land

Urban Ecosystem Services

Edited by

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Printed Edition of the Special Issue Published in *Land*

www.mdpi.com/journal/land

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Figure 1. Geographical distribution of ClimateScan datapoints (source: climatescan.org).

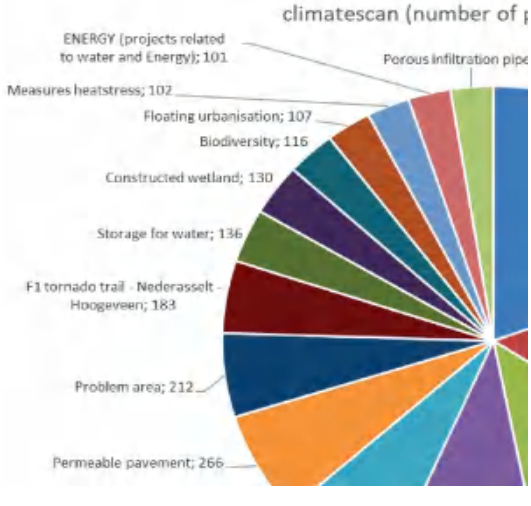


Figure 2. Overview of nature-based solutions uploaded to ClimateScan, to keep the figure readable only categories with more than 100 projects are depicted (based on ClimateScan database).

Moreover, the openness also has the advantage that it leads to surprising content. For example, a more recent example is the category "tornado trails", where users follow the traces of storms and the damage they leave in the landscape in The Netherlands. Looking at the Dutch content in particular also shows that the content uploaded on ClimateScan evolves with the climate adaptation debate. In the beginning, most measures uploaded were related to water storage, as flooding has always been a major concern in The Netherlands. Later, the positive impact of nature-based solutions such as green roofs and green walls on heat stress was emphasized more strongly, as The Netherlands suffered from

several heatwaves in a row (visible in the naming and categorization of projects, the request by users to be able to assign more than one category to an example). The new category "tornado trails" shows that storms and wind have gained importance in the debate.

The list with the top 15 most visited projects on the ClimateScan platform (see Table 2) includes some very known examples (e.g., waterquares in Rotterdam), but also some rather unknown examples (e.g., swale in Dalfsen). Projects that are uploaded for a longer period have a higher change to be in the top 15 such as the Swale in Haren that was the second project uploaded to the database (last column of Table 2). Hence, ClimateScan also provides a platform for small-scale initiatives and municipalities that usually do not get so much attention. All the projects have in common that they have good visual content, mostly with photos and video footage. For example, the most visited project, the gully free road in the small town Nieuwleusen, includes a video about how the system functions during a heavy rain event (T100).

To sum up, over the years, ClimateScan had to find a balance between being open and low-threshold to stimulate the upload of examples on the one hand and data maturity on the other. Sometimes, datapoints only include a short text description or only a photo. There is a check on the data quality by the admins, scanning aerial photos and searching the web to validate the datapoint and accompanying information. If possible and in reach, the datapoint is also being visited. In recent years, only few datapoints had to be removed because they included false information or were not meant seriously.

5.2. Users of ClimateScan: Many Registered Users, But Only a Small, Yet Diverse Active Community

Over the years, the attention for ClimateScan has grown, as the timeline with the number of visitors per day shows (see Figure 3). The platform receives on average 100 visits per day, with the highest peak of 1326 (unique) visitors on one day in February 2019 (a day with a university workshop where students were giving an assignment to use ClimateScan as a source for NBS).

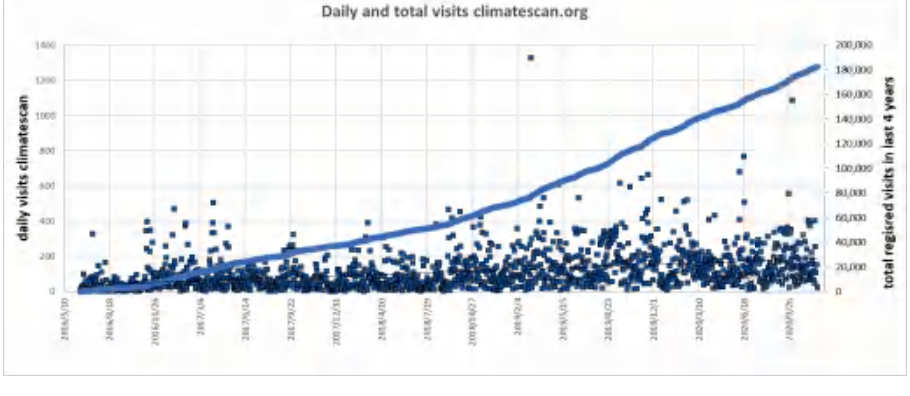


Figure 3. Daily and total visits of ClimateScan (based on data from Google Analytics).

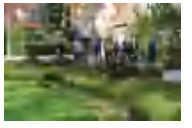
Table 2. Top 15 most visited projects on the ClimateScan platform (based on project site visits retrieved from Google Analytics).

	Name and Explanation of NBS	Illustration [Source: Climatescan.org]	Site Visits	Location	Small Municipality	Good Visuals (Photos and or Video)	Project Number and Hyperlink
1.	Swale combined with a playground function for children in Dalfsen		962	Dalfsen (NL)	yes	yes	935
2.	Gully free road in Nieuwleusen, caught on camera during an intensive rainfall event (T100)		635	Nieuwleusen (NL)	yes	yes	1113
3.	Green infiltration zone/rainwater-garden in Amsterdam, one of the first raingardens in Amsterdam		604	Amsterdam (NL)	no	yes	921
4.	Gully free road, bioswale and permeable pavement in Alkmaar		541	Alkmaar (NL)	yes	yes	9
5.	Watersquare in s'Hertogenbosch, flooded for performance research ('full scale test')		540	Den Bosch (NL)	yes	yes	177
6.	Sustainable water management in UNESCO cultural heritage area Bryggen, including a 'treatment train' infiltration of stormwater with swales, raingardens, sub surface infiltration units and permeable pavement		304	Bergen (Norway)	no	yes	16

Table 2. *Cont.*

	Name and Explanation of NBS	Illustration [Source: Climatescan.org]	Site Visits	Location	Small Municipality	Good Visuals (Photos and or Video)	Project Number and Hyperlink
7.	Swales in Paddepoel Groningen, research conducted on the topsoil quality using XRF		262	Groningen (NL)	no	yes	2528
8.	Waterstoring roundabout in Huizen, multifunctional water storage		258	Huizen (NL)	yes	yes	2050
9.	Swale at school OBS de Wissel, Haren, research conducted on the hydraulic conductivity of this swale		251	Groningen (NL)	no	no	2
10.	Fieldlab permeable pavement in Grubbenvorst, research conducted on the hydraulic conductivity of this permeable pavement		233	Grubbenvorst (NL)	yes	yes	4380
11.	Watersquare Bellamyplein in Rotterdam, one of the first watersquares in The Netherlands		224	Rotterdam (NL)	no	yes	241
12.	Watersquare Benthemplein in Rotterdam, one of the first watersquares in The Netherlands		222	Rotterdam (NL)	no	yes	240

Table 2. *Cont.*

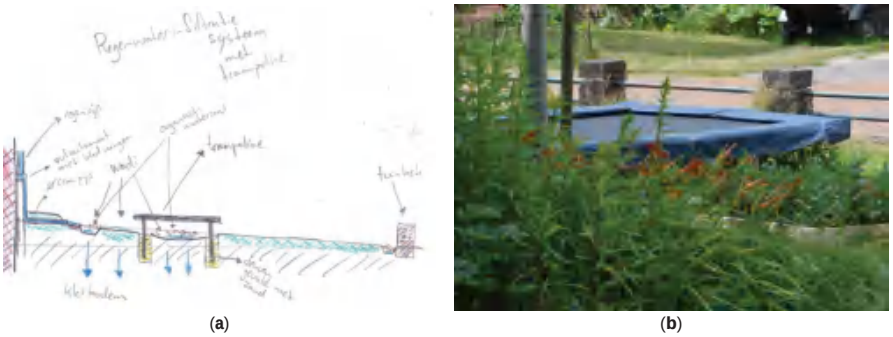
	Name and Explanation of NBS	Illustration [Source: Climatescan.org]	Site Visits	Location	Small Municipality	Good Visuals (Photos and or Video)	Project Number and Hyperlink
13.	Bioswale, nature-friendly, Harkstraat in Amsterdam, research conducted on the hydraulic conductivity of this swale		220	Amsterdam (NL)	no	yes	2224
14.	Restored wetland in urban setting American International School Johannesburg		216	Johannesburg (South-Africa)	no	yes	2689
15.	Swales Ruwenbos in Enschede, oldest swale in The Netherlands (1997), research conducted on the hydraulic conductivity and removal efficiency of these swales		213	Enschede (NL)	no	yes	211

On 24 September 2020, Climate Scan had 806 registered users, and the numbers keep growing. Some of these users can be subtracted because their registration details show clear signs of bots. Of the remaining 766 registered users, only 233 have actively contributed content to the ClimateScan platform (see Table 3). The data show that people register after ClimateScan has been presented on a conference or a meeting. Hence, the story of the platform seems to spark people's interest, but they feel not involved enough to actually contribute.

Table 3. Level of involvement of registered users (based on data from ClimateScan database).

Amount of Projects Submitted	Amount of Users	
0	533	70%
1–4	171	22%
5–<10	37	5%
10–100	21	3%
100 and more	4	1%

While many users can be linked back to a particular event or project, there are also several users that can be considered unexpected users: for example, a user uploading two green roofs in Moscow, although there have never been any links to Russia. Another unexpected user in The Netherlands contributes a rather unconventional solution from his own property: a trampoline with water storage, with a sketch explaining the technical details of how it works (see Figure 4). The Canadian citizen initiative "Depave Paradise" has reached out through social media and subsequently submitted several projects that they have worked on. These projects concerned a transformation of places dominated by asphalt and stones into green spaces, with a "before" and "after" illustration for each project. The online communication with this initiative revealed that they presented themselves on ClimateScan to get in touch with similar initiatives in Europe.



(**a**) (**b**)

Figure 4. (**a**)Trampoline with water storage, technical sketch (source: climatescan.org) and (**b**) photo of the actual implementation.

Depave Paradise belongs to the 25 top users that have uploaded 10 or more projects. For the majority of these top users, there has been offline contact first (e.g., through a conference, a project or a meeting), which has stimulated the person to register and contribute to the map. As a result of this offline contact, we could also classify from which sector these top users are coming (see Figure 5).

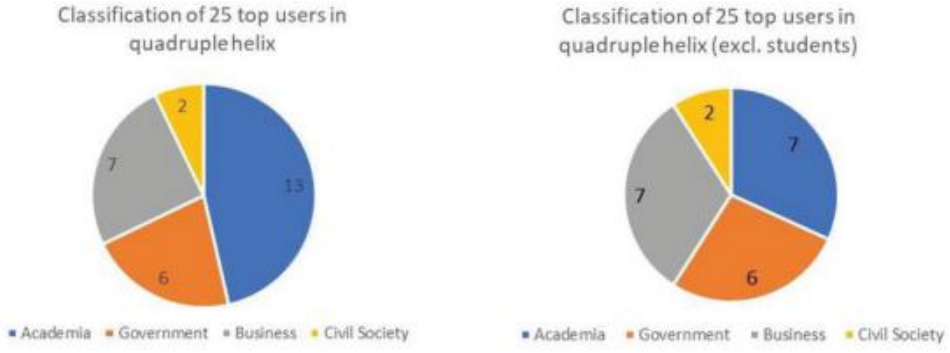


Figure 5. Classification of 25 top users in quadruple helix, with two people having a double function "academia" and "business", and one person having a double function "government" and "business". **Left chart** including students, **right chart** excluding students.

Although most of the users can be related to academia, as Hammill et al. (2013) [9] found in their study, there are also quite a few top users that come from business parties or local governments. The distribution between academia, government and business parties is actually rather even, when students are excluded who usually contribute to ClimateScan as part of an assignment. Only civil society is still rather underrepresented. The low representation of civil society is not surprising, as they have not yet been targeted directly. For business parties, it is an opportunity to present the exact locations of their own innovations in the field (e.g., water harmonica or a particular permeable pavement). Interestingly, only two of the seven top users on ClimateScan coming from business parties use ClimateScan as such; the others also upload other examples simply because they are interested in the topic and experience it as fun to share these examples with a wider audience. The representatives from government mostly come from municipalities and like to share examples of nature-based solutions and climate adaptation from their own city (e.g., Nijmegen, Groningen, and Enschede). While motives such as pride and a certain element of competitiveness certainly play a role, we also know from personal conversations with representatives from municipalities in The Netherlands that ClimateScan gives them the opportunity to create an overview of the nature-based solutions in their municipality. Often, municipalities in The Netherlands do not have such an overview, because measures such as NBS cannot easily be included in the usual sewer asset management software, which is being used to calculate storage capacity and floodings in the urban areas. Therefore, local government officials also use ClimateScan as a free data repository for themselves and in order to draw more attention to these nature-based solutions.

The ClimateScan community that is active and shows a high level of commitment is small yet diverse in their backgrounds. ClimateScan has contributed to intensified contacts between some of the top users. For example, some of the top users have actually made appointments to go "treasure hunting" on the weekends, in which they try to find new and innovative examples of climate adaptation.

6. Discussions and Conclusions

This paper addresses how online knowledge-sharing platforms can stimulate stakeholder engagement and promote NBS by providing in depth insights into the case of ClimateScan—an innovative, bottom–up approach to map best practices of NBS around the world using citizen science.

Based on an analysis of the content, the actual users, and the community behind the ClimateScan platform, we have identified the following potentials and pitfalls of ClimateScan.

A typical concern related to online platforms is that many online platforms are only managed actively for a certain period of time and content becomes quickly outdated [10]. A strength of ClimateScan's citizen science approach is that the database and user numbers only keep growing. Moreover, the content of the platform is "adaptive" and does not easily run the risk of being outdated,

as users themselves create and update the content of the website with concrete examples of NBS. Since concrete examples are a manifest of their time, the website can also grow with changing terminology or new developments in the debate (see example "tornado trails"). However, the freedom that is given to users in the way they describe and illustrate examples also leads to varying data maturity and a rather heterogeneous database. Some data points are filled with much information and visual materials, whereas others only contain a dot on the map and a rough description. Although some variation in data maturity will always remain with a citizen science approach, better guidance on the website in the form of video tutorials as well as the training of volunteers would improve the overall data quality. To create a more homogeneous and neater dataset, this training could find inspiration in existing classifications of NBS [1–3]. As visual information seems to be most appealing, the addition of photos and video material could be made a requirement during the data submission process.

Another concern related to online adaptation platforms refers to the actual users and the inclusivity of online adaptation platforms. Online platforms often tend to have an overrepresentation of researchers and the Global North [9]. ClimateScan certainly shows similar characteristics, with a dominance of uploaded projects from The Netherlands and Western Europe due to its origin and active promotion in The Netherlands. However, looking at the top users and their background shows that ClimateScan is appealing not only to researchers but also representatives from business parties and local governments. ClimateScan has managed to give a platform to small-scale initiatives that are otherwise undocumented and receive hardly any attention. To further increase its usage, ClimateScan should maintain and further build on its "niche function". The focus on small-scale measures such as (bio)swales, green roofs, and green walls and their design makes it low key and easy for registered users to upload examples, as the imagery can speak for itself, and no detailed knowledge of the example is necessary.

Last but not least, online adaptation platforms often struggle with creating and maintaining a well-functioning community of practice [9,10]. The openness of the website and active promotion in online and offline fora has resulted in quite a diverse and practice-oriented user group. However, although quite an amount of people have registered over the years, people seem to lose interest after a while. Engaging with the ClimateScan community with workshops and social media updates could stimulate long-term engagement and recruit new users. Here, we can learn from the motivations of top users, which show that mapping can unite people and that mapping together can be a fun activity. Workshops could address different actor groups. Creating teams and using the element of competitiveness (who finds most nature-based solutions in a short amount of time) could be an idea to grow and foster the ClimateScan community in the future.

Author Contributions: Conceptualization, B.R.; methodology, B.R. and F.C.B.; software, B.R. and F.C.B.; validation, B.R. and F.C.B.; formal analysis, B.R. and F.C.B.; investigation, B.R. and F.C.B.; resources, F.C.B.; data curation, F.C.B.; writing—original draft preparation, B.R.; writing—review and editing, B.R. and F.C.B.; visualization, B.R. and F.C.B.; funding acquisition, F.C.B. All authors have read and agreed to the published version of the manuscript.

Funding: ClimateScan was applied as a tool in the international project WaterCoG (WaterCo-Governance) co-funded by the North Sea Region Programme 2014–2021. Ref: http://waterjpi.eu/jointcalls/joint-call-2015/funded-projects-under-the-2015-water-jpi-joint-call and https://northsearegion.eu/watercog/.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data available in a publicly accessible repository. The data presented in this study are openly available in climatescan.org.

Acknowledgments: We would like to thank everyone who has contributed to ClimateScan over the years. Without the effort of these volunteers, ClimateScan would not be such a lively platform. Moreover, we would like to thank Koen Salemink for his helpful suggestions during the writing process.

Conflicts of Interest: The authors declare no conflict of interest.

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ISBN 978-3-0365-0583-1