing knowledge on climate change adaptation and Nature-Based Solutions among the participants, ClimateCafés aim to increase awareness and stimulate capacity building. The storytelling methodology used in Malmö has shown that the participants benefit from the ClimateCafé, which can be categorized in three topics: (i) getting knowledge on the theme by discussions and demonstration of techniques, (ii) networking, (iii) getting inspiration from examples for new studies and to apply climate adaptation in their home towns.

In this event the UN Sustainable Development Goals (SDGs) were included. The results from the storytelling show that the UN SDGs were not emphasized enough during the workshops and the participants did not fully understand the concept or benefit of incorporating the goals. This is a lesson learned, which will be improved in future ClimateCafés.

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