**Financial Model Climate Adaptive Business Parks**

This excel file will help you further in creating a business case for making your work environment climate adaptive. Implementation of climate adaptive measures is something that requires an upfront investment but comes with several benefits over the years.

The excel model is interactive which means you can fill in the exact numbers and dimensions for the business plot your company or the company you work for is on. The model can be filled in step by step and in the coming part, the steps will be explained with tips and tricks on how to determine and interpret the numbers. If you want a more extensive (academic) background for the numbers, please read the second part of this document. The main sources used for creating this excel model are the TEEB.stad tool (RIVM, 2022a), the Climate Resilient City Tool (CRCTool) (Deltares, 2022), calculations from Rebel Group (Rebel Group, personal communication, 2022) and other scientific sources. The TEEB.stad tool and the Climate Resilient City Tool are publicly available.

1. **Basic input numbers**

In this step, you are asked to fill in the numbers in the yellow excel cells to tailor the model to your specific situation. The rest of the model is linked with formulas to calculate the corresponding values.

**Plot dimensions**

These numbers form the basis of your calculations and will give an overview of the **current** dimensions of the different parts of the business plot you are on.

**Plot size**: here you fill in the square metres of the total business plot the building is on. This information can be retrieved from the property owner or you can look up the business plot your company’s building is on online at the website of the [Kadastrale Kaarten](https://kadastralekaart.com/kaart/perceel/STN02/K/4600). When you have determined the business plot you are on, you can find the dimensions through [Google Maps](https://www.google.nl/maps/%4052.3750243%2C4.8977791%2C3513m/data%3D%213m1%211e3). Here you can look up your business plot and by using the right click, you can click on ‘afstand meten’ and draw the dimensions of your business plot to determine the square meters of the whole business plot and building.

**Flat roof/building size**: in business parks, it is often the case that the roof is flat which makes the roof size as big as the building. By using the same technique through Google Maps as explained in plot size, you can determine the surface of the roof and building. These flat roofs play an important part in making business parks climate adaptive as a green roof can have many benefits.



**Number of parking spaces**: here you fill in the number of parking spaces that are present at your business plot. These could be counted from Google Maps again, or you can easily count them whilst at work!

**Building year**: this information can be requested from the property owner, or you can make your own estimation based on when the business park was built. Often, you can find the information on when the development in the area has happened as large parts of business parks are being built at once. A quick search on Google can give you a good estimation on the year it was built.

**Number of employees**: this information asks for the average number of employees working at location on an average day.

**Environmental factors**

As plants have the capacity to purify the air, they play an important role when it comes to air quality and our health. Therefore, information on air quality is of importance. For this part of the basic input numbers, you can search up the different air quality values through an [interactive map of the RIVM](https://data.rivm.nl/apps/gcn/). On the website, click on the dropdown menu under ‘Selecteer een kaart’ to select one of the different types of air quality pollutants. Next, select the most recent year under ‘Selecteer een jaar’. Zoom into your area and fill in the corresponding value using the legend in the top left.

**Plot price**

The plot price might be known at the company your work for, or if you are in contact with the plot owner. Otherwise, an estimation can be made through the website of [Funda in Business](https://www.fundainbusiness.nl/). Search in your area for similar business plots and fill in the corresponding price.

1. **Added climate adaptive measures**

This is where the fun begins. Here you can fill in the dimensions of the different types of climate adaptive measures you wish to implement and play around with them. Please note that green roofs and plants/extra grass need to be filled in in terms of square meters but that for trees and climate adaptive parking spaces you fill in the corresponding number of how many you wish to add. If you do not want to implement a certain measure, you can just leave it at 0. In need of a recap of what these different measures have to offer? Check out step 2 of the webpage for short and simple explanatory videos!

1. **Costs of implementing climate adaptive measures**

This part provides a simple overview of the different costs that come from the numbers you have filled in during the first part of this model. An overview of where the different numbers come from for this step is given in the second part of this document ‘assumptions and explanations of calculations’. The costs are costs incurred now.



1. **Financial benefits from implemented measures**

Adding more greenery and being better protected to the changing environment comes with a range of different benefits, from better health to decreased potential damage after heavy rainfall. The benefits are calculated over a period of 30 years, as this is the average lifespan of greenery (Buck Consultants International, 2016). To make the value of greenery comparable to the current value of the money spent for implementation, the Net Present Value of the benefits over a period of 30 years is calculated. For more background information on this, please check the second part of the document.

**Health benefits**

One of the largest benefits of greenery for humans is the fact that they can filter the air. Especially in (industrial) business parks, air quality tends to be worse than in surrounding areas. Plants can absorb these pollutants and thus make our air cleaner which decreases health care costs in the long run. Therefore, the group benefiting from this measure is the local **workforce**.

**Climate related benefits**

There are different other benefits that smart implementation of greenery can offer to our surrounding climate. The first is that water purification costs are lower, as water can infiltrate into the ground or be absorbed by the greenery which reduces overall costs of purification. These are monetary benefits for the **local water board**. Next to that, trees store carbon in their stems, which can also be expressed in monetary value and are to the benefit of **society as a whole**. Next to that, green roofs can play an important part in insulation of the building, depending on the year that the property was built. This can be an important factor for businesses to invest in them. Do check however with a local expert on whether your roof is currently fit for supporting such a structure. These decreased costs because of better insulation are for the **business owner**, as it reduces his/her energy bill.

**Potential water damage**

Extreme weather events are expected to happen more often, which could lead to potential damage to your business and its operations. Although the chances of such heavy rainfall are still slim (but are expected to worsen in the coming years), the associated costs from flooding damage are considerable both directly to inventory, but also because businesses can’t operate for a couple of days as a result of it. For a more in depth explanation of the numbers behind these calculations, please refer to the second part of this document. These benefits are (partially) for **property owners** because damage to their properties is reduced, **business owners** because damage to their goods inside the facility are reduced and **insurance companies** in case they would have reduced claims.

**Saved costs from loss in labour productivity**

You as an employee are one of the most valuable assets of the company you work for, but increasing heat can drastically reduce your output and create an unhealthy living environment. In the coming years, more extreme heat is expected to occur which could lead to lower output levels and interfere with production processes causing a loss to the company revenue. Increasing the amount of greenery around and on the business plot can help prevent that. The benefits of these prevented losses are for the **business owner**.

**Increased property value**

Creating a line of greenery or trees in direct line of sight from the building itself leads on average to a 5% higher property value (TEEB.stad, 2022). Therefore, adding more greenery to the business plot can be directly beneficial to the **property owner** as well.

1. **Net Present Value of benefits/loss over 30 years**

This last part provides an overview of the different costs and direct and potential benefits. The direct benefits are the benefits for health, the climate related benefits and increase in property value as they are ‘known’ factors that are sure taken into account. The real difference in terms of monetary value is actually made for the potential benefits, which are related to cost savings when the measures are implemented correctly. It is clear that over 30 years time, the potential costs of damage by water overflow or loss in labour productivity are quite substantial and should be avoided.

**Assumptions and explanations of calculations**

In this part, the different sources, assumptions and explanations of the different parts of the financial model will be given to better understand the numbers. The main sources of input for these calculations are the TEEB.stad tool, the Deltares Climate Resilient City Tool (CRCTool), calculations from Rebel Group and other scientific sources.

**Costs of implementing climate adaptive measures**

In the excel model, the different costs per square metre are presented.

**Green roofs:** the costs for the green roofs are retrieved from the website of the Dakdokters, a company specialised in transforming flat roofs into green roofs. The costs taken are for the basic green roof of a size of >250 m2.

**Plants/extra grass and CA parking spaces**: when it comes to the costs for installing plants and greenery and the costs of the water absorbing parking spots, these are retrieved from the Deltares Climate Resilient City Tool (CRCTool) (Publicwiki.Deltares, 2020). The costs for the water absorbing parking spots are the average of ‘*waterabsorberende/bergende verharding*’ and ‘*waterdoorlatende verharding*’ in the CRCTool and are cross-checked with one of the suppliers of such parking spots (Rain(a)way, 2022, personal communication). The costs of adding more greenery on ground level is chosen from the costs of ‘*ontharden: verharding eruit, groen erin*’ in the CRCTool.

**Trees**: The costs of trees are estimated, as the costs indicated by CRCTool were considered too low and not realistic at 11,4 euros per m2. Installing trees on a larger scale can be a costly procedure as it often requires extra equipment such as digging machines and the transport of trees and it being cheaper than planting simpler types of greenery therefore did not make sense. The estimation is based on adding 10 trees of 100 euros each and include wages for four workers, 8 hours for 40 euros per hour. Next to that, 1000 euros for machinery and transport have been estimated as well as 2000 euros of site preparation costs. These numbers are based on information from the webpage Hovenier.website (2022). From research, it is apparent that an average urban tree has a surface of 38,5 square meters (based on an average diameter of 3.5) (Pretzsch et al., 2015). The total costs are for the property or business owner.

**Financial benefits of implemented measures**

The benefits are given over a period of 30 years, as this is the average lifespan of greenery (Buck Consultants International, 2016). In the coming 30 years, the (monetary) effects of greenery will be experienced every year, but the costs are incurred now. Therefore, the benefits are discounted to get a present value of those benefits which can be compared to the value of the investment for the implementation costs which are incurred now. In line with the TEEB.stad tool, we use a discounting factor of 3% which is standard for costs for nature of a social cost-benefit analysis (Buck Consultants International, 2016). This leads to a discounting factor of 20,6 for a period of 30 years and the yearly benefits that are derived from this measure will therefore be multiplied with this factor to get the present value of these benefits over the coming 30 years. The value of all benefits are therefore given over a 30 year timeframe apart from the cases where it is stated otherwise. 

In the TEEB.stad tool, climate adaptive parking spaces are not an option. Therefore, the same numbers as for grass have been taken but divided by 2 since climate adaptive parking spaces are roughly half made out of bricks and for the other half out of grass.

**Benefits health:** the health benefits are derived from the TEEB.stad tool (RIVM, 2022a). The first component for which the benefits are determined is the health of people in the area and more specifically the reduced healthcare costs associated with the improvement in air quality. Some other components of the healthcare calculations of the tool are left out of scope for different reasons. The generic reduction in healthcare costs and the prevented loss in employee fallout by the tool is left out of scope because the way the tool calculates them focuses specifically on the environment surrounding the homes, which is different from their workplace as researched in this research and therefore the calculations cannot be applied. Also, the reduced healthcare costs as a result of reduced noise because of the increased vegetation is left out, because there are many production companies in the area which presents a source of noise itself and therefore it is not possible to draw a clear line on whether or not it influences the people working there.

The reduced healthcare costs as a result of improved air quality are calculated taking the aforementioned environmental factors into account and the estimated population density. The population density has been a moderate estimation of 50 and will be set for these calculations, as people do not live in the area but only spend a part of their day there. The calculations take into account the deposition speed of the different air quality parameters on the vegetation as well as the resuspension fraction (parts of the air pollutants that lands on the vegetation, but is blown in the air again by wind). The group benefiting from this measure is the **local workforce**.

**Decreased water purification costs for waterboard**: a component which falls under the benefits of climate adaptation within the TEEB.stad tool is the avoided water purification costs (RIVM, 2022a). By preventing water from ending up into a mixed sewage system which is often the case in older neighbourhoods such as business parks, clean water infiltrates directly into the ground again or is reabsorbed by plants which reduces the amount of water needed to be purified and therefore the costs. The tool looks at placing grass, green roofs and trees. The buffering capacity of grass is 0,87 m3/m2/year of a green roof is 0,45 m3/m2/year and of a tree 0,67 m3/m2/year. These are benefits for **Waternet** and therefore also partially the **government**.

Another climate adaptive benefit is the captured carbon dioxide by trees over their lifetime. As input for these calculations in the tool, it is assumed that 15 trees are installed with a diameter of 16-30 cm at chest height, as these are the most common urban trees (Pretzsch et al., 2015). These are benefits for **society** at large.

There is energy saving coming from a green roof. This depends on the year the building was built. Only for buildings that were built until 1992, green roofs have a direct effect on isolation effects. Buildings built before 1975 are benefiting most from green roofs, between 1976-1991, the isolation effectiveness is only 50% of other types of isolation (RIVM, 2022a). These are benefits for the **business owner**, as it reduces his/her energy bill.

**Benefits property value:** from the TEEB.tool the increased property value of adding a line of greenery on the property is 5% of the current value of the property (RIVM, 2022a). The TEEB.stad tool focuses on the value of houses to live in, and so it is questionable whether or not this should be incorporated and if the value is equal for business property. There are other parts of adding greenery which would increase the property value, but they focus on greenery on a neighbourhood level of focus on adding water ponds, which is not likely to affect the case of a single business plot. These benefits are immediate. These benefits are for the **property owner**.

**Benefits saved costs of water damage:** as input for these calculations, information was derived from supporting information and calculation guidelines from Rebel Group (personal communication, 2022) and guidelines provided by STOWA as part of a pilot project in Amsterdam West (STOWA, 2019).

First, the average damage per company in a business park per year is calculated to then calculate a cost per square meters based on the dimensions of the business plot. The following input has been used for these calculations. From the STOWA report and guidelines from Rebel Group, there is an average direct damage in the built environment of 250 euros/m2 assuming 30 cm of water in the building after a rainfall of 70 mm per hour. In business parks, there are often many areas where the water levels are 30 cm or more after such rainfall (Klimaateffectatlas, 2022). From the guidelines of the Rebel Group, around 35% of the businesses in a business park are affected by such water damage if such a rainshower happens, and chances of it happening are 1% every year (Rebel Group, personal communication, 2022). From this, you can calculate the direct damage to businesses. In terms of indirect damage, businesses are on average 3 days not able to operate which results in costs of around 80 euros/m2/day with again 35% of the businesses being affected.

These numbers are based on green roofs. To extrapolate these numbers to different green measures such as for example trees, a multiplication factor is needed. The multiplication factor for trees is derived from the extra water buffering capacity of trees as seen in the previous part *benefits climate adaptation* (as 0,67/0,45 = 1.5). For green parking spots, the same buffering capacity as green roofs is used, so a multiplication factor of 1. These benefits are (partially) for **property owners** because damage to their properties is reduced, **business owners** because damage to their goods inside the facility are reduced and **insurance companies** in case they would have reduced claims.

**Benefits of costs saved from preventing loss of labour productivity: i**ncreased temperatures can lead to a loss in labour productivity which results in lower output of workers and thus revenues. The input for these calculations are derived from different sources. The first source is a research in which different scientific articles on the effect of the interior environment of office spaces on the people working there are explained (Boerstra & Leijten, 2003). The second source is a research of the European Union on heat stress in the work environment (Mekjavic et al., 2018) and the third source is the KNMI’14 climate scenarios (KNMI, 2014).

For calculating the loss in labour productivity, it is assumed that the average revenue generated per worker per month is around 6500 euros (Boerstra & Leijten, 2003). In the excel model, you can fill in the average amount of employees in your company. The revenue per employee can also be adapted by unhiding rows 31-61 and play around with the numbers. From this, the average revenue per year can be calculated and also the average revenue per m2 per year.

For every degree of temperature above 25, labour productivity drops by 2% (Mekjavic et al., 2018). Given the climate scenarios of the KNMI (2014), there will be 13 days in which the temperature is more than 30 degrees Celsius in the next 30 years as compared to 3 days currently. Therefore, the average number of days in which the temperature is above 30 degrees Celsius is 8 per year in the coming 30 years. With these numbers, the model calculates the loss in revenue as a result of days on which the temperature is above 30 degrees. The total loss is given over 30 years using the discount factor of 20,6. The benefits of these prevented losses are for the **business owner**.

**Reference list**

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