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D4.3 – Development of an alternative value scale for NBS implementation in cities

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Table of Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730468

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 730468

Table of Tables

Table of Figures

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730468

Glossary

Acronym	Full name
AMA	Amsterdam Metropolitan Area
DHC	Descendant Hierarchical Classification
ECU	Elementary Context Unit
EFA	Exploratory Factorial Analysis
EQoL	Environmental Quality of Life
FAC	Factorial Analysis of Correspondance
IPCC	Intergovernmental Panel on Climate Change
N4C	Nature4Cities
NBS	Nature-based Solutions
QoL	Quality of Life
UHI	Urban Heath Island
WHO	World Health Organization

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1 Executive Summary

1.1 Purpose and methodologies

The main aim of task 4.3 is to develop an alternative valuation scale for nature-based solutions (NBS) based on 'quality of life' indicators (QoL). This scale is meant to assess individual and collective perceptions and the impact of NBS on the different sub-dimensions of quality of life (i.e. physical, psychological and social quality of life). As we will develop further, the perception of an NBS is a major predictor of the environmental quality of life related to NBS. Thus, understanding NBS perception and NBS perceived benefits would be a major step in promoting existing NBS, as well as a key to success for new NBS projects.

In its final form the EQoL scale is an operational tool dedicated to the assessment of NBS benefits on quality of life. In this sense, the EQoL scale can be used to understand how people in a given area perceive and assess the benefits of a given NBS around where they live, with the possibility of targeting a particular type of inhabitant (for example, elderly people or patients). It can also be used to target users of a particular NBS and understand if a given NBS is perceived as enhancing quality of life.

For operational purposes, the EQoL scale is composed of six independent modules that target different NBS (parks and gardens, urban farms or collective gardens, natural spaces, blue spaces, green surfaces and biodiversity). Each of these modules can deliver a score. In this case, it is possible to consider implementing the EQoL scale for studies about the impact of physical, perceived or psychological predictors on environmental quality of life related to NBS.

In order to develop the EQoL scale, three qualitative studies were carried out for the identification of the different links between NBS and QoL. These studies are briefly presented in this deliverable.

1.2 Key Findings and Conclusions

Following the validation of the EQoL scale, two implementation scenarios of the EQoL scale were proposed. In each scenario, we tested an integrated model that included several physical, perceived and psychological indicators in relation with the EQoL modules for parks

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and gardens and blue spaces. Interestingly, in the two examples the amounts of green and blue spaces were identified as significant predictors of the environmental quality of life. This implies that the availability and proximity of these spaces have a positive impact on the environmental quality of life linked to public gardens and parks and blue spaces.

This emphasizes the possibility to use the EQoL scale for assessing environmental quality of life: it can be used as a tool to assess the impact of an NBS before it is implemented, or as an assessment tool to measure the efficiency of an NBS after its implementation.

This is especially interesting if we consider that the lack of green spaces around the living place can have a detrimental effect on physical and psychological health. It emphasizes the need to promote the access and availability of green spaces (public gardens, parks or blue spaces) as accessibility and availability are predictors of how much people would benefit from these spaces. Furthermore, for vulnerable people, the development of NBS near where they live should be considered.

1.3 Link With N4C Platform

The EQoL scale is an alternative valuation scale dedicated to the assessment of NBS benefits on quality of life. As such, it can provide additional information on the possible benefits of NBS on several dimensions of quality of life (social, physical and environmental) and its use can give specific hints if specific public are targeted (such as vulnerable people).

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2 Introduction

2.1 Purpose

The main aim of task 4.3 is to develop an alternative valuation scale for nature-based solutions (NBS) based on 'quality of life' indicators (QoL). This scale is meant to assess individual and collective perceptions and the impact of NBS on the different sub-dimensions of quality of life (i.e. physical, psychological and social quality of life). Quality of life also integrates multiple aspects of interactions between individuals and their environment, such as thermal comfort, noise, air quality, ambience, etc. The effects of NBS on these different factors should therefore have a positive impact on quality of life. In its final form the EQoL scale is an operational tool dedicated to the assessment of NBS benefits on quality of life. In this sense, the EQoL scale can be used to understand how people in a given area perceive and assess the benefits of a given NBS around where they live, with the possibility of targeting a particular type of inhabitant (for example, elderly people or patients). It can also be used to target users of a particular NBS and understand if a given NBS is perceived as enhancing quality of life.

The different sub-tasks will be addressed successively in this deliverable.

- Identification of the different indicators of QoL related to NBS (Leader: UN): To identify relevant indicators of QoL related to NBS, task 4.3 included two preliminary studies as part of the development of the EQoL scale. These studies focused, respectively, on how the inhabitants of Nantes (France) perceived NBS and how the inhabitants of Lyon (France) perceived the benefits of NBS on thermal comfort. Details of these studies are presented in Section **Erreur ! Source du renvoi introuvable.**.

- Socio-spatial resilience (Leader: UN): A complementary aim of task 4.3 was to address the socio-spatial resilience of spaces incorporating NBS, i.e. their capacity to be used differently and the differences between uses and functions over time. Indeed, to discern the key points of NBS implementation success or failure to attain this socio-spatial resilience, it is necessary to identify the influences of design and

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management strategies on social practices and citizen satisfaction. Details of this sub-task are presented in Section 6

- Choice of case studies (Leader: UN): The main criteria for the choice of case studies were the type of NBS, the geographical situation of cities and the availability of NBS-related data. The pilot cities involved in the Nature4Cities (N4C) project were solicited for data collection. A call for contributions was also launched to recruit new partners for data collection from inside and outside the consortium. The result was that eight different cities from various European regions participated in the development and validation of the EQoL scale. A full description of these cities is presented in 7).

- Validation of an alternative value scale for NBS based on quality of life (Leader: UN): A quantitative validation of the EQoL scale is presented, as well as an integrated model in which the EQoL scale is inserted among various physical, psychological and health indicators, as well as a perceived NBS indicator. This integrated model was designed as an operational example and should allow us to better understand how NBS contribute to enhancing quality of life. The full validation process of the EQoL scale is presented, together with the integrated model, in Section 7.

2.2 Contribution of partners

University of Nantes (UN) was in charge of the preliminary studies, the conception and validation process of the EQoL scale, and writing the deliverable. UN also coordinated the different partners involved in task 4.3. More specifically, the municipalities of Alcala de Henares (AH), Milan (CMM), Ankara (CAN) and Szeged (SZEG), as well as DuneWorks (DW) were involved in translations and data collection, as well as the recovery of physical and social data related to NBS in the different cities. Plantes & Cités (PC) provided support during the development of the EQoL scale and resources for disseminating the survey. More specifically, PC wrote and disseminated the call for contributions that was launched as part of task 4.3 to recruit partners for data collection (municipalities or academics).

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Finally, TRIBU, an external partner of UN, contributed to data collection for the qualitative study depicted in Section 5 (Focus on thermal comfort among inhabitants of two districts of Lyon (France)).

Table 1 - Contribution of partners

Activities of Task 4.3.	**Responsible partners**
State of the art and case studies selection	UN
Qualitative studies in Nantes	UN
Data collection in Lyon (on thermal comfort)	UN and TRIBU
Development of the EQoL scale	UN
Translation of the EQoL scale and translation of the integrated model questionnaire	AH, CMM, CAN, SZEG, DW
Data collection for the EQoL scale validation	AH, CAN, SZEG, DW, UN + external partners
Call for contributions and dissemination of the EQoL validation study	PC
Validation of the EQoL scale	UN
Writing of the deliverable	UN

2.3 Expected audience

This report is addressed to any person or organization (local authority, association, company, etc.) involved in the implementation or assessment of nature based solutions and more particularly to the public authorities, at all levels of governance. It is also intended for researchers interested in the links between environmental quality of life and NBS.

This report proposes an operational scale of evaluation of the benefits related to NBS (EQoL) (Sections 8 and 9) and also presents three qualitative studies realized prior to the development of the scale in order to gather base material for this development (Sections 4, 5 and 6). The reader will find in this report an overview of the knowledge available in psychology on the links between NBS and quality of life as well as examples of practical projects and practical recommendations concerning the scale achieved. However, it does

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not constitute a comprehensive and full review of NBS projects and their benefits on quality of life.

2.4 Structure of the deliverable

Following the executive summary and this introduction, a brief reminder of the NBS definition is proposed as well as a definition of environmental quality of life (Section 3). Then, three qualitative studies are presented in the fourth, fifth and sixth section. These qualitative studies were carried out in order to gather sufficient data for the development of the EQoL scale and they were designed to be complementary. In details:

- Section 4: Perceived links between quality of life and NBS among inhabitants of Nantes (France): An overview of the perceived links between NBS and QoL: a qualitative study was conducted with a sample of 25 inhabitants. Discursive data was collected through semi-structured interviews and analyzed through lexicometric analysis. To do this, a descendant hierarchical classification (DHC) was conducted on the whole corpus, followed by a factorial analysis of correspondences (FAC). The results suggest that NBS are mainly associated with the positive dimensions of quality of life, with the social dimension and sociability coming out on top. Following these analysis, these discursive data were used as input for the development of the EQoL scale;

- Section 5: Focus on thermal comfort among inhabitants of two districts of Lyon (France): This second qualitative survey focused on thermal comfort. Inhabitants from two districts of Lyon (France) were interviewed and a comparative analysis of their perception and habits regarding thermal comfort and heat events was performed. This study highlights that beyond the immediate perception of extreme heat events, thermal comfort assessment depends on previous experiences of heat events, personal history, social trajectory and social background. Results emphasized the need to take into account personal aspects and longer periods of time in the assessment of thermal comfort. Qualitative data gathered during this study were used as input for the development of the EQoL scale.

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- Section 6: Socio-spatial resilence: Designers and managers were interviewed on their knowledge and point of view regarding environmental and social issues and policies and management. Also, we observed in this study that professionals relied less on technology to solve these environmental challenges and more on social aspects.

The following figure presents the general organization of the deliverable. The development, validation and implementation of the EQoL scale are presented in part 8 and 9. The previous sections present qualitative studies carried out in order to gather sufficient data for the development of the EQoL scale (Sections 4, 5, 6).

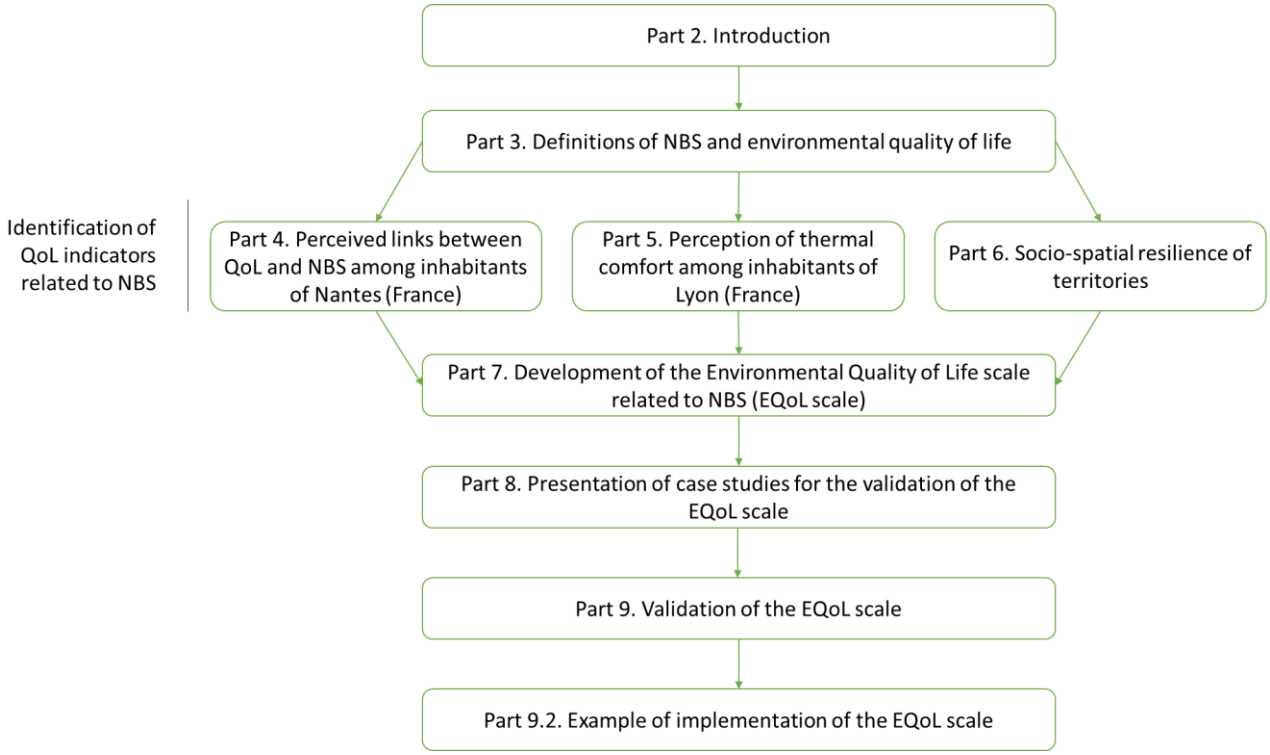

Figure 1 - Structure of the deliverable

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2.5 Links between task 4.3 and the other tasks

Task 4.3 has several links with other tasks in the Nature4Cities project. In particular, the development of the EQoL scale is based on the definition of NBS and the typology of NBS developed in WP1, task 1.1.

Furthermore, a toolkit should be produced for the implementation and development of the EQoL scale as part of WP7, task 7.2. and data collection is planned with the help of Terranis to replicate the study and extend the scope of the EQoL scale in the task 7.4.
Finally, input from the tasks 4.3. and 7.4. related to the EQoL scale should be implemented into the N4C online platform. These links are summarized in Figure 2.

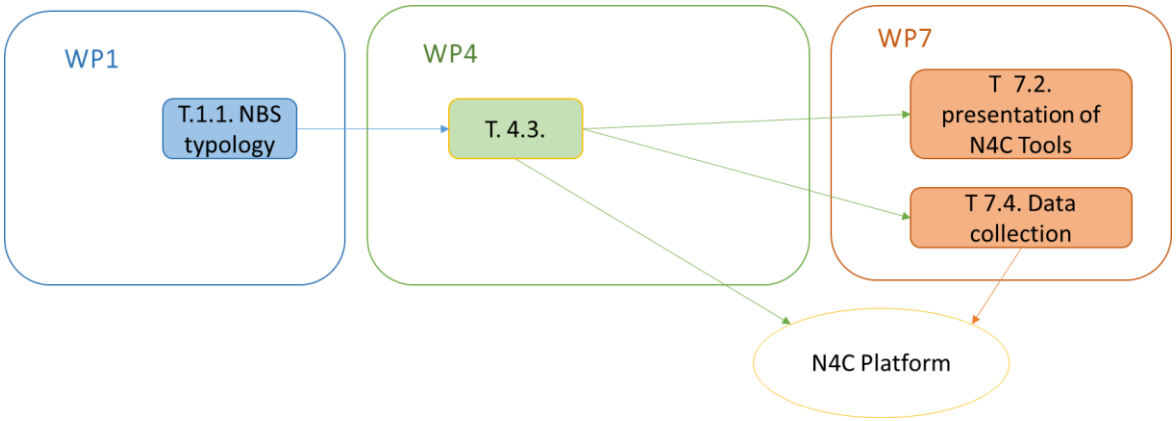

Figure 2 - Links between the Task 4.3. and other tasks

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3 Definitions

3.1.1 NBS definition in relation to Quality of Life

The notion of nature-based solutions is recent and is not well oultlined yet (Albert, Spangenberg, & Schröter, 2017; Nesshöver et al., 2017). According to Potschin et al. (2015), the early use of the term in the scientific literature dates from 2000 in agricultural context. In the N4C project, the EU definition of NBS was made explicit and refined as part of the task 1.1. (D1.1. NBS multi-scalar and multi-thematic typology and associated database) (CEREMA, 2018). NBS refer to actions inspired, supported or copied from nature and incorporating living solutions or supports for life. In that sense, NBS are positive answers to societal challenges and designed to target a whole range of urban challenges connected to climate change. They tend to achieve environmental sustainability as well as social and economic objectives at the same time. NBS are conceived as part of a complex and functional system – in that sense, they are the opposite of hyper-specialized solutions and bring ever more diverse nature or natural features to cities. More information is available on the Nature4Cities blog[1].

NBS can demonstrate certain characteristics, as it stated in Deliverable 1.1. (NBS multi-scalar and multi-thematic typology and associated database) (CEREMA, 2018):

- Richness: NBS are supposed to target different environmental challenges at the same time. However, they are not equal when it comes to answer these environmental challenges. Some NBS are linked to more challenges and sub-challenges than others, and certain NBS are more efficient to deal with certain challenges than others.

- Hierarchy: Given that NBS targets different environmental, social and economic challenges at the same time, it should be possible to identify a main challenge and

[1] https://www.nature4cities.eu/blog/nature4cities-multi-scalar-and-multi-thematic-nature-based-solutions-typology

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several secondary challenges, for which the NBS will produce co-benefits. In this case, a hierarchy of urban challenges targeted should emerge.

- Trade-offs: It is possible to identify NBS that are highly effective in responding to several challenges. However, environmental, social and economic challenges are often contradictory and implementing some NBS could have a negative impact with regard to non-targeted challenges.

Further research is necessary to identify the links between these NBS and an enhancement of or a reduction in quality of life. As previously mentioned, NBS have the potential to provide an answer to social challenges and can also improve quality of life for inhabitants in urban environments. However, NBS interventions are diverse in their design, scope and scale and thus not all NBS are equal when it comes to influencing the quality of life. Whereas some NBS will meet social demands highly effectively, other NBS will improve quality of life as a co-benefit (2nd ranked benefit). In particular, research has highlighted that NBS interventions at a microscale do not have such positive effects if compared to interventions at a medium or a large scale. Finally, certain NBS will improve quality of life at a certain cost or under certain conditions and can have a detrimental effect if these conditions are not successfully met. For examples, public parks are often related to an increase of the environmental quality of life but, to be fully effective, it is necessary that these parks are also perceived as sufficiently safe to provide these benefits. Also, if blue spaces are not well managed, the proliferation of mosquitos can be a counterproductive effect and decrease environmental quality of life.

3.1.2 Environmental quality of life

Many studies have already shown the positive impact of NBS on urban spaces for managing floods, episodes of high temperature or pollution. The same goes for the links between NBS and health or well-being. However, it is rarer to find studies interested in the perceived links between solutions based on nature and a gain or loss of quality of life in its different dimensions. Nevertheless, the question of quality of life is transversal to the different climatic and social challenges cities face today and has obvious links with economic, socio-cultural, psychological and environmental spheres (van Kamp, Leidelmeijer, Marsman, & de

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Hollander, 2003). Moreover, NBS have direct and indirect impacts on quality of life. Given that they provide answers to environmental challenges, such as climate hazards or air pollution, or territorial challenges of justice and social cohesion, potential perceived gains in quality of life are expected, which should also lead to the adoption or rejection of NBS in the city.

In the field of environmental studies, notions of quality of life, residential satisfaction and well-being are often confused (van Kamp et al., 2003). To better understand the concept of quality of life, however, it is possible to distinguish between everything that relates to the material living conditions of individuals from an objective point of view and their subjective appreciation of satisfaction concerning quality of life as well as subjective well-being (Organisation Mondiale de la Santé, 1998). This integrative approach combines objective indicators of living conditions with satisfaction, well-being and happiness (Szalai, 1980).

Most authors agree that quality of life is a multidimensional concept and it is thus common to differentiate between its physical, psychological and social dimensions (Organisation Mondiale de la Santé, 1998), as well as its environmental dimension. The environmental dimension of quality of life, proposed by the WHO, accounts for the inconvenience of pollution, noise and climate, as well as certain characteristics of places of residence, such as accessibility of health services and presence of recreational facilities or means of transport. Its integration into the notion of quality of life emphasizes the importance of satisfaction with regard to the living environment. (Shafer, Lee, & Turner, 2000).

The work of Fleury-Bahi, Marcouyeux, Préau, and Annabi-Attia (2013) identified four components making up the quality of urban environmental life: the social image of the neighborhood, stores and services, traffic and the environmental state of the urban transport network, and pollution and inconvenience. Thus, three components of environmental quality of life are generally identified in the literature: satisfaction with the social environment, physical environment and urban development.

Some articles develop the links between quality of life and nature-based solutions, but these articles focus mostly on the social benefits of green spaces and they do not take into account the environmental challenges that NBS are meant to meet (such as heat reduction or pollution). Also, there is a complete lack of research concerning certain nature-based solutions (in particular, green surface areas or collective gardens) in terms of QoL enhancement.

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Considering these facts, not all NBS can be considered as equal when it comes to enhancing the quality of life, as some will only enhance specific aspects of QoL, whereas others will offer other advantages. Research is necessary to determine how the different NBS can increase QoL in its different dimensions (including co-benefits or 2nd ranked benetifs of NBS on QoL provided by the answer of NBS to certain detrimental environmental phenomenon such as heat or pollution).

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4 Perceived links between quality of life and NBS among inhabitants of Nantes (France)

Prior to the development and validation of the EQoL scale, two different qualitative studies were conducted with inhabitants. The first study (Section 4) aimed to verify the links previously identified and understand how inhabitants perceive NBS in their living environment. The second study (Section 5) focused on thermal comfort and aimed to understand the perceived benefits of NBS to provide an answer to environmental challenges related to thermal issues.

4.1 Objectives of the study

By restricting the scope of this research to perceived links between quality of life and nature, this research aimed to analyze the discourse of inhabitants of the city of Nantes and identify spontaneous associations between environmental quality of life in the city and certain forms, structures or systems associated with nature-based solutions.

As previously stated, while there is clear evidence of the effect of green spaces in urban areas on heat, flooding, pollution and psychological health, there is no information about specific qualities or aspects of these green spaces and quality of life. Such information is required to identify quality of life indicators related to NBS. This is why, in this part, we sought to qualitatively establish how nature-based solutions are perceived by individuals, and which NBS characteristics are mainly associated with an enhancement of or a reduction in quality of life. Furthermore, considering that nature-based solutions are meant to provide an answer to a combination of environmental, social and economic challenges, we will discuss the potential benefits and limitations of nature-based solutions.

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4.2 Methods

4.2.1 Material

An interview guide was drawn up to conduct interviews and ensure that they followed a similar pattern.

The final version of this guide was comprised of four different parts:

- Positive and negative aspects of nature in cities,
- Perceived benefits and inconveniences of nature-based solutions on quality of life.

In addition, data on several personal parameters were gathered at the beginning of the interview for the purpose of this research: gender, age, district of residence, professional and marital statuses, composition of the household, type of residence, and ownership of a garden. All the participants were asked for consent before the interviews took place, and all the research material was anonymized and aggregated after the data collection in order to ensure confidentiality.

4.2.2 Participants and Procedure

25 semi-directive interviews were carried out to meet the objective of this first study. The research was presented as a study on the beneficial effect of nature in cities on health and quality of life. Participants were recruited by email, via social media and through personal networks. Participants with different profiles volunteered for the qualitative study. However, only participants that had lived in Nantes for at least two years were retained. Explicit consent was requested before the interviews took place. The interviews lasted between 20 minutes and an hour. They were carried out at the participant's home most of the time, though several interviews were conducted in the university's offices for convenience.

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4.2.3 Data Analysis

To attain our objectives, a lexicometric analysis of the interviews was carried out, using the Iramuteq (R Interface for Multidimensional Analyses of Texts and Questionnaires) package (Ratinaud, 2019; Ratinaud & Déjean, 2009).

We performed two different analyses, each with a distinct goal. Firstly, we performed a Descendant Hierarchical Classification (DHC). A DHC makes it possible to obtain coherent thematic classes from the discourse of participants on the basis of term co-occurrence patterns.

Iramuteq software splits the corpus into elementary context units (ECU), consisting of segments from 10 to 15 words each. It then searches for the most frequently associated words within these ECUs and regroups the most similar ECUs within classes – also called thematic profiles (Roy & Garon, 2013). For each of the words in these classes, the software computes a χ^2 and its significance value, which makes it possible to identify the words that structure the thematic classes and thus interpret them. Finally, the DHC made it possible to identify the most representative categories (age, gender and status) associated with thematic classes among the categories previously filled in by the researcher for each of the corpus texts.

Secondly, we performed a Factorial Analysis of Correspondence (FAC) to graphically represent the organization of the different thematic classes. This second analysis gave information about the proximity and the relationships between the different classes, which is essential for discussing the general organization of the discourse.

In this study, we opted for a software approach to analyze the data because it made it possible to analyze and compare long interviews on a single topic without any side-effects, such as exhaustion and subjectivity of the researcher. Furthermore, the software offered a significant contribution in terms of data visualization.

Throughout the discussion, most of the representative text samples (most significant ECUs), identified by the Iramuteq software, will be introduced as examples.

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4.3 Results: Identification of Quality of Life indicators related to NBS

4.3.1 Descendant Hierarchical Classification (DHC)

The descendant hierarchical classification analysis reveals that the discourse is organized into five thematic classes (Figure 3), which indicates a strong heterogeneity of the participants' discourse. These thematic classes all refer to positive or negative perceived attributes of nature in the city. The corpus comprises 1774 ECUs, of which 1616 were taken into account in the analysis (91.09% of total ECUs). An analysis of the dendrogram (Figure 3) reveals that classes 3 and 4, which refer to social and environmental issues, separate very early from classes 1, 2 and 5, which relate to the benefits of nature in city for oneself, on the different facets of quality of life (physical, psychological, social).

The first class, called "Connectedness to nature", includes 11.2% of classified ECUs. It is characterized by natural elements, like "flower" (χ^2 (1) = 199.15, p <0.001), "trees" (χ^2 (1) = 185.12, p <0.001) or "birds" (χ^2 (1) = 110.89, p <0.001). It also contains words that relate to the connections between individuals and nature, as demonstrated by verbs such as "looking" (χ^2 (1) = 82.13 p <0.001), "walking" (χ^2 (1) = 57.41, p <. 001), "listening" (χ^2 (1) = 37.69, p <0.001), "gardening" (χ^2 (1) = 37.16, p <0.001) or "enjoying" (χ^2 (1) = 12.71, p <.001). Finally, a number of positive attributes are associated with this class: "magnificent" (χ^2 (1) = 22.74, p <0.001), "pleasant" (χ^2 (1) = 12.50, p <0.001) or "good" (χ^2 (1) = 22.44, p <0.001). A list of the main words characterizing this class is given in Annex 9.

This class is mostly associated with the discourse of participants aged 60 or over (χ^2 (1) = 5.61 p <0.05) and the retired (χ^2 (1) = 4.11 p <0.05).

The second class, "Well-being and nature", includes 27.48% of classified ECUs. It is characterized by words that relate to "nature" (χ^2 (1) = 85.44, p <.001) and its restorative effects. The word "well-being" itself appears as part of this class (χ^2 (1) = 19.74, p <.001). A single NBS is associated to this class, "Natural spaces" (χ^2 (1) = 36.52, p <.001) as well as "countryside" (χ^2 (1) = 30.0, p <.001). The main verbs included in this class are: "to breathe" (χ^2 (1) = 26.62, p <.001), "to live" (χ^2 (1) = 32.84, p <.001) and "to feel" (χ^2 (1) = 25.89, p <.001). Finally, the main words included in this class are "green" (χ^2 (1) = 29.28, p <.001), "air" (χ^2 (1) = 20.96, p <.001), "oxygen" (χ^2 (1) = 19.74, p <.001), "quiet" (χ^2 (1) = 18.50, p <.001), "agreeable" (χ^2 (1) = 18.00, p <.001), "sun" (χ^2 (1) = 11.19, p <.001) and "vital" (χ^2

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(1) = 10.58, p <.01). In conclusion, all of the words and verbs of this second class imply that nature in the city clearly benefits the psychological health of participants. A list of the main words characterizing this class is given in Annex 10.

The third class, entitled "Territorial links", includes 30.88% of the classified ECUs. It is characterized by words that relate to social events, such as "concerts" (χ^2 (1) = 22.52, p <.001), “coffee” (χ^2 (1) = 22.52, p <.001), places, such as “district” (χ^2 (1) = 42.83 p <.001), or social groups, such as “neighborhood” (χ^2 (1) = 11.23 p <.001). An NBS, “collective gardens” (χ^2 (1) = 11.23 p <.001), is associated with this class. The main verbs are “to know” (χ^2 (1) = 75.27 p <.001), “to develop oneself” (χ^2 (1) = 20.93 p <.001) or “to exchange” (χ^2 (1) = 14.74 p <.001). Finally, this class also includes the words “social” (χ^2 (1) = 72.03 p <.001), “links” (χ^2 (1) = 30.93 p <.001), “culture” (χ^2 (1) = 23.80 p <.001) and “access” (χ^2 (1) = 15.59 p <.001). A list of the main words characterizing this class is given in Annex 11.

The fourth class, "Security and environmental challenges", includes 13.37% of the classified ECUs. It is the only class that is not clearly associated to a particular NBS. It includes words such as “insecurity” (χ^2 (1) = 57.45, p <.001), “night” (χ^2 (1) = 48.58, p <.001), “manners” (χ^2 (1) = 25.99, p <.001), “risk” (χ^2 (1) = 25.99, p <.001), “safety” (χ^2 (1) = 21.10, p <.001), “ecology” (χ^2 (1) = 19.48, p <.001), or “confidence” (χ^2 (1) = 13.15, p <.001). Two verbs are included in this class, “to fear” (χ^2 (1) = 15.50, p <.001) and “to help” (χ^2 (1) = 14.01, p <.001). A list of the main words characterizing this class is given in Annex 12.

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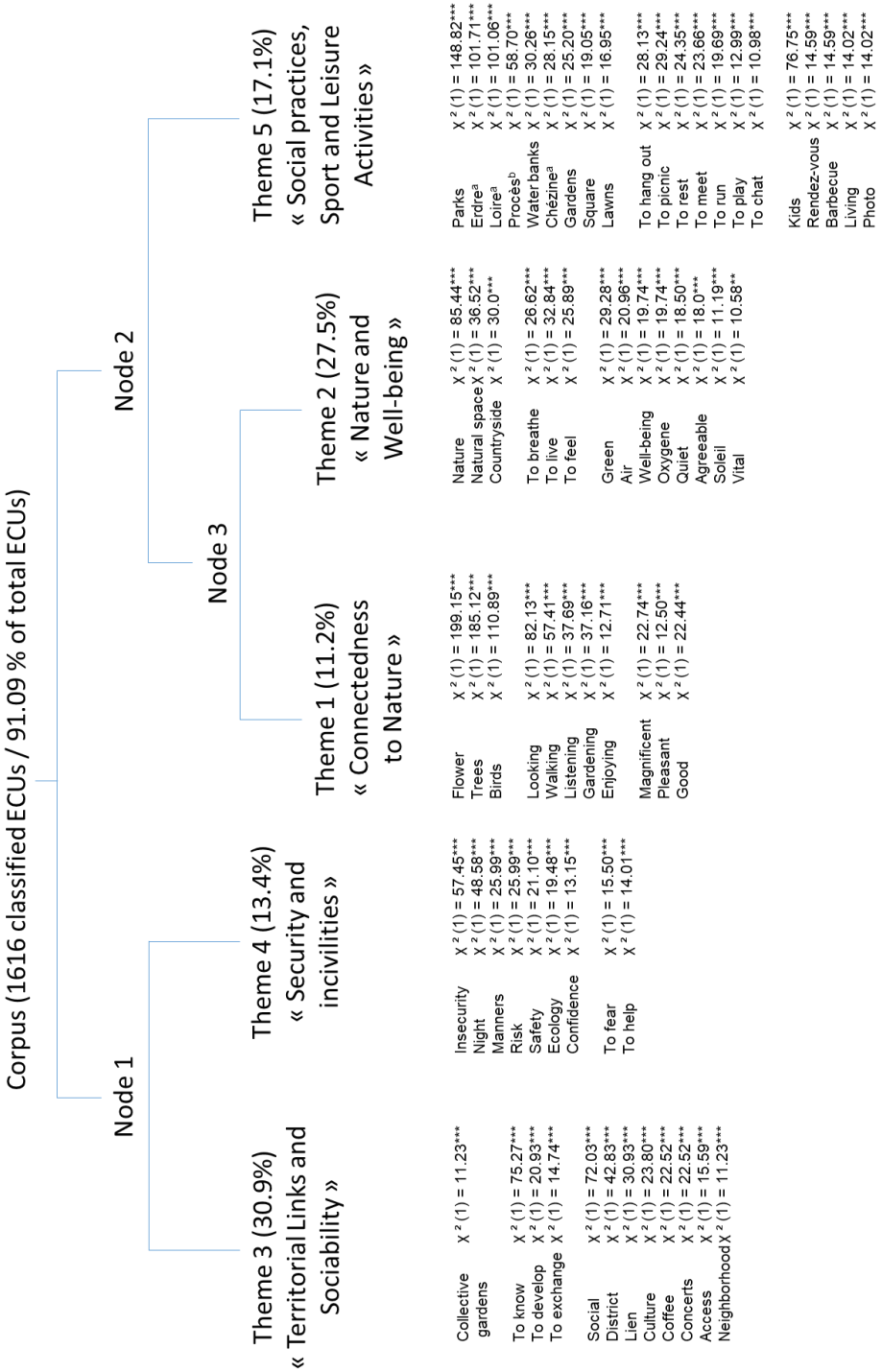

Note: [a]: rivers in Nantes; [b]: parks in Nantes.

Figure 3 - Descendant Hierarchical Classification (DHC) of the discourse of inhabitants of Nantes

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Finally, the last class, "Social Practices, Sport and Leisure Activities", includes 17.08% of the classified ECUs. Several NBS are clearly associated with this class, “parks” (χ^2 (1) = 148.82, p <.001), “water banks” (χ^2 (1) = 30.26, p <.001), “gardens” (χ^2 (1) = 25.20, p <.001), “square” (χ^2 (1) = 19.05, p <.001) and “lawns” (χ^2 (1) = 16.95, p <.001). Several parks and blue spaces of Nantes are also significantly associated with this class, “Erdre” (χ^2 (1) = 101.71, p <.001), “Loire” (χ^2 (1) = 101.06, p <.001), “Procès” (χ^2 (1) = 58.70, p <.001) and “Chézine” (χ^2 (1) = 28.15, p <.001), for example. The class is characterized by verbs that relate to activities, such as, “to hang out” (χ^2 (1) = 28.13, p <.001), "to picnic" (χ^2 (1) = 29,24 p <.001), “to rest” (χ^2 (1) = 24.35, p <.001), “to meet” (χ^2 (1) = 23.66, p <.001), “to run” (χ^2 (1) = 19.69, p <.001), “to play” (χ^2 (1) = 12.99, p <.001) and “to chat” (χ^2 (1) = 10.98, p <.001). Finally, this class includes several other words: “kids” (χ^2 (1) = 76.75, p <.001), “rendezvous” (χ^2 (1) = 14.59, p <.001), “barbecue” (χ^2 (1) = 14.59, p <.001), “living” (χ^2 (1) = 14.02, p <.001) and “photography” (χ^2 (1) = 14.02, p <.001). A list of the main words characterizing this class is given in Annex 13.

4.3.2 Factorial Analysis of Correspondence

The Factorial Analysis of Correspondence reveals that four factors organize the five classes. The first two factors in particular account for most of the relationships observed between them. The first axis (30.34%) reveals a clear opposition between elements perceived as more natural (Classes 1, 2 and 5) and elements that relate more to the quality of social life applied to the territory (Classes 3 and 4) (Figure 4). The second axis (25.54%) suggests an opposition between elements that refer to affective and cognitive spheres (Classes 1, 2 and 3) and behaviors, whether positive (Class 5) or negative (Class 4). Finally, the very close links between Classes 1 and 2 should be noted.

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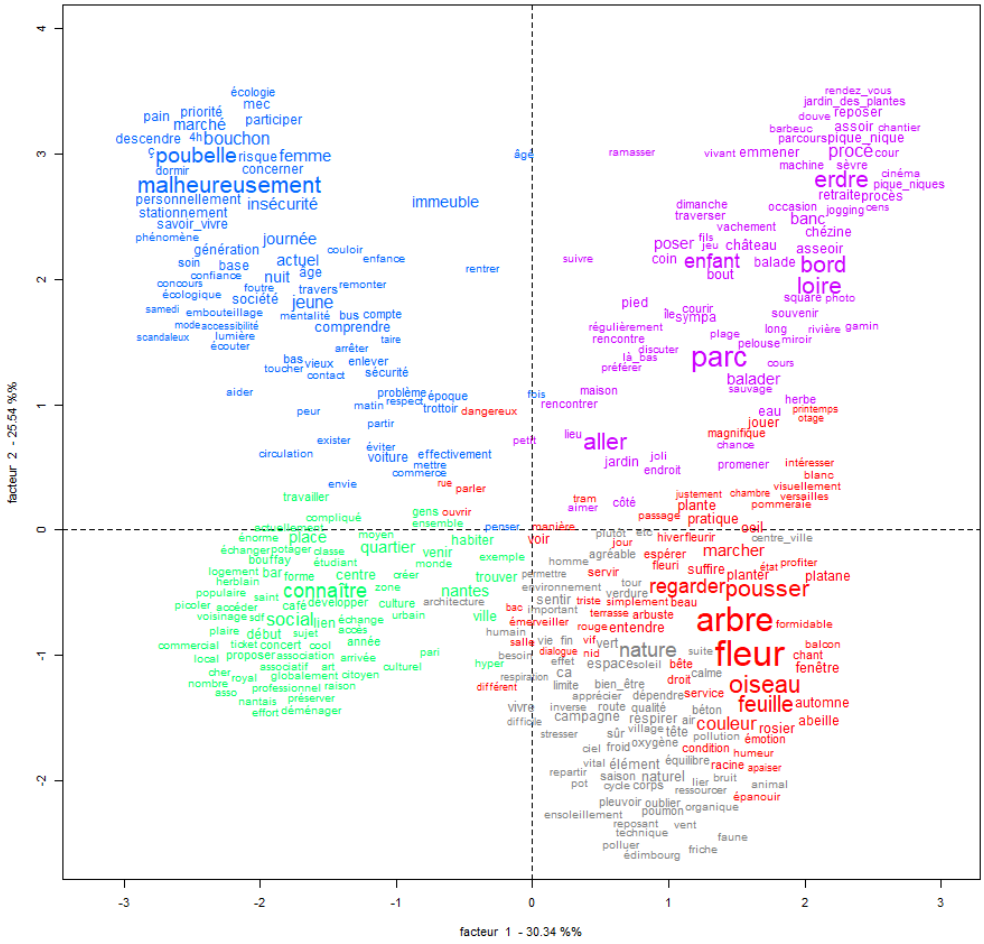

Note: The first class, “Connectedness to nature”, is shown in red, the second class, “Nature and well-being”, is shown in gray, the third class, “Territorial links and sociability”, is shown in green, the fourth class, “Security and incivilities”, is shown in blue and the fifth class, “Social practices, sport and leisure activities” is shown in purple. These classes correspond to the class previously identified by the descendant hierarchical classification.

Figure 4 - Factorial analysis of correspondences

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4.4 Discussion

The first qualitative analysis revealed that different forms of NBS are clearly identified by inhabitants: blue spaces, collective gardens, green spaces and biodiversity being particularly clearly identified as elements of nature in cities. In addition, each of these NBS was linked to certain sub-dimensions of quality of life (social, physical or psychological quality of life). However, these perceived links are very partial and the associations made between NBS and quality of life are often based on irrelevant attributes of the NBS. For example, the role of urban parks and gardens in regulating city temperatures as well as improving air quality is not known or recognized by residents. Furthermore, unmaintained spaces, often regarded as more natural, and elements of nature (trees, flowers, animals) are perceived as improving quality of life, even though these spaces and elements are also included in other NBS, such as public gardens and parks.

The visibility, accessibility and aesthetic qualities of NBS appear to be particularly important when considering perceived gains in quality of life. However, the various observations suggest that a greater effort to inform and communicate with the general public is still required. This study emphasizes the need to develop separate, independent and operational modules for the EQoL scale, focusing on the different NBS, to enable the assessment of projects that focus on a particular type of NBS.

Insecurity and waste were identified as environmental challenges and potential problems for nature in cities, but were not linked to a particular type of NBS. They are transversal problems that concern several NBS, and they should be addressed in the related modules of the scale (in particular for gardens and parks, blue spaces and natural spaces).

In short, the social sub-dimension of quality of life was central in the discourse of inhabitants. Collective gardens, public gardens and, especially, parks were associated with social events, social practices and activities.

Inhabitants did not address the problem of Urban Heat Islands and the question of thermal comfort was not spontaneously addressed in their discourse, though we previously identified this environmental challenge as a major challenge in cities with implications and consequences on environmental quality of life too.

Finally, green walls and green roofs were not identified as elements of nature in cities and were not identified as having a positive effect on the quality of life, even though there is

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plenty of literature about the benefits of these green surfaces on quality of life, and how they co-benefit because of their impact on other environmental issues such as air pollution or heat.

The lack of this NBS in the discourse of participants led us to reintroduce green surfaces in the EQoL scale for operational purposes, and to develop a module for this less known category of NBS.

Details regarding the development of each module and the associated sub-dimension of QoL are provided in Section 8 (Elaboration of the Environmental Quality of Life Scale (EQoL Scale) related to NBS).

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5 Focus on thermal comfort among inhabitants of two districts of Lyon (France)

The construction of NBS adapted to social and environmental issues implies a good upstream understanding of the relations that the inhabitants of cities maintain with the urban environment, in particular the urban climate. It is also important to measure and understand in greater detail how city dwellers' experiences of thermal comfort and quality of life are constructed through their everyday lives. To respond to this challenge of NBS based on an empirical understanding of socio-environmental dynamics, a qualitative survey was conducted on the inhabitants of Lyon from samples of diverse populations in two neighborhoods. These two districts present very different features in terms of their architectural and urban forms, nature elements and NBS as well as their social, cultural and economic characteristics.

5.1.1 Presentation of the two districts selected as case studies

In the region of Auvergne-Rhône-Alpes in France, the city of Lyon is located at the confluence of the Rhone and the Saone and is surrounded by the Massif Central and the Alps. The city reflects major social, economic and historical developments in Europe. As a hub for exchanges and migration, Lyon has become one the main French metropolises. Nowadays confronted with important climate issues, the city has become an interesting playground for researchers from the ESO laboratory to explore thermal comfort topics.

The climate of Lyon is characterized by a semi-continental climate influenced by the ocean (between CFA and CFB according to the Köppen Classification) with a significant thermal amplitude (8.8°C). The Massif Central is an orographic barrier against the influence of the Atlantic Ocean. The prevailing winds follow the north-south axis of the Rhone corridor. This same relief greatly influences the annual precipitation height, which is higher here than in cities on the same latitude. Temperature can reach -10°C in winter and 37°C in summer (Météofrance, 2018). In addition to this large thermal amplitude, extreme events are quite common, with many episodes of heat waves. The city of Lyon thus appears to be particularly vulnerable to the effects of climate change. Aware of this vulnerability, public authorities, and more specifically the Greater Lyon authority, committed earlier and more seriously than

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most of French metropolises to combatting climate change. Indeed, Greater Lyon has been involved in this combat since 2007, mobilizing local authority services, the “Agence Locale de l’Energie” (ALEC) and research organizations.

The choice of two districts was motivated by the fact that they possess heterogeneous social, cultural, morphological and climatic characteristics. Consequently, taking account of those fields for research investigations on thermal comfort makes it possible to examine how differently inhabitants understand and perceive the weather and climate.

5.1.1.1 “La Guillotière” district

The district of “La Guillotière” is divided in two parts by the Lyon-Marseille railway line, and two distinct urban identities can be identified: a dense and residential northern area (district of “La Guillotière”) and a porous and industrial southern area (Gerland). The neighborhood is characterized by a tight, dense urban fabric. It includes many small squares, created by intersections and road crossings, and some small parks bringing vegetation into the city.
It showcases numerous urban development projects that have improved the climatic characteristics of the district. For example, the left bank of the Rhone has been totally restructured. The local Brin d’Guill association has transformed two urban areas of this neighborhood into shared gardens. However, the district remains very built-up. Furthermore, La Guillotière has a high population density. These two parameters increase the risk of thermal discomfort in the district. The population density is partly due to the attractiveness of this district which has hosted several waves of successive immigrants (Italian, Turkish, North African, Asian and sub-Saharan African). It is also the district of Lyon which has seen the biggest demographic increase since 1975. However, from a transport perspective, its high, built-up density reduces its CO2 emissions compared with other neighborhoods in Lyon, which are more affected by traffic. Finally, according to INSEE data, the population of this district seems fairly representative of the municipality of Lyon (average income, percentage of workers, percentage of executives, etc.).

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5.1.1.2 The 6th arrondissement of Lyon

The 6th arrondissement of Lyon is a very different district from La Guillotière. Indeed, its population appears to be much more homogeneous. In fact, it is a historically privileged neighborhood and is still the most affluent neighborhood of Lyon today. Moreover, the social segregation of this neighborhood has increased in recent years compared to the rest of the city. The district is not very dense demographically compared to the Lyon average and has a relatively stable population growth. The 6th arrondissement is mainly composed of city buildings comprising four to seven levels. The Parc de la Tête d'Or is surrounded by old houses and bourgeois villas built in the second half of the 19th century. The high amount of vegetation and the wide avenues reduce its climatic vulnerability, especially to urban heat island effects.

5.1.2 Participants and procedure

Data about the demographic and economic characteristics of the population in the two districts were collected. On this basis, we built representative samples to be representative of the social diversity of the districts. For that, we relied on the most recent INSEE data available (2015). Different criteria were used to select the profiles of inhabitants: age, gender, socio-professional category and cultural communities. Among other things, we wanted the different diasporas to be represented to examine the social and cultural diversity of relationships with thermal comfort of inhabitants. This last criterion seemed particularly important to us for the La Guillotière neighborhood, which has historically been the host district for various waves of immigration. The important cultural mix of people from North Africa, Asia, sub-Saharan Africa, India and so on shapes the identity of the neighborhood, characterized by a strong cultural cosmopolitanism. More than 70 individuals were surveyed in total: about 30 individuals were interviewed in the sixth arrondissement and about 40 in the district of La Guillotière. This qualitative survey is based on semi-structured interviews of between 30 minutes to an hour, which were analyzed using a grid that was developed with themes and assumptions from the interview guide.

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Table 2 - Description of the sample

	La Guillotière	6th arrond.	Total
GENDER			
Men	19	12	31
Women	21	19	40
AGE			
15 - 19 years	3	3	6
20 - 29 years	5	3	8
30 - 39 years	6	0	6
40 - 49 years	4	4	8
50 - 59 years	6	4	10
60 - 69 years	7	9	16
70 - 75 years	7	7	14
>75 years	2	1	3
SOCIO-PROFESSIONAL CATEGORY			
Craftsman, shopkeeper, business owner	4	3	7
Manager, professor of higher education	13	6	19
Teacher	2	1	3
Employee	3	2	5
Worker	2	0	2
Retired	11	11	22
Unemployed	3	2	5
Pupil, student	2	6	8
DIASPORA			
Portugal	0	1	1
Algeria	2	0	2
Morocco	0	0	0
Tunisia	4	0	4
Other African countries	1	2	2
Other countries	5	0	5

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5.1.3 Results and discussion

We have split our analysis into two parts. Firstly, we will summarize the main results of the qualitative survey, which will emphasize the mains trends observed concerning thermal comfort as reported by inhabitants and city users. Secondly, we will discuss implications from a methodological point of view.

The qualitative survey carried out by the ESO laboratory among the inhabitants of the city of Lyon primarily improves our understanding of the way in which the perception of thermal comfort by inhabitants and users of the city is constructed. The first observation that emerges from the survey is that this perception, which takes place at a given time and in a specific geographical context, is in fact influenced by all the previous experiences of the individual. Our research highlights that, beyond the instantaneous physiological, cognitive and corporal mechanisms that intervene at a specific moment and in a particular place, other cognitive mechanisms that mobilize the memory of individuals from their previous experiences are used. The “feeling” of the climatic comfort of the inhabitants and users of the city also depends on their previous experiences and is related to their history, their social trajectory, their geographical trajectory, and more broadly, their entire “life course”.

Exposure, sensitivity and adaptability to a climate at a specific moment and in a particular geographical context constitute "knowledge of uses” (Sintomer, 2008) and therefore of real climatic skills for individuals. These skills highlight the notion of “capability” which considers the constraints as well as the resources with which people have to live daily and exploit to adapt to evolutions of various orders (Laigle & Blanc, 2015). To understand the logics of exposure, sensitivity and adaptability of populations, it seems important to bring the past (previous experiences of individuals and social groups, memories of climates experienced during their trajectory, places frequented in the past, etc.), the present (immediate sensory and physical experience: perception at a given time and place, etc.) and the future together (estimation of vulnerability and adaptability for future meteorological events).

The qualitative survey conducted confirms that individuals have different perceptions of climatic comfort, because of their spatial practices and knowledge of the microclimatic characteristics of these spaces. Three main categories of factors can be identified.

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The first concerns the classic social and economic characteristics: age, health, gender, socio-economic level (which will determine the fields of vulnerability) can influence the experience of thermal comfort, sensitivity, exposure, and the adaptability of individuals to the weather.

Current lifestyles, mobility and territorial links of individuals also influence their thermal comfort. For example, individuals who travel mostly by bicycle and on foot in their daily lives appear to be more exposed to extreme episodes during their journeys than individuals who prefer cars or public transport. These mobility strategies seem to have a significant impact on the individual's thermal comfort, exposure, sensitivity and adaptability to the weather.

Finally, other aspects of lifestyles such as activities (types of activities, duration, frequency, etc.) and the work or leisure environment in which people unfold have major repercussions on the thermal comfort of individuals. So-called outdoor activities illustrate that particularly "weather-sensitive" activities determine significant exposure fields of the populations concerned. These activities may be professional, such as the construction work from craftsmen in the building industry, or encompass else practiced outdoor leisure or social activities. These "systems of places" (Molina, 2004) practiced in everyday life where the activities of individuals are concerned can be used as resources to ensure their climatic comfort. The microclimatic islets of these areas optimize their coping strategies. In the event of a heat wave they can choose to visit cooler places in or outside of the city, according to the economic resources available to them as well as their mobility skills.

Past lifestyles can also be used to understand the way in which individuals construct their experience of thermal comfort. We took into account several factors, such as the geographical (and therefore climatic) contexts in which the individual previously lived, environmental education and, more broadly, the family context and the family and social strategies for adapting to climate, along with the strategies for adapting to and preserving thermal comfort used in the environment in which the individual has grown and evolved. This past mobility or "immobility" experienced over the whole of their life is an experience that strongly influences their relation to climatic comfort. The research carried out highlights in particular the socialization of climate at primary, secondary, lifelong scales that allows individuals to constitute a set of resources and experiences that they will re-mobilize to try and ensure their thermal comfort in other given geographical and temporal contexts. For

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example, the geographical trajectory of individuals seems to play an important role in both sensitivity and adaptation strategies that individuals develop to ensure their thermal comfort. Some individuals who have lived in cold climates in northern Europe say that since this experience they have been able to adapt more easily to the cold snaps in Lyon. Having developed cold adaptation strategies in these countries, they can now mobilize these resources in Lyon. Similar trends can be observed for individuals who have lived in Mediterranean and tropical climates, who report less sensitivity to the warmer periods experienced in Lyon, and have developed differentiated adaptation strategies. Another example that underlines the diversity of the influence of past experiences on the perception of thermal comfort is related to the notion of “heat in the city” compared to other territories. The definition of heat is understood in different ways, as demonstrated by the testimony of a person from the district of La Guillotière: “In Lyon the heat is less bearable than that of Mauritania. Here, when it is 40°C, I suffocate, my body is slow. In Africa I can bear it ... It is 10°C hotter yet ... My father explained that there is more air, we do not feel the pollution. Here in Lyon there is tarmac and over-construction, which accentuate the sensation of suffocation. There is sand that absorbs heat ...”

5.1.4 Conclusion

This qualitative survey conducted in Lyon highlights the relationships that city dwellers maintain with the environment, in particular how they experience the weather and the climate, through their lifestyles. It has emphasized that the thermal comfort of city dwellers in a given situation and space is dependent of perceptions, representations and long-term practices that involve a set of lifestyles and past and present experiences of individuals. It also underlines the complexity of the factors influencing thermal comfort and the diversity of relations that individuals and social groups have with thermal comfort. It leads to the following recommendations to facilitate the social appropriation of NBS, and therefore their success: these NBS must be conceived and developed in advance integrating, as an important feature, a prior diagnosis of geographical, social and cultural contexts of the territories. It is clearly important to focus on surveys of specific populations, their lifestyles and the resident strategies previously deployed by the inhabitants of places where these solutions are to be implemented.

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6 Socio-spatial resilience

6.1 Interviews of designers and managers

A third qualitative study was carried out before the development of the EQoL scale. In this study, designers and managers were interviewed on their knowledge and point of view regarding environmental and social issues and policies and management. Results reveal a shift in the way professionals address these issues. It appears that they rely less on technology to solve these challenges and more on social aspects. Qualitative data and results were taken into account for the development of the EQoL scale.

6.1.1 Sample and methods

A qualitative survey was conducted on a sample of ten professionals from the Nantes metropolitan area. These professionals were selected because they play key roles in the implementation of urban environmental policies in Nantes, and they hold positions of responsibility in the introduction and monitoring of these policies. These professionals work in different sectors to provide diagnostic services, establish strategies, and implement transition policies, including NBS. The transition policies involving NBS particularly integrate the following different aspects: climate, energy, air quality and waste. The point of view of these professionals was gathered through the following method: three one hour appointments were set per individual to be able to sound out the point of view of these professionals on a broad scope of topics concerning environment-related urban policies, ecology in the city and solutions proposed in response to the environmental crisis (NBS and other solutions).This provided a total of 30 hours of material, a part of which contained the professional point of view of these individuals on their work as professionals and their practices as inhabitants. A semi-structured interview format was used with both open and closed questions

Our aim was to examine the possible differences between the point of view of these urban professionals and the point of view of other populations. Furthermore, results are discussed in relation to previous research conducted over a decade or so on professionals in the city from the fields of planning and construction (Molina, Musy, & Lefranc, 2018; Richard &

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Molina, 2014). The comparison with past research allows us to identify changes in terms of knowledge or practices of urban professionals over a longer period of time.

6.1.2 Results and conclusions

This qualitative survey and the link with parallel or previous surveys make it possible to highlight four large series of conclusions and open up a discussion around several elements. To begin with, the analysis of the knowledge of the professionals surveyed shows a good appropriation of scientific knowledge, including recent knowledge on questions relating to the city and the environment. The comparison between the point of view of professionals and that of “ordinary” inhabitants (on the climatic phenomena, their evolution and the solutions for fighting climate change and adapting territories and their populations) reveals very clear differences and much more precise and well-argued knowledge, which was not the case in the previous surveys mentioned above (Molina, 2012a, 2012b; Molina et al., 2018; Richard & Molina, 2014; Roudil & Molina, 2015). This positive evolution seems to show that professionals have a better grasp of environmental issues and have increased their knowledge and skills. This trend has accelerated significantly and could be explained by a more recent interface between researchers and actors in the city, along with a process of acculturation between the two communities that has been reinforced (researchers specialized in urban environmental and professional issues).

In addition, professionals were questioned about their knowledge of the systems used by actors within the territory, in relation to environmental issues. They were asked more specifically about their knowledge of citizen initiatives and of inhabitants and networks of associations working on these problems – especially their roles and their actions in establishing alternative solutions. The comparison of the results obtained with previous research yet again seems to favor the hypothesis of acculturation over 10 years. They show a decline in stereotypical and “caricatural” representations observed in previous surveys (Molina, 2012a, 2012b; Molina et al., 2018; Richard & Molina, 2014; Roudil & Molina, 2015), and quite a profound understanding of the complementarities between institutional actors, researchers, citizens and civic engagement actors.

Another salient feature that emerges in comparing the results obtained during this qualitative survey and those from previous surveys carried out a few years ago is that in the sample of

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professionals surveyed in Nantes, we observed a greater coherence between environmental values and professional practices on the one hand, and individual practices implemented in the private sphere on the other. The professionals in our sample outdid the professionals surveyed previously by partaking more in transition processes as residents and adopting more “ecological” lifestyles, particularly with regard to transport (severely limiting the use of airplanes and cars and using bicycles, especially for commuting; eating habits that respect the cycle of the seasons; sensible consumption patterns; etc.).

Finally, concerning the point of view of these professionals on the solutions to environmental problems and the ecological crisis, this survey seems to indicate a recent evolution: a shift from thinking that “innovation” or the use of “technologies” will provide solutions, to the idea that solutions may be more forthcoming if we focus on the social aspect and logic of preservation, conservation and restoration. One hypothesis that could explain this result is that these professionals may have become aware of the limits and perverse effects (rebound effects, gray energy problem, life-cycle analysis, trajectory of solutions) of using technologies and of the race for technological progress. These actors also clearly state their preference for the development and implementation of solutions based on principles of decline, reduction of consumption, adoption by society of more virtuous behavior, changes in lifestyles and a better social appropriation of environmental issues. The success of the envisaged transition therefore involves social appropriation, changes in lifestyle and a better articulation of political, social, technical and environmental issues.

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7 Choice of case studies

Data were collected from eight cities in seven countries (Figure 5) for the development and validation of the EQoL scale. The main criteria for choosing case studies were the geographical situation of cities and the availability of data about environmental impacts of NBS. These different case studies belong to different European regions and reflect geographical, climatic and cultural differences.

To recruit cities and extend the scope of task 4.3, the partner cities involved in the Nature4Cities project were initially contacted for the translation of the different tools used in the task, the EQoL scale developed for the task in particular, and for data collection in the different countries. Within the consortium, four different cities (Amsterdam, Ankara, Nantes, Szeged) were selected as case studies for this task: Duneworks agreed to translate the tools into Dutch and to disseminate the questionnaire in Amsterdam (Netherlands), the municipalities of Ankara (Turkey) and Szeged (Hungary) agreed to participate in translation and data collection and in Nantes (France), data collection was carried out by the University of Nantes (UN). Unfortunately, some consortium partners (Alcala de Henares (AH, Spain) and the Metropolitan City of Milan (MCM, Italy)) did not had the necessary time and resources for data collection.

A call for contributions was also launched to recruit cities outside of the consortium and several academic partners were recruited for translation and data collection in Magdeburg (Germany), Lisbon (Portugal) and Albacete (Spain).

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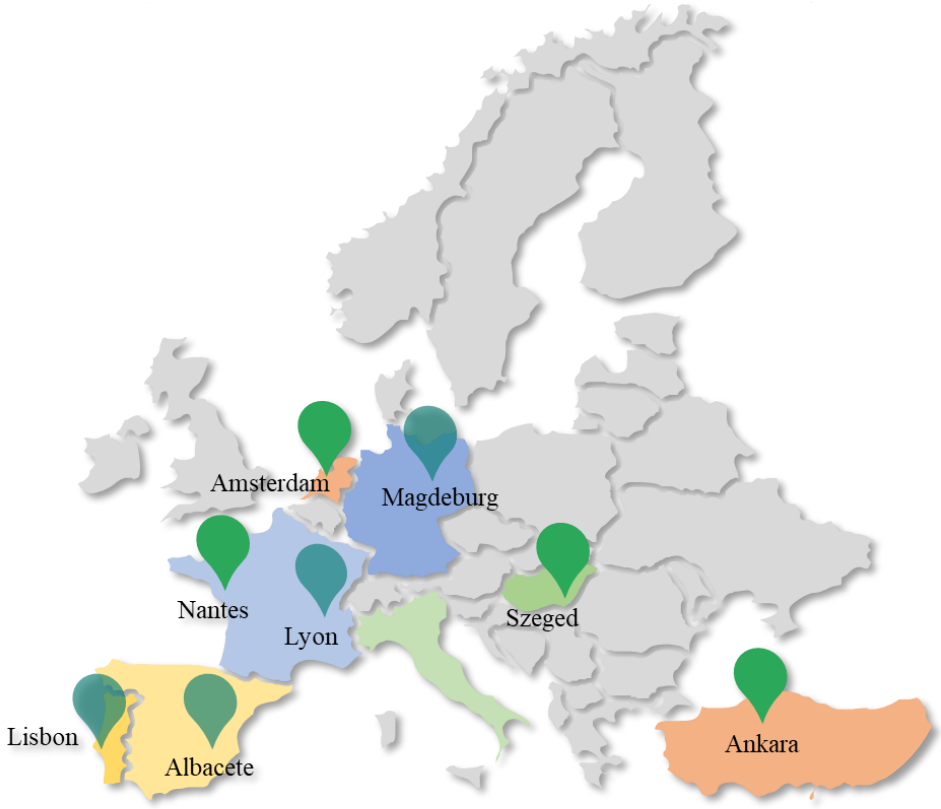

Figure 5 - General map of the different case studies

Note: In green, case studies from within the consortium; in blue, case studies from outside of the consortium.

7.1 Partner cities and cities where consortium partners live

7.1.1 Amsterdam

The Amsterdam Metropolitan Area (AMA) is located to the north of the Randstad and encompasses the city of Amsterdam and the Dutch provinces of North Holland and Flevoland. It is connected to the North Sea by the long North Sea Canal. The land around Amsterdam is flat and formed of large polders and the city itself lies only two meters above sea level.

Amsterdam covers a total area of 219.33 square kilometers and counts 834,713 inhabitants (2,388,318 in the AMA) (Eurostat, 2019).

According to the Köppen Climate Classification, Amsterdam has an oceanic climate (CFB). Its climate is influenced by the North Sea to the west, with prevailing westerly winds. Amsterdam has an average temperature of between 9.4 and 6.7 °C. The temperature rarely

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falls below -5 °C due to the proximity of large water bodies, the Amstel river, numerous canals and an urban heat island effect. In summer, Amsterdam has an average temperature of 22.1°C and heat waves are relatively rare. Though, Amsterdam is facing various environmental issues such as storms and stormwater.

There are 40 parks in the city, which cover approximately 11.3% of the total surface area of Amsterdam, while natural areas (forests) account for approximately 2.3% of its surface area. Though, in certain areas the lack of green spaces is accompanied by a decrease of biodiversity.

7.1.2 Ankara

Ankara is the capital of Turkey and the second largest city after Istanbul. Ankara covers a total area of 24,521 square kilometers and counts 5,150,072 inhabitants (2015).

Because of its continental location and its elevation, winters are cold and snowy while summers are hot and dry. According to the Köppen Classification, Ankara has a hot-summer Mediterranean climate (CSA) bordering on a hot-summer Mediterranean continental climate (DSA). There is a strong urban heat island effect in Ankara (Çiçek & Doğan, 2006) and a lack of green spaces in Ankara and most of the existing parks consist of grass mainly. The municipality is already implementing NBS actions, as one of its fundamental visions is to create and use environmentally-friendly systems to ensure a good future for the next generations. However, these actions lack holistic and systematic framework and assessment methods. Introducing the platform and building up the capacities of municipal employees should make the different implementations more efficient and bring about the deployment of NBS practices.

7.1.3 Nantes

Nantes is a city on the Loire Estuary near the Atlantic Ocean in the north-west of France. It is the sixth largest city in France and is located south-west of Paris (Ville de Nantes, 2019). Nantes covers a total surface area of 65.19 square kilometers (3,302 km² for the

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metropolitan area) and counts 303,382 inhabitants (949,316 for the metropolitan area) (Eurostat, 2019).

The city is well-known for its sustainable development policy and won the European Green Capital award in 2013. Today, there are 100 public parks, gardens and squares in Nantes, which represent a total surface area of 218 hectares, and various natural areas that cover approximately 180 hectares. Furthermore, the Loire has two branches in Nantes, flowing on either side of the Isle of Nantes, and several of its tributaries cross the city: the Sèvre, the Erdre, the Chèzine, the Cens, the Aubinière and the Gesvres (L'Auran, 2018). According to the L'Auran agency (2018), these different spaces (including private green spaces) account for approximately 45% of Nantes' territory. It is estimated that there are approximately 95 square meters of green spaces per inhabitant, with strong variation between the different districts of the city (ranging from 15m² to 230 m²), although this estimation does not include some of the nature-based solutions such as green roofs or green walls (L'Auran, 2018).

According to the Köppen Climate Classification, Nantes has an oceanic climate (CFB), which is under the influence of the Atlantic Sea (Ville de Nantes, 2019). Temperatures range from an average of 5°C during winter to an average of 18.5°C during summer (Météo France, 2019).

7.1.4 Szeged

Szeged is located in the south of the Great Hungarian Plain, near Hungary's southern border with Romania and Serbia. It is located at the confluence of the rivers Tisza and Maros. Two large lakes and fifteen small lakes are located within the city limits. The two large lakes (Fehér-tó and Sándorfalvi halastó) are located to the north of the city. Most notably, the Tisza riverbank re-naturing project is a challenge the city plans to tackle over the next few years because of the flooding risk.

Szeged covers a total surface area of 280.84 square meters. Its population was 170,285 in 2011 (Eurostat, 2019). More details about its demography are presented in Annex 4. According to the Köppen Classification, Szeged's climate is between oceanic (CFB) and continental (DFB), with low rainfall, hot summers and cold winters. The area surrounding Szeged is the sunniest in Hungary, with around 2,100 hours of sunshine every year, which is why Szeged is often called *City of Sunshine* (*Napfény városa*).

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Szeged is not as densely populated than other case studies. In particular, it is less densely built than Ankara.

7.2 Cities outside of the consortium

7.2.1 Albacete

Albacete is the capital of the province of Albacete in the autonomous community of Castile-La Mancha in Spain. It is located about 300 km south-east of Madrid. It counts 171,390 inhabitants (218,110 for the metropolitan area) (Eurostat, 2019).

According to the Köppen Classification, Albacete has a semi-arid continental climate. The main characteristic of this climate is the large thermal amplitude between winter and summer temperatures.

7.2.2 Lisbon

Lisbon is the capital and the largest city of Portugal. It covers a total area of 100 square kilometers and counts 545,733 inhabitants (2011), while the Metropolitan Area of Lisbon counts more than 2 million inhabitants.

According to the Köppen classification, Lisbon has a Mediterranean climate (CSA), with mild, rainy winters and warm-to-hot, dry summers. It is located on the coast of the Atlantic Ocean at the mouth of the Tagus River. Ten percent of the municipality is occupied by the Monsanto Forest Park, one of the largest urban parks in Europe (10 km^2).

7.2.3 Magdeburg

Magdeburg is the capital of the state of Saxony-Anhalt in eastern Germany. It is situated on the banks of the River Elbe. In 2011, it had 228,910 inhabitants. Magdeburg lies near the Hercynian massifs of Middle Germany and the Great Germanic and Polish Plain. According to the Köppen Classification, Magdeburg has a humid continental climate (DFB).

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7.3 Conclusion on case studies

Seven cities were selected as case studies for the implementation and validation of the EQoL scale. These case studies are diverse in size, context and face different environmental challenges. While most of the cities selected have an average number of inhabitants around 200,000 Ankara has more than 5 million inhabitants. Also, these cities are very diverse in regard to climate and experience environmental and social issues of different kinds. Some of these cities are very dense (Ankara for example) while others not so much (Magdeburg or Szeged), some of them have a large number of NBS (for example, Nantes have more than 100 public parks) while others lack parks and gardens (Ankara for example) … Such diversity is needed for scale validation. Indeed, the EQoL scale needs to account for the enhancement of environmental quality of life related to NBS in a large number of situations. Applying the scale in a single city or context would have reduced its potential for operationalization. By multiplying contexts, such a study makes it possible to verify and increase the relevance of the proposed scale.

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8 Elaboration of the Environmental Quality of Life Scale (EQoL Scale) related to NBS

Based on the data gathered during the qualitative studies and, in particular, we crossed the perceived links between NBS and an enhancement or a reduction of the quality of life in order to develop the EQoL scale. The selection and definition of these NBS is based on the work carried out on the NBS typology developed in deliverable 1.1. (CEREMA, 2018). In this typology, however, a certain number of NBS relate to management. As they appeared to be irrelevant for the EQoL scale, we focused on tangible NBS identified by inhabitants. This process led us to select six different NBS. A module was then developed for each of these NBS (public gardens and parks, collective gardens, natural spaces, green surfaces and blue spaces, and a complementary and transversal module on biodiversity). The modules were designed to be independent for operational purposes. This choice makes them flexible to use as separate assessment tools to assess NBS projects. In each module, we identified the main links between the selected NBS and sub-dimensions of quality of life, whether these links corresponded to an enhancement of or reduction in certain aspects (psychological, physical, social) of the quality of life.

In this section, the six different modules are presented with an emphasis on the different choices made by the authors during the development of the EQoL scale.

In order to develop the EQoL scale, qualitative data gathered in the different qualitative studies (Section 4, 5 and 6) were analyzed in order to identify the links between NBS and quality of life. This first step led us to identify six sub-dimensions of environmental quality of life often related to NBS. These sub-dimensions (accessibility, aesthetic properties and quality, social, security, practices, environmental challenges) are summarized and defined in Table 3. Also, not all NBS were linked to all these sub-dimensions. Depending on the module, the number of sub-dimensions associated ranges from 1 to 6. Following this first step, several specific questions were chosen on the basis of the qualitative data to assess each association between an enhancement of the environmental quality of life and a given NBS.

An overview of this whole process is provided in Table 4 at the end of this section.

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Table 3 - Summary of the QoL sub-dimensions investigated in the EQoL scale

QoL sub-dimension	Definition
Accessibility	Accessibility refers to the actual possibility of accessing Nature-Based Solutions in the environment. The lack of access to green spaces or only having access to insufficiently welcoming green spaces, for example, will have a detrimental effect on quality of life and health.
Aesthetic properties and quality	Perceived aesthetic properties and quality of the surrounding environment play a role in how NBS are perceived and have an impact on QoL, as well as on health and place attachment.
Social	The social component is a major aspect of quality of life. It refers to the possibility of developing and maintaining valuable social links. At a certain level, some NBS have an impact on this dimension. For example, parks or collective gardens could be perceived as places where you can meet friends or new people (see Study 1)
Security	Security refers to the feeling of safety in certain spaces, especially parks or natural spaces. It is known that these spaces have to be under some kind of "social regulation" to be perceived as safe and to have a positive impact on quality of life. If a park is not socially regulated or is perceived as unsafe, inhabitants around this park will certainly avoid it and this will have a negative impact on QoL.
Practices	Practices relate both to the possibility of doing activities and social practices linked to NBS. These practices have a direct impact on QoL. In the EQoL scale active and passive activities are considered as well as practices related to food production in the "urban farms" module.
Environmental Challenges	NBS have the potential to provide an answer to urban environmental challenges. Therefore, they should produce indirect positive effects on quality of life. In this work, we focused on perceived thermal comfort (extreme heat or cold events) and air quality linked to NBS.

8.1 Module 1: Public gardens and parks

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Urban public gardens and parks refer to “large green areas within a city with a variety of active and passive recreational facilities that meet the recreational and social needs of residents and visitors to the city” (CEREMA et al., 2018, p. 28). Even though these public gardens and parks can be diverse in nature, character, size and situated in various locations (inner city, suburbs), they all evoke passive recreational activities, i.e. quiet and low-intensity activities that require minimal amenities (like paths or benches), and active recreational activities, which may involve cooperative or team activities. As they all share these core elements, the various sub-types of public gardens and parks were not differentiated in the EQoL scale.

A vast amount of research has demonstrated the benefits of public gardens and parks on health, well-being and quality of life, including the social sub-dimension of QoL. It is known that public green spaces can potentially enhance people’s health and its different components: physical health (Maas et al., 2009), perceived health (Bowler, Buyung-Ali, Knight, & Pullin, 2010; de Vries, Verheij, Groenewegen, & Spreeuwenberg, 2003; Maas, Verheij, Groenewegen, De Vries, & Spreeuwenberg, 2006), psychological health (Grahn & Stigsdotter, 2003; Ottosson & Grahn, 2005), lower stress-levels (Ward Thompson et al., 2012), longevity (Takano, Nakamura, & Watanabe, 2002), as well as general well-being (Ward Thompson, 2011) and social well-being (de Vries, 2010; Maas et al., 2009; Sullivan, Kuo, & Depooter, 2004).

Relationships between green spaces and quality of life are less clear, but most of the studies observed a link between a greener environment and an enhancement of the quality of life (Ward Thompson, 2011). The availability and general perceived quality of the public gardens and parks are key factors of this enhancement, as well as neighborhood appearance and safety. Indeed, if attractive green areas are to serve as a meeting place for informal social interactions and strengthening social ties and social cohesion (Coley, Sullivan, & Kuo, 1997; Kweon, Sullivan, & Wiley, 1998; Seeland, Dübendorfer, & Hansmann, 2009), they need to be socially regulated in order to enhance quality of life. A feeling of insecurity would lead to the avoidance of these spaces, which could be detrimental for quality of life. As observed by Bertram and Rehdanz (2015), living very close to urban spaces is associated with benefits but also certain disadvantages, such as noise, congestion, insecurity or fear of crime (Bixler & Floyd, 1997). It also appears that inequalities in access to public gardens

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and parks have a detrimental effect on the health and quality of life of deprived populations, who also demonstrated poorer health (Mitchell & Popham, 2007; Raymond, Gottwald, Kuoppa, & Kyttä, 2016). For Crompton (2001), the positive effects of parks depend on the quality of the park (including security issues), its accessibility and its usage. Consequently, green space planning, design and management could have a positive impact on health, well-being and quality of life and help to reduce social and spatial inequalities in cities.

Among other environmental challenges identified with regard to public gardens and parks, thermal comfort and air quality are especially important. Even though these aspects were not clearly identified by inhabitants during the qualitative study, public gardens and parks are known to reduce the surrounding temperature by about 1°C in cities during the day, and to mitigate temperature during extreme heat events (Bowler et al., 2010). The use of green spaces is known to alleviate thermal discomfort during extreme heat events (Lafortezza, Carrus, Sanesi, & Davies, 2009), and a systematic review of literature previously demonstrated that there is strong evidence for a positive effect of green spaces on improved affect as well as on heat reduction (van den Bosch & Ode Sang, 2017).

Associated QoL sub-dimensions (Module 1): Accessibility of public gardens and parks; Aesthetics and quality; Social; Security; Practices; Environmental challenges (thermal comfort and air quality).

8.2 Module 2: Urban farms (collective gardens)

Urban Farms (or collective gardens, as they were identified by inhabitants during the qualitative study) are “for-profit or non-profit organizations whose aim is to grow flowers, vegetables, herbs and/or raise animals within a city” (CEREMA et al., 2018, p. 148), whether or not they tend to achieve self-efficiency and/or well-being through agriculture and animal rearing. These farms are often maintained by individual entrepreneurs or a local community

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and were identified as especially important during the qualitative study for their social role on territories. Other urban agricultural initiatives are school gardens, therapeutic gardens, allotment gardens and community gardens (Lawson, 2005).

Researchers have pointed out the potential benefits of regular gardening activity on health, especially among older people (Milligan, Gatrell, & Bingley, 2004). Studies also suggest a possible link between gardening and mental well-being (Finlay, Franke, McKay, & Sims-Gould, 2015; Fowler, 2002), as it may provide opportunities for empowerment, development of competence, social support and resources within the broader community (Armstrong, 2000; Myers, 1998). Also, collective gardens allow gardeners to make meaning and sense of a place, which in return is beneficial to quality of life (Camps-Calvet, Langemeyer, Calvet-Mir, & Gómez-Baggethun, 2016; Noori & Benson, 2016).

All these beneficial effects of collective gardens can be attributed to various factors, from the enhancement of physical activity, reduced levels of stress and mental fatigue and a better social and cultural integration (Armstrong, 2000).

Associated QoL sub-dimensions (Module 2): Social; Practices (including practices related to food production).

8.3 Module 3: Natural spaces (“unmaintained” urban forest or river banks)

On the EQoL scale, we chose to distinguish public gardens and parks from natural spaces, i.e., green spaces inside the city that are not maintained, or visibly maintained, e.g. some river banks or a small patch of land left untouched by municipal services. One of the reasons was that our research showed that unmaintained green spaces were perceived as more natural and associated with clear benefits in terms of air quality and physical restoration, while urban gardens and parks were more about leisure activities and social practices.

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These observations are in line with previous observations by Grahn and Stigsdotter (2010). Certain dimensions of green spaces (especially serenity, space, nature and species richness) appear to be perceived as more important than others, and these characteristics are associated with higher levels of restoration and lower levels of stress (Grahn & Stigsdotter, 2010).

Access to a natural environment and exposure to such an environment are recognized for their beneficial effect on health and well-being. Carrus et al. (2013) identified several direct and indirect effects of natural environment on health and well-being. Natural environments reduce stress and mental disorders (Hartig, Mitchell, de Vries, & Frumkin, 2014; Triguero-Mas et al., 2015), foster healthy behaviors, as they encourage physical activity, and reduce mortality (Hartig et al., 2014; Triguero-Mas et al., 2015), and increase social interactions as well as decreasing risk factors such as air pollution or urban heat.

These beneficial effects are still more visible in vulnerable groups such as children (see for example, Wells & Evans, 2003) and older people (Broekhuizen, de Vries, & Pierik, 2013; Takano et al., 2002).

Associated QoL sub-dimensions (Module 3): Accessibility; Aesthetics and quality; Social; Security; Environmental challenges (thermal comfort and air quality).

8.4 Module 4: Green surfaces (green walls and green roofs)

Green roofs and walls serve many purposes as they are able to absorb rainwater (Simmons, Gardiner, Windhager, & Tinsley, 2008), provide insulation (Alexandri & Jones, 2008), provide a habitat for wildlife (Nagase & Tashiro-Ishii, 2018), and lower urban air temperatures (Jin, Bai, Luo, & Zou, 2018). They also provide a more aesthetically pleasing landscape, which is linked to an increase in benevolence and a decrease in stress (Ragheb, El-Shimy, & Ragheb, 2016). For these reasons, one of the modules of the EQoL scale

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focuses on green surfaces (green roofs and walls) to account for the perceived benefits of these surfaces on the quality of life, even though they were not spontaneously identified in the surroundings by the inhabitants of Nantes during the qualitative study. According to CEREMA et al. (2018), three main types of green roofs can be distinguished, as well as three different types of green walls:

- extensive green roofs, which "are generally made up of a very thin layer of the substrate (from 8 cm to 15 cm) or other planting medium with shallow-root plants like sedum, herbs, mosses, and grasses" (CEREMA et al., 2018, p. 261);
- semi-intensive green roofs, which are "characterized by small herbaceous plants, ground covers, grasses and small shrubs, requiring moderate maintenance and occasional irrigation" with a growing depth of 15 to 30 cm (CEREMA et al., 2018, p. 278);
- intensive green roofs, which are made up of more substrate (usually 20 to 200 cm) and provides the potential for a large plant option, although the "stress imposed on the structure is very large" (CEREMA et al., 2018, p. 270);
- climber-green walls, which relates to "the use of self-climbing plants [directly rooted into soil] to cover walls and façades" (CEREMA et al., 2018, p. 288);
- green wall systems with no direct connection to the ground, which are characterized by "a wide range of shrubs, herbs or grasses […] used to generate a green coverage" (CEREMA et al., 2018, p. 294);
- planter green walls, which relates to "the use of planters or pots with artificial substrate […] on the ground or directly on the building or balconies" (CEREMA et al., 2018, p. 300).

As green roofs and walls were not identified by inhabitants during the qualitative study 4, we chose to merge both categories into a single module: green surfaces.

Associated QoL sub-dimensions (Module 4): Aesthetics and quality; Environmental challenges (thermal comfort and air quality).

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8.5 Module 5: Blue spaces

This module encompasses several NBS identified in deliverable 1.1. related to water bodies (CEREMA, 2018). Indeed, there is a lack of consensus around the definition of blue spaces in research studies in environmental psychology. Also, particular NBS related to water were not identified by inhabitants during the qualitative study, whereas riverbanks and floodplains were named and associated to social practices and activities. For these reasons, we chose to combine blue spaces into a single module in which we considered all of the different links between blue spaces and QoL sub-dimensions.

Blue spaces are especially important for inhabitants. For example, Burmil, Daniel and Hetherington (1999) observed that views of water were potentially beneficial for health. Lianyong and Eagles (2009) also observe a clear relationship between waterscape and environmental health, while Velarde, Fry and Tveit (2007) noted a relationship between water bodies and well-being and health. In another study, the appreciation of water bodies is correlated to quality of life (Ogunseitan, 2005). More than a single restorative effect, blue spaces have their own intrinsic properties and facilitate certain nature-based activities, including social activities (Barton, Bragg, Wood, & Pretty, 2016; Völker & Kistemann, 2015). Kabisch, van den Bosch and Lafortezza (2017) observed a general positive association between blue spaces and health but the results are less clear where vulnerable groups such as children and the elderly are concerned, as other socioeconomic factors play a role in this relationship.

Depending on the context, management and planning, blue spaces can also help reduce air pollution levels (Cameron & Blanuša, 2016) and heat (Bowler et al., 2010; Burkart et al., 2016).

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Associated QoL sub-dimensions (Module 5): Accessibility; Aesthetics and quality; Social; Practices; Environmental challenges (thermal comfort and air quality).

8.6 Module 6: Biodiversity

Conceived as an NBS and an environmental challenge, biodiversity is associated with multiple nature-based solutions. This is why we developed an independent module for the EQoL scale rather than a redundant question in each module. This module could be used separately or in addition to another module of the EQoL scale, depending on the project to be assessed. Literature shows a positive relation between biodiversity and restoration, as well as between biodiversity and self-reported benefits in urban or peri-urban green spaces (Carrus et al., 2015).

Another study by Fuller, Irvine, Devine-Wright, Warren and Gaston (2007) revealed that greenspace users perceive species richness with more or less accuracy, and that this perceived species richness of urban greenspaces is linked to psychological benefits.

Associated QoL sub-dimensions (Module 6): Environmental challenges attained in relationship with biodiversity.

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Table 4 - Overview of the EQoL scale modules and associated QoL sub-dimensions

NBS Categories	Quality of life sub-dimensions	Specific questions
Module 1: Public gardens and parks	Accessibility	The possibility of reaching a public garden or park in my town quickly Easy access to public parks and gardens The difficulty of access to the public gardens and parks in my town
	Aesthetic properties and quality	The charm of the public parks and gardens in my town The cleanliness of the public gardens and parks The atmosphere of the public parks and gardens in my town
	Social	The possibility of meeting up with friends or relatives in public gardens and parks in my town The opportunity of meeting people in the public gardens and parks The opportunity to talk more easily with strangers in the public gardens or parks
	Security	The sense of safety in the public gardens and parks The lack of security in some public gardens and parks in my town The behavior of other users in the public gardens or parks
	Practices	The possibility of relaxing and strolling through the parks and public gardens The possibility of exercising or engaging in leisure activities in the parks and public gardens The possibility of unwinding in the parks and public gardens
	Environmental challenges	The way public gardens and parks enhance air quality The possibility of taking shelter in the public gardens and parks in my town when faced with noise pollution The possibility of taking refuge in the public gardens and parks in the event of severe heat
Module 2: Collective gardens	Social	The exchange of knowledge in collective/shared gardens Social diversity within collective/shared gardens The dynamics around collective/shared gardens The opportunity to meet other people in collective/shared gardens
	Practices	The possibility of finding oneself again through gardening in collective/shared gardens The opportunity to reconnect with nature through gardening within the town

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		The possibility of producing your own fruit and vegetables thanks to shared/collective gardens
Module 3: Natural spaces	Aesthetic properties and quality	Facilities available in the areas left in their natural state in town The charm of the wild, natural areas of my town The well-being that emerges from the areas left in their natural state in my town The possibility of cutting yourself off from the town in its areas that have been left in their natural state
	Accessibility	The accessibility of areas left in their natural state in my town The way the areas left in their natural state are landscaped in my town The opportunity to appropriate the areas left in their natural state
	Social	The opportunity to meet new people in the areas left in their natural state in my town The way the areas left in their natural state in my town promote social diversity The possibility of meeting up with friends in the areas left in their natural state in my town
	Security	The feeling of security in the areas left in their natural state The presence of threatening individuals in the natural areas of my town The behavior of other users in the areas left in their natural state
	Environmental challenges	The sensation of “breathing better” in the natural areas of my town The presence of wild animals in the areas left in their natural state (birds, fish, etc.) The way the natural areas serve to fight against pollution The discomfort caused by allergens in the natural areas of my town
Module 4: Green surfaces	Aesthetic properties and quality	The aesthetics of green walls and roofs The way green walls and roofs fit into the town The way some walls and roofs are planted
	Environmental challenges	The coolness provided by green walls and roofs when the weather is hot The way green roofs and walls help to fight against noise pollution The way green roofs and walls fight pollution efficiently
Module 5: Blue Spaces	Accessibility	The way facilities have been added to the banks of rivers, lakes and ponds in my town The way rivers, lakes and ponds are maintained The lack of facilities on the banks of rivers, lakes or ponds
		The appeasement procured by the river banks, rivers, lakes or ponds in my city

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	Aesthetic properties and quality	The lack of cleanliness of rivers, lakes or ponds The charm of rivers, lakes or ponds
	Practices and Social	The possibility to walk along the rivers, lakes or ponds The way the rivers, lakes or ponds encourage encounters and social contact The opportunity to meditate and contemplate on the banks of the rivers, lakes or ponds The possibility of practicing all kinds of leisure activities related to the rivers, lakes or ponds in my town
	Environmental challenges	The coolness brought to the town by the rivers, lakes or ponds during summer The possibility of taking shelter alongside the banks of the rivers, lakes or ponds during heat waves
Module 6: Biodiversity	Environmental challenges	The way the presence of animals in town helps people become sensitized to nature The presence of too many insects The way the presence of birds in town allows us to reconnect to nature The services that some animals can provide us in a town (keeping grass short, apiaries, etc.)

Note: The EQoL scale has two different entry levels: the first level (first column) corresponds to the NBS selected for the development of each module, and the second level corresponds to the different sub-dimensions of QoL (second column), which are linked to multiple NBS. Based on the inventory of the different links between nature-based solutions and quality of life dimensions, different questions were elaborated for each of these links (third column), based on qualitative data gathered in the three qualitative studies carried out and presented in Section 4, 5 and 6 of this deliverable.

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9 Validation of an alternative value scale of NBS based on Quality of Life

Following the development of the EQoL scale, the validation of the EQoL was carried out on the different case studies identified and presented in Section 7. The validation process is presented in the first part of this section (9.1). Data collection process, data analysis and results of the validation are presented and discussed in this first part. Then, to go further, two different scenarios of implementation were tested in Nantes in order to establish the relevance and reliability of the EQoL scale. These scenarios are presented in the second part of this section (9.2) as well as the methodology used.

9.1 Validation of the scale

9.1.1 Translation procedure and participants

The EQoL scale was developed in French. An English version was then produced by a professional translator and sent to the different teams as a common version. In the different cities involved in this part of the research (Albacete, Ankara, Amsterdam, Lisbon, Magdeburg, Nantes, Szeged), local teams took part in the translation of the questionnaire and data collection. When needed, modifications were discussed. Several adjustments were made for cultural purposes in particular. Whenever necessary, the meaning of the sentences took precedence to keep the meaning intact in the different versions of the scale.

Due to the lack of resources in Milan and Alcala-de-Henares, data collection was finally cancelled. As a result, data collection occurred in seven cities in seven different countries (Albacete, Amsterdam, Cankaya (Ankara), Lisbon, Magdeburg, Nantes and Szeged,). Data collection was carried out between April 2018 and January 2019, Nantes and Amsterdam being the first to start, followed by Szeged and Ankara. The cities recruited outside of the consortium began collecting data towards the end of October 2018.

The questionnaire was implemented online on the Limesurvey platform. A paper version of the questionnaire was also produced for some of the locations, depending on the data

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collection strategy defined with the local partner. All participants were asked for consent at the beginning and end of the questionnaire. All data, including personal data, were aggregated after collection in order to guarantee confidentiality.

One of the criteria the participants had to fulfill to be part of the study was to have lived in the case study area for at least one year. Details of the different samples are presented in Section 7 of this deliverable.

The average duration for filling in the whole questionnaire was between 15 and 20 minutes. For the EQoL scale alone, the duration for this part was about 10 minutes. Future implementations of the scale would not need to include all of the different modules.

9.1.2 Data analysis: Process of validation

Every answer with missing values was deleted before the Exploratory Factor Analysis (EFA). Also, skewness and kurtosis were verified, and two different tests were performed: the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity. These values and tests have an informative value, but they have to stay within certain thresholds to allow data factorability. While possible, data factorability would be non-advisable if these thresholds were not respected.

More specifically, an EFA should be performed on data which follow a univariate normal distribution. However, data can deviate from normal distribution in two different ways: they can lack symmetry (skewness) or there can be a high number of extreme values (or outliers) (kurtosis). More often than not, skewed distributions, or non-symmetrical distributions, have scores grouped at one or both ends of the scale. Ideally, data should be normally distributed in order to perform an EFA. Thus, kurtosis and skewness were both tested before analysis (Table 5). Values between -2 and +2 for asymmetry and kurtosis can be considered as good in proving normal univariate distribution (Field, 2009, 2013; George & Mallery, 2003; Gravetter & Wallnau, 2013).

The Kaiser-Meyer-Olkin (KMO) measure varies between 0 and 1. This statistic indicates the proportion of variance in the data that might be explained by underlying factors; thus, high values indicate that a factorial structure can be identified and that an EFA can be performed. Kaiser (1974) recommends performing an EFA only if the KMO is superior to 0.5. However, according to Hutcheson and Sofroniou (1999), a KMO score superior to 0.7 can be

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considered as moderate, while a KMO of between 0.8 and 0.9 is good and a KMO score of 0.9 and higher is considered very good.

Finally, Bartlett's test of sphericity tests the hypothesis that the variables in the correlation matrix are unrelated and therefore unsuitable for structure detection. Small values (under 0.05) indicate that an EFA can be performed on the data.

Once these steps had been taken and the remaining data deemed suitable, an EFA was performed to highlight patterns in the data sets and statistically confirm or invalidate the theoretical structure of the modules. During the EFA step, attention must be paid to items that may be identified as unrelated to others (in this case, deletion is advisable). Finally, the reliability of the measure for each module was estimated by the computation of Cronbach's alpha in addition to the EFA. Cronbach's alpha shows to what extent a measure consistently reflects the construct that it is measuring. Usually, a value higher than 0.7 is required to guarantee sufficient reliability in the measure. Higher thresholds (0.8 or 0.9) are advised.

9.1.3 Results

9.1.3.1 Prerequisites to the EFA

Details of the results for the prerequisites of the EFA are presented in Table 5.

In our samples, skewness and kurtosis remain within the range of -2 / + 2, except for the public gardens and parks module in samples from Nantes and Albacete. In these two samples, a single item suffers a slight deviation from normality, though Hair et al. (2010) and Bryne (2010) state that a kurtosis between 7 to +7 can be accepted. In these two samples, the deviation of a single item did not alter the overall estimation of participants' scores for the module.

Regarding the KMO, the module on biodiversity has the lowest values but they are still higher than 0.7. The KMO for the other modules ranged from 0.8 to 0.9 and higher. According to Hutcheson and Sofroniou (1999), such scores confirm that an exploratory factorial analysis can be performed on the data to establish the factorial structure of these modules.

As for Bartlett's test of sphericity, the results are extremely satisfying, with scores under the threshold of 0.001.

All these results allowed the computation of an EFA on the data.

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Table 5 - Kurtosis, Skewness, KMO and Bartlett's test of sphericity for the modules of the EQoL scale in the different cities

		Cities						
		Nantes	Amsterdam	Szeged	Ankara	Magdeburg	Lisbon	Albacete
Modules	*n*	210	198	284	154	102	91	191
Public parks and gardens	Kurtosis min – max	-0.34 – 2.78	-0.69 – 1.5	-0.97 – 2.5	-0.89 – -0.09	-1.68 – 0.13	-0.58 – 1.98	-0.83 – 3.6
	Skewness min - max	-1.17 – 0.03	-1.1 – 0.16	-1.15 - -0.27	-0.66 – 0.03	-0.66 – 0.13	-1.14 – 0.11	-1.15 – 0.04
	KMO	0.79	0.88	0.87	0.92	0.84	0.83	0.87
	Bartlett's test of sphericity	***	***	***	***	***	***	***
Collective gardens	Kurtosis min – max	-0.11 – 1.46	-0.83 – 1.36	-0.05 – 0.36	-1.16 – -0.67	-1.07 – 1.77	-0.18 – 2.08	-0.24 – 0.81
	Skewness min - max	-0.90 – -0.10	-0.45 – 0.43	-0.18 – 0.1	-0.25 – -0.05	-0.57 – 0.77	-0.51 – 0.57	-0.18 – 0.19
	KMO	0.82	0.85	0.88	0.89	0.89	0.7	0.9
	Bartlett's test of sphericity	***	***	***	***	***	***	***
Natural spaces	Kurtosis min – max	-0.60 – 1.79	-0.81 – 0.99	-0.2 – 0.64	-1.11 – -0.52	-0.82 – 0.37	-0.81 – 1.29	-0.99 – 0.47
	Skewness min - max	-1.07 – 0.09	-0.99 – 0.0	-0.25 - 0.53	0.0 – 0.57	-0.59 – 0.32	-0.65 – 0.01	-0.79 – 0.12
	KMO	0.82	0.89	0.91	0.91	0.89	0.89	0.91
	Bartlett's test of sphericity	***	***	***	***	***	***	***
Biodiversity	Kurtosis min – max	-0.42 – 0.21	-0.85 - -0.64	0.08 – 0.78	-0.78 – -0.57	-0.59 – -0.47	-0.70 - -0.87	-0.83 - -0.19
	Skewness min - max	-0.54 – 0.32	-0.27 - -0.09	-0.77 – 0.21	-0.20 – -0.13	-0.15 - -0.3	-0.47 - -0.23	-0.8 – 0.11

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	KMO	0.73	0.73	0.71	0.74	0.7	0.73	0.74
	Bartlett's test of sphericity	***	***	***	***	***	***	***
Green roofs and walls	Kurtosis min – max	0.09 – 0.64	-0.74 - -0.09	-0.12 - -0.73	-0398 – -0.66	-0.8 - -0.29	-0.17 - -0.87	-0.59 - -0.19
	Skewness min - max	-0.28 – 1.11	-0.88 - -0.21	-0.79 - -0.36	-0.31 – -0.05	-0.73 - -0.24	-0.47 – 0.23	-0.35 - -0.05
	KMO	0.89	0.82	0.87	0.87	0.84	0.75	0.89
	Bartlett's test of sphericity	***	***	***	***	***	***	***
Blue spaces	Kurtosis min – max	-0.35 – 1.18	-0.53 – 1.21	-0.22 – 0.61	-0.82 – -0.37	-0.5 – 2.42	-0.87 – 1.5	-1 - -0.49
	Skewness min - max	-0.98 - -0.08	-0.94 - -0.25	-0.68 - -0.37	-0.58 – 0.32	-1.3 – 0.4	-0.96 - -0.21	-0.27 – 0.39
	KMO	0.87	0.75	0.9	0.92	0.84	0.85	0.93
	Bartlett's test of sphericity	***	***	***	***	***	***	***

Note: ***: $p < .001$

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9.1.3.2 Exploratory Factorial Analysis and analysis of Reliability

If we consider the percentage of explained variance, it would appear that most of the modules explain a significant part of the variance observed between the participants, with a minimum of 53.59% of explained variance for the natural space module in the Hungarian sample. Furthermore, a closer look at the reliability score, estimated by Cronbach's alpha, reveals that the scores are always above the threshold of 0.7 and most of the values are superior to 0.8 or 0.9, which indicates a good reliability of the global measure delivered by the modules in the different cities. Details are presented in Table 6.

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Table 6 - Exploratory factorial analysis and analysis of reliability for the modules of the EQoL scale in the different cities

		Cities						
		Nantes	Amsterdam	Szeged	Ankara	Magdeburg	Lisbon	Albacete
Modules	\ *n*	210	198	284	154	102	91	191
Public parks and gardens	Mean	3.82	3.59	3.45	3.05	3.84	3.49	3.50
	SD[a]	*0.49*	*0.53*	*0.55*	*0.82*	*0.56*	*0.57*	*0.56*
	Cronbach's a	0.86	0.96	0.88	0.95	0.9	0.91	0.90
	% of explained variance	57.22	59.37	56.87	75.17	58.81	67.6	61
Collective gardens	Mean	3.34	3.53	3.47	2.61	3.45	3.3	3.12
	SD[a]	*0.70*	*0.74*	*0.60*	*1.01*	*0.78*	*0.54*	*0.71*
	Cronbach's a	0.90	0.91	0.89	0.96	0.9	0.8	0.93
	% of explained variance	63	68	59.52	82.97	64.15	63.66	72.98
Natural spaces	Mean	3.53	3.27	3.38	2.44	3.44	3.26	2.89
	SD[a]	*0.52*	*0.69*	*0.58*	*0.95*	*0.74*	*0.71*	*0.77*
	Cronbach's a	0.86	0.92	0.9	0.97	0.94	0.95	0.94
	% of explained variance	60.29	59.83	53.59	71.26	69.56	71.31	64.28
Biodiversity	Mean	3.61	3.20	3.67	2.99	3.27	3.30	2.82
	SD[a]	*0.60*	*0.96*	*0.74*	*1.06*	*0.78*	*0.90*	*0.90*
	Cronbach's a	0.77	0.86	0.81	0.92	0.79	0.88	0.88
	% of explained variance	78.73	78.48	73	86.58	70.50	81.39	81.39
Green roofs and walls	Mean	3.29	3.53	3.59	2.86	3.5	3.35	2.72
	SD[a]	*0.73*	*0.88*	*0.86*	*1.09*	*0.98*	*0.83*	*0.95*
	Cronbach's a	0.90	0.91	0.94	0.97	0.94	0.91	0.97
	% of explained variance	63.04	70.14	75.96	85.31	75.89	69.02	85.77

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Blue spaces	Mean	3.29	3.59	3.64	2.92	3.85	3.47	2.57
	SD[a]	*0.73*	*0.61*	*0.67*	*0.93*	*0.65*	*0.63*	*0.89*
	Cronbach's a	0.84	0.86	0.91	0.95	0.89	0.91	0.96
	% of explained variance	55.83	68.74	65.56	81.82	63.34	68.26	75.49

Note: a: Standard Deviation

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9.1.4 Discussion on the validation of the EQoL scale

The prerequisites were carefully verified and confirmed the possibility of considering the modules of the EQoL scale as an independent measure regarding a particular NBS. In addition, it confirmed its relations with QoL, and the estimated overall reliability of the measure was highly satisfactory.

In this first study, mean scores for the different modules ranged between 3 and 4 on average. This can be interpreted as a good level of environmental quality of life. However, it must be noted that we decided to give inhabitants the option of declaring themselves as unconcerned by the NBS. This was necessary because we did not target just one specific NBS in the different case studies.

Although there is always room for improvement, the EQoL scale in its current state is a reliable tool for assessing how much individuals benefit from NBS implemented near their living-place in terms of environmental quality of life. The EQoL scale would also be a good tool for measuring satisfaction among users of an existing NBS or for assessing changes in reported environmental quality of life before and after the implementation of a new NBS.

At this stage, we decided to include a second step in this validation process, which consisted of developing two scenarios as base examples for the use of the EQoL scale in an operational context. We actually decided to go further than just the process of designing and validating the EQoL scale to have as a second measure of reliability. The scale not only had to be satisfactory on a statistical basis but also on theoretical and operational levels. These scenarios are presented in the following section.

9.2 Integrated model

In order to verify the relevance of the EQoL scale for implementation, it was decided to integrate the EQoL scale into a larger questionnaire which included several health indicators, psychological indicators and perceived indicators of nature-based solutions.

Indeed, environmental quality of life is known for its links with physical and psychological indicators as well as indicators related to physical and mental health. That is why we chose

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to design an integrated model to verify the links between the scores of the EQoL scale and these indicators. Such process is a regular step in validation of psychological indicators that makes it possible to verify the pertinence of the measure developed. The choice of these indicators was based on their reliability and their availability in the different languages of the study. For example, the WHOQOL-BREF scale, developed by the World Health Organization, was available in Dutch, French, German, Hungarian, Portuguese, Spanish, and Turkish. Thus, the translated and validated versions of the psychological indicators were recovered wherever possible. When a particular version of the scale was not available, the English version was presented to the different teams as a common version to be translated into the different languages.

Finally, the survey also included a series of questions about the frequency of visits to green spaces (including natural areas outside of the cities) and the length of time spent there, as well as the activities and social practices carried out there. The questionnaire equally included questions on socio-economic and demographic characteristics, as well as ownership of a private garden.

The objective of an integrated model was to understand how physical, perceived or psychological indicators could predict the environmental quality of life related to NBS as experienced by inhabitants.

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Table 7 - Availability of the health and psychological indicators in the different languages of the study

Language	CNS Scale	MHC-SF	WHOQOL Bref	Minimum European Health Module
French	Yes	Yes	Yes	Yes
Spanish	Yes	Yes, but not recovered[b]	Yes	Yes
Turkish	Yes, but not recovered[b]	Yes	Yes	No translation available
Hungarian	No translation available	Yes, but not recovered[b]	Yes	Yes
Dutch	No translation available	Yes	Yes	Yes
Portuguese	Yes	Yes	Yes	Yes
German	Yes	No translation available	Yes	Yes
English[a]	Yes	Yes	Yes	Yes

Note: a: The English version of the questionnaire was developed as a common version of the questionnaire to be translated by the different partners, even though no data collection took place in an English-speaking country. The English questionnaire was developed by a professional translator. *b*: Authors of the translated versions of the questionnaires were unsuccessfully contacted.

9.2.1 Material: Selection of the different indicators for the model

9.2.1.1 Psychological and health indicators

1.1.1.1.1 General quality of life indicator (WHOQOL-BREF)

The World Health Organization Quality of Life project (WHOQOL) was initiated in 1991. The primary goal of this project was to develop and promote an international quality of life instrument. It is an extremely reliable instrument, which was developed collaboratively by a number of professionals worldwide. To this day, WHOQOL has been used in many research studies and clinical trials worldwide and is available in many languages. Official translations were recovered and incorporated to the questionnaire.

In the two scenarios developed, a general item of global quality of life was introduced as a competing measure of QoL. This measure did not focus on environmental benefits perceived

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by inhabitants and consisted of a subjective and large estimation of the overall satisfaction with living conditions.

1.1.1.1.2 Well-being indicator (MHC Short Form)

The MHC-SF is not categorically superior to other questionnaires for the assessment of well-being, but it presents several advantages. It has been validated in a large number of languages and is quite a short questionnaire (14 items) that allows the computation of a global score of well-being and various sub-dimensions of well-being: social ("How often did you feel that people are basically good"), psychological ("How often did you feel that you had warm and trusting relationships with others") and emotional well-being ("How often did you feel satisfied with life").

For each of the statements in the questionnaire, respondents have to select the frequency with which they experienced several well-being symptoms over the past month, using a 6-point Likert scale ranging from 1 (never) to 6 (every day). All these criteria led us to retain the MHC-SF out of all the different questionnaires available in the scientific literature.

Well-being is a complex and multidimensional concept that integrates physical and mental health, and is generally linked to other health measures and factors in the social and physical environment, including quality of life and environmental quality of life. If compared to QoL, well-being can be conceived as an inner state or feeling, while QoL relates to external elements and factors and their quality.

1.1.1.1.3 Connectedness to Nature indicator (CNS)

In our study we included the seven-item version of the CNS recently developed by Pasca, Aragonés and Coello (2017), and based on item response theory. In their research, Pasca et al. (2017) demonstrated that seven items were sufficiently discriminating and difficult, while six others had inadequate discrimination indices and did not present a good fit. They concluded that this shorter version has adequate levels of reliability and validity. However, their work does not account for the reliability and validity of this seven-item version of the CNS in languages other than Spanish. With the CNS, respondents have to answer all seven items on a 5-point Likert scale ranging from 1 ("completely disagree") to 5 ("completely agree").

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Connectedness to nature describes how much an individual feels connected to nature. In this scenario, we expected connectedness to nature to partially explain environmental quality of life, because individuals with higher levels of connectedness to nature usually declare more benefits when they are in contact with nature.

1.1.1.1.4 Health indicator (Minimum European Health Module (MEHM))

The MEHM module was developed by Eurostat and has been implemented in a number of international social surveys, such as the European Health Interview Survey (EHIS) and the EU Statistics on Income and Living Conditions (EU-SILC) survey. This module comprises three separate questions about complementary aspects of health:

- Self-perceived health: “How is your health in general? Is it…” with answer categories Very good/Good/Fair/Bad/Very bad;
- Chronic morbidity and presence of long-standing health problems: “Do you have any longstanding illness or health problem?” Yes/No
- Activity limitations due to health problems: “For at least the past 6 months, to what extent have you been limited because of a health problem in activities people usually do? Would you say you have been …” with answer categories “severely limited/limited but not severely/not limited at all?”.

This self-reported health score was introduced in the scenarios to explore possible links between scores from the EQoL scale and self-reported health. As stated earlier, vulnerable individuals can benefit from a natural environment. The environmental quality of life scale can be implemented to assess how vulnerable people (such as the elderly) benefit from their environment. In these scenarios, we wanted to explore such possibility with the EQoL scale.

9.2.1.2 Physical indicators

In order to establish the possible links between physical data (in particular, proximity and amount of green and blue spaces), data were recovered concerning the amount of green spaces and blue spaces existing in each district for Nantes. These data were recovered from the work of L’Auran (2018). For each participant, we considered the proportion of green

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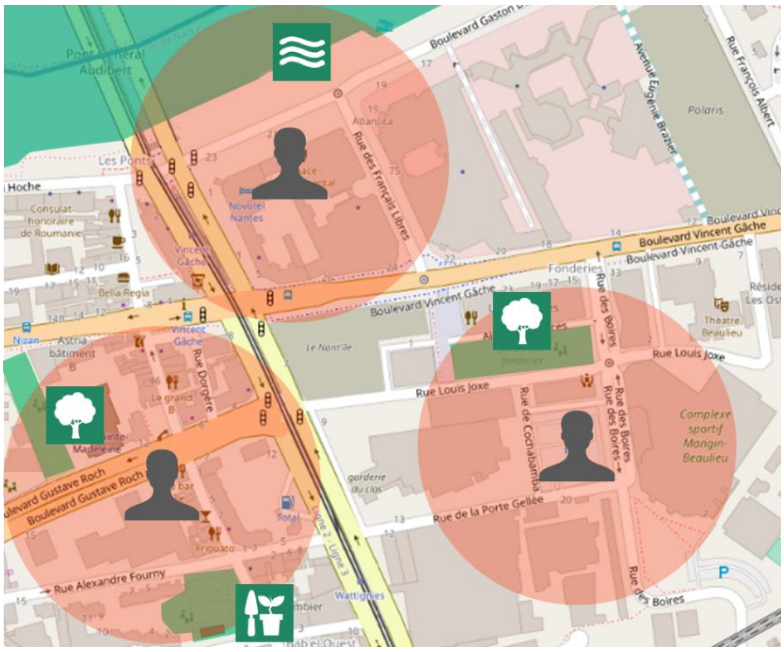
spaces and blue spaces around their location, as a percentage of green spaces/blue spaces. By doing this, we could identify the accessibility of green or blue spaces.



Note: For a given participant, we considered: physical characteristics of the environment; NBS perception and psychological indicators (Well-being, Connectedness to Nature). A statistical approach allowed us to determine how these three types of indicator would predict answers to the Environmental Quality of Life Scale.

9.2.1.3 Perceived indicators of Nature-Based Solutions

To go beyond the objective availability of green spaces and blue spaces around the participant's location, we decided to include a complementary NBS perception indicator in the questionnaire because the existence and availability of Nature-Based Solutions does not guarantee that these NBS are known, and neither does it account for how people perceive these NBS. This indicator was designed to account for the way people perceive and assess the nature-based solutions around where they live. For each of the NBS we selected in the EQoL scale, respondents were asked to rate the availability of these NBS around their living place on a 5-point Likert scale.

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9.2.2 Data analysis

In this part, a Bayesian linear regression was performed to conclusively identify the most probable model for the public gardens and parks and blue spaces modules. The choice of this module is based on the available data provided by L'Auran (2018) for the amount of green and blue spaces in Nantes.

In both cases, the outcome variable is the environmental quality of life score. In the first model, we observed how the environmental quality of life score related to public gardens and parks is predicted by nine independent variables: namely, the amount of green spaces and blue spaces around the participant's location; the perceived amount of green spaces (all green spaces, without distinction) and the perceived amount of public gardens and parks around the participant's location; the connectedness to nature scale scores; the general well-being score; the economic situation of the participant; self-reported health; and general quality of life.

In the second model, we observed how the environmental quality of life score related to blue spaces is predicted by eight independent variables: namely, the amount of green spaces and blue spaces around the participant's location; the perceived amount of blue spaces around the participant's location; the scores from the connectedness to nature scale; the general well-being score; the economic situation of the participant; self-reported health; and general quality of life.

Bayesian linear regression takes two aspects into account for evaluating the quality of a regression: the quality of its adjustment to the data (measured by the likelihood) and its complexity (measured by its number of unknown parameters). Bayesian linear regression leads to selection of the solution that achieves the best compromise between quality of fit and parsimony of the model. In fact, it introduces a penalty term for the number of parameters in the model. Every combination was tested using this method and all combinations were compared to a null model, on the basis of the thresholds determined by Lee and Wagenmakers (2014) for the estimated Bayes factor. All analyses were performed using JASP software.

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9.2.3 Results

9.2.3.1 Environmental quality of life related to public gardens and parks

A Bayesian multiple regression was performed to determine the best model out of all the possible models that would predict the environmental quality of life related to public parks and gardens. The best possible option considers that this aspect of quality of life is partly explained by general health, two physical indicators (the amount of trees and the amount of blue spaces near the individual's home), two perceived indicators of NBS (perceived amount of general green spaces and perceived amount of public parks and gardens around the individual's home) and two psychological indicators (Well-being and Connectedness to Nature) (BF10 = 6418.45). This Bayes factor indicates that this solution is 6418.45 times more probable than the null model. According to Lee and Wagenmakers (2014), a Bayes higher than 150 suggests decisive evidence for the alternative hypothesis rather than the null hypothesis.

On this basis, a linear multiple regression was conducted, considering that the best possible model had already been identified using the Bayes factor. The results of the regression indicated that these seven predictors explained 22% of the variance ($R2 = .22$, $F(7,153) = 6.34$, $p < .001$). Our predictions are partly confirmed. As we expected, environmental quality of life related to public parks and gardens is significantly predicted by general health ($\beta = .15$, $p < .05$). It also appears that the amount of trees around the home ($\beta = .22$, $p < .05$) and the amount of blue spaces ($\beta = .19$, $p < .05$) are significant predictors of this aspect of environmental quality of life. The perceived amount of green spaces is also significant ($\beta = .29$, $p < .001$) as well as the perceived amount of public parks and gardens ($\beta = -.26$, $p < .001$). Finally, well-being ($\beta = -11$, $p = .13$) and connectedness to nature ($\beta = 10$, $p = .16$) were selected in the best model as predictors of environmental quality of life related to public parks and gardens, but we only observe a tendency. Interestingly, the other variables introduced in the model were not significant. The economic situation of the respondents, general quality of life and self-reported health were not significant predictors of environmental quality of life related to NBS. Implications will be discussed in the conclusion.

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Table 8 - Means, standard deviation and regression analysis summary for environmental QoL related to public gardens and parks predictors

Independent variables	M	SD	β	t	*p*
Amount of green spaces	23.88%	10.79	0.22	2.38	*
Amount of blue spaces	7.65%	7.1	0.19	2.13	*
Perceived indicator of green spaces	3.43	0.76	0.29	3.95	***
Perceived indicator of public gardens and parks	3.39	0.78	0.26	3.46	***
General health	3.96	0.87	0.15	1.95	*
Well-being	3.50	0.45	0.11	1.53	*0.13*
Connectedness to nature	3.78	0.80	0.10	1.42	*0.16*
F	6.34				
R^2	0.22				
N	161				

Note: 1. Dependent variable: Environmental quality of life related to public gardens and parks. 2. The entries are standardized regression coefficients. 3.: * significant at .05. ** significant at .01. *** significant at .001

9.2.3.2 Environmental quality of life related to blue spaces

A Bayesian multiple regression was performed in order to determine the best model out of all the possible models that would predict the environmental quality of life related to blue spaces. The best possible option considers that this aspect of quality of life is partly explained by two physical indicators (the quantity of trees and blue spaces in the proximity of an individual's home), the perceived amount of blue spaces and a psychological indicator (Well-being) (BF_{10} = 1379.87). This Bayes factor indicates that this solution is 1379.87 times more probable than the null model. According to Lee and Wagenmakers (2014), a Bayes higher than 150 suggests decisive evidence for the alternative hypothesis rather than the null hypothesis.

On this basis, a linear multiple regression was conducted for this model. The results of the regression indicated that these four predictors explained 17% of the variance (R2 =.17, F(4,153) = 7.74, p < .001). Environmental quality of life related to blue spaces is significantly predicted by the amount of blue spaces (β = .23, p < .05) and the quantity of trees around the home (β = .20, p < .05). The perceived amount of blue spaces is also significant (β = .34, p < .001). Finally, well-being was again selected in the best model as a predictor of environmental quality of life related to blue spaces, but we observed a tendency (β = 14, p =

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0.6). The other variables introduced in the model, such as the economic level of the respondents, their self-reported health or their general quality of life score, were not significant.

Table 9 - Means, standard deviation and regression analysis summary for environmental QoL related to blue space predictors

Independent variables	M	SD	β	t	*p*
Amount of green spaces	23.73%	10.63	0.20	2.11	*
Amount of blue spaces	7.72%	7.16	0.23	2.47	*
Perceived indicator of blue spaces	3.26	0.94	0.34	4.63	***
Well-being	3.50	0.46	0.11	1.53	*0.06*
F	7.74				
R^2	0.17				
N	158				

Note. 1. Dependent variable: Environmental quality of life related to blue spaces. 2. The entries are standardized regression coefficients. 3.: * significant at .05. ** significant at .01. *** significant at .001

9.2.4 Discussion

In the two examples presented here as possible implementation scenarios of the EQoL scale for the assessment of environmental quality of life related to NBS, the results are similar. In both cases, it appears that the score of the inhabitants for the two modules (public gardens and parks and blue spaces) is linked to physical, perceived and psychological predictors. In each scenario, the perceived amounts of NBS around where people live were the best predictors. The physical indicators related to NBS were also identified as good predictors of the environmental quality of life in the two scenarios. Interestingly, in both cases the amount of green and blue spaces were identified as significant predictors. This implies that the availability and proximity of these spaces have a positive impact on the environmental quality of life linked to public gardens and parks and blue spaces, without distinction.

This is especially interesting as, given that the lack of green spaces around the living place can have a detrimental effect on physical and psychological health, it emphasizes the need to promote the access and availability of green spaces (public gardens, parks or blue spaces); this accessibility and availability is a predictor of how much people would benefit from these

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spaces. Furthermore, for vulnerable people, the development of NBS near where they live should be considered.

More importantly, it appears that the perception of NBS near places where people live is a better predictor than the actual availability of NBS (estimated by the distance between the NBS and the home). More research could determine if this perception depends on the quality or the visibility of the NBS, but this initial indication is encouraging all the same. Communication about the NBS and the services provided by the NBS could improve environmental quality of life without necessarily having to develop new NBS. In any case, it seems that more communication about NBS or a design enhancement on existing NBS is needed to reveal their true potential.

Lastly, a few psychological predictors also appeared to be significant. well-being for the blue spaces module, and both well-being and connectedness to nature for the public gardens and parks module. These results have several implications. First, they seem to imply that the environmental quality of life is partly predicted by the psychological states of the inhabitants. Inhabitants with higher levels of well-being appear to perceive public gardens, parks and blue spaces as more beneficial than inhabitants with lower levels of well-being. This is partially validated by the fact that the general score for health was identified as a predictor of the score for the public gardens and parks module. In this case, inhabitants with higher levels of physical and psychological health appear to be more satisfied and benefit more than the other inhabitants of the sample. Another implication is that, while these NBS are known to have a positive impact on physical and mental health, people with low levels of health or well-being are more attentive to the quality and to the services provided by the NBS. Furthermore, although general health was not a predictor of the environmental quality of life related to blue spaces, it should be noted that this may be because they are also more associated to low-energy activities and psychological restoration.

Regarding connectedness to nature, our results suggest that people with higher levels of connectedness to nature, i.e. people that define themselves as closer to nature, enjoy more and benefit more from green spaces than others. It is consistent with literature on this topic. For example, Mayer et al. (2009) observed that an increase of the connectedness to nature is accompanied by an increase of positive emotions.

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More importantly, two possible examples for the implementation of the EQoL scale as an operational tool were developed. Consequently, we included several physical, perceived and psychological indicators in addition to the EQoL scale scores in our analysis. These scores were successfully linked to various indicators and a large part of the overall variance was explained by these factors (22% and 17%). This emphasizes the possibility of using the EQoL scale for assessing environmental quality of life: it can be used as a tool for diagnostics before the implementation of a new NBS, or as an assessment tool to measure the efficiency of NBS. The main limit of the implementation of the EQoL scale on site for a whole district is the lack of physical indicators or the differences in precision or operationalization of the physical indicators for comparisons. In our case, we obtained sufficiently precise data in Nantes only, which led us to develop these scenarios for Nantes. The availability of physical data need to be ensured before EQoL implementation if these data are needed, which depends of the goal and context of its implementation.

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10 Conclusion on the development and validation of an alternative value scale of NBS based on quality of life indicators: the EQoL scale

The Environmental Quality of Life Scale (EQoL) is an operational tool dedicated to the assessment of perceived benefits in terms of quality of life linked to Nature Based Solutions. To serve that purpose, the scale was developed with the idea of six separate modules, each one dedicated to a particular type of NBS: public gardens and parks, natural spaces, urban farms or collective gardens, green roofs and walls, blue spaces and biodiversity.

The EQoL scale in its final form can be used in a variety of ways. In our examples we demonstrated the possibility of linking the EQoL scale scores to a variety of other physical, perceived or psychological indicators. In this sense, the EQoL scale can be used as a diagnostic tool in order to understand how people in a given area perceive and assess the benefits of NBS around where they live, with the possibility of targeting a particular type of inhabitant (for example, elderly people or patients). As we observed in our examples, the perception of an NBS is a major predictor of the environmental quality of life related to NBS. Thus, understanding NBS perception and NBS perceived benefits would be a major step in promoting existing NBS, as well as a key to success for new NBS projects. It will also help to understand and to read into the contributions of inhabitants involved in local participation process.

In addition, the EQoL scale can target both inhabitants of a given area and users of a particular NBS. For example, the EQoL scale can be used as a tool for assessing an individual's satisfaction of a given park or green space. Once again, understanding the perception of an NBS is an asset and can be used to improve NBS potential.

The EQoL scale presented in this work can deliver global environmental quality of life scores for each of the modules within the scale, which are related to the most common and well-known NBS forms. In this case, it is possible to consider implementing the EQoL scale for studies about the impact of physical, perceived or psychological predictors on environmental quality of life related to NBS. So far, the EQoL scale has been developed in eight different languages (English, French, Spanish, Dutch, German, Portuguese, Hungarian and Turkish), but base materials already exist for translation into other languages. Furthermore, following

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this first work on the development and validation of the EQoL scale, a full set of guidelines for its implementation and translation should be made available as part of WP7 of the N4C project.

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