Dynamic Assessment Methodology
Support Document

NATURE 4 CITIES

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What is

Dynamic Monitoring and Assessment?

First of all, below terms are highly related with the data management concept. You should think about all of these keywords in the course of data and time dimension. Their relations are the main concerns for this mini document.
Our ambition is to acquire, arrange and assess relevant data sequences to understand the value of Nature Based Solutions, under study in the context of a progressive perspective.

*Let us start with some descriptions including “**What is**” series:*

Data?	Any kind of numbers, observations, factual information in digital form, measurements, set of characters, words which are mostly quantitative
Static?	Stationary, unchanged, constant, still
Dynamic?	Periodically updated, change in situation, non-stationary, growing or shrinking, constantly changing
Baseline?	Set point or reference point for the comparison purposes
Assessment Monitoring?	Tracking is essential in every circumstances of life to reduce or eliminate uncertainties or to check the variation within a period or to log the progress or the process in operation. This can be achieved via technology aided monitoring or manually observed by human eyes. By this way, it is possible to establish a qualitative or quantitative evidence for performance follow-ups. These follow-ups are only be available by managing the data and assessing respectively to obtain different pinpoints throughout the monitoring stage

“Dynamic Monitoring and Assessment” is the art of tracking the change in time of an object/ event and then value its performance against a target spot(s) or a set point(baseline) regarding the subject in concern.

Nomenclature	Description
concept	Generalization of a type of thing; describing its essential features
concept model	Set of defined concepts and the relationships between them, chosen to be independent of design or implementation concerns, that can be used to describe a domain
dataset	Managed collection of structured data
descriptive data	Describe the current state of affairs
diagnostic data	Serving to understand the underlying reasons in a causal manner
entity	Thing with distinct and independent existence for which a concept can be assigned
interoperability	Ability of systems to provide services to and accept services from other systems and to use the services so exchanged to enable them to operate effectively together [Source:PAS 180:2014, 3.1.40]
interval of evaluation	Repetition frequency of the assessment
predictive data	Serves to look at what probable future changes will occur given current and past changes
prescriptive data	Utilizes past or current data to find with analytical algorithms better outcomes
relationship	Way in which two concepts can be connected
smart city	Effective integration of physical, digital and human systems in the built environment to deliver a sustainable, prosperous and inclusive future for its citizens [Source: PAS 180:2014, 3.1.62]
time frame	Time period that the assessment made
time resolution	The frequency of the dynamic assessment. “How often the assessment repeated?”
time series	An ordered sequence of values of a variable observed at equally spaced time intervals are referred to as a time series. [Source: Glossary of Forecasting Terms-Rob J Hyndman]
trend analysis	Trend analysis (or trend-line analysis) is a special form of simple regression in which time is the explanatory variable. [Source: Glossary of Forecasting Terms-Rob J Hyndman]

The concept of ***“Time Series” Analysis***

This analysis technique is an extensive topic covered by various professionals in different areas along the literature. However, this booklet is trying to encourage the reader to explore further researches carried out in the that field. Moreover, as our major ambition is to wrap up the concept in a nutshell to increase the usability of this booklet, following paragraphs were prepared to establish a general vision for the reader.

To briefly describe the concept, we should consider measurement over time that form a sequence including different sample points. These consecutive points are combined to create a meaningful pattern, which is much more informative than a scatter plot, from them identifying the future tendencies. These consecutive points are describing the term “time series” covering a general sequence in which he points are not necessarily independent and the distribution is not necessarily stable.[1]

To exemplify such sequences,

- Yearly deviation in average global temperature
- Monthly/annual rainfall data
- Monthly/annual deviation in different air pollutants in a neighborhood/district/ city
- Increase in population/number of cars in a city/electricity consumption figures of a building/number of cold days in a month/ weekly based number of urban park visitors/etc.

As we notified before, aggregating different data points taken from different fields of work can draw different and unique sequence patterns illustrated as below (Figure 1).

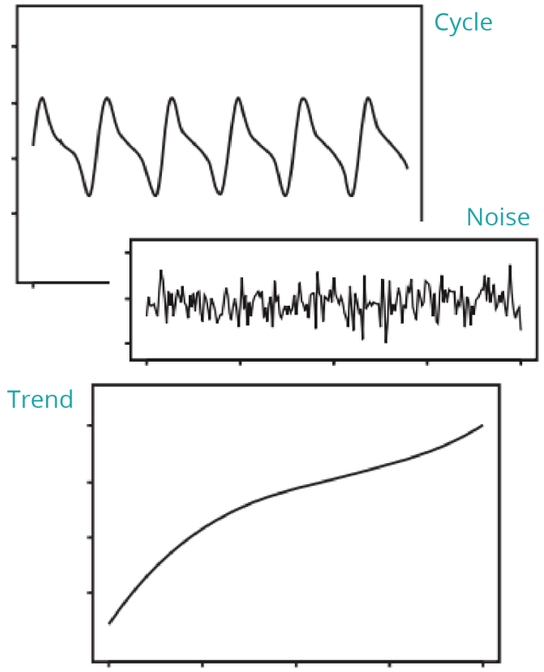

Figure 1: *Time Series Pattern Illustration*

In Figure 1, single pattern types are shown however combination of these patterns including two or three components is also possible. These patterns are derived from the variations in behaviors observed in nature, physics and even human facilitate the future prediction(~forecasting) and learning process by taking consecutive measurements at equally spaced time intervals. In that respect, a concept model is built up to answer two objectives of time series analysis such as:

1. Behavioral assessment
2. Forecasting

First objective which is “Behavioral Assessment”

1 Wild, C. J., & Seber, G. A. F. (1999). Chapter 14 - Time Series. Chance Encounters: A First Course in Data Analysis and Inference.

can be explained as to identify the underlying behavior of the observed sequence(s) in a dataset or the behavioral linkages between multiple datasets. For the case of forecasting aim, the ambition is to be able to forecast and predict future values of the series. In a broad sense, the extrapolation of the identified pattern is revealing the prediction for future events. Following components[2] are the essential items worth to mention in this document:

a) Trend: Consistent data changes over time in a particular pattern that does not repeat regularly, at least not within the time range captured out by data.

b) Seasonality: The component of data repeating itself in systematic time intervals.

c) Cyclical: Medium-term changes in the series which repeat in cycles

d) Irregular(Random): Unpredictable variations that are not regular and do not repeat in a particular pattern

> "My interest is in the future because I am going to spend the rest of my life there." C.F.Kettering

For the forecasting of the future values, data in hand gives only a predictive information which is connected to the past data. It means that concluding into a pattern from the past data points for the future prediction needs some stability to reduce the uncertainty. There could be unexpected changes that leads to a faulty prediction process which are identified as "Spike" or "Step". These are also explained as sudden changes that should be considered as outliers in a series of data. Following figure (Figure 2) is describing these two situations in a simple manner.

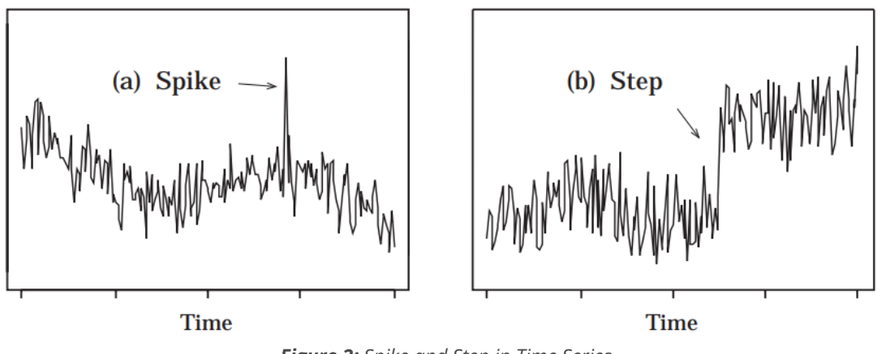

Figure 2: *Spike and Step in Time Series*

> The procedure of fitting a time series to a proper model is referred to as Time Series Analysis

A number of standard models used in many fields include:

a) Linear: All the variables in the data series are additive.

b) Quadratic: At least one of the variables is raised by the power of 2

c) Logarithmic: Exponential growth that dampens out

2 Adhikari K., R., & R.K., A. (2013). An Introductory Study on Time Series Modeling and Forecasting Ratnadip Adhikari R. K. Agrawal. ArXiv Preprint ArXiv:1302.6613. https://doi.org/10.1210/jc.2006-1327

NBS, Awareness & Benefits

Word by word "Nature Based Solutions (NBS)" definition is[3]:

N nature — From the point of view of biologic sciences, it relates to biodiversity. However, for the earth sciences, it also includes the physical abiotic elements.

nature **B**ased — Utilization of elements of nature

Solutions — Answers to a specific problem

(For the proposed NBS definition by European Commission, please check out "Towards an EU Research and Innovation Policy Agenda for Nature-based Solutions & Re-naturing Cities - Final Report of the Horizon 2020 Expert Group", annex 1, page 25.")

In this guideline, basically, the solutions inspired from nature are considered as remedy for various urban challenges that can be categorized as stated in Figure 3. Nowadays, these challenges are confronted extremely by cities. The methodology summarized in this booklet is mainly concerning the environmental urban challenges, but it could be adapted into different structures(replicability) which consist parameters that change in time as well.

Figure 3: *Topics of Urban Challenges*

3 N4C Project Deliverable 1.1 "NBS multi scalar and multi thematic typology"

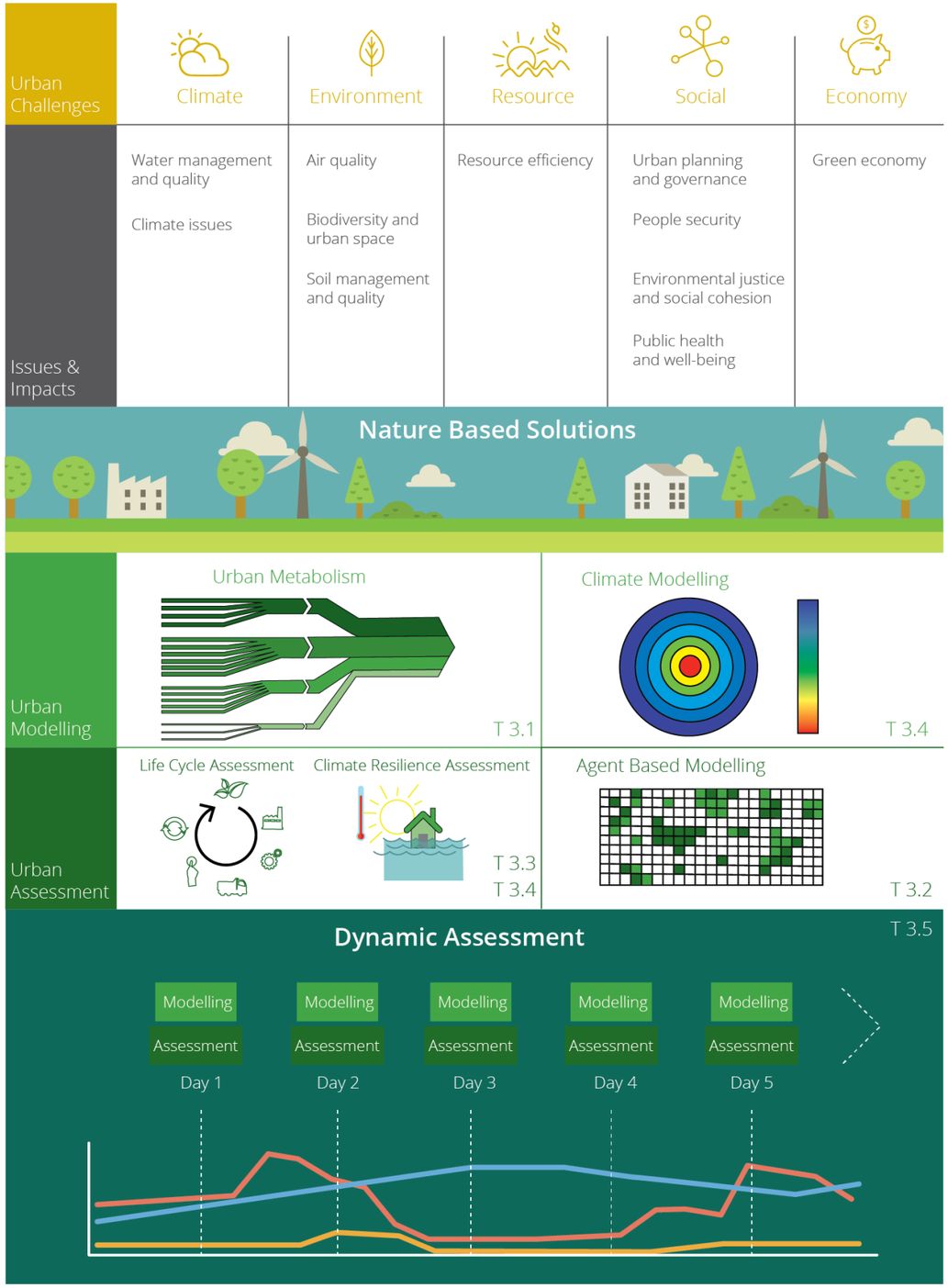

Figure 4: *General structure of Environmental Evaluation within N4C Project*

In order to address NBS to different environmental challenges, a master plan before applying the implementation decision should be carried out. Performance tracking/evaluation/ monitoring of the NBS during and after the implementation phase are quite beneficial to improve decision making process. Hence, this methodology that shows the dynamic nature of the urban ecosystem is quite useful especially for municipalities, citizen, researchers or expert urban planners, landscape planners and other relevant actors.

Depending on the performance criteria that you want to measure along the timeline of the NBS, some input parameters are required for the performance monitoring to evaluate the deviations of the performance criteria selected over time[4]. The availability of the data and other points will be briefly mentioned in the following chapter.

By applying such methodology, following benefits come into play:

- *Revealing the potential of the NBS(s) implemented or in planning stage whether it can reach to the target set by the national or international agreements.*
- *Providing support for planning of the implementation phase.*
- *Monitoring the performance of NBS throughout the infrastructure's lifetime.*
- *Determining the need for intervention on NBS to improve or maintain the infrastructure.*
- *Supporting periodic maintenance actions to be taken whenever necessary.*
- *Enabling scenario comparisons between business as usual(baseline) vs NBS*
- *Enhancing Sustainable Urbanization*

Focusing on greening the cities with the support of Nature Based Solutions are essential for urban resilience and acting as a backbone for climate mitigation and adaptation actions in city context. This strategy can be initiated and enhanced by arising public awareness and realized via adaptive management structure in the sustainable urban planning context. In fact, this is an important gap to be fulfilled with innovative and supportive methodologies to evaluate the performance of the NBS implemented for an effective urban management. This knowledge gap could be closed by supporting good-practice strategies and revealing multi benefits of NBS compared to conventional(grey) solutions. Hence, along the life cycle of the NBS, evidence-based decision-making process by means of dynamic monitoring is found at the heart of adaptive management context where tracking the performance of the NBS considered as an important component. The magic behind this assessment is the ability to see the trade-offs while trying to achieve committed targets.

The gap between the NBS performance obtained through Performance Indicators (KPIs), and the target levels can help the decision makers and planners to understand what rate of improvement is necessary to close the gap.

-Intervention Strategy-

4 The concept of "over time" depends on the time frame you are interested in and the interval of tracking that depends on the time resolution of the data.

Data *Management Concept*

In city planning, urban data system plays a significant role for the monitoring and evaluation activities. Dynamic assessment needs a well-structured urban data system which can be realized by proper data management. It is important to identify the most critical data to acquire for the key performance indicators. By this way, it is possible to reveal the trends and patterns during the dynamic monitoring process.

Urban planning stages can be categorized as “Plan”, “Build” and “Operate” which should be continuously supported by monitoring actions giving feedback to the planner or expert respectively. This continuous feedback loop is only possible if the data is available. Moreover, other parameters like the data gathering, sharing, analyzing, aggregating, storing and managing strategies should be considered and managed carefully. One way to handle data management activities is the application of On-Line Analytical Processing (Figure 5) that enables the data interrogation by examining multiple data-series including intuitively their relations. (i.e. different NBS Key Performance Indicators and their changes over time) (Figure 5).

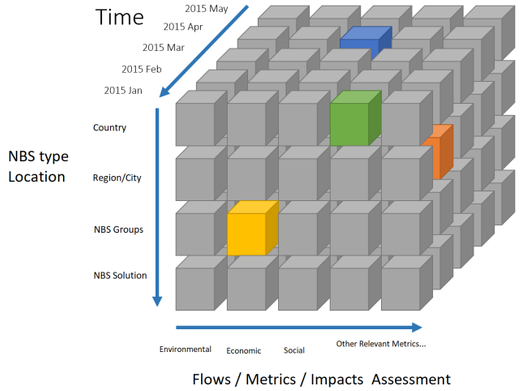

Figure 6: *On-Line Analytical Processing Cube*

Are you able to find the data you need?

Dynamic assessment methodology totally depends on the development of data management protocols. These include ready-to-implement data collection together with hardware and software systems tailored to each specific NBS typology. This data driven decision making structure is also valid for smart cities concept which invest in data and analytics. It should be noted that adequate resource for data can only be acquired with governmental awareness (e.g. city leaders)

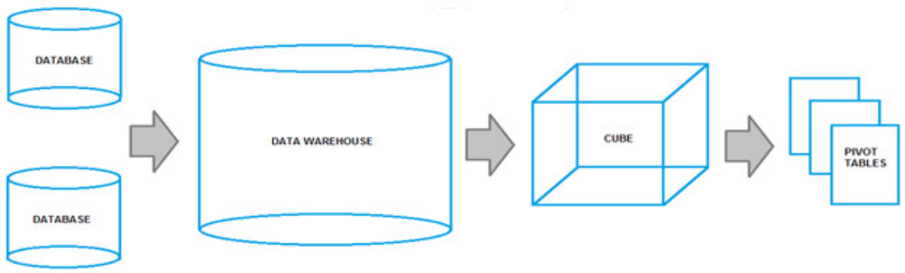

Figure 5: *On- Line Analytical Processing (OLAP)*

Data or Whata?

There are lots of limitations even if you obtain a dataset in hand. These;

- Quality
- Knowledge
- Measurement time interval selection
- Monitoring equipment limitations
- Complexity
- Uncertainty
- Random variations
- Data cost

are shaping the boundaries of the dynamic assessment framework.

Continuous surveillance with the support of various sources of fine grain data enables a city to develop real insight into different urban challenges i.e. resilience. It depends on the ability to extract data from a wide array of sensors, in public spaces, in transportation systems, in energy grids, in all kinds of consumer devices provides real-time insight in transportation flows, energy flows, pollution and human behavior. The extraction, analyzing and evaluation process of data need a broader transition towards digital economy (further readings is recommended).

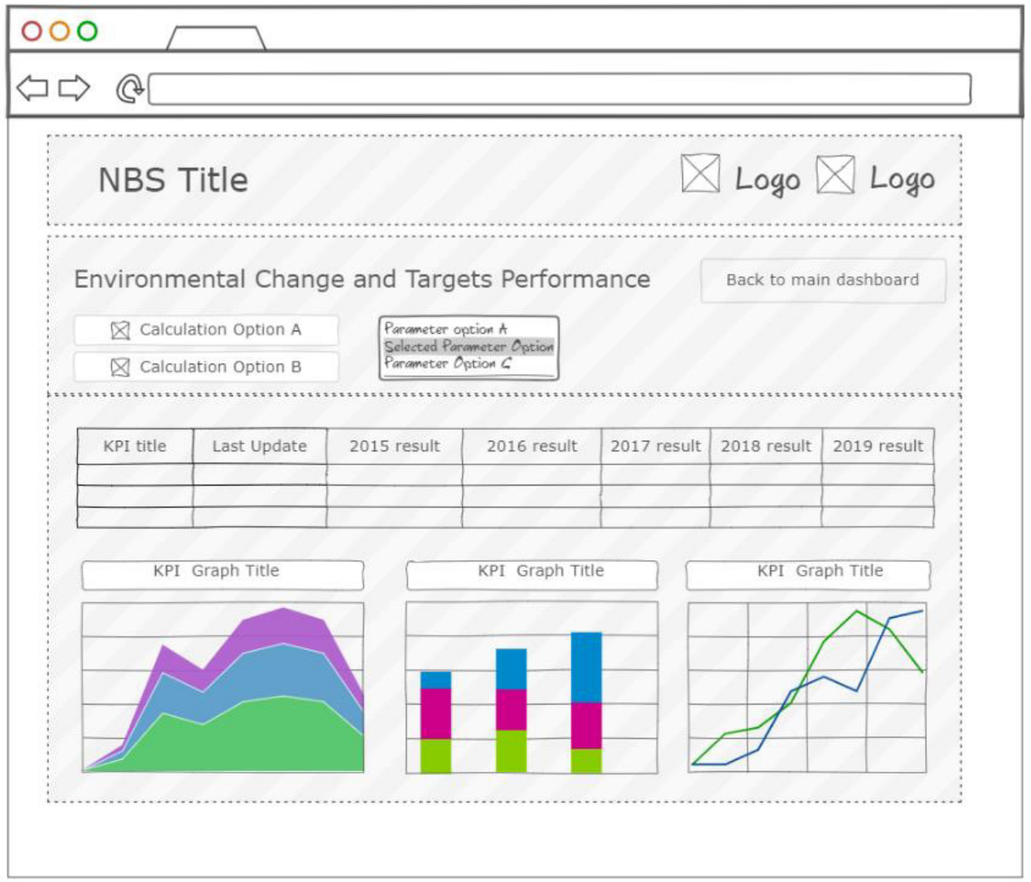

Figure 7: *Assessment Result Presentation Mock-up*

Dynamic Assessment Evaluation steps

Step 1 **Time frame and time resolution setting**

Step 2 **Baseline data establishment**

Step 3 **Target setting**

Step 4 **Time- series future trend analysis**

Step 5 **Comparison of trends with targets**

Figure 8: *Assessment steps*

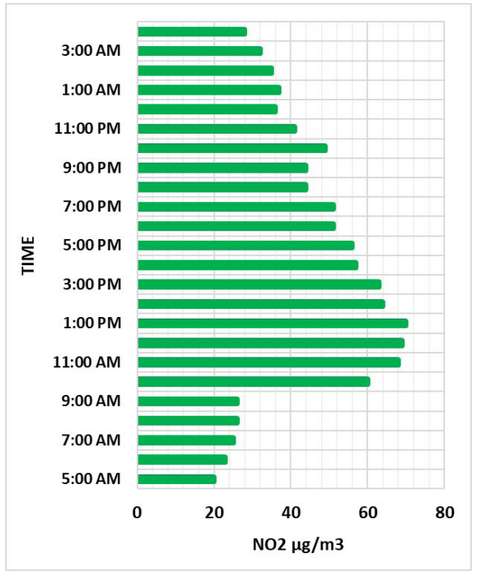

Figure 9:*Total GHG Emissions in the EU (historical emissions 1990-2017, forecast emissions 2018-2030)*

Sample ***Application***

Figure 9 shows hourly NO_2 concentrations for a European city, where NO_2 is considered as one of the primary urban pollutants besides PM10 and PM2.5 caused by traffic. (All three pollutants are traffic related pollutants).

Let's assume an urban park having a huge space for picnic and paths for walking, cycling, running and etc. which is located in the city centre of the city. Moreover, a measurement of above 200µg/m³ is considered as high pollution. As it is seen from the graph, after 9 AM in the morning, NO_2 starts to increase since the park is getting people from different location using their car and/or public transportation so the air pollution increases because of the traffic background. In addition to that, this dynamic monitoring will help us to see the decrease in night time.

Green bars in the graph show the monitored data. So the upper point of the each bar reveal a dynamic variation pattern over time.

This is an example based on hourly time resolution for a dynamic environmental assessment and if it is needed to reveal a daily situation, a daily average can be used as a time series data. Hence, decision makers could understand easily the time based variation pattern for a selected KPI with respect to the implemented NBS.

Another example is the yearly based time resolution shown in Figure 10[5]. The dotted projection lines are the forecast which is determined via linear regression. It will help the decision makers and observer whether it is necessary to interfere and modify a/any parameter(s) to reach the target. Hence, this is very useful for determining the appropriate time for the maintenance of the NBS in concern or the location of the NBS during planning stage(before implementation) respectively.

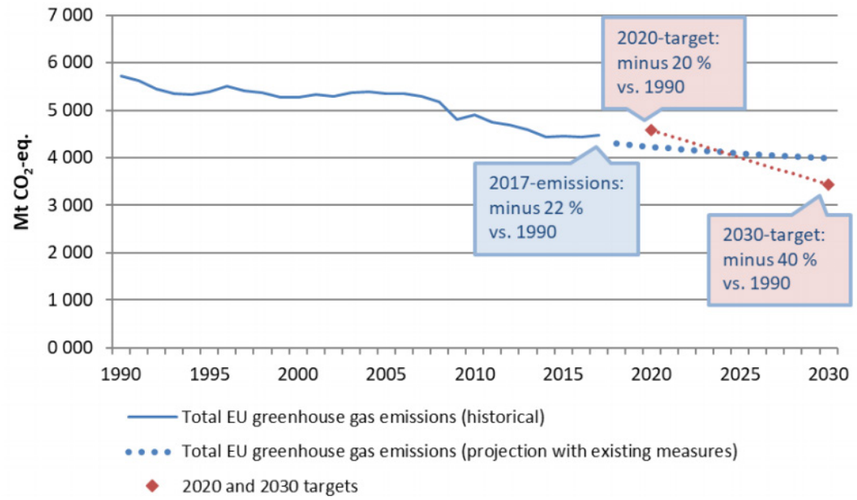

Figure 10: *Total GHG Emissions in the EU (historical emissions 1990-2017, forecast emissions 2018-2030)*

5 "EU and the Paris Climate Agreement: Taking stock of progress at Katowice COP24, COM(2018)716," the Commission to the European Parliament and the Council, 2018.

Further Readings
(or Extras)

No particular order is implied in the following references:

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Who we are?

***Led** by* ekodenge

Ekodenge was founded in 1996 to provide consultancy, research and engineering services shaped around the vision of sustainability and related EU policy. With growing experience, the interdisciplinary team has developed expertise in the fields of architecture and sustainable built environment together with information technologies, projecting a holistic approach and bringing different skill sets to all its projects. A branch company of Ekodenge was established in London in 2016 and launched Ecowise brand for its services.

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