

INHERIT

Cost-Benefit Analysis of Four INHERIT Case Studies


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AUTHORS

Silvestre García de Jalón[1], Aline Chiabai[1], Tim Taylor[2], Sonia Quiroga[3], Cristina Suarez[3], Naiara Artaza[1], Tamara Blas[1], Amaya de Ayala[1], Pablo Martínez[3], Cecilia Latorre[3], Monica Lillefjell[4], Kirsti Sarheim Anthun[4]

1. Basque Centre for Climate Change (BC3), Spain
2. University of Exeter, United Kingdom
3. Universidad de Alcalá, Spain
4. Norwegian University of Science and Technology, Norway

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List of abbreviations

APPLE: Alberta Project Promoting Active Living and healthy Eating

BC3: Basque Centre for Climate Change

BCR: Benefit-Cost Ratio

BMI: Body Mass Index

CBA: Cost-Benefit Analysis

CEA: Cost–Effectiveness Analysis

CO2eq: Carbon Dioxide Equivalent

COPD: Chronic Obstructive Pulmonary Disease

CPI: Consumer Price Index

FMSC: Fadura´s Municipal Sports Centre

GDP: Gross Domestic Product

HRR: Health Risk Reduction

IRR: Internal Rate of Return

iSOPARC: System for Observing Play and Active Recreation in Communities

LSOA: Lower Super Output Area

NDVI: Normalized Difference Vegetation Index

NOx: Nitrogen oxides

NPV: Net Present Value

O&M: Operation and Maintenance

OECD: Organisation for Economic Co-operation and Development

OLS: Ordinary Least Square

PBP: Payback Period

PM: particulate matter

QALY: Quality Adjusted Life Year

SO2: Sulphur dioxide

SWOT: Strengths, Weaknesses, Opportunities, and Threats

TA: Target Area

TBBMC: Total-Body Bone Mineral Content

VSL: Value of Statistical Life

WHO: World Health Organization

WTP: Willingness To Pay

Summary

This report presents a comprehensive economic analysis in four case studies within the INHERIT project: Thinking Fadura in Getxo, Basque Country, Spain; Malvik path in Trøndelag county, Norway; Sustainable food in public schools in Madrid, Spain; and Retrospective Analysis on Energy Efficiency Investments in the United Kingdom.

A cost-benefit analysis has been developed in each case-study project to evaluate associated costs and benefits considering the perspectives of key stakeholders and taking into account environmental and social externalities. Both market and non-market costs and benefits have been taken into account on the basis of relevance and data availability of monetary metrics. The economic profitability has been evaluated through various economic indicators such as the net present value, benefit cost ratio, payback period and the internal rate of return to decide whether the case-study project is considered as an acceptable and beneficial investment to the society. A sensitivity analyses has been conducted to identify and measure the main sources of uncertainty.

This report has also developed a common methodology for systematizing meta-analysis data on health impacts. The Heckman model based on a literature review process has been used to assess health risk reduction as a response to public interventions. The model allows transferring knowledge on areas for which no evidence existed from epidemiological studies. This has been estimated for both the response to green areas exposure and for the introduction of healthier and more sustainable food for children.

The four case studies have assessed different fields within the INHERIT project. Whilst Thinking Fadura and Malvik Path focus on green areas, Sustainable food in public schools focuses on health diets among children and Retrospective Analysis focuses on energy efficiency investments in households such as double glazing, insulation and improved heating systems. Overall, the economic evaluations show that the four case studies are clearly profitable from a societal perspective. The four assessments suggest implementing the projects with the purpose of enhancing societal welfare. Finally, these cost-benefit analyses offer the possibility for policy-makers to design new studies with similar characteristics, which can serve as a reference in decision-making processes.

1. Introduction

The purpose of this report is to present and discuss the methodological framework and results obtained from the cost-benefit analysis applied to the selected Inherit case studies: Thinking Fadura in Getxo, Basque Country, Spain, Malvik path in Trøndelag county, Norway, Sustainable food in public schools in Madrid, Spain, and Retrospective Analysis on Energy Efficiency Investments, United Kingdom.

The first objective is to analyse costs and benefits associated with main impacts of the selected case studies and find out their profitability in the medium term and what is the period for recovering the costs (considering that implementation costs are supported in the present, while benefits are usually future flows provided after some time). Second, we were interested to complement the CBA with additional perspectives based on stakeholders' and citizens' views: (i) how to integrate the CBA approach with inputs of key stakeholders and agents responsible of the practice implementation, and their usefulness (combining different type of information: qualitative perceptions of impacts versus quantitative/economic impacts), (ii) how to integrate citizens' perceptions about the impacts of the practice and their attitudes towards change in behaviour. Third, we were interested to explore the use of conceptual frameworks (based on multidisciplinary analysis) to analyse the complex cause-effect relationships between green areas and impacts on human health and ecosystem and derive lessons to support the operationalization of the quantitative assessment of the CBA. Finally, we explored the possibility of deriving new approaches for health modelling related to green areas exposure and food consumption, considering the heterogeneity of the literature in this context in terms of methods and metrics applied.

In this introduction, the main purpose of the report is described. The second section describes the background on cost benefit analysis and describes the state of the art on environmental valuation studies. The third section describes the methodology commonly used for the cost benefit analysis in the case studies. The next four sections describe the economic evaluation carried out in each case study. The last section concludes this report by extracting some major insights and findings across the four case studies.

2. Background

This section introduces the concept of cost-benefit analysis and then describes the state of the art of economic valuations as well as the benefits of urban green areas and healthy diets.

2.1. Introduction to Cost Benefit Analysis

Cost–benefit analysis (CBA) is a recognised analytical tool of economic analysis for decision-making. It offers a method of economic evaluation of all benefits against all costs from a societal perspective (Hutton et al., 2006). CBA is a systematic approach to estimate the strengths and weaknesses of alternatives (e.g., in transactions, activities, functional business requirements or projects investments). CBA is often used, as already mentioned above, by policy-makers to help deciding how to allocate public funds between competing projects or programmes (Hutton et al., 2006b). There are two main purposes in CBA. The first one is to determine if an investment or decision is sound, justified and/or feasible. This is verified whether its benefits outweigh the costs, and by how much. The other main purpose is to provide a basis for comparing projects which involve comparing the total expected cost of each option against its total expected benefits and identify the option with the higher profitability.

Overall, CBA allows measuring the net effect or result of a defined intervention or mix of interventions on societal welfare in which both benefits and costs are typically presented in monetary units. The main difference with cost–effectiveness analysis (CEA) is that CEA measures intervention impacts, in non-monetary units, of decision-making in a single sector. The results of CBA can be used to select the most efficient intervention to achieve a determined objective in a specific sector and can also be used to assign resources between various sectors of the economy.

In CBA, benefits and costs are typically calculated in monetary terms and are adjusted for the time value of money. The Net Present Value (NPV) is used to express all flows of benefits and costs over time on a common basis that can take into consideration the time when they are incurred. Other main indicators for measuring the economic feasibility in CBA are the Internal Rate of Return (IRR), the Benefit-Cost Ratio (BCR) and the Payback Period (PBP). The IRR is the rate of return that sets the net present value of all cash flows from the investment equal to zero, i.e., it is the discount rate at which the net present value of the future cash flows is equal to the initial investment. BCR is the ratio of the discounted benefits of an investment, expressed in monetary terms, relative to its discounted costs, also expressed in monetary terms. Payback period is the period of time required to recoup the funds expended in an investment, or to reach the break-even point (Farris et al., 2010).

2.2. Economic evaluations

Numerous guidelines on economic evaluation have been developed since the late 1960s. Hutton and Rehfuess (2006) stated that this was produced as a consequence of CBA becoming a routine part of development project appraisal by the World Bank and bilateral government donors with the publication of two major reference guidelines for the economic appraisal of development projects (Little and Mirrlees, 1968; United Nations Industrial Development Organization, 1972). Since 1970s numerous economic evaluations and guidelines have become available which further develop and clarify the basic economic evaluation framework (Little & Mirrlees, 1968; Dasgupta, 1970; Layard, 1972; United Nations Industrial Development Organization, 1972; Little & Mirrlees, 1974; Mishan, 1975; Sugden & Williams, 1978; Pearce & Nash, 1981; Asian Development Bank, 1997; MacArthur, 1997).

Guidelines on economic evaluation have also been produced in the last decades for different specific sectors such as the environment (Hanley & Spash, 1993; Field, 1997; Organisation for Economic Cooperation and Development, 1995; Postle, 1997), health (Levin, 1983; Philips et al., 1993; Rovira, 1994; Gold et al., 1996; McGuire et al., 1989; Johannesson, 1996; Drummond et al., 1997; Preker et al., 1997; Drummond & McGuire, 2001; Tan-Torres Edejer et al., 2003), agriculture (Gittinger, 1984; García de Jalón et al., 2017) and water resources management (Asian Development Bank, 1999)., Hutton and Rehfuess (2006). Within the field of health care, a number of costing guidelines which detail specific applications of costing have been produced (WHO, 1979; WHO, 1988; Creese & Parker, 1994; Pepperall et al., 1994; Baladi, 1996; Luce et al., 1996; Sawert, 1996; WHO, 1998; Kumaranayake et al., 2000; Johns et al., 2002; Hutton & Baltussen, 2005).

There are several reviews on investment of public health interventions (e.g., Masters et al., 2017; Khoshbakht et al., 2017). Masters et al. (2017) found that local and national public health interventions were mostly highly cost saving. They also stated that cuts to public health budgets in high income countries could represent a false economy (an action or investment that seems to save money at the beginning but which, over a longer period of time, results in more money being spent than being saved) and could generate billions of pounds of additional costs to health services and the wider economy. Khoshbakht et al. (2017) undertook a literature review of cost-benefit prediction methods combined with a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis, particularly emphasising data collection and analytical approach. Their findings showed that the methods used in green building cost-benefit studies could be grouped into different categories in terms of data collection and analytical approach. The literature review revealed that much of the current cost-benefit research lacked validity and reliability and had different degrees of bias. Markandya and Chiabai (2009) reviewed a number of studies about the costs of planned adaptation in the health context and performed a critical investigation of the methodologies used and aims at identifying research weaknesses and gaps. van Baal et al. (2018) used a CEA to assess the optimal allocation of the health care budget in the presence of a health care input constraint in Zambia. The study showed that applying default decision rules in the presence of a health care input constraint led to suboptimal decisions. The study illustrated examples of how such adjustments could be made and made clear that optimal decisions depended on such adjustments.

There are numerous studies that used the CBA technique to evaluate the profitability of a particular intervention from a societal perspective. Recently numerous studies that have been published in scientific journals used CBA to assess the profitability of policy interventions in different economic sectors. Zhang and Chen (2016) used a modified cost-benefit analysis based on emergy accounting in urban biogas projects (emergy is a measure of quality differences between different forms of energy). Thus, supporting environment which was typically neglected by conventional cost-benefit analysis was incorporated into the accounting boundary from emergy perspective. Their results showed that the payback period was 4.26 years due to the potential environment benefits. Proag and Proag (2014) assessed the profitability from a societal perspective by using a CBA and concluded that as benefits and costs are frequently difficult to estimate with certainty, some measure of uncertainty or sensitivity has to be discussed when comparing the resilience project options.

In the literature, there are several studies focusing on the economic valuations of urban green areas (Harnik and Welle, 2009; del Saz Salazar and García Menéndez, 2007). Harnik and Welle (2009) set forth a methodology for valuing the benefits of urban parks. They stated that not every aspect of a park system could be quantified and pointed out that, for instance, the mental health value of a walk in the woods is not known, and there is no agreed-upon methodology for valuing the carbon sequestration value of a city park. However, they found seven major factors that could be quantified and valued in parks: property value, tourism, direct use, health, community cohesion, clean water, and clean air. del Saz Salazar and García Menéndez (2007) estimated the non-market benefits derived from the provision of a new urban park where there was an old train station. Through a contingent valuation method, they found that the mean willingness to pay (WTP) was considerably higher for people who live closer to the planned park as it was more accessible to them. Neun and Haubold (2016) showed the economic benefits of cycling in the EU. They quantified the positive effects of cycling on society, the environment and the economy, and elaborated a systematic classification of these effects in line with the European Active Mobility Agenda. The report shows that the benefits of cycling occur not only in specific, isolated fields like transport or environmental policy, but in many other areas where the EU has competences as well, like industrial policy, employment, health and social policy. Summing up the calculated and estimated benefits of cycling in all sectors, the authors arrived at the aggregate figure of the total value of 513.19 billion euros.

2.3. Benefits of green areas

This literature review on the benefits of urban green areas is based on the work done in Chiabai et al. (2018) within the framework of the Inherit project.

Urban green spaces provide multiple benefits to local communities and wider society. Within urban areas, greenspaces may vary significantly in quality, size and morphology and may have a multi-functional role within an urban area. The health benefits derived from ecosystems are delivered as a consequence of the biodiversity, ecological composition and processes within the greenspace (Cardinale et al., 2012). Harnessing ecological processes and working with natural systems more broadly, can provide a variety of additional co-benefits to both ecosystems and improving public health by enhancing the natural capital rather than depleting it.

It is expected that by 2050, 70% of the global population will reside in towns and cities. In urban settings, greenspaces deliver several key services to adapt to these health impacts. These include regulation in microclimates though modifying local temperature regimes and reducing urban heat island effects, acting as a buffer to reduce air and acoustic pollution, regulating water flow to alleviate flood risk and improving water quality, and promoting opportunities for improved wellbeing.

In terms of the available evidence of beneficial effects of urban green spaces on health, WHO (2016) highlighted multiple benefits such as improved mental health, reduced cardiovascular morbidity and mortality, obesity and risk of type 2 diabetes, and improved pregnancy outcomes. Mechanisms leading to these health benefits include psychological relaxation and stress alleviation, increased physical activity, reduced exposure to air pollutants, noise and excess heat.

Urban greenspaces have been shown to have lower extreme air temperatures by approximately than the surrounding countryside (Bowler et al., 2010). Furthermore, unlike impermeable surfaces such as roads and buildings, leaf surfaces reflect solar radiation back into the atmosphere thereby maintaining a lower temperature (Grant et al., 2003). However, these cooling effects are subject to variation owing to the different sizes, shapes and species composition of the greenspaces. Urban pollution is a well-known cause of health problems that takes special part in urban ecosystems (Gordian et al., 1996; Pope III et al., 2002). Green areas can help to capture some of the particles that cause health problems, even if it is also suspected that particulate retention may be just temporal. By retaining particulates and gases urban trees mitigate the impacts of air pollution, improve air quality and reduce respiratory related infections/disease (Lovasi et al., 2008). Furthermore, in urban settings, trees have beneficial impacts on the aesthetics of local environments. Urban greenspaces have significant potential to alleviate the risks posed to urban centres. Absorption of rainfall by soil and canopies can play a role in diminishing the hazard of floods (Claessens et al., 2014; Graceson et al., 2013; Warhurst et al., 2014).

Public open green spaces may encourage various forms of interaction among humans, promoting community cohesion, sense of identity, education and learning. Active lifestyle promotion (Almanza et al., 2012; De Jong et al., 2012; Fan et al., 2011; Gidlow et al., 2016; Giles-Corti et al., 2005; Mytton et al., 2012) and the development of social networks (Dadvand et al., 2016; Eriksson and Emmelin, 2013; Fan et al., 2011; Maas et al., 2009a) may play an important role as underlying factors in capturing such benefits from green spaces. The relation between health inequalities and the green environment has been also observed, notably by Mitchell and Popham (2008). They found a negative relationship between green spaces and health inequalities, which means that people living in (more) deprived areas may benefit in greater degree from health benefits of nearby green areas, which would narrow the gap in health issues among income groups. Germann-Chiari and Seeland (2004) found that urban green spaces are not optimally distributed in terms of social cohesion in the case of Swiss cities.

Greenspaces play also a key role in tourism and recreational activities. The conjunction between social tourism and ecotourism might bring important health and wellbeing benefits, especially among vulnerable groups (McCabe et al., 2010). Promotion and development of new forms of tourism would have an impact on a region’s economy. Evaluation of the economic impacts from green areas go further than the financial benefits of activities related to them but must take into account all benefits provided. Recreational activities performed in a park, for example, do not necessarily imply market transactions, but have an impact on wellbeing. Methodologies that evaluate these impacts have been developed and discussed in the economic literature and include approaches that value environmental goods through alternative markets known as revealed preferences (such as the costs of visiting a place or the costs of restoring it after its loss) or stated preferences (such as the willingness to pay of individuals to maintain the good or the willingness to accept a compensation for the loss of the good).

2.4. Benefits of healthy diets

Here we present an analysis of literature assessing the impacts on health of several different interventions and programs that enhance healthier diets for children. This review of the literature has been carried out with the intention of evaluating the impact on health in quantitative terms of some of the interventions that have been carried out in the framework of the case study of sustainable food in nursery schools. The interventions considered are diverse but can be included in one of the following categories: (i) oriented to increase the consumption of fruits and/or vegetables, including organic food, (ii) referred to reduction of consumption of sweets, edulcorated beverages or other high-caloric products, (iii) related to educational programs on nutrition. Therefore, the purpose of this literature review is providing the figures on health impacts for the case study intervention, based on quantitative results already provided by interventions of similar nature.

Studies analysed in the context of the literature review offer heterogeneous methodologies and results. First, they differ in the dietary aspects analysed. Studies like Maluccio et al (2009); Qian et al (2016); Fung et al (2011); Veugelers and Fitzgerald (2005); Foster et al (2008); Rosário et al (2012); and Kafatos et al (2005) analyse different types of interventions and programs. Maluccio et al (2009) analysed the effects of an intervention based on the provision of a dietary supplement. After preforming an analysis of the effects of the intervention over educational outcomes. Significant positive impacts were found after performing a two-stage least squares- based econometric regression. The second of these studies (Qian et al, 2016) targeted the impacts of a nutrition assistance program offering funding for the purchase of fresh fruits and vegetables. They found positive and significant impacts of the intervention over obesity. Fung et al (2011) look for the impacts of the

Alberta Project Promoting Active Living and healthy Eating (APPLE) program over different aspects of health and nutrition. They observed lower obesity levels in schools implementing the program. Veulgers and Fitzgerald (2005) analysed the results of an intervention following school-based food consumption recommendations designed by previous programs, to find those interventions effective from the point of view of the reduction of childhood obesity as well as comorbid conditions. The study by Foster et al (2008) also addressed a school intervention program with the reduction of obesity and overweight at focus. Authors found a reduction in incidence for overweight after the intervention. Nevertheless, results for obesity's prevalence were not found to be significant, and neither was the remission of obesity and overweight. Rosário et al (2012) analysed the impacts of a different program at early ages. The intervention was designed to prevent overweight and obesity through nutrition training. Authors found significant and positive effects arising from the intervention. The last of the studies based on interventions (Kafatos et al, 2005) searched on the long-term effects of an intervention in primary schools over Body Mass Index (BMI), to find lower average BMI after the intervention. Findings on prevalence of obesity were found, though, non-significant.

Food security has also been tackled by various of the studies included in this review process, such as Gundersen and Kreider (2009) and Cook et al (2004). Cook's team assessed fair versus poor health in infants and toddlers; lifetime hospitalisations; their admissions on ED visit; and those at risk for growth problems, to find that fair-to-poor health was almost as twice as common among food insecure children as those in food secure environments. Odds of hospitalisation also grew significantly. Gundersen and Kreider meanwhile, looked at general health and obesity levels to analyse the negative impact of food insecurity over those two aspects.

Fruits and vegetables consumption were also a relevant issue for the search performed. Studies that took this matter into consideration for their analysis were Pate et al (1996); Maynard et al (2003); Vatanparast et al (2018); Farvid et al (2016); Okoko et al (2007); You and Choo (2016); Pierce et al (2007); Joshipura et al. (2001) and McNaughton et al (2008). The first of this list (Pate et al, 1996) had the aim of determining the links among different healthy behaviours in adolescents in the United States. High correlation between fruit consumption and physical activity was found. The second of this list, the study performed by Maynard et al (2003), searched for cancer incidence and mortality in a long-term analysis to find few significant connections between early consumption of fruits and vegetables and cancer. Vatanparast et al (2018), found a connection between vegetables and fruit consumption and total-body bone mineral content (TBBMC) in ages 8 to 20. Next in the list (Farvid et al, 2016) focused their study on breast cancer. They found total fruit consumption at adolescence to be linked to lower risks of breast cancer. Okoko et al (2016), searched for the interconnections between wheezing and asthma and fruit consumption in infants. Authors found improvements in respiratory health not always to be significantly related to fruit consumption. You and Choo (2016) study the interconnections among socioeconomic status, fruit and vegetable consumption, and overweight and obesity. Lower levels of BMI were found for higher levels of fruit and vegetable consumption. Pierce et al (2007) found associations between reduced breast cancer mortality and increased consumption of fruits and vegetables for groups consuming the highest amounts of these items. The analysis by Joshipura et al (2001) inquired over the potential effects of fruit and vegetable consumption over coronary heart disease risk. Authors found relevant improvements by comparing highest and lowest consumption quintiles. McNaughton et al (2008) focused on several dietary patterns including fruit and vegetable consumption patterns, as well as a high fat and sugar pattern. They found interconnections of different sign between those patterns and BMI, systolic and diastolic blood pressure.

Further aspects, such as breakfast consumption and breakfast skipping, have also been studied. Kleinman et al (2002) found 19% of the sample improving their nutrient intake. These children decreased in symptoms of hunger on the Child Hunger Index. In the study by Sampson et al (1995), breakfast skipping patterns were found not to be significantly related to the prevalence of obesity. Consumption of organic products (Kummeling et al., 2008) and Italian Mediterranean organic diet (De Lorenzo et al., 2010). The Study by Kummeling et al (2008) searched for patterns between the consumption of organic foods and atopic disease to find organic dairy products to be associated with lower risk of developing eczema. Nevertheless, they found no association for organic meat, fruit, vegetables or eggs. The study of De Lorenzo et al (2010), in contrast, found significant evidence of a reduction in fat mass as a result of Italian Mediterranean organic diet.

From the aspect of the health perspective, overweight and related issues –such as obesity and BMI– dominate. Nevertheless, other aspects related to health and general wellbeing have been analysed, such as asthma and respiratory health, cardiovascular health or educational achievement. For the cost-benefit analysis, all the reported benefits were considered into 4 categories: (i) general health, (ii) cardiovascular, (iii) obesity and (iv) others.

3. Cost-Benefit Analysis for the INHERIT case studies

We discuss first the key aspects related to the application of the economic Cost-Benefit Analysis (CBA) common to the four INHERIT case studies. Then this section describes the choice of the discount rate and time horizon, the methodological steps and the Inherit case studies.

3.1. Economic Cost-Benefit Analysis (CBA)

The economic Cost Benefit Analysis (CBA) aims to evaluate costs and benefits of projects from the point of view of the society as a whole. It takes into account the perspectives of all social actors or stakeholders affected by the implementation of the project itself. Ideally, it considers all tangible and intangible impacts in terms of costs and benefits and convert these into monetary values, using a variety of methodological approaches, depending on the type of impact. It includes environmental and social costs and benefits that can be reasonably quantified, using methodologies for the non-market valuation. In practice, it is hard to value all intangible impacts, so that only those for which reasonable non-market values are available are usually considered.

The economic appraisal differs from a financial appraisal which estimates costs and benefits from the perspective of private entities without consideration of externalities (e.g. health impacts, environment), measuring the return to investments in terms of cash flows. In the CBA, in contrast, costs and benefits refer to social welfare losses and gains. Although CBA can provide an informed estimate of the most profitable option from a social perspective, a perfect appraisal of all present and future items of costs and benefits is extremely complex. Best practices usually involve identifying main groups affected by the project under evaluation and including a sensitivity analysis of key parameters. CBA

The economic appraisal builds upon the financial appraisal (marketed good and services) and includes benefits and costs for those non-marketed goods and services affected by the implementation of the practice or intervention. Thus, these non-marketed goods and services are valued into monetary terms and included in the CBA as costs or benefits. Hence, the NPV for the economic appraisal (NPV_E) is denoted as

$$NPV_E = \sum_{t=0}^{T} \left(\frac{(B_t - C_t)}{(1+r)^t} \right) + \sum_{t=0}^{T} \left(\frac{BE_t - CE_t}{(1+j)^t} \right) \qquad \text{Eq. 3.1.}$$

where BE_t represents the value of the non-marketed benefits in monetary terms and CE_t the values of the non-marketed costs in monetary terms.

In order to account for future generations and their interests (Campbell and Brown, 2003), the discount rate for societal costs and benefits j is adjusted from the private market rate. In contrast to the discount rate for private investments, the UK Green Book suggested a social time preference rate of 3.5% for projects with environmental purposes (HM Treasury, 2003).

3.2. The choice of the discount rate

There is no consensus about the choice of the discount rate. However, the actual value of the discount rate has a potential large impact on the results. In the literature, values of the discount rate can vary between 0% and 10%, and arguments can be found to support this wide range (Hutton and Rehfuess, 2006). A competitive market interest rate reflected the average preference for future over present consumption. However, this could be strongly influenced by the level of economic development of a society. Moreover, the gross market interest rate does not reflect the return on investment to private investors. In addition to this, private investment decisions do not always reflect the interests of future generations and consequently, a lower discount rate would give future generations greater weight in the analysis (on both sides, costs and benefits). Hutton and Rehfuess (2006) recommended the use of a discount rate of 3% for consistency with previous guidelines in the literature.

3.3. Time horizons

The selected time horizon in a CBA can determine the profitability of a given intervention. Tan-Torres Edejer et al. (2003) raised two questions regarding the time horizon: what is the time period of the intervention? and what is the time period for following up the benefits of the intervention?

In regard to the first question (time period of the intervention) the WHO recommend generalised economic evaluations such as CBA or CEA to evaluate interventions implemented over a period of 10 years but taking into account impacts or benefits over a life-course horizon of 100 years (Hutton and Rehfuess, 2006). However, the WHO also recognised that the time horizon can be tailored to fit the intervention in question.

In regard to the second question (time period for following up the benefits) it is important to take into account that CBA often evaluates investment projects, where intervention costs are front-loaded and benefits tend to be delayed and spread over a longer period. In the literature most cost-benefit analyses in this work measured intervention effects for a maximum of 15–20 years since extending the time horizon of the analysis to the long-term, can lead to costs and impacts becoming increasingly uncertain (Hutton and Rehfuess, 2006).

3.4. Methodological steps

One key aspect of the CBA proposed for the INHERIT case studies is the involvement of the key local agents responsible for the implementation of the case study in the evaluation process. Local agents were involved in all key methodological steps:

- Identification of status quo and policy change.: the implementation of each case study was compared against the current status quo scenario identified as the non-implementation scenario, as it is explained below.
- Identification of affected and vulnerable groups, and related categories of impacts (costs and benefits).
- Data on implementation costs, which have been identified and collected together with the local agents.
- Time horizon for the evaluation of the intervention impacts.
- Quantitative evaluation of key items in the CBA, as well as inputs in the construction of the citizens' surveys and stakeholders' workshops.
- Consideration of qualitative aspects in the interpretation of results (e.g. social justice, participatory processes),

Ad hoc stakeholders' participation processes and citizens' surveys have been put in place to gather specific information needed for the evaluation of quantitative aspects, such as categories of benefits and risks, current and use, perceptions on impacts, attitudes, socio-economic factors, which are discussed in detail in each INHERIT CBA.

Nine methodological steps were identified to perform the CBA of those practices that were economically evaluated. These steps are common to the four CBA case studies analysed within INHERIT.

1. Set the policy change for the analysis. This is the first step and aims to specify the current status quo and the policy change we aim to value in each INHERIT CBA. The implementation of each case study was compared against the current status quo scenario identified as the non-implementation scenario. The status quo scenario versus the implementation scenario is specific to each CBA case study and discussed. This step has been discussed and decided with the local agents responsible for the pilot implementation.
2. Decide whose costs benefits should be included. In this step, both affected groups (and vulnerable groups) as well as the geographic scale of the analysis was determined. Each local agent identified the area of influence by the case study. Affected groups were identified through stakeholders' workshops specifically run in each case study, which were co-organised with the local agents.
3. Identify and categorise costs and benefits. This has been done in agreement with the local agents responsible for the case study implementation, and with specific ad-hoc stakeholders' workshops.
4. Quantify costs and benefits over the analysed time horizon. This process implied assessing how costs and benefits changed throughout the years. In collaboration with the local agents, we quantified the costs and benefits affected by the implementation of the practice. Specific indicators for the "physical change" (e.g. number of users and potential increase in the future, number of houses affected in the surroundings of a park, decreased car traffic, etc) have been selected and assessed in relation to each category of costs and benefits. The support from local agents was essential also in these steps specifically in relation to factors related to current and future use and assessment of behaviours.
5. Monetise costs and benefits. This step has been carried out specifically by the economic team Basque Centre for Climate Change BC3, University of Exeter and University of Alcalá.
6. Discount costs and benefits to obtain present values. This step means converting future costs and benefits into present value according to specific time horizon decided in agreement with the local agents.
7. Compute net present values. This is done by subtracting costs from benefits (see Eq. 3.1). The practice was considered efficient if a positive result was produced; however, it is important to think about the practice's feasibility and social justice, which is discussed in the interpretation of the results taking into account as well the views of the local agents.
8. Perform sensitivity analysis. This step allows assessing the accuracy of the CBA estimates and assumptions. This is normally done by varying the utilised social discount rate and varying assumptions on key parameters.
9. Make a recommendation according to the CBA results and taking into account other qualitative considerations discussed with the local agents.

3.5. INHERIT CBAs

Four INHERIT four case studies were selected for a CBA. The selection process of the case studies can be found in Milestone 5.4.

1. Thinking Fadura in Getxo, Basque Country, Spain
2. Malvik path in Trøndelag county, Norway
3. Sustainable food in public schools in Madrid, Spain
4. Retrospective Analysis on Energy Efficiency Investments, United Kingdom

The case studies are covered in the following four chapters.

4. Thinking Fadura

4.1. Background

Thinking Fadura aims to design a new public space where sporting facilities are linked and coexist with a natural park and a river to promote healthier lifestyles, so that physical activity is promoted along with access to the natural park in the same area through a combination of nature-based solutions with sporting facilities. A description of Thinking Fadura can be found in Anthun et al. (2019).

Such initiative is the result of a community reflection based on participatory design methodology carried out in 2017 (Ayuntamiento de Getxo, 2018; 2019), where participants proposed to open the green areas of Fadura´s Municipal Sports Centre (FMSC) to the general public. In the past, only people who were registered in the Sports Centre and payed the annual fee had access to the area. FMSC´s facilities occupy around 20 hectares along the Gobela River. It has many green spaces and numerous sports facilities such as indoor and outdoor swimming pools, gym, soccer fields, rugby, basketball, tennis and paddle tennis, among others.

The opening of the park is conceived as an urban and landscaping project for the Bolue wetland area and the river bank of the Gobela river as it passes through the sporting facilities of FMSC. The new public park will have 8.2 hectares of green land surrounded by both public and private sports facilities. Users willing to access private facilities will have the opportunity to do so by buying a one-day ticket.

The main objective of the case study is to increase the accessibility and usage of green spaces, as a way to promote physical activity, to facilitate social cohesion, and to bring citizens closer to the natural environment. The implementation of the case study will allow the general public to get access and enjoy the green areas surrounding FMSC, but also will serve to cross and connect the city, like a green belt. Nowadays only a third of the green areas are actually opened to the public, but it is expected that in 3 years approximately it will be entirely opened. In terms of public works opening the Fadura park implies the following which will be carried out through the next 3 years, as also indicated in figure 4.1:

- 1st Planting trees along the Gobela River
- 2nd Creating tracks and paths that will cross the park and connect it with existing walking paths and biking tracks
- 3rd Promoting public access to certain multipurpose sports facilities
- 4th Creating leisure facilities as a way to promote social interaction and cohesion

Figure 4.1. Main features of Fadura´s Municipal Sports Center (FMSC)

The Thinking Fadura CBA evaluates the benefits of implementing the pilot against all costs from a societal perspective. The baseline scenario is the situation before the fence was removed and the green areas were still not rehabilitated for recreation purposes. For this reason, the baseline scenario assumed that there were not recreation visits.

4.2. Methodological framework

A multi-approach framework to assess costs and benefits of the interventions related to Thinking Fadura has been followed combining different theoretical approaches, methods and tools (Figure 4.2):

1. Conceptual framework based on eDPSEEA model (Reis et al, 2015) to analyse the relationship between green areas, ecosystem services and human health, and to support the operationalisation of the assessment (qualitative and quantitative) and the modelling exercise in the different steps. This serves as a framework of reference for the assessment of co-benefits from green spaces in general. Conceptual frameworks have previously been applied in contexts such as the impact of changes in the water environment on health, as in Gentry-Shields and Bartram (2014), who took the Driving force-Pressure-State-Exposure-Effect-Action (DPSEEA) as the starting point in creating their framework. DPSEEA was developed by the WHO as a framework to develop environment health indicators (Kjellström and Corvalán, 1995). The modified DPSEEA extended this framework to explicitly consider the impact that context has on the environment-health relationship (Morris et al., 2006). A more recent model, the ecosystems-enriched DPSEEA considers the impacts that changes in ecosystems and associated ecosystem services can have on health (Reis et al, 2015). In our analysis, we are proposing this framework beyond its current use in the literature to support the qualitative and quantitative assessment of benefits of the practice and to identify main gaps in the literature.
2. Modelling of health benefits from green spaces using econometric approaches (Heckman model, Heckman, 1974) to assess how heath is affected from exposure in a context of study

heterogeneity as analysed in the literature. Application of the model for benefit transfer to the local context of Thinking Fadura.

3. Stakeholders' workshop to make a preliminary identification and evaluation of impacts related to the case study of Thinking Fadura, and qualitative assessment of stakeholders' perspectives on the impacts of the new park (perceived costs and benefits.
4. Citizens' survey to assess frequency of use and potential increase in use of the park, travel costs, and analyse perceptions about benefits and costs, with two questionnaire-based surveys for the case study of Thinking Fadura, for users and for general residents in the area (citizens' perspective).
5. iSOPARC tool to assess physical activity in-situ (see Bell at al., 2019).
6. Cost-benefit analysis (CBA) to compare monetary costs and benefits under different scenarios of use, time horizon, discount rate and CBA-parameters variation.

Approaches 1 to 5 are described next, stating the case study objectives, findings and how each approach has contributed to the development of the CBA, included in section 4.3.

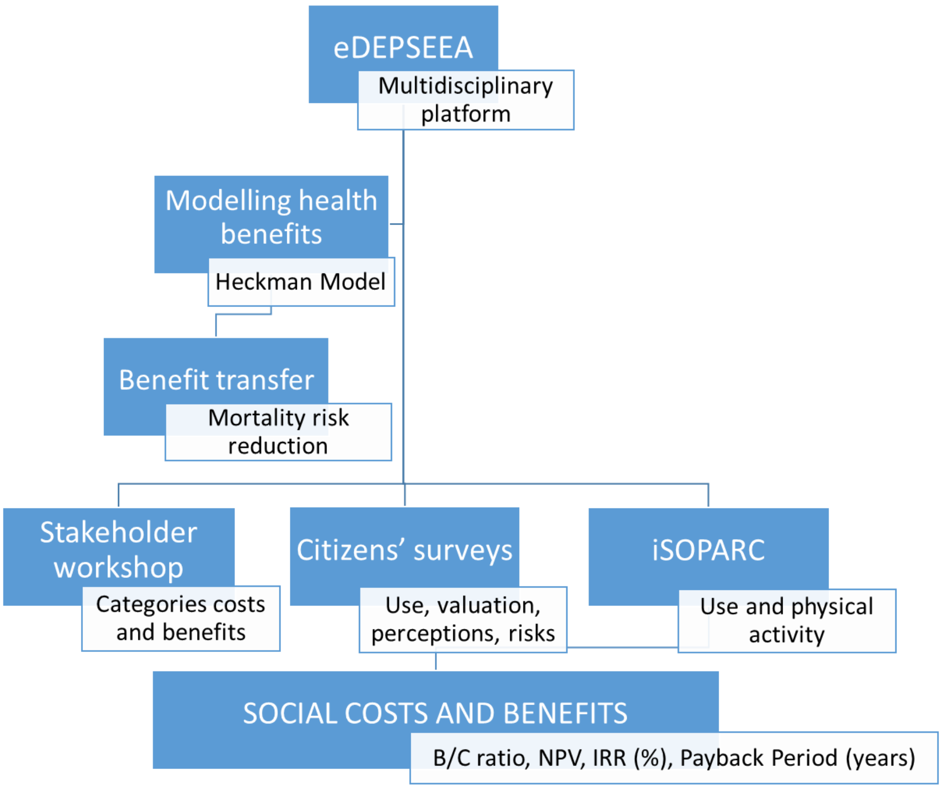

Figure 4.2. Multi-approach framework to assess costs and benefits for the Thinking Fadura case study

4.2.1. The eDPSEEA model as a multidisciplinary platform

The first step was to build a conceptual model to analyse the complex cause-effect relationships among green areas and their impacts on human health and the ecosystem functioning. The objective is to synthesise the nexus among different types of studies in the existing literature in this area, and the main factors of influence in these relationships.

We developed a model drawn from the "ecosystems enriched" Driver, Pressure, State, Exposure, Effect, Action (eDPSEEA) model (Reis et al., 2015), which considers potential co-benefits of green areas in terms of improved ecosystem services and human health through population exposure and contextual factors (Figure 4.3). Climate change is a key driver in this context, where green spaces can also act as important adaptation options to reduce impacts on the environment and increase population resilience. For this purpose, the proposed model includes specifically climate change in the chain of cause-effects relationship. The conceptual model has been developed in Chiabai et al (2018) within the INHERIT project and serves as a basis to operationalise the assessment of the benefits of green areas, both from a quantitative (CBA) and qualitative perspective (citizens' survey). It has helped in identifying which associations have been more addressed in the literature and where research gaps still exist for the assessment. It is also a good framework to facilitate communication among different expertise and analyse key indicators for each component of the system. We summarise hereby the key points of the study published by Chiabai et al (2018).

As a basis for the model development, a literature review has been first carried out taking into account two perspectives: the ecosystem and the health perspectives. The first analyses the numerous ecosystem services provided by green spaces and parks (reduction of urban heat island effect, reduction of noise and air pollution, water regulation, climate regulation, recreation, etc.), and an extract of this literature is provided in Section 2.2. The second focuses on studies addressing specifically the benefits of green spaces on human health. An extract of the reviewed 117 studies with quantifiable results are presented in Table 1 in Annex 1, and the corresponding literature review in Annex 2. Findings from this literature have supported the identification of the main elements of the conceptual model, and in a second step, they have been used as a basis to assess the co-benefits of the pilot Thinking Fadura, and to gather relevant data and information.

We synthesise hereby the main relationships among the different elements of the eDPSEEA model in Figure 4.3, and the main lessons which have been drawn from this analysis.

The "driver" in our model is climate change and includes carbon emissions and concentrations which put a "pressure" on green spaces in terms of increased temperature and precipitation patterns, heat and air pollution as well as extreme weather events. The pressure will lead to a potential change in the amount/size or quality of that space (the "state"), producing alterations in terms of ecosystem functioning as well as the flow of ecosystem services they provide in the short and long run. The state has been characterised in our framework by six types of ecosystem services which will affect the use or perception of the site through "exposure": UHI effect, air pollution, water regulation, social environment, recreation and tourism, and microbiome.

Depending on a range of contextual factors, which may include socio-economic characteristics of the impacted group (e.g. incomes, ages, equity), health status (e.g. obesity), culture, attitudes and beliefs, and environmental factors (e.g. baseline climate, availability of alternative sites), changes in ecosystem services may impact on health either directly or indirectly, positively or negatively (the "effect").

"Actions" refer here to any intervention affecting green spaces and population exposure, which can impact ultimately on human health. These interventions could increase the existing pressure on green spaces if they are not appropriately designed (what we call "mal-adaptation") or, on the contrary, they could reduce pressure through an improved state of the ecosystem and associated ecosystem services (EbA) (UNEP, 2014). Creation of green areas are regarded as a "soft" measures, they can provide many co-benefits and may also help to avoid some of the negative impacts of hard-adaptation measures.

The evidence of the literature is not uniformly distributed across the model: the literature review based on an ecosystem services perspective showed a well-documented association. While for the literature based on the health perspective, relative to the impacts of exposure to green areas on health, evidence is mixed and not always clear. The diversity of methodologies employed to assess health benefits from a quantitative point of view, as well as the metrics used for exposure and health outcomes, make it difficult to compare studies and implies an added difficulty in obtaining results that are adequate to be generalised through a quantitative meta-analysis.

In this context, making a comprehensive review of the existing literature is a complicated task, mainly because of the study heterogeneity, which occurs at different stages of the research, such as the variable measurement (e.g. health effect, exposure), the population selection, the inclusion of contextual factors, and the analytical tools employed. Issues of comparability among studies and the use of different unit of measurement for health and green space complicate the identification of the underlying dose-response relationships. This leads to uncertainty as to the "true" relationship between green spaces and health. While there is a seemingly positive relation explored along the literature, the presence of non-significant and negative correlations has led some authors into questioning the validity of any generalisation (Lee and Maheswaran, 2010). Providing some uniformity in order to allow for benefit transfer in this area is one of the identified research gaps. This is addressed in the next section 4.2.2, which explores a new approach to deal with the exiting study heterogeneity in order to contribute to more generalizable conclusions and support benefit-transfer exercises.

Other two important arguments in the eDPSEEA model include the type of exposure and the role of contextual factors, both playing a key role in the effects on health.

As regards the first aspect, several of the positive (and negative) health impacts of green areas over human health are associated to either active, consumptive or passive forms of engagement or exposure. Active exposure requires involvement of the subject. This type of connection can include actions such as taking a stroll in a park (Roe and Aspinall, 2011; Takano et al., 2002), social interactions in green public open space (Eriksson and Emmelin, 2013; Fan et al., 2011; Fleming et al., 2016; Maas et al., 2009a; Wood et al., 2010) or exercising in green areas such as an urban forest (Hansmann et al., 2007; Kerr et al., 2006; Scully et al., 1998). A substantial part of the literature focuses on such interactions.

We classify as consumptive means of exposure those interactions with nature that involve consuming some of its products or services. Though ecosystem services provide health benefits through consumptive exposure (e.g. the provision of medicines and the regulation of products such as clean water that are consumed by individuals allowing them for healthier lifestyles), these services are not common in small green areas. A case for increased health through consumptive exposure to green areas is green tourism.

The mere presence of green areas may also have an impact over health, whether or not individuals actively interact with them, which we classified as passive exposure. Green areas can provide health benefits through the reduction of air pollution (Sæbø et al., 2012); by regulating climate, particularly reducing the UHI effect (Bowler et al., 2010); or by creating a suitable environment for the developing of healthier microbiotic conditions (Hanski et al., 2012; Rook, 2013; Rook et al., 2013).

Regarding the role of contextual factors, these appear throughout the literature and have an important role modulating the interrelationships between the ecosystem and health. Contextual variables can affect the relation addressed in various ways according to how subjects are exposed to them. Population density, ageing, health status are some examples. There is a direct relation between population density and pollution that could imply higher benefits in health. This would be due to the increased marginal impact of green spaces in a more polluted environment. On the contrary, congestion of parks and green spaces could deter people from using parks or reduce the restorative effects of park visitation. Age has been another factor considered. Ageing populations could benefit from clean air and open space to walk and engage in social activities. Takano et al (2002) deal with diverse demographic aspects by focusing the research on elderly populations in a densely populated environment and by offering gender-specific results. Socioeconomic questions such as income (Mitchell and Popham, 2008) or joblessness (Roe et al., 2013; Ward Thompson et al., 2014, 2012) have also been considered in the literature. Social aspects may also influence attitudes towards green spaces influencing the relation, such as time spent in open space or use of such areas to perform physical activity (Wendel et al., 2011). Active lifestyles can be considered a product of cultural ecosystem services, as it has been theorised that aesthetically appealing environments may enhance the performance of different activities (Richardson et al., 2013). The level of involvement on active lifestyles can also be affected by air quality, as contaminants may dissuade individuals from participation in physical activity. Active lifestyle can by itself generate improvements in a wide range of health aspects but will also reduce the negative impacts related with ageing and obesity, though it can have both positive and negative impacts over the musculoskeletal system.

Social, economic and demographic characteristics not only influence health, but also affect the way in which green space interacts with it. Studies can handle these variables in different ways. Some studies overlook them entirely, whereas others consider them as control variables.

Application of the conceptual model in the next steps

The analysis performed supports, as a first step, the development of an econometric model (the Heckman model) to assess the impacts of green areas on human health, and its application in the specific context of Thinking Fadura as an exemplification of the benefit-transfer for mortality risks (section 4.2.2.).

The literature reviewed to develop the conceptual framework was useful to identify main benefits and contextual factors, and to derive specific indicators for the qualitative and quantitative assessment of the benefits of Thinking Fadura, both in the CBA exercise, as well as in the citizens' survey-based questionnaire development to value attitudes and perceptions of users and general citizens.

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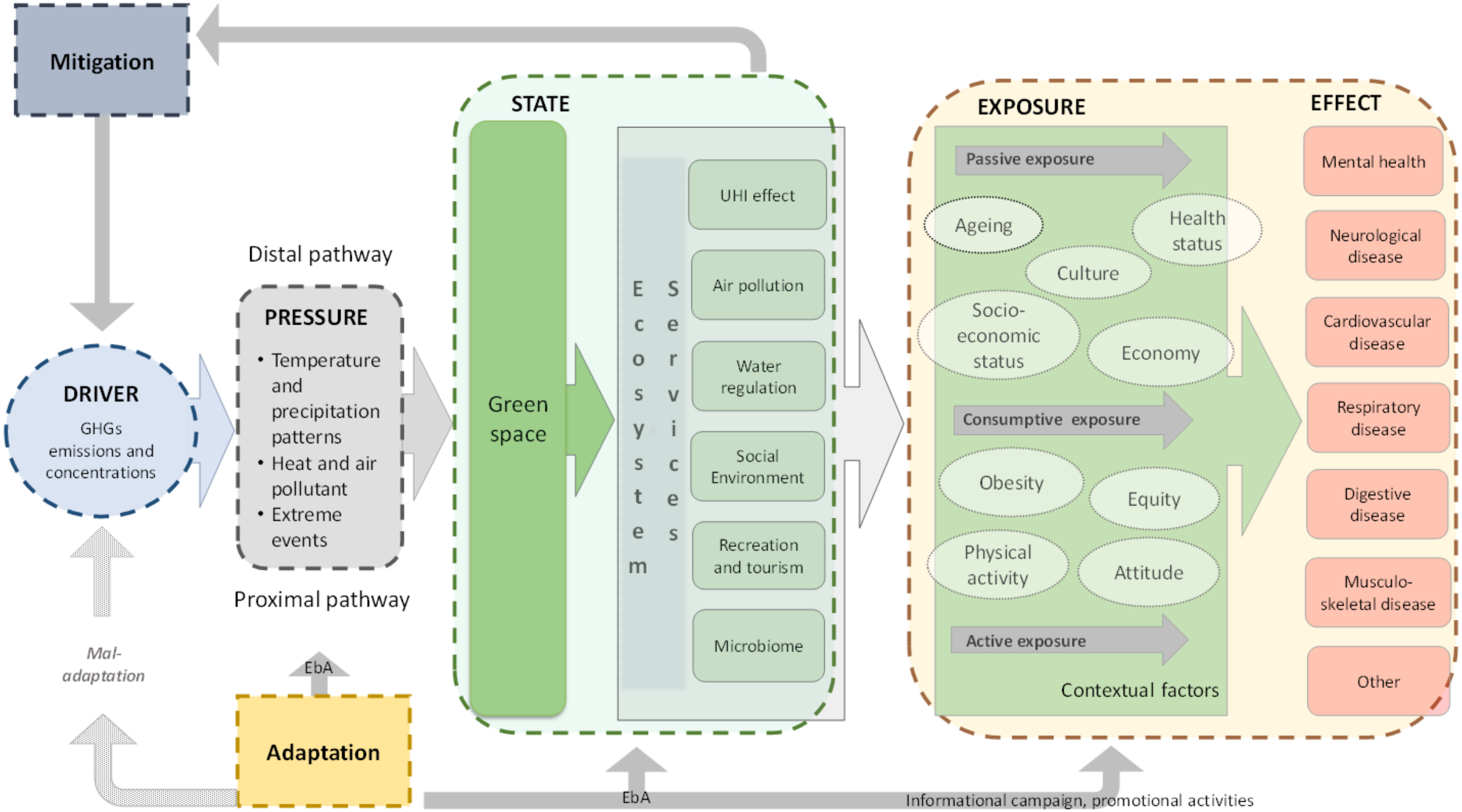


Figure 4.3. A conceptual framework based on eDPSEEA model towards a holistic approach on green spaces, health and ecosystem services.

4.2.2. Modelling health benefits in a context of study heterogeneity

In this section we present a new approach to deal with the existing study heterogeneity in the literature linking green spaces with health impacts, as discussed in the previous section. Heterogeneity occurs in terms of methodological approaches, metrics employed to measure exposure and health outcomes, which complicates the task of comparing studies through a meta-analysis.

As analysed in Chiabai et al (2018), evidence suggests that availability of urban green spaces promotes better health associated with reductions in stress, anxiety and depression, reductions in diabetes and cardiovascular and respiratory disease through an increase in opportunities for physical activity (Hartig et al., 2014, Shanahan et al., 2016).

In this context, we explore the use of the Heckman selection model, as a way of identifying the factors influencing the significance of the relationship throughout existing studies and calculating the marginal effects of selected factors found to be crucial. We created a database including studies with quantitative results on the health benefits (in terms of risk reductions) associated with increased availability of green areas, and all relevant variables believed to influence this relationship were included (extracted from the literature review included in Table 1 of Annex 1). A detailed analysis of the outcomes and approaches was also conducted in order to incorporate the information the dataset which was used afterwards for the econometric analysis.

This work has been submitted to Ecologic Economics and it is currently under revision (together with a data article presenting the database used from a meta-analysis). We attach the data article in Annex 3 which describes the steps taken from the literature review to the construction of a quantitative database summarising the main results extracted and used for the econometric analysis. The article presents as well the table with the studies included in the database in terms of study location, methods, type of health outcomes, health and green exposure indicators, number of observations available in each study as well as those with significant results in the undertaken analysis. The observations are those extracted from each study to build the Heckman model and carry out the statistical analysis. Each observation is recorded in terms of a specific health indicator which measures the change in the health outcome due to increased availability of green areas. For example, in Maas et al (2009), the observations are in terms of changes in annual prevalence rate (health indicator) in different diseases (health outcome), associated to an increase in green spaces availability near the respondents' residence.

Results of the reviewed studies are mixed with significance varying considerably by study and type of health outcome, suggesting that there is no unique and clear evidence of the impact produced by green environment on human health. The first point to highlight is the variety of methods and statistical techniques used in the literature to analyse the relationship health-green environment, depending on the type of data available, the purpose of the analysis and the health outcome analysed. The studies reviewed can be categorised in two main groups, "objective" and "subjective" studies. The first use health indicators computed with objective measures drawn from health registries (mortality rate, prevalence/incidence of specific diseases, hospitalisation rate, life expectancy). The second rely on subjective measures such as opinions and individual perceptions on health status, quantified in survey-based questionnaires with qualitative measures using the Likert scale technique (e.g. "very poor" to "very good"). Both types of measures were used in the econometric analysis based on the recognition that they are equally important in defining the relationship between exposure and individual health status. There is some evidence that self-reported, subjective measures of health may underreport the prevalence of certain conditions, including cardiovascular diseases, and that such measures may mask socioeconomic gradients in disease risk (Mosca, Ní Bhuacalla and Kenny, 2013). Controlling for the impact of the type of health measures used is hence important.

In terms of the definition of exposure to green areas, the studies reviewed generally refer to increased availability of green spaces within a certain distance from people's living environment and use different metrics for this purpose (e.g. spatial land cover data, Normalised Differences Vegetation Index – NDVI). Accessibility, usability and quality of the green space, on the other side, are associated with a number of factors such as promotional activities, provision of footpaths and exercise facilities, appropriate lighting, enhanced aesthetics and mixed land-use, good air quality, while it can be hindered by factors such as low path connectivity, heavy traffic and contamination. There are not many studies in literature with quantitative analysis in regard to the wider quality and accessibility metrics that could be used in our modelling exercise. Greenspace is heterogeneous in nature, and though studies are starting to consider these factors (e.g. Wheeler et al, 2015), they are as yet few in number. As a result, these factors have not been contemplated in our analysis. We consider "increased availability" of green spaces and use it as a proxy of "exposure" as referred in the reviewed literature. Future research might build on the basic model developed in the current analysis to include more complex analysis based on more refined indicators reflecting exposure.

Variables in the model

We first describe the two main variables, the health benefits (dependent variable) and the increased exposure to green areas (as explanatory variable). Given the diversity of indicators used for these two variables, some assumptions for standardisation are needed to carry out the analysis under a common measurement framework. Our first order of business was, therefore, to create standardised indicators for a common measure allowing for comparison among the results.

The health indicator in each study measures the change in the health effects due to an increase in exposure to green areas. In the reviewed studies, the health indicator may refer to objective indexes, such as mortality incidence rate, five years' survival rate, life expectancy, annual prevalence/incidence of diseases, hospital admissions, measured from estimated coefficients in epidemiological functions. Alternatively, it may also refer to subjective indexes, such as the general health perception measured on a Likert scale. All these indexes were transformed into a standardised percent variation rate referring to different health outcomes, which defines our standardised indicator "health risk reduction" (HRR).

As regards the explanatory variable of exposure to green areas, the indicators used in the reviewed studies may refer to the distance of the respondents' home to the nearest park, or percentage of green spaces in the surroundings of respondents' living environment, or normalised difference vegetation index (NDVI) in the living environment which identifies if a target space contains green vegetation or not. In order to create a common standardised indicator for exposure, we constructed a qualitative variable taking three values for exposure: low, medium and high. For each study, we created three intervals based on the cumulative distribution function of the specific indicator of exposure used in the corresponding analysis (size or distance from the homes of participants). In each study, the lowest level of exposure is taken as the baseline, the second tercile is taken as a medium exposure level, while the third tercile group represented a high exposure. The baseline acts as reference and refers to those groups of individuals who are less exposed to green areas.

The full set of variables included in the database is presented in Table 2 and detailed in Annex 3. The rationale behind the selected explanatory variables rest on their use in the two equations of the Heckman model. A first set of explanatory variables are assumed to be affecting the health risk reduction in the outcome equation, and these include increased exposure, mortality, disease cluster, a dummy variable to reflect whether the study used subjective measures or not, age, a dummy variable for gender, income per capita and hospital beds density.

In order to differentiate the health impacts, the following variables were constructed, discriminating among (a) mortality versus morbidity effects (dummy “mortality”), (b) objective versus subjective studies (dummy “subjective”), and (c) type of illness (categorical variable “disease type”). Five dummies were derived from the categorical variable: mental health, cardiovascular diseases, respiratory diseases, other health impacts not included in previous categories (e.g. musculoskeletal, neurological, digestive, diabetes, cancer), and a universal category “general” (all-cause and general health). The latter is used in the literature as a comprehensive classification to refer to the general individual health status.

The variable “subjective” is related to the differentiation between indicators used in “objective” and “subjective” studies respectively, which might affect in a different way the relationship health-exposure. The same applies for the “mortality” and “disease type”. We also include a number of demographic and socio-economic variables as control factors. Some of them were available in the studies reviewed in the database (“female” and “age”), while others were taken from secondary sources, such as “hospital beds density” and “income per capita” at the country level. Hospital beds density (defined as the number of hospital beds per 1,000 people) represents a proxy for the access to the health care system, under the assumptions that higher access to health care services would guarantee better population health status. The variable “income per capita” is assumed to negatively affect the health risk reduction, in line with previous studies in the literature according to which poorer groups are benefitting more from exposure to green areas.

A second set of explanatory variables, some of the them in common with the first set, are capturing the i-Study Effect in the selection equation designating:

- Socio-economic aspects in the country where the study was done, captured by “income per capita”, “urbanization”, “literacy” at the country level, taken from secondary sources. “Urbanization” refers to the percentage of people living in urban areas and reflects a proxy for urban lifestyle. “Literacy” refers to the percentage of people literate aged 15-24 and reflects the effect of knowledge.
- Characteristics of the study, captured by “subjective” (meaning subjective versus objective nature of the study) and “mortality” (meaning that the study focus on mortality versus morbidity outcomes), taken from the reviewed studies.

Some of these variables are in both equations, as they capture both the effect on the health risk reduction as well as the i-Study Effect. This is the case of “income per capita”, “subjective” and “mortality”. Their interpretation in light of the results obtained is discussed in Section 3.

Table 4.1. Description of variables

Variable	Description	Data source	Units
Health risk reduction	% change in the health indicator due to an increase in exposure respect to a baseline defined as low exposure.	Reviewed studies	% change
Exposure to green areas	Availability of green spaces in the surroundings of people's living environment, measured in terms of vicinity and/or % or density of green.	Reviewed studies	Categorical variable (1 for low exposure, 2 for medium exposure and 3 for high exposure)
Mortality	Mortality versus morbidity impact. It allows measuring the differential effect between mortality and morbidity.	Reviewed studies	Dummy variable (1 for mortality, 0 morbidity)
Disease type	General (all-cause, general health), mental, cardiovascular, respiratory, others (diabetes, cancer, etc.).	Reviewed studies	Categorical variable
Female	Proportion of female population over the total.	Reviewed studies	Percentage (of female on total)
Age	Age groups: young <16, adults 16 to 65, elderly >65.	Reviewed studies	Percentage (of population in each age group)
Subjective	If the study relies on self-reported health, the observation is regarded as subjective, otherwise not.	Reviewed studies	Dummy variable (1 for the subjective studies, 0 otherwise)
Income per capita	GDP/ population by country.	Secondary source: IMF (http://www.imf.org/external/pubs/ft/weo)	GDP per capita
Hospital beds	Hospital bed density (by country).	Secondary source: CIA library (https://www.cia.gov/library/publications)	Number hospital beds per 1,000 people
Literacy	Literacy rate, youth total (% of people ages 15-24, by country).	Secondary source: World Bank (http://data.worldbank.org/indicator)	Percentage
Urbanization	% people living in urban areas (as defined by countries' statistical agency)	Secondary source: World Bank (http://data.worldbank.org/indicator)	Percentage

Source: Chiabai et al. (under revision).

The Heckman Model

Although most of the studies reviewed support the idea that green areas can have beneficial effects on human health, this relationship is influenced by multiple factors (environmental, socio-demographic and economic) and is therefore characterised by high levels of complexity and uncertainty. Indeed, many of the studies found in the review, show non-significant results. This implies unclear evidence for health benefits from green areas at the current stage. In such cases, considering only the studies providing significant results would generate a censored sample which would lead to inconsistent and biased parameter estimates (Copas, 2013). At the same time, the presence of more than one estimated coefficient reported per study would give an excess weight to studies with many estimates (Stanley, 2001).

Previous studies introduced a dummy variable for each study that provided more than one observation for the meta-analysis (Jarrell and Stanley, 1990). Other solutions (Jeppesen et al, 2002) try to derive estimates from meta-analyses combining a probit model and an unbalanced panel data model to take into account the random researcher effect and to assess the impact due to the commonality within a study and assuming that reporting a significant result in a study is separate from the amount observed. Further studies (Rolfe and Brouwer, 2012), used a mixed-effects Tobit model to take into account the censored nature of the data and the intra-study effects, assuming structural similarity restrictions on coefficients for censored and non-censored observations. One way to take into account some of the limitations mentioned would be to estimate with panel data a model selection (Wooldridge, 1995; Semikyna and Wooldridge, 2010), but this procedure would not be feasible due to the nature of our data, as it presents neither the proper rationale (we could not compare the observations among the different papers), nor enough degrees of freedom to adequately select the cohorts for the pseudo-panel needed to estimate the j-Probit models in the first step, as proposed in those articles. Therefore, in this context of uncertainty, we tested the Heckman selection model as a way to deal with the unobserved selection factors and correct for the bias in estimating the outcome equation, and we introduced variables related with the study to control for the researcher effect. In our analysis, we name this effect as the i-Study Effect, as it is explained in the next sections.

Our objective is to gather the quantitative results available in the literature about the relationship health and green areas in a meta-analysis in order to model quantitative impacts on health associated with exposure to green areas in a context of study heterogeneity.

The Heckman selection model is usually expressed in terms of latent variable models and relies on two equations, an outcome equation which includes factors affecting the outcome variable, and a selection equation which considers the part of the sample which is observed and the factors influencing the selection process.

In our case, the outcome equation relates the health risk reduction with a set of explanatory variables such as increased exposure level, income per capita, type of disease and so on.

In its general form, the outcome equation R_i can be expressed as:

$$R_i = X_i\beta + \varepsilon_i \qquad \text{Eq. 4.1}$$

where X_i are the explanatory variables determining the health risk reduction R_i; β is a vector of parameters to be estimated; and ε_i is the error term. In our analysis *Eq. 4.1* takes the following form:

$$\begin{aligned} R_i = \beta_0 + \beta_1 mort_i + \beta_2 sub_i + \beta_3 car_i + \beta_4 res_i + \beta_5 men_i + \beta_6 gen_i + \beta_7 exp_{m,i} \\ + \beta_8 exp_{h,i} + \beta_9 fem_i + \beta_{10} old_i + \beta_{11} adult_i + \beta_{12} logGDP_i \\ + \beta_{13} logbed_i + \varepsilon_i \end{aligned} \qquad \text{Eq. 4.2}$$

The explanatory variables are those reported in Table 4.1, though some of them have been further transformed in dummies, as specified hereby. *$mort_i$* is the dummy variable “mortality” when mortality is measured in study *i*. *sub_i* is the dummy variable “subjective” indicating if the observation is a subjective health perception derived from surveys. The four variables *car_i*, *$resp_i$*, *men_i*, *gen_i* are dummies derived from the categorical variable “disease type” in Table 4.2, and they are interpreted in comparison with the category “others” (diabetes, cancer, etc.). *car_i*, is the dummy variable for cardiovascular diseases, *res_i* for respiratory diseases, *men_i* for mental health and neurologic diseases, and *gen_i* for other diseases (digestive, muscular, etc.). Exposure is measured with two dummies, exp_m

and exp_h, derived from the categorical variable “exposure to green areas” in Table 4.2 and representing medium and high respectively compared with low exposure. *fem*$_i$ is the proportion of females in each observation. *old*$_i$ and *adult*$_i$ denote the proportion of population over 65 and between 16 and 65 respectively, taken from the variable “age” in Table 4.2. *GDP* is the “income per capita” expressed in 2005 USD. *bed*$_i$ is the number of “hospital beds” in the country per 1,000 inhabitants.

The *selection* equation is the probability that the health risk reduction due to exposure is significant (probability of significance being observed, S_i), which can be expressed as:

$$S_i^* = Z_i\alpha + v_i \qquad \text{Eq. 4.3}$$

where Z_i are the explanatory variables assumed to capture the *i-Study Effect*; α is a vector of parameters to be estimated; and v_i is the error term. Equation 1 is observed if $S_i = 1$, meaning that S_i^* shows significant effects on risk reduction from exposure, and $S_i = 0$ otherwise.

In our analysis the *selection* equation takes the following form:

$$S_i^* = \alpha_0 + \alpha_1 mort_i + \alpha_2 sub_i + \alpha_3 urb_i + \alpha_4 logGDP_i + \alpha_5 lit_i + v_i \qquad \text{Eq. 4.4}$$

Where *urb*$_i$ is the variable “urbanization” (percentage people living in urban areas, per country) and *lit*$_i$ is the percentage of literate people aged 15-24 in the country.

This is the latent variable model. If S_i^* shows significant effects of exposure on risk reduction then the observed latent function equals to 1, otherwise $R_i = 0$. The regression equation observes the value of R_i if $S_i = 1$. ε_i and v_i are the error terms of the two equations which are distributed according to a bivariate normal with mean zero, $\varepsilon_i \sim N(0, \sigma_\varepsilon^2), v_i \sim N(0,1)$ and covariance $\rho = Corr(\varepsilon_i, v_i)$. The error terms are independent of both sets of explanatory variables. The model allows for correlation between unobservable information of the two equations. As it is well known, if $\rho = 0$, the standard regression model applied to equation 1 provides consistent and asymptotically efficient estimators for all model parameters. When $\rho \neq 0$, the standard regression model applied to equation 1 provides biased results, while the Heckman model with sample selection provides consistent and asymptotically efficient estimators for all model parameters.

The application of Heckman model in our context allows differentiating among those factors affecting the significance of exposure on the health risk reduction and to identify the key variables in this relationship.

To estimate the model coefficients, we used the full information maximum likelihood estimation method. The estimation involves forming the joint distribution of the two random variables [ε_i, v_i] and then maximizing the full log-likelihood function. The marginal risk reduction induced by the model determinants was then calculated on the basis of the estimated model considering the non-linear effects and for the mean values in the quantitative variables and the median values in the dummy variables.

The interpretation of the results from the model requires the transformation of the coefficients obtained in order to avoid selectivity bias. Vance (2009) proposes marginal effects and significance testing following the equation:

$$\frac{\partial E(R_i | S_i^* > 0, X)}{\partial X_{ki}} = \beta_k - \alpha_k \rho \sigma_\varepsilon \delta_i(-Z\alpha) \qquad \text{Eq. 4.5}$$

where the inverse of the Mills ratio is denoted as *δ(-Zα)*, and it is to control for potential bias emerging from sample selectivity and it is calculated from the linear predictions *(-Zα)* of the selection equation. In general, the marginal effect of a variable X_k will be different for each observation (individual). As usual in such situations, we compute the value of the marginal effect for *Z*, a mean or median vector of variables (for quantitative or qualitative variables, respectively). The marginal effect estimated represents the variation in the health risk reduction HRR associated with a variation in the explicative variable once corrected for the selection bias.

Main findings of the model

Table 4.2 shows the results of the Heckman Selection model separately for each equation. The *outcome* equation (R_i) explains the health risk reduction associated with exposure to green areas with a set of explanatory variables identifying different determinants. The *selection* equation, on the other hand, reveals the determinants affecting the probability of finding significant results in the risk reduction estimated in the reviewed studies. These determinants describe the *i-Study Effect* and include variables characterising the study and socio-economic factors in the country under analysis.

The results arising from the *selection* equation show that the probability of seeing significant results in the health risk reduction from increased exposure to green areas is significantly higher in studies conducted in urbanised countries, with lower income per capita and literacy rate, as well as in those studies looking at mortality outcome and subjective health indicators. The negative effect identified for income in determining the likelihood of a significant result may reflect the potential publication bias in the publication of negative results. Research in the medical sciences on clinical trials suggests that the odds ratio for the publication of significant results in higher income countries relative to other countries was 0.41 in 2003 (Yousefi-Nooraie et al, 2006), implying that studies in richer countries are more likely to report negative results.

As it can be seen in Table 4.2, the Wald test shows that the covariance between errors in the two equations is significantly different from zero, so that the two equations have to be jointly estimated. Also, we have tested the adequacy of our specification and our conclusions are: (i) we reject the null hypothesis of non-global significance of the outcome equation ($\chi2(13) = 143.38$***), (ii) we reject the adequacy of the Tobit specification for the structural similarity restrictions on coefficients for censored and non-censored observations ($\chi2(15) = 207.15$***) and (iii) we observe problems of collinearity if we introduce a dummy variable for each study.

Table 4.2. Heckman Selection model results

Explanatory variables	**Outcome equation (R_i): HRR**			**Selection equation (S_i): Probability that HRR significant**		
Mortality *[mort]*	0.5716	(0.897)		1.7911	(0.435)	***
Subjective *[sub]*	-0.0523	(0.849)		1.1635	(0.334)	***
Cardiovascular *[car]*	-0.0875	(0.388)				
Respiratory *[res]*	-0.0309	(0.282)				
Mental health *[men]*	0.3941	(0.579)				
General health *[gen]*	-1.7318	(0.672)	***			
Medium exposure *[exp_m]*	2.5682	(0.367)	***			
High exposure *[exp_h]*	3.4530	(0.591)	***			
Female *[fem]*	0.0051	(0.016)				
Elderly *[old]*	0.0593	(0.035)	*			
Adults *[adult]*	0.0599	(0.038)	*			
log income per capita *[log(GDP)]*	-2.1062	(1.310)	*	-0.8408	(0.473)	*
log hospital beds per capita *[log(bed)]*	2.6754	(0.715)	***			
Urbanisation *[urb]*				0.0793	(0.028)	***
Literacy *[lit]*				-1.3205	(0.615)	**
Constant	13.0054	(12.947)		132.1250	(62.209)	**
Wald test of indep. eqns. (rho = 0): chi2(1) 3.27 *						

Note 1: Figures are the estimated coefficients of the model and figures in brackets are standard errors.
Note 2: GDP and beds per capita have been transformed into log to consider the non-linearity effects.
** p < .1; ** p < .05; *** p < .01*
Note 3: number of observations=182.

In order to assess the magnitude of health risk reduction and its determinants, however, we need to look at *Eq. 4.5* which estimates the marginal effects from the system of equations. In other words, in order to explain the results on the HRR we need to jointly estimate the outcome and selection equations and interpret the resulting marginal effects in light of both equations. *Eq. 4.5* measures the marginal values for the health risk reduction as a response to changes in the determinants—dy/dx for quantitative variables and discrete change of dummy variables from 0 to 1. Results are reported in Figure 4.4 and show that changes from baseline to medium exposure levels are expected to generate reductions in health risks of about 2.6% on average in the study population. This impact increases to a 3.5% for high exposure levels compared to the baseline, though diminishing returns to scale can be intuited from the data, consistent with the literature (Pampalon et al., 2006). This implies that, all values held constant at the average, policies that increase availability of natural or semi-natural spaces for the citizens may generate health benefits up to 3.5% risk reduction.

Higher risk reductions are estimated for mortality compared to morbidity (+1.4%). As regards the type of illnesses, mental health has the largest impact on risk reduction (+0.39%) compared with the category “other diseases” (encompassing many diseases, such as cancer, diabetes, etc.). Though the coefficient is not significant, it shows a tendency of the importance of green areas on mental health in the current context where mental disorders are strongly contributing to the world disease burden (Burton and Rogerson, 2017). The broad and comprehensive category “general health” shows lower risk reductions (-1.7%) compared to “other diseases” addressing specific health conditions from exposure to green areas.

As for the demographic variables, gender does not affect significantly the impact, while adults and old people are those gaining slightly more from increased exposure to green spaces, compared to young people (< 16 years old), though the magnitude of the effect is small.

Socio-economic variables have also an impact on risk reductions. Income per capita was found to be moderators of the improvement in health. In studies conducted in poorer countries, increased exposure to green areas could lead to higher reduction in health risks, taking into account the publication bias (-2.5%). From a different methodological approach, other authors such as Wright Wendel et al (2012) or Germann-Chiari and Seeland (2004) have also considered the role of access to green space in low-income groups and areas. Finally, health risk reductions are expected to be higher in countries with higher access to healthcare (measured as number of hospital beds per 1,000 inhabitants in the country) (+2.7%).

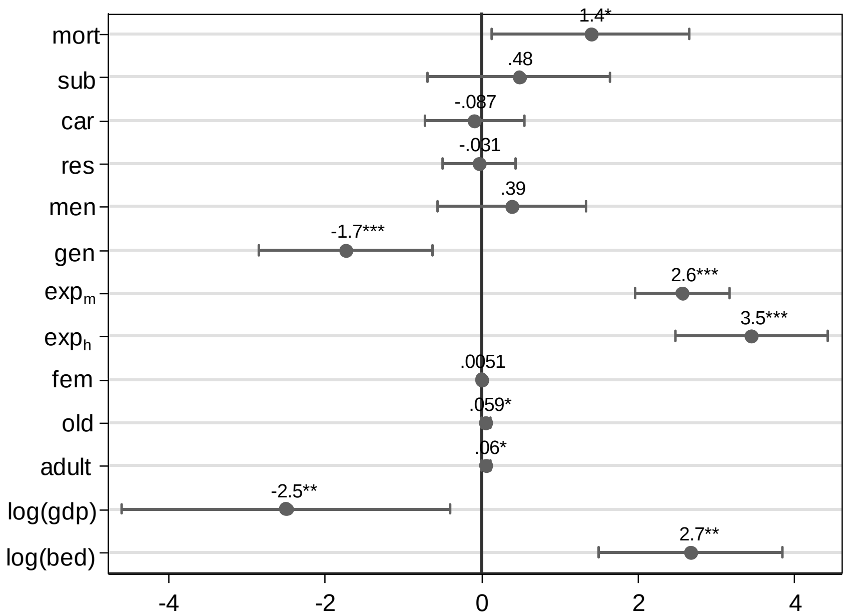


Figure 4.4. Marginal effects for the Heckman model. Note: marginal effects calculated on the basis of the estimated model considering the non-linear effects and for mean values of quantitative variables and median values of dummy variables. Mortality (mort), Subjective (sub), Cardiovascular (car), respiratory (res), mental health (men), general health (gen), medium exposure (exp$_m$), high exposure (exp$_h$), female (fem), elderly (old), adults (adult), log income per capita (log(gdp)), log hospital beds per capita (log(bed)). Note: number of observations=182.

Our results show that, while diverse, studies in the literature tend to find a positive correlation between green spaces and health benefits, especially strong for high levels of exposure. One of the most significant conclusion extracted from this analysis is the relevance of contextual factors. The notion that different contexts yield different interconnections is supported by the results obtained, which pointed towards income, education, and urbanisation as possible factors affecting the results of the different studies.

Limitations

First, the approach does not consider the pseudo panel structure of the database. Due to the nature of our data (the observations responding to different health indicators), we do not have either the rationale (we cannot compare the observations among the different papers), nor the numbers of observations and associated degrees of freedom to adequately select the cohorts for the pseudo-panel. Second, we are unable to consider the quality of green space as well as accessibility and usability given the gaps in the literature in terms of quantitative analysis on health benefits. Third, heterogeneity of literature in relation to exposure required us to construct a qualitative indicator for this metric and ideally this would be standardised across the literature to allow for comparability in quantitative terms. This study has been performed in a field where the literature is growing but heterogeneous. While its intention is precisely to help in the task of having a general overview of the potential health benefits of green spaces in health, it highlights the need for a more common approach to metrics used in such studies.

Strengths

This is the first time that the Heckman model has been used in a meta-analysis study to our knowledge, which guarantees a better approach compared to the Tobit model to synthetise the literature on environmental exposure to human health, because it allows considering both significant and non-significant results in the same analysis. This is also among the first studies that derive a marginal effect of exposure to green areas on health from existing studies that could be used for identifying health impacts in different contexts. Shanahan et al (2016) found that the health benefit can be affected by the “dose” of nature experience. We found similar non-linear benefits.

Furthermore, this paper is based on the sound idea that the use of meta-analysis in reanalysing key but heterogeneous studies from the literature, taking into account both their significant and insignificant results, can provide a better understanding of the relationship between exposure to green spaces and human health.

Applications to other contexts

Figure 4.5 shows a simulation of expected HRR using OECD GDP per capita. It shows the negative and logarithmic decrease in impact associated to higher income levels as simulated using sample’s average values as reference. It can also be seen in the figure the difference in impacts between higher and medium exposure levels. The graph marks average income as calculated from OECD countries, as well as the lower decile from the sample of OECD country average income. Potential for improvement, therefore, depends on context in the model drawn from this study. Richer countries require stronger improvements in their environmental conditions in order to achieve health improvements in their populations. While less developed countries can also benefit from stark environmental action, they can obtain these advancements with less effort. Investment on green areas may, therefore, be a strategy to alleviate health inequalities in poor areas. Our findings suggest, however, that interventions may require important increases in green space available to obtain a certain level of health benefits.

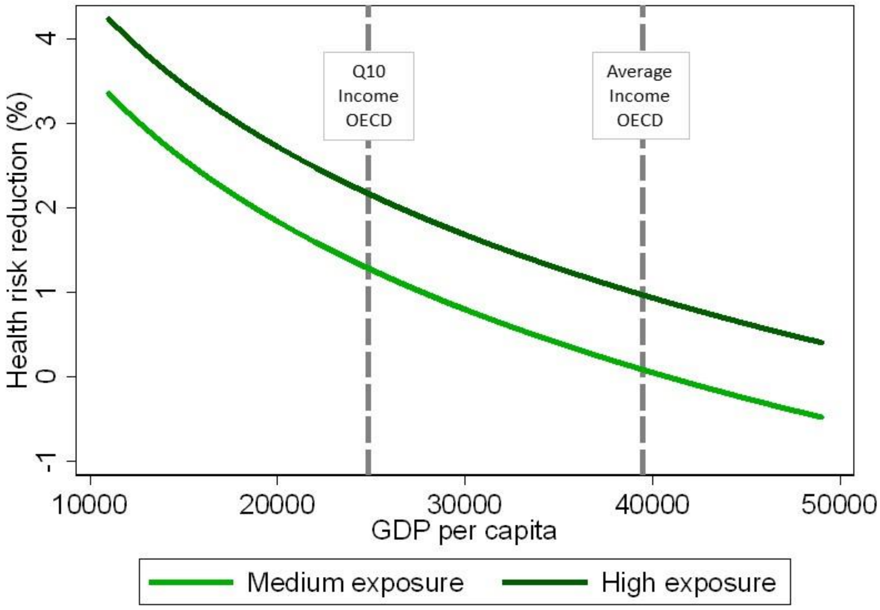


Figure 4.5. Change in health risk reduction (HRR) in relation to GDP per capita for all-cause morbidity, 10% quantile (Q10) and average. Marginal effects are calculated for mean values of quantitative variables and median values of dummy variables. Source: own data and OECD Income Distribution Database (via http://oe.cd/idd). Note: number of observations=182.

An area where this could have implications is urban planning. The urban areas in developed countries are increasingly taking an ecological perspective towards development and new built areas include public open spaces including green areas. Literature suggests that green spaces are not optimally distributed among all citizens but that wealthier neighbourhoods dispose of higher amount of them (Germann-Chiari and Seeland, 2004; Mitchell and Popham, 2008). Therefore, development of green spaces in poorer neighbourhoods may decrease health inequalities within developed countries.

Applications to the Thinking Fadura case study

The Heckman model has been used to simulate the health benefits, in terms of percent risk reduction in annual mortality rate associated with the exposure to urban park of Thinking Fadura.

The marginal effects on the health risk reductions and their confidence boundaries have been calculated for the specific conditions in the Getxo municipality for the baseline period (in terms of population, income per capita, etc.). Changes in health risks attributable to the park are considered constant over time. Exposure is assessed from medium level (Getxo area is surrounded by green spaces, both public and private, and the park of Fadura was already present, though not opened to the public, which implies that some benefits already existed) to high exposure (benefits specifically related to intervention of Thinking Fadura). To calculate the expected reduction on mortality risk we calculate the differences in the marginal effects related to a change from medium to higher level of exposure. We run Chi(2) test to contrast the differences significance.

Table 4.3 shows the predicted differences in terms of reduction on mortality risk for the assumed change in exposure. The predicted marginal effects are estimated to be 2.42% decrease in mortality rate applied to the general population living in the municipality of Getxo. To contextualise these numbers let us consider that the mortality attributable risk for heatwaves in the Basque Country by Diaz et al (2015) has been estimated in the order of magnitude of 5.66% increase, which includes the effects on particulate matter and noise. Attributable risks specifically applied to extreme temperatures (heatwave), after controlling for other confounding factors, have been estimated in the order of 2.22% increase (for lag 1) in the context of Madrid (Linares et al, 2014).

Table 4.3. Predicted marginal effects associated with increased exposure to the park of Thinking Fadura, and Chi(2) test for difference

High exposure	Medium exposure	Difference	Test for difference ($\chi^2(1)$)
4.068	6.488	2.42	30.76***

For assessing the health benefits, we apply this risk reduction to the current values of mortality in Getxo municipality. The current annual rate of mortality for Getxo municipality is 167.79 per 100,000 (Source: www.Euskadi.es), to which we apply a reduction of 2.42% as the expected reduction on mortality rate, in two scenarios: immediate benefits (occurring from year 0), and delayed benefits (occurring from year 10). This is because mortality risk reductions will probably start emerging after some time and not immediately.

The health benefits associated with the opening of the park of Thinking Fadura are the avoided deaths related with a risk reduction on total baseline mortality for the area of influence (municipality of Getxo). The annual expected avoided deaths can be calculated as follows:

$$Avoided\ deaths_t = HR_t \times \mu \times (pop_t \times g_t) \qquad \text{Eq. 4.6}$$

Where *t* represents the year of reference, HR_t is the health risk reduction attributable to the opening of the park, μ is the average annual mortality rate for all causes for Getxo population, pop_t is the population of Getxo municipality per year t, and g_t is the annual population change rate for Spain (Eurostat, 2017). The time span considered is 2020-2050.

For the monetisation of the health benefits, the Value of Statistical Life (VSL) is used, which can be defined as the marginal value of a mortality risk reduction:

$$VSL = \delta WTP / \delta Risk \qquad \text{Eq. 4.7}$$

Where WTP is the Willingness to Pay defined as the maximum amount that an individual is willing to pay for a risk reduction in mortality rate while keeping unchanged his expected utility. In this case study we used values for VSL suggested by OECD (2011), which range from 1.8 to 5.4 million US$2005 for EU27, with a central estimate of 3.6 million. These values have been adjusted following OECD guidelines (2011) taking into account:

- Conversion to national currencies (PPP-adjusted exchange rates).
- Domestic Consumer Price Index (CPI) for adjust to the current prices in Spain.
- Income adjustment for Spain (in terms of GDP per capita) from the study site to the policy site.
- Correction of increased real income in time.

Table 4.4. shows the adjusted values under different hypothesis of income elasticity over time and space. OECD guidelines suggest using an elasticity of 0.8 for space and 1 for time (OECD 2011), so that we report our final results for the central estimate of VSL using the suggested elasticities (2.94 million Euro 2018).

Table 4.4. VSL adjusted for Spain, million Euro 2018

VSL original (OECD report 2011) million US$2005	VSL adjusted million Euro2018
income elasticity over space	0.8
income elasticity over time	1
1.80	1.47
3.60	2.94
5.40	4.41

Finally, the total benefits for mortality risk reduction are calculated by multiplying the avoided number of deaths by the VSL value adjusted for Spain, and discounted over time:

$$Mortality\ benefits = \frac{Avoided\ deaths_t \times VSL}{(1+d)^t} \qquad \text{Eq. 4.8}$$

Total benefits are estimated applying different discount rates (0%, 3.5%, 10%), central and lower bound estimates of the VSL, and for two scenarios of immediate and delayed mortality benefits. The period of reference is 30 years. Population growth is not considered in the sensitivity analysis of the scenarios, as the range values are quite small applied to the population of reference in the municipality of Getxo. Total discounted benefits are estimated between 48 and 287 million Euro for the 30 years-period in the scenario of immediate risk reduction, corresponding to the range 1.6-9.5 million Euro on average flow per year, depending on the VSL reference value and the discount rate applied. In the scenario of delayed risk reduction, the discounted mortality benefits are between 17 and 194 million Euro for the 30 years-period.

Table 4.5. Discounted benefits associated with reduced mortality, 30 years, million Euro 2018

Immediate (year=0)			***Delayed (year=10)***	
Discount rate	*VSL central estimate*	*VSL upper bound*	*VSL central estimate*	*VSL upper bound*
Undiscounted	143	287	97	194
d=3.5%	90	179	50	100
d=10%	48	97	17	34

These benefits are kept separated from the full range of benefits calculated in section 4.4, for two reasons. First, they include the effect on physical activity and reduction in air and noise pollution related to less traffic, so there is a double counting effect. Second, the monetarization of mortality risk reductions, generally resulting in very high values of VSL in environmental projects, has been often criticised in the literature on the basis that human life is immeasurable, and cannot be priced (Ackerman and Heinzerling, 2004; Patokos, 2010). The inclusion of mortality benefits in the CBA would results in very high rates of benefits as mortality benefits valued with VSL will largely overweigh all the costs and dominate considerably all benefits, so that we decided to show this benefit as a separate scenario.

4.2.3. Participatory workshop: perspective of key stakeholders and experts

There are several ways to evaluate the impacts of public interventions, such as the opening of the Fadura Public Park to the general public in Getxo. The CBA in Thinking Fadura aimed to be framed as ‘socially participatory’, and key stakeholders have participated both in the design of the interventions and in their qualitative assessment. The combination of participation processes with representatives of different social groups with the opinion of experts should lead to a more precise evaluation regarding the impacts of public interventions on the welfare of society. In the case of the CBA of Thinking Fadura, the participation process was used as a tool to complement the economic assessment of the costs and benefits from a social point of view: specific objectives include the identification of impacts of the park, taking into account impacts on different population groups and sectors, and the qualitative evaluation of these impacts. In addition to this workshop organised by BC3 in collaboration with the municipality of Getxo, further stakeholders’ workshops have been organised specifically (n=20) by the municipality to involve key agents in the design of the interventions themselves (see Section 4.1 on the design of Thinking Fadura).

The stakeholders’ workshop organised by BC3 was held in Fadura, Getxo on May 24, 2018 and included stakeholders and experts from the public and private sectors to discuss about the social, environmental and economic impacts of the opening of the Fadura park. A total of 20 participants attended the workshop including members from different departments of the municipality such as social welfare, equality, multiculturalism, development cooperation, environment, urban planning, housing, civil protection, economic promotion and health and Fadura sporting area (Getxo Kirolak), the latter being the agent implementing the practice. In the development of the workshop there were two people facilitating the session.

The workshop aimed: i) to identify the population that could be affected (positively and negatively) with the opening of the park, ii) to identify new uses of the park that could impact these populations (e.g. access the river or the use of bicycles instead of cars, urban gardens and links to healthy food consumption), iii) to analyse impacts of each new use of the park in terms of costs and benefits and iv) to assess qualitatively the costs and benefits identified through a Likert scale.

Impacts were categorised by the workshop participants themselves, who identified 8 different categories of impacts, as reported in ANNEX 4: environment, living place, community and society, safety and comfort, employment and economy, food, mobility and physical activity. For each category, stakeholders identified specific indicators distinguishing among positive and negative effects related to the interventions of Thinking Fadura park, measures to encourage positive impacts, and measures to minimise negative impacts.

The results of this workshop (Annex 4) show that the most relevant positive impacts, as a consequence of opening the Fadura park to the general public, were those within the category of "environment" and "community and society". Within the category of the environment, the most notable positive impacts were the creation of green areas and itineraries (communication pathways) and the improvement of the environmental awareness of society. Within the community and society category, the most relevant positive impacts were a greater space for children to enjoy, improvement of the well-being of the elderly, recreation, use for people living in disadvantaged circumstances and social integration. Other categories of impacts include the creation of urban communication networks, and physical activity. Finally, the possibility of creating urban gardens (allotments for local communities) and organizing healthy food training opportunities are related to new future uses that could be created within the park, though not been planned yet.

Among the negative impacts, those related to “environment”, “community and society” and “safety and comfort” received the highest score. The most notable are related to people taking dogs without leash with the risk of making the area dirty or suffering environmental degradation due to an incorrect use of the restored green areas. Related to community/society and safety/comfort, the most relevant negative impacts were possible social conflicts between users, the possibility that the area became a frequent place to drink alcohol among young people, vandalism and a decrease in citizen security because the area could be open to anyone outside the sporting facilities.

Figure 4.6. Exercise in the evaluation workshop of impacts of the opening of Fadura to the citizenship (Getxo, May 24, 2018)

4.2.4. Citizens' surveys: perspective of the general public

Within the INHERIT project, two face-to-face surveys were implemented for the pilot Thinking Fadura. One survey aimed to collect data on the citizens of Getxo and the other one on the users of the green areas that are currently open to the public in Fadura. In both surveys, the sample size of respondents was 256. This section describes the objectives, target populations, structure and methods of the two surveys. Questionnaires are presented in Annex 5.a and 5.b, and a brief description of some survey responses is shown in Annex 6.

4.2.4.1. Survey to Citizens of Getxo (neighbours)

Objective

This survey aimed to study the opinion of the citizens of Getxo with regards to Thinking Fadura´s initiative of opening Fadura´s Municipal Sports Centre´s (FMSC) green areas to the general public. Through this survey we have obtained qualitative and quantitative information that has been taken into account in the different analysis carried out in this study. By qualitative in our approach we mean information related to perceptions of citizens about which are positive and negative impacts of the park (closed-ended questions) and their importance on a likert scale. The term "qualitative assessment" is used as opposed to the quantitative assessment of benefits and costs in the CBA.

Target population

The target population is made up of people over 16 years of age and registered as citizens in the municipality of Getxo. To identify this population, two screening questions have been included in the introduction of the survey. In total, 256 surveys were completed in 12 different areas of the municipality. The sample is representative of the population of Getxo in terms of the different areas of residence.

Structure

The survey has the following sections: introduction and screening, user profile, impacts, attitudes, push & pull factors, and socioeconomic data.

As in the user's survey, <u>the introductory section</u> has a double objective. On one hand, to explain to the potential respondent the objective of the survey and to ask for his or her consent in order to proceed with it; and on the other one, to screen for potential respondents.

<u>The user profile section</u> aims to know if the respondent is an actual user of FMSC (or not), and whether (or not) he or she has heard about the Thinking Fadura project. It also seeks to identify the reasons, uses and frequencies of current users of the park, as well as the reasons for not using it. After explaining the Thinking Fadura project to both profiles (users and non-users) they are asked to assess the possibility and the potential frequency of the future use of the public park of Fadura. In order to know if the respondent spends leisure time in open spaces at Getxo, a specific question is posed regarding places and frequencies.

As in the user´s survey, <u>the impact section</u> aims to know the impacts that could occur as a result of opening the park. The set of impacts has been obtained from the work carried out with a stakeholder´s focus group. The scale proposed allows the respondent to categorise the impact as positive or negative, and also to determine to what degree s/he considers it positive or negative.

<u>The attitudes section</u> contains 3 subsections: environment, self-perceived health, and physical activity.

The subsection environment tries to determine whether or not the respondent is concerned about environmental issues, and in that case, to what degree.

The subsection self-perceived health includes a set of questions that help to determine the state of self-perceived physical and mental health.

In *the subsection of physical activity*, the respondent is asked whether he or she exercises and, if so, how often it is done for the following types of activities: vigorous activity, moderate activity or walking.

The Push & Pull section seeks to know the opinion of the respondent in relation to different factors that may influence the general use of urban parks. These factors have been identified from different studies (e.g., Barker et al., 2017; Kothencz and Blaschke, 2017; Noralizawati and Othman, 2012). As it has been done in the impact section, the respondent is asked to categorise the impact as positive or negative, and to determine to what degree he or she considers it positive or negative.

Finally, as in the user´s survey, the socio-economic data section contains information on gender, age, descendants, level of education and household income.

Visual Aids

As in the user´s survey, to support the explanations of the interviewer, a series of visual aids have been used to help the respondent to better understand the explanations in relation to the current and future state of FMSC´s public park. In addition to the 4 types of visual aids described in the user´s survey, this survey, has also used photographs of the park´s green areas that are currently opened to the general public (see Figure 4.7).

Figure 4.7. Photos of green areas nowadays opened to the general public

4.2.4.2. Survey to users of the green areas that are currently open to the public in Fadura Municipal Sports Centre's (FMSC).

Objective

This survey aims to study the affluence and profile of users of the areas of Fadura´s Municipal Sports Centre's (FMSC) green areas that are currently open to the public. Through this survey we have obtained both qualitative and quantitative information that has been used for the different analysis carried out in this study. By qualitative in our approach we mean information related to perceptions of citizens about which are positive and negative impacts of the park (closed-ended questions) and their importance on a likert scale. The term "qualitative assessment" is used as opposed to the quantitative assessment of benefits and costs in the CBA.

Target population

The target population is made up of people who transit through the green areas of FMSC that are currently open to the public. Both people under 16-year-olds and Fadura´s workers (whether hired or subcontracted) have been excluded from the sample. To identify these two types of subjects, two screening questions have been included in the introduction of the survey. A total of 250 surveys were completed.

Structure

The survey has the following sections: introduction and screening, user profile, means of transport, frequency and uses, impacts, self-reported health and socioeconomic data.

The introductory section has a double objective. On the one hand, to explain to the potential respondent the objective of the survey and to ask for his or her consent in order to proceed with it; and on the other hand, to screen for potential respondents.

The user profile section aims to categorise the type of user, as well as to know the reason why s/he goes to the park. This section explains the Thinking Fadura project and asks the respondent if s/he knows or has participated in the collaborative reflection that has led to open up the park of FMSC to the public.

The means of transport section contains questions that provide the necessary information to quantify the recreational benefit of using the park; to do so, the travel cost method has been used (del Saz Salazar, 1997; Farré and Duro, 2010; Nogueraet al., 2010).

In the section related to frequency and uses, the actual frequency of use of the park is asked. In addition, the respondent is inquired to determine the future potential frequency of use, as well as the means of transport that s/he plans to use, taking into account the road and bike lane connections that will exist once the parked is fully opened.

The impact section aims to know the impacts that could occur as a result of opening the park. The set of impacts has been obtained from the work carried out with a stakeholder´s focus group. The scale proposed allows the respondent to categorise the impact as positive or negative, and also to determine to what degree he or she considers it positive or negative.

The section of self-reported health includes a question that helps to determine the self-perceived health status. This question has been obtained from the health survey carried out by the Department of Health of the Basque Government in 2018 (Departamento de Salud del Gobierno Vasco, 2018).

Finally, the socio-economic data section contains information on gender, age, descendants, level of education and household income.

Visual Aids

In order to support the explanations of the interviewer, a series of visual aids have been created to help the interviewee to better understand the current and future state of FMSC´s public park. Specifically, 4 types of visual aids have been used, the following ones:

a) A map of current and future features of the FMSC´s public park (Figure 4.8)

b) An illustrative photographic infographic about the future shape of the park (Figure 4.9)

c) A map of the area of influence of FMSC´s public park (Figure 4.10)

d) A visual scale that supports the question about impacts that could occur as a result of the opening of the park (Figure 4.11)

To determine the area of influence of the park, a review of the literature has been conducted. Different studies (Sturm and Cohen, 2014; Nutsford et al., 2013; Van Den Berg et al., 2010; del Saz Salazar and García Menendez, 2005; World Health Organization, 2017) delimit the area of influence between 400m and 1000m. Taking these studies into account, and for the purposes of our study, we have considered 4 zones in the area of influence of Fadura (see Figure 4.10). Being zone 1, the one that includes a perimeter of 250m counted from the limit of FMSC; being zone 2 the one that includes a perimeter of 250m counted from the limit of zone 1; being zone 3 the one that considers a perimeter of 500m counted from the limit of zone 2; and finally the zone 4, which considers everything that exceeds zone 3.

Inflow

To determine the number of users of the park, visual counting has been made by interviewers. The counting has consisted in observing and taking note of the number of people who have transited through FMSC´s green areas that are currently open to the public. Such registry has been done with indication of whether these people were alone or accompanied, and in such case of how many people. Likewise, it has been observed and described the way in which users moved through the area (being the registered options: walking, running or going by bike or by other means). The observed information has been collected in Table 4.5.

Figure 4.8. Current and future features of the FMSC´s public park

Figure 4.9. Photographic infographics about the future shape of the park

Figure 4.10. Area influence of Fadura´s Municipal Sports Center (FMSC) public park

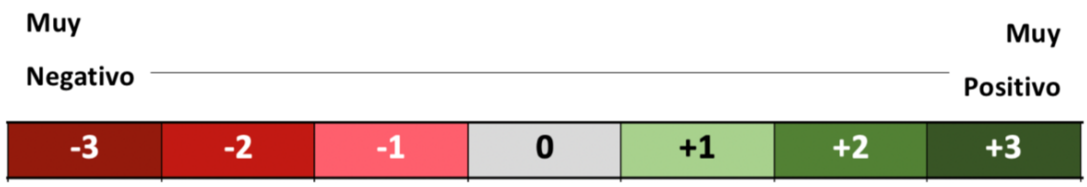


Figure 4.11. Scale of potential impacts

Table 4.5. Counting people

CONTEO PERSONAS.

DÍA: _______

Apunte	Acompañamiento		¿En qué va?			Comentarios
	Solo/a = 1 Acompañado/a = 2	*Sí acompañado,* ¿Cuántos son?	Andando	Corriendo	Bicicleta u otros medios	
1						
2						
3						
4						
5						
6						
7						
...						

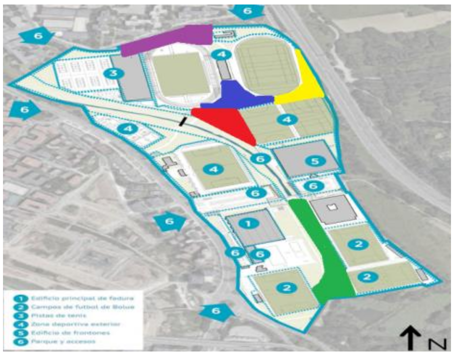
4.2.5. Physical activity in the park: the iSOPARC method

The number of people in greenspaces such as parks is usually measured through the use of fixed counters that can inform the total number of visitors at every time of the year. In Fadura, since there were no fixed counters in the pathway an estimation had to be done. The tool System for Observing Play and Active Recreation in Communities (iSOPARC) was utilised to quantify the usage and the physical activity in the greenspaces of Fadura.

iSOPARC is an established and validated observation tool to assess the use of public spaces in community settings (McKenzie et al., 2006). iSOPARC is used to record individual (gender, age, physical activity level, and ethnicity) and contextual characteristics (in a given area) and primary activity for each observed person. The tool is typically used for assessing physical activity on parks and recreation aiming to assist to generate important data from the field and to store, process and export it. The main features are a digital counter, paperless collection, consistency and foolproof, project oriented, easy exportation and fast development. Through visual scans, iSOPARC determines the usage and physical activity of the greenspace at a determined time.

In Thinking Fadura, the iSOPARC assessment was carried out in order to determine the number of people increasing physical activity as a result of the restoration of the pathway and the improved accessibility in Fadura.

The green areas of Fadura occupy around 4ha and was divided in 5 target areas (Figure 4.12). The observations were done by two observers (Ander Aranceta and Silvestre García de Jalón) in August 2018. In total sixteen site visits were done in each Target Area (5 TAs) at different time of the day. These times were at 9.00am, 12.00pm, 5.00pm and 8.00pm. The site visits were done in twelve different days covering both weekdays and weekends. Table 4.6 shows the temporal distribution at different times. Every site visit covered the five target areas.



TARGET AREA	COLOR
Target Area 1	Green
Target Area 2	Red
Target Area 3	Blue
Target Area 4	Purple
Target Area 5	Yellow

Figure 4.12. Target areas in the iSOPARC assessment in Thinking Fadura.

Table 4.6. Site visits in the iSOPARC assessment in Thinking Fadura.

Visit time	**Visit days**												**Total**
	1	2	3	4	5	6	7	8	9	10	11	12	
09:00		1		1	1		1						4
12:00			1					1			1	1	4
17:00	1	1	1			1							4
20:00			1			1			1	1			4

In the five target areas, the iSOPARC tool counted an average of 2.05 people per scan. For the physical activity benefit only those people who were doing walking or vigorous activities were considered. Thus in the five target areas, the average of people increasing physical activity for walking and vigorous activities were 1.06 and 0.21, respectively (Table 4.7). Hence, the sum of people doing physical activity was 1.27 (people / iSOPARC scan).

Table 4.7. Mean number of people using the space for different levels of physical activity (sedentary, moderate, vigorous) in the iSOPARC assessment in Thinking Fadura.

Type of physical activity	**Mean number of people increasing physical activity (people / iSOPARC scan)**
SEDENTARY	0.78
WALKING	1.06
VIGOROUS	0.21
TOTAL	2.05

4.3. Data collection and calculation for the CBA

This section describes the data used in the calculation of the benefits and costs of Thinking Fadura.

4.3.1. Benefits

The following benefits have been economically assessed in the CBA of the pilot Thinking Fadura, and the selection is based on relevance and data availability:

- Benefits related to people using less cars:
    - Reduction in CO2eq emissions
    - Reduction in air pollutants emissions
    - Reduction in noise pollution
    - Fuel savings
- Increased property value
- Health benefits from physical activity
- Recreation

4.3.1.1. Reduction in carbon dioxide equivalent (CO2eq) emissions

Reduction in CO2eq emissions refers to the benefit associated to the mitigation of climate change. The pilot Thinking Fadura produces a reduction in CO2eq emissions due to people using fewer cars as a result of the built pathway in Fadura. Before the Fadura area was fenced and after the pilot people can cross the area through the new pathway. Consequently, it is expected that people who live in the surroundings of Fadura could sometimes walk through this new pathway instead of driving for short distances. As fewer cars will be used fewer CO2eq emissions are produced.

Reduction in CO2eq emissions was calculated as the product of the total km reduced by cars and the CO2 emissions per km (Eq. 4.9). The economic value was estimated by using the CO2 externality value (see below).

$$\text{CO2 reduction (€ / year)} = \text{Total km reduced (km / year)} * \text{CO2 emissions per km (CO2 kg / km)} * \text{CO2 externality value (€ / CO2 kg)} \quad \text{Eq. 4.9}$$

$$\text{CO2 reduction (€ / year)} = 2383.9 \text{ (km / year)} * 0.119 \text{ (CO2 kg / km)} * 0.01475 \text{ (€ / CO2 kg)} = 4.18 \text{ (€ / year)}$$

Total km reduced (km / year)

The total number of reduced kilometres was estimated as the product of the reduced number of cars as a consequence of people walking instead of driving and the average distance (4.10).

Total km reduced (km / year) = reduced number of cars (cars / year) * average reduced distance (km / car) Eq. 4.10

Total km reduced (km / year) = 476.8 (cars / year) * 5 (km / car) = 2383.9 (km / year)

The estimation of the reduced number of cars was estimated as the product of the number of new visitors in Fadura and the percentage of visitors who walk instead of driving (Eq. 4.11). The estimation of the number of new visitors in Fadura and the percentage of visitors who walk instead of driving was done from the data obtained in the survey implemented in Fadura.

Reduced number of cars (cars / year) = Percentage of people walking instead of driving (%) * Mean number of people (people / year) / Number of people per car (people / car) Eq. 4.11

Reduced number of cars (cars / year) = 0.01 (%) * 47,677 (people / year) / 1 (people / car) = 476.8 (cars / year)

The average reduced distance including return trip was assumed to be 5 km per car. It was considered that when people needed to do long distances would use the car instead of walking.

CO2 emissions per km (CO2 kg / km)

CO2 emissions per kilometre of car was estimated on the basis of the average emissions level of a new car sold in 2017. According to the European Environmental Agency (2017), the average emissions level is 118.5 grams of CO2 per kilometre (for more details see, https://ec.europa.eu/clima/policies/transport/vehicles/cars_en). Eq. 4.12 converts the units g per km into kg per kg

CO2 emissions per km (CO2 kg / km) = 118.5 (CO2 g / km) * 1 (CO2 kg / 1,000 CO2 g) = 0.119 (CO2 kg / km) Eq. 4.12

CO2 externality value (€ / CO2 kg)

The externality value of CO_2e was €14.75 (t CO_2e)$^{-1}$ (UK Department for Energy and Climate Change, DECC 2019). Although DECC predicts that these values will increase over time up to €93 (t CO_2e)$^{-1}$ at some stage between 2018 and 2030), the current value is used in this study. When converted to kilograms the CO2 externality value was 0.01475 (€ / CO2 kg).

4.3.1.1. Reduction in air pollutant emissions as a result of people using less cars

4.3.1.1.1. Nitrogen oxides (NOx) emissions reduction as a result of people using less cars

Reduction in NOx emissions refers to the benefit associated to the mitigation of air pollution and its health effects. The pilot Thinking Fadura produces a reduction in NOx emissions due to people using fewer cars as a result of the built pathway in Fadura. As fewer cars will be used fewer NOx emissions are produced.

Reduction in NOx emissions was calculated as the product of the total km reduced and the NOx emissions per km (Eq. 4.13). The economic value was estimated by the use of the NOx externality value.

NOx reduction (€ / year) = Total km reduced (km / year) * NOx emissions per km (NOx kg / km) * NOx externality value (€ / NO2 kg) Eq. 4.13

NOx reduction (€ / year) = 2,383.9 (km / year) * 0.0004 (NOx kg / km) * 4.964 (€ / NOx kg) = 4.73 (€ / year)

The total number of kilometres reduced was estimated following Eq. 4.10.

NOx emissions per km (NOx kg / km)

NOx emissions per kilometre of car was estimated on the basis of the average emissions level of cars in the European Union. According to the European Environmental Agency, the average emissions level is around 0.4 grams of NOx per kilometre (EEA, 2017). Eq. 4.14 converts the units g per km into kg per km.

NOX emissions per km (NOX kg / km) = 0.400 (NOX g / km) * (NOX kg / 1,000 NOX g) = 0.0004 (NOX kg / km) Eq. 4.14

NO2 externality value (€ / NOx kg)

The valuation of NOx was based on the damage cost approach or the dose-response method. This method focuses on the quantification of the explicit impact that the emissions have on human health, environment and economic activity (Ricardo-AEA, 2014). Ricardo-AEA (2014) calculated the externality value of NOx in each EU country. In Spain the externality value used was €4,964 $(t\ NOx)^{-1}$ which equals to 4.964 (€ / NOx kg).

4.3.1.1.2. Sulphur dioxide (SO2) emissions reduction as a result of people using less cars

Reduction in SO2 emissions refers to the benefit associated to the mitigation of air pollution and its health effects. The pilot Thinking Fadura produces a reduction in SO2 emissions due to people using fewer cars as a result of the built pathway in Fadura. As fewer cars will be used fewer SO2 emissions are produced.

Reduction in SO2 emissions was calculated as the product of the total km reduced and the SO2 emissions per km (Eq. 4.15). The economic value was estimated by the use of the SO2 externality value.

SO2 reduction (€ / year) = Total km reduced (km / year) * SO2 emissions per km (SO2 kg / km) * SO2 externality value (€ / SO2 kg) Eq. 4.15

SO2 reduction (€ / year) = 2,383.9 (km / year) * 6.285714286 *1e-6 (SO2 kg / km) * 7.052 (€ / SO2 kg) = 0.11 (€ / year)

The total number of kilometres reduced was estimated following Eq. 4.10.

SO2 emissions per km (SO2 kg / km)

SO2 emissions per kilometre of car was estimated on the basis of the average emissions level of cars in the European Union. According to the European Environmental Agency, the average emissions level is around 0.00629 grams of SO2 per kilometre (EEA, 2017). Eq. 4.16 converts the units g per km into kg per km.

SO2 emissions per km (SO2 kg / km) = Car consumption (Fuel l / 100 km) / Density (Fuel l / Fuel kg) * SO2 concentration (SO2 kg / Fuel kg) Eq. 4.16

SO2 emissions per km (SO2 kg / km) = 0.055 (Fuel l / km) / 0.875 (Fuel l / Fuel kg) * 0.0001 (SO2 kg / Fuel kg) = 6.29 * 1e-6 (SO2 kg / km)

SO2 externality value (€ / SO2 kg)

The valuation of SO2 was based on the damage cost approach or the dose-response method. This method focuses on the quantification of the explicit impact that the emissions have on human health, environment and economic activity (Ricardo-AEA, 2014). Ricardo-AEA (2014) calculated the externality value of SO2 in each EU country. In Spain the externality value used was €7,052 (t SO2)$^{-1}$ which equals to 7.052 (€ / SO2 kg).

4.3.1.1.3. Particulate matter (PM) emissions reduction as a result of people using less cars

Reduction in PM emissions refers to the benefit associated to the mitigation of air pollution and its health effects. The pilot Thinking Fadura produces a reduction in PM emissions due to people using fewer cars as a result of the built pathway in Fadura. As fewer cars will be used fewer PM emissions are produced.

Reduction in PM emissions was calculated as the product of the total km reduced and the PM emissions per km (Eq. 4.17). The economic value was estimated by the use of the PM externality value.

PM reduction (€ / year) = Total km reduced (km / year) * PM emissions per km (PM kg / km) * PM externality value (€ / PM kg) Eq. 4.17

PM reduction (€ / year) = 2,383.9 (km / year) * 0.00002857 (PM kg / km) * 48.012 (€ / PM kg) = 3.27 (€ / year)

The total number of kilometres reduced was estimated following Eq. 4.10.

PM emissions per km (PM kg / km)

According to the European emission standards NOx limits in passenger cars are around 14 times greater than PM limits. This ratio was assumed to be similar to emissions. Hence **Eq. 4.18** was used to calculate PM emissions.

PM emissions per km (PM kg / km) = PM emissions per km (NOx kg / km) / 14 = 0.0004 / 14 = 0.00002857 (PM kg / km) Eq. 4.18

PM externality value (€ / PM kg)

The valuation of PM was based on the damage cost approach or the dose-response method. This method focuses on the quantification of the explicit impact that the emissions have on human health, environment and economic activity (Ricardo-AEA, 2014). Ricardo-AEA (2014) calculated the externality value of PM in each EU country. In Spain the externality value used was €48,012 (t PM)$^{-1}$ which equals to 48.012 (€ / PM kg).

4.3.1.2. Noise pollution reduction as a result of people using less cars

Noise emissions from traffic is health and environmental problem. Noise exposure disturbs people and can result in health impairments and lost productivity and leisure (Ricardo-AEA, 2014). Noise pollution problems are accentuated with urbanisation development, more individuals being exposed to traffic noise and an increase in traffic volume, higher noise levels.

Reduction in noise pollution refers to the health benefit due to people using fewer cars as a result of the built pathway in Fadura. As fewer cars will be used fewer noise pollution are produced.

Reduction in noise pollution was calculated as the product of the total km reduced and the noise pollution reduction externality value (Eq. 4.19).

Noise reduction (€ / year) = Total km reduced (km / year) * Noise externality value per km (€ / km) Eq. 4.19

Noise reduction (€ / year) = 2,383.9 (km / year) * 0.001325 (€ / km) = 3.16 (€ / year)

The total number of kilometres reduced was estimated following Eq. 4.10.

The valuation of the noise externality value per km was based on the bottom-up estimates of marginal noise costs from Delft et al. (2011). These values depend on the type of vehicle, type of traffic and population density exposed to the noise. These values for cars in suburban areas in the EU are the following:

- Suburban, Dense, Day: Noise externality value per km (€ / km) = 0.5 (€ / 1000 km)
- Suburban, Thin, Day: Noise externality value per km (€ / km) = 1.4 (€ / 1000 km)
- Suburban, Dense, Night: Noise externality value per km (€ / km) = 0.9 (€ / 1000 km)
- Suburban, Thin, Night: Noise externality value per km (€ / km) = 2.5 (€ / 1000 km)

In this study, the noise externality value per km (€ / km) was calculate as the average of the four values described above (Eq. 4.20):

Average Noise externality value per km (€ / km) = (0.5 + 1.4 + 0.9 + 2.5) / 4 = 1.325 (€ / 1000 km) = 0.001325 (€ / km) Eq. 4.20

4.3.1.3. Fuel savings as a result of people using less cars

Fuel savings refers to the economic benefit associated to a lower use of cars as a result of the built pathway in Fadura. As cars will be less used less money will be spent on fuel and people will save money for other purposes. The benefit fuel savings was calculated following Eq. 4.21.

Fuel savings (€ / year) = Total km reduced (km / year) * Proportion diesel cars (%) * Diesel consumption per km (diesel l / km) * Diesel price (€ / diesel l) + Total km reduced (km / year) * Proportion Gasoline cars (%) * Gasoline consumption per km (gasoline l / km) * Gasoline price (€ / gasoline l) Eq. 4.21

Fuel savings (€ / year) = 2,383.9 (km / year) * 67 (%) * 0.07 (diesel l / km) * 1.197 (€ / diesel l) + 2,383.9 (km / year) * 33 (%) * 0.08 (gasoline l / km) * 1.236 (€ / gasoline l) = 211.6 (€ / year)

The total number of kilometres reduced was estimated following Eq. 4.10.

Diesel cars

The considered proportion of diesel cars was 67% (Statista, 2019, according to the EU car sales). The diesel price assumed was 1.197 (€ / diesel l). Mean diesel consumption per km (diesel l / km) in Getxo was estimated to be 0.07 (l / km). It was calculated as the sum of official diesel consumption and the difference between official and real diesel consumption (Eq. 4.22):

Diesel consumption per km (diesel l / km) = Official diesel consumption (diesel l / km) + Difference between official and real diesel consumption (diesel l / km) Eq. 4.22

Diesel consumption per km (diesel l / km) = 0.046 (l / km) + 0.024 (l / km) = 0.07 (l / km)

Gasoline cars

The considered proportion of gasoline cars was 33% (Statista, 2019, according to the EU car sales). The gasoline price assumed was 1.236 (€ / gasoline l). Mean gasoline consumption per km (gasoline l / km) in Getxo was estimated to be 0.08 (l / km). It was calculated as the sum of official gasoline consumption and the difference between official and real gasoline consumption (Eq. 4.23):

Gasoline consumption per km (gasoline l / km) = Official gasoline consumption (gasoline l / km) + Difference between official and real gasoline consumption (gasoline l / km) Eq. 4.23

Gasoline consumption per km (gasoline l / km) = 0.055 (l / km) + 0.025 (l / km) = 0.08 (l / km)

4.3.1.4. Increased property value

Past research has demonstrated that people are willing to pay more for houses that are close to greenspaces and natural areas (Harnik and Welle, 2009; Rouwendal and van der Straaten, 2008). Since people's preferences are revealed in the willingness to pay for a higher rental and sale prices the increase in property values is a benefit that could be brought by the urban green space (Bianchini and Hewage, 2012).

The increase in property value as a result of an improved access to greenspaces was calculated following Eq. 4.24.

Increased property value (€) = Total number of houses affected (houses) * Price increase of houses (%) * Average price of houses (€ / house) Eq. 4.24

Increased property value (€) = 600 (houses) * 1 (%) * 344,134 (€ / house) = 2,064,804 (€)

Total number of houses affected (houses)

Some authors have found that the increase in property value decreases with distance away from the greenspaces. Harnik and Welle (2009) suggested that this effect can be measured up to around 700 metres from the green space, with the greatest value found within first 150 meters. In our study, it was considered that only those houses in a distance shorter than 200 meters would be benefited from the improved access to Fadura. This is explained due to Thinking Fadura does not provide new greenspaces it just improves accessibility an only in those houses very close to the Fadura the hedonic value would increase. Within the 200-meter distance, a total of 600 houses were counted.

Price increase of houses (%)

The price increase of houses was estimated based on the characteristics of Thinking Fadura and previous valuation studies. According to Bianchini and Hewage (2012), with greenspaces nearby, property values in urban areas could increase by 15-25% in general. Luttik (2000) concluded that with a view of open space, the house price would increase by 6-12%. In Thinking Fadura, only an increase in property value of 1% percent was considered. This is explained due to fact that the valuations in Bianchini and Hewage (2012) and Luttik (2000) were focused on the benefit of greenspaces and in the valuation of Thinking Fadura only improved accessibility to greenspaces was measured.

Average price of houses (€ / house)

The average price of the houses in a distance shorter than 200m was calculated from a state agency (www.idealista.com). 103 houses were found to be on sale in a distance shorter than 200m (see Figure 4.13). The average of the price of all houses within the state agency was calculated. The average was 344,134 (€ / house).

Figure 4.13: Houses considered to be affected by the improved accessibility to Fadura greenspaces (< 200 meters).

4.3.1.5. Physical activity

Regular physical activity decreases the risk of numerous diseases such as obesity, coronary heart disease, diabetes, mental ill health, and mortality (World Health Organization, 2009). Some authors have highlighted the potential of urban greenspaces such as parks, woodlands and beaches, to support and encourage regular outdoor physical activity (White et al., 2016; Hunter et al., 2015). Greenspaces offer opportunities for physical activity among people who, due to lack of time, money or confidence, are reluctant to participate in organised sports or gym-related activities (White et al., 2016; Schutzer and Graves, 2004; Withall et al., 2011).

Thinking Fadura will restore the pathway and provide access to the general public. Thus many people will use the pathway for making different types of physical activity such as jogging, walking or cycling. The increase in physical activity as a result of an improved access to greenspaces was calculated following Eq. 4.25.

Physical activity (€ / year) = Mean number of people increasing physical activity (people / year) * Mean amount of time doing physical activity (min / person in each visit) * Effect on QALY (QALY / min) * QALY value (€ / QALY) Eq. 4.25

Physical activity (€ / year) = 25818.99 (people / year) * 10 (min / person in each visit) * 6.844230769 * 10^-6 (QALY / min) * 22968.16 (€ / QALY) = 40587.29 (€ / year)

Mean number of people increasing physical activity (people / year)

The number of people increasing physical activity as a result of the restoration of the pathway and improved accessibility is crucial to determine the value of increased physical activity. The mean number of people increasing physical activity per year was calculated following Eq. 4.26.

Mean number of people increasing physical activity (people / year) = Mean number of people increasing physical activity (people / iSOPARC scan) / Mean time per iSOPARC scan (min / iSOPARC scan) * Mean time during the year for visits excluding rain (min / year) = 1.27 (people / iSOPARC scan) / 10 (min / iSOPARC scan) * 203299.16 (min / year) = 25818.99 (people / year) Eq. 4.26

Through the iSOPARC tool, the mean number of people increasing physical activity per scan was estimated (see section above on iSOPARC in Thinking Fadura). Subsequently, the mean time spent inside Fadura was estimated. Despite this variable being necessary for the calculations of the annual usage of the greenspaces it is not included in the iSOPARC tool. Thus the mean time spent inside Fadura was assumed to be 10 minutes per iSOPARC scan.

In order to calculate the number of people increasing physical activity per year is important to consider weather conditions since during bad weather is comprehensible that less people would use greenspaces. In this CBA, the time during rain events was excluded from the analysis. For doing so, the mean rain time during the year was calculated from the Euskalmet weather station in Getxo. The percentage of rain time was calculated from the measured hourly precipitation data and the mean time during the year for visits excluding rain was estimated following Eq. 4.27:

Mean time during the year for visits excluding rain = Mean annual time during the year for visits (min / year) * Mean percentage of time excluding rain (%) = 240,240 (min / year) * (1 – 0.1537664) = 203299.16 (min / year) Eq. 4.27

The mean available time for visits during the day (units: minutes / day) was calculated as the average between the mean time in summer and in winter (Eq. 4.28). Subsequently, the estimated mean annual time for visits during the day was converted on an annual basis (units: minutes / year) following Eq. 4.29:

Mean available time during the day for visits (min / day) = Average between summer and winter = (780 (min / day) + 540 (min / day)) / 2 = 660 (min / day) Eq. 4.28

Mean annual time during the day for visits (min / year) = 660 (min / day) * 365 (days / year) = 240,900 (min / year) Eq. 4.29

For the calculation of the mean time for visits during the day in summer, only daylight time was considered. It was assumed the time for visits in summer would start at 8 am and finish at 9 pm. Thus the estimation of the time during the day for visits in summer was calculated following Eq. 4.30:

Time during the day for visits summer = 13 (hours / day) = 13 * 60 (min / hour) = 780 (min / day) Eq. 4.30

For the calculation in winter, it was assumed the time for visits would start at 9 am and finish at 6 pm (Eq. 4.31).

Time during the day for visits winter = 9 (hours / day) = 9 * 60 (min / hour) = 540 (min / day) Eq. 4.31

Effect of physical activity on health

The potential health effect associated with the cumulative level of physical activity was estimated in terms of Quality Adjusted Life Years (QALYs) (Beale et al., 2012; White et al., 2016). According to the National Institute for Health and Care Excellence (NICE) in the United Kingdom, QALY is "a measure of the state of health of a person or group in which the benefits, in terms of length of life, are adjusted to reflect the quality of life. One QALY is equal to 1 year of life in perfect health."

In this analysis, we used QALY estimates derived by (Beale et al., 2007; Beale et al., 2012; White et al., 2016) which aimed to estimate the potential health benefits of greenspaces to promote physical activity. Beale et al. (2007) estimated that 30 min a week of moderate-intense physical activity during the whole year would be equivalent to 0.010677 QALYs per individual and year. Considering that 30 minutes a week of physical activity would be equivalent to 1,560 minutes a year, Eq. 4.32 shows how the effect of physical activity on QALYs was calculated

Effect on QALY = 0.010677 (QALY / year) / 1560 (min with moderate exercise / year) = 6.844230769 * 10^-6 (QALY / min) Eq. 4.32

QALY value (€ / QALY)

The final step in the calculation of the increased physical activity was to convert the health effect on monetary terms. The QALY is often used to evaluate the relative cost effectiveness of interventions by the National Institute for Health and Care Excellence (NICE). White et al. (2016) estimated the implicit social value of a QALY in England, based on the NICE cost-effectiveness threshold which was £20,000. This study converted that value in sterling pounds into euros in 2019. Thus the economic value of the QALY was € 22968.16.

4.3.1.6. Recreation

The recreation value of a natural ecosystems is usually associated with the direct use that individuals make of these natural assets (Mendes and Proença, 2005). In this assessment, the recreational value was estimated by the use of the travel cost method. The travel cost method assumes that the costs and time that people incur during a recreational trip to a 'natural resource' site can be used to infer the recreation value of that site. Briceno and Schundler (2015) estimated the recreation land use in Washington State. They estimated that the annual trip related visitor's expenditure for the public outdoor recreation land uses were about US$10.7 billion, including gas and oil, food and beverage, grocery, retail etc.

Thinking Fadura will restore the pathway and provide access to the general public. Thus, people will use the pathway for recreational purposes. This value was calculated following Eq. 4.33.

Recreation (€ / year) = Mean number of people (people / year) * Travel cost (walking) (€ / person) * Proportion of visitors (walking) (%) + Mean number of people (people / year) * Travel cost (cycling) (€ / person) * Proportion of visitors (cycling) (%) + Mean number of people (people / year) * Travel cost (driving) (€ / person) * Proportion of visitors (driving) (%) + Mean number of people (people / year) * Travel cost (public transport) (€ / person) * Proportion of visitors (public transport) (%) Eq. 4.33

Recreation (€ / year) = 47,677 (people / year) * 1.7 (€ / person) * 82.8 (%) + 47,677 (people / year) * 0.6 (€ / person) * 6.6 (%) + 47,677 (people / year) * 0.7 (€ / person) * 9.4 (%) + 47,677 (people / year) * 5 (€ / person) * 1.2 (%) = 74,580.8 (€ / year)

Mean number of users for recreation (people / year)

The mean number of users for recreation was estimated from the counting done by the hired company CPS. The time during the year during rain events was excluded from the analysis (Eq. 4.34).

Mean number of people (people / year) = Mean number of people (people / year during non-rain events) * Mean percentage of time excluding rain (%) = 56,340 (people / year) * (100% – 15.377%) = 47,677 (people / year) Eq. 4.34

Travel cost (€ / person)

Once the number of users for recreation was estimated the next step was to quantify the travel cost of the different types of users. The typology of users was based on the transport means to go to Fadura. Three main types of users were identified: people who go to Fadura on foot, by bicycle, by car and by public transport.

From the survey implemented in Fadura within the Inherit project, it was estimated that the proportion of visitors go to Fadura on foot, by bicycle, by car and by public transport were 82.8%, 6.6%, 9.4% and 1.2%, respectively.

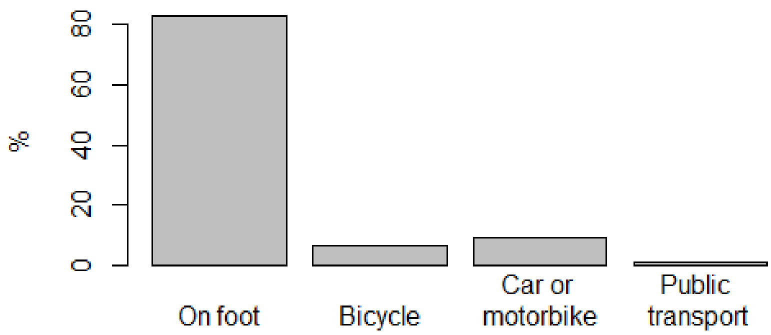


Figure 4.14. Proportion of transport means to visit the green areas of Fadura.

For the visitors that go to Fadura on foot, the travel cost was estimated following Eq. 4.35**.** From the Inherit survey in Fadura, the distance of each type of transport means (on foot, bicycle, car or motorbike and public transport) was estimated (see Table 4.8 and Table 4.9).

Table 4.8. Proportion of visitor's residence distance and transport means in the green areas of Fadura.

	Zone 1 (125 m)	Zone 2 (250 m)	Zone 3 (750 m)	Zone 4 (2000 m)
On foot	28.9%	14.8%	13.7%	25.4%
Bicycle	2.0%	0.4%	1.2%	3.1%
Car or motorbike	0.4%	0.4%	1.2%	7.4%
Public transport	0.0%	0.0%	0.0%	1.2%

Table 4.9. Proportion of visitor's residence distance and transport means in the green areas of Fadura.

	Zone 1 (125 m)	Zone 2 (250 m)	Zone 3 (750 m)	Zone 4 (2000 m)	Estimated mean distance (m)
On foot	35%	18%	17%	31%	848
Bicycle	29%	6%	18%	47%	1132
Car or motorbike	4%	4%	13%	79%	1698
Public transport	0%	0%	0%	100%	2000

The estimated mean distance for walkers was 0.848 km (Table 4.9). It was assumed a walking speed of 5 km per hour and a time opportunity cost of € 10 per hour (Gutiérrez-Domènech, 2008).

Travel cost (€ / person) = Mean distance (km / person) / Speed (km / h) * Time opportunity cost (€ / h) = 0.848 (km) / 5 (km / h) * 10 (€ / h) = 1.7 (€ / person) Eq. 4.35

For cyclists, the travel cost was estimated following Eq. 4.36. The estimated mean distance for cyclists was 1.132 km (Table 4.9). It was assumed a speed of 20 km per hour and a time opportunity cost of € 10 per hour (Gutiérrez-Domènech, 2008).

Travel cost (€ / person) = Mean distance (km / person) / Speed (km / h) * Time opportunity cost (€ / h) = 1.132 (km) / 20 (km / h) * 10 (€ / h) = 0.6 (€ / person) Eq. 4.36

For drivers, the travel cost was estimated following Eq. 4.37. The estimated mean distance for walkers was 1.698 km (Table 4.9). The mean number of people per car was assumed to be 1.5. It was assumed a speed of 30 km per hour and a time opportunity cost of € 10 per hour (Gutiérrez-Domènech, 2008).

Travel cost (€ / person) = Mean distance (km / person) / Speed (km / h) * Time opportunity cost (€ / h) + Fuel spent (€ / car) / Mean number of people per car (people / car) = 1.698 (km) / 30 (km / h) * 10 (€ / h) + 0.151 (€ / car) / 1.5 (people / car) = 0.7 (€ / person) Eq. 4.37

The calculation of the fuel spent per car followed Eq. 4.38:

Fuel spent (€ / car) = Distance per car (km / car) * Proportion diesel cars (%) * Diesel consumption per km (diesel l / km) * Diesel price (€ / diesel l) + Distance per car (km / year) * Proportion Gasoline cars (%) * Gasoline consumption per km (gasoline l / km) * Gasoline price (€ / gasoline l)

Fuel spent (€ / car) = 1.698 (km / car) * 67 (%) * 0.07 (diesel l / km) * 1.197 (€ / diesel l) + 1.698 (km / car) * 33 (%) * 0.08 (gasoline l / km) * 1.236 (€ / gasoline l) = 0.151 (€ / car) Eq. 4.38

For public transport users, the travel cost was estimated following Eq. 4.39. From the Inherit survey in Fadura, it was estimated that the mean time spent was 0.4 hours. A time opportunity cost of € 10 per hour was considered (Gutiérrez-Domènech, 2008).

Travel cost (€ / person) = Mean time spent (h / person) * Time opportunity cost (€ / h) + Bus ticket cost (€ / person) = 0.4 (h / person) * 10 (€ / h) + 1 (€ / person) = 5 (€ / person) Eq. 4.39

4.3.2. Costs

The following costs have been economically assessed in the CBA of the pilot Thinking Fadura:

- Traffic congestion during construction works
- Costs related to increase of recreation
    - CO_2 emission
    - Air pollution
    - Noise pollution
- Investment and maintenance costs

4.3.2.1. Slow traffic (congestion) during construction works

Construction works on the road have been considered as one of the major reasons for traffic congestion (Hsu, 2016; Transport Advisory Committee, 2014). The delayed amount of time depends on a large number of variables. For instance, while construction work has been estimated to cause traffic delay for two minutes in average in Nigeria (Atomode, 2013), more delay time is found in the US, where a traffic delay of 10-15 minutes has been found in New Jersey and Salt Lake City (McCann et al., 1999). This traffic delay represents a significant cost to the commuters and other drivers, in which time cost lost is the major concern.

The estimation of externality costs associated to the slow traffic during construction works is mainly affected by the total amount of the time delayed, the number of people affected and the time opportunity cost (Eq. 4.40).

Slow traffic (congestion) (€) = Average traffic delay (h) * Mean number of people per car (people / car) * Number of affected cars per day with construction works (car / day) * Number of days of slow traffic (days) * Time opportunity cost (€ / h) Eq. 4.40

Slow traffic (congestion) (€) = 0.01667 (h) * 1.5 (people / car) * 3388.24 (car / day) * 10 (days) * 10 (€ / h) = 8470.77 (€)

Since the construction works associated to Thinking Fadura were relatively small it was assumed that the average traffic delay would be one minute (0.01667 hours) during ten days of slow traffic. The mean number of people per car was obtained from the survey implemented in Fadura (1.5 people / car). A time opportunity cost of € 10 per hour was considered (Gutiérrez-Domènech, 2008).

Number of affected cars per day with construction works (car / day with construction works)

The number of cars per day with construction works was calculated following Eq. 4.41.

Number of cars per day with construction works (car / day with construction works) = Number of time slots in selected distance (time slot / day with construction works) * Mean presence of cars in selected distance (cars / time slot) = 338.824 (time slot / day with construction works) * 10 (cars / time slot) = 3388.24 (car / day with construction works) Eq. 4.41

Through the satellite view of Google Maps (Google), the distance on the road affected by the construction work was identified and the mean presence of cars in that distance was measured. Google Maps showed a mean of 10 cars in the selected distance (0.85 km). According to Google Maps it takes 1.4166667 minutes (0.0236111 hours) to drive by car the selected distance which is the mean time spent in the time slot. Since it was considered that the duration of the construction works was 8 hours per day, the number of time slots in the selected distance was calculated following Eq. 4.42:

Number of time slots in selected distance (time slots / day with construction works) = 8 (h / day with construction works) / 0.0236111 (h / time slot) = 338.824 (time slot / day with construction works) Eq. 4.42

4.3.2.2. CO2 emissions increase as a result of recreation

The increase of recreation activities can produce some negative externalities. Thus the increase in the number of visitors that go to Fadura by car can lead to an increase in CO2eq emissions. The increase in CO2eq emissions was calculated following the same equations as the ones described in the benefit 'Reduction in CO2eq emissions':

CO2 increase (€ / year) = Total km increased (km / year) * CO2 emissions per km (CO2 kg / km) * CO2 externality value (€ / CO2 kg)

CO2 increase (€ / year) = 5,073.2 (km / year) * 0.119 (CO2 kg / km) * 0.01475 (€ / CO2 kg) = 8.9 (€ / year) Eq. 4.43

The total number of kilometres increased as a result of an increase in the number of visitors was the only variable that differed. This was calculated as the product of the mean distance per car and the number of cars per year. From the Inherit survey in Fadura, it was estimated that the mean distance was 1.698 km, the mean number of people per car was 1.5 and the proportion of visitors that went to the green areas of Fadura by car was 9.4%. The mean number of people was 47,677 (see the calculations of the 'Recreation' benefit). The number of cars per year was calculated following Eq. 4.44:

Number of cars (cars / year) = Mean number of people (people / year) * Proportion of visitors that go to the green areas of Fadura by car (%) / Mean number of people per car (people / car) = 47,677 (people / year) * 9.4 (%) / 1.5 (people / car) = 2,987.8 (cars / year) Eq. 4.44

4.3.2.3. Increase in air pollutant emissions as a result of recreation

4.3.2.3.1. NOx emissions increase as a result of recreation

Other externality associated to the increase in the number of visitors by car is the increase in NOx emissions. The increase in NOx emissions was calculated following the same equations as the ones described in the benefit 'Reduction in NOx emissions' (Eq. 4.45). The calculation of the total number of kilometres by car increased as a result of recreation is shown in Eq. 4.44.

NOx increase (€ / year) = Total km increased (km / year) * NOx emissions per km (NOx kg / km) * NOx externality value (€ / NO2 kg)

NOx increase (€ / year) = 5,073.2 (km / year) * 0.0004 (NOx kg / km) * 4.964 (€ / NOx kg) = 10.1 (€ / year) Eq. 4.45

4.3.2.3.2. SO2 emissions increase as a result of recreation

An increase in SO_2 emissions was an externality associated to the increase in the number of visitors by car in Fadura. The increase in SO_2 emissions was calculated following the same equations as the ones described in the benefit ‘Reduction in SO_2 emissions’ (Eq. 4.46). The calculation of the total number of kilometres by car increased as a result of recreation is shown in Eq. 4.44.

SO2 increase (€ / year) = Total km increased (km / year) * SO2 emissions per km (SO2 kg / km) * SO2 externality value (€ / SO2 kg)

SO2 increase (€ / year) = 5,073.2 (km / year) * 6.285714286 *1e-6 (SO2 kg / km) * 7.052 (€ / SO2 kg) = 0.2 (€ / year)

Eq. 4.46

4.3.2.3.3. PM emissions increase as a result of recreation

An increase in PM emissions was an externality associated to the increase in the number of visitors by car in Fadura. The increase in PM emissions was calculated following the same equations as the ones described in the benefit ‘Reduction in PM emissions’ (Eq. 4.47). The calculation of the total number of kilometres by car increased as a result of recreation is shown in Eq. 4.44.

PM increase (€ / year) = Total km increased (km / year) * PM emissions per km (PM kg / km) * PM externality value (€ / PM kg)

PM increase (€ / year) = 5,073.2 (km / year) * 0.00002857 (PM kg / km) * 48.012 (€ / PM kg) = 7.0 (€ / year)

Eq. 4.47

4.3.2.4. Noise pollution increase as a result of recreation

An increase in noise pollution was an externality associated to the increase in the number of visitors by car in Fadura. The increase in noise pollution was calculated following the same equations as the ones described in the benefit Noise pollution reduction (Eq. 4.48). The calculation of the total number of kilometres by car increased as a result of recreation is shown in Eq. 4.44.

Noise increase (€ / year) = Total km increased (km / year) * Noise externality value per km (€ / km)

Noise increase (€ / year) = 5,073.2 (km / year) * 0.001325 (€ / km) =6.7 (€ / year)

Eq. 4.48

4.3.2.5. Initial investment and O&M

Thinking Fadura created an open public access park cohesive with the urban area and the Bolue wetland, allowing citizens to enjoy a natural environment linked to sport. The project supports the scenario of an open park by removing the perimeter limits and generating a sense of continuity and openness of the public park. Pedestrian accessibility to the park is guaranteed from all adjoining areas thanks to the projected entrances. The accessibility by bike is encouraged thanks to the proposal of safe parking for bicycles distributed throughout the park and, also, in the bike path (bidegorri) network that reaches the park by the street and crosses Fadura for its central zone.

The perimeter limits of this zone are eliminated in their entirety with the exception of the multipurpose court. The border between the sports facilities and the public park are defined by a wooden fence that provides some visibility and increases the feeling of opening the park without compromising security. Controlled access to sports facilities is solved by two zones: one will allow entry from the river park and the other, from the east of Fadura near the track. Sustainable mobility is guaranteed by access on foot from different areas and safe parking of bicycles and skates in the new building, next to the access from the east.

The planned actions of Thinking Fadura are:

- Build the walkway on both banks of the river for pedestrians and corridors with specific pavement for each use.
- Incorporate access to the riverbed.
- Build pedestrian paths inside the park that facilitate the flow of people and access to sports facilities and recreational and accommodation spaces.
- New urban furniture and fountains.
- Incorporate new vegetation to the park -the proposal must be agreed and finalised with URA in later phases-.
- Enable and delimit outdoor sports areas in different areas of the park.
- Install small areas of children's games integrated into the landscape related to sport distributed by different areas of the park.
- Enable two public restrooms.
- New lighting installation with environmental criteria of respect for fauna.
- Install a new signage at the entrances to the public park.
- Incorporate rainwater harvesting facility for park irrigation and sports facilities.

These actions produce initial investment costs and operation and maintenance costs. These costs include the urbanization of the roads on both banks of the river and throughout the public space, the urbanization of the new access to the main building and to a car parking located in the central area of Fadura, the intervention in the fenced area both to eliminate the current perimeter limits and to install the new ones, the conditioning of the outer slopes in the area of the present uncovered padel court, the expenses of renovation of furniture and outdoor lighting along the river walk and in the recreation areas. In addition, the replanting of the park and the adequacy of the land is also considered in the budget. The initial investment costs and operation and maintenance costs are summarised in Table 4.10:

Table 4.10. Initial investment costs, operation and maintenance costs in Thinking Fadura. Source: Thinking Fadura (2019)

Initial investment costs, operation and maintenance costs	**(€)**
Urbanization roads (wood)	-296,000
Urbanization roads (all one)	-100,000
Urbanization access main building	-102,000
Wood fencing (+ demolition)	-132,000
Conditioning outdoor tracks	-400,000
Furniture + lighting	-142,500
Vegetation	-20,000
Land adjustment (including parking)	-818,110

4.4. Cost-Benefit Assessment

Here, we present the summary of costs and benefits for 2 main scenarios of frequency of use. The frequency of use can have great impact on the estimated economic value of certain benefits. BC3 implemented a survey to count the number of users in Fadura. Nevertheless, at the time when the survey was implemented only around half of the green areas were opened. The other half remained closed to the public due to construction works. The fact that not all the green areas were open when the survey was implemented hinders the estimation of new visitors in Fadura as a result of the pilot Thinking Fadura. To have an idea of the number of new visitors, green areas users (in the "users survey") in Fadura were asked about their intention to come to the green areas once the total area will be opened to the general public. Around 72.6% of respondents stated that they would come to the park with the same current frequency, 25.6% would come with higher frequency and 0.8% with lower frequency (Figure 4.15). The difference between the percentage of respondents that would increase their frequency of use and those that would decrease it was 24.8%. This value indicated the percentage of respondents that would increase their frequency of use once the pilot will be fully open. Thus, the profitability of Thinking Fadura was evaluated under two scenarios:

- Scenario 1: based on number of users in Fadura park counted during the "users' survey" implemented in May 2019.
- Scenario 2: same number of users as in Scenario 1 + increased future frequency of use (Δ=+24.8% visits per year)

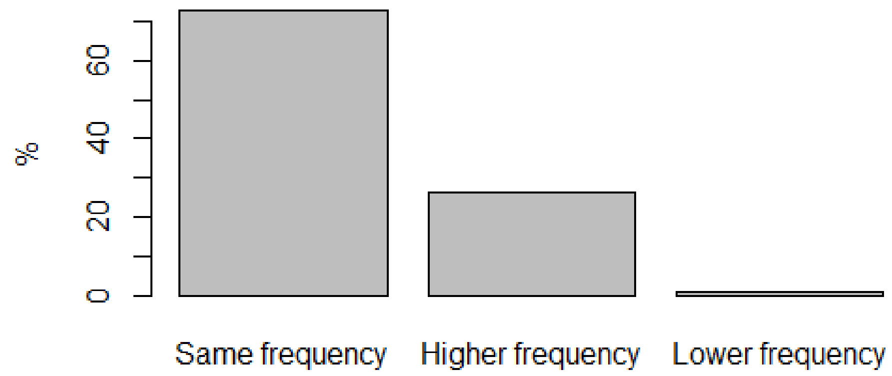


Figure 4.15. Changes in the frequency of visits per year in Fadura (% of users). The change compares when all green areas of Fadura will be opened with the situation when the survey was implemented (around half of the green areas were opened).

The CBA was conducted for a time horizon of 20 years and 3.5% discount rate. As shown, in both scenarios Thinking Fadura seems to be clearly beneficial (Figure 4.16). Whilst the first scenario shows a NPV of around € 1.2 million (IRR = 11.7%), the second scenarios has a NPV of € 1.7 million (IRR = 14.4%) (Table 4.12). The payback period in the first and second scenarios is 10.6 and 9.1 years, respectively. In Scenario 2, the number of users will increase by 24.8% and the NPV is 33.7% greater than the NPV in Scenario 1. This is explained by the great impact of the number of visitors in the economic value of the recreation and physical activity benefits.

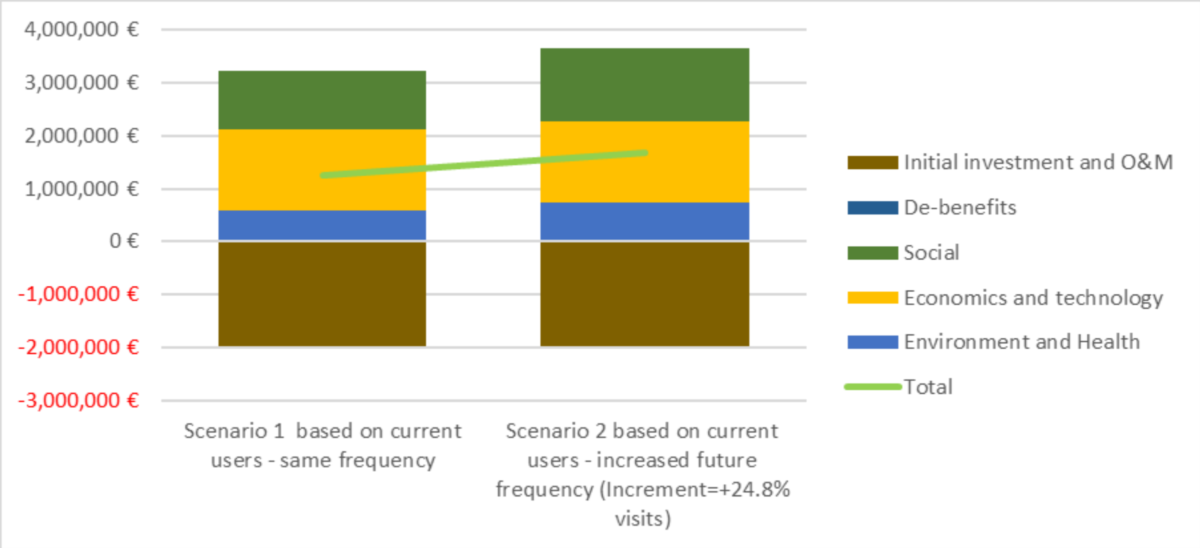


Figure 4.16. Net Present Value (NPV) results in Thinking Fadura. Time horizon and discount rate were 20 years and 3.5%, respectively.

Table 4.11 shows the discounted benefits, dis-benefits and costs. The highest benefits are the increased property value (around € 1.5 million) and recreation (around € 1.1 million in the first scenario) which are within the groups economics and technology and social, respectively. The highest dis-benefit was slow traffic (congestion) during construction works which was around € 8,000. Within the initial investment and O&M, the highest cost was land adjustment including parking (around € 0.8 million).

Table 4.11. Summary of Benefits, Dis-benefits, Costs of Thinking Fadura. Time horizon 20 years and discount rate 3.5%.

Summary	Benefits, Dis-benefits, Costs	**Scenario 1 based on current users - same frequency**		**Scenario 2 based on current users - increased future frequency (Δ=+24.8% visits/yr)**		**Relative change between scenarios 1 and 2**	
		Items (€)	**Group (€)**	**Items (€)**	**Group (€)**	**Items (%)**	**Group (%)**
Environment and Health	Reduction in CO2eq emissions	62 €	597,260 €	77 €	745,380 €	24.2%	24.8%
	Reduction in air pollutant emissions	119 €		149 €		25.2%	
	Reduction in noise pollution	46 €		58 €		26.1%	
	Physical activity	597,033 €		745,097 €		24.8%	
Economics and technology	Fuel savings	3,113 €	1,521,759 €	3,885 €	1,522,531 €	24.8%	
	House pricing	1,518,647 €		1,518,647 €		0.0%	
Social	Recreation	1,097,072 €	1,097,072 €	1,369,146 €	1,369,146 €	24.8%	24.8%
Dis-benefits	Slow traffic (congestion) during construction works	-8,187 €	-8,671 €	-8,187 €	-8,791 €	0.0%	1.4%
	Increase in CO2eq emissions for recreation	-131 €		-163 €		24.4%	
	Increase in air pollutant emissions for recreation	-254 €		-317 €		24.8%	
	Increase in noise pollution for recreation	-99 €		-123 €		24.2%	
Investment and O&M	Urbanization roads (wood)	-286,103 €	-1,959,591 €	-286,103 €	-1,959,591 €	0.0%	0.0%
	Urbanization roads (all one)	-96,656 €		-96,656 €		0.0%	
	Urbanization access main building	-98,590 €		-98,590 €		0.0%	
	Wood fencing (+ demolition)	-127,587 €		-127,587 €		0.0%	
	Conditioning outdoor tracks	-386,626 €		-386,626 €		0.0%	
	Furniture + lighting	-140,091 €		-140,091 €		0.0%	
	Vegetation	-19,662 €		-19,662 €		0.0%	
	Land adjustment (including parking)	-804,277 €		-804,277 €		0.0%	
Total		**1,247,829 €**	**1,247,829 €**	**1,668,675 €**	**1,668,675 €**	**33.7%**	**33.7%**

Table 4.12. Economic assessment of Thinking Fadura. Time horizon 20 years and discount rate 3.5%.

	Scenario 1 based on current users - same frequency	**Scenario 2 based on current users - increased future frequency (Δ=+24.8% visits)**
Discounted Benefits (€)	3,216,091 €	3,637,057 €
Discounted Costs (€)	1,968,262 €	1,968,382 €
Discounted Profitability (€)	1,247,829 €	1,668,675 €
Ratio B/C	1.63	1.85
IRR (%)	11.66%	14.38%
Payback Period (years)	10.56	9.12

4.5. Sensitivity analysis

Sensitivity analysis is normally used to assess the robustness of economic assessments by focusing on how uncertainty in the input parameters propagates through the overall analysis. Typically, the sources of uncertainty are derived from subjective judgements of the researcher such as assuming values of certain parameters in the CBA. In Thinking Fadura, four criteria or types of sources of uncertainty were evaluated in the sensitivity analysis:

- Discount rate: Three different discount rates were evaluated (0%, 3.5% and 10%)
- Time horizon: Three time horizons were included (10, 20 and 30 years)
- Assumed values for items with high uncertainty: These parameters are reported in Table 4.13. The value of these parameters can be taken from the literature (e.g. expected change in housing price due to increased accessibility of green areas), or from the expert knowledge of Fadura area (e.g. price of houses in the area, average traffic). By expert knowledge we mean information and data gathered about the areas, from available official databases, personal communications with the responsible local agent and in-situ assessments. Three scenarios were included in this criterion (-20%, 0% and +20% of the assumed value of the items with high uncertainty).
- Changes in future use: This criterion refers to the two scenarios described in the previous section (Scenario 1 and 2) in relation to the change in the frequency of visits per year in Fadura (% of users) when all green areas will be opened.

The four criteria led to a total of 54 distinct scenarios (3*3*3*2). In these 54 scenarios, the benefits, costs and profitability as well as their evolution throughout time were assessed in the sensitivity analysis. The full set of parameters used in the equations in Section 4.2 are reported in Annex 7.

Table 4.13. Items with highest uncertainty in the CBA of Thinking Fadura.

Items with high uncertainty	**Assumed values**
Average reduced distance (km / car)	5
Percentage of people walking or cycling instead of driving (%)	1%
Mean time per iSOPARC scan (min / iSOPARC scan)	10
Number of days of slow traffic (days)	10
Average traffic delay (h)	0.0167
Mean amount of time doing physical activity (min / person in each visit)	10
Price increase of houses (%)	1%

The discounted cumulative cash flow, benefits and costs in the evaluated 54 scenarios in the sensitivity analysis is shown in Figure 4.17. Whilst the black curve shows the selected scenario (discount rate = 3.5%, time horizon = 20 years, assumed values for items with high uncertainty = 0%, and changes in future use = 0%) the grey area indicates the confidence intervals estimated as the 5% and 95% percentiles of the calculated values in the 54 scenarios. The upper graph shows that from year 15 onwards Thinking Fadura seems to be profitable in most scenarios. The width of the grey area which indicates the range of variability, increases as the time horizon increases. Comparing the second and third graphs, it can be concluded that the estimated benefits seem to be more uncertain than the estimated costs since the width of the grey area is considerably higher.

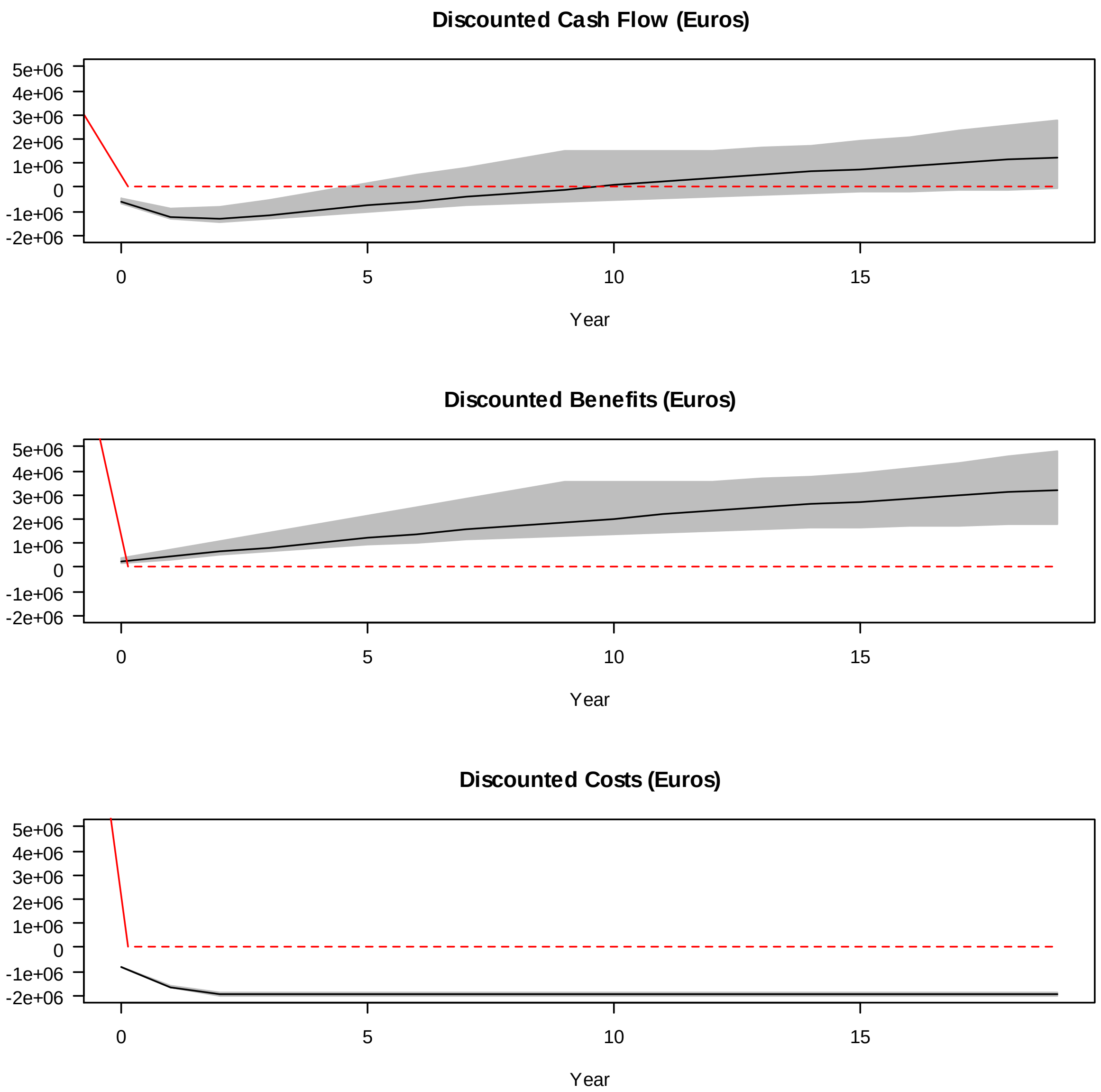


Figure 4.17. Discounted cumulative cash flow, benefits and costs in Thinking Fadura. Black curve shows the selected scenario (discount rate = 3.5%, time horizon = 20 years, Assumed values for items with high uncertainty = 0%, and Changes in future use = 0%). Grey area indicates the range of variability. Upper limit and lower limit of the grey area indicate percentile 5 and percentile 95 of the 54 evaluated scenarios in the sensitivity analysis. Red and dashed line indicates 0 euros.

Figure 4.18 shows the distribution of the values of the disaggregated benefits, costs and profitability (Total) in the 54 scenarios. As shown, physical activity, recreation and house pricing are the benefits that present the highest variability depending to the chosen scenario. The high variability in these three benefits is reflected subsequently in the total profitability which shows the NPV. The sensitivity analysis shows that the intervention was profitable (above 0 euros) in 52 scenarios (96.3% of the 54 scenarios). Thinking Fadura presented a negative NPV at 10% discount rate, time horizon of 20 years and/or 30 years, -20% of the assumed values for items with high uncertainty, and no increase in future use. For the remaining scenarios the NPV of the pilot was positive.

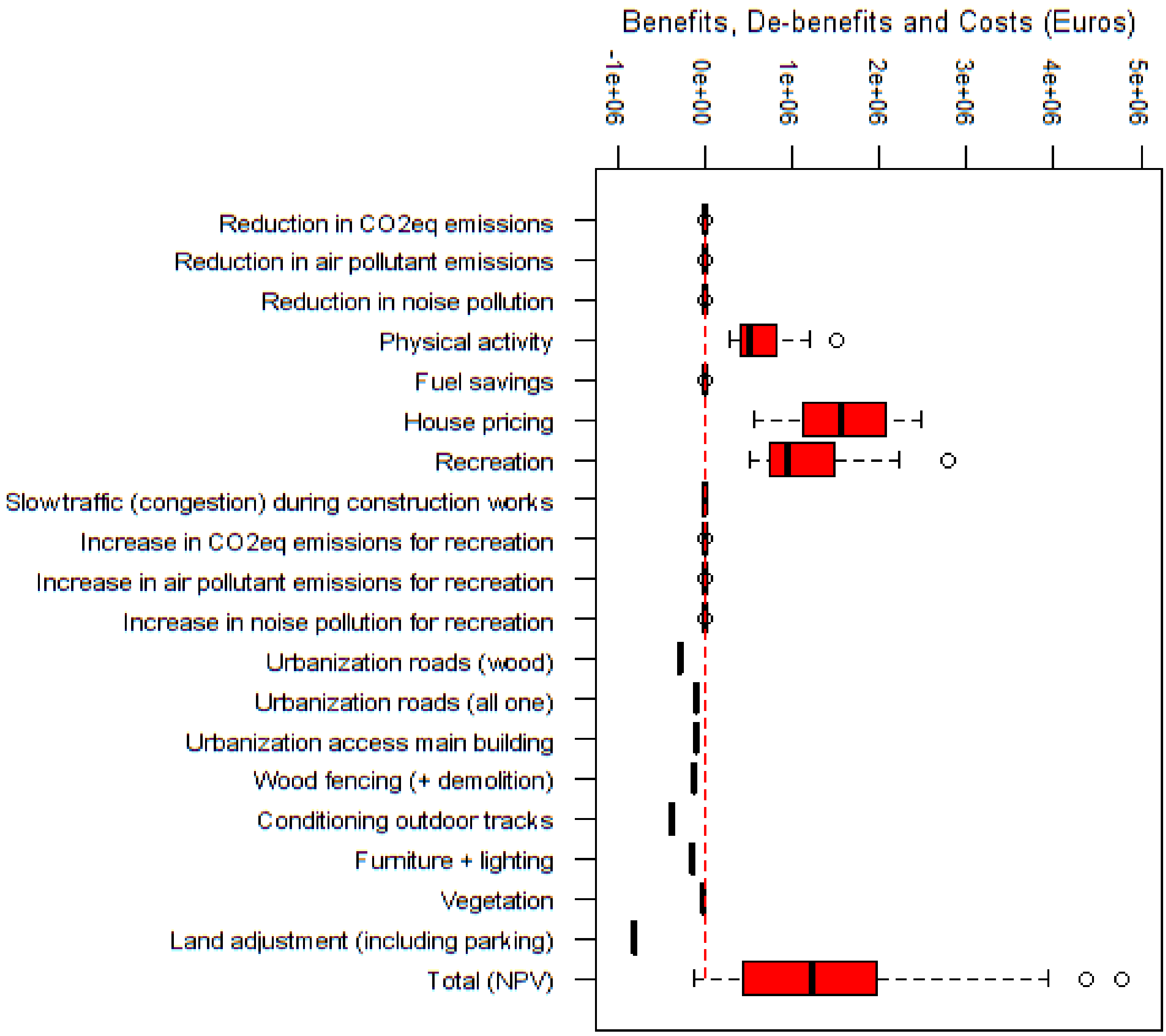


Figure 4.18. Distribution of the values of the disaggregated benefits, costs and profitability (Total) in Thinking Fadura. The horizontal lines in the boxes indicate the median values (percentile 50) of the 54 scenarios. The box limits indicate percentile 25 and 75. The whiskers are calculated as 1.5 times the interquartile range (Q3 –Q1). Circles indicate values out of the interquartile range (outliers). Red and dashed line indicates 0 euros.

Overall, the sensitivity analysis shows that the highest source of uncertainty in the CBA comes from the distinct values of the discount rates (0%, 3.5% and 10%), having an inverse relationship between profitability and discount rate. House pricing, recreation and physical activity which represent the highest benefits are notably influenced by the discount rate. The second highest source of uncertainty is the time horizon, and the third is the parameters' assumed values. Changes in future use had the least influence on total estimated NPV. This can be explained because it did not influence the house pricing benefit. Uncertainty can also be analysed by type of benefit. For example, changes in future use affects mainly recreational benefits (after discount rate and time horizon which have the highest impact), while uncertainty in CBA parameters affects mainly the house pricing, after discount rate.

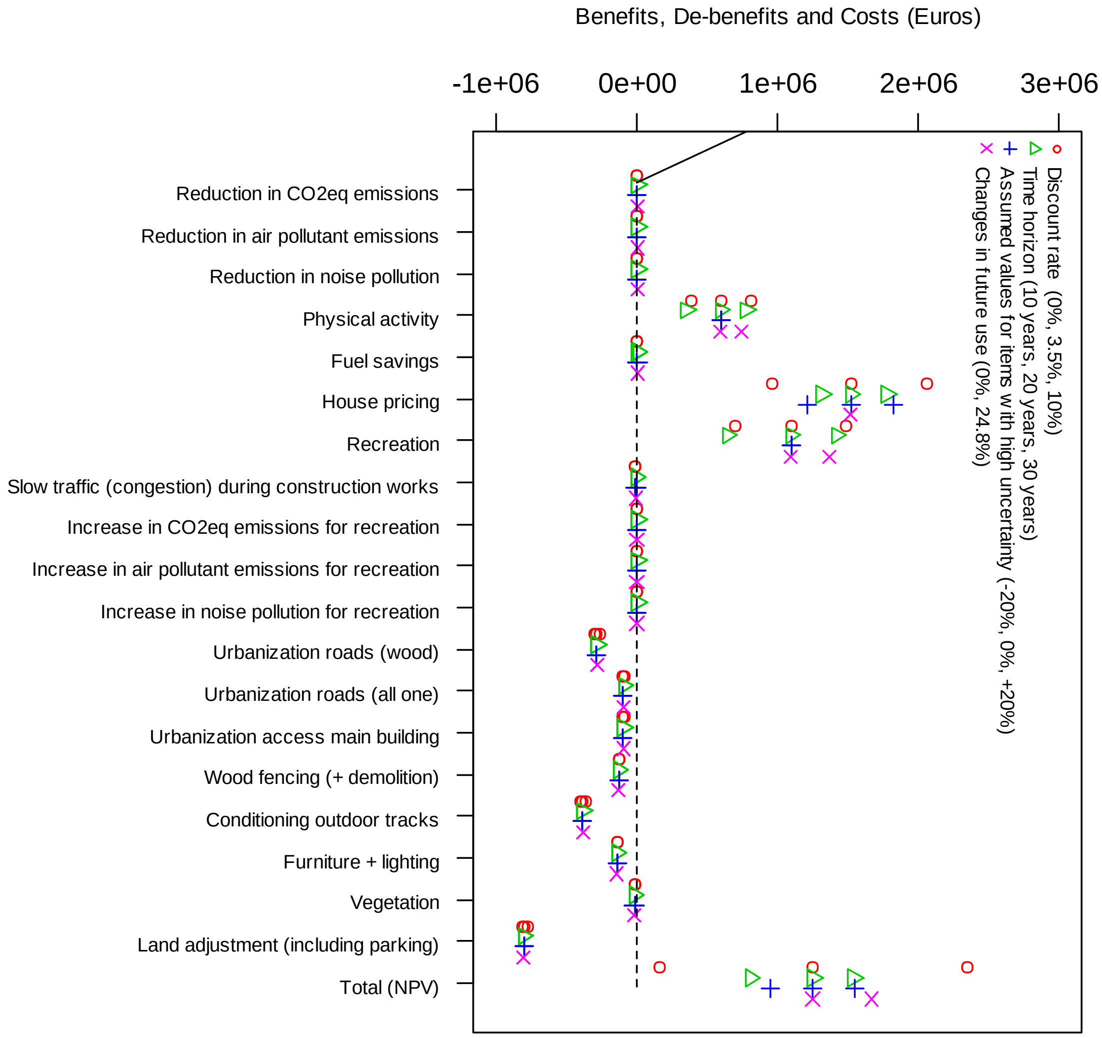


Figure 4.19. Cumulative discounted benefits, dis-benefits, costs and Net Present Value (NPV) in the different values of each source of uncertainty (Discount rate, Time horizon, Assumed values for items with high uncertainty and Changes in future use). Black and dashed line indicates 0 euros.

The influence of the items with high uncertainty on the NPV is shown separately for each item in Figure 4.20. Price increase of houses (%) and mean time per iSOPARC scan (min / iSOPARC scan) were the items that presented the highest influence on the NPV. Applying changes between -100% and +100% of the values utilised in the CBA, the results show that their influence on the NPV ranged from -121.7% to 121.7% for price increase of houses and from -23.9% to 191.4% for mean time per iSOPARC scan.

Therefore, it could be assumed that the profitability of Thinking Fadura is relatively sensitive to the values of these two items.

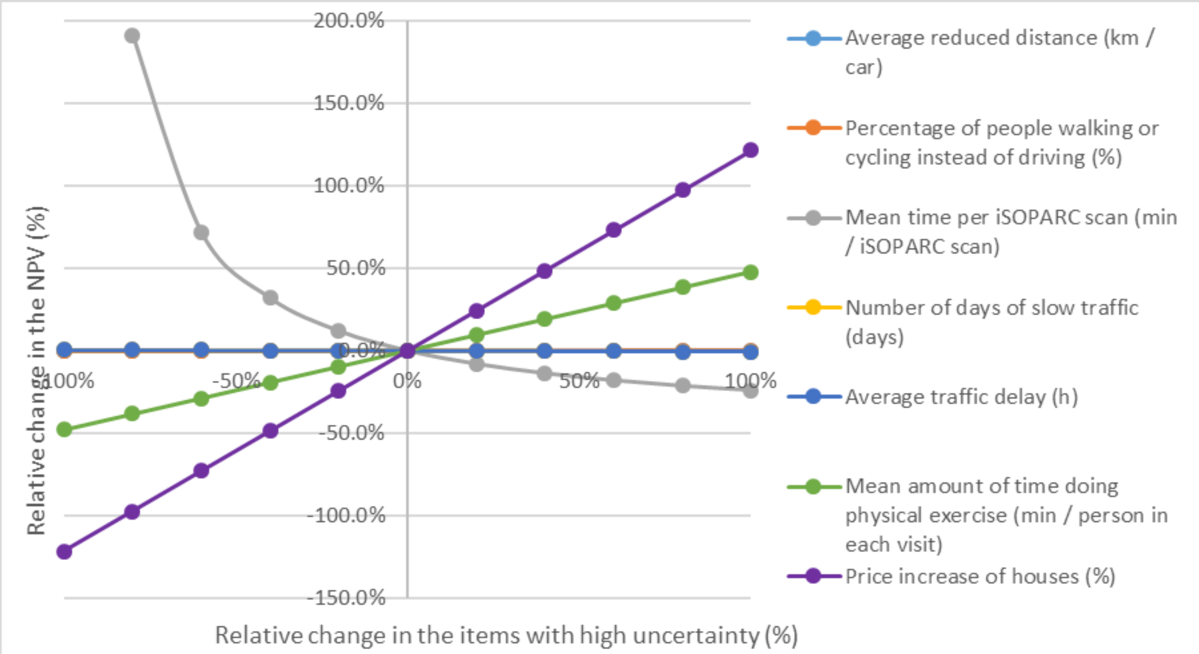


Figure 4.20. Variation in the Net Present Value (NPV) in the different items with high uncertainty.

4.6. Lessons learned

The CBA of Thinking Fadura can serve as a reference in the decision-making process. Both market and non-market costs and benefits were taken into account (on the basis of relevance and data availability of monetary metrics) to compute the NPV, B/C ratio, and the IRR to decide whether the Thinking Fadura project was considered as an acceptable and beneficial investment to the society. Most scenarios show a positive NPV (52 over the 54 scenarios produced), a B/C ratio greater than 1, and an IRR greater than the selected discount rate (3.5%). Based on these decision rules, the Thinking Fadura project is hence considered as economically feasible and profitable from a societal perspective.

In the selected scenario (discount rate = 3.5%, time horizon = 20 years, assumed values for items with high uncertainty = 0%, and changes in future use = 0%) the NPV is around € 1.2 million (IRR = 11.7%), and reaches 0 in 10.6 years. Starting from year 15 onwards Thinking Fadura seems to be profitable in most scenarios. This is in line with the existing literature, where for most projects related to green infrastructures, the discounted payback period often tends to extend to more than ten years (Valderrama et al., 2013; Ding et al., 2014). The highest benefits turned to be the increased property value (around € 1.5 million) and recreation (around € 1.1 million in the first scenario) which are within the groups economics and technology and social, respectively, followed by physical activity. The highest dis-benefit was slow traffic (congestion) during construction works which was around € 8,000 and the highest cost was land adjustment including parking (around € 0.8 million), within the group initial investment and operation and maintenance.

If we consider avoided mortality (section 4.2.2), the associated discounted benefits for immediate risk reduction are estimated in the range of 48-287 million Euro for the 30 years-time span, depending on the VSL reference value and discount rate. For delayed risk reduction (most conservative scenario), the corresponding discounted benefits are in the range of 17-194 million Euro for the same period.

The lower bound of “delayed” mortality benefits exceeds total discounted benefits estimated in Section 4.4 (=2.6-2.9 million euro excluding the health benefits of physical activity) by a factor of 6.5-5.8 on average over the 30 years-time span, depending on the scenario of frequency of use.

The approach of applying the VSL has been criticised by some studies in the literature on the basis that human life cannot be priced. Furthermore, the fact that it is grounded on the willingness to pay for a small risk reduction in statistical life has been questioned on the basis of the cognitive effort required. Nevertheless, this metric has been commonly used for valuing mortality benefits in environmental projects. For these reasons, the analysis over NPV and cash flow (Section 4.4) excludes mortality benefits in order to show the most conservative approach. However, under a scenario where avoided mortality is considered, using the VSL would lead to benefits largely overweighing all costs, and mortality reduction would dominate benefits under all scenarios.

The sensitivity analysis was carried out to test the significance of the variables to the NPV and to the economic value of the benefits, costs and dis-benefits. Four main sources of uncertainty were chosen (discount rate, time horizon, assumed values for items with high uncertainty and changes in future use), and the results show that the discount rate value had the greatest impact on the NPV, followed by the time horizon and input parameters. Increased property values and recreation were the variables more sensitive to these sources of uncertainty. It is not surprising that these two variables have the greatest influence to the NPV as they share the highest proportion among all the benefits in terms of present value.

The economic evaluation of Thinking Fadura could serve as a reference in the decision-making process in numerous European case studies. Firstly, there are numerous green urban areas in Europe where use is restricted to some sections of the population, which was the case of the sporting area of Fadura, where only members of the sporting club could use and enjoy the green areas. Furthermore, the case study of Fadura exemplifies how public sporting clubs can remove their fences and become accessible to the general public in order to increase societal usage of urban green areas. Thus the CBA presented here could be used to show the feasibility and profitability from a societal perspective of opening restricted green areas to the general public. Finally, we can complement these results with the perceptions of citizens on impacts generated by opening the park. We see that the majority of respondents in Getxo consider very positive impacts related to recreational activity and improved health, trees and biodiversity, improved accessibility to vulnerable groups and better connected community. While the increased value of house prices is considered very important by a lower percentage of respondents and some are even contemplating it as a negative impact (though a very low percent), in contrast with what we find in the economic assessment where the house pricing turns out to be the highest benefit. Trees and biodiversity have not been assessed, as in reality there will be very small changes in this respect in comparison with the baseline scenario of Fadura park. Improved accessibility to vulnerable groups and better connected community are intangible benefits which cannot be converted into monetary values, though they are key factors to consider for decision-making. Intangible costs, which cannot either be translated into a monetary impact, include security problems and dirt, teenager gathering for drinking, possible conflicts among users, and greater affluence of dogs.

As regards the overall methodological framework proposed, the main lessons acquired are summarised here below.

eDPSEEA conceptual framework

The eDPSEEA conceptual framework assisted the operationalization of the benefit assessment of the pilot Thinking Fadura, both for the quantitative (CBA) and qualitative perspective (citizens' survey). It supported the literature review taking into account the two perspectives of ecosystem and human health/wellbeing. It helped identifying which associations have been more addressed in the literature, supporting the discussion on contextual factors and exposure, as well as identifying where research gaps still exist for the assessment. It can be considered a good framework to facilitate communication among different expertise and to support the identification of key indicators for qualitative and quantitative assessment.

Modelling health benefits of green areas

The analysis based on the eDPSEEA model supported the development of an econometric model (the Heckman model) to assess the impacts of green areas on human health in a context of study heterogeneity occurring at different levels (methods, metrics for indicators), which complicates the task of comparing studies through a meta-analysis. The model allowed the identification of the factors influencing the significance of the relationship throughout existing studies and was applied in the Thinking Fadura case study as an exemplification of the benefit-transfer for mortality risks to other contexts. It was also used for simulating expected health risk reductions in relation to different levels of GDP per capita, thus considering the opportunity of green spaces to decrease health inequalities.

Results of the Heckman model show that, while diverse, studies in the literature tend to find a positive correlation between green spaces and health benefits, especially strong for high levels of exposure. One of the most significant conclusion extracted from this analysis is the relevance of contextual factors. The notion that different contexts yield different interconnections is supported by the results obtained, which pointed towards income, education, and urbanisation as possible factors affecting the results of the different studies. The results suggest that investment on green areas may be a strategy to alleviate health inequalities in poor areas. However, interventions may require important increases in green space available to obtain a certain level of health benefits.

We found that the Heckman model can be used to derive information on marginal health effects from exposure to green areas, which is then useful for benefit transfer. It has considered both significant and non-significant results of the literature which allows a better analysis of the relationship health-green areas. Among the limitations, we did not consider the quality and accessibility of green areas in a quantitative way in the CBA, but we limited the analysis to their availability. Future research could look at the quantification of exposure associated to different levels of accessibility/quality of the green areas. It might also build on the basic model developed in the current analysis to include more complex analysis based on more refined indicators reflecting exposure.

5. Malvik Path

5.1. Background

The Malvik path is a green space area with a 3-kilometer-long path along the coast in the municipality of Malvik, just outside the city of Trondheim, Norway. It is a public space that has contributed to transform the community's identity, and an example of how something old and unused can be turned into something useful and new. Originally the area was a disused railway-line, linking the former industrial area of Hommelvik to nearby areas. But the old railway trails hindered access to the sea and was just wasteland. So, in 2012 the process of adapting it into a cycle- and walking path started, initiated because the community inhabitants wanted it to happen. It was officially opened to the public in June 2016. It has become a destination and a public space valued by both inhabitants and visitors. Benches have been placed along the path, inviting people to take a rest and admire the scenery, and historical artefacts and information boards on historical event and the areas wildlife are being displayed here to provide a sense of the place in a wider context. Moreover, the path has been designed according to the principles for universal designed (defined by the Disability Act of 2005), meaning that the design and composition is so that it can be accessed and used by all people regardless of their age, size, ability or disability. Along the trail there are also designated places for fishing, swimming, barbequing and playing. People who like a more adventurous walk, can choose an alternative route that departs from the path and in to the surrounding forest area and hillside. Toilet facilities have recently been built at both ends of the path, and currently the municipal administration, together with developers, have started the construction of a park for children and families just where the path is starting (see Anthun et al. (2019) for more details).

The established path along the seaside is easily accessible, free of charge and universally designed. The plan is to investigate whether and how the path is beneficial for health, social inclusion and physical activity for all citizens of small, rural communities. The case study has several similarities with the Thinking Fadura case study. This is considered as an advantage in the cost-benefit analyses, as potential benefits of green space on citizen health in rural (Malvik Path) versus urban (Thinking Fadura) areas can be explored.

The main objectives of this case study are to provide knowledge on whether and how green spaces are beneficial for health, social inclusion and physical activity for all citizens of small, rural communities. To compare potential benefits of green space on citizen's health in rural (Malvik Path) and urban (Thinking Fadura) areas.

5.2. Data collection and calculation

This section describes the data used in the calculation of the benefits and costs of the Malvik Path case study.

5.2.1. Benefits

5.2.1.1. Reduction in CO2eq emissions

Malvik Path produces a reduction in CO2eq emissions due to people using fewer cars because of the built pathway in Malvik. It is expected that people who live in the surroundings of Malvik Path could sometimes walk through this new pathway instead of driving for short distances. Therefore, CO2 emissions levels may diminish.

Reduction in CO2 emissions was calculated as the product of the total km reduced and the CO2 emissions per km (Eq. 5.1). The economic value was estimated using the CO2 externality value.

CO2 reduction (€ / year) = Total km reduced (km / year) * CO2 emissions per km (CO2 kg / km) * CO2 externality value (€ / CO2 kg)

CO2 reduction (€ / year) = 2,018 (km / year) * 0.119 (CO2 kg / km) * 0.01475 (€ / CO2 kg) = 3.54 (€ / year) Eq. 5.1

Total km reduced (km / year)

The total number of kilometres reduced was estimated as the product of the reduced number of cars because of people walking instead of driving and the average distance (Eq. 5.2).

Total km reduced (km / year) = reduced number of cars (cars / year) * average reduced distance (km / car) Eq. 5.2

Total km reduced (km / year) = 403.6 (cars / year) * 5 (km / car) = 2,018 (km / year)

Reduced number of cars (cars / year)

The estimation of the reduced number of cars because of people walking instead of driving was calculated as the product of the number of new visitors in Malvik Path and the percentage of visitors who walk instead of driving (Eq. 5.3). The number of new visitors in Malvik Path was counted by the fix counter established in the path, it has been excluded 25% of visitors which is the percentage estimated of people who is walking to and from within a short time frame. Thus, the number of visitors will be 40360. The estimation of the percentage of visitors who walk instead of driving was done from the data obtained in the survey implemented in Malvik.

Reduced number of cars (cars / year) = Percentage of people walking instead of driving (%) * Mean number of people (people / year) / Number of people per car (people / car) Eq. 5.3

Reduced number of cars (cars / year) = 1 (%) * 40,360 (people / year) / 1 (people / car) = 403.6 (cars / year)

The average reduced distance including return trip was assumed to be 5 km per car. It was considered that when people needed to do long distances would use the car instead of walking.

CO2 emissions per km (CO2 kg / km)

CO2 emissions per kilometre of car was estimated based on the average emissions level of a new car sold in 2017. According to the European Environmental Agency, the average emissions level is 118.5 grams of CO2 per kilometre (for more details see, https://ec.europa.eu/clima/policies/transport/vehicles/cars_en). converts the units g per km into kg per kg

CO2 emissions per km (CO2 kg / km) = 118.5 (CO2 g / km) * 1 (CO2 kg / 1,000 CO2 g) = 0.119 (CO2 kg / km) Eq. 5.4

CO2 externality value (€ / CO2 kg)

The externality value of CO_2e was €14.75 (t $CO_2e)^{-1}$ (UK Department for Energy and Climate Change, DECC 2019). When converted to kilograms the CO2 externality value was 0.01475 (€ / CO2 kg).

5.2.1.2. NOx emissions reduction because of people using less cars

Malvik Path produces a reduction in NOx emissions due to the reduced cars use thanks to the building of the pathway in Malvik. As fewer cars will be used, fewer NOx emissions are produced.

Reduction in NOx emissions was calculated as the product of the total km reduced and the NOx emissions per km (Eq. 5.5). The economic value was estimated using the NOx externality value.

NOx reduction (€ / year) = Total km reduced (km / year) * NOx emissions per km (NOx kg / km) * NOx externality value (€ / NO2 kg)

NOx reduction (€ / year) = 2,018 (km / year) * 0.0004 (NOx kg / km) * 5.95 (€ / NOx kg) = 4.8 (€ / year) Eq. 5.5

The total number of kilometres reduced was estimated following Eq. 5.2.

NOx emissions per km (NOx kg / km)

According to the European Environmental Agency, the average emissions level is around 0.4 grams of NOx per kilometre (EEA, 2017). Eq. 5.6 converts the units g per km into kg per km.

NOX emissions per km (NOX kg / km) = 0.400 (NOX g / km) *1 (NOX kg / 1,000 NOX g) = 0.0004 (NOX kg / km) Eq. 5.6

NO2 externality value (€ / NO2 kg)

In the North Sea, which includes the Norwegian coast, the externality value used was €5,950 (t NOx)$^{-1}$ which equals to 5.95 (€ / NOx kg).

5.2.1.3. SO2 emissions reduction because of people using less cars

Malvik Path produces a reduction in SO2 emissions due to people using fewer cars because of the built pathway in Malvik. As fewer cars will be used fewer SO2 emissions are produced.

Reduction in SO2 emissions was calculated as the product of the total km reduced and the SO2 emissions per km (Eq. 5.7). The economic value was estimated using the SO2 externality value.

SO2 reduction (€ / year) = Total km reduced (km / year) * SO2 emissions per km (SO2 kg / km) * SO2 externality value (€ / SO2 kg)

SO2 reduction (€ / year) = 2,018 (km / year) * 6.285714286 *1e-6 (SO2 kg / km) * 7.6(€ / SO2 kg) = 0.096 (€ / year) Eq. 5.7

The total number of kilometres reduced was estimated following Eq. 5.2.

SO2 emissions per km (SO2 kg / km)

According to the European Environmental Agency, the average emissions level is around 0.00629 grams of SO2 per kilometre (EEA, 2017). Eq. 5.8 converts the units g per km into kg per km.

SO2 emissions per km (SO2 kg / km) = Car consumption (Fuel l / 100 km) / Density (Fuel l / Fuel kg) * SO2 concentration (SO2 kg / Fuel kg)

SO2 emissions per km (SO2 kg / km) = 0.055 (Fuel l / km) / 0.875 (Fuel l / Fuel kg) * 0.0001 (SO2 kg / Fuel kg) = 6.29 * 1e-6 (SO2 kg / km) Eq. 5.8

SO2 externality value (€ / SO2 kg)

In the North Sea, which includes the Norwegian coast, the externality value used was €7,600 (t SO2)$^{-1}$ which equals to 7.600 (€ / SO2 kg).

5.2.1.4. PM emissions reduction because of people using less cars

Malvik Path produces a reduction in PM emissions due to people using fewer cars because of the built pathway in Malvik.

Reduction in PM emissions was calculated as the product of the total km reduced and the PM emissions per km (Eq. 5.9). The economic value was estimated using the PM externality value.

PM reduction (€ / year) = Total km reduced (km / year) * PM emissions per km (PM kg / km) * PM externality value (€ / PM kg)

PM reduction (€ / year) = 2,018 (km / year) * 0.00002857 (PM kg / km) * 25.8 (€ / PM kg) = 1.49 (€ / year) Eq. 5.9

The total number of kilometres reduced was estimated following Eq. 5.2.

PM emissions per km (PM kg / km)

According to the European emission standards NOx limits in passenger cars are around 14 times greater than PM limits. This ratio was assumed to be like emissions (Eq. 5.10).

PM emissions per km (PM kg / km) = PM emissions per km (NOx kg / km) / 14 = 0.0004 / 14 = 0.00002857 (PM kg / km) Eq. 5.10

PM externality value (€ / PM kg)

In the North Sea, which includes the Norwegian coast, the externality value used was 25,800 ($€/t\ PM)^{-1}$ which equals to 25.8 (€ / kg PM).

5.2.1.5. Noise pollution reduction because of people using less cars

Reduction in noise pollution refers to the health benefit due to people using fewer cars because of the built pathway in Malvik. As fewer cars will be used there will be a noticeable reduction of the noise pollution.

Reduction in noise pollution was calculated as the product of the total km reduced and the noise pollution reduction externality value (Eq. 5.11).

Noise reduction (€ / year) = Total km reduced (km / year) * Noise externality value per km (€ / km)

Noise reduction (€ / year) = 2,018 (km / year) * 0.001325 (€ / km) =2.67 (€ / year) Eq. 5.11

The total number of kilometres reduced was estimated following Eq. 5.2.

The valuation of the noise externality value per km was based on the bottom-up estimates of marginal noise costs from Delft et al. (2011). These values depend on the type of vehicle, type of traffic and population density exposed to the noise. These values for cars in suburban areas in the EU are the following:

- Suburban, Dense, Day: Noise externality value per km (€ / km) = 0.5 (€ / 1000 km)
- Suburban, Thin, Day: Noise externality value per km (€ / km) = 1.4 (€ / 1000 km)
- Suburban, Dense, Night: Noise externality value per km (€ / km) = 0.9 (€ / 1000 km)
- Suburban, Thin, Night: Noise externality value per km (€ / km) = 2.5 (€ / 1000 km)

In this study, the noise externality value per km (€ / km) was calculated as the average of the four values described above (Eq. 5.12):

Average Noise externality value per km (€ / km) = (0.5 + 1.4 + 0.9 + 2.5)/4 = 1.325 (€ / 1000 km) = 0.001325 (€ / km) Eq. 5.12

5.2.1.6. Fuel savings because of people using less cars

Fuel savings refers to the economic benefit associated to a lower use of cars because of the built pathway in Malvik. As cars will be less used less money will be spent on fuel and people will save money for other purposes. The benefit fuel savings was calculated following Eq. 5.13.

Fuel savings (€ / year) = Total km reduced (km / year) * Proportion diesel cars (%) * Diesel consumption per km (diesel l / km) * Diesel price (€ / diesel l) + Total km reduced (km / year) * Proportion Gasoline cars (%) * Gasoline consumption per km (gasoline l / km) * Gasoline price (€ / gasoline l)+ Total km reduced (km / year) * Proportion electric cars (%) * Electricity consumption per km (KWh / km) * Electricity price (€ / KWh) Eq. 5.13

Fuel savings (€ / year) = 2,018 (km / year) * 17.75 (%) * 0.07 (diesel l / km) * 1.6 (€ / diesel l) + 2,018 (km / year) * 22.04 (%) * 0.08 (gasoline l / km) * 1.66 (€ / gasoline l) + 2,018 (km / year) * 31.16 (%) * 0.16 (KWh / km) * 0.1 (€ / KWh) = 109.24 (€ / year)

The total number of kilometres reduced was estimated following Eq. 5.2.

Diesel cars

The considered proportion of diesel cars was 17.75% (Statista, 2019, Norway: sales share of cars by fuel type 2017-2018). The diesel price assumed was 1.6 (€ / diesel l). Mean diesel consumption per km (diesel l / km) in Malvik was estimated to be 0.07 (l / km). It was calculated as the sum of official diesel consumption and the difference between official and real diesel consumption (Eq. 5.14):

Diesel consumption per km (diesel l / km) = Official diesel consumption (diesel l / km) + Difference between official and real diesel consumption (diesel l / km) Eq. 5.14

Diesel consumption per km (diesel l / km) = 0.046 (l / km) + 0.024 (l / km) = 0.07 (l / km)

Gasoline cars

The considered proportion of gasoline cars was 22.04% (Statista, 2019, Norway: sales share of cars by fuel type 2017-2018). The gasoline price assumed was 1.66 (€ / gasoline l). Mean gasoline consumption per km (gasoline l / km) in Malvik was estimated to be 0.08 (l / km). It was calculated as the sum of official gasoline consumption and the difference between official and real gasoline consumption (Eq. 5.15):

Gasoline consumption per km (gasoline l / km) = Official gasoline consumption (gasoline l / km) + Difference between official and real gasoline consumption (gasoline l / km) Eq. 5.15

Gasoline consumption per km (gasoline l / km) = 0.055 (l / km) + 0.025 (l / km) = 0.08 (l / km)

Electric cars

More than 30% of cars sale in Norway are electric cars (Statista, 2019, Norway: sales share of cars by fuel type 2017-2018), a figure that is expected to continue to increase. The electricity price assumed was 0.1(€/kwh). Mean electricity consumption per km in Malvik was estimated to be 0.16 (KWh/km).

Electricity saving (€ / year) = Total km reduced (km / year) * Proportion electric cars (%) * Electricity consumption per km (KWh / km) * Electricity price (€/KWh)

Electricity saving (€ / year) = 2,690.7 (km / year) * 31.16 (%) * 0.16 (KWh / km) * 0.1 (€ / KWh) =13.41 (€/KWh)

5.2.1.7. Increased property value

The increase in property value because of an improved access to greenspaces was calculated following Eq. 5.16.

Increased property value (€) = Total number of houses affected (houses) * Price increase of houses (%) * Average price of houses (€ / house) Eq. 5.16

Increased property value (€) = 278 (houses) * 5 (%) * 391,645 (€ / house) = 5,443,865.5 (€)

Total number of houses affected

In our study, it was considered that only those houses very close to the path would benefit from the improved access to Malvik Path. This is explained due to Malvik Path does not provide new greenspaces it just improves accessibility and only in certain houses the hedonic value would increase. A total of 278 houses were counted.

Figure 5.1. Houses considered to be affected by the improved accessibility to Malvik greenspaces.

Price increase of houses (%)

The price increase of houses was estimated based on the characteristics of Malvik Path and previous valuation studies.

In Malvik Path, an increase in property value of 5% percent is expected to achieve, according to the information offered by a local estate agent. Although this increase may not be the same for all the houses close to the path, the increase in property value could change depending on the distance to the path, Figure 5.2 shows an array of possibilities.

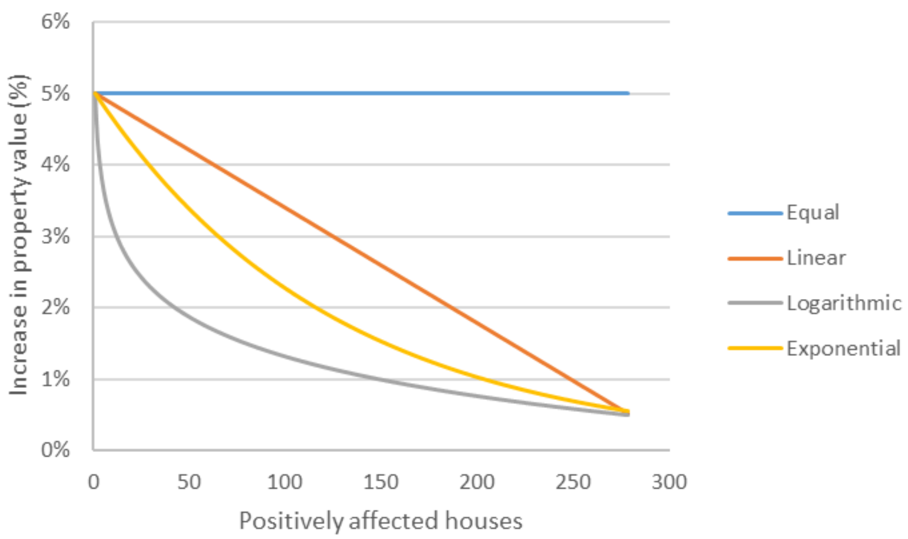


Figure 5.2. Percentage of increase in property value and positively affected houses.

This Figure shows that as the number of positively affected houses increases, the percentage of property value could be the same (equal) or decrease as it is possible to observe in the rest of situations. Depending on the proportion used in each case, the benefits of Increased property value will be different. This is analysed in the sensitivity analysis.

Another approach to determinate the proportion of houses affected by the greenspace is using sections. In this study, it is possible to assume that a few houses will increase their value by 5%or by 0.5% (the highest and lowest value). Most of houses will be increased in value by between 4% and 1%. Figure 5.3 shows an estimation of houses affected by sections, so the closer the house is to the path, the higher percentage increase in value it will have.

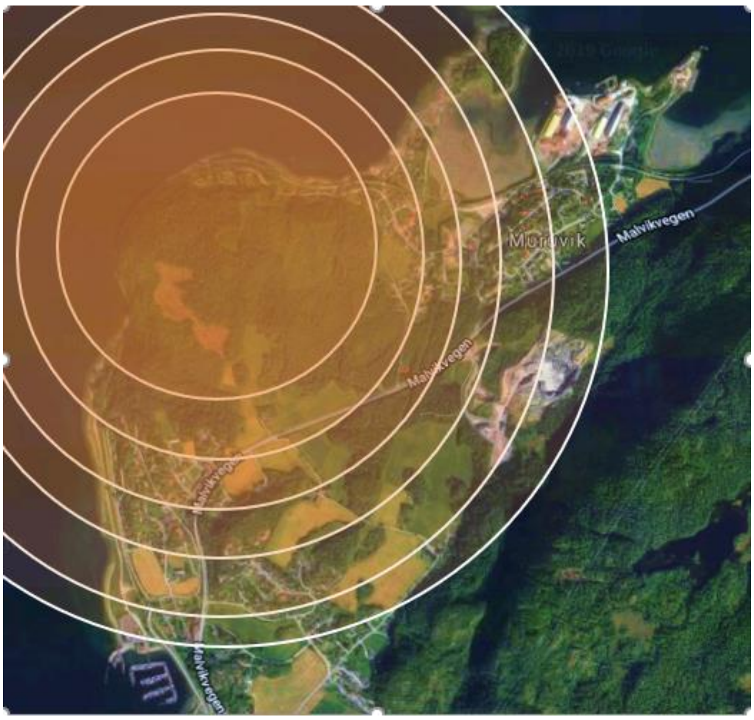


Figure 5.3. Estimation of houses affected by sections.

Average price of houses (€ / house)

According to the national statistical institute of Norway, the average square metres usable area of housing in Malvik is 145 m2. Also, considering the information offered by a local estate agent, the average price of house is 2701 € per square metre. Thus, the average price of a house in Malvik is 391,645€.

5.2.1.8. Physical activity

Malvik Path is a pathway which provides access to the public. Thus, many people are using the pathway for different types of physical activity such as jogging, walking or cycling. The increase in physical activity because of an improved access to greenspaces was calculated following Eq. 5.17.

Physical activity (€ / year) = Mean number of people increasing physical activity (people / year) * Mean amount of time doing physical activity (min / person in each visit) * Effect on QALY (QALY / min) * QALY value (€ / QALY) Eq. 5.17

Physical activity (€ / year) = 24,619 (people / year) * 30 (min / person in each visit) * 6.844230769 * 10^-6 (QALY / min) * 22968.16 (€ / QALY) = 116,102.75 (€ / year)

To calculate the mean number of people increasing physical activity, it was necessary to collect some information about the use of the path.

According to the data generated by a digital counter, placed half way along the path that registers the number of passing per day, the total number estimated of people who visited, in 2018, Malvik path was 40,360.

Malvik Path covers an extension of 3 km along the seaside and is divided in three areas (Figure 5.4).

- Target area 1: Hommelvik. It is the starting point for the path, it is a stretch of the road surrounded by nature which grows naturally.
- Target area 2: Muruvik. It is the end of the path and a very popular area with the locals.
- Target area 3: Beach area. It is an area for a varied set of activities like swimming, climbing, or sun- bathing.

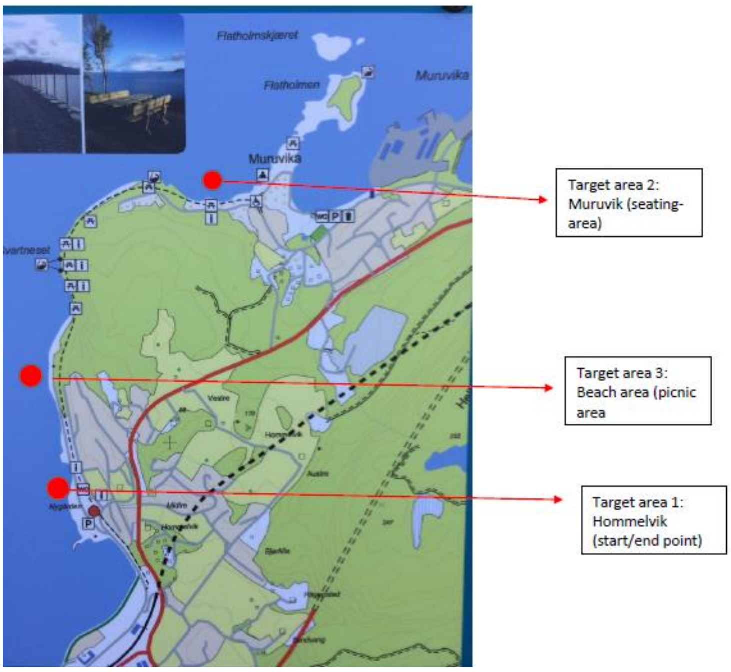


Figure 5.4. Target areas in the iSOPARC assessment in Malvik Path.

According to the information gathered by the iSOPARC, Table 5.1 shows an activity type description in each area of Malvik Path.

Table 5.1. Activity Type description (primary activity).

Description/Name			Frequency	Percent	Valid Percent	Cumulative Percent
Beach area	Valid	NO ACTIVITY	45	68.2	68.2	68.2
		Picnicking (food involved)	2	3.0	3.0	71.2
		Sitting	11	16.7	16.7	87.9
		Standing	2	3.0	3.0	90.9
		Walking	6	9.1	9.1	100.0
		Total	66	100.0	100.0	
Hommelvik starting point	Valid	Jogging/running	13	25.0	25.0	25.0
		Jogging/Running	3	5.8	5.8	30.8
		NO ACTIVITY	3	5.8	5.8	36.5
		Walking	33	63.5	63.5	100.0
		Total	52	100.0	100.0	
Muruvik starting point	Valid	Jogging/running	9	19.6	19.6	19.6
		Jogging/Running	2	4.3	4.3	23.9
		NO ACTIVITY	1	2.2	2.2	26.1
		Walking	34	73.9	73.9	100.0
		Total	46	100.0	100.0	

Based on this data, it is possible to estimate that 45% of visitors use the parkland to engage in moderate intensity activities (i.e. walking), 16% of people engage in vigorous activities (i.e. running and cycling) and the rest engaged in further activities, such as picnic. The majority of the relaxing activities were observed in the beach area. As a result, it is possible to determinate that the percentage of people doing moderate to vigorous intensity physical activity was 61% of visitors.

In accordance with the results obtained, it was possible to calculate the mean number of people increasing physical activity, calculated following Eq. 5.18:

Mean number of people increasing physical activity (people / year) = Total number of visitors (people / year) * Percentage of people doing physical activity (%) Eq. 5.18

Physical activity (€ / year) = 40,360 (people / year) * 61 (%) = 24,619 (people / year)

On the other hand, the World Health Organization (WHO, 2010) stipulates that adults should do 150 minutes per week of moderate- intensity activity, in order to improve cardiorespiratory and muscular fitness, bone health and reduce risk of depression. Based on this information it has been determined that 30 min per visit in Malvik Path it is an appropriated period of time during 5 days per week.

Effect of physical activity on health

Beale et al. (2007) estimated that 30 min a week of moderate-intense physical activity during the whole year would be equivalent to 0.010677 QALYs per individual and year. Considering that 30 minutes a week of physical activity would be equivalent to 1,560 minutes a year, Eq. 5.19 shows how the effect of physical activity on QALYs was calculated:

Effect on QALY = 0.010677 (QALY / year) / 1560 (min of moderate physical activity / year) = 6.844230769 * 10^-6 (QALY / min) Eq. 5.19

QALY value (€ / QALY)

White et al. (2016) estimated the implicit social value of a QALY in England, based on the NICE cost-effectiveness threshold which was £20,000. This study converted that value in sterling pounds into euros in 2019. Thus, the economic value of the QALY was €22,968.16.

5.2.1.9. Recreation

In this assessment, the recreational value was estimated by the use of the travel cost method. Malvik Path is a pathway providing access to the public. Thus, people are also using it for recreational purposes. This value was calculated following Eq. 5.20.

Recreation (€ / year) = Mean number of people (people / year) * Travel cost (walking) (€ / person) * Proportion of visitors (walking) (%) + Mean number of people (people / year) * Travel cost (cycling) (€ / person) * Proportion of visitors (cycling) (%) + Mean number of people (people / year) * Travel cost (driving) (€ / person) * Proportion of visitors (driving) (%) + Mean number of people (people / year) * Travel cost (public transport) (€ / person) * Proportion of visitors (public transport) (%) Eq. 5.20

Recreation (€ / year) = 40,360 (people / year) * 2 (€ / person) * 70 (%) + 40,360 (people / year) * 2.5 (€ / person) * 12.5 (%) + 40,360 (people / year) * 2.86 (€ / person) * 12.5 (%) + 40,360 (people / year) * 7.89 (€ / person) * 5 (%) = 99,467.22 (€ / year)

As specified above, the number of visitors, in 2018, in Malvik Path was 40,360.

Travel cost (€ / person)

Once the number of users for recreation has been detailed, the next step was to quantify the travel cost of the different types of users. The typology of users was based on the mean of transport to reach the Malvik Path. Four main types of users were identified: on foot, by bicycle, by car and by public transport.

From the population survey and interview data from interview conducted on the path, it was estimated that the proportion of visitors go to Malvik Path on foot, by bicycle, by car and by public transport were 70%, 12.5%, 12.5% and 5%, respectively.

For the visitors that go to Malvik Path on foot, the travel cost was estimated following Eq. 5.21. It was estimated that the mean distance was 1km. It was assumed a walking speed of 5km per hour and a time opportunity cost of € 0 per hour (Gutiérrez-Domènech, 2008).

Travel cost (€ / person) = Mean distance (km / person) / Speed (km / h) * Time opportunity cost (€ / h) = 1 (km) / 5 (km / h) * 10 (€ / h) = 2 (€ / person) Eq. 5.21

For the visitors who reached the Malvik Path by bicycle, the travel cost was estimated following Eq. 5.22. It was estimated that the mean distance was 5km. It was assumed a speed of 20km per hour and a time opportunity cost of €10 per hour (Gutiérrez-Domènech, 2008).

Travel cost (€ / person) = Mean distance (km / person) / Speed (km / h) * Time opportunity cost (€ / h) = 5 (km) / 20 (km / h) * 10 (€ / h) = 2.5 (€ / person) Eq. 5.22

For the visitors who reached the Malvik Path by car, the travel cost was estimated following Eq. 5.23. It was estimated that the mean distance was 10km and the mean number of people per car was 1.5. It was assumed a speed of 40km per hour and a time opportunity cost of €10 per hour (Gutiérrez-Domènech, 2008).

Travel cost (€ / person) = Mean distance (km / person) / Speed (km / h) * Time opportunity cost (€ / h) + Fuel spent (€ / car) / Mean number of people per car (people / car) = 10 (km) / 40 (km / h) * 10 (€ / h) + 0.5413 (€ / car) / 1.5 (people / car) = 2.86 (€ / person) Eq. 5.23

The calculation of the fuel spent per car followed Eq. 5.24:

Fuel spent (€ / car) = Distance per car (km / car) * Proportion diesel cars (%) * Diesel consumption per km (diesel l / km) * Diesel price (€ / diesel l) + Distance per car (km / year) * Proportion Gasoline cars (%) * Gasoline consumption per km (gasoline l / km) * Gasoline price (€ / gasoline l) + Distance per car (km / car) * Proportion electric cars (%) * Electricity consumption per km (Kwh l / km) * Electricity price (€ / Kwh l) Eq. 5.24

Fuel spent (€ / car) = 10 (km / car) * 17.75 (%) * 0.07 (diesel l / km) * 1.6 (€ / diesel l) + 10 (km / car) * 22.04 (%) * 0.08 (gasoline l / km) * 1.66 (€ / gasoline l) + 10 (km / car) * 31.16 (%) * 0.16 (Kwh l / km) * 0.1 (€ / Kwh l) = 0.5413 (€ / car)

For the visitors that go to Malvik by public transport, the travel cost was estimated following Eq. 5.25. It was estimated that the mean time spent was 0.4 hours. A time opportunity cost of €10 per hour was considered (Gutiérrez-Domènech, 2008). According to AtB, a mobility company who administrates the public transport in Trøndelag, the bus ticket costs 38 NOK which is 3.89€

Travel cost (€ / person) = Mean time spent (h / person) * Time opportunity cost (€ / h) + Bus ticket cost (€ / person) = 0.4 (h / person) * 10 (€ / h) + 3.89 (€ / person) = 7.89 (€ / person) Eq. 5.25

5.2.2. Dis-benefits and Costs

5.2.2.1. Slow traffic (congestion) during construction works

In this case, the vehicles which works in the construction of the path mainly used the disused rail track, therefore, the local traffic was not affected in a negative way.

5.2.2.2. CO_2 emissions increase as a result of recreation

The increase in the number of visitors that go to Malvik Path by car can lead to an increase in CO2eq emissions. The increase in CO2eq emissions was calculated following the same equations as the ones described in the benefit 'Reduction in CO2eq emissions':

CO2 increase (€ / year) = Total km increased (km / year) * CO2 emissions per km (CO2 kg / km) * CO2 externality value (€ / CO2 kg)

CO2 increase (€ / year) = 33,633 (km / year) * 0.119 (CO2 kg / km) * 0.01475 (€ / CO2 kg) = 59.03 (€ / year) Eq. 5.26

The total number of kilometres increased as a result of an increase in the number of visitors was the only variable that differed. This was calculated as the product of the mean distance per car and the number of cars per year. From the survey in Malvik, it was estimated that the mean distance was 10km, the mean number of people per car was 1.5 and the proportion of visitors that went to the green areas of Malvik Path by car was 12.5%. The mean number of people was 40,360. The number of cars per year was calculated following Eq. 5.27:

Number of cars (cars / year) = Mean number of people (people / year) * Proportion of visitors that go to the green areas of Malvik by car (%) / Mean number of people per car (people / car) = 40,360(people / year) * 12.5 (%) / 1.5 (people / car) = 3,363 (cars / year) Eq. 5.27

5.2.2.3. NOx emissions increase as a result of recreation

The increase in NOx emissions was calculated following the same equations as the ones described in the benefit 'Reduction in NOx emissions' (Eq. 5.28). The calculation of the total number of kilometres by car increased as a result of recreation is shown in Eq. 5.27.

NOx increase (€ / year) = Total km increased (km / year) * NOx emissions per km (NOx kg / km) * NOx externality value (€ / NO2 kg)

NOx increase (€ / year) = 33,633 (km / year) * 0.0004 (NOx kg / km) * 5.95 (€ / NOx kg) = 80.05 (€ / year) Eq. 5.28

5.2.2.4. SO2 emissions increase as a result of recreation

An increase in SO_2 emissions was an externality associated to the increase in the number of visitors by car in Malvik Path. The increase in SO_2 emissions was calculated following the same equations as the ones described in the benefit 'Reduction in SO_2 emissions' (Eq. 5.29). The calculation of the total number of kilometres by car increased as a result of recreation is shown in Eq. 5.27.

SO2 increase (€ / year) = Total km increased (km / year) * SO2 emissions per km (SO2 kg / km) * SO2 externality value (€ / SO2 kg)

SO2 increase (€ / year) = 33,633 (km / year) * 6.285714286 *1e-6 (SO2 kg / km) * 7.6 (€ / SO2 kg) = 1.61 (€ / year) Eq. 5.29

5.2.2.5. PM emissions increase as a result of recreation

An increase in PM emissions was an externality associated to the increase in the number of visitors by car in Malvik Path. The increase in PM emissions was calculated following the same equations as the ones described in the benefit 'Reduction in PM emissions' (Eq. 5.30). The calculation of the total number of kilometres by car increased as a result of recreation is shown in Eq. 5.27.

PM increase (€ / year) = Total km increased (km / year) * PM emissions per km (PM kg / km) * PM externality value (€ / PM kg) Eq. 5.30

PM increase (€ / year) = 33,633 (km / year) * 0.00002857 (PM kg / km) * 25.8 (€ / PM kg) = 24.79 (€ / year)

5.2.2.6. Noise pollution increase as a result of recreation

An increase in noise pollution was an externality associated to the increase in the number of visitors by car in Malvik Path. The increase in noise pollution was calculated following the same equations as the ones described in the benefit Noise pollution reduction (Eq. 5.31). The calculation of the total number of kilometres by car increased as a result of recreation is shown in Eq. 5.27.

Noise increase (€ / year) = Total km increased (km / year) * Noise externality value per km (€ / km)

Noise increase (€ / year) = 33,633 (km / year) * 0.001325 (€ / km) = 44.56 (€ / year) Eq. 5.31

5.2.2.7. Initial investment and O&M

Built on an abandoned railway, Malvik Path is a long scenic path along the coast which connects two local residential areas. The surface material of the path was chosen carefully to make the path accessible to wheelchair users, families with kids… In such a way that the path is universally accessible, allowing citizens to enjoy a natural environment linked to sporting and recreational activities.

The stone and gravel were placed directly upon the trail-tracks, and this has made the pathway a bit higher than the surrounding area. The path is complemented by some facilities like signs, barbecue sites and benches, a parking area, etc.

These actions produce initial investment costs and operation and maintenance costs. These costs include the construction of the path, the consulting services, the advertisement costs… In addition, the costs to maintain the greenspace in good conditions are included. The initial investment costs and operation and maintenance costs are summarised in Table 5.2 and 5.3:

Table 5.2. Initial investment costs in Malvik Path. Source: Malvik Path (2019)

Initial investment costs	**(€)**
Advertisement	-2,167
Printing	-62
Building application fee	-1,238
Construction and construction services	-311,352
Materials for new construction	-18,989
Materials for technical installations	-826
Materials for outdoor facilities	-12,694
Consulting services	-41,589
Internal consulting services	-7,327
Disadvantage compensation	-1,032
Various investment costs	-1,032
	-398,308

Table 5.3 Operation and maintenance costs in Malvik Path. Source: Malvik Path (2019)

Operation and maintenance costs	(€)
Supervision-garbage disposal (weekly)	-1,342
Repairs-signs / gates (occasionally)	-1,032
Deforestation (annual)	-1,032
Gravel laying (every five years)	-1,032
Supervision grill / benches (every other year)	-516
	-4,954

5.3. Cost-Benefit Assessment

According to the data generated by a digital counter that registers the number of passes per day, the total number estimated of visitors who visited, in 2018, Malvik path was 40,360. In our study, three possible assumptions were analysed: the first assumption considered that all visitors counted were new visitors, the second considered that only half of the people registered in the counter were new visitors and the third that only 10 percent were new visitors.

The price increased of houses is another variable with which is possible to make some assumptions. According to a local state agent, the Increased property value is being increased a 5% thanks to the recovery of the path. This increase may have an equal evolution where all houses will increase a 5%, also it is possible to assume that houses closed to the path will have an increase bigger than those furthest the path, in this case, the relation could be linear or logarithmic.

According to these assumptions, it is possible to create nine different scenarios: 100% new visitors and equal increase, 100% new visitors and linear increase, 100% new visitors and logarithmic increase, 50% new visitors and equal increase, 50% new visitors and linear increase, 50% new visitors and logarithmic increase, 10% new visitors and equal increase, 10% new visitors and linear increase, 10% new visitors and logarithmic increase.

Using these scenarios, benefits, costs and final results can be analysed. Figure 5.5 shows the evolution of the different benefits under studied scenarios.

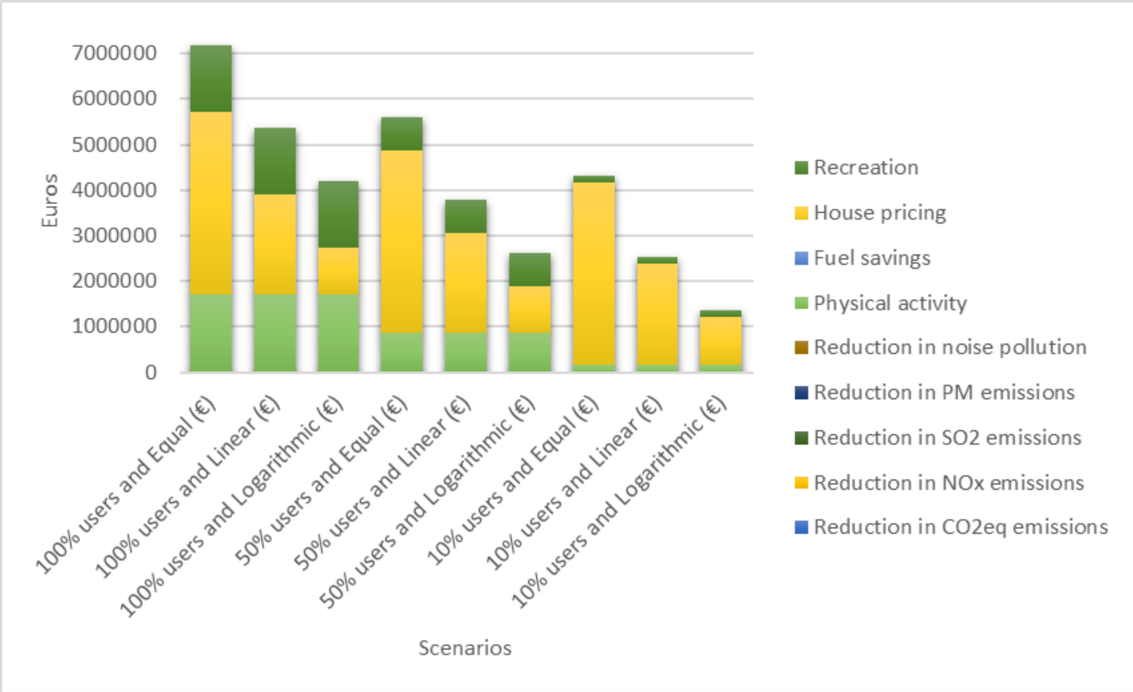


Figure 5.5. Estimated benefits under different scenarios.

According to Figure 5.5, recreation, Increased property value and physical activity are the most important benefits. Except in the scenario where 100% users are new visitors with a logarithmic increase, Increased property value is the variable that has a greater weight in the benefits.

Table 5.4. Estimated benefits under different scenarios:

Summary	Benefits	100% users and Equal (€)	100% users and Linear (€)	100% users and Logarithmic (€)	50% users and Equal (€)	50% users and Linear (€)	50% users and Logarithmic (€)	10% users and Equal (€)	10% users and Linear (€)	10% users and Logarithmic (€)
Environment and Health	Reduction in CO2eq emissions	52	52	52	26	26	26	5	5	5
	Reduction in NOx emissions	71	71	71	35	35	35	7	7	7
	Reduction in SO2 emissions	1	1	1	1	1	1	0	0	0
	Reduction in PM emissions	22	22	22	11	11	11	2	2	2
	Reduction in noise pollution	39	39	39	20	20	20	4	4	4
	Physical activity	1.707.915	1.707.915	1.707.915	853.958	853.958	853.958	170.792	170.792	170.792
Economics and technology	Fuel savings	1.607	1.607	1.607	803	803	803	161	161	161
	Increased property value	4.003.919	2.207.200	1.030.737	4.003.919	2.207.200	1.030.737	4.003.919	2.207.200	1.030.737
Social	Recreation	1.463.231	1.463.231	1.463.231	731.616	731.616	731.616	146.323	146.323 €	146.323

Concerning the investment and operation and maintenance costs, these costs are not conditional on either the number of visitors or the increased property value, so there will not be a change. Nevertheless, dis-benefits change if the number of visitors varies, Figure 5.6 shows its evolution.

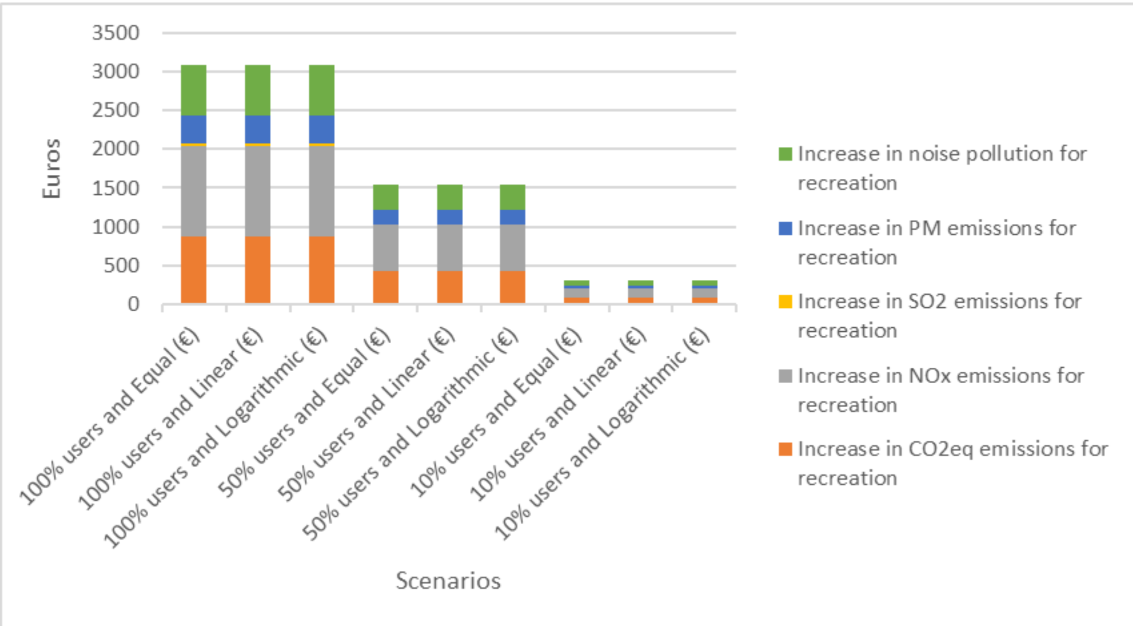


Figure 5.6. Estimated dis-benefits under different scenarios.

Table 5.5. Estimated dis-benefits and costs under different scenarios:

Summary	Dis-benefits, Costs	100% users and Equal (€)	100% users and Linear (€)	100% users and Logarithmic (€)	50% users and Equal (€)	50% users and Linear (€)	50% users and Logarithmic (€)	10% users and Equal (€)	10% users and Linear (€)	10% users and Logarithmic (€)
Dis-benefits	Increase in CO2eq emissions for recreation	-868	-868	-868	-434	-434	-434	-87	-87	-87
	Increase in NOx emissions for recreation	-1.177	-1.177	-1.177	-589	-589	-589	-118	-118	-118
	Increase in SO2 emissions for recreation	-24	-24	-24	-12	-12	-12	-2	-2	-2
	Increase in PM emissions for recreation	-365	-365	-365	-182	-182	-182	-36	-36	-36
	Increase in noise pollution for recreation	-656	-656	-656	-328	-328	-328	-66	-66	-66
Investment and O&M	Advertisement	-2.167	-2.167	-2.167	-2.167	-2.167	-2.167	-2.167	-2.167	-2.167
	Printing	-62	-62	-62	-62	-62	-62	-62	-62	-62
	Building Application Fee	-1.238	-1.238	-1.238	-1.238	-1.238	-1.238	-1.238	-1.238	-1.238
	Construction and construction services	-311.352	-311.352	-311.352	-311.352	-311.352	-311.352	-311.352	-311.352	-311.352
	Materials for new construction	-18.989	-18.989	-18.989	-18.989	-18.989	-18.989	-18.989	-18.989	-18.989
	Materials for technical installations	-826	-826	-826	-826	-826	-826	-826	-826	-826
	Materials for outdoor facilities	-12.694	-12.694	-12.694	-12.694	-12.694	-12.694	-12.694	-12.694	-12.694
	Consulting services	-41.589	-41.589	-41.589	-41.589	-41.589	-41.589	-41.589	-41.589	-41.589
	Internal consulting services	-7.327	-7.327	-7.327	-7.327	-7.327	-7.327	-7.327	-7.327	-7.327
	Disadvantage compensation	-1.032	-1.032	-1.032	-1.032	-1.032	-1.032	-1.032	-1.032	-1.032
	Various investment costs	-1.032	-1.032	-1.032	-1.032	-1.032	-1.032	-1.032	-1.032	-1.032
	Supervision-garbage disposal (weekly)	-19.741	-19.741	-19.741	-19.741	-19.741	-19.741	-19.741	-19.741	-19.741
	Repair-signs /gates (occasionally)	-15.181	-15.181	-15.181	-15.181	-15.181	-15.181	-15.181	-15.181	-15.181
	Deforestation (annual)	-15.181	-15.181	-15.181	-15.181	-15.181	-15.181	-15.181	-15.181	-15.181
	Gravel laying (every five years)	-15.181	-15.181	-15.181	-15.181	-15.181	-15.181	-15.181	-15.181	-15.181

Finally, Figure 5.7 shows the changes in benefits, dis-benefits, cost and total results. According to this Figure, when the number of visitors and the Increased property value vary, benefits have a significant change in contrast to the costs.

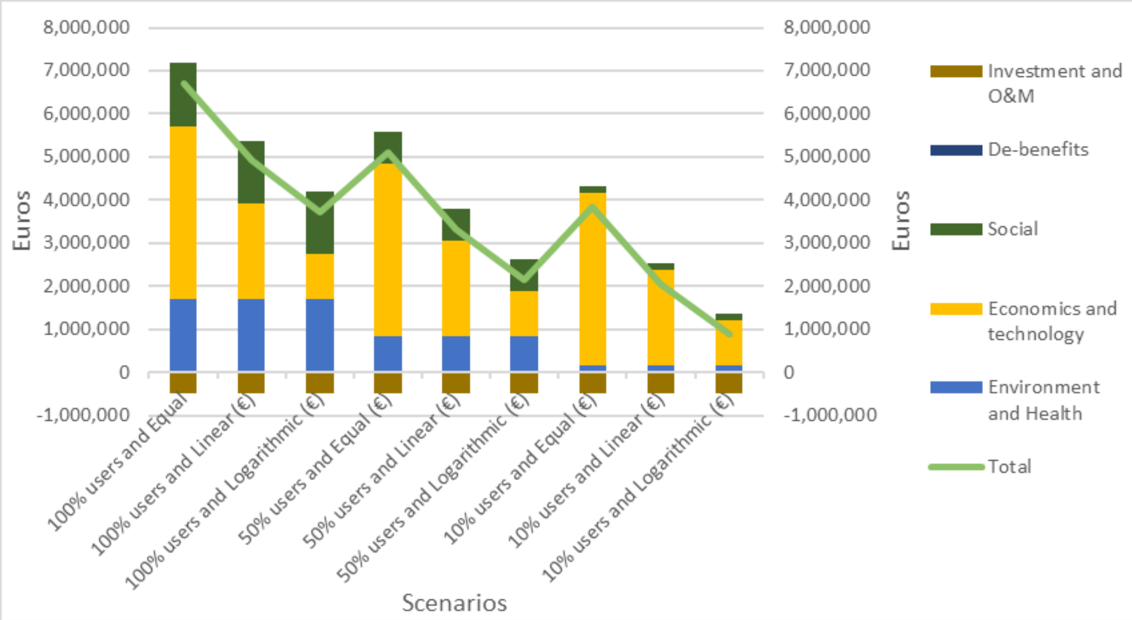


Figure 5.7. Summary of estimated benefits, dis-benefits, and costs.

Table 5.6. Summary of estimated results under different scenarios:

Summary	100% users and Equal (€)	100% users and Linear (€)	100% users and Logarithmic (€)	50% users and Equal (€)	50% users and Linear (€)	50% users and Logarithmic (€)	10% users and Equal (€)	10% users and Linear (€)	10% users and Logarithmic (€)
Environment and Health	1.708.101	1.708.101	1.708.101	854.050	854.050	854.050	170.810	170.810	170.810
Economics and technology	4.005.526	2.208.807	1.032.344	4.004.722	2.208.004	1.031.541	4.004.080	2.207.361	1.030.898
Social	1.463.231	1.463.231	1.463.231	731.616	731.616	731.616	146.323	146.323	146.323
Dis-benefits	-3.090	-3.090	-3.090	-1.545	-1.545	-1.545	-309	-309	-309
Investment and O&M	-471.181	-471.181	-471.181	-471.181	-471.181	-471.181	-471.181	-471.181	-471.181
Total	6.702.588	4.905.869	3.729.406	5.117.663	3.320.944	2.144.481	3.849.723	2.053.005	876.542

5.4. Sensitivity analysis

In Malvik Path four criteria have been evaluated in the sensitivity analysis:

- Discount rate: Three different discount rates have been evaluated (0%, 3.5% and 10%)
- Time horizon: Three time horizons have been included (10,20 and 30 years)
- Price increased of houses: Three types of proportion increase have been evaluated in this study (equal, linear and logarithmic)
- Proportion of new users: Three percentage of new users have been taken in account (100% new users, 50% new users and 10% new users).

The four criteria led to a total of 81 scenarios (3x3x3x3). In these 81 scenarios, an evaluation of the benefits, costs and profitability as well as their evolution throughout time has been conducted in the sensitivity analysis.

Figure 5.8 represents the discounted cumulative cash flow, benefits and costs in the evaluated 81 scenarios. The black curve shows the development of the base scenario (discount rate= 3.5%, time horizon= 20 years, price increased of houses = linear and proportion of new users = 50%) while the grey area indicates the confidence intervals of the calculated values in the evaluated scenarios estimated at 90%. The first graph shows that Malvik Path seems to be profitable in all scenarios through all the years, except the first year. The range of variability which is represented by the width of the grey area, increases while increasing time horizon. The variability of the cash flow depends on the uncertainty of the benefits since costs do not undergo major changes.

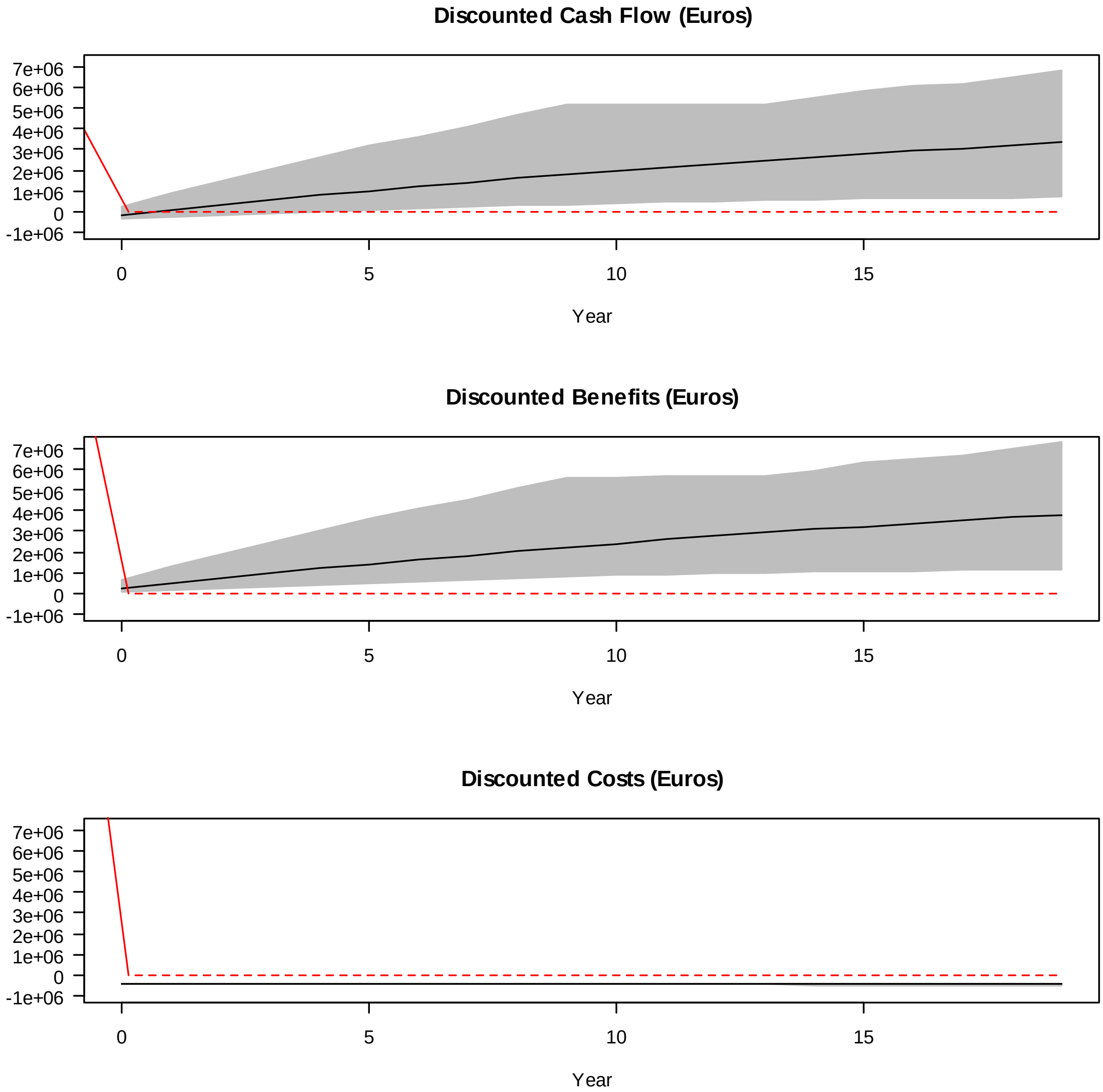


Figure 5.8. Discounted cumulative cash flow, benefits and costs in Malvik Path. Black curve shows the selected scenario (Discount rate = 3.5%, Time horizon = 20 years, Price increased of houses = Linear, and Proportion of new users = 50%). Grey area indicates the range of variability. Upper limit and lower limit of the grey area indicate percentile 5 and percentile 95 of the 81 evaluated scenarios in the sensitivity analysis. Red and dashed line indicates 0 euros.

According to Figure 5.9, the variables which change most when changing scenarios are physical activity, house pricing and recreation. The median of these values is €601,992.018, €2,028,373.11 and €515,747.818, respectively. This means that 50 percent of scenarios are above these values.

It is possible to extract a wealth of information of their distributions, based on this figure. Concerning physical activity, 25% of the data is above of €1,161,070.2 and the interquartile range, that is to say, 50% of the scenarios, is comprised in €940,051.58. Upon analysing house pricing, 75%of scenarios exceeds €1,206,303.35 and the maximum value is €5,443,865.5. Finally, in relation with the variable "recreation", there is no such difference in the values when changing scenarios although there is an outlying value (€2,984,189.5).

In respect of the final results, they change considerably depending on the scenarios. Also, it is possible to observe that 25%of the lowest values are more concentrated than the 25%of highest values. The interquartile range is comprised in €3,094,435.58.

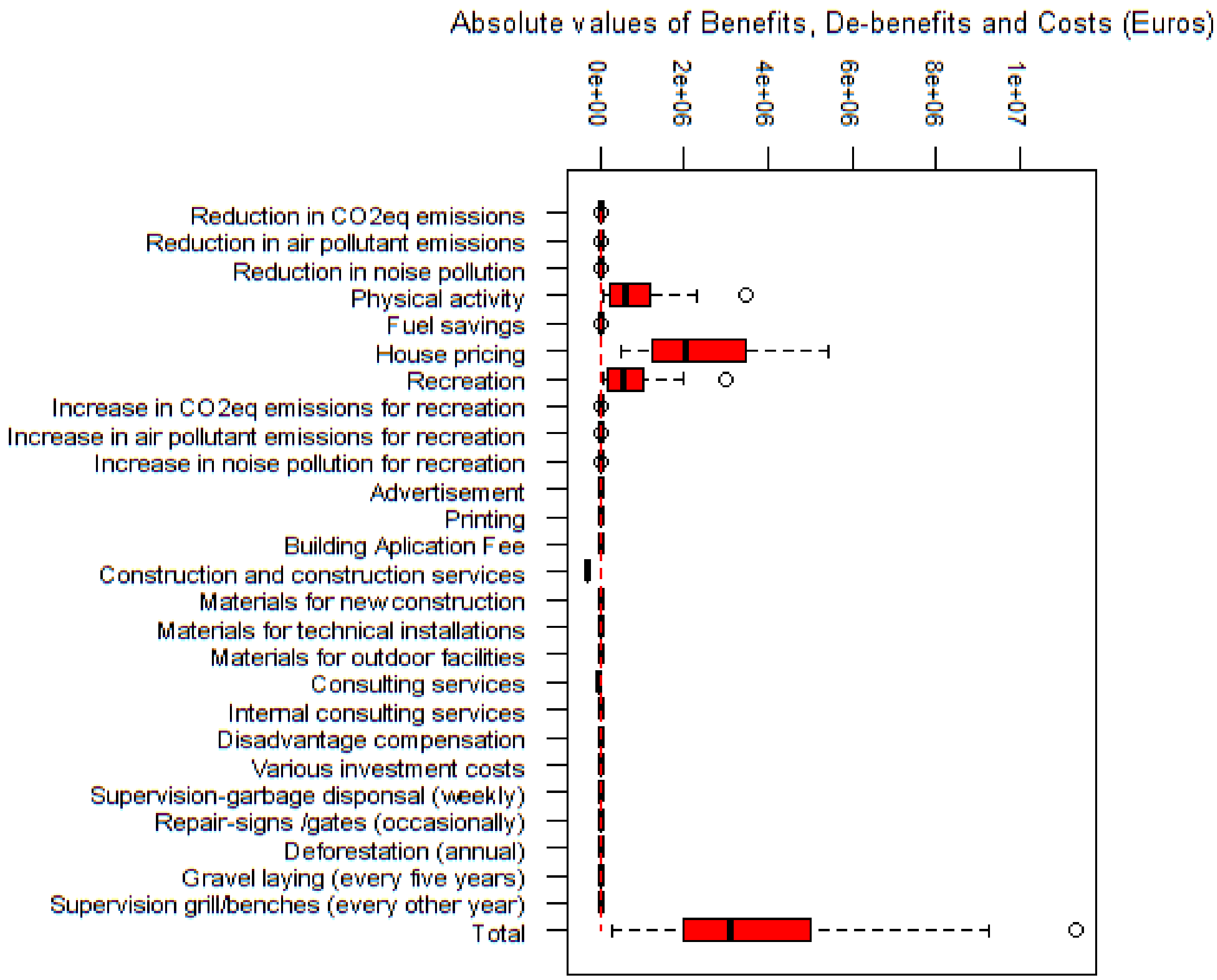


Figure 5.9. Distribution of the values of the disaggregated benefits, costs and profitability (Total) in Malvik Path. The horizontal lines in the boxes indicate the median values (percentile 50) of the 81 scenarios. The box limits indicate percentile 25 and 75. The whiskers are calculated as 1.5 times the interquartile range (Q3 –Q1). Circles indicate values out of the interquartile range (outliers). Red and dashed line indicates 0 euros.

Overall, the sensitivity analysis shows that the least source of uncertainty in the CBA comes from the different time horizons (10, 20 and 30 years), in other words, a change in the time horizon does not lead a relevant change. Furthermore, discount rate, price increase of houses and proportion of new users have a similar impact on the variability of the results.

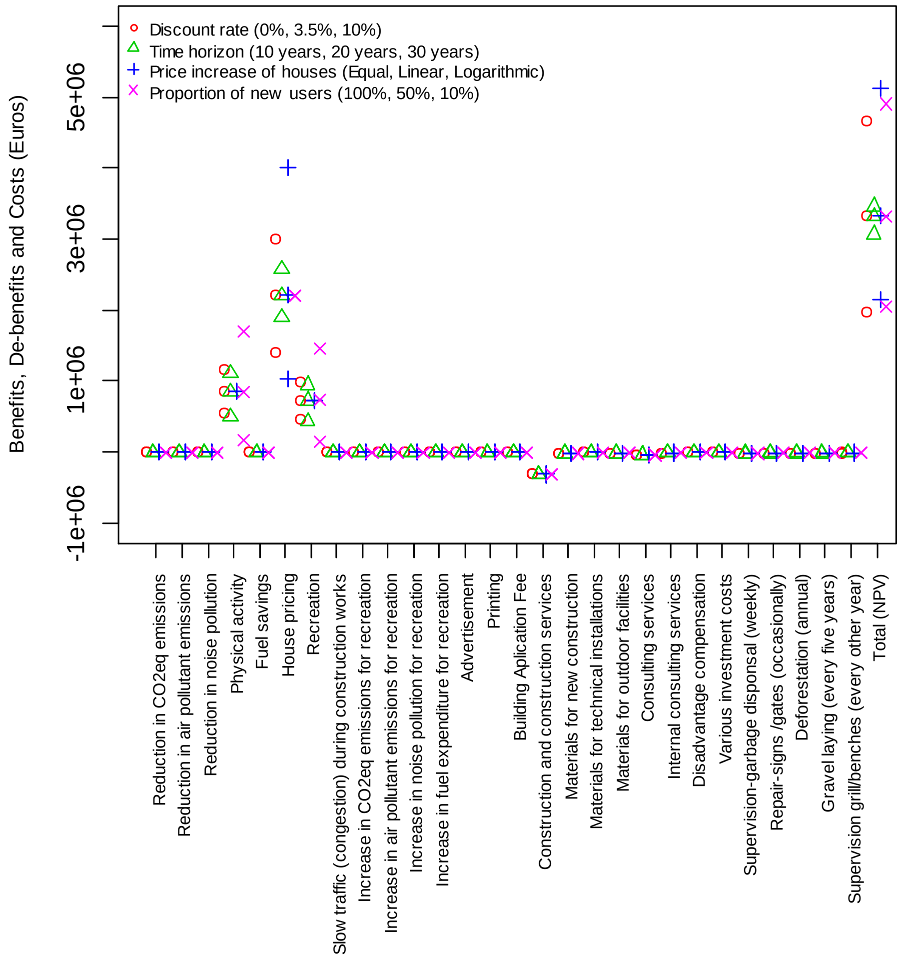


Figure 5.10. Cumulative discounted benefits, dis-benefits, costs and Net Present Value (NPV) in the different values of each source of uncertainty (Discount rate, Time horizon, Price increased of houses and Proportion of new users).

5.5. Lessons learned

For deciding whether the Malvik Path project was well-thought-out as a satisfactory and beneficial investment to the society, market and non-market costs and benefits were considered to compute the NPV, B/C ratio and the IRR. Categories of costs and benefits included are selected based on relevance and data availability on monetary metrics. All scenarios show a positive NPV, a B/C ratio greater than 1.5 and an IRR at least five times greater than the selected discount rate (3.5%). Based on the decision rules, the Malvik Path project is hence considered as economically feasible and profitable from a societal perspective.

In the selected scenario (discount rate = 3.5%, time horizon = 20 years, price increased of houses = linear and proportion of new users = 50%) the NPV is around €3.3 million (IRR = 174%) and reaches 0 in one year. The early recovery due to the lowest costs which is assumed by the project. The highest benefits turned to be the increased property value (around €2.2 million), physical activity (around €800,000) and recreation (around €730,000) which are recorded in the economics and technology, environment and health, and social group, respectively. On the cost side, construction and construction services is the variable which affects most to the final results (around €310,000), within the initial investment and O&M group.

Concerning sensitivity analysis, four criteria have been evaluated due to the uncertainty of the number of new visitors and the house price. Thus, the four chosen sources were discount rate, time horizon, price increased of houses and proportion of new users. Although there is great variability in the results depending on the scenario, all the cases have a positive NPV. House pricing, recreation and physical activity are the most sensitive variables, an evident fact considering that these are the variables which affect most to the results.

Malvik Path is a fine example of how an abandoned area, in this case a railway, if recovered and transformed into an accessible greenspace, could be beneficial for health, social inclusion and physical activity for all citizens of small, rural communities. The economic evaluation of Malvik Path could be considered as a reference in the decision-making in numerous European case studies, showing the feasibility and profitability from a societal perspective of recovery a green area, improving the accessibility to citizenship.

6. Sustainable food in public schools

6.1. Background

In June 2016 the city of Madrid adhered to the Milan Food Policy Pact. The implementation plan included a series of 12 projects involving three departments of the City Council. One of them involved the introduction of organic food products in the 56 nursery schools in Madrid. A detailed description of the case study can be found in Anthun et al (2019).

School canteens will adapt their menus in order to offer food that is both healthier and more sustainable. To achieve this, locally produced food will be introduced. In addition, awareness will be raised among families and staff from schools. The process includes the cooperation of different stakeholders, including the local authority, associations and suppliers.

The project started with two nursery public schools in 2017, which are directly managed by the local authority. The fifty-four remaining nursery schools joined this initiative in a second period (2018). The latter schools are outsourced by the local authority.

The main aim of the case study is to promote nursery school menu changes, taking care to enable acceptance of those menus by the community (parents and children; educators, school management teams and headteachers, and kitchen staff), in order to provide healthier and more sustainable food for infants attending public nursery schools in the city of Madrid, following guidelines from the Milan Food Policy Pact.

The INHERIT project contributed with workshops oriented to school communities in order to improve awareness and acceptability of the new menus. The changes adopted in the menus have been generated by the schools with the supervision of nutritionists. The local authority regulation of the canteen providers changed in order to generate more sustainable habits. Some of the measures introduced are:

- Introduction of organic food
- Introduction of fair-trade products
- Substitution of animal by vegetable protein one day a week in the menu
- Elimination of fish such as sway, tilapia or Nile perch
- Reduction to a maximum of two the number of intermediaries between school diners and producers or farmers
- Elimination of food precooked or prepared by other industries or businesses in school diners
- Use of non-prepared food items as kitchen ingredients
- Four days with fruit servings as dessert
- Serving natural dairy products, without sweeteners, flavouring or artificial colouring
- Elimination of fruit juices not prepared in the school
- Compulsory use of extra virgin olive oil
- Introduction of goat milk and goat milk cheese
- Introduction of wholemeal products (cereals, pasta, bread)

This INHERIT case study included a number of workshops (See Figure 6.1) that aimed to increase awareness about the need for healthy food for children and to help kitchen staff to: 1) better process the food and avoid losing nutrients; and 2) to learn varied and tasty vegetable-based recipes.

Figure 6.1. Kitchen staff participating in one of the cooking workshops aimed at fostering the introduction of vegetables in diets through tasty meals.

6.2. Data collection and calculation

6.2.1. Implementation of the case study and implementation costs

The analysis here presented consists of two different implementation angles. On the one hand, a change in regulations affecting procurement in the 56 public nursery school network in Madrid; and on the other, the implementation of the INHERIT case study. The first part refers to a series of changes in municipal regulations that pushed nursery schools into providing organic and local products in their menus. This change was designed to be gradual over a period of 4 years (2017-2020). Data on the changes in costs recorded by schools have been used as reference for implementation costs in this part of the analysis.

The second set of costs were those related to the INHERIT implementation phase. This implementation included a series of procedures. First, setting a series of follow-up groups, one per school to lead the process of change into more sustainable and healthy food options. Meetings between nutritionists and follow-up groups were conducted in order to prepare the renewed menus, meetings among school stakeholders and between nutritionists and families were set in order to ease the information-sharing process and improve acceptance amongst community (parents and children; educators, school management teams and headteachers, and kitchen staff)for the changes implemented.

Furthermore, a series of training opportunities (i.e. workshops) for kitchen staff were also carried out. These had also the objective of easing the transition towards healthy and sustainable menus. The inclusion of new ingredients and the changes in aspects, such as conservation of fresh organic products raised different doubts among kitchen staff, and, therefore, these activities were found necessary as a complement to awareness raising activities. . The costs arising from these activities were financed by the INHERIT project developed within Work Package 4 and were budgeted at 9 860€. This budget was complemented with additional funding from charities, associations and the own city hall. It was considered that further administrative costs would be undertaken by the nursery school owner, i.e. the City Hall. Figure 6.2 depicts the implementation schedule carried out by the different teams involved in the case study developed by the local authority of Madrid, implementing associations and the University of Alcalá as part of the INHERIT implementation team.

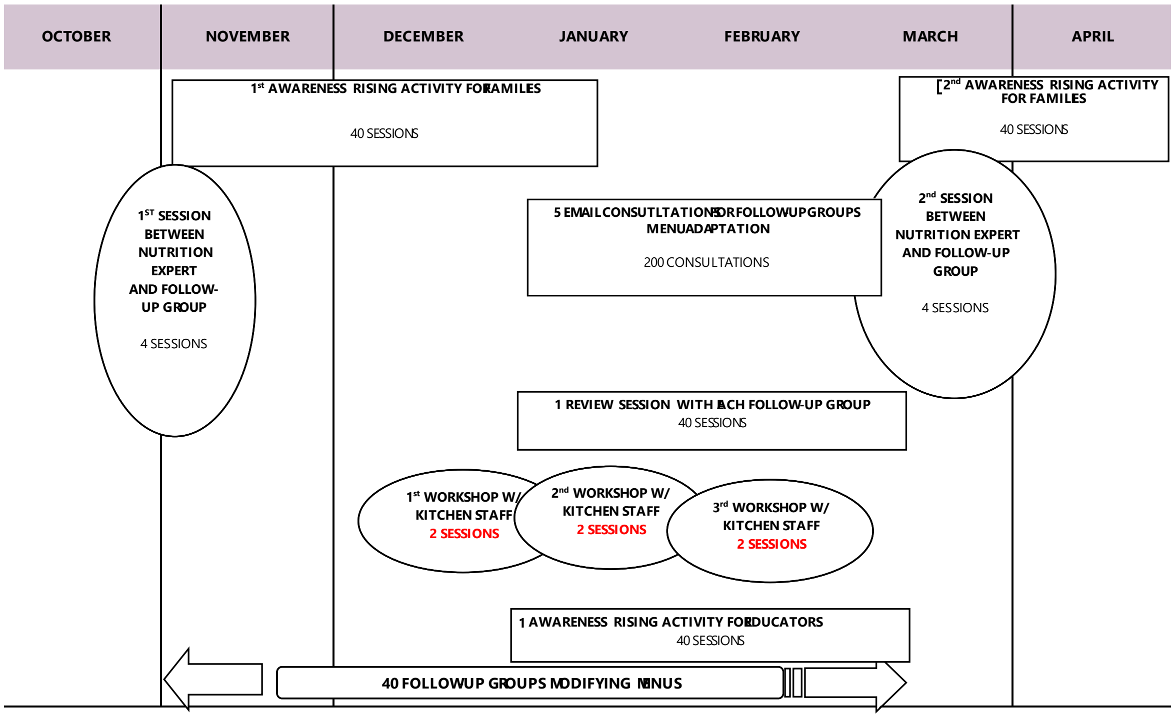


Figure 6.2 implementation schedule carried out by the different teams involved in this case study (October 2018 and April 2019).

6.2.2. Calculating the benefits from Dietary interventions in children

6.2.2.1. Literature review on health benefits

A literature review was performed to calculate the potential benefits that early improvements in diet could cause. This review analysed a total of 127 references containing research linking dietary improvements and health impacts. Among those studies, 22 were taken for deeper analysis. Table 1 in Annex 7 summarises the studies selected specifying their location and time period. Studies from Europe and North America are prevalent. These 22 studies offered quantitative assessments on how different aspects of diet could potentially improve health. From these studies, different notions of the magnitude of the health benefits of the case study implementation could be extracted. Moreover, information about the context of each article was used to complement the data on potential health improvements.

Health improvement was the main variable of interest in the studies. In order to obtain comparable measures of this health improvement, a percent variation on outcome was calculated for each of the studies. Whether results found in each of the research pieces having a significant effect was incorporated as a variable into the database gathering the collected information. This database also included dummy variables to incorporate two qualitative variables: the first one, identifying which aspect of health was linked to the study –overweight, obesity, body mass index (BMI), cardiovascular general health, etc.; the second one, referencing the different nutritional aspects analysed –organic food consumption, intake of fruits and vegetables, food insecurity, caloric intakes, sweets and soft drinks consumption, or nutritional program implementation. Two other categorical variables referred to age and gender structures of the participants in each study.

6.2.2.2. Estimating a Heckman selection model

Once the articles were selected, a series of variables were taken from them. Table 6.1 shows the variables either directly extracted from the publications or derived from them. Each of the individualizable results extracted from the studies was incorporated to the database as a new observation. HRR (Health Risk Reduction) refers to the homogenised measure of health improvement taken as dependent variable. Due to the heterogeneity in the procedures and results found in the literature, it was necessary to create a comparable measure of the level of health improvement described by each study. In order to achieve that, the procedures by Chiabai et al (under revision) were followed. Variable SIG was taken to denote the significance of each of the observations generated for the analysis. As each observation is extracted from an individual result of the studies analysed, the significance of the observation denotes the significance of the result taken. A 90% confidence level was used as reference to assess whether the observation had a value of 1 for this variable. High impact interventions refers to those observations that were deemed to assert a higher than usual change in diets. Health type is the categorical variable formed by four individual dummy variables denoting each one type of health issue (General health, cardiovascular health, obesity, or other health issues) that have been reported in the observations. In a similar manner, Food is a categorical variable formed by four individual dummy variables denoting each type of nutritional aspect (consumption of fruits & vegetables, consumption of sweets and soft drinks, fast food, etc., and nutritional education programs) analysed in each of the cases. Finally, age was also constructed in a similar fashion. Table 6.1 shows the descriptive statistics associated to each variable.

Table 6.1: Summary of the variables extracted from the studies

Variable		Description	Data source	Units
HRR		Refers to the change in health status described by each study result	Own creation from studies analysed	%
SIG		Refers to whether each result described in the literature is deemed significant at the 90% confidence level	Studies analysed	Binary
Health type	General health	Differentiates observations linked to general health	Studies analysed	Binary
	Cardiovascular	Differentiates observations linked to cardiovascular health or disease	Studies analysed	Binary
	Obesity	Differentiates observations linked to obesity	Studies analysed	Binary
	Other	Differentiates observations based on none of the above dimensions of health	Studies analysed	Binary
High impact interventions		Refers to the results extracted from studies where dietary changes were compared between lowest and highest population terciles	Own creation from studies analysed	Binary
Food	Fruits & vegetables	Refers to results related to consumption of fruits and/or vegetables	Studies analysed	Binary
	Sweets and soft drinks, fast food, etc.	Refers to results related to consumption of sweets, sweetened beverages or other high-caloric products	Studies analysed	Binary
	Nutritional education	Refers to results related to educational programs	Studies analysed	Binary
Age	0-3	Shows the proportion of participants aged 3 or less in the study	Studies analysed	Proportion
	4-14	Shows the proportion of participants between the ages of 4 and 14 in the study	Studies analysed	Proportion
	14+	Shows the proportion of participants over the age of 14 in the study	Studies analysed	Proportion

Table 6.2: Descriptive statistics for the variables included in the econometric regression.

		Mean	**Std. Dev.**
HRR		11.547	22.857
Health type: General health		0.111	0.316
Health type: Cardiovascular		0.148	0.357
Health type: Obesity		0.102	0.304
Health type: Other		0.519	0.502
High impact interventions		0.704	0.459
Fruits & vegetables		0.611	0.490
Sweets and soft drinks, fast food, etc		0.083	0.278
Nutritional education		0.093	0.292
Age: 0-3		0.161	0.349
Age: 4-14		0.496	0.487
Total Observations	107		

The connections between food consumption and health, while evidently close are extremely complex. As already mentioned in Section 5.2.2, this relationship is influenced by multiple factors (genetic, socio-demographic, economic, and environmental), and therefore is characterised by a high degree of uncertainty. Non-significant results appeared throughout the literature and have been included in this compilation. Considering only the significant results obtained by the different studies would imply a censored sample. This would lead to inconsistent and biased estimates for the different parameters (Copas, 2013). Moreover, the presence of more than one estimated coefficient reported per study would give an excess weight to studies with many estimates (Stanley, 2001). Section 5.2.2 make a detailed description of the reasons for estimating a sample selection Heckman model in this context.

The aim of the meta-analysis performed had the objective of extracting quantitative results from a heterogeneous literature, identifying the potential benefits of dietary improvements over health, particularly for cases where those improvements occur at early ages. Choosing a Heckman selection model as statistical tool appears due to the existence of both significant and non-significant results in the literature. This is a two-equation model. In the first place, an outcome equation including factors that impact the outcome variable; and second, a selection equation considering the observed part of the sample and those factors affecting the selection process. For this case, improvement in health – R_i– status comes as a result of a series of explanatory variables –X_i.

$$R_i = X_i\,\beta + \varepsilon_i \qquad \text{Eq. 6.1}$$

where β is the vector of parameters to estimate; and ε_i is the error term. Rewritten in a nonvectoral form, Eq. 6.2 includes:

$$\begin{aligned} R_i = \beta_0 + \beta_1 general_i + \beta_2 cardio_i + \beta_3 obesity_i + \beta_4 other_i + \beta_5 high_i \\ + \beta_6 fruits_i + \beta_7 sugar_i + \beta_8 neducation_i + \beta_9 age3_i \\ + \beta_{13} age414_i + \varepsilon_i \end{aligned} \qquad \text{Eq. 6.2}$$

In this equation, $general$ would stand for general health; $cardio$ for cardiovascular health; $obesity$ for obesity; $other$ for other health issues; $fruits$ for high impact interventions; $fruits$ for fruits & vegetables; $sugar$ for Sweets and soft drinks, fast food, etc.; $neducation$ for nutritional education; $age3$ for ages 0 to 3; and $age414$ for ages 4 to 14. ε_i would again stand for the error terms.

In contrast, the selection equation relates the probability that the change in health status due to dietary changes is significant (probability of significance being observed, S_i), to be written as:

$$S_i^* = Z_i\alpha + v_i \qquad \text{Eq. 6.3}$$

with Z_i showing the explanatory variables and α being the vector of parameters to be estimated. In this case, the error term is identified as v_i. Equations X and Y are observed in the case that $\mathrm{S_i} = 1$, which would imply that $\mathrm{S_i^*}$ represents a significant result, and $\mathrm{S_i} = 0$ otherwise. Equation 6.4 can be reinterpreted as:

$$S_i^* = \alpha_0 + \alpha_1 fruits + \alpha_2 sugar_i + \alpha_3 neducation_i + v_i \qquad \text{Eq. 6.4}$$

All variables in Equation 6.2 are present and therefore equivalent to those in Equation 6.3.

The error terms of the two equations –ε_i and v_i– are distributed according to a bivariate normal with mean zero, $\varepsilon_\mathrm{i} \sim \mathrm{N}(0, \sigma_\varepsilon^2), \mathrm{v_i} \sim \mathrm{N}(0,1)$ and covariance $\rho = \mathrm{Corr}(\varepsilon_\mathrm{i}, \mathrm{v_i})$. While error terms are correlated between them, they remain independent of both sets of explanatory variables. In case of error independence –$\rho = 0$–, standard regression models, such as Ordinary Least Squares (OLS) would offer consistent and unbiased estimators for β parameters. The Heckman equation system on the other hand, offers consistent and asymptotically efficient estimators for all model parameters in cases of correlated sets of errors.

Table 6.3: Results extracted from the Heckman selection equation.

	Outcome equation			Selection equation		
	Health Risk Reduction			Probability that HRR significant		
Variables	**Coef**	**Std. Err.**		**Coef**	**Std. Err.**	
Health type: General health	35.760	(7.027)	***			
Health type: Cardiovascular	6.022	(2.850)	**			
Health type: Obesity	12.813	(5.890)	**			
Health type: Other	34.707	(4.431)	***			
High impact interventions	1.015	(5.923)				
Fruits & vegetables	22.367	(11.038)	**	0.204	(0.321)	
Sweets and soft drinks, fast food, etc.	19.940	(11.516)	*	1.693	(0.622)	***
Nutritional education	59.268	(13.201)	***	-0.809	(0.611)	
Age: 0-3	23.163	(19.396)				
Age: 4-14	-3.641	(9.724)				
Constant	-21.642	(12.609)	*	-0.473	(0.280)	*
Wald test global significance chi2(10)		623.040	***			
Wald test of (rho = 0): chi2(1)		2.650	*			

6.2.2.3. Marginal effects within the Heckman model

Once estimations for the β and α parameters are obtained, the estimation of the marginal effects of each independent variable over the dependent variable requires a further step. This step involves the formation of the joint distribution of the two random variables –ε_i, v_i– followed by the maximisation of the complete log-likelihood function. The marginal health impact was estimated by including into consideration non-linear effects of variables as well as the mean values in the quantitative variables and the median values in the dummy variables. The equation proposed by Vance (2009) –Equation 6.5–, allows determining the value of the marginal effects as well as testing their significance:

$$\frac{\partial E(R_i|S_i^* > 0, X)}{\partial X_{ki}} = \beta_k - \alpha_k \rho \sigma_\varepsilon \delta_i(-Z\alpha) \qquad \text{Eq. 6.5}$$

where the inverse of the Mills ratio can be found denoted as$\delta_i(-Z\alpha)$, and it is to control for the potential bias caused by from sample selection. The linear predictions $(-Z\alpha)$ of the selection equation allow for its calculus. The marginal effect of a variable X_k will be particular for each of the individual observations. We compute for those cases the magnitude of the marginal effect for Z, a mean or median vector of variables (mean in the case of quantitative variables and median for qualitative ones). The marginal effect estimated show therefore the extent of the health risk reduction (HRR) associated with a variation in each of the independent variables after correcting for the selection bias.

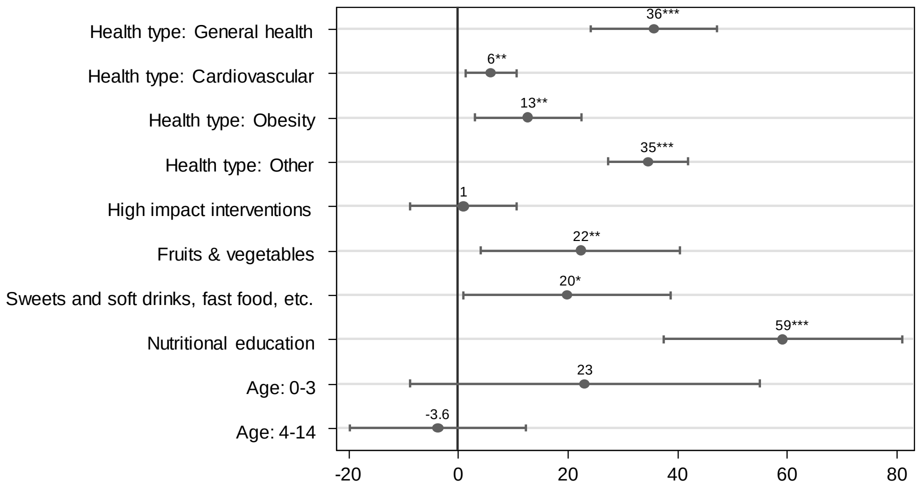


Figure 6.3. Marginal effects over health status resulting from each of the variables analysed.

6.2.2.4. Implementation degree

Improving food consumption has progressive effects over health. Therefore, benefits arising from dietary changes should be considered to progressively appear. Therefore, the use of a binomial cumulative distribution function to control for this factor. The function employed assumed a non-linear increase in the impacts of the implementation, reaching its full effect level once the 20-year line is crossed. Figure 6.4 shows the function used.

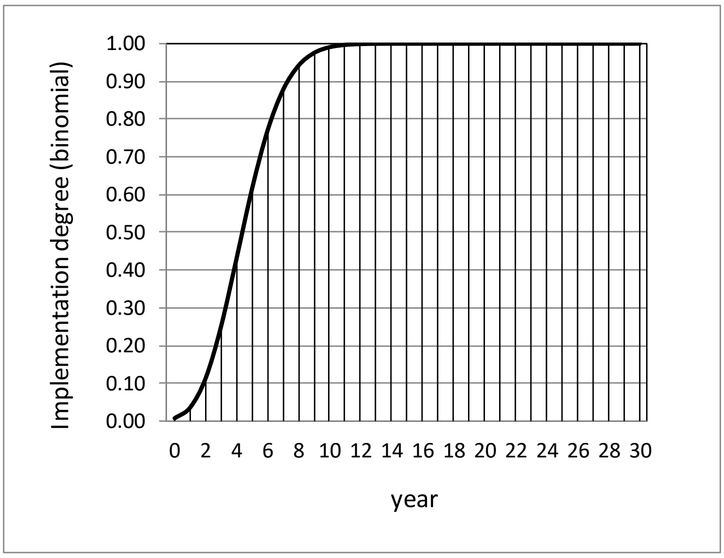


Figure 6.4. Binomial distribution used to control for the delayed effects of changes in food consumption over health.

6.2.3. Costs of obesity

In order to estimate the economic benefit of health improvements due to changes in nutritional status, different estimations of the cost of obesity were calculated. A series of studies were taken as reference, using the literature review performed by Von Lengerke and Krauth (2011) as starting point.

Costs: Total direct medical costs, absenteeism, presenteeism, short-term disability, disability, pension insurance, premature mortality, workers' compensation, and personal costs (Dor et al, 2010). Table 6.4 shows a summary of a selected number of studies. The monetary value considered in the CBA as cost of obesity is the average value of annual costs in the European studies on Table 6.4.

Table 6.4. Summary of the results compiled by Von Lengerke and Krauth (2011), with the extrapolated results.

Reference	Country and Year(s)	Type	Costs	Annual per capita costs (€)
Von Lengerke et al, 2010	Germany, 2000	BMI	BMI (18.5-24.9): 890€; BMI (25-29.9): 535€; BMI (30-34.9): 798€; BMI (>35): 1428€	498.77
Konnopka et al, 2011	Germany, 2000	Obesity	Total direct costs: 4 854 M€; Indirect: 5 019 M€	10.29
Hogaard et al, 2008	Denmark, 1996-2004	Obesity	Men: BMI (18.5-24.9): 2137$; BMI (25-29.9): 2247$; BMI (30-34.9): NA; BMI (>35): 3131$. Women: BMI (18.5-24.9): 2049$; BMI (25-29.9): NA; BMI (30-34.9): 2303$; BMI (>35): 2607$	608.95
Vellinga et al, 2008	Ireland, 1997-2004	Obesity/ Overweight	Total hospital costs for obesity per year: 4.3M€ (1997); 6.3M€ (98); 5.6M€ (99); 5.9M€ (2000); 8.4M€ (01); 10.5M€ (02); 11.1M€ (03); 9.5M€ (04)	1.59
Veiga, 2008	Portugal; 1995-96, 97-98	BMI	Total costs per year: 132.69 M€ (overweight, 1995/96); 365.7 M€ (overweight, 1998/99); 123.72M€ (obese, 1995/96); 261.23 M€ (obese 1998/99)	34.73
Sicras Mainar et al, 2008	Spain, 2004-2005	Obesity	332€ per capita cost from non-obese to obese	332.00
Knoll and Hauner, 2008	Germany, 2003	BMI	Annual direct costs: 85.71 M€ (ICD-10 E65-68); 11 265M€ (associated diseases)	127.46
Worre-Jensen et al, 2007	Denmark, 2003	BMI	Hospital costs related to obesity: 137.3 M€	20.47
Emery et al, 2007	France, 2002	Obesity	Annual excess costs caused by obesity: 2.1 to 6.2 B€	65.00
Folman et al, 2007	Denmark, 1996-99	BMI	Men: BMI (18.5-24.9): 1000$; BMI (>30): 1574$. Women: BMI (18.5-24.9): 1427$; BMI (>30): 1908$	653.08

First, von Lengerke et al (2010) carry out a study with a sample of German adults. A comparison of excess costs of obesity is made, considering different socioeconomic statuses. The results indicate that the costs associated with a BMI between 18.5 and 24.9 correspond to €890/€676, while at a BMI higher than 35, costs rise to €1,428/€3,082. In the study by Konnopka et al (2011), the direct and indirect costs of obesity and overweight are estimated in a sample of German participants. Rehabilitation costs, in-patient and out-patient treatments, and non-medical costs were all considered as direct costs. On the other hand, mortality rate, sickness absence and early retirement-related expenses constituted the indirect costs. The results showed direct obesity costs of €4,854 million and indirect costs of €5,019 million yearly..

In the study by Højgaard et al (2008), which was carried out on Danish populations, it was found a direct link between the increase of abdominal fat (for all levels of BMI) and the increase in health care costs. More specifically, in the case of men, a BMI between 18.5 and 24.9 was associated with costs of $2 137, while a BMI greater than 35 was associated with costs of $3 131. In the case of women, a BMI between 18.5 and 24.9 is associated with costs of $2 049, while a BMI greater than 35 corresponds to costs of $2 607. In this regard, in the research of Folman et al (2007), which is also carried out in Denmark, similar results to Hoggard et al. (2008) study are obtained. Thus, a cost of $1000 is indicated for BMI levels of 18.5-to-24.9, and costs of $1574 for BMI levels greater than 30 for men. In addition, a BMI of 18.5-24.9 is associated with a cost of $1427, while a BMI greater than 30 is levelled to a cost of $1908 in women.

In another set of studies, results refer to the total annual expenditure on health care. For that reason, they have been expressed in millions of euros. An example of this is the study of Vellinga et al. (2008) carried out in Ireland. In this study, hospital costs of obesity are analysed based on the total number of days care. If we compare the costs foreseen for 1990, the first year of the study (4.3 M€) with 2003 and 2004 (11.1 M€ and 9,5 M€), a perceivable annual cost increase can be detected. In Portugal, similar studies have also been developed. Veiga (2008) applies an econometric model to calculate health costs that involve obesity and overweight in adults. Her results show an increase in these costs in the three years in which the study variables are analysed. For example, the costs of obesity increase from 123.72 M€ in 1995/96, to 261.23 M€ in 1998/99.

In Spain, the results of the study by Sicras Mainar et al. (2008) indicate substantially high health care costs of obesity. Exactly, a difference of 332€ is accounted for a person with obesity, to a person without obesity. Emery et al. (2007) aim to estimate the costs of obesity in France. The total annual cost of obesity is between 2.1 and 6.2 billion € which means, according to the authors, between 1.5 and 4.6% of expenditure on health in 2002 in France. These results are comparable to the study of Worre-Jensen et al. (2007), who also offer data on the costs of obesity in Denmark in total millions of euros per year. In this way, the hospital costs related to obesity amount to a total of 137.3 M€. Similarly, Knoll and Hauner (2008) obtain direct annual costs of 85.71 M€ for obesity in Germany, and 11265 M€ in associated diseases.

The average per-capita cost of obesity considered for the CBA analysis is the average of the direct costs reported in Table 6.4. We excluded those evaluations considering VSL to keep the evaluation in the lower bond. Therefore, we have considered results based on health expenditures of people with obesity and not the valuation of indirect costs derived from the loss of human lives, loss of labour productivity or energy costs derived from obesity or overweight. Studies that consider this type of indirect impacts show an order of magnitude very different in the projection of the expense. As an example, Dor (2011) presents a study in the USA where considering indirect costs of obesity, including VSL, per capita expenditure is between 6518-8365 USD. Therefore, in this study we present a conservative value for the cost of obesity. However, it should be noted that the value that is computed is an average per capita value, and therefore, should be interpreted as a potential savings throughout the life of an obese person. That is, the expenses of childhood obesity are computed considering their impact also in adulthood.

6.2.4. School menus, costs and carbon footprint

In order to analyse the evolution of menus, local authorities and school management teams provided several examples of school menus. These menus were studied to obtain a view of the changes experienced throughout the implementation phase. Figure 6.5 shows an example of menu after the intervention.

MENU FEBRUARY 2019

MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
				1 Rice with chicken and vegetables; Fruit
4 Fish Fideua with peas, carrot and green beans; Natural Yogurt	5 Lentils with rice and vegetables; Fruit	6 Cabbage with potatoes and carrot; Salmon with salad; Fruit	7 Hake stewed with potatoes and vegetables; Fruit	8 Rice with homemade tomato; Omelette with lombarda; Fruit
11 Vegetablespuree; Sardines in oil and tomato salad; Fruit	12 Romanescusalted with jam and peas; Natural Yogurt	13 Meatballs with peas, carrot and potatoes; Fruit	14 Breast chicken with vegetables; Fruit	15 Pumpkin puree; Hake with salad; Fruit
18 Pasta with homemade sauce (tomato, vegetables and meat); Natural Yogurt	19 Chickpeas stewed with leeks, carrots, potatoes and rice.; Fruit	20 Green beans with potatoes; Baked chicken fillet with apple; Fruit	21 Lentils with rice and vegetables; Fruit	22 Mashed potatoes, leeks and carrots; Baked hake; Fruit
25 Fish Fideua with peas, carrot and onion; Fruit	26 Lentils with rice and vegetables; Fruit	27 Vegetables puree; Chicken fillet breaded with broccoli; Fruit	28 Spanish soup (stewed with vegetables); Natural Yogurt	

Note: Everyday : mid-morning seaso nal fruit; legumes and o il are ecological production; wholemeal bread

Figure 6.5. Example of menu after the intervention (One of the intervened nursery schools, February 2019).

Alongside menus, schools' management teams and local authority provided a summary of potential costs. Table 6.5 shows average costs of menus in 3 nursery schools for two periods of time: September 2017 to January 2018, and September 2018 to January 2019. Table 6.6 shows the change between those two periods after deflating the values for the year 2017.

Table 6.5. Summary of school menu costs 2017/2018 and 2018/2019.

Period	Year	Fruits & veg	Dairy	Rice & pasta	Legumes	Olive oil	Bread	Meat	Frozen & processed	Total
September	2017	€ 576.10	€ 222.47	€ 377.39	€ 43.99	€ 143.99	€ 80.10	€ 445.79	€ 192.15	€ 2,001.88
October	2017	€ 509.67	€ 282.00	€ 434.50	€ 22.46	€ 95.00	€ 78.40	€ 428.64		€ 1,850.67
November	2017	€ 497.61	€ 269.85	€ 470.16	€ 43.99	€ 95.00	€ 81.20	€ 556.16	€ 326.08	€ 2,340.05
December	2017	€ 486.19	€ 220.43	€ 147.12	-	€ 84.00	€ 68.70	€ 442.11	€ 413.23	€ 1,861.78
January	2018	€ 281.64	€ 110.00	€ 316.71	€ 43.99	-	€ 79.30	€ 400.75	€ 478.48	€ 1,631.57
Sep-Jan	2017/18	€ 2,351.21	€ 1,104.75	€ 1,745.88	€ 154.43	€ 417.99	€ 387.70	€ 2,273.45	€ 1,409.94	€ 9,685.95
September	2018	€ 676.10	€ 257.87	€ 277.39	€ 43.99	€ 444.00	€ 81.50	€ 397.79	€ 213.29	€ 2,391.93
October	2018	€ 907.99	€ 293.99	€ 427.27	€ 43.99	-	€ 79.20	€ 656.04	€ 406.50	€ 2,814.98
November	2018	€ 721.61	€ 207.51	€ 256.90	€ 33.76	-	€ 80.60	€ 655.06	€ 269.36	€ 2,224.80
December	2018	€ 1,177.39	€ 153.84	€ 262.27	€ 43.99	-	€ 69.10	€ 311.84	€ 303.28	€ 2,321.71
January	2019	€ 1,219.32	€ 269.79	€ 262.27	-	-	€ 77.30	€ 464.95	€ 92.40	€ 2,386.03
Sep-Jan	2018/19	€ 4,702.41	€ 1,183.00	€ 1,486.10	€ 165.73	€ 444.00	€ 387.70	€ 2,485.68	€ 1,284.83	€ 12,139.45

Table 6.6. Percent changes in expenditure 2017/18-2018/19.

Period	Year	Fruits & veg	Dairy	Rice & pasta	Legumes	Olive oil	Bread	Meat & fish	Frozen & processed
September	2017/19	15%	14%	-28%	-2%	202%	0%	-13%	9%
October	2017/19	75%	2%	-4%	92%	-	-1%	50%	-
November	2017/19	42%	-25%	-46%	-25%	-	-3%	15%	-19%
December	2017/19	137%	-32%	75%	-	-	-1%	-31%	-28%
January	2017/19	324%	140%	-19%	-	-	-4%	14%	-81%
Sep-Jan	2017/19	96%	5%	-17%	5%	4%	-2%	7%	-11%

In order to calculate the carbon footprint and the changes in it, consumption levels of each item were extracted from menus and considering changes in expenditure in each of the items (see Table 6.6). This information was complemented with information extracted from carbon calculations for Spain[1]. Following the methodologies described in previous sections a value of 0.0078€ per CO_2 equivalent Kg was used.

6.2.5. Awareness and acceptance: stakeholder surveys

6.2.5.1. The survey

The school community through informal meetings with the local authority expressed fears in terms of the policies regarding the improvement of the school food. Two are highlighted for being expressed by several different schools: acceptance of the menu changes among the families and costs. A series of activities were implemented in this case study, which focused on This case study rising awareness about the importance of school food quality among families and other school stakeholders and

[1] Source: http://www.alimentoskilometricos.org/

acceptability of the improved menus. In order to monitor and evaluate the impact of the case study on the awareness and acceptance increase, two surveys were conducted. The first survey took place in April 2018, during an event organised by the Madrid local authority, that gathered different school stakeholders including schools' management teams, educators, kitchen staff, and parents. This survey was taken as the baseline measure, as it was performed before the start of the awareness-rising activities. The second survey was conducted in April 2019, after those awareness-rising activities took place. Principal questions asked within the survey are summarised in Table 6.7. Questionnaires are presented in Annex 8, and a brief description of some survey responses are shown in Annex 9.

Table 6.7. Questions present in the survey (alongside context indicators: school, type of relation with school, etc.).

Q.ID	Question
Q2	Do you think that present food in school is healthy?
Q2.1	Do you think there has been a change in relation to the previous year?
Q3	Do you think that present food in school is ecologic?
Q3.1	Do you think there has been a change in relation to the previous year?
Q4	Do you think the path at which healthy and ecologic food is being implemented is adequate?
Indicate for each el the measures described below, in what measure you agree	
Q5.1	Introduction of ecologic food
Q5.2	Introduction of fair-trade products
Q5.3	Substitution of animal to vegetal protein one day a week in the menu
Q5.4	Elimination of fish such as sway, tilapia or Nile perch
Q5.5	Reduction to a maximum of two the number of intermediaries between school diners and producers or farmers
Q5.6	Elimination of food precooked or prepared by other industries or businesses in school diners
Q5.7	Use of non-prepared food items as kitchen ingredients
Q5.8	Four days with fruit servings as dessert
Q5.9	Serving natural dairy products, without edulcorates, flavouring or artificial colouring
Q5.10	Elimination of fruit juices not prepared in the school
Q5.11	Compulsory use of extra virgin olive oil
Q5.12	Introduction of goat milk and cheese
Q5.13	Introduction of integral products (cereals, cookies, pasta, bread)
Among the previously described measure, name the three you find most important or improving food quality	
Q6.1	First measure:
Q6.2	Second measure:
Q6.3	Third measure:
Q7	Do you think that implementing some of these measures will promote dietary changes in families outside of school?

6.2.5.2. Summary of the survey results

Perceptions over different issues related to the food offered by schools were gathered and compared between periods. The effect analysis of individual choice that is the focus of this survey analysis has been calculated analysing the perceptions through discrete outcomes (Y) models. The appropriate specification, estimation, and use of models for the probabilities of individual's choice is among a set of two or more alternatives (j). The individual chooses among two or more than two choices making the choice that provides the greatest utility. Figure 6.6 shows the estimated models that link the outcome to a set of methods in the general framework of probability models.

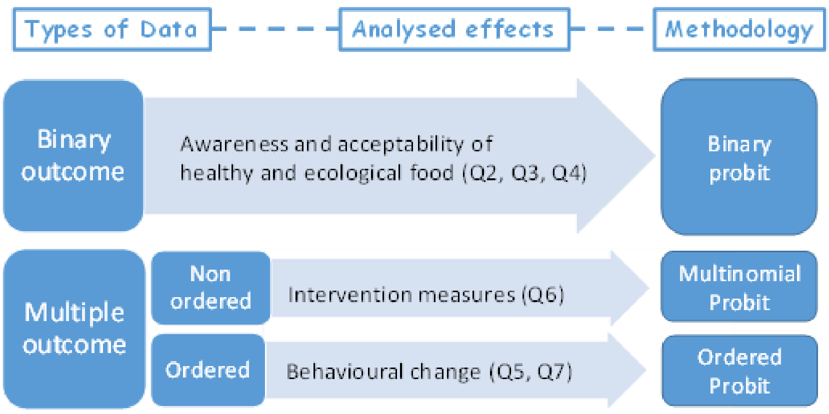


Figure 6.6. Summary of methods used for the survey analysis. Note: Q2 to Q7 are the analysed questions from the survey questionnaire in Annex 8.

The general framework for the analysis estimates probability of a given outcome as:

$$Prob(Y = j) = F[relevant\ effects,\ parameters] = F(X, \beta)$$

Where the relevant effects (*X*) in this analysis are: (i) the intervention effect, (ii) nursery school community differences and (iii) location differences, all of them defined as dummy variables. The set of parameters β reflects the impact of changes in *X* on the probability and F(.) is the normal distribution function and different specifications of F(.) correspond to the different models estimated for each of the analysed questions. See Greene (2012) for a full specification on the equations for $F(X, \beta)$ for the models used: binary probit, multinomial probit and ordered probit respectively.

Table 6.8 shows statistical tests applied to each of the questions appearing in the survey through the models specified in Figure 6.6. Data appearing in the column "intervention effect" analysed whether differences between the 2018 and the 2019 survey are significant. It shows that perception of health and environmental sustainability of the food offered in Madrid's nursery school network [Q2, Q3] increased from one period to the other, yet the perception of a change in neither of these characteristics grew significantly [Q2.1, Q3.1]. The question on whether the path taken by the city hall was the right one in this sense [Q4] had significantly more positive responses in the *ex-post* survey as compared to the *ex-ante* survey. The questions related to the adequacy of specific changes [Q5.1-13] showed different patterns, even with different signs. For example, while the adequacy of the introduction of fair-trade products [Q5.2] diminished ($z = -2.2$), the perception over the use of non-prepared food items as kitchen ingredients [Q5.7] increased ($z = 2.32$). The question on whether implementing some of these measures will promote dietary changes in families outside of school [Q7] showed no statistical variation between periods.

The following column, 'nursery school community differences", makes reference to whether differences among stakeholder groups were found to be statistically significant. Significance was, here also, unevenly distributed among questions. Contrary to the case of intertemporal variations, questions on whether food was found to be healthy and organic [Q2, Q3] showed no statistical variation among groups, while questions on perceived changes [Q2.1, Q3.1] did show variability. Questions on individual measures showed higher levels of variability with respect to stakeholder groups as compared with variation between periods. Highest levels of variability were recorded in questions about the elimination of food precooked or prepared by other industries or businesses in school diners [Q5.6] ($\chi2(5) = 38.6$) and about introduction of ecological food [Q5.1] ($\chi2(5) = 26.66$). The question on whether implementing some of these measures will promote dietary changes in families outside of school [Q7] did show in this case statistical changes among stakeholder groups.

The last column, "location difference", tests whether differences among schools were significant. Schools analysed in this section are located in districts with a wide range of socioeconomic characteristics. Significance varied, once again, along the set of questions proposed, though overall, less items showed statistical changes. As with intertemporal variability, questions about the perception of health and environmental sustainability of the food offered in Madrid's nursery school network [Q2, Q3] showed significant variations among locations, while homogeneity in the perception of a change those characteristics could not be statistically discarded [Q2.1, Q3.1]. Questions over individual measures also showed little variance, with questions over the elimination of fruit juices not prepared in the school [Q5.10] and the introduction of goat milk and cheese [Q5.12] showing the highest variability ($\chi2(20) =37.06$ and $\chi2(20) = 36.55$ respectively). The question on whether implementing some of these measures will promote dietary changes in families outside of school [Q7] did show again statistically significant changes among districts.

Table 6.8 Analysis of significant effects of the intervention on nursery school community perceptions.

Question	Intervention effect	Nursery school community differences	Location differences
Q2. Do you think that present food in school is healthy?	z = 2.49**	χ2(5) = 1.06	χ2(11) = 19.13*
Q2.1. Do you think there has been a change in relation to the previous year?	z = 0.92	χ2(5) = 14.84***	χ2(12) = 11.66
Q3. Do you think that present food in school is ecologic?	z = 3.24***	χ2(5) = 4.65	χ2(18) =42.18***
Q3.1. Do you think there has been a change in relation to the previous year?	z = 0.74	χ2(5) = 14.53***	χ2(14) = 15.65
Q4 Do you think the path at which healthy and ecologic food is being implemented is adequate?	z = 2.66***	χ2(5) = 5.44	χ2(13) = 13.73
Indicate for each el the measures described below, in what measure you agree			
Q5.1. Introduction of ecologic food	z = -0.24	χ2(5) = 26.66***	χ2(20) = 19.46
Q5.2. Introduction of fair-trade products	z = -2.20**	χ2(5) = 9.26*	χ2(20) = 26.16
Q5.3. Substitution of animal to vegetal protein one day a week in the menu	z = 0.55	χ2(5) = 11.26**	χ2(20) = 27.31
Q5.4. Elimination of fish such as sway, tilapia or Nile perch	z = 1.96**	χ2(5) = 19.35***	χ2(20) = 24.91
Q5.5. Reduction to a maximum of two the number of intermediaries between school diners and producers or farmers	z = -0.45	χ2(5) = 23.27***	χ2(20) = 21.47
Q5.6. Elimination of food precooked or prepared by other industries or businesses in school diners	z = 1.79*	χ2(5) = 38.60***	χ2(20) = 22.16
Q5.7. Use of non-prepared food items as kitchen ingredients	z = 2.32**	χ2(5) = 29.43***	χ2(20) = 25.90
Q5.8. Four days with fruit servings as dessert	z = 0.22	χ2(5) = 8.15	χ2(20) = 19.04
Q5.9. Serving natural dairy products, without edulcorates, flavouring or artificial colouring	z = 1.85*	χ2(5) = 8.52	χ2(20) = 38.64***
Q5.10. Elimination of fruit juices not prepared in the school	z = 1.67*	χ2(5) = 33.63***	χ2(20) =37.06**
Q5.11. Compulsory use of extra virgin olive oil	z = -0.05	χ2(5) = 16.96***	χ2(20) = 19.09
Q5.12. Introduction of goat milk and cheese	z = -0.70	χ2(5) = 12.35**	χ2(20) = 36.55**
Q5.13. Introduction of integral products (cereals, cookies, pasta, bread)	z = 0.85	χ2(5) =25.28**	χ2(20) =25.64
Among the previously described measure, name the three you find most important or improving food quality			
Q6.1. First measure:	χ2(12) = 21.74**	χ2(60) =25.64	n.d.
Q6.2. Second measure:	χ2(11) = 17.67*	χ2(55) = 41.46	n.d.
Q6.3. Third measure:	χ2(12) = 14.56	χ2(60) = 45.10	n.d.
Q7. Do you think that implementing some of these measures will promote dietary changes in families outside of school?	z = 1.39	χ2(5) =21.01***	χ2(20) = 33.85**

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

Figure 6.7 shows the variation, differentiating stakeholder groups –Parents (Families), educators, [School] Schools' management teams, [School] Headteachers, Kitchen staff, and others–, between acceptance rates in the *ex-ante* (2018) survey and the *ex-post* (2019) survey. It can be observed that for every stakeholder group acceptance increased from one period to the following.

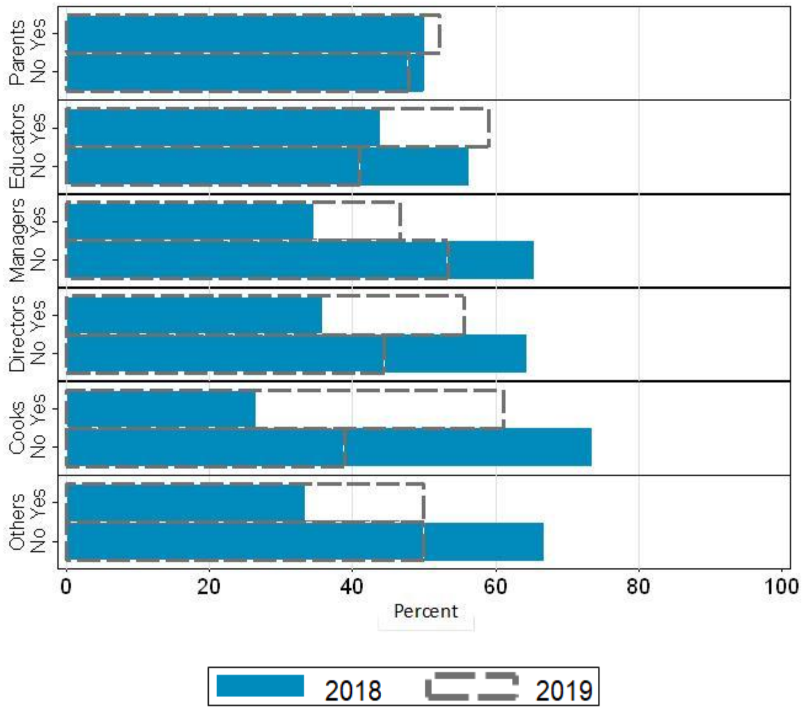


Figure 6.7. Acceptability of menus before and after the intervention for the nursery school community

Figures 6.8 and 6.9 show respectively, the changes in stakeholders' perceptions over health-adequacy and environmental-adequacy of school menus. Figure 6.8 segregates results for each of the stakeholder groups included. The perception that 'the food served is healthy' increased for every stakeholder group except for families. Nevertheless, perception of that 'food served is healthy' is widespread among all stakeholder groups, reaching the 100% of surveyed participants across four of the six groups distinguished within the survey (except for parents and educators). Figure 6.8 shows more variability among groups when asking whether they find the food offered as environmentally sustainable, though for all groups except for kitchen staff (which showed the same result in both periods), the perception that the 'the food served is environmentally sustainable' increased from the *ex-ante* survey to the *ex-post* survey. The highest confidence on the environmental sustainability of the food served is recorded among school managers, while the lowest appears among kitchen staff. This fact may be explained because 1 to 3 organic products were introduced by the time of the second survey. In the informal discussions during the workshops, kitchen staff showed their concern with the fact that the organic products were not local because of lack of availability.

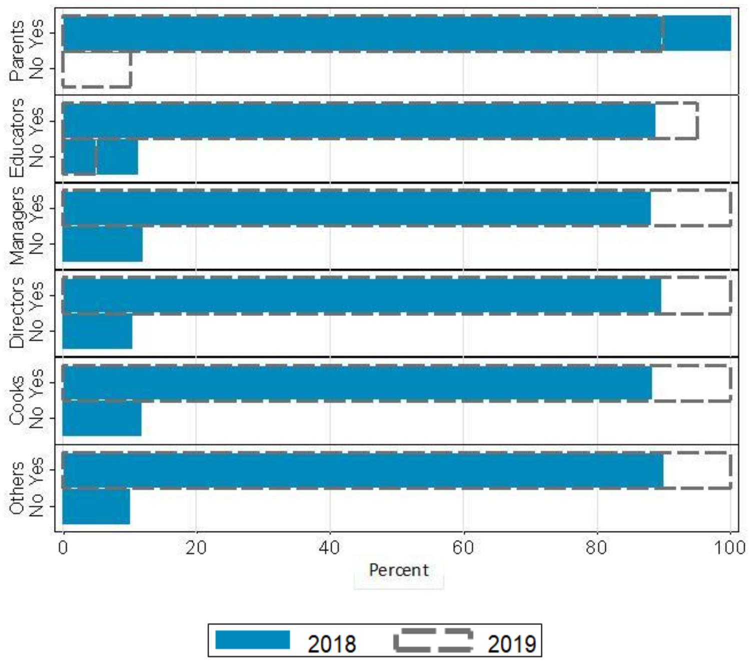


Figure 6.8. Health and environmental awareness before and after the intervention for the nursery school community (Perception that food served is healthy).

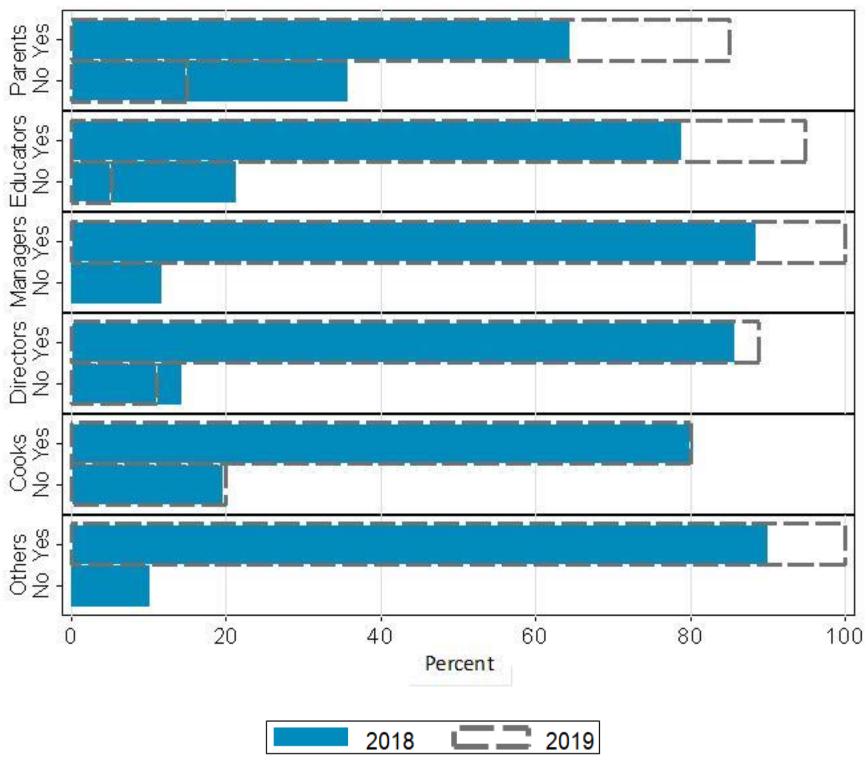
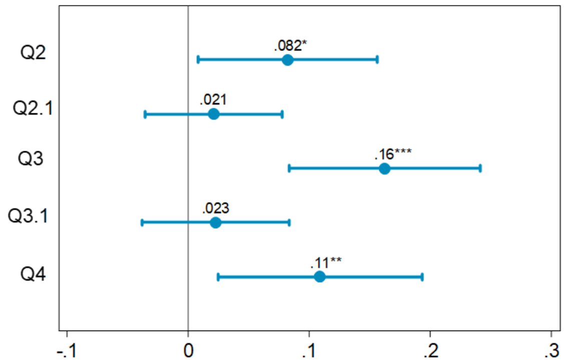


Figure 6.9. Health and environmental awareness before and after the intervention for the nursery school community (Perception that food served is environmentally sustainable).

Marginal effects of the intervention (i.e. those appearing while comparing pre-intervention results with post-intervention surveys) are displayed in Figure 6.10. Confidence intervals show the pattern described in the previous Table (6.9). All marginal effects, significant or not, show an increase in positive answers to the first set of questions [Q2-Q4], with the highest marginal change occurring in the question dedicated to the ecological suitability of the food served [Q3].



Q2. Do you think that present food in school is healthy?
Q2.1. Do you think there has been a change in relation to the previous year?
Q3. Do you think that present food in school is ecologic?
Q3.1. Do you think there has been a change in relation to the previous year?
Q4 Do you think the path at which healthy and ecologic food is being implemented is adequate?

Figure 6.10. Intervention marginal effects on nursery school by awareness and acceptability of healthy and ecological food.

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

Figure 6.11 shows also marginal changes between the 2018 and the 2019 surveys, though focusing on questions on the individual measures for food improvement proposed by the survey [Q5.1-13]. This set of questions was designed as a series of categorical questions. The figure shows marginal changes in each of the possible answers. Highest level of increase in agreement with measures was achieved for the use of non-prepared food items as kitchen ingredients [Q5.7] and the serving of natural dairy products, without edulcorates, flavouring or artificial colouring [Q5.9].

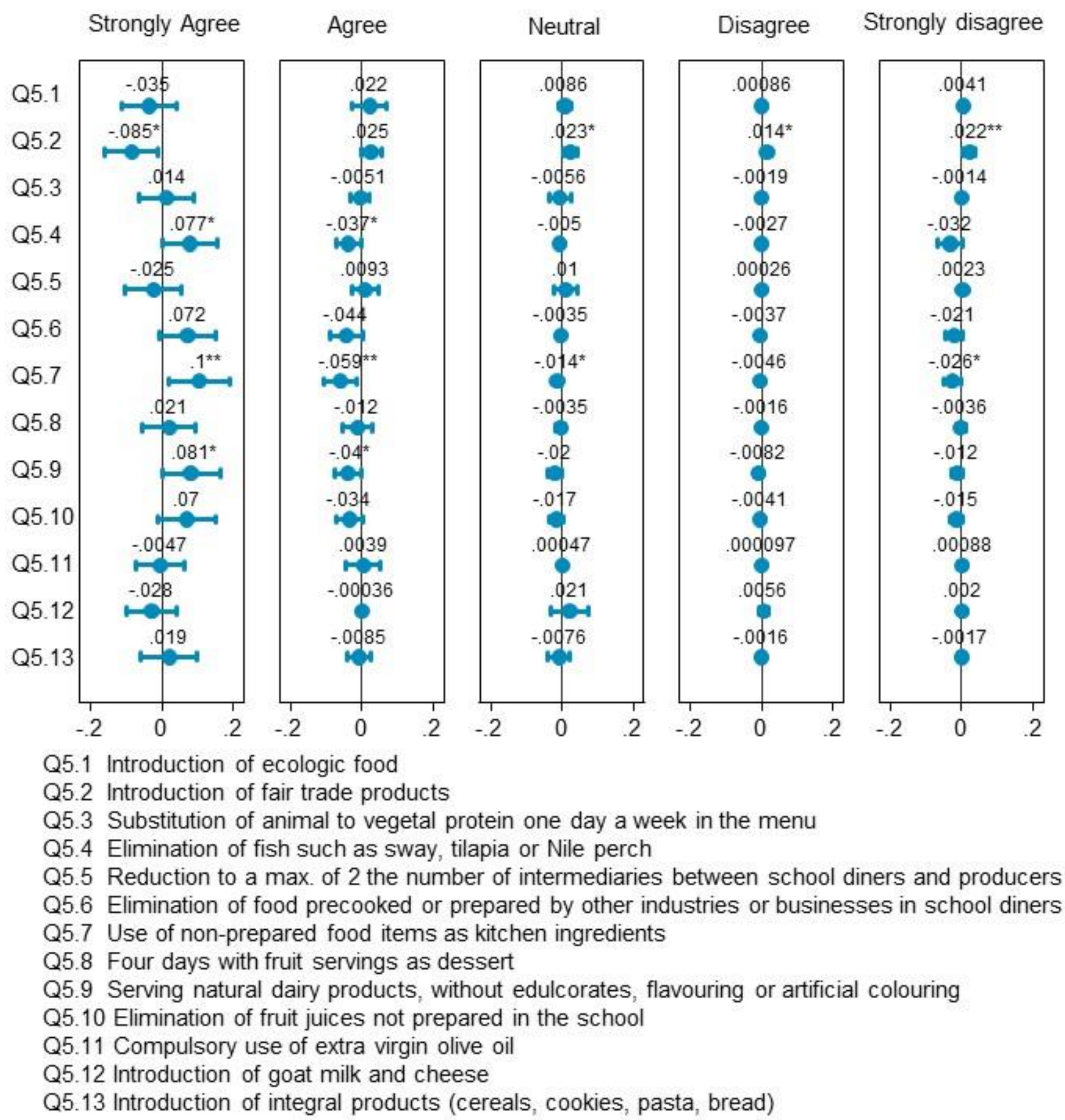


Figure 6.11. Intervention marginal effects on nursery school by behavioural change (Behavioural measure change). Note: *p < 0.1; **p < 0.05; ***p < 0.01.

Figure 6.12 shows how response to the question on whether implementing some of these measures will promote dietary changes in families outside of school [Q7] varied between surveys. Variations, as Table 6.8 showed, are not significant, but the trend is of an increase in the view that changes implemented at the school level would not be corresponded with changes in family cooking habits.

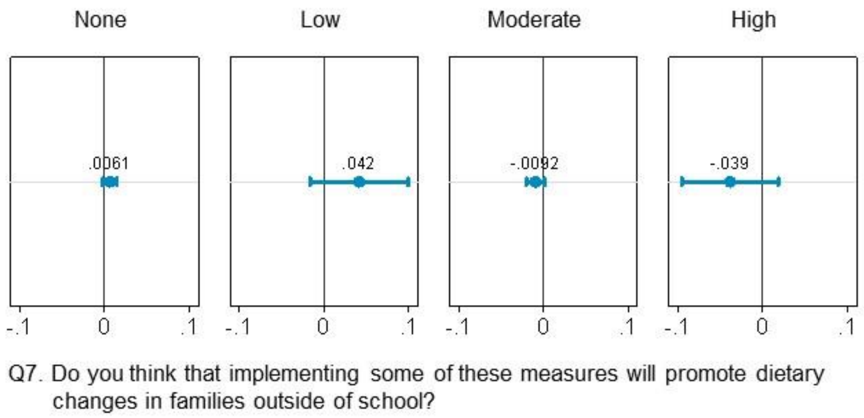


Figure 6.12. Intervention marginal effects on nursery school by behavioural change (Behavioural family change). Note: *p < 0.1; **p < 0.05; ***p < 0.01.

6.3. Cost-Benefit Assessment

6.3.1. Summary of costs and benefits

In order to estimate cumulative benefits and costs, a time period of 30 years has been selected, as justified in Section 4 dedicated to the common methodological procedures for the CBA. Table 6.9 shows the individualised cumulative results. Estimates of benefits arising from health impacts have been created taking into account the marginal impacts on health on individual changes in eating patterns and through the estimations for the costs caused by obesity. As already mentioned, those costs of obesity are per capita values considering average impacts through the whole life of one person. For that reason, this benefits should be interpreted as a potential of the intervention, if the attained changes in diets are sustained in later ages as well with appropriate complementary programs. Otherwise, considering only the direct impacts on 0-3 years old, the benefits would be underestimated, since as already mentioned, interventions on this range of age tends to have an effect on the relationship with food on adult ages. Acceptance increase was calculated using the results of the survey estimating the marginal impact of the activities carried out in the context of the case study. These benefits add up to a total of almost €73.36 million. Table 6.9 also shows the costs associated to the changes. Most of the costs derive from the changes in food purchases in which schools incur. Nevertheless, these costs take in occasions negative value. This implies a reduction in those costs, therefore, an increase in net benefits. Total costs take the value of almost €8.84 million including these diminished costs. The net nominal impact of the case study would take a value of approximately €64.52 million.

Table 6.9. Summary of aggregated benefits (30 years, nominal)

Cost / Benefit	Costs and benefits per item (€mil	Total Benefits and Costs
Health impact (Fruits and vegetables)	15,778,435.86	
Health impact (sugar)	13,508,416.16	
Health impact (Education)	31,216,745.30	
Reduction in CO_2 emissions	259.41	
Acceptance increase	16,335,971.28	
Total benefits (€)		**73,358,851.62**
Δ Cost (Fruits and vegetables)	9,600,118.05	
Δ Cost (Dairy)	233,964.19	
Δ Cost (rice & pasta)	-1,227,828.08	
Δ Cost (legumes)	34,211.98	
Δ Cost (olive oil)	73,537.79	
Δ Cost (bread)	-32,306.27	
Δ Cost (meat)	694,793.03	
Δ Cost (frozen & processed)	-638,745.78	
Δ Cost (Acceptance and awareness workshops)	80,519.04	
Increase in CO2 emissions	9,600,118.05	
Total Costs (€)		**8,838,663.14**
Profitability (€)		**64,520,188.49**

6.3.2. Aggregated results

The consideration of the present value of all costs, benefits and net benefits requires, nevertheless, to take into account discount rates as described in Section 4.2. In order to discount for future impacts a discount rate of 4% was selected as baseline in the range of what discussed in Section 4.2, in order to improve coherence and clarity. Upper and lower bounds of 0% and 12% were used to complement this analysis with a sensitivity analysis to discount rate. The analysis covers a 31-year period, starting at year-0, when the case study was implemented, and reaching the following 30 years. Each of the annual costs and benefits were discounted and aggregated in order to obtain final measures of costs, benefits and the global NPV of the case study. Through this analysis it is possible also to estimate the break-even point of the measure, i.e. the point at which net cumulative benefits overpass net cumulative costs.

Table 6.10 summarises the key variables for the analysis carried out, such as project timing, benefits, and the discount rate. As previously mentioned, a discount rate of 12 percent was used to complement the discount rate of 4% used as baseline. Moreover, it is possible to use the nominal outcomes as a lower bound to the analysis, equivalent to a 0% discount rate.

Table 6.10. Key variables for the analysis.

Key variables	Value
Project timing	
Case study implementation Schedule	Year 0
Total BCA analysis period	30 years (+ Year 0)
Discount rate	
Lower value for sensitivity analysis	3%
Base case	4%
Upper value for sensitivity analysis	12%

Table 6.11 summarisescumulative costs and benefits of the implementation process once applied a 4% discount rate. By definition, discounted values are lower than their nominal counterparts, as the discount rate is higher than 0. The results are, nevertheless, similar to the ones obtained in the nominal analysis. The present value (PV) of the benefits totals an amount of about 40.593 million €, while the PV of costs add to a total of almost 5.231 million €. Once subtracted costs from benefits we can obtain a measure of the NPV, which nears 35.363 million €.

Figure 6.13 represents costs, benefits and NPV throughout the period. Bars refer to the discounted annual benefits and costs (Y axis on the left). The maximum annual benefits are obtained after 8 years. After this point, discount affects benefits at a higher rate than increase in the health impacts described by a binomial cumulative distribution (see Figure 6.5, section 6.2.2.4), benefits at this point are slightly over 2.03 million €. Costs reach their maximum during the first year, close to 0.289 million €. cumulative net benefits (, i.e., Net Present Value) have an increasing trend since year 1. This number is denoted by the green arrow (Y axis on the right).

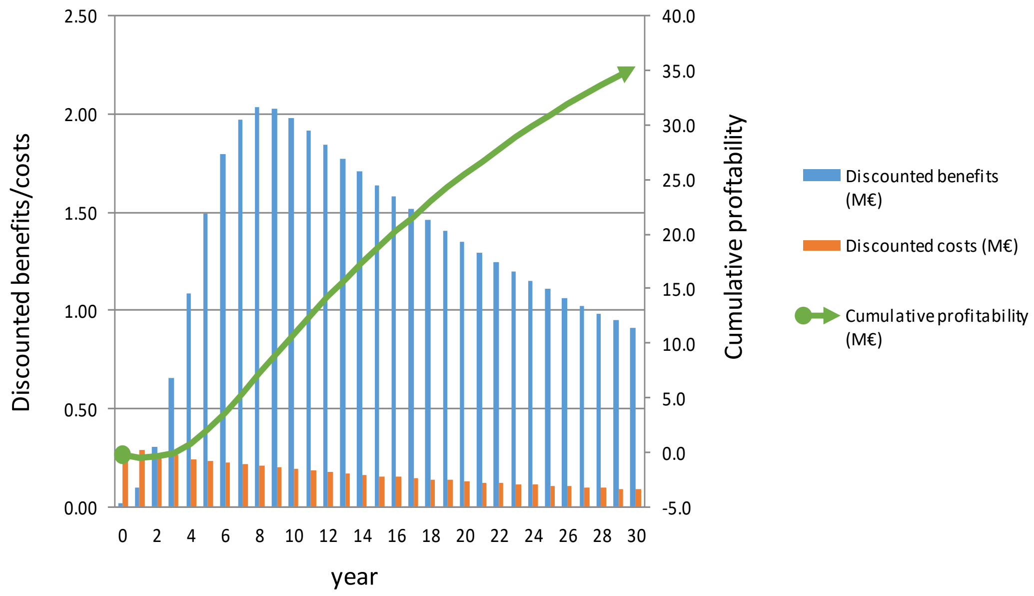


Figure 6.13. Evolution of discounted benefits and, costs, and NPV throughout the 30-year span.

Table 6.11. Present Value (PV) of aggregated costs and benefits and Net Present Value (NPV).

Cost / Benefit	Costs and benefits per item	Total Benefits and Costs
Health impact (F&V)	8,335,540.31	
Health impact (sugar)	7,136,318.73	
Health impact (Education)	16,491,396.30	
Reduction in CO2 emissions	153.07	
Acceptance increase	8,630,078.94	
Total benefits (€)		**40,593,487.35**
Δ Cost (F&V)	5,664,699.33	
Δ Cost (Dairy)	138,054.22	
Δ Cost (rice & pasta)	-724,499.10	
Δ Cost (legumes)	20,187.31	
Δ Cost (olive oil)	43,392.12	
Δ Cost (bread)	-19,062.82	
Δ Cost (meat)	409,973.46	
Δ Cost (frozen & processed)	-376,901.91	
Δ Cost Acceptance and awareness workshops	62,716.78	
Increase in CO2 emissions	12,036.85	
Total Costs (€)		**5,230,596.24**
NPV (€)		**35,362,891.11**

Summarising the results obtained, Table 6.12 shows us expected benefits, costs and NPV. As shown in Table 6.11, benefits in a 4% discount rate scenario add up to 40.59 million €, with costs of 5.23 million €, leaving an NPV of approximately 35.62 million €. Increasing the discount rate to 12% reduces each of the values. Benefits decrease to 15.27 million €, while costs go down to 2.6 million €. The NPV of the pilot is therefore 12.67 million €. Benefit-cost ratio also changes, decreasing too, from 7.76 to 5.87. Internal Rate of Return (IRR) for both cases is of 53%, and benefits overcoming the costs during the 4th year.

Table 6.12. Summary of the results obtained by the CBA at 4% and 12% discount rates.

Discount rate (%)	**4.0%**	**12.0%**
Time horizon (years)	30	30
Benefits	40.59	15.27
Costs	5.23	2.60
NPV	35.36	12.67
Ratio B/C	7.76	5.87
IRR	53.00%	53.00%
Break-Even-Year	4	4

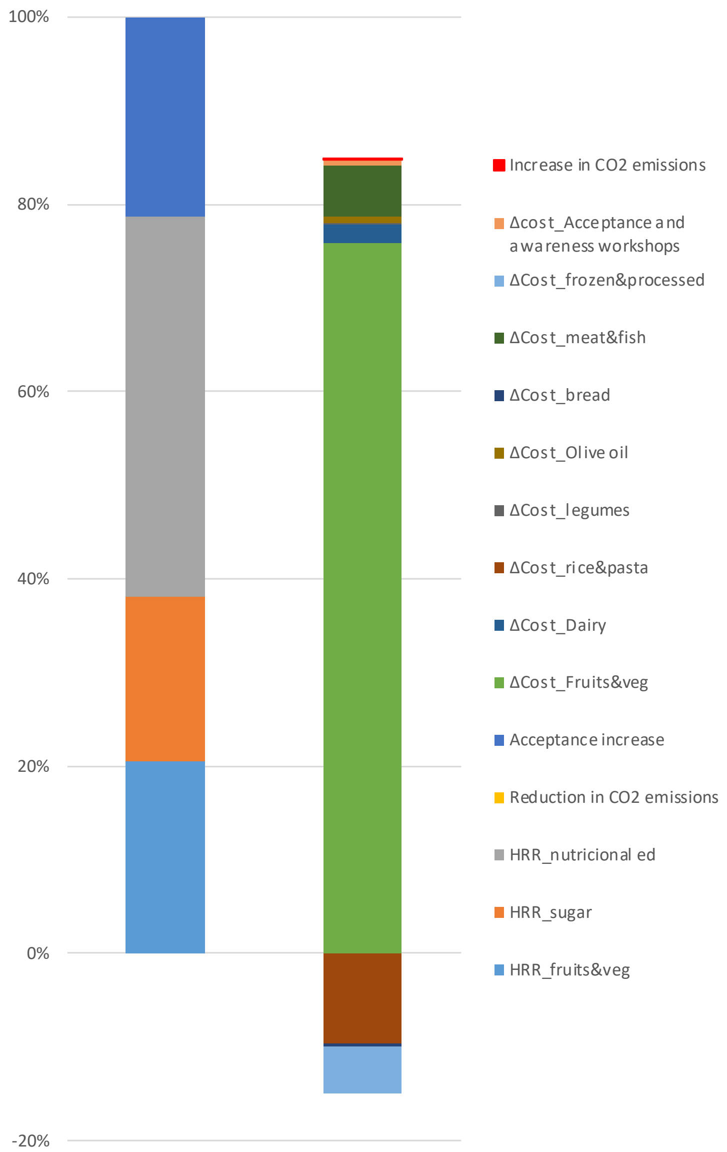


Figure 6.14. Summary of annual costs and benefits

6.4. Sensitivity analysis

Given the uncertainty in several parameters used in the analysis, we undertake sensitivity analysis to see which factors may change the initial indication of the viability of the pilot. Holding other project variables constant, we examine (i) the impact of the discount rate, (ii) a decrease of 20 percent in the benefit estimates and an increase of 20 percent in the cost estimates (lower estimate), and (iii) an increase of 20 percent in the benefit estimates and a decrease of 20 percent in the costs estimate (upper estimate). Figure 6.15 shows the NPV of benefits from each of the three subsequent sensitivity analyses. The pilot shows high socio-economic benefits even in a framework whose assumptions are conservative.

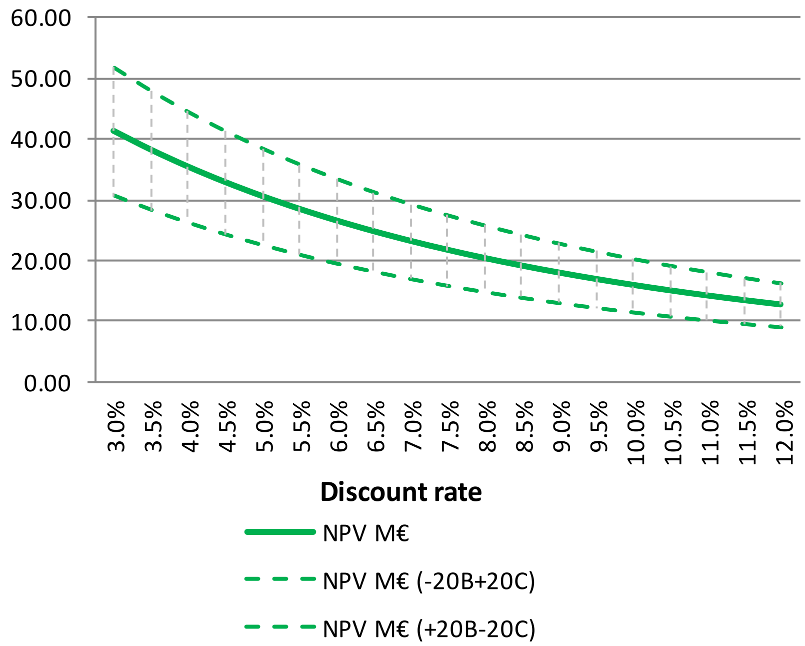


Figure 6.15. Present value of benefits for different discount rates (sensitivity analysis).

Note: -20B+20C = decrease of 20 percent in the benefit estimates and an increase of 20 percent in the cost estimates (lower estimate); +20B-20C = increase of 20 percent in the benefit estimates and a decrease of 20 percent in the cost estimates (upper estimate).

6.5. Lessons learned

Acceptability and awareness are key factors to achieve improvements on the food offered to children in nursery schools, thanks to which important economic benefits are obtained. In general terms, positive perceptions have been reported towards the introduction of changes in children's school menus by the educational community. The comparative analysis of perceptions of families, educators, schools' management teams, headteachers and kitchen staff, before and after carrying out the activities conforming the intervention, has evidenced substantial changes in the way in which each one perceives the improvements achieved. Modifying these mental perceptions and inducing behavioural changes on people who are responsible for healthy infant feeding is an issue of critical importance. In fact, awareness is the first step to introduce improvement in health that translates into economic benefits.

Figure 6.16 allows the reader to appreciate the changes that have been recorded between the *ex-ante* and *ex-post* surveys performed on perceived likelihood that these improvements in nutrition will be implemented at home. With the exception of the families, who have considered that the probability of introducing these changes at home has slightly diminished after performing the intervention, the rest of the stakeholder groups did consider that it is likely that families will adopt these changes at home to improve child nutrition. Therefore, it is concluded that the educational community has highly positive expectations about the transfer of healthy behaviours at home, which would add to the positive impacts of food improvements at school. Therefore, **still room for improvement in order to increase parent's awareness on healthy food benefits, in order to increase the probability of implementing some of the measures at home.**

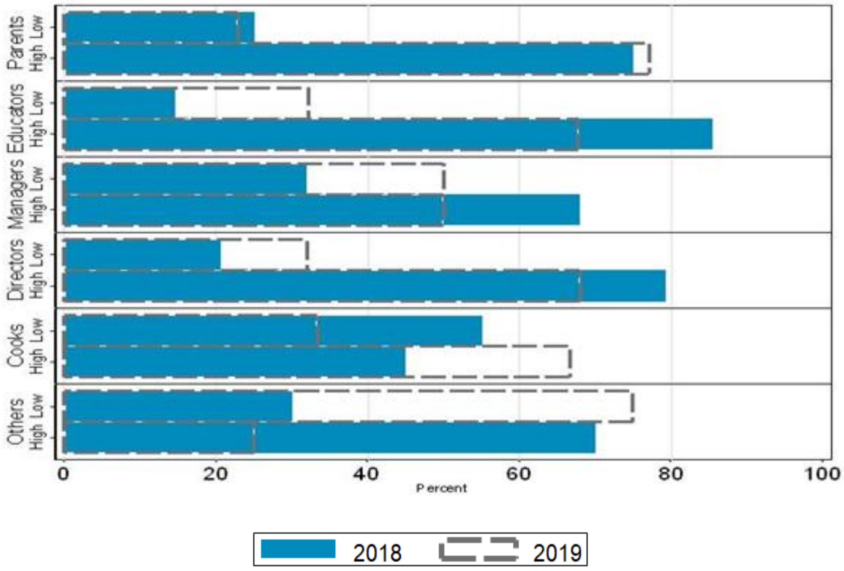


Figure 6.16. Changes between the ex-ante and ex-post surveys performed on perceived likelihood that the intervention improvements in nutrition will be implemented at home

A short food circuit does not guarantee that the food has been produced in the immediate environment in which it is going to be consumed. The fact that in the ToR stablished by the local authority to the school management teams included the condition of having no more than two intermediaries between the food product and the consumer, in practice it has not guaranteed that these products have been grown in the Community of Madrid. It has been pointed out in the participatory process that kitchen staff has not been able to get organic products such as some legumes in sufficient quantities by local producers.

To achieve success, health and wellness policies must win acceptance as part of school's core missions and must become integrated into school cultures and plans (PHLC, 2009). **Kitchen staff are key professionals in the development of the intervention in food improvement**. The preparation of healthy meals, the knowledge of new products and different ways of coking them, the preparation of healthy recipes, etc. All constitute essential tasks that the kitchen staff have had to assume during the months in which the intervention activities have been carried out. In addition to this, throughout the participatory process the cooks have manifested a visible interest and involvement in learning these healthy cooking strategies. Subsequently, this has led them to have the possibility of transferring these lessons to the reality of the nursery public schools. A new learning community has been created in the framework of this case study to share experiences among kitchen staff. (https://maresmadrid.es/proyecto/comedores-ecologicos-en-escuelas-infantiles)

Figure 6.17. Kitchen staff discussion during one of the workshops of the pilot

Ecological production local to the Community of Madrid is not enough to supply the provision of nursery schools. Probably public policies supporting organic crop production will be needed if we want to achieve a real impact on CO2 emissions. The current arable space available for the cultivation of ecological food products is limited by the population density of Madrid. The high amount of ecological food that would be needed to supply the nursery schools of Madrid, would require large arable land of which, due to this very concentrated population, it is not possible to dispose.

The early childhood is an ideal stage to start working healthy nutrition habits. The learning that is acquired in this stage of development constitutes a fundamental action on which habits of later ages are established. If children begin to be aware of the importance of taking care of their diet, it increases the likelihood that they will maintain these healthy routines in childhood, adolescence and adulthood. Campbell and Hesketh (2007) showed through a systematic review of interventions in early childhood some level of effectiveness on at least one obesity-behaviour and the revised studies support, at a range of levels, the premise that parents are receptive to and capable of some behavioural changes that may promote healthy weight in their young children.

The behaviours of families of children from 0 to 3 years are much more permeable to the introduction of changes in this initial stage of children's development. **Parents attach greater importance to the recommendations made to them and are more aware of their children's food health.** The analysis presented here highlight an important awareness and acceptance of the educational community after the intervention.

This case study for the promotion of healthy habits in early childhood demonstrates that the intervention has a long-term economic return. As it is possible to appreciate in Figure 6.17, **for every euro that is invested in training and intervention activities for the awareness of healthy habits, an economic return of 5.8 to 8 euros is obtained**. Undoubtedly, this fact shows how important is the need to allocate financial funds to the implementation of healthy interventions of these characteristics. In addition to having a direct impact on health in early childhood (which will be transferred to later ages), interventions in health habits such as the one described, lead to obtaining economic benefits in the context in which they are carried out. To correctly interpret this value, it is necessary to remember that although the estimated benefits consider conservative figures for the costs of obesity, we are assuming here that such benefits are derived from the fact that reducing childhood obesity will have an effect on the health of the children throughout their lives. It is true that practically no studies have followed-up on individuals into adulthood to assess the effects of childhood interventions, so the value of benefits should be considered as potential — and in a pessimistic scenario, such interventions would only have short-term effects. To guarantee this potential, public policies that ensure the success achieved on childhood habit changes, reinforcing interventions also in adolescence and adulthood will be of high importance.

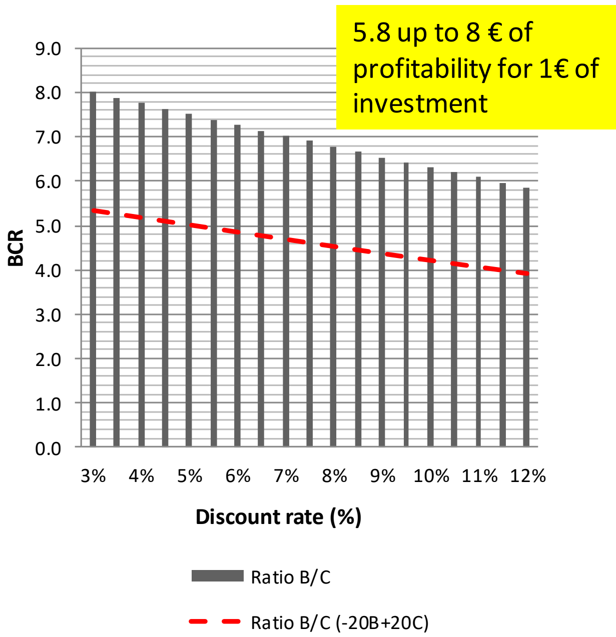


Figure 6.18. Benefit-Cost Ratio of the intervention responding to discount rate changes. Note: Estimated shows the baseline estimations while the red line shows a lower-estimate scenario (20% less benefits than baseline and 20% more costs).

7. Retrospective Analysis on Energy Efficiency Investments

7.1. Background

Energy efficiency improvements may offer potential “triple wins” (in terms of environment, health and health equity) – in part because measures put in place to encourage them have often been targeted at those in poorer groups or living in social housing. They may also offer “quadruple wins” – in terms of being economically viable, yielding net social or financial benefits – as energy and carbon savings may offset the financial cost of the measures put in place.

In a previous study (Sharpe et al, submitted), the associations between different levels of energy efficiency measures in England over the period 2007 to 2014 and hospital admissions for asthma, chronic obstructive pulmonary disease (COPD) and cardiovascular disease were assessed. Some of the energy efficiency measures were found to be associated with increased hospital admissions for certain conditions, others were associated with reduced admissions.

There has been significant investment in improving energy efficiency in the UK – and in this study we attempt to conduct a retrospective cost-benefit analysis of these investments and examine the impact that including the relationship with health may have. One of the difficulties is that the issue of causality is difficult to prove – the health relationship we base this analysis on is an association and the causality may run both or either way. In this analysis we explicitly assume that the energy efficiency measures impact on health of residents – it may be in fact that those with poorer health are more likely to have energy efficiency measures installed or that the relationship found is indirect – e.g. through reducing other health impacts such as mortality due to winter cold the numbers of cases of different diseases may rise as the sicker in society live longer.

The analysis was supported by contact with stakeholders and experts, notably Richard Sharpe (Public Health, Cornwall Council), Ben Wheeler (European Centre for Environment and Human Health, University of Exeter Medical School) and Ian Hutchcroft.

7.2. Data collection and calculation

Energy Efficiency Measures

Sharpe et al (2018) presents estimates of the measures put in place in 2007-14 in terms of an average number per 100 houses as shown in Table 7.1. The analysis on health was done at Lower Super Output Area (LSOA) level data – and based on these averages we estimate the average annual interventions (by dividing the total by the number of years) and the total count, by multiplying the prevalence by the number of homes in England (23.9 million dwellings). The interventions considered in this analysis were:

- Loft insulation – with over 250mm thickness of insulation put in place;
- Double glazing installation;
- Draught proofing; and
- Boiler replacement.

The original data that Sharpe et al (2018) draws on is the Home Energy Efficiency Database (HEED) from the Energy Saving Trust.

Table 7.1. Energy efficiency metrics for LSOA.

Energy efficiency measure	Average per 100 homes	Average annual per 100	Estimated count
Loft insulation >250mm	24.6	3.075	734,925.00
Double glazing	6.56	0.82	195,980.00
Draught proofing	31.29	3.91125	934,788.75
Boiler replacement	0.31	0.03875	9,261.25

Source: Own calculations based on Sharpe et al (2018)

Costs of Energy Efficiency Measures

In all of this analysis, we use 2016 as the base year for costs and benefits. We drew largely on the estimates in BEIS (2017). This presents costs for different types of dwellings based on a survey of those installing energy efficiency measures. Costs vary by different types of housing – and we took the mean of the mean costs of the energy efficiency measure for each dwelling type. The costs consider only the investment costs – with the exception of fuel savings, operation and maintenance costs are assumed to be zero or the same as in the baseline (i.e. the cost of maintenance of a replacement boiler is assumed the same as the boiler that is replaced). For simplicity, we assume that boiler replacement refers solely to gas boilers.

Table 7.2. Summary of Costs for Energy Efficiency Measures.

Energy efficiency measure	**Investment cost per dwelling**	**Source**
Loft insulation >250mm	698	Average based on BEIS (2017)
Double glazing	5289	Average based on BEIS (2017)
Draught proofing	101	Estimate from WWF(2012)
Boiler replacement	2656	Average based on BEIS (2017)

It is assumed that double glazing has a 20 year life span, that boiler replacement and draught proofing have a 25 year life span and that loft insulation has a 40 year life span.

Carbon savings

To assess the carbon savings, we take the energy savings above and estimate the reduced carbon due to the efficiency measure per house per year. We make the assumption that the energy saved is in the form of natural gas, using the average price of natural gas (0.04 per kWh) and a conversion factor for carbon of 0.18416 to give the $kgCO_{2eq}$ of the measure. This is then multiplied by the value of carbon of £12.76 per tonne. This will underestimate the true value – as the cost of carbon is likely to rise over time.

Table 7.3. Estimated carbon savings per year.

Energy efficiency measure	**Carbon savings (kgCO2 equivalent) per home**
Loft insulation >250mm	777
Double glazing	357
Draught proofing	92
Boiler replacement	625

Source: Own Calculations

Amenity value – Double Glazing

Having double glazing in a house has an impact on the price of a house. In order to take this value into account, we use the estimate from Abdulai and Owusu-Ansah (2011) that house prices increase by 8.2% in the case where a house moves from no double glazing to double glazing. It is difficult to distinguish the numbers of newly glazed homes to those which have had replacement glazing units installed. We know that 15.9% of homes had no double glazing at the start of this period (based on Utley and Shurrock, 2007) and given that the proportion with full double glazing rose to 80% from 30% (DCLG, 2015) – it is perhaps not unreasonable to assume that 50% of houses moved to full double glazing. Taking an average house price of £232,530 in England, this leads to significant benefits for this measure.

Health Impact Quantification

To quantify the health impacts, we take the significant coefficients for each energy efficiency measure estimated in Sharpe et al (2018). Table 7.4 below shows the estimated adjusted rate ratios from Sharpe et al (2018). A rate ratio of 1.04 means that for every 1-point increase in an energy efficiency measure there is a 4% increase in admissions for that condition. We should again express caution here – we are assuming causality from an ecological study.

Table 7.4. HEED energy efficiency metrics associations with 3 year total admission rates.

Total 3 year admissions	**Crude model**			**Fully adjusted model**		
	RR	**95% CI**	**p**	**RR**	**95% CI**	**p**
Asthma						
Loft insulation [a]	1.011	[1.010,1.011]	<0.001	1.004	[1.004,1.005]	<0.001
Wall insulation [b]	1.006	[1.003,1.008]	<0.001	1.000	[0.998,1.002]	0.798
Full double/triple glazing [c]	1.001	[1.000,1.003]	0.115	0.999	[0.997,1.000]	0.128
Rate of draught proofing measures [d]	1.005	[1.004,1.005]	<0.001	1.000	[0.999,1.001]	0.814
Rate of boiler replacement measures [e]	1.027	[1.018,1.035]	<0.001	0.998	[0.994,1.002]	0.398
COPD						
Loft insulation [a]	1.012	[1.011,1.013]	<0.001	1.002	[1.001,1.003]	<0.001
Wall insulation [b]	1.008	[1.005,1.011]	<0.001	1.002	[0.999,1.004]	0.155
Full double/triple glazing [c]	1.004	[1.002,1.007]	0.001	0.999	[0.998,1.001]	0.476
Rate of draught proofing measures [d]	1.011	[1.010,1.012]	<0.001	1.002	[1.002,1.003]	<0.001
Rate of boiler replacement measures [e]	1.038	[1.028,1.048]	<0.001	**0.992**	**[0.987,0.996]**	**0.001**
CVD						
Loft insulation [a]	1.010	[1.010,1.011]	<0.001	1.004	[1.003,1.004]	<0.001
Wall insulation [b]	1.004	[1.002,1.006]	<0.001	0.999	[0.998,1.001]	0.356
Full double/triple glazing [c]	0.999	[0.998,1.000]	0.175	**0.999**	**[0.998,1.000]**	**0.011**
Rate of draught proofing measures [d]	1.003	[1.003,1.004]	<0.001	1.000	[1.000,1.001]	0.282
Rate of boiler replacement measures [e]	1.028	[1.020,1.036]	<0.001	1.000	[0.996,1.004]	0.935

a. ≥250mm loft insulation per 100 dwellings; b. Wall insulation per 100 dwellings; c. Full double/triple glazing per 100 dwellings; d. Measures per 100 dwellings; e. Measures per 100 dwellings.

Source: Sharpe et al (2018)

We estimate the additional cases using the hospital admissions rates by gender – weighting for gender differences and multiplying through by the change in energy efficiency measures. For simplicity, we assume that the energy efficiency measures are applied equally over the years of the study (2007-14).

Table 7.5. Hospital admission rates stratified for age and gender.

Age Group	Total admission rate*			Winter admission rate*		
Male	Asthma	COPD	CVD	Asthma	COPD	CVD
18-29	1.69	0.04	0.14	0.41	0.01	0.03
30-44	1.64	0.24	1.19	0.41	0.06	0.29
45-59	1.62	2.02	6.53	0.44	0.57	1.63
60-69	1.37	8.60	12.81	0.37	2.49	3.21
70-79	1.89	19.25	23.51	0.52	5.57	5.95
80-89	2.73	31.74	41.60	0.77	9.38	10.67
90+	4.03	39.60	62.68	1.15	12.33	16.98
Total	1.69	4.85	7.71	0.44	1.41	1.95
Female						
18-29	4.07	0.05	0.11	1.02	0.01	0.03
30-44	3.35	0.27	0.59	0.87	0.08	0.15
45-59	2.87	2.28	2.89	0.80	0.67	0.71
60-69	2.27	7.68	6.44	0.65	2.26	1.58
70-79	3.13	15.47	15.56	0.92	4.62	3.88
80-89	4.04	20.70	32.38	1.23	6.38	8.24
90+	4.80	17.69	51.07	1.50	5.79	13.23
Total	3.27	4.56	5.77	0.89	1.37	1.45

* Admissions per 1000 population per year

Source: Sharpe et al (2018)

Costs of health endpoints

A quick review of the literature was done to find relevant health costs for the different conditions. Table 7.6 gives an estimate of the treatment cost of hospital admissions for asthma, COPD and CVD. It can be seen that the average cost of an asthma admission is far lower than that for CVD, which is understandable as CVD includes strokes and the average admission of this type involves 8.7 days in hospital.

It should be noted that these values underestimate the true cost of an admission, as they do not include pain and suffering or time costs.

Table 7.6. Average cost of hospital admission for different health conditions.

Type of hospital admission	Cost per admission (£)	Source
Asthma	906	Mukherjee et al (2016)
COPD	2,517	PSSRU (2018)
CVD	5,930	Estimated based on EHN (2011), adjusted for price year and exchange rate

7.3. Cost-Benefit Assessment

The overall findings of the cost benefit analysis of energy efficiency measures implemented in 2007-2014 in England are shown in Table 7.7. The table shows the impact of including health in the estimation - with boiler replacement moving from a slight negative net present value without health to a positive one with. Both draught proofing and loft insulation have lower rates of return when health is considered – as the health impacts are negative for the health endpoints considered.

Table 7.7. Overview of cost-benefit analysis findings for different measures in England (2007-14).

Measure	Without health		With health	
	NPV	**IRR**	**NPV**	**IRR**
Boiler Replacement	- 12,976,947	1%	5,845,824	4%
Double glazing	7,344,469,771	N/A	7,489,050,761	N/A
Draught proofing	1,323,774,197	26%	1,197,058,568	20%
Loft insulation	16,424,212,530	34%	12,496,809,471	26%
Overall	25,427,735,301	N/A	21,188,764,623	N/A

7.4. Sensitivity analysis

Sensitivity analysis was conducted on a range of variables, notably:

- The discount rate
- The proportion of housing moving from no double glazing to full double glazing
- Energy savings (which affects both estimated energy bill reductions and carbon)

Discount rate

The analysis of the variation of the net present value with different discount rates is shown in Table 7.8 for the case of all of the energy efficiency measures – considering only the case where health impacts are considered. It can be seen that the net present value remains positive across the range 3 to 10% for all measures apart from replacement boilers. The switching value (at which NPV=0) occurs at a discount rate of 3.848%.

Table 7.8. Sensitivity Analysis: Discount Rates.

Energy Efficiency Measure	**Discount rate**				
	3	3.5	4	5	10
Boiler Replacement	15	6	- 2	- 16	- 52
Double glazing	7,723	7,489	7,267	6,858	5,313
Draught proofing	1,319	1,197	1,086	896	335
Loft insulation	14,024	12,497	11,162	8,966	3,316
Overall	23,082	21,189	19,514	16,703	8,912

Proportion of housing moving from no double glazing to full double glazing

For the double glazing measure, the amenity value dominates much of the benefit side of the analysis. Hence, it is important to know the switching value for this attribute. The proportion of housing moving from no double glazing to full double glazing at which the net present value switches from positive to negative for double glazing is around 20.845%.

Energy and Carbon Savings

Sensitivity analysis was also conducted on energy and carbon savings. We considered scenarios where:

- No energy or carbon savings were included;
- 50% of base case energy and carbon savings were included;
- 150% of base case energy and carbon savings were included

These scenarios are compared to the base case below in Figure 7.1. It can be seen that the economic analysis of most of the measures is highly sensitive to the energy savings (and hence carbon savings). For the extreme case of no energy or carbon savings, only double glazing still has a positive net present value. For the case of 50% of base case energy and carbon savings, loft insulation, double glazing and draught proofing have positive net present values.

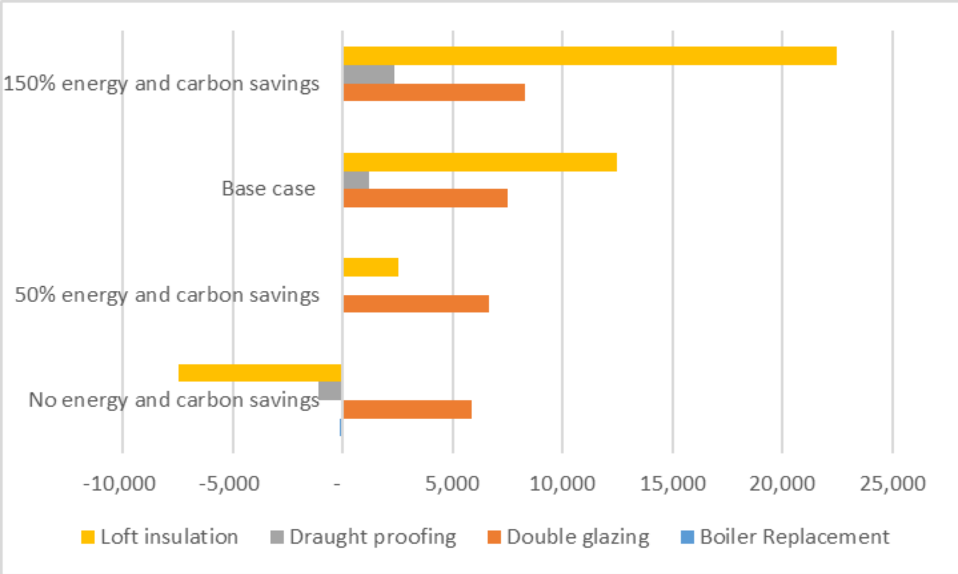


Figure 7.1. Sensitivity to energy and carbon savings (Net Present Value, £mn for different scenarios).

7.5. Lessons learned

Significant investments have been made in the United Kingdom to improve energy efficiency. These have been in part targeted towards reducing fuel poverty and in part to reduce carbon emissions. In this study, we have examined the costs and benefits of four distinct energy efficiency measures. Previous work has shown associations between these energy efficiency measures and hospital admissions for COPD, asthma and CVD. We have attempted to build on this by taking the assumption of a causal relationship – noting the difficulties in using ecological studies for this purpose. The results show the following:

- Boiler replacement becomes economically viable when the health benefits are taken into account. Boiler replacement is associated with lower COPD admissions, which pose a significant burden on the National Health Service;
- Loft insulation has been associated with higher admissions for asthma, COPD and CVD – maybe following the "sealing hypothesis" (whereby insufficiently ventilated properties pose health threats for residents). A similar finding was made for draughtproofing and COPD.
- The health impacts for both loft insulation and draught proofing reduce the internal rate of return for both investment types, but the measures are beneficial overall;
- The benefits for double glazing are dominated by the amenity impact of double glazing as reflected by property price increases. Further work is needed to disaggregate the impacts of different glazing levels on properties;
- Energy savings and carbon savings are important factors in the analysis – boiler replacement is shown to have a net present value with a 50% reduction in base case energy and carbon savings.

There are a number of factors not taken into account in this analysis. First, we have assumed that all energy savings are in the form of natural gas – future work could disaggregate the impact of improvements to different types of boilers and include other energy types in the analysis of energy and environmental improvements. Second, we have only quantified the health impacts for 3 conditions in terms of hospital admissions – other health endpoints may show different associations with energy efficiency investments. Notably, we do not consider the impact on winter mortality.

This analysis does show that it is by no means certain that energy efficiency investments lead to "triple wins" - in terms of environment the impact is likely to be unambiguously positive due to energy and carbon savings, though we do not consider life cycle impacts including construction and disposal. For health, the picture shown here is mixed. In terms of health equity, the targeting of lower socioeconomic groups and those in social housing for energy efficiency investments may lead to health inequalities unless the measures put in place are appropriately designed to avoid the sealing of properties and the negative health impacts associated with this.

8. Conclusions

The aim of this report was to present and discuss the economic assessment of the four selected case studies: Thinking Fadura in Getxo, Basque Country, Spain; Malvik path in Trøndelag county, Norway; Sustainable food in public schools in Madrid, Spain; and Retrospective Analysis on Energy Efficiency Investments in the United Kingdom.

A Cost Benefit Analysis has been developed to evaluate costs and benefits of the four case-study projects considering the perspectives of key stakeholders affected by the implementation of the case study itself, taking into account environmental and social costs and benefits that can be reasonably quantified through market and non-market valuation.

A second key aspect of the CBA proposed for the INHERIT case studies is the development of a common methodology for systematizing meta-analysis about health impacts. For that purpose, the team has proposed a common framework that has been used for the estimation of a Heckman model based on literature review process, that has allowed to assess health risk reduction as a response to a certain intervention when evidence in the literature is varied and heterogeneous. Also, the model proposed allows to transfer knowledge in areas for which no evidence exist from epidemiological studies. In INHERIT economic evaluation process, this has been estimated for both, (i) the response to green areas exposure and (ii) for the introduction of healthier and more sustainable food for children. This exemplify that the method can be, therefore, generalised for other types of interventions and it constitutes an important achievement of the evaluation process.

A last key point is the analysis of the citizens' perspective (through ad hoc surveys) to analyse perceptions and attitudes of people on the acceptability and impacts of the practice. This analysis was useful to complement the CBA approach based on quantitative indicators.

In Thinking Fadura, a multi-approach framework to assess costs and benefits of the interventions has been followed combining different theoretical approaches, methods and tools: (i) conceptual framework based on eDPSEEA model to analyse the relationship between green areas, ecosystem services and human health; (ii) modelling of health benefits from green spaces using the Heckman model and application to the local context of Thinking Fadura; (iii) stakeholders' perspective about the social impacts of the case study; citizens' perspective about the social impacts of the case study, acceptability and propensity of use; (iv) iSOPARC tool to assess physical activity in-situ; social cost-benefit analysis.

In this context, the analysis performed supported the development of a new approach based on the Heckman model, to assess the impacts of green areas on human health, and its application in the specific context of Thinking Fadura as an exemplification of the benefit-transfer for mortality risks. The Heckman model was suggested to deal with the existing study heterogeneity and to identify the factors influencing the significance of the relationship health-green areas, using a database of studies collected and reviewed in the phase of development of the eDPSEEA. Findings show that changes from baseline to medium exposure levels are expected to generate reductions in health risks of about 2.6% on average in the study population. This impact increases to a 3.5% for high exposure levels compared to the baseline, though diminishing returns to scale can be intuited from the data, consistent with the literature. One of the most significant conclusion extracted from this analysis is the relevance of contextual factors. The notion that different contexts yield different interconnections is supported by the results obtained, which pointed towards income, education, and urbanisation as possible factors affecting the results of the different studies. The study is based on the sound idea that the use of meta-analysis in reanalysing key but heterogeneous studies from the literature, taking into account both their significant and insignificant results, can provide a better understanding of the relationship between exposure to green spaces and human health.

The literature reviewed to develop the conceptual framework was also useful to identify main benefits and contextual factors, and to derive specific indicators for the qualitative and quantitative assessment of the benefits of Thinking Fadura, both in the CBA exercise, as well as in the citizens' survey-based questionnaire development to value attitudes and perceptions of users and general citizens.

The four CBAs evaluated in this report inform in a quantitative way about the costs and benefits of public interventions with the purpose of enhancing societal welfare. Therefore, these CBAs offer the possibility for policy-makers to design new studies with similar characteristics, which can serve as a reference in decision-making processes. The four case studies assess different fields within the INHERIT project. Whilst Thinking Fadura and Malvik Path focus on green areas, Sustainable food in public schools focuses on health diets among children and Retrospective Analysis focuses on energy efficiency investments in households such as double glazing, insulation and improved heating systems. Overall, the economic evaluations show that the four case studies are clearly profitable from a societal perspective.

Comparing Thinking Fadura with Malvik Path, the results show that Malvik Path seems to be more profitable. The results seem to show that this is mainly due to the difference in the costs of the case studies. Whilst the discounted benefits of the selected scenario in Malvik Path are around €3.8 million, in Thinking Fadura they amount to €3.2 million. On the contrary, the discounted costs in Malvik Path are less than €0.5 million in comparison with Thinking Fadura where they reach almost €2 million. Furthermore, in Thinking Fadura most scenarios present a positive NPV (52 over the 54 scenarios produced), a B/C ratio greater than 1, and an IRR greater than the selected discount rate (3.5%). In Malvik Path, the 81 scenarios evaluated in the sensitivity analysis show a positive NPV, a B/C ratio greater than 1.5 and an IRR at least five times greater than the selected discount rate (3.5%). In Thinking Fadura in the selected scenario (discount rate = 3.5%, time horizon = 20 years, assumed values for items with high uncertainty = 0%, and changes in future use = 0%) the NPV is around € 1.2 million (IRR = 11.7%), and the discounted payback period is 10.6 years, which means that it takes 10.6 year to recover the initial cash flow investment.

Starting from year 15 onwards Thinking Fadura seems to be profitable in most scenarios. In Malvik Path, the selected scenario (discount rate = 3.5%, time horizon = 20 years, price increased of houses = linear and proportion of new users = 50%) shows a NPV around €3.3 million (IRR = 174%) and the discounted payback period is in one year. The early recovery is mainly due to the low costs. In both pilots the highest benefits turned to be the increased property value (around € 1.5 million in Thinking Fadura and around €2.2 million in Malvik Path) and recreation (around € 1.1 million in Thinking Fadura and around €730,000 in Malvik Path) which are within the groups economics and technology and social, respectively, followed by physical activity. In Thinking Fadura, the highest cost was land adjustment including parking (around € 0.8 million) and in Malvik Path construction services (around €310,000), which are in both cases within the group initial investment and O&M.

Both economic evaluations could act as examples showing how public investments in the restoration and improvement of green areas can provide much greater benefits for society. There are numerous cases in Europe where this analytical approach could be replicated. For instance, as in the case of Thinking Fadura, there are many green urban areas in Europe where use is restricted to some part of the population. Thus, the case study exemplifies how public sporting clubs can remove their fences and become accessible to the general public in order to increase societal usage of urban green areas and make a net profit out of it. As in the case of Malvik Path, there are numerous areas around Europe, such as disused railways and other abandoned sites that could be recovered and transformed into accessible green space to provide net benefits in terms of environment, health, social and economics.

The CBA results of the Sustainable food in public schools showed that introducing more sustainable food products in nursery schools can provide economic benefits substantially greater than costs. Whilst the present value of the benefits was around €40.6 million the present value of the costs was almost €5.2 million in a 30 years horizon. This led to a NPV around €35.363 million. When increasing the discount rate to 12%, the benefits decreased to €15.3 million, the costs to €2.6 million and the NPV €12.7 million. Benefit-cost ratio decreased from 7.76 to 5.87, and in both cases IRR was of 53% and benefits overcoming the costs during the fourth year. The economic assessment has demonstrated that the intervention has a long-term economic return. For every euro that is invested in training and intervention activities for the awareness of healthy habits, an economic return of 5.8 to 8 euros is obtained. Undoubtedly, this fact shows how important is the need to allocate financial funds to the implementation of healthy interventions of these characteristics. In addition to having a direct impact on health in early childhood (which will be transferred to later ages), interventions in health habits such as the one described, lead to obtaining economic benefits in the context in which they are carried out.

Any food program aiming at improving diet of children at early ages can potentially strongly affect the development of children's eating behaviour (Birch et al, 2007). It is in the first years of life that food acceptance and food preferences are developed. However, it is also important to note the need to reinforce interventions at early ages with follow-up and public policies aimed at maintaining their effects at later ages. The expected benefits should therefore be interpreted as potentially attainable under the assumption that changes in behaviour cultivated in those early ages through this type of programs are sustained later with complementary interventions to create a favourable and stimulating milieu for people to be able to maintain their new habits (e.g. educational program, food programs in schools, universities and working places). In other words, specific policies aiming at improving easy access to healthy and sustainable food are needed to maintain changes in habits throughout the entire life, otherwise any benefit acquired as a result of any specific program could be at risk if the achievements are not enhanced.

The survey results of the pilot Sustainable food in public schools showed that acceptability and awareness of introducing changes in children's school menus by the educational community were key factors to achieve improvements on the food offered to children in nursery schools. Furthermore, the comparative analysis of perceptions of families, educators, schools' management teams, headteachers and kitchen workers, before and after carrying out the activities conforming the intervention evidenced substantial changes in the way the improvements achieved are perceived. However, there is still room for improvement to increase parent's awareness on healthy food benefits in order to increase the probability of implementing some of the measures at home. The survey results suggest that a short food circuit does not guarantee that the food has been produced in the immediate environment in which it is going to be consumed. The fact that there are no more than two intermediaries between the food product and the consumer does not mean that these products have been grown in the region. Early childhood is a very good time to start health interventions (Campbell and Hesketh, 2007). The review of the literature has shown efficiency in these interventions and within the case study there have been no problems of acceptance on the part of the children or of the educational community. On the contrary, the study of perceptions shows the high degree of acceptance and awareness achieved. Parents at this stage are receptive to and capable of some behavioural changes that may promote healthy weight in their young children (Campbell and Hesketh,

2007) A special mention should be dedicated to the kitchen staff' involvement, the case study success in the INHERIT experience was dependant on the support of the kitchen staff for the intervention. The empowering process that the case study experience produced in this group was a very important success factor. The implications of this analysis lead us to conclude that there is the need to initiate interventions for the improvement of nutritional habits from early childhood. Family, educators, kitchen staff and other professionals (headteachers, managers…) should join efforts and collaboration in order to raise awareness among children about the benefits of taking care of their health.

The retrospective cost-benefit analysis of energy efficiency investments in the UK case shows some interesting findings. In terms of the "triple win", it may not be unambiguously true that energy efficiency measures lead to positive health outcomes for all types of interventions. Overall, the economic analysis suggests that despite some negative health outcomes in terms of hospital admissions for selected health outcomes, the net present values of double glazing, draught proofing and loft insulation are overall positive. For replacement boilers, including these health outcomes moves a negative net present value to a positive one. The findings for double glazing are highly reliant on the assumptions around the house price increase that can be attributed to new double glazing.

To achieve the "triple win", it is important that policies be appropriately assessed both before and after the intervention. More work is needed to test the causality between health outcomes and energy efficiency measures – but we know that sealed housing may be bad for health. The only solution to this conundrum is a whole systems approach, to take into account the different interactions people have with their housing, and the same is true also for green spaces like Thinking Fadura and the Malvik Path, and for nutritional interventions like those discussed in the Sustainable Foods in Public Schools case. It is only if we take this approach and fully identify the potential pathways to benefits and negative impacts on health and the environment that we can ensure that interventions will lead to "triple wins".

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9. Annexes

Annex 1. Summary of articles describing impacts of green spaces over health

Table 1. Summary of articles describing impacts of green spaces over health.

Study type	Reference and location	Health outcome	Exposure	Main Contribution	Results
Objective	(Maas et al., 2009b) Netherlands	Persistence of disease (grouped in clusters).	Presence of green space in residential area.	To assess whether physician-based morbidity outcomes are related to green space in living environments.	Reduction in morbidity in 15 of the 24 disease clusters when quantity of green space in the 1 km radius area was 10% above average, significance limited to 3 clusters when 3km radius is analysed.
	(Takano et al., 2002) Tokyo (JP)	Five-year survival rate.	Range of neighbourhood characteristics, including green items.	To find the relation between public areas' greenery in residential environments and elderly populations' longevity in densely populated urban contexts.	Space for taking a stroll, street parks and tree lined near the residence found to be positively related to survival rate, though not always with significant relationship.
	(Hu et al., 2008) Escambia and Santa Rosa counties (US)	Stroke mortality.	Greenness and pollutants measured through GIS.	To determine the relation between stroke mortality and a series of factors (air pollution, income and greenness).	Significant correlation found between mortality reduction and green areas.
	(Mitchell and Popham, 2008) England (GB)	General health and on cardiovascular disease (CVD) among other factors.	Statistical area classification according to percentage of greenspace.	To test whether health inequalities correlated with income would be less pronounced in populations more exposed to greenery.	Significant reductions in health inequalities both for all-cause mortality and for circulatory disease correlated to the presence of green space.
	(Pampalon et al., 2006) Québec (CA)	Life expectancy and different cause mortality.	Census areas according to their urbanization level.	To compare the health contexts of rural and urban areas in Québec.	Impact of urbanity level varying among variables. Health problems often greater in rural areas.

(Cusack et al., 2017) Texas (US)	Preterm births, small for gestational age cases and term birth weights as birth outcome measures.	Normalized Difference Vegetation Index (NDVI).	To study birth outcomes with respect to residential greenness in the Texan context.	Term birth weight presented the only significant results in fully adjusted models. Birth weights for mothers in greener environments were 1.9 g higher than the baseline.
(Hanski et al., 2012) Eastern Finland	Atopic sensitization/allergic disposition analysed in a sample of adolescents.	Surrounding biodiversity in residence area.	To provide evidence to the “biodiversity hypothesis”, that reduced contact with environmental features is related to the increase in prevalence of certain illnesses.	A relationship was found among surrounding biodiversity, presence of skin microbiota and lower levels of atopy.
(Henke and Petropoulos, 2013) Wales (GB)	Measures of limiting long term illnesses, mortality, physical activity guidelines met and life expectancy.	Recreational areas in Wales were identified and their extension measured as proportion of each local authority.	To explore the interconnections among ecosystem services, human health and deprivation in a context where green ecosystems are abundant.	Low levels of correlation were found between relative amount of recreational areas and life expectancy or long-term disease.
(Huynen et al., 2004) Not local	Disability adjusted life expectancy, infant mortality and percentage low-birthweight babies.	Different indicators were used to calculate biodiversity loss: percentage of threatened species, changes in forest cover and the percentage of land highly disturbed by man.	To address the potential relation between biodiversity loss and health at a global scale.	Significant effects of biodiversity loss were found for some variables, but authors were not able to provide obtain a general association between biodiversity loss and health.
(Tamosiunas et al., 2014) Kaunas (LT)	Both CVD-related deaths and non-fatal cases.	GIS data on parks larger than 1ha were taken. Use of parks was also considered.	To study the interrelations between distance and sue of green areas on the one hand and prevalence of CVD and its risk factors on the other.	Health benefits were found in certain cases studied such as when considering males and distance to parks or female park use.

Subjective	(Van Herzele and De Vries, 2012) Ghent (BE)	Self-reported health and well-being.	Two neighbourhoods were selected similar in all terms except the availability of green spaces.	To study the connection between local environment's greenness and health and wellbeing of those living in such environment.	No significant results for self-reported health.
	(Dunstan et al., 2013) South Wales (GB)	Self-reported general health.	Three tertiles were constructed through the Residential Environment Assesment Tool (REAT), which includes environmental elements	To investigate the relation of health with residential environment's quality taking an objective measure of the latter.	No significant effects were found when analysing natural elements.
	(De Vries et al., 2003) Netherlands	Survey-based on diagnostic interviews for mental health assessment, focusing on anxiety disorders, mood disorders, substance abuse and common mental disorders (CMD).	Presence of green space in residential area.	To address the question of whether greener areas' populations are healthier by studying self-reported health of Dutch populations in combination with land use data.	The study found significant results for the effects of presence of green space over CMD and anxiety disorders.
	(De Jong et al., 2012) Scania (SE)	Self-reported: Neighbourhood satisfaction (NS), physical activity (PA) and general health (GH).	Scania Green Score (SGS): Index based on perceived green neighbourhood qualities, "culture", "serene", "lush", "spacious" and "wild"; as well as perception over each of the components. GIS-based objective greenness was also a measure taken.	To implement the SGS index in the context of analysing health and wellbeing of Scanian population.	When analysing SGS and GIS-based greenness in separate regressions, it was found that both measures implied higher levels of physical activity, while subjectively measured green spaces also implied improved self-reported health. This last relation disappeared when using GIS. When including both greenness measures within simultaneous regressions, results were similar except for the link between GIS-based greenness and general health, which turned negative.

	(Mansor et al., 2012) Taiping (MY)	Questions on the relation between green space and wellbeing were included in the questionnaire.	Combination of a questionnaire survey and semi-structured interview on urban green areas of the city chosen.	To study the attitudes of citizens with respect to green infrastructure in relation with wellbeing.	Green infrastructures were found to be influencing levels of physical activity. Perceptions on greenness diversity was correlated to perceptions on the wellbeing effects.
Proxy	(Grazuleviciene et al., 2015) Kaunas (LT)	Systolic and diastolic blood pressures (SBP; DBP), heart rate (HR) and recovery, and exercise duration.	Two randomised patient groups exposed to different walking settings: urban and green. All of them were exposed to 30-minute walks during a 7-day period.	To assess whether walking in a green environment has an increased effect over coronary artery disease.	Effects appeared for all variables after the 7-day period, which implied a cumulative effect of green exercise over hemodynamic variables.
	(McKenzie et al., 2013) Scotland (GB)	Medication prescriptions as a proxy for mental health.	Urban and rural classification of neighbourhoods.	To analyse the potential association between living environments and mental health problems such as anxiety, depression and psychosis.	Urban areas accounted for a higher proportion of prescriptions for mental illnesses.
	(Witten et al., 2008) New Zealand	Body Mass Index and measures of activity.	Car travelling times as proxy measure for distance between neighbourhoods and parks and beaches	To tackle the question of whether access to public space can lead to increased levels of physical activity.	No significant outcomes found when including all of the controls, but correlation found between BMI and access to beaches.
	(Grazuleviciene et al., 2014) Kaunas (LT)	Four blood pressure categories (optimal -baseline-, normal, high-normal blood pressure, and hypertension).	Subjects were classified among three groups according to distance between residence and the nearest park. Apart from this discrete measure, continuous distance was also used.	To analyse the effect of distance to urban parks over blood pressure categories during the early stages of pregnancy.	Once adjusted to risk factors, data the study indicated an increase in OR for intermediate groups with respect to the baseline group when comparing lower distance group with those living closest. Another significant increase was found when analysing distance continuously. For the case of the hypertense group increased OR diminished and lost statistical significance.

	(Li et al., 2011) Tokyo (JP)	Blood and urine measurements before and after the activity.	Two randomised subject groups (all healthy male) exposed to different settings: urban and green. They spent a day within the assigned environment, walking for 2 hours in the morning and afternoon.	To study the effects of walking in forests over cardiovascular and metabolic indicators of male subjects.	Blood pressure, dopamine and urinary noradrenaline levels were found to be significantly reduced in the group spending the day in the greener location. Serum adiponectin and dehydroepiandrosterone sulphate (DHEA-S) on the contrary were found to be significantly higher.
Combined subjective and objective measurements	(Min et al., 2017) South Korea	Depression referring to the immediate 12-month period, depressive symptoms through a standardised questionnaire.	Extension of parks and green areas in each residential geographical code along South Korea.	To scale the research on the potential benefits of parks and green spaces over mental health from the local to the national level.	Individuals living in the least low area quartile presented odds of suffering from depression and presenting suicidal indicators a 16-27% higher than those living in the greenest quartile.
	(Pereira et al., 2012) Perth (AU)	Coronary heart disease (CHD) and stroke based on self-reported cases and analysis of records of hospitalizations.	NDVI	To investigate in a specific manner the greenness of a neighbourhood in relation to CHD.	Overall greenness no significantly related to decreased odds of diagnosed coronary disease and stroke. Variance of the NVDI inside wards was found to be relevant on stroke risk.
Combined subjective and proxy measurements	(Ward Thompson et al., 2012) Dundee (GB)	Cortisol levels and self-reported stress and well-being measures in individuals in vulnerable situation.	Percentage of green zone over the total area of the neighbourhood.	To study health benefits of green areas using “ecologically valid objective measures” and to determine whether salivary cortisol may be used as a biomarker in the research of stress levels.	No significant correlation between mean values of cortisol and green areas, but a link was found with self-reported measures.
	(Yang et al., 2011) Zhejiang (CN)	Brainwave activity, complemented by a questionnaire	Visual stimuli of areas with different degree of greenness	To address the psychological side of noise reduction provided by plants.	Additional subjective noise reduction perception in group watching greener environments.

(Roe et al., 2013) Dundee (GB)	Salivary cortisol and perceived stress in jobless men and women residing in deprived districts. Wellbeing using shortened version of the Warwick and Edinburgh Mental Well-being Scale (SWEMWBS).	Green space measured according to percentage of green spaces in the Census Area Statistics.	To analyse the mechanisms operating under the relation between the environment and mental health, particularly in the context of stress in jobless populations.	Positive correlation was found between cortisol slope and physical activity and green space, and higher amount of neighbourhood green space was found to be related to lower perceived stress. The regression performed to analyse the relations found perceived stress to be negatively and significantly related to the green space percentage. The presence of a garden in home was only a relevant factor for males.

Source: Chiabai et al (2018).

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Annex 2. Literature review on green spaces and wellbeing: the health perspective

Literature review on green spaces and wellbeing: the health perspective (Source: Chiabai et al. 2018).

Green spaces have diverse impacts on human health and wellbeing, and this is reflected in the diversity of the studies performed in the exploration of the relationships between ecosystems and health in this context. Human health is highly dependent on the environment. It has been postulated since early times (Ward Thompson, 2011) that being surrounded by nature improved human wellbeing. With the arrival of the industrial revolution the impact of pollution became more relevant for public health (Ward Thompson, 2011) so that the role of urban green areas can be key in this context. The links between natural environments and improved health are well documented (Alcock et al., 2015, Maas et al., 2006, Shanahan et al., 2015a, Shanahan et al., 2015b, Triguero-Mas et al., 2015), however the mechanisms remain elusive. Evidence suggests that access to and availability of urban green and blue spaces provide a wealth of health promoting opportunities, associated with reductions in stress, anxiety and depression, reductions in diabetes and cardiovascular and respiratory disease through an increase in opportunities for physical activity (Hartig et al., 2014, Shanahan et al., 2016).

We performed a search through web resources such as Web of Knowledge and Google Scholar combining terms related to the areas of environment and health. A series of combinations including health-related terms (health, disease, life expectancy, mortality, epidemiology, etc.) and their derivatives, and environment-related words (environment, nature, ecosystem, pollution, green spaces/areas, etc.) and their derivatives were used. Complementary terms (such as qualitative, statistical, literature review, etc.) were introduced when necessary. Snowballing from the literature, particularly literature reviews, was another source of references. We included previous literature reviews and meta-analysis looking at quantitative health impacts, qualitative studies using empirical data from surveys looking at subjective perceptions, and finally a number of studies offering theoretical approaches and discussions to analyse the interaction. In total 117 studies were identified that investigated these relationships.

The diversity of the literature with quantifiable results spans throughout three main axes which we can classify as: type of study in terms of broad methodological approach, heath outcome and exposure. Methodological approaches used in the literature were classified into three groups (Martinez-Juarez et al., 2015a). Namely we distinguished among “objective studies” (using objective measurements of health), “subjective studies” (relying on subjective or survey-based measurements) and “proxy measure based-studies” (relying on proxies that can be precursors of health problems). In the next three sub-sections we discuss some key studies identified in each of the three groups, commenting the specific methodology used and main results obtained. Based on the analysis of the 117 studies we subsequently propose different types of exposure characterising the type of individual involvement with nature, and finally present a discussion on the role of contextual factors in the interaction health-environment.

1 Objective studies

Objective studies use different types of health data such as hospital admissions for specific health conditions, changes in life expectancy or mortality, all of which could be measured in an objective manner using risk factors and statistical metrics. Studies of this type include epidemiological studies such as the one performed by Maas et al. (2009b). The authors analysed one-year persistence rate of illnesses aggregated in 24 clusters in order to study the effect of greener living environments on health. Positive impacts were found in most of the health clusters for greener areas located closer living environments (1 km radius), while effects diminished when more distant areas were taken (3 km). Mental health impacts were most notable. According to their results, green spaces impacted anxiety in a higher degree, with a decreased odds ratio (OR) of 0.95, while depression exhibited a reduction in persistence associated with an OR of 0.96. Both results were significant at the 95% significance level. Other illnesses with significant decreased ORs were coronary heart disease (0.97 odds ratio), several musculoskeletal complaints, such as back and neck complaints (with OR diminishing to 0.98), asthma, COPD and upper respiratory tract infection (OR of 0.97), neurological disorders (ORs between 0.97 and 0.98), and digestive infectious disease of the intestinal canal (OR 0.97).

A different approach was taken by Takano et al (2002), who analysed changes in survival rates in the city of Tokyo, and found that environmental aspects such as the presence of space for taking a stroll, streets with parks and trees near the residence areas were associated with higher survival rates. This study found that spaces for taking a stroll could significantly increase survival rates both for males and females. For example, parks and trees were positively related to overall survival rates, showing an increase from 66.2% to 74.2% when parks and trees increased from a minimum amount (defined qualitatively as “very little”) to a maximum (defined as “plenty”). The relationship was, however, not always significant when analysing specific subgroups of the population (e.g. females).

While also objective, a somehow different approach was taken by Hu et al. (2008), who analysed stroke mortality in two US counties and also found evidence linking greener environments to improved health conditions. Their specificity in the approach lies in the proposed model which uses a combination of mapping with Bayesian hierarchical modelling combined with Monte Carlo analysis. The resulting figures showed that greenness presented a mean effect of -0.161, with a credible set spanning from -0.289, to -0.031, which implies a significant reduction of stroke mortality in greener areas. Air pollution also had relevant effects, though of the opposite sign.

Mitchell and Popham (2008) also considered mortality rates in their study, though their finding was that not only green spaces could have a positive impact over health, but that this impact could be stronger in groups with lower income levels, having thus an reduction effect over health inequalities. Incidence rate ratios (IRR) varied among groups. For all-cause mortality, IRR between most and least deprived areas in least green areas was of 1.93, while in the greenest areas IRR was reduced to 1.43. Circulatory disease mortality showed a change from 2.19 to 1.54 under same circumstances.

Another study considering mortality we wish to highlight was performed by Pampalon et al. (2006). The study was centred over the differences in health between urban and rural areas. Mortality in rural areas was found to be significantly higher, compared to urban areas. The study also emphasised the importance of contextual factors in this relationship. In this study, improved health in urban areas resulting from improved access to healthcare puts a limit over the greener-is-better relation.

2 Subjective studies

A second group of studies use self-reported measures of health, which we named “subjective studies”. Health questionnaires are used in order to obtain measures of general health as well as to tackle specific health problems as anxiety or cardiovascular health. Likert scales are often used in this type of studies in order to facilitate respondents in reporting their perceived health status. Semi-structured interviews and Yes/No question sets or inquiring over the number of symptoms remembered over a time period can also help in analysing population’s health. Although self-reported measures exhibit a number of biases, they can ease the task of addressing health in a subjective way. These methods are often combined with different measurement metrics such as proxy indicators which can detect a health problem. Such mixed analyses are included in the third group of studies and described later.

Van Herzele and de Vries (2012), used a questionnaire in order to ask for the health status of inhabitants of two neighbourhoods in Ghent, one being substantially greener than the other, while other characteristics being similar. Inquiry over self-reported health used a 1-7 Likert scale to ask for general health and added a question over the number of symptoms experienced by individuals. The study found no significant improvement in self-reported symptoms, but it did find higher levels on reported general wellbeing in the greener neighbourhood. A different questionnaire was used by De Vries et al (2003) when conducting their research on the relationship between greenspace and health. They examined the amount of green in the study subjects’ living environments and found a positive relation between greener environments and self-reported health. The latter was measured combining a five-point Likert scale for perceived general health combined with an inquire to recall symptoms in the last 14 days. In this case, a version of the General Health Questionnaire was used to determine propensity of participants to psychiatric morbidity. De Jong et al (2012) used self-reported levels of physical activity as well as perceived green qualities in their study, finding a positive association among these variables. In their analysis of a series of neighbourhoods in South Wales, Dunstan et al (2013) studied reported levels of poor health and objectively measured neighbourhood quality. REAT (Residential Environment Assessment Tool) serves as index for neighbourhood quality, and is comprised by a series of 28 items encompassing aspects such as physical nuisance and incivility, territorial functioning, defensible space, natural elements and miscellaneous other factors. Natural elements (green spaces and infrastructures) had however no significant impact over health in this analysis.

3 Proxy measure based-studies

The third type of studies are those relying on proxy measures. These proxy measures can be intended as a precursor to disease and health status, so they are particularly relevant to detect health benefits from exposure before the disease can manifest. This is the case of cholesterol measures, cortisol presence, prescription of medications, Body Mass Index (BMI), etc. Some of the studies using such variables combine them with other measurement types such as perceived health from survey-based analysis. We include here examples of the use of proxy measures and of combined systems.

Yang et al (2011) studied brainwave activity through electroencephalogram (EEG) in order to assess psychological noise reduction gained when using landscape plants as buffering system. The study involved visually and stimulating participants with either green images or images showing traffic elements while noise stimulation was also applied. A control group was also employed as reference. The study relied too on subjective measurements provided by participants. These last measurements showed that there was a widespread belief that landscape plants had an impact over noise reduction, 90% of respondents believed so, with an 80% of participants considering them the most efficient option. Participants tended to overrate the noise reduction capacity of plants measured, with 55% of them overstating the capacity, 40% giving accurate values and 5% underestimating the effect. Significant variations were found un beta-1 and beta-2 waves between those subjected to green stimulation, and traffic and control groups. Variations in alpha-1 and alpha-2 waves were restricted to a couple of brain areas. No significant changes in delta and theta waves was found. They found an additional reduction caused by the use of these elements.

McKenzie et al (2013) used drug prescription levels in order to analyse mental health in different settings in Scotland, finding that urban settings were more prone to the use of prescription drugs targeting depression and anxiety. Blood pressure is another common measure in studies. Such are the cases of two studies performed in Lithuania (Grazuleviciene et al., 2015, 2014). Both studies found improvements in their measuring in groups more influenced by parks and green areas. In the 2015 study, researchers tested whether coronary artery disease (CAD) patients' hemodynamic parameters would show more positive effects after park walks than after urban strolls. Systolic (SBP) and diastolic (DBP) blood pressures as well as heart rate (HR) were analysed at rest, after exercise (differences after 1 and 30 minutes) and after a 7-day exercise period. Effects appeared for all variables after the week. The second study analysed blood pressure in the early pregnancy. Participants were classified into four groups, ranging from optimal (blood pressure) to hypertension. In order to measure exposure to ecosystems distance of residence to a park was used, both continuous and discrete (<300m, 300-1,000m, >1,000m). OR were calculated by comparing odds of being classified in a higher-blood pressure group according to proximity of residence to an urban park. OR adjusted to risk factors indicated increased OR for intermediate groups with respect to the baseline group (optimal) when comparing lower distance group with those living closest. Increase was also significant when analysing distance continuously. For the case of the hypertense group increased OR diminished and lost statistical significance.

Similarly, Li et al (2011) took measurements of participants' blood pressure after walks in different contexts (a walk in a forest park and an urban walk). These measurements were combined with urine samples which were used to calculate noradrenaline and dopamine levels. Evaluation of the proxy variables led researchers to determine a positive effect of walking in greener contexts. Among those that employed different proxy measures we can find Witten et al (2008), who combined BMI, sedentary behaviour and physical activity levels. The aim of the study was to analyse the impact of access to public open space over those variables. In order to determine access to parks and beaches, minutes of travel by car were used as variable via GIS. They found access to parks not linked to reduced BMI or sedentary behaviours, though they found a correlation when studying access to beaches.

Ward Thompson et al (2012) took a combined approach when analysing stress in deprived communities. They used salivary cortisol as their main measure for stress, complementing it with a self-reported measure. Salivary cortisol was measured at different points during the day. Between 3 and 12 hours after the awakening time. Greenness and deprivation measure were based on participants' postal areas. Self-reported stress was found to be correlated to greenness. steeper cortisol evolving patterns (higher in the early hours after awakening and lower after 12 hours) were correlated to wellbeing, physical activity and greenness, as well as with improved self-reported stress.

Mean levels of cortisol were not associated to greenness or lower levels of stress. These relations were significant at the 95% level.

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Annex 3. Quantifiable results from a literature review in health impacts of changes in exposure to greenness

Chiabai, A., Suarez, C., Martinez Juarez, P., García de Jalón, S., Quiroga, S., Taylor, T., 2019. Exposure to green areas: Modelling health benefits in a context of study heterogeneity. *Ecological Economics* (*in press*).

Aline Chiabai*[a], Sonia Quiroga[b], Pablo Martinez-Juarez[b], Cristina Suárez[b], Silvestre García de Jalón[a], Tim Taylor[a]

a) Basque Centre for Climate Change (BC3), Leioa, Spain
b) Department of Economics, Universidad de Alcalá, Spain
c) European Centre for the Environment and Human Health, University of Exeter Medical School, United Kingdom

Abstract

This article shows the result of the meta-analysis performed over a series of articles that focused on the potential health improvements (or deteriorations) of human health conditions related to increases in exposure to natural or seminatural environments. This database shows the studies where these impacts were able to be homogenised into coherent indexes –percentage change in health state, which we describe as health risk reduction (HRR) and change in exposure to the environment. This database was built mainly from information contained in the articles analysed for its construction, nevertheless, for all information not provided by articles, external sources were used.

Specifications Table *[please fill in right-hand column of the table below]*

Subject area	*Economics*
More specific subject area	*Climate change adaptation and health assessment*
Type of data	*Database*
How data was acquired	*Literature Review*
Data format	*Analyzed data*
Experimental factors	*Results extracted were homogenised as percental changes in the variable, while greenness was evaluated as a qualitative variable*
Experimental features	*Dataset based in a metanalysis*
Data source location	*Not applicable, varied locations*
Data accessibility	*Data with this article*

Value of the data

- This dataset offers a brief summary of key studies with quantitative results linking health and exposure to green areas.
- Results from each piece of research have been individualised as observations for this dataset.

- Information has been complemented with external data to reflect contextual factors to each observation.

Data

The database presented alongside this paper has been fruit of an extensive literature review and summarises the results from a series of research papers reviewed in the process. The literature review was performed on studies analysing impacts of exposure to natural and seminatural spaces over human health. After a process of evaluation, selection and homogenization of the results, the resulting database shows the health impacts of natural and seminatural spaces expressed as percental changes in health risks linked to a change in exposure to green areas.

The database also shows which aspect of health is dealt with at each point (general health, cardiovascular diseases, respiratory diseases, mental health and other health endpoints are distinguished). Additional information over the health result is related to mortality (as opposed to morbidity) and a second stating whether the observation was extracted from a subjective measurement obtained through a survey to citizens or patients (as opposed to objective or physician assessed measurements, which included for obvious reasons mortality-related results). The database also specifies exposure levels to natural and seminatural spaces as a baseline, low, medium and high exposures.

This material is complemented with contextual information extracted from papers when available and from external sources otherwise. These variables include age structure, gender, per capita income, literacy rate, hospital beds per capita and percentage of urban population.

Experimental Design, Materials and Methods

This data is one among the results obtained after an extensive literature review performed over studies that tried to determine health impacts of different forms of exposure to natural and seminatural environments. This systematic search was mainly done through ScienceDirect and Web of Knowledge, using a set of selected keywords related to natural environment such as green areas, ecosystem, ecosystem services; and health, as mental health, non-communicable diseases, epidemiology, cardiovascular and respiratory diseases. This process and its main outcomes, including a conceptual framework built from what was learned from the literature were described by Chiabai et al (2018). From this initial process, those studies offering quantitative information were selected for further analysis.

The detailed analysis of the outcomes and approaches was also conducted in order to incorporate the information into the dataset accompanying this paper, which was used afterwards for the econometric analysis in Chiabai et al. (under revision).

The scope of this analysis was to include studies providing quantitative measurements of the relationship natural and semi natural environments and human health, taking into account a variety of approaches and measures of the health outcome as well as of exposure. This was necessary in order to gather a sufficient number of data, which resulted in a database characterised by a high level of methodological heterogeneity.

Table 1 summarisesthe studies extracted from the literature review and included in the database, including information over study location, methods, health outcomes and indicators, the number of observations available in each study as well as those with significant results in the analysis performed. Each study presents several research cases with individualizable results, in terms of effects on health from exposure to green areas, that we consider as observations in our database. The latter is composed of 12 studies with a total of 182 observations, of which 88 find a significant relationship between health and exposure to green areas at the 95% of confidence interval.

Table 1. Studies included in the database in the order appearing in the database.

Study	Location	Method	Health outcomes	Observations		Health indicator	Green exposure indicator
				Total	Significant effects		
Maas et al., 2009	Netherlands	Multilevel logistic regression analyses	24 outcomes*	58	26 (44.8%)	Annual prevalence rate	Percentage of green space in a radius of 1 and 3 km around the postal code of respondent's home
Maas et al., 2006	Netherlands	Multilevel logistic regression analyses	Perceived general health	6	6 (100%)	Percent of responses (5-point Likert scale – very poor to very good)	Percentage of green space in a radius of 1 and 3 km around the postal code of respondent's home
Takano et al., 2002	Tokyo, Japan	Multiple logistic regression analysis	All-cause mortality	21	8 (38.1%)	Five-year survival rate for the elderly	Presence of walkable green spaces near the residence (parks and tree lined streets) measured with qualitative indicators
Mitchell and Popham, 2008	England	Binomial regression model	All-cause mortality, circulatory diseases and cancer	15	9 (60%)	Mortality incidence rate	Population classified into 5 exposure groups based on the proportion of green space of residence
Pereira et al., 2012	Perth, Australia	Logistic regression	Coronary heart disease	4	1 (25%)	Hospital admissions and self-reported medically diagnosed cases	Neighbourhood greenness for a 1600 m service area around residence using remote sensing data
White et al., 2013	England	Fixed effect regression	Perceived general and mental health	12	10 (83.3%)	Percent of responses (5-point Likert scale – poor to excellent)	Distance to the coast (0–5km; 5–50km; >50 km) and percentage of green space
Dunstan et al., 2013	South Wales	Multilevel logistic regression model.	Perceived general health	3	2 (66.7%)	Percent of responses (3-point Likert scale – not good-fairly good-good)	Neighbour measure of natural environment through Residential Environment Assessment Tool (REAT)
Tamosiunas et al., 2014	Kaunas, Lithuania	Multivariate Cox proportional hazards regression	Cardiovascular disease, fatal and non-fatal	21	0 (0%)	Age-adjusted prevalence (%)	Distance to city parks larger than 1 hectare, categories classified based on spatial land cover data
Pretty et al., 2005	Colchester, UK	One-way ANOVA test	Perceived mental health	4	3 (75%)	Percent of responses (5-point Likert	Exposure to visual stimuli (rural and urban photographic scenes)

			(depression and anxiety)			scale –not at all to extremely)	
Marselle et al., 2013	England, UK	One-way ANOVA test	Perceived stress and depression	14	2(15%)	Use of Major Depressive Inventory and a 10-item Perceived Stress Scale	Questionnaire on participants' walking environments
Roe et al., 2013	Dundee, UK	Multiple linear regression	Perceived mental health (stress)	4	2 (50%)	Perceived stress score (5-point Likert scale – never to very often)	Percentage of green space (parks, woodlands, scrub and other)
Kerr et al., 2006	Japan	Doubly multivariate profile analysis (MANOVA)	Anxiety	2	1 (50%)	Tension and Effort Stress Inventory	Outdoor running session vs-outdoor running in natural environment

The presence of quantitative results was the key element for inclusion. Nevertheless, it was not the only one. Inclusion on the database was considered when studies took measures of health, and therefore, studies that focused on wellbeing were excepted. Measurements of exposure were also considered. This dataset includes primarily studies that considered the amount of greenspace in urban or peri-urban areas and the use of green space. It excluded studies that focused on the urban-rural classification and studies where the environmental elements were fictious such as photographs. Another reason for exclusion was the impossibility of obtaining information necessary to homogenise measurements either of health impact or of exposure to natural and seminatural environments. Due to the process timing, studies posterior to 2015 were also not considered in the final database.

In order to construct the database, quantitative results were individualised. Most of the studies analysed offered a range of results, distinguishing between the health outcome considered (e.g. cardiovascular disease vs asthma), the population (e.g. adults vs elderly groups), outcome of the disease (morbidity vs mortality), etc. All results meeting the criteria for inclusion were added to the database. Studies with results both meeting the criteria and not were also detected. For such cases only, results meeting the criteria were included.

Dependent variable and exposure index:

Given the diversity of indicators used for the two main variables, health outcome and exposure, some assumptions for standardization are needed to carry out the analysis under a common measurement framework. Our first order of business was therefore to create standardised indicators for a common measure allowing for comparison among the results in terms of (i) health risk reduction (HHR) and (ii) exposure to green areas.

(i) Health risk reduction (HRR)

Changes in health status were transformed into an index representing percental change with respect to a baseline exposure level. Transforming results achieved in papers into this index implied different levels of complexity. Papers taking Odds Ratios (OR) were among the simplest, as differences between the baseline (1 or 0 depending of the reference used in the paper) and the OR were taken and multiplied by 100 in order to obtain a percent variation (positive for improvements in health or negative for detriments). This system was used for example for the study by Maas et al (2009). Studies making use of econometric tools could be divided among those offering level results and those based on logarithmic changes. Logarithmic results offered by definition percental variations. For those using levels, the outcome variable was calculated by using average values and compared to post-intervention average result. Percent increases between those values were used as final result. This system was used for example for the study by White et al (2013) or Maas et al (2006).

(ii) Exposure to green areas

In order to deal with the heterogeneity of exposure to natural and seminatural environments a qualitive approach was taken. We constructed three intervals based on the cumulative distribution function of the specific indicators used in the reviewed studies, which allowed us to build a new metrics with three levels of exposure: baseline, medium exposure and high exposure. As with the measurement of health impacts, the exposure variable was found to vary vastly among studies, which make use of different metrics, such as distance to the nearest park, percentage of green space (Maas et al, 2006; 2009), normalised difference vegetation index (NDVI), etc. Therefore, the classification was made by constructing three intervals based on the cumulative distribution function for each indicator as reported in the reviewed study. We considered the lowest level of exposure described in each study as the baseline for the observation to be included in the database. Then, medium exposure is in every case the second tercile group and high exposure is the third tercile group of the distribution. See Figure 1. for an example with the data from White et al (2013) and Maas et al (2009) representing two different situations. In order to achieve consistency those two transformation systems were taken as reference.

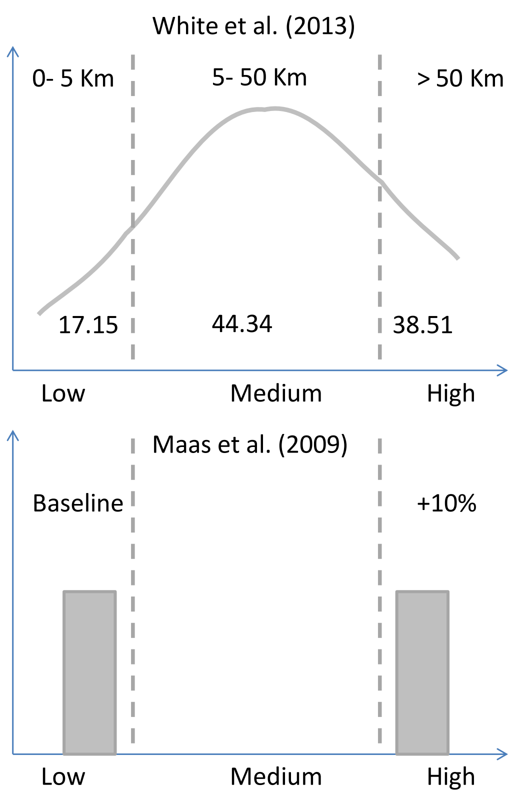

Figure 1. Distribution of observation according to the level of exposure to natural and seminatural environments (baseline, medium exposure and high exposure) defined in each paper studied.

(iii) Other health-related variables:

The variable **mortality** refers to indicators such as mortality incidence rate, five years' survival rate, life expectancy, measured from estimated coefficients in epidemiological functions. In our database, this variable appears in contraposition to the omitted variable morbidity. The latter may refer either to objective indicators (e.g. annual prevalence/incidence of diseases, hospital admissions) or subjective indicators (e.g. general health perception measured on Likert scale).

Subjective refers also to how the health outcome is measured in each study. Subjective studies were those based on self-assessed measurements of health, such as self-assessed general health or declared cardiovascular incidents among others. It relies on subjective measures such as opinions and individual perceptions on health status, quantified in survey-based questionnaires with qualitative measures using the Likert scale technique (e.g. "very poor" to "very good"). This category is contraposed to objective studies which are based on objective metrics drawn from health registries (mortality rate, prevalence/incidence of specific diseases, hospitalization rate, life expectancy).

Disease type was structured as a categorical variable consisting of a series of dummies corresponding to five groups into which different health or disease issues were classified. The clusters used were: mental health, cardiovascular health, respiratory health, other health impacts not included in previous categories (such as musculoskeletal, neurological, digestive, diabetes, cancer, etc.), and a universal category general health. Mental health included all results related to the psychological impacts of exposure to natural environments. These impacts included stress relief, reduction in anxiety levels, physician or self-assessed mental health, etc. Cardiovascular health included a series of issues related to the heart and the circulatory system, such as stroke mortality or declared cardiovascular events among others. A separate category was dedicated to respiratory health, which includes diseases such as chronic obstructive pulmonary disease and asthma. The literature also considered other issues that were not as thoroughly assessed as those three, such as the impact of greenery over cancer, gastrointestinal health, etc. Those issues fell into our "other" category. Finally, general health referred to a generic qualitative category of health status as well as all-cause mortality.

(iv) Other variables:

A series of contextual variables were added to the database. The categorical variable **Age** divided the study population into three age groups: young (0-15-year-old); adult (16-65-year-old) and elderly (over 65). Data was extracted from the study whenever possible. When this information was not available the age structure from the region or country was used. Similarly, the variable **female** made reference to the proportion of females in either the study population when available or in the region or country otherwise.

Other contextual variables were added. In these cases, information was not available in the study and external data was used. **Income per capita** referred to the per capita GDP of the country. **Hospital beds per capita** is a measure of hospital beds per 1,000 people in the country where the study was conducted. **Urbanization** was a measure of population living in urban environments as defined by each countries' statistical service and gathered by the World Bank (WB) database. Finally, **literacy** was also a measure taken from external databases referring to literacy rate among of people ages 15-24 in each country.

The database constructed for the modelling includes a number of demographic and socio-economic variables as control factors. Most of them were available in the studies reviewed, while others were taken from secondary sources. The full set of variables included in the database is presented in Table 2.

Table 2. Description of variables.

Variable	**Description**	**Data source**	**Units**
Health risk reduction [*HRR*]	% change in the health indicator due to an increase in exposure respect to a baseline defined as low exposure.	Reviewed studies	% change
Mortality *[mort]*	Mortality versus morbidity impact. It allows measuring the differential effect between mortality and morbidity.	Reviewed studies	Dummy variable (1 for mortality, 0 morbidity)
Subjective *[sub]*	If the study relies on self-stated health, the observation is regarded as subjective, otherwise not.	Reviewed studies	Dummy variable (1 for the subjective studies, 0 otherwise)
Disease type [*gen/car/res/ men/gen/oth*]	General (all-cause, general health), mental, cardiovascular, respiratory, others (diabetes, cancer, etc.).	Reviewed studies	Categorical variable
Exposure to green areas [$exp_b/exp_m/ exp_h$]	Availability of green spaces in the surroundings of people's living environment, measured in terms of vicinity and/or % or density of green.	Reviewed studies	Categorical variable (1 for low exposure, 2 for medium exposure and 3 for high exposure)
Female *[fem]*	Proportion of female population over the total.	Reviewed studies	Percentage (of female on total)
Age [young/adult/ old]	Age groups: young <16, adults 16 to 65, elderly >65.	Reviewed studies	Percentage (of population in each age group)
Income per capita *[log(GDP)]*	GDP/ population by country.	Secondary source: IMF (http://www.imf.org/external/pubs/ft/weo)	GDP per capita
Hospital beds per capita *[log(bed)]*	Hospital bed density (by country).	Secondary source: CIA library (https://www.cia.gov/library/publications)	Number hospital beds per 1,000 people
Urbanisation *[urb]*	% people living in urban areas (by country)	Secondary source: World Bank (http://data.worldbank.org/indicator)	Percentage
Literacy *[lit]*	Literacy rate, youth total (% of people ages 15-24, by country).	Secondary source: World Bank (http://data.worldbank.org/indicator)	Percentage

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Annex 4. Perceived impacts from stakeholders' workshop

Table 1:. Positive impacts of the opening of the new Fadura park identified by the stakeholders.

Category	**Identified indicators**	**Score**	**Measures to encourage potential positive impacts**
Environment	Urban gardens Recreation activities Green areas and itineraries Environmental awareness	8.8	Create itineraries and green corridors. Design of leisure areas and free leisure, and sports areas for free use for visitors.
Living place	-	-	Promote a union of the park with the city.
Community and society	Use for children Use for the elderly Use for people with fewer resources Social integration Recreation activities	8.6	Enable non-sport leisure areas for the elderly and infants. Spaces for outdoor social celebrations.
Safety and comfort	Social cohesion	2.0	Put public WC.
Employment and economy	Business	3.0	Develop actions to promote companies in the sector and innovation and entrepreneurship.
Food	Urban gardens Healthy food education	7.0	Promote the existence of vegetable gardens and activities related to food.

Mobility	Urban communication network	6.1	Promote the use of the bike and skates and raise awareness and minimize the use of the car., Promoting safe roads from different parts of the municipality and articulate public transport. It is necessary to open greater access to the park from different places in the municipality.
Physical activity	Outdoor sports Use for walking New outdoor facilities	6.9	Encourage spaces for the practice of outdoor physical activity and storage of spaces for the rainy season.

Table 2: Negative impacts of the opening of the new Fadura park identified by the stakeholders.

Category	**Identified indicators**	**Score**	**Measures to minimize possible negative impacts**
Environment	Dogs Messing up the area Noise Environmental degradation	-10.0	Safety and regulations for the use and enjoyment of green areas. Limitation of pets and permanent cleaning of spaces.
Living place	-	-	-
Community and society	Social conflicts Security	-8.0	Regulation of uses and flows according to mobility styles and uses.
Safety and comfort	Vandalism Security Meeting place for young people consuming alcoholic drinks	-7.5	Rules of use and enjoyment, security measures.
Employment and economy	-	-	-
Food	-	-	-
Mobility	Social conflicts	-2.0	Regulate the use of bikes and skates.

Physical activity	-	-	-

Annex 5. Questionnaire in Thinking Fadura

5.a Questionnaire for users of the green areas of Fadura (PDF)

Externally hosted: Questionnaire for users of the green areas of Fadura

5.b. Questionnaire for neighbours of Getxo (PDF)

Externally hosted: Questionnaire for neighbours of Getxo

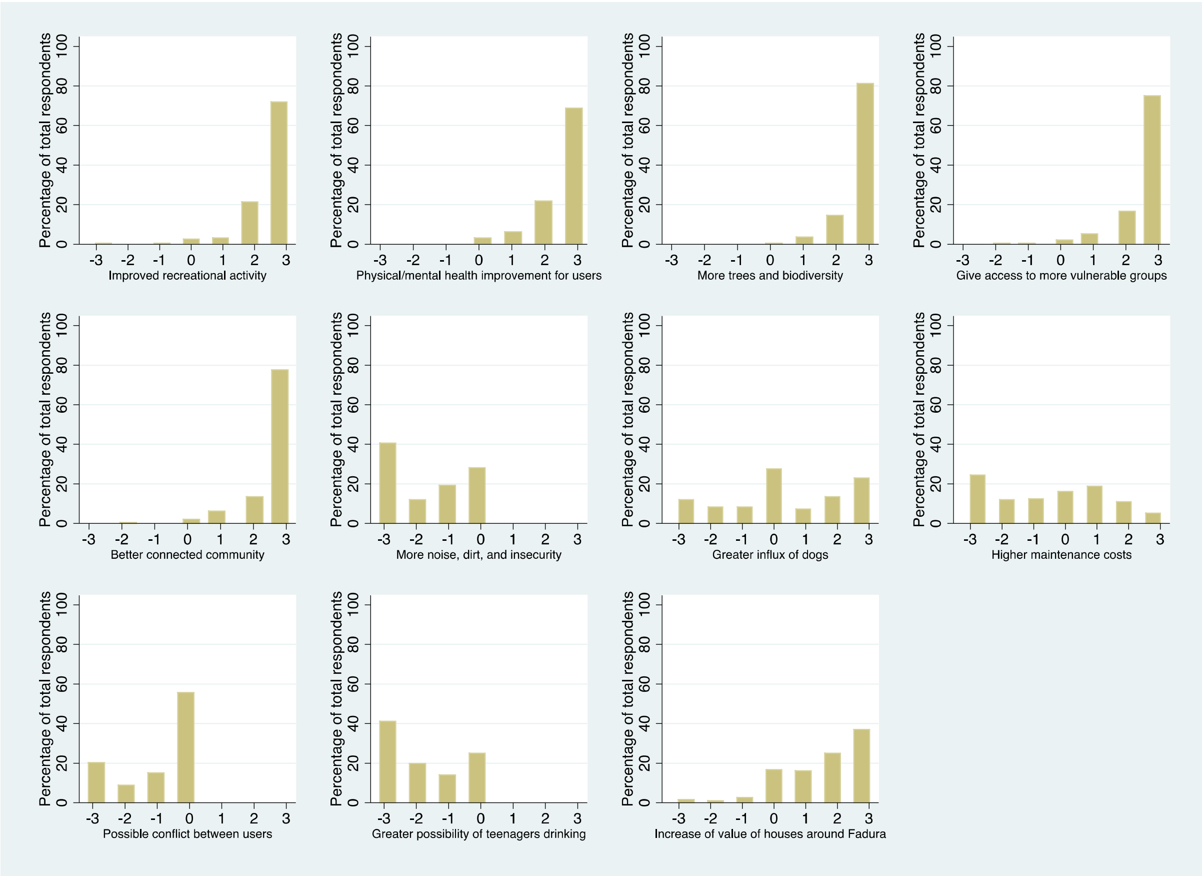
Annex 6. Perceived impacts from the general public (survey)

This Annex shows the response of some questions of the two surveys done in Thinking Fadura.

1. **Impacts**

There are 11 specific impacts to respond to for this question “B1. How would you assess the impacts that could arise as a consequence of the opening of the park?”, rated on a Likert scale of -3 to +3, -3 representing the respondent assessing the impact as very negative, and +3 as the respondent seeing the impact as very positive. Those who had “not sure” and “no answer” responses, as well as “not going to happen” responses were left out of this analysis. To begin, there were 256 respondents but after eliminating these responses it became 192.

Figure 1: Frequency analysis of survey responses to the question “B1. How would you assess the impacts that could arise as a consequence of the opening of the park?”.

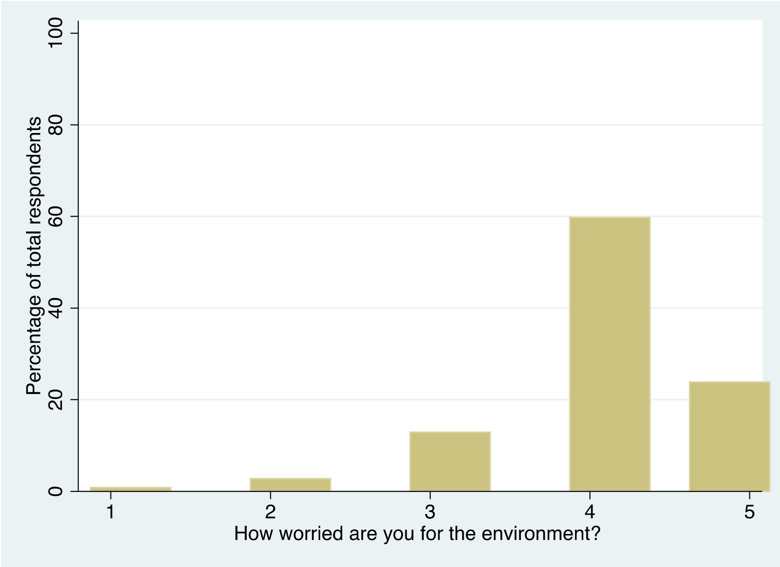


2. Attitudes

C1. Environment

This is from the section asking how worried the respondents are for the environment. 5 represents extremely worried and 1 represents not worried at all. There was a total of 256 respondents, demonstrating that the majority of respondents do feel quite aware and worried of the environmental situation. Nearly 80% of total respondents feel very worried.

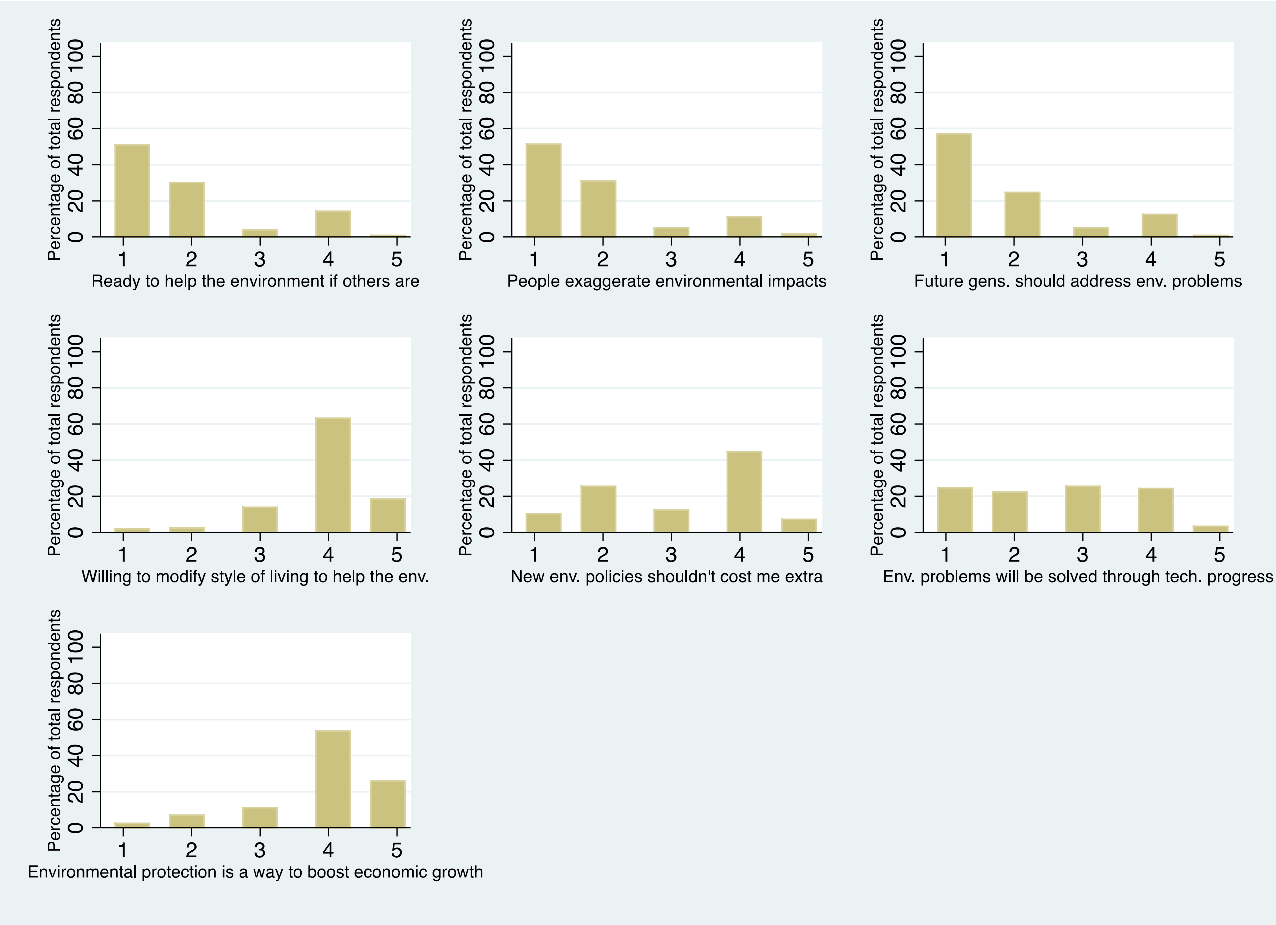
Figure 2: Frequency analysis of survey responses to the question “B1. How are you worried about the environment?”.



C2. Please indicate your degree of agreement or disagreement with the following statements.

There are 7 specific statements within this question, rated on a scale of 1 signifying complete disagreement, and 5 representing completely in agreement. Those who responded with 3 represent a neutral stance. Those who had "not sure" and "no answer" responses were left out of this analysis. There were just under 256 respondents included in this as very few responded with "NS/NC" (no sabe/no contesta). In general, respondents' attitudes seem to match with that of the impacts question – that there is a general disagreement with negative statements regarding preservation of the environment, and agreement with statements suggesting making an effort to help protect the environment now.

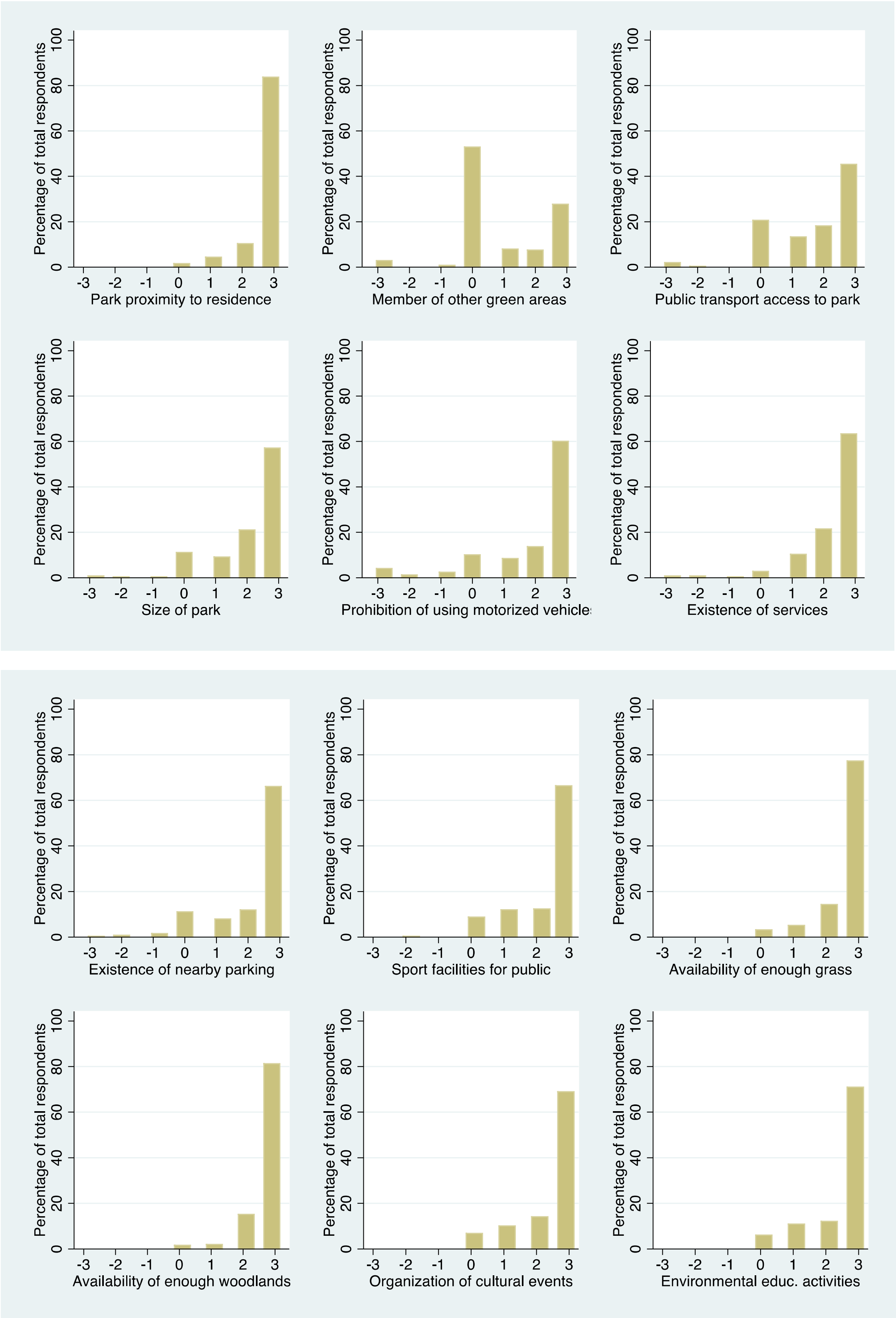
Figure 3. Frequency analysis of survey responses to the question “C2. Please indicate your degree of agreement or disagreement with the following statements”.

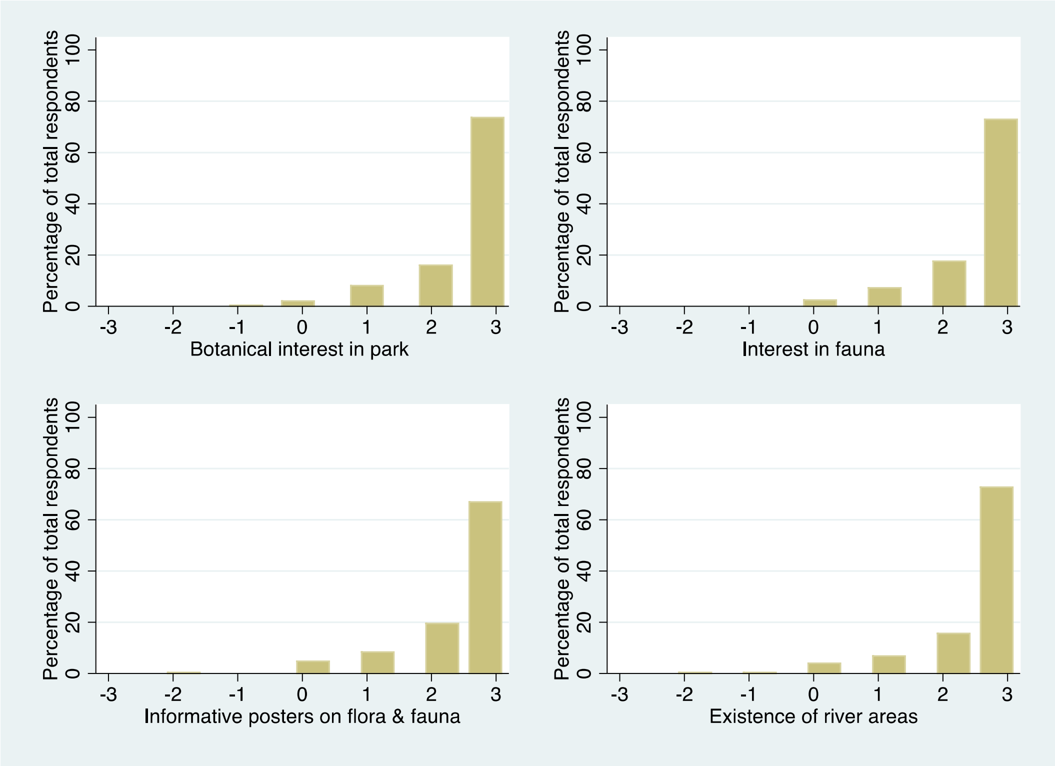


D1. Indicate to what extent the following factors influence in the utilization you make of urban parks in general.

There were just under 256 respondents included in this as very few responded with “NS/NC” (no sabe/no contesta), or “do not use urban parks”. There are 16 different factors to respond to in this question, rated on a Likert scale of -3 to +3, -3 representing the respondent assessing the impact as very negative, and +3 as the respondent seeing the impact as very positive. 0 represents neither negative nor positive, a neutral standpoint. Those who had “not sure” and “no answer” responses, as well as “do not use urban parks” responses were left out of this analysis.

Figure 4. Frequency analysis of survey responses to the question “D1. Indicate to what extent the following factors influence in the utilization you make of urban parks in general”.





In the responses above, it can be seen that the majority of respondents find that most of these factors would be a positive influence in the utilization of urban parks. The only ones that have visible negative proportions are "being a member of other clubs with green areas", "prohibition of using motorised vehicles", and "park access through public transport"– the last two could be because some of the survey respondents find parks useful to use their motorised scooters, and maybe the few people who found park access through public transport to be negative think that it would make the green space more busy. It is unclear the motivation behind these responses but overall most of these factors have a positive reaction from those surveyed.

Table 1: Summary Statistics for users of the green areas of Fadura.

Variable	Mean	Std. Dev.	Min	Max
Gender	1.355	0.479	1 (male)	2 (female)
Age	33.13	14.72	17	87
Has children	1.29	0.45	1 (yes)	2 (no)
Education	1.52	0.69	1 (university)	4 (none)
Household monthly income	2.19	0.77	1 (<€1,200)	4 (>€5,000)

Total Obs: 256.

Table 2: Summary Statistics for neighbours of the green areas of Fadura.

Variable	Mean	Std. Dev.	Min	Max
Gender	1.54	0.50	1 (male)	2 (female)
Age	51.86	19.36	16	93
Has children	1.34	0.47	1 (yes)	2 (no)
Residence Area	6.28	3.55	1	12
Education	1.67	0.69	1 (university)	3 (none)
Household monthly income	2.21	0.77	1 (<€1,200)	4 (>€5,000)

Total Obs: 256

Annex 7. Summary of studies used to estimate health impact of the sustainable food for nursery schools case study project

Table 1: Summary of studies used to estimate health impact of the pilot project.

Study	Location	Method	Health outcomes	Observations		Health indicator	Food health-quality
				Total	Significant effects		
Kleinman et al., 2002	Boston, USA	Categorical differences contrasted by Pearson χ^2 analysis	General health and academic performance	2	1 (50%)	Improvements in student academic performance and psychosocial functioning and decrease in hunger	Breakfast consumption and total energy intakes
Gundersen and Kreider, 2009	USA	Nonparametric bounding methods	General health and obesity	2	2 (100%)	BMI scores and general health of the child as reported by the mother (1) excellent, very good; (2) fair or poor	Food security
Cook et al., 2004	USA	Logistic regression	General health	4	2 (50%)	Response of caregivers to questions about their child's overall health status	Household food insecurity
Sampson et al., 1995	East Orange, NJ, USA	Chi-square statistic and nonparametric tests	Obesity	1	0 (0%)	Prevalence of obesity (%)	Breakfast skipping

Maluccio et al., 2009	Rural Guatemala	Regression analysis	Adult academic performance	2	1 (50%)	Reading comprehension test (SIA) z-scores and non-verbal cognitive ability test (Raven's) z-scores	Intervention with highly nutritious food supplements
Pate et al., 1996	USA	Logistic regression analysis	Physical activity levels	1	1(100%)	Significant results found for vegetables. In the case of fruit, depending on ethnicity	Fruits and vegetable servings on the previous day
Maynard et al., 2003	Great Britain	Logistic regression analysis	Risk of adult cancer	28	3 (10,7%)	Odds ratios for associations between incidence of cancer and the dietary factors	Fruits and vegetable and antioxidant consumption
Vatanparast et al., 2018	Canada	Multilevel regression method	Total-body bone mineral content	2	2 (100%)	TBBMC (total-body bone mineral content) data in grams	Consumption of milk products, vegetables and fruit
Qian et al., 2016	AK, USA	Panel models	Obesity and overweight	2	1 (50%)	BMI z-score and BMI percentile	Assistance program funding for free distribution of fresh fruits & vegetables
Farvid et al., 2016	USA	Multivariate regression models	Breast cancer	8	4 (50%)	Risk for breast cancer (responses to a questionnaire: yes – no)	Fruits and vegetable intake during adolescence
Kummeling et al., 2008	Netherlands	Multivariate logistic regression models	Atopic manifestation s in the first 2 years of life	11	1 (9%)	Percent of responses (3-point scale: yes – no – unknown)	Organic food consumption
Fung et al., 2011	Alberta, Canada	Multilevel regression methods	Obesity	1	0 (0%)	BMI scores	Alberta Project Promoting active Living and healthy Eating Schools (APPLE)
Okoko et al., 2007	London, UK	Logistic regression analysis	Asthma and wheezing	6	2 (33,3%)	Incidence (percentage) of current wheeze, ever wheeze, and ever-asthma	Fruits intake
You and Choo, 2016	South Korea	Logistic regression analysis	Obesity	4	3 (75%)	BMI scores	Fruit and vegetables intake

Veugelers and Fitzgerald, 2005	Nova Scotia, Canada	Multilevel regression methods	Obesity and overweight	2	0 (0%)	BMI scores	School-based healthy eating programs
De Lorenzo et al., 2010	Rome, Italy	Paired samples t-test, and Mann-Whitney test	Body Mass Index and fat mass reduction	2	1 (50%)	Average BMI scores and percentage of fat mass reduction	Italian Mediterranean Diet, consisting of organic versus conventional foods
Pierce et al., 2007	USA	Left-truncated Cox proportional hazard regression model	Survival	2	2 (100%)	10-year survival rate	Physical activity and fruit and vegetables intake
McNaughton et al., 2008	Australia	ANOVA and linear regression analysis	Body Mass Index and blood pressure	12	12 (100%)	Average BMI scores and average of the two measurements of systolic and diastolic blood pressures	3 dietary patterns: fruit, salad, cereals, and fish pattern; a high fat and sugar pattern; and a vegetables pattern
Foster et al., 2007	Philadelphia, PA, USA	Generalized estimating equations	Obesity and overweight	2	1 (50%)	Incidence (percentage) of overweight and obesity	School Nutrition Policy Initiative
Rosário et al., 2012	Portugal	Generalized linear models	Obesity and overweight	2	0 (0%)	BMI z-score variation	Six-month nutrition program
Kafatos et al., 2005	Crete, Greece	Multiple linear regression analysis	Overweight and Body Mass Index	4	0 (0%)	Percentages of overweight and average BMI scores	School-based health and nutrition education programme
Joshipura et al., 2001	USA	Pooled logistic regression with 2-year follow-up increments	Coronary Health Disease	8	4 (50%)	Relative risks for coronary heart disease (incidence rate ratios)	

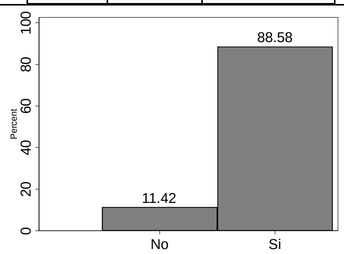
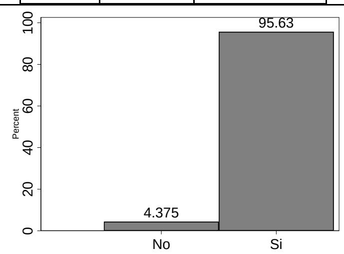
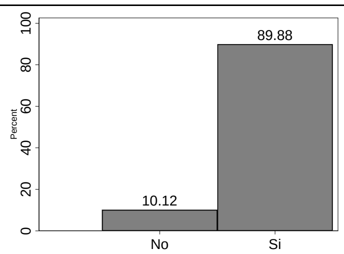
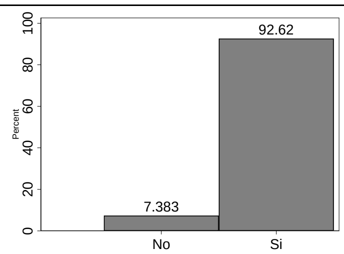
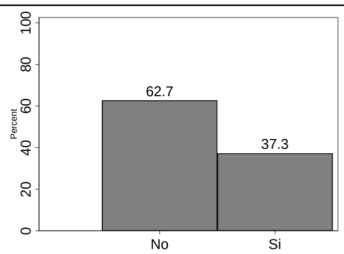
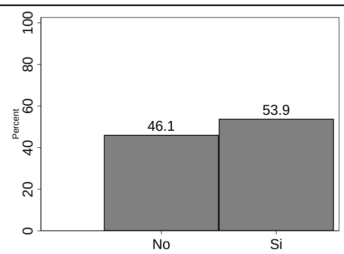
Annex 8. Questionnaire for nursery school community (PDF)

Externally hosted: Questionnaire for nursery school community

Annex 9. Perceived impacts from the school community (survey)

This Annex shows the response of some questions of the two surveys done in school community (based on 260 ex-ante and 161 ex-post answers).

Table 1: Perceived impacts from the school community

<table>
<tr><th>Questions</th><th>April 2018</th><th>April 2019</th></tr>
<tr><td>P1. Relation
1=Parents
2=Educators
3=Managers
4=Directors
5=Cooks
6=Others</td><td><table><tr><td>p1</td><td>Freq.</td><td>Percent</td></tr><tr><td>1</td><td>21</td><td>8.17</td></tr><tr><td>2</td><td>108</td><td>42.02</td></tr><tr><td>3</td><td>27</td><td>10.51</td></tr><tr><td>4</td><td>33</td><td>12.84</td></tr><tr><td>5</td><td>56</td><td>21.79</td></tr><tr><td>6</td><td>12</td><td>4.67</td></tr></table></td><td><table><tr><td>p1</td><td>Freq.</td><td>Percent</td></tr><tr><td>1</td><td>50</td><td>31.45</td></tr><tr><td>2</td><td>40</td><td>25.16</td></tr><tr><td>3</td><td>15</td><td>9.43</td></tr><tr><td>4</td><td>28</td><td>17.61</td></tr><tr><td>5</td><td>20</td><td>12.58</td></tr><tr><td>6</td><td>6</td><td>3.77</td></tr></table></td></tr>
<tr><td>P2. Do you think that present food in school is healthy?
1=No
2=Yes</td><td>
</td><td>
</td></tr>
<tr><td>P2.1. Do you think there has been a change in relation to the previous year?
1=No
2=Yes</td><td>
</td><td>
</td></tr>
<tr><td>P3. Do you think that present food in school is ecologic?
1=No
2=Yes</td><td>
</td><td>
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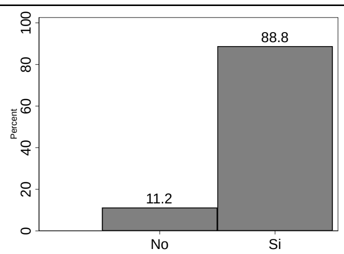
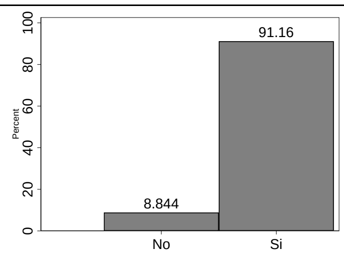
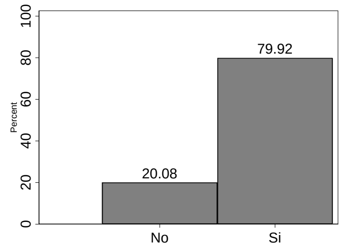
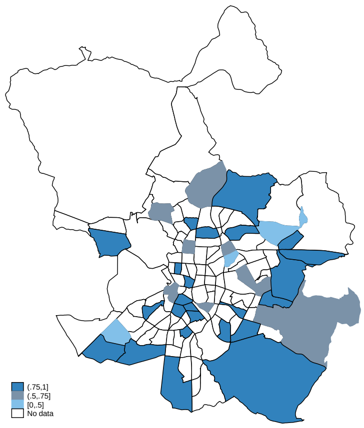
<tr><td>P3.1. Do you think there has been a change in relation to the previous year?
1=No
2=Yes</td><td>
</td><td>
</td></tr>
</table>

<table>
<tr>
<td>P4 Do you think the path at which healthy and ecologic food is being implemented is adequate?

1=No

2=Yes</td>
<td>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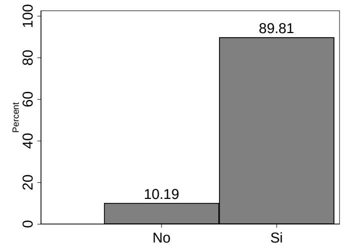
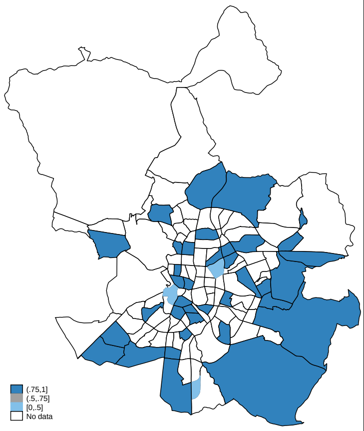
<td>

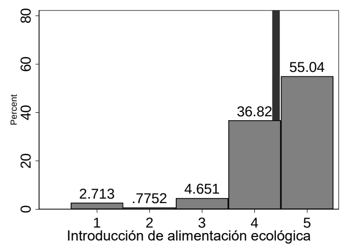

</td>
</tr>
<tr>
<td colspan="3">Indicate for each el the measures described below, in what measure you agree</td>
</tr>
<tr>
<td>P5.1. Introduction of ecologic food

1= Strongly disagree

2= Disagree

3= Neutral

4= Agree

5= Strongly agree</td>
<td>
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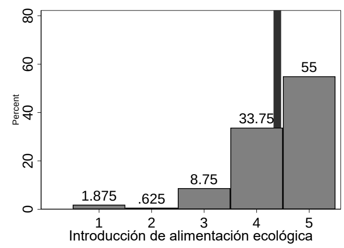
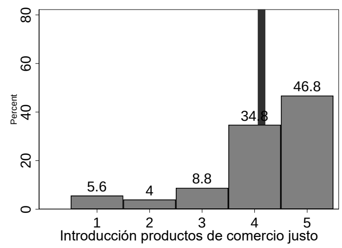
<td>
</td>
</tr>
<tr>
<td>P5.2. Introduction of fair-trade products

1= Strongly disagree

2= Disagree

3= Neutral

4= Agree

5= Strongly agree</td>
<td>
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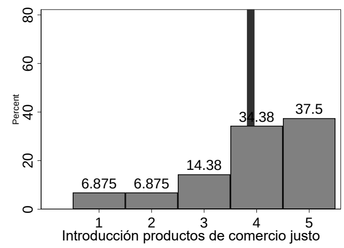
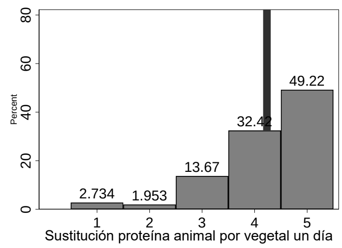
<td>
</td>
</tr>
<tr>
<td>P5.3. Substitution of animal to vegetal protein one day a week in the menu

1= Strongly disagree

2= Disagree

3= Neutral

4= Agree

5= Strongly agree</td>
<td>
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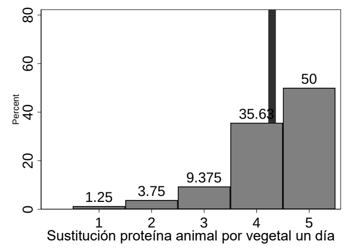
<td>
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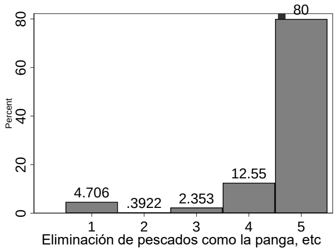
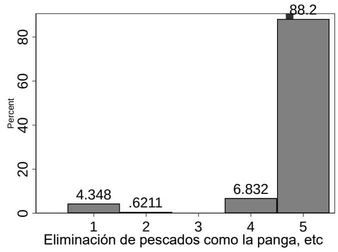
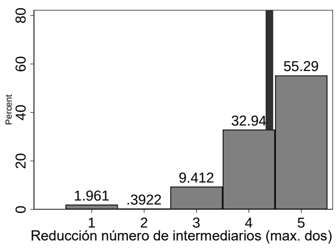
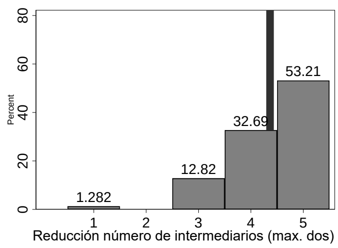
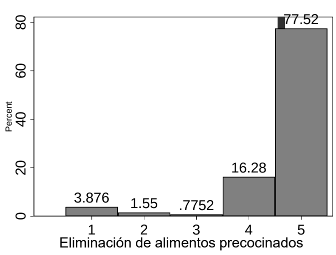
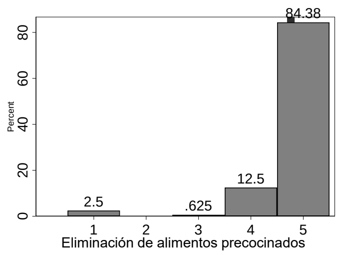
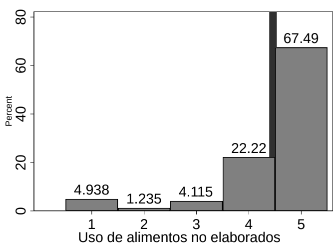
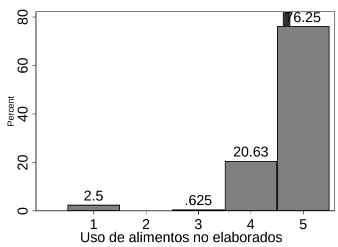
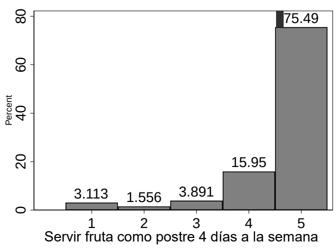
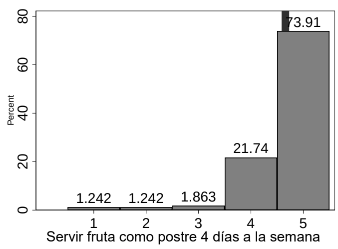
<table>
<tr><td>P5.4. Elimination of fish such as sway, tilapia or Nile perch
1= Strongly disagree
2= Disagree
3= Neutral
4= Agree
5= Strongly agree</td><td></td><td></td></tr>
<tr><td>P5.5. Reduction to a maximum of two the number of intermediaries between school diners and producers or farmers
1= Strongly disagree
2= Disagree
3= Neutral
4= Agree
5= Strongly agree</td><td></td><td></td></tr>
<tr><td>P5.6. Elimination of food precooked or prepared by other industries or businesses in school diners
1= Strongly disagree
2= Disagree
3= Neutral
4= Agree
5= Strongly agree</td><td></td><td></td></tr>
<tr><td>P5.7. Use of non-prepared food items as kitchen ingredients
1= Strongly disagree
2= Disagree
3= Neutral
4= Agree
5= Strongly agree</td><td></td><td></td></tr>
<tr><td>P5.8. Four days with fruit servings as dessert
1= Strongly disagree
2= Disagree
3= Neutral
4= Agree
5= Strongly agree</td><td></td><td></td></tr>
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<table>
<tr><td>

P5.9. Serving natural dairy products, without edulcorates, flavouring or artificial colouring

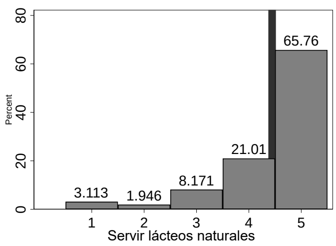
1= Strongly disagree

2= Disagree

3= Neutral

4= Agree

5= Strongly agree

</td><td>


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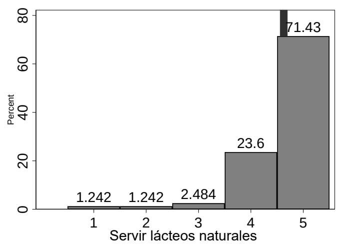


</td></tr>
<tr><td>

P5.10. Elimination of fruit juices not prepared in the school

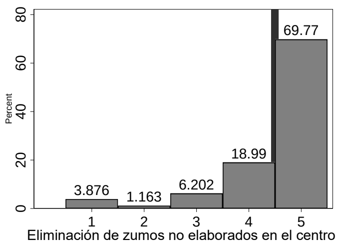
1= Strongly disagree

2= Disagree

3= Neutral

4= Agree

5= Strongly agree

</td><td>


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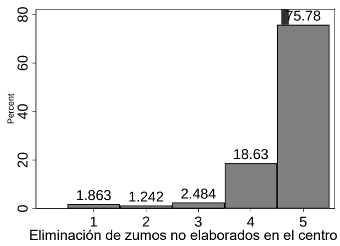


</td></tr>
<tr><td>

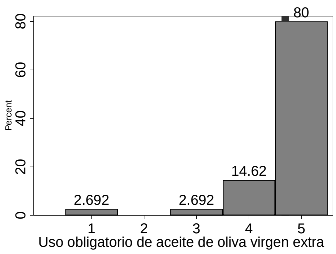
P5.11. Compulsory use of extra virgin olive oil 1= Strongly disagree

2= Disagree

3= Neutral

4= Agree

5= Strongly agree

</td><td>


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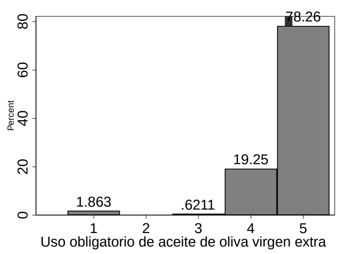


</td></tr>
<tr><td>

P5.12. Introduction of goat milk and cheese

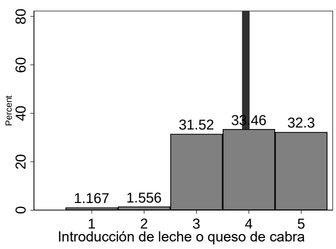
1= Strongly disagree

2= Disagree

3= Neutral

4= Agree

5= Strongly agree

</td><td>


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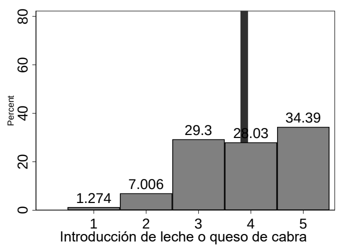


</td></tr>
<tr><td>

P5.13. Introduction of integral products (cereals, cookies, pasta, bread)

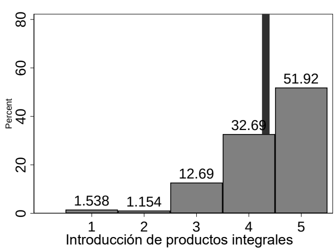
1= Strongly disagree

2= Disagree

3= Neutral

4= Agree

5= Strongly agree

</td><td>


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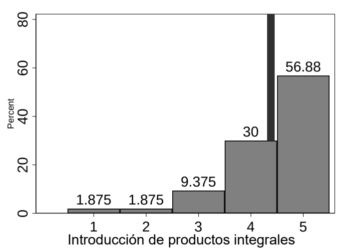
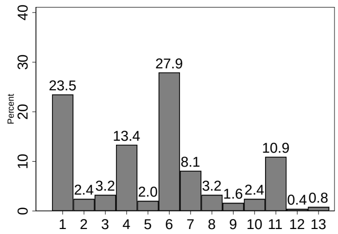
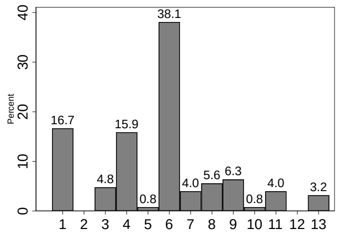
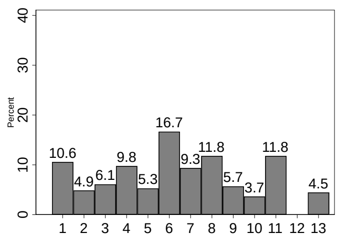
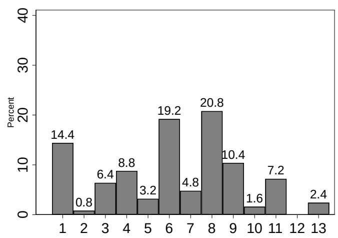
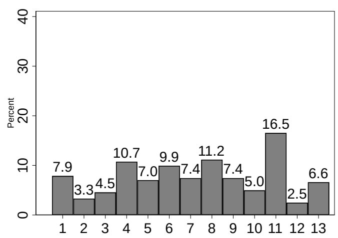
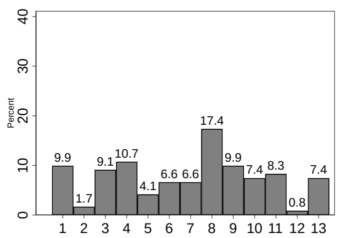


</td></tr>
<tr><td colspan="3">Among the previously described measure, name the three you find most important or improving food quality</td></tr>
</table>

P6.1. First measure: 1=Introduction of ecologic food 2=Introduction of fair-trade products 3=Substitution of animal to vegetal protein 4=Elimination of fish such as sway, tilapia,… 5=Reduction to a maxi. of 2 the intermediaries 6=Elimination of food precooked 7=Use of non-prepared food as ingredients 8=Four days with fruit servings as dessert 9=Natural dairy products, without edulcorates,.. 10=Elimination of juices not prepared in school 11=Compulsory use of extra virgin olive oil 12=Introduction of goat milk and cheese 13=Introduction of integral products		
P6.2. Second measure: 1=Introduction of ecologic food 2=Introduction of fair-trade products 3=Substitution of animal to vegetal protein 4=Elimination of fish such as sway, tilapia,… 5=Reduction to a maxi. of 2 the intermediaries 6=Elimination of food precooked 7=Use of non-prepared food as ingredients 8=Four days with fruit servings as dessert 9=Natural dairy products, without edulcorates,.. 10=Elimination of juices not prepared in school 11=Compulsory use of extra virgin olive oil 12=Introduction of goat milk and cheese 13=Introduction of integral products		
P6.3. Third measure: 1=Introduction of ecologic food 2=Introduction of fair-trade products 3=Substitution of animal to vegetal protein 4=Elimination of fish such as sway, tilapia,… 5=Reduction to a maxi. of 2 the intermediaries 6=Elimination of food precooked		

<table>
<tr>
<td>7=Use of non-prepared food as ingredients

8=Four days with fruit servings as dessert

9=Natural dairy products, without edulcorates,..

10=Elimination of juices not prepared in school

11=Compulsory use of extra virgin olive oil

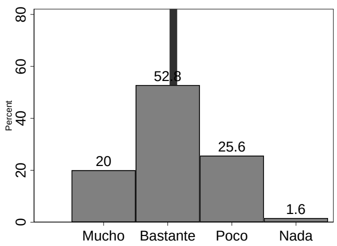
12=Introduction of goat milk and cheese

13=Introduction of integral products</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P11. Do you think that implementing some of these measures will promote dietary changes in families outside of school?

1= High

2= Moderate

3= Low

4= None</td>
<td>
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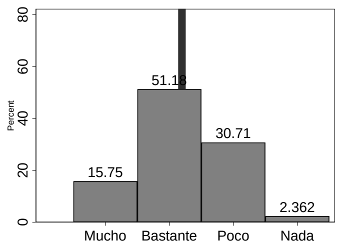
<td>
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Source: Own Elaboration